# STEcoMed2024

## 1st International Congress for Sustainable Ecosystems in the Mediterranean Area

**October 2 – 3, 2024. Split, Croatia**

# *Book of Abstracts*

Photo by V. Šimat

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1st ***International Congress for Sustainable Ecosystems in the Mediterranean Area***

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# STEcoMed2024

# PROGRAM

# STEcoMed2024 - Program

## Wednesday, 2nd October 2024 / Day 1

| | | |
|---|---|---|
| 8:00-9:00 | Registration and Welcome Reception | |
| | ***Moderator: Zrinka Koludrović*** | |
| 9:00-10:00 | OPENING CEREMONY<br>• Maja Krželj, Conference Chair<br>• Igor Jerković, Vice-rector for Science and Quality of the University of Split<br>• Vida Šimat, Scientific programme Chair | |
| | ***Moderator: Vida Šimat*** | |
| 10:00-10:40 | PLENARY SPEAKER<br>**Abdo Hassoun, France**<br>*Food industry 4.0 and food sustainability: opportunities, key challenges and significance of interdisciplinarity* | |
| 10:40-11:10 | INVITED SPEAKER<br>**Giulia Tabanelli, Italy**<br>*Microbial biodiversity valorization as a tool for sustainable food productions* | |
| | | |
| 11:10-12:10 | POSTERS & coffee break | Sessions<br>• Agro-food sector |

**List of posters:**

P1. Petra Brzović, Croatia - SEA FENNEL FLAVORED VEGETABLE OILS
P2. Željana Fredotović, Croatia - TREASURE OF ENDEMIC PLANTS – VOLATILE COMPOSITION AND BIOLOGICAL ACTIVITY OF *Chaerophyllum coloratum,* L.
P3. Roberta Frleta Matas, Croatia - THE CHEMICAL COMPOSITION AND ANTIOXIDANT POTENTIAL OF MICROALGAE *Chaetocerus costatus*
P4. Alexandre Gonçalves, Portugal - CHESTNUT 'TERRA FRIA' PDO: SUITABLE INGREDIENT FOR INNOVATIVE PRODUCTS
P5. Martina Jakovljević Kovač, Croatia - SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY ISOLATION OF PHENOLIC ACIDS FROM NETTLE EXTRACT USING DEEP EUTECTIC SOLVENTS AND MACROPOROUS RESINS
P6. Andrea Tadić, Croatia - CHEMICAL COMPOSITION AND BIOLOGICAL POTENTIAL OF GARLIC BY-PRODUCTS
P7. Toni Jurić Šolto, Croatia - DEVELOPMENT OF QUALITY INDEX METHOD FOR ADRIATIC SHRIMP (*Parapenaeus longirostris*)
P8. Danijela Skroza, Croatia - IMPACT OF EXTRACTION METHOD AND SOLVENT ON CAFFEIC AND CHLOROGENIC ACID CONTENT IN COFFEE BY-PRODUCT EXTRACTS
P9. Barbara Soldo, Croatia - NUTRITIONAL COMPOSITION OF COFFEE AND COFFEE BY-PRODUCTS
P10. Stela Jokić, Croatia - IN-DEPTH ANALYSIS OF BROWN MACROALGAE *Sargassum hornschuchii* BY UHPLC-ESI-HRMS

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|---|---|---|
| | ***Moderator: Danijela Skroza*** | |
| 12:10-13:10 | INVITED SPEAKERS<br>**Ivona Nuić, Croatia**<br>*Potential use of natural materials and food processing by-products in wastewater treatment*<br>**Ivo Kara-Pešić, Croatia**<br>*Snailpace to win the race - A Brief History of Slow Food* | |
| 13:10-13:40 | SPEAKERS<br>**Piotr Kulawik, Poland** - *Long-term exposure of meat to UV-a led radiation at 4 °c – the effect on native bacteria and color*<br>**Domenico D'Ausilio, Italy** - *The determinants of Mediterranean diet adherence in Italy: a historical analysis (1861-2015)* | |
| 13:50 - 15:15 Lunch | | |
| | ***Moderator: Željka Trumbić*** | |
| 15:25 - 16:10 | SPEAKERS<br>**Sara Najjari, Morocco** - *Evaluation of physiological traits of lentil introduced in an agroforestry system: joint impact of soil and species in leguminous culture*<br>Film projection " Slow Food Story" (2013)<br>directed by Stefano Sardi | |
| 16:15 - 17:15 | POSTERS & coffee break | Sessions<br>• Agro-food sector<br>• Environmental protection, waste management and environmental engineering |

**List of posters:**

P11. Lillian Barros, Portugal - ALMONDS INTERCROPPED WITH OTHER CROPS CULTIVATED IN CROATIA: STUDY OF NUTRITIONAL PROPERTIES AND BIOACTIVITIES

P12. Alexandre Gonçalves, Portugal - VALMEDALM PROJECT - VALORIZATION OF MEDITERRANEAN ALMOND ORCHARDS THROUGH THE USE OF INTERCROPPING INTEGRATED STRATEGIES

P13. Cristina Caleja, Portugal - EVALUATION OF THE NUTRITIONAL PROPERTIES AND MINERAL COMPOSITION OF ALMONDS INTERCROPPED WITH CHICKPEAS AND CLOVER IN DIFFERENT IRRIGATION SYSTEMS IN NORTHEASTERN PORTUGAL

P14. Ana Lobo Santos, Portugal - EVALUATION OF ALMOND TREE' FERTILITY WHEN THE SOIL IS SUBJECTED TO DIFFERENT MAINTENANCE SYSTEMS AND DIFFERENT WATER CONDITIONS

P15. Sara Najjari, Morocco - AGROFORESTRY ALMOND ORCHARDS TO ASSESS INTERACTIONS BETWEEN TREES AND CROPS UNDER THE MEDITERRANEAN CLIMATE IN MOROCCO

P16. Domagoj Ivan Žeravica, Croatia - THE EFFECT OF WATER SALINITY ON TRANSPIRATION AND PHOTOCHEMISTRY IN *Citrus unshiu* Marc. 'IWASAKI' IN CROATIA
P17. Ines Cindrić, Croatia - EFFECTIVE REMOVAL OF SYNTHETIC DYE CRYSTAL VIOLET USING ACTIVATED CARBON FROM ORANGE BIOMASS
P18. Adnane El Yaacoubi, Morocco - ROLE OF THE BLACK SOLDIER FLY IN ORGANIC WASTE MANAGEMENT AND PRODUCTION OF BIOFERTILIZER FOR FAVA BEAN CULTIVATION
P19. Ana Maravić, Croatia - PREVALENCE AND ANTIBIOTIC RESISTANCE DETERMINANTS OF CARBAPENEM-RESISTANT *Acinetobacter baumannii* FROM WASTEWATER TREATMENT PLANTS IN SPLIT, CROATIA
P20. Sunčica Mileta, Croatia - OLIVE PITS AS ECO-FRIENDLY SORBENT FOR TREATMENT OF ZINC(II)-CONTAMINATED WATER
P21. Mario Nikola Mužek, Croatia - SORPTION OF COPPER, COBALT AND NICKEL IONS FROM TERNARY SOLUTIONS ON THE ZEOLITE 13X
P22. Lucia Vidošević, Croatia - FTIR ANALYSIS OF THE RECYCLED CELLULOSE FROM THE LABORTORY WASTE MATERIALS VIA REGENERATION PROCESS
P23. João Vieira, Portugal - CONVERSION OF ROCKROSE (*Cistus ladanifer* L.) SCRUBLAND INTO BIODIVERSE PASTURES

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| 19:30 | Judita (Play) | Social event at the Meštrovićev Kaštelet duration 70 min |

## Thursday, 3nd October 2024 / Day 2

| | ***Moderators: Frane Strikić*** |
|---|---|
| 9:00-10:00 | INVITED SPEAKERS<br><br>**Angjelina Belaj, Spain**<br>*Preservation of plant genetic resources – case olive*<br><br>**Zlatko Šatović, Croatia**<br>*Preservation of biodiversity in the Mediterranean: the case of the Dalmatian sage* |
| 10:00-10:30 | SPEAKERS<br><br>**Tomislav Kos, Croatia**<br>*Olive moth flight tracking using artificial neural network tools*<br><br>**Ana Romana Armanda, Croatia**<br>*The influence of agroecological conditions on the life traits of Cydalima perspectalis in Central Dalmatia* |
| 10:30-10:50 | **Amelia Rubini, Italy**<br>*Overcoming insularity through efficient use of energy, water, and waste management*<br>**Daniela Giordano, Italy**<br>*Coffee and climate: metadiscourse analysis of research articles* |

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| 10:50-11:50 | POSTERS & coffee break | Sessions<br>• Biodiversity<br>• Climate change |

**List of posters:**

P24. Giulia Bellanti, Italy - MACROPHYTE COMMUNITIES IN THE NORTHERN ADRIATIC SEA: LONG-TERM CHANGES AND THE NEED OF NEW TOOLS FOR MONITORING

P25. Martina Kadoić Balaško, Croatia - MONITORING OF INVASIVE ALIEN PLANT SPECIES IN THE BREGANA RIVER AREA

P26. Ana Lobo Santos, Portugal - ABUNDANCE AND DIVERSITY OF SOIL ARTHROPODS IN NON-IRRIGATED AND IRRIGATED ALMOND GROVES IN THE TRÁS-OS-MONTES REGION (PORTUGAL)

P27. Ivana Paladin Soče, Croatia - RESEARCH ON THE BIOLOGICAL CHARACTERISTICS OF THE SPECIES ALEUROCANTHUS SPINIFERUS (QUINTANCE, 1903) IN THE CLIMATIC CONDITIONS OF THE DUBROVNIK-NERETVA COUNTY

P28. Ermelinda Silva, Portugal - RECOVERY OF BURNED AREAS IN NATURAL PARK OF SERRA DA ESTRELA: THE POWER OF NATIVE PLANTS

P29. Ermelinda Silva, Portugal – UNVEALING THE EFFECTS OF SOIL RESTORATION MEASURES ON ARTHROPOD ABUNDANCE IN A PORTUGUESE NORTHEASTERN FOREST

P30. Damir Viličić, Croatia- PROTECTION AND SUSTAINABILITY OF BIOLOGICAL DIVERSITY IN THE SEA AND ON THE ISLANDS OF DALMATIA

P31. Elma Vuko, Croatia - GLANDULAR AND NON-GLANDULAR TRICHOMES AND ANTIPHYTOVIRAL ACTIVITY OF *Inula spiraeifolia* L.

P32. Ivona Siber, Croatia - SPATIAL AND TEMPORAL ANALYSIS OF SEA SURFACE HEIGHT VARIATIONS IN THE MEDITERRANEAN SEA USING NEURAL GAS AND THEIR LINK TO BIOLOGICAL PARAMETERS

***Moderator: Marin Ordulj***

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| 11:50-12:30 | PLENARY SPEAKER<br>**Roberto Danovaro, Italy**<br>*Biodiversity and marine ecosystem restoration* |
| 12:30-13:00 | INVITED SPEAKER<br>**Jakov Dulčić, Croatia**<br>*Changes in the biodiversity of the Mediterranean/Adriatic Sea ichthyofauna – are there reasons for concern?* |
| 13:00-13:30 | SPEAKERS<br>**Cristina Gioia Di Camillo, Italy**<br>*Resilience of Adriatic benthic communities subject to repeated heatwaves and mucilage episodes*<br>**Biljana Apostolska, Croatia**<br>*Microplastics in anchialine caves* |

13:30 - 14:45 Lunch

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|---|---|---|
| | ***Moderator: Martina Čagalj*** | |
| 14:50 - 15:20 | SPEAKERS<br>**Francesco Rendina, Italy**<br>*Biodiversity of benthic communities from Italian mesophotic rhodolith beds*<br>**Dalka Zanki, Croatia**<br>*Beach litter in the Vis archipelago, Croatia* | |
| 15:20 - 16:20 | POSTERS& coffee break | Session<br>• Fisheries, aquaculture and marine pollution |

**List of posters:**

P33. Enrico Cecapolli, Italy - TWO DECADES OF OCEANOGRAPHIC AND CATCH DATA COLLECTION USING FISHING VESSELS TO MODEL THE SPATIO-TEMPORAL DISTRIBUTION OF SMALL PELAGICS IN THE ADRIATIC SEA: PRELIMINARY RESULTS

P34. Tena Ćurko, Croatia - THE MICROBIOME OF FARMED MUSSEL *Mytilus galloprovincialis* IN THE ESTUARY OF KRKA RIVER

P35. Francesca Maria Veneziano, Italy - DIET AND FEEDING HABITS OF THE MEDITERRANEAN HAKE, *Merluccius merluccius* (LINNAEUS, 1758) IN THE SOUTHERN TYRRHENIAN SEA (MEDITERRANEAN SEA)

P36. Marin Ordulj, Croatia - ISOLATION AND MORPHOLOGICAL CHARACTERIZATION OF A *Vibrio gigantis* BACTERIOPHAGE

P37. Sanja Puljas, Croatia - GENDER DETERMINATION IN THE MEDITERRANEAN MUSSEL *Mytilus galloprovincialis* (BIVALVIA: MYTILIDAE) BASED ON THE COLORATION OF THE GONAD TISSUE

P38. Ines Rebac, Croatia - THE IUCN GLOBAL STANDARD FOR NATURE-BASED SOLUTIONS AND BIVALVE FARMING

P39. Francesca Maria Veneziano, Italy - OCTOCORALLIA FORESTS HAVE THE POTENTIAL TO BE BOTH A BIODIVERSITY HOTSPOT AND A NURSERY AREA FOR ELASMOBRANCH

P40. Mia Dželalija, Croatia - DE NOVO PLASMID ASSEMBLY FROM CARBAPENEM RESISTANT ENTEROBACTERIACEAE IN CENTRAL ADRIATIC SEA

P41. Lorenzo Zacchetti, Italy - DEPTH-DEPENDENT DIETARY INFLUENCE ON THE GUT MICROBIOME OF NORWAY LOBSTER (*Nephrops norvegicus*) FROM THE CENTRAL ADRIATIC SEA (MEDITERRANEAN SEA)

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| 17:00 - 18:30 | Split – City tour |

20:00-23:00 Gala dinner

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1st ***International Congress for Sustainable Ecosystems in the Mediterranean Area***

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# PLENARY PRESENTATION ABSTRACTS

The authors are solely responsible for the data, contents and errors found in the abstracts.

# FOOD INDUSTRY 4.0 AND FOOD SUSTAINABILITY: OPPORTUNITIES, KEY CHALLENGES, AND SIGNIFICANCE OF INTERDISCIPLINARITY

**Abdo HASSOUN**

*Sustainable AgriFoodtech Innovation and Research (SAFIR), Arras, France*
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The fourth industrial revolution, or Industry 4.0, is driving profound changes across various sectors, including agriculture and the food industry. Industry 4.0 introduces key enabling technologies, encompassing digital innovations such as artificial intelligence, big data, blockchain, digital twins, and cloud computing; physical innovations like smart sensors, the Internet of Things, robotics, and drones; and biological advancements such as gene-editing technology and nanobiotechnological tools. These technologies are revolutionizing the food sector by creating precision agriculture systems and smart food factories, improving food quality, safety, traceability, and significantly reducing waste, production costs, and environmental impact.
This presentation will explore the opportunities and challenges of applying Industry 4.0 technologies in the agri-food sector, highlighting their potential to accelerate the transition towards a more sustainable food system. It will also emphasize the importance of interdisciplinary collaboration to advance food sustainability across its social, economic, and environmental dimensions, while aligning with the Sustainable Development Goals (SDGs). Attendees will gain insights into the interplay between Industry 4.0 and food sustainability, along with discussions on the fundamental drivers and barriers to the adoption of these transformative technologies. This presentation is essential for researchers, food engineers, producers, and technologists seeking to understand how technological advancements are shaping the future of food production and sustainability.

*Keywords*: Fourth industrial revolution, digitalization, automation, digital transformation, smart food factory, precision agriculture

# BIODIVERSITY AND MARINE ECOSYSTEM RESTORATION

**Roberto DANOVARO**

*Dept. of Life and Environmental Sciences, Polytechnic University of Marche & National Biodiversity Future Centre, Italy*
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Marine habitats are under unprecedented threat, with no less than 66% of coastal areas already altered and degraded. Bottom fishing, which relies on indiscriminate trawling, physically damages approximately 4.9 million km2 (equivalent to 1.3% of the global ocean) of the seabed every year. Other impacts such as litter and chemical pollution are increasingly affecting key ecosystem processes and functions at various levels and threatening marine biodiversity. In addition, the physical impacts of drilling for oil and gas extraction can have further impacts on the ecosystem. These examples illustrate just some of the direct impacts of humanity's long-term exploitation of the world's oceans, which could lead to the collapse of animal populations and the expansion of habitats, resulting in the extinction of many marine species. Restoring these lost habitats will require restoration efforts through the reintroduction and expansion of ecosystem engineers and habitat-forming species (e.g., seagrass beds, mangroves, kelp/macroalgae, tropical coral reefs, and temperate animal forests). Here I will highlight the successes and failures of restoration efforts in a variety of marine habitats worldwide. The available data show that restoration efforts: 1) are feasible for a wide range of marine habitats; 2) are highly successful for most habitat-forming species; 3) are successful at all spatial scales; 4) are scalable through appropriate policies, regulations and funding instruments. Restoration measures can be effective even in areas where direct human impacts persist. This shows that successful restoration does not require the preventive removal of all stressors.

*Keywords:* marine ecosystems, marine biodiversity, ecosystem restoration


# INVITED PRESENTATION ABSTRACTS

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# MICROBIAL BIODIVERSITY VALORIZATION AS A TOOL FOR SUSTAINABLE FOOD PRODUCTIONS

**Giulia TABANELLI[1,2*], Federica BARBIERI[1], Chiara MONTANARI[1], Ida MERCURIO[1], Martina FILIPPINI[1], Vida ŠIMAT[3], Fausto GARDINI[1,2]**

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The increasing global demand for food is reaching the planetary limits of food supply and is raising concerns about environmental sustainability and food security. Indeed, it is not only important to ensure the supply of calories, but also to ensure a balanced diet with diverse, nutrient-rich foods. In this respect, biodiversity plays a crucial role in achieving sustainable food production, especially in traditional agricultural and food systems. Underutilized aspects of biodiversity include microbial diversity and the microbial solutions derived from it, which can be a fundamental pillar for sustainable approaches to food production. The enhancement of microbial diversity through the selection of new functional bacterial strains can develop innovative industrial applications. Spontaneously fermented foods harboring a rich microbial diversity represent a valuable reservoir of microorganisms with desirable technological properties for both fermentation and bioprotection. The study and selection of these microbial resources, tailored to specific applications, can represent an important tool for the safety and quality of food production by inhibiting spoilage and pathogenic microorganisms, thus extending food shelf life and reducing food waste. This selection of microbial strains includes comprehensive analyses of their metabolic properties, their resistance under industrial processing conditions and their ability to confer additional properties such as the production of natural antimicrobials. Furthermore, by selecting customized starter cultures, it is possible to develop safe, healthy and innovative products from underutilized raw materials, thus contributing to food diversification. This approach helps to reduce the environmental impact and promotes the use of smaller or regional food matrices, which is in line with the general objectives of food sustainability.

*Keywords*: microbial biodiversity, microbial strain selection, food sustainability, starter cultures, bioprotective cultures

# POTENTIAL USE OF NATURAL MATERIALS AND FOOD PROCESSING BY-PRODUCTS IN WASTEWATER TREATMENT

**Ivona NUIĆ[1*], Sunčica MILETA[2], Marin UGRINA[1], Ana PALČIĆ[3], Sanja PERINOVIĆ JOZIĆ[1]**

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Globally, an increasing number of water bodies are struggling with problems such as pollution, overexploitation and the destruction of ecosystems.. The aquatic environment is burdened by various pollutants, of which heavy metals are particularly common. As they are very difficult to decompose, they tend to bioaccumulate and biomagnify, threatening the survival of numerous aquatic organisms and human health. Therefore, sustainable management of water resources is becoming increasingly urgent to ensure the availability of clean water for future generations. The development of technologies for the effective and eco-friendly removal of heavy metals from polluted waters is crucial. By using natural aluminosilicate mineral zeolite, satisfying resultshave been achieved in the removal of lead(II) (up to ≈ 80%) and zinc(II) (up to ≈ 36%) from wastewater. The use of its modified sodium-rich and iron-rich forms resulted in significantly higher removal efficiencies in the range of ≈ 95-98% for lead and ≈ 85-88% for zinc, respectively. In order to achieve a more sustainable and cost-effective approach, food processing by-products from local processing plants such as olive pits, cherry pits and sour cherry pits were tested in their native form for the environmentally friendly removal of lead(II) and zinc(II) from wastewater. The removal efficiencies achieved ranged from of 10.3-90.9% for lead and 4.9-69.5% for zinc, depending on the different test conditions, with sour cherry pits showing the highest removal efficiency. The use of food processing by-products as low-cost sorbents could provide a double benefit by contributing to waste management and providing an environmentally friendly solution for the treatment of water contaminated with heavy metals.

*Keywords*: food processing by-products, heavy metals, low-cost sorbents, cost-effective wastewater treatment

# SNAILPACE TO WIN THE RACE A Brief History Of Slow Food

**Ivo KARA-PEŠIĆ**

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Slow Food was founded in 1986, an international movement whose aim is to protect traditional agriculture and preserve biodiversity. It supports sustainable agriculture that develops local food traditions, local crops and small or local producers with an immense number of projects around the world. We will elaborate on the movement's response to the increasing challenges posed by climate change and present its own vision for the transition away from the environmentally damaging production forms of industrial agriculture. Agroecology, i.e. a philosophy of environmentally friendly food production that preserves biodiversity and cultural heritage, is at the heart of Slow Food's idea. The lecture will also present Slow Food's main projects: the Ark of Taste, a catalog of endangered foods, and the Presidia, which protect traditional products and practices that are under threat today. Through these projects, we will look in depth at how the movement encourages local communities to get involved in the protection of biodiversity, food sovereignty and the reduction of food waste. We will also discuss how the Slow Food philosophy is promoted through community-supported agriculture, farmers' markets and various food education programs at the local level. We will take a look at how such initiatives help to preserve and develop local gastronomic and cultural heritage. The talk will be followed by a screening of the documentary Slow Food Story 2013 by Stefano Sardo, which gives a historical overview of the movement and its global influence.

*Keywords*: slow food, preservation, agriculture, biodiversity, heritage

# PRESERVATION OF PLANT GENTIC RESOURCES – CASE OLIVE

**Angjelina BELAJ**

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Germplasm collections are fundamental tools for the conservation, characterization and efficient use of genetic resources. In this sense, the World Olive Germplasm Collection of Córdoba (WOGBC), Spain, founded almost 50 years ago at the IFAPA Center 'Alameda del Obispo', was the first international attempt to conserve and manage olive germplasm. Today, this collection is a national and international germplasm bank of distinction. It belongs to the IOC network and is Spain's national reference collection. It comprises 1257 accessions from 29 countries, most of them from the Mediterranean region. The identification of the olive varieties included in this collection is an important ongoing task that has been carried out using EST-SNP markers. With their help, a total of 757 different varieties have been identified. At the same time, cases of synonymy and homonymy, mislabeling and propagation errors were also detected in the collection. A high degree of genetic diversity was also detected in the olive germplasm. In addition, the WOGBC collection shows a high diversity in several important agronomic traits, such as vigor, resistance to biotic and abiotic factors, fruit characteristics, olive oil content and composition, etc. This enabled the selection of elite varieties for further use in comparative trials and olive breeding programs.

*Keywords*: genetic resources, biodiversity, olive

# PRESERVATION OF BIODIVERSITY IN THE MEDITERRANEAN: THE CASE OF THE DALMATIAN SAGE

**Zlatko ŠATOVIĆ[1,2*], Ivan RADOSAVLJEVIĆ[2,3], Marija JUG-DUJAKOVIĆ[4], Filip VARGA[1,2], Martina GRDIŠA[1,2] and Zlatko LIBER[2,3]**

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Dalmatian sage (*Salvia officinalis* L., Lamiaceae) is a well-known aromatic and medicinal Mediterranean plant native to the coastal regions of the western Balkans and the central and southern Apennine Peninsula and is cultivated worldwide. A total of 1,350 specimens were collected and genotyped from 50 populations from the Balkan Peninsula and 12 from the Apennine Peninsula. We used eight microsatellite markers and two chloroplast DNA regions to analyse genetic diversity and population structure. A model-based population structure analysis revealed the presence of five geographically coherent genetic clusters that differed significantly in terms of allelic richness and expected heterozygosity. The highest allelic richness was found in populations in the central part of the eastern Adriatic coast, while allelic richness decreased towards the northwestern Adriatic coast and the southeastern regions of the Balkan Peninsula. A large group of closely related haplotypes was distributed throughout the Balkans and the central Apennines, while the private lineage occupied the southern Apennines. The results suggest that a single refugium of Dalmatian sage from the last glacial period was located in the central part of its distribution range in the Balkans. Numerous microrefugia, probably extending over several glacial cycles, were scattered across the Balkans, while the Apennines were colonised at least twice from the Balkans.

*Keywords*: medicinal and aromatic plants, *Salvia officinalis*, genetic diversity, population structure, Balkan and Apennine Peninsula

# CHANGES IN THE ICHTHYOFAUNA OF THE MEDITERRANEAN/ADRIATIC SEA: ARE THERE REASONS FOR CONCERN?

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The marine biodiversity of the Mediterranean Sea today is faced with significant structural changes in flora and fauna. Similar changes were recorded in the Adriatic Sea. During the last few decades, various factors such as climate change, anthropogenic activities and Lessepsian migrations have changed the composition of the Mediterranean/Adriatic ichthyofauna. Extensive research carried out in the last decades allowed us to recognize species that were not previously recorded or reported from this area. So far, 188 exotic fish species have been recorded in the Mediterranean Sea, a large number of which are Lessepsian migrants of Indo-Pacific origin. Of the 15 Lessepsian fish species recorded in the Adriatic, *Lagocephalus sceleratus*, *Fistularia commersonii* and *Siganus luridus* were the only species recorded more than once and with geographically scattered records suggesting a successful biological invasion. The firefly *Pterois miles* shows a rapid geographical spread in the Mediterranean Sea since 2012, mainly in the eastern part of the Mediterranean. Recent records in the Ionian and Adriatic seas point to the fact that this should be a warning sign and there is an urgent need to undertake and promote control measures. The influence of successful colonizers on the original communities in the Adriatic Sea is not yet fully known, but in the eastern part of the Mediterranean it is very large. However, the speed of biological invasions suggests that the potential negative effects may become very relevant in the near future.

*Keywords*: marine biodiversity, Adriatic Sea, Lessepsian migrants, ichthyofauna, invasion

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# ORAL PRESENTATION ABSTRACTS

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# LONG-TERM EXPOSURE OF MEAT TO UV-A LED RADIATION AT 4 °C – THE EFFECT ON NATIVE BACTERIA AND COLOR

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UV-C has been proven as an effective method for microbial inactivation. However, the method has disadvantages including potential hazard to the user, environmental impact and legislation issues, all of which restrict direct application to food products. The use of UV-A could be a viable alternative to UV-C as it eliminates all of these disadvantages and proves to be a valid method of extend the shelf-life of perishable food products and thus reduce food losses. The aim of the study was to investigate the effect of long-term / low-fluence UV-A at 365 nm on the microbial quality and color of cold stored pork loin slices. Fresh pork loin slices were packed in PP bags and placed in the specially designed UV-A irradiation chamber with a cooling system, which made it possible to maintain the temperature of the product surface at 4 +/- 0.5 °C. Two experiments were carried out: In the first, fresh pork loin with low initial surface contamination (2.38 ± 0.40 log cfu/cm$^2$) was exposed to monetary fluence of 565 µJ/cm$^2$ for 240 h (LF/LT) and analyzed periodically for changes in total plate count and color using Lab scale. In the second experiment, pork loin with higher initial contamination (6.13-6.76 log cfu/cm$^2$) was exposed to a high-fluence (momentary fluence of 1570 µJ/cm$^2$) / short-term treatment (24h) (HF/ST). The results of the first experiment showed that the LF/LT led to an inhibition of microbial growth by approximately 1 log cfu/g after 72 h exposure and the reduction was maintained for 240 h. However,the treatment caused a discoloration of the samples, which became paler after 72 h. The results of the second experiment showed a more pronounced microbial decontamination with a difference of over 3.5 log cfu/cm$^2$ between HF/ST and control samples after 24 h. However, the treatment again caused discoloration of the meat samples. UV-A treatment may be an effective means of decontaminating perishable food products, but further studies are needed, particulary on the mechanism of the observed discoloration and to establish the dose/time at which inactivation can be achieved without color change.

*Keywords*: UV-A, pork loin, microbiology, shelf-life, color

# THE DETERMINANTS OF MEDITERRANEAN DIET ADHERENCE IN ITALY: A HISTORICAL ANALYSIS (1861-2015)

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This study examines the factors that influenced adherence to the Mediterranean diet in Italy between 1861 and 2015. The study aims to determine the extent to which fluctuations in macronutrient prices, along with other factors such as human capital and income, influenced the adoption of this dietary pattern. To reconstruct historical price series, a representative basket of goods was selected, including bread, pasta, rice, potatoes, beef, pork, eggs, milk, butter, olive oil and beans. The price of each commodity was calculated in relation to its macronutrient content, and these prices were then converted into kilocalories. Five methods were used to aggregate these prices: arithmetic mean, weighted mean, data envelopment analysis (DEA) calculated weights, autoregressive (AR) models and autoregressive integrated moving average (ARIMA) models. This approach can be used to assess whether the choice of aggregation method influences the price level. The analysis used an autoregressive distributed lag (ARDL) model with error correction to examine the relationship between macronutrient price changes and dietary adherence, considering both short-term dynamics and long-term equilibrium relationships. This research provides a comprehensive perspective on the historical trends and economic determinants of adherence to the Mediterranean diet in Italy, improving our understanding of how economic and socio-demographic changes have influenced adherence to this dietary pattern over time. Policy makers can benefit from the results of this study, which provide important insights on how to promote healthier dietary habits.

*Keywords*: Mediterranean diet, time-series analysis, dietary trend, macronutrient prices

# EVALUATION OF PHYSIOLOGICAL TRAITS OF LENTIL INTRODUCED IN AN AGROFORESTRY SYSTEM: JOINT IMPACT OF SOIL AND SPECIES IN LEGUMINOUS CULTURE

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Intercropping supports numerous ecosystem services and contributes to a promising approach thanks to its many benefits, including the creation of a favourable microclimate and the improvement of soil fertility. Climate change is putting increasing pressure on land and water resources while reducing yield growth, which has a direct impact on global food security. This study aims to evaluate the production of a legume crop and shows that agroforestry systems can improve the productivity of catch crops. The experimental design consists of almond trees (Ferragnes and Ferraduel) planted at a spacing of 7x7m in Ain Taoujdate, Morocco. Lentil was grown in a completely randomised block cropping system and in a control cropping system. Physiological, morphological and agronomic parameters of the lentil plants were measured, including plant height and branching, root length, seed width and thickness, fresh and dry weight of plants and roots, the fresh weight of seeds per plant, the number of pods per plant, the number of seeds per pod, the total number of seeds per plant and the weight of 100 seeds. The results obtained provided important information on the differences observed in the different treatments and the almond tree offers many advantages in relation to the environmental variables considered. Stomatal density and conductance were higher in the intercropping treatment compared to the control. In addition, the water content of the above-ground parts, plant height and branching were higher in the intercropping treatment. Overall, the study showed that the agroforestry system has a positive effect on legumes and that this type of cropping system could be improved.

*Keywords*: Leguminous, almond tree, agroforestry system, lentil, production

# OLIVE MOTH FLIGHT TRACKING USING ARTIFICIAL NEURAL NETWORK TOOLS

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The olive moth (*Prays oleae*, Bernard, 1788) is becoming a serious economic pest in certain olive-growing areas of Croatia. It causes early fruit drop, lower yields and slower tree growth. Classic pheromone traps are used to monitor the pest, which are crucial for decision-making in pest control. Automatic pest detection tools based on image recognition using artificial neural networks (ANN) are proving to be an excellent solution for this activity. The aim of this work is to develop and investigate the reliability of the ANN-based model in detecting adult olive moths using the visual data (images) of the sticky boards. By collecting image samples from olive groves in Zadar County, classifying the visual data on the sticky boards, labelling the photos with adult *P. oleae* and learning an ANN, a model for automatic monitoring of this pest was developed. The model was trained to recognise not only the olive moth but also other insects and other elements in the images. The detection accuracy for *P. oleae* was 59% compared to visual inspection, which was higher than the detection accuracy for other insects and elements in the sticky panel photos. This study is preliminary and the recognition accuracy of the developed model can be improved by using an even larger data set. Therefore, this study provides an excellent basis for future research. The tools of the developed ANN models can be of great use in the early detection and monitoring of olive moth flight.

*Keywords*: artificial neural networks, flight monitoring, image recognition, *Olea europaea* L., olive moth

# THE INFLUENCE OF AGROECOLOGICAL CONDITIONS ON THE LIFE TRAITS OF *Cydalima perspectalis* IN CENTRAL DALMATIA

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The box tree moth *Cydalima perspectalis* Walker 1859 (Lepidoptera, Crambidae) originates from East Asia and has spread to 40 countries in Europe and the Middle East as well as two countries in North America. The exact route of invasion is uncertain, but it is thought to have reached Europe and the United States through multiple introductions of boxwood plants, followed by further spread due to the biological characteristics of the species, climatic conditions and the wide distribution of the host plant. This pest was detected in Croatia in 2012 and has subsequently spread throughout the country. In its native range, the host plants of *C. perspectalis* belong to the genus *Buxus* and to some other host plants that do not belong to the genus *Buxus*. In the Western Palaearctic region and in Croatia, the genus *Buxus* is widely represented, which enabled the rapid spread of the pest. The larvae of *C. perspectalis* cause damage to the leaves and bark of the plant, leading to complete defoliation and death of the host plant. Assumed climate models have confirmed that *C. perspectalis* becomes a serious pest in southern and central Europe, while the spread of *C. perspectalis* in the north and south is limited by the temperature requirements for completion of the generation cycle and entry into diapause. In this study, we investigated the effects of different agroecological conditions in two areas in Split-Dalmatia County (Kaštelansko polje and Sinjsko polje) on the abundance of the pest, population dynamics, infestation levels and the onset and end of diapause.

*Keywords*: preimaginal stages, population dynamics, adult captures, Unitrap.

# COFFEE AND CLIMATE: METADISCOURSE ANALYSIS OF RESEARCH ARTICLES

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Climate change has an impact on natural ecosystems, agriculture, yields and their sustainability. Coffee plays a central role in the agricultural and food chain, as it is produced in developing and exported mainly to industrialised countries. Climate change poses a significant threat to supply chains and economic stability, as it is estimated that coffee cultivation and production will be largely affected by environmental impacts by 2050. Although coffee is mainly imported, it is one of the most important symbols of "*Made in Italy*" products in the world: Italy has influenced the coffee scenario through its roasting techniques, brands and culture. In fact, coffee is not only a symbol of a drink, but also a socio-cultural phenomenon. Linguistic expressions such as *espresso*, *cappuccino* and *caffè solidale* carry significant Italian (socio-cultural) connotations that lend themselves to linguistic investigation. On this basis, I use Hyland's (2005) metadiscourse taxonomy in a representative corpus of research articles to examine how authors structure their arguments in author-reader interactions and frame environmental issues related to coffee, advancing scientific knowledge in the field and addressing global issues and challenges in this form of academic communication.

*Keywords*: research articles, interactive metadiscourse, interactional metadiscourse, climate change, coffee

# RESILIENCE OF ADRIATIC BENTHIC COMMUNITIES SUBJECT TO REPEATED HEATWAVES AND MUCILAGE EPISODES

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The increased frequency and severity of marine heatwaves (MHW) and mucilage episodes in the Mediterranean Sea have been causing drastic changes in benthic diversity and mass mortality of habitat-formers. Among the most affected populations, the ancient forests of *Paramuricea clavata* (Risso, 1827) are succumbing under the blanket of mucilage and heated waters, with a dramatic impact on the entire coralligenous community. The main objective of this study was to document the shift in the benthic community from 2019 to 2024 from the surface to a depth of 35 m, near the Island of Vis (Croatia, Adriatic Sea). To assess the resilience of the infralittoral and coralligenous communities affected by repeated summer events of MHWs and mucilage, photo and video surveys were conducted in 2019, 2022, 2023 and 2024 in three sites of the study area.
Among the most evident changes in the considered temporal window, the shallow and well-lighted rocks, once dominated by *Padina pavonica* (Linnaeus) Thivy, are now almost totally covered with the Lessepsian *Stypopodium schimperi* (Kützing) Verlaque & Boudouresque. In deeper waters, the gorgonians' populations were replaced by conspicuous but ephemeral bryozoan forests, which were subsequently covered by crustose coral algae (CCA). These bioconstructions could represent the first stage of the formation of coral concretions.
The obtained results will be a milestone in understanding the stages of the natural recovery process in the study area and contribute to the knowledge of ecological shifts in the coralligenous assemblages in the Mediterranean Sea.

*Keywords*: coralligenous, mesophotic, seaweeds, invasive species, *Stypopodium schimperi*, heatwaves

# MICROPLASTICS IN ANCHIALINE CAVES

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Microplastics (<5 mm) are widely distributed in the marine environment, both in coastal waters and sediments and in pristine deep-sea areas. Due to their location, anchialine caves are sensitive to various effects of the interaction between marine and terrestrial processes. They represent extreme conditions due to wider ranges or extreme values of physico-chemical water parameters, lack of light and nutrients and physical restrictions. These particular characteristics make anchialine caves natural laboratories where the effects of environmental variability can be studied from a biotic and abiotic perspective, not only for specific local purposes but also from a global change perspective.
Here, we present for the first-time results from analyses of microplastics in four anchialine caves located on the coastline around Split and the island of Brač. In total, we isolated 1100 microplastic particles from different plastic materials. The most polluted cave was Well Plano with 454 particles per liter.

*Keywords*: microplastics, anchialine caves, Island of Brač, Adriatic Coast

# BIODIVERSITY OF BENTHIC COMMUNITIES FROM ITALIAN MESOPHOTIC RHODOLITH BEDS

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Rhodolith beds are structurally complex biogenic habitats which support a high biodiversity. In the Mediterranean Sea, they are protected by the European Community through a wide range of policy instruments. Despite their high conservation importance, their structural complexity and biodiversity are poorly known. This study estimates the characteristics of four rhodolith beds (50-71 m) and their associated macrofaunal assemblages in the Tyrrhenian Sea (Capri, Sorrento, Ischia, and Cilento). Additionally, for the first time in the Mediterranean beds, meiofauna was analysed in Capri and Sorrento. A strong variability of rhodolith abundance and structural complexity was found. Rhodoliths showed a high coralline algal diversity (> 10 taxa). The Cilento bed, where the highest rhodolith abundance and structural complexity was measured, was characterized by the highest faunal abundance and species richness. However, similar dominances of the main taxa (Polychaeta, Mollusca, Crustacea and Echinodermata) have been detected at all beds. In particular, polychaetes were the most abundant taxon, but molluscs contributed with the highest species richness. Deposit feeders were among the dominant feeding guilds structuring the community, highlighting the role of rhodoliths in the detrital food web. Rhodoliths also showed a distinct meiofauna represented by copepods and many representative taxa of temporary meiofauna (macrofaunal juveniles), supporting the nursery role of rhodolith beds. These findings attest to the high floristic and faunistic diversity of mesophotic Mediterranean rhodolith beds, stressing their key role as ecosystem engineers and biodiversity enhancers.

*Keywords*: rhodolith beds, biodiveristy, habitat-formers, biogenic habitats, benthic community.

# BEACH LITTER IN THE VIS ARCHIPELAGO, CROATIA

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In this ongoing two-year project, category, size and mass of drifted marine litter (ML) were investigated on the shores of six beaches on the islands of Vis and Biševo, the most remote inhabited islands in Croatia. Due to their geographical position, they are heavily influenced by southwest winds and currents from the south of the Adriatic Sea. Three of the researched beaches are exposed and the other three protected from southerly winds and currents. The field research method applied here is based on the DeFishGear methodology. The composition of the ML found on the beaches so far was mostly made up of plastics. The most common objects found were: polystyrene boxes, various plastic parts, bottles, plastic caps, rings, remains of fishing tools primarily made for shellfish industry, remains of cosmetic packaging and hygienic items. The assumption is that this is related to the highly developed tourism. From spring 2023 until now, more than 800 kg marine litter was collected, from which 68.35% was plastic, 11.37% wood, 7.57% metal, 5.73% rubber, 2.81% glass/ceramics, 2.67% cloth/textile, 1.35% paper/cardboard and 0.12% chemicals. Stronger enforcement of the Single Use Plastics Directive is urgently needed to reduce plastic waste, which consequently has a negative impact on the environment, health and economy.

*Keywords*: Adriatic Sea, marine litter, plastic, islands, SUP Directive

# OVERCOMING INSULARITY THROUGH EFFICIENT USE OF ENERGY, WATER, AND WASTE MANAGEMENT

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The European islands are part of 13 Member States and comprise approximately 2,400 inhabited islands accounting for 4,6% of the European Union's population: 95% of this population is concentrated in the Mediterranean region. The unique characteristics of islands often result in geographical and socioeconomic isolation, which can exacerbate inequities and make islands vulnerable. The primary challenge for islands is to achieve balanced and sustainable territorial development by enhancing their economic competitiveness and growth potential while preserving natural resources and maintaining social cohesion.
In this scenario, water, energy, and waste management pose considerable challenges for islands, particularly due to their limited capacity for waste management and insufficient water supplies, which often require the importation of water or desalination. The paper aims to analyze the state of the art of solutions implemented in islands to manage these problems. Through the literature analysis and case study, we highlight some replicable best practices for European islands that can help them to become completely self-sufficient, in line with the principles of the Green Deal.
The disadvantage of insularity necessitates the development of innovative solutions, with islands that can serve as platforms for piloting pioneering projects considering the extensive variety of renewable energy sources available on the islands, such as solar, wind, marine, and geothermal energy. The utilization of these resources can lead to substantial socio-economic benefits for the EU islands.

*Keywords:* Mediterranean islands, insularity, sustainable development, carbon reduction, energy transition, waste management


# POSTER PRESENTATION ABSTRACTS

The authors are solely responsible for the data, contents and errors found in the abstracts.

# SEA FENNEL FLAVORED VEGETABLE OILS

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Traditionally, various herbs and spices are used to enhance the flavour and aroma of vegetable oils, but also to improve their nutritional value and stability. The aim of this work was to investigate the effects of infusion of ground and whole freeze-dried leaves of sea fennel (*Crithmum maritimum* L.) (1 g/ 100 mL oil), an aromatic edible Mediterranean halophyte plant, on the chemical composition of four unrefined edible vegetable oils (olive, sunflower, sesame and flaxseed oil). During the 90-day storage period, the quality parameters of the oils (peroxide value, free fatty acids and fatty acid profile) as well as the phenolic content of the oils and their volatiles were monitored. Free fatty acids and peroxide values increased in all samples, with the greatest increase in the olive oil samples (11% and 45%, respectively), and these changes also affected the fatty acids and volatile oil profile. Total phenolics in the infused oils increased in sunflower oil, where the final values almost doubled, while they decreased significantly in olive oil, which was generally the richest in phenolics. GC-MC analysis showed the effect of aromatization of the oil by the addition of dried plants and confirmed the differences between the samples. The result suggest that the addition of sea fennel to vegetable oils leads to changes in their chemical composition. Although the parameters tested varied between the oils used, in most cases the addition of sea fennel had a negative effect on the chemical composition and stability of the oil during the test period.

*Keywords*: vegetable oils, sea fennel, phenolic compounds, fatty acids, peroxyde number, volatile profile

# TRESURE OF ENDEMIC PLANTS – VOLATILE COMPOSITION AND BIOLOGICAL ACTIVITY OF *Chaerophyllum coloratum* L.

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In the present study, the composition of volatile organic compounds (VOCs) and the biological activity of *Cheaerophyllum coloratum* L. (Apiaceae), a species endemic to the Mediterranean region, were investigated. The essential oil and hydrosol were extracted from the air-dried leaves by hydrodistillation and, for the first time, the chemical composition of both extracts was analysed by gas chromatography-mass spectrometry (GC-MS) coupled with headspace solid-phase microextraction (HS-SPME) of VOCs from the hydrosol and the fresh plant material. The oxygenated sesquiterpenes spathulenol was the most abundant constituent of the essential oil, while the non-oxygenated sesquiterpenes β-caryophyllene and germacrene D dominated in the fresh plant material. The hydrosol was dominated by monoterpenes, with p-cymen-8-ol being the most abundant. Based on the fact that the biological potential of *C. coloratum* is sparsely described, we tested its cytotoxic activity on cancer and healthy cell lines and its antiphytoviral activity on tobacco mosaic virus-infected plants. The moderate cytotoxic activity of the methanol extract was demonstrated in three cancer cell lines, the cervical cancer cell line, the human colon cancer cell line and the human osteosarcoma cell line, with significantly lower toxicity in healthy retinal pigmented epithelial cells using a MTS-based cell proliferation assay. The antiphytoviral activity of the hydrosol is evidenced by a significant reduction of local lesions on the leaves of the host plants. The results of the present study in terms of composition and biological activity indicate that *C. coloratum* belongs to an endemic treasure that offers potential for future research.

*Keywords: Chaerophyllum coloratum*, essential oil, hydrosol, GC-MS, HS-SPME, antiphytoviral activity, cytotoxic activity

*Acknowledgments:* This research was supported by the institutional project “Hidden Treasures of Dalmatia - Biology and Biological Activity of Selected Plant Species”, funded by the Faculty of Science, University of Split.

# THE CHEMICAL COMPOSITION AND ANTIOXIDANT POTENTIAL OF MICROALGAE *Chaetocerus costatus*

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Microalgae are a promising source of valuable bioactive compounds that have strong antioxidant properties. In this study, the antioxidant potential and chemical composition of the marine microalgae *Chaetocerus costatus* (CIM953) cultured in F/2 medium were investigated. After cultivation, the microalgae biomass was freeze-dried and different solvents were used for the preparation of extracts (ethanol, acetone and hexane). Ultrasound-assisted extraction was performed for 30 minutes at 40 °C. The chemical composition of the extracts was determined by high-performance liquid chromatography with high-resolution mass spectrometry with electrospray ionisation (UHPLC-ESI-HRMS). The antioxidant potential of the microalgae extracts was determined by DPPH and ORAC assays. The highest DPPH inhibition was found for the ethanol extract (9.17 ± 0.99 % of inhibition), while the acetone extract showed the highest inhibition of peroxyl radicals (50.66 ± 2.22 mM TE/L). Pigments and derivatives, fatty acid derivatives and steroids and derivatives were identified in the extracts. The results of this study indicate that the microalgae *C. costatus* is an excellent and underutilised source of various potent antioxidants and other valuable bioactive compounds with significant commercial potential for various industries.

*Keywords*: microalgae, *Chaetocerus costatus*, chemical composition, antioxidant activity

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*BEST POSTER REWARD 1st PLACE*

# CHESTNUT 'TERRA FRIA' PDO: SUITABLE INGREDIENT FOR INNOVATIVE PRODUCTS

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Chestnuts are one of the most important nuts in Northeast Portugal. Terra Fria is the main production region for which a Protected Designation of Origin (DOP) is recognized. Chestnuts are a very versatile product with high nutritional value (rich in carbohydrates, fiber, vitamins and minerals), gluten-free and with a slightly sweet flavour. However, as they are highly perishable, Portuguese chestnuts are mainly sold as a fresh product during the harvest season or as a frozen product all year round. The development of new products could be a way to promote the integration of this fruit in a wide range of food products, as well as, to contribute to a Mediterranean diet. The aim of the present work was to develop two innovative products: gluten-free cuscos, maintaining the traditional production process, and chestnut spread with a lower sugar content. Different formulations were tested to obtain the desirable consistency and taste. After an analysis, three variations of cuscos (cooked, roasted and raw) and two spreadable chestnuts (with and without carob) were selected and the nutritional composition and shelf-life were evaluated. It was found that the three variations of chestnut cuscos had similar macronutrient contents. Regarding spreadable, the formulation with carob had a lower sugar and protein content, while the formulation without carob had a higher fat content. No microbial growth was observed in any of the spreads during the 6- month storage period. In summary, it can be said that Portuguese chestnuts are a suitable ingredient for the production of gluten-free and healthy products.

*Keywords:* chestnut, Innovative products, Gluten-free, Healthy, Mediterranean diet.

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# SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY ISOLATION OF PHENOLIC ACIDS FROM NETTLE EXTRACT USING DEEP EUTECTIC SOLVENTS AND MACROPOROUS RESINS

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The increasing demand for plant extracts and isolated compounds in the pharmaceutical and food industries necessitates the development of extraction methods that are both effective and selective as well as environmentally sustainable.
*Urtica dioica* L., commonly known as stinging nettle, is a wild herbaceous perennial plant rich in antioxidant compounds, including phenolic acids. These compounds provide it with a range of bioactivities, such as antioxidant, antibacterial, antiproliferative and anti-inflammatory properties. According to previous studies, the solvent choline chloride:lactic acid (1:2) was selected for the extraction of chlorogenic, caffeic, neochlorogenic, sinapic, chicoric, and caffeoylmalic acids. The highest yield of these components was obtained by ultrasound-assisted extraction at 70°C for 90 minutes. The obtained extract was then treated with five different macroporous resins as well as five different desorbents. Static isolation was conducted, where the extract was mixed with the macroporous resin during the adsorption process, followed by desorption using a desorbent with the macroporous resin. The influence of time and volume of the desorbent was investigated to achieve the highest yield of phenolic acids in the desorbent. Additionally, the potential for recycling the macroporous resin and the deep eutectic solvents was evaluated. According to the results, varying the macroporous resin, adsorption and desorption times, and desorbent volume can selectively influence the component yield in the desorbent. The applied solvent and macroporous resin can be recycled and reused with high yields over three cycles. These findings support the sustainability and environmental friendliness of this purification and isolation method.

*Keywords*: deep eutectic solvents, extraction, isolation, HPLC, macroporous resins

# CHEMICAL COMPOSITION AND BIOLOGICAL POTENTIAL OF GARLIC BY-PRODUCTS

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Garlic, a vegetable from the Allium genus, has been valued for its medicinal properties since ancient times. The processing of garlic produces valuable by-products rich in phenolic compounds known for their exceptional biological properties, including antioxidant and antimicrobial activities. In addition to white garlic, its fermented variant, black garlic, is increasingly appreciated for its beneficial properties and high nutritional value. The aim of this study was to analyze the chemical composition and evaluate the antioxidant and antimicrobial activities of white and black garlic by-products prepared by microwave and ultrasonic extraction. The phenolic profile of the samples was determined by high performance liquid chromatography (HPLC). Antioxidant activity was determined using the ferric reducing antioxidant power (FRAP) assay and the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. The antimicrobial activity against foodborne pathogens: *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli* and *Salmonella enteritidis* was evaluated using the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) methods. High levels of the polyphenols rutin (6.4 mg/L) and catechin (4.9 mg/L) and the best antioxidant activity were found in the extract of white garlic by-products prepared by microwave and ultrasonic extraction. The by-products obtained by microwave extraction showed better antimicrobial activity compared to ultrasonic extraction. The antimicrobial and bactericidal activity of the white and black garlic by-products against L. monocytogenes at a concentration of 2.5 mg/mL stands out. The results underline the potential of garlic by-products as a valuable source of bioactive compounds for functional foods, nutraceuticals and natural preservatives.

*Keywords:* garlic by-product, black garlic, polyphenols, antioxidant and antimicrobial activity

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# DEVELOPMENT OF QUALITY INDEX METHOD (QIM) FOR ADRIATIC SHRIMP (*Parapenaeus longirostris*)

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The scientific aim of Quality Index Method (QIM) and its practical application is to determine the quality index of fish, which changes linearly with the time of storage in ice. Compared to the sensory evaluation scheme of European legislation, the QIM is species-specific and very accurate in determining quality criteria. In this study, the QIM was developed for Adriatic shrimp (*Parapenaeus longirostris*) stored in ice. The aim was to develop a descriptive scheme based on specific quality characteristics of this species, but also to describe sensory changes over time in the ice and to determine shelf life. A total of 770 shrimps caught in the Adriatic Sea were used. The QIM scheme was developed in three steps: description of parameters (colour and odour changes, meat quality, gill appearance, and melanosis) of the shrimp each day over 14 days to develop a preliminary scheme, testing and modification of the preliminary scheme, and creation and testing of the final QIM table. Grades 0, 1, 2 and 3 were used to characterise a specific change in sensory properties during the time in the ice. The evaluation was carried out on a homogeneous group of randomly selected samples (six or more), which were tested by six trained panellists. The maximum quality index score of the newly developed QIM was 18. Considering the sensory properties, the shrimps (without pre-treatment) can be considered suitable for human consumption when stored at a temperature of 1 ± 2 °C for up to eight days. By developing a QIM scheme, it is possible to estimate the remaining shelf life of shrimp, which can contribute to better management of catches and thus reduce waste.

*Keywords*: QIM, *Parapenaeus longirostris*, quality index, sensory assesment

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# IMPACT OF EXTRACTION METHOD AND SOLVENT ON CAFFEIC AND CHLOROGENIC ACID CONTENT IN COFFEE BY-PRODUCT EXTRACTS

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Coffee by-products such as pulp, husks and coffee grounds are rich in bioactive compounds, including phenolic acids. The efficiency of extraction of phenolic acids from these by-products can be significantly influenced by the extraction method and the choice of solvent. Current research focuses on green extraction principles. The aim of this study was to investigate the effects of ultrasound-assisted extraction (UAE) and accelerated solvent extraction (ASE) as well as different water and ethanol solvent ratios on the total phenolic content and the dominant phenolic acids, caffeic acid and chlorogenic acid in the coffee husks remaining after roasting. Total phenols (TP) were determined spectrophotometrically, while chlorogenic and caffeic acids were detected by high performance liquid chromatography (HPLC). The optimization of these parameters aimed to maximize the recovery of phenolic acids, improve the use of coffee by-products and promote sustainability in the coffee industry. The results showed a significant TP content in all samples (343.3-1126.7 mg GAE/L), with caffeic acid being more dominant than chlorogenic acid (11- to 26-fold). The differences in the results were significantly influenced by the solvent used and the extraction method. In the ASE extracts, TP content decreased with decreasing water content in the solvent mixture, a trend that was not observed in the UAE extracts. The influence of the solvent was evident in the levels of caffeic and chlorogenic acid, with the ASE extracts showing higher levels than the UAE extracts. This study provides valuable insights for the development of efficient extraction processes to produce high-quality extracts that can potentially be used as natural additives in the food industry.

*Keywords:* coffee by-product, phenolic compounds, chlorogenic acid, caffeic acid

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# NUTRITIONAL COMPOSITION OF COFFEE AND COFFEE BY-PRODUCTS

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The roasting of coffee, the world's second most popular beverage, generates significant by-products such as husks, so utilizing these by-products can reduce environmental impact. In this study, the fatty acid and amino acid composition in by-products (BP) as well as in raw (BR), light roasted (LR) and dark roasted (DR) coffee was analysed. The dominant fatty acids in these samples were C18:2, C16:0, C18:1 and C18:0. Unsaturated fatty acids (USFA), especially C18:2 and C18:1, accounted for 52.11-53.95% of the total fatty acids in DR and LR coffee and about 35% in BP. BR coffee consisted mainly of saturated fatty acids, with C16:0 being the most abundant at 66.84%. In addition, fatty acids such as C20:0, C21:1, C20:4 and C22:0 were mainly present in BP, which had a high C22:0 content of 17.01%. The analysis of amino acids showed slight differences between BR and roasted coffee and BP. Glutamine (15.81-20.16%) and glycine (12.71-14.88%) were the most abundant. BR coffee had slightly higher levels of arginine and threonine (10.59%) and lysine (2.98%). Although the amino acid profiles were similar, the concentration in BP was 2.5 to 3 times lower. Coffee BPs are an inexpensive source of fats and amino acids and offer potential as functional food ingredients.

*Keywords:* coffee by-products, raw coffee, roasted coffee, fatty acids, amino acids

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# IN-DEPTH ANALYSIS OF BROWN MACROALGAE *Sargassum hornschuchii* BY UHPLC-ESI-HRMS

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The characteristics of the sea make it a challenging and extreme environment which include high salinity, temperature and oxygen concentrations decreasing with the increasing depth, and intense UV radiation at the surface but low at the bottom. This has led to macroalgae developing bioactive compounds that have potential applications in the cosmetics, pharmaceutical and food industries. *Sargassum hornschuchii* was sampled from the Adriatic Sea, extracted with methanol:dichloromethane and further fractionated by SPE to obtain less polar fractions. The chemical composition of fractions F3 (MeOH) and F4 (MeOH:DCM = 1:1, *v/v*) was determined by UHPLC-ESI-HRMS. The antioxidant activity of the obtained fractions was assessed using three assays, while the neuroprotective activity was determined with acetylcholinesterase inhibition assay. The toxicity potential of *S. hornschuchii* fractions was determined *in vivo* using zebrafish *Danio rerio* embryos. UHPLC-ESI-HRMS analysis revealed oleamide and six other fatty acid primary amides as the most abundant compounds. Oleamide as signalling molecule acts in diverse cell types which can lead to triggering different biological and pharmacological effects. It has also been suggested that it has neuroprotective properties and contributes to increased antioxidant activity. The fraction tested has found to be highly effective in inhibiting acetylcholinesterase, an enzyme associated with neurological disorders: at 1, 0.5 and 0.25 mg/ml, the fraction showed acetylcholinesterase inhibition levels of 61.11±0.79%, 41.48±3.48% and 17.60±1.18%, respectively. This study has shown that the bioactive molecules isolated from *S. hornschuchii* possess significant antioxidant activity, which is closely linked with neuroprotective properties as they play a crucial role in reducing oxidative stress, a key factor in the development of neurological disorders. The toxicity assessment performed on zebrafish embryos provided valuable insights into the safety of the tested fraction.

*Keywords*: algae, fatty acid primary amides, antioxidants, acetylcholinesterase, zebrafish

# ALMONDS INTERCROPPED WITH OTHER CROPS CULTIVATED IN CROATIA: STUDY OF NUTRITIONAL PROPERTIES AND BIOACTIVITIES

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In recent years, crop diversification in agroforestry systems has been recognized as a sustainable strategy to improve land use efficiency, restore environmental balance, mitigate climate change, provide economic benefits and ensure food security. Research has shown that practices such as intercropping can significantly enhance soil quality, which in turn increases the quality of almonds. This study aimed to evaluate the nutritional and bioactive aspects of almonds to investigate the benefits resulting from crop interactions, using different almond cultivars. The centesimal composition of the almond samples, including protein, fat, carbohydrates, ash, and moisture, was determined using Official Food Analysis Methodologies, and their total energy value was calculated. The Ferraduel cultivar had the highest moisture and carbohydrate content. The Texas cultivar had the fighest crude fat content, while the AI cultivar had the highest protein content. There was no significant difference in ash content among the cultivars. Regarding the bioactive composition, several tests were conducted to evaluate the antioxidant, antiproliferative and antimicrobial activity. For antioxidant activity, the extracts were tested using the 2,2-diphenyl-1-picrylhydrazyl radical scavenging activity (DPPH) and the lipid peroxidation inhibition assay (TBARS). The Ferraduel cultivar showed the highest antioxidant activity. Cytotoxicity was tested in five human tumor cell lines and one non-tumor cell line. Antibacterial activity was tested against eight bacteria, with *B. cereus* being the most sensitive to the Texas cultivar. In terms to antifungal activity, the Ferragnès cultivar showed the lowest MIC for *Aspergillus brasiliensis*. Overall, the study shows that interaction with other crops can improve the nutritional profile and health benefits of almonds, underlining the importance of sustainable agricultural practices.

*Keywords*: almonds, bioactivity, intercropping, health benefits.

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# VALMEDALM PROJECT - VALORIZATION OF MEDITERRANEAN ALMOND ORCHARDS THROUGH THE USE OF INTERCROPPING INTEGRATED STRATEGIES

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Almond is a typical Mediterranean crop well adapted to diverse edaphoclimatic conditions. In the Mediterranean region, almond orchards are on a mono-cropping system with long tree spacing for rainfed farming or intensively cultivated (with intensive irrigation, fertilization, and plant protection practices), which increase cultivation costs with high yields expectations. However, the soil management practices used over the last decades, in conjunction with the climatic conditions of the Mediterranean region and the current climate change scenario, have led to decreased soil organic matter, soil erosion, water scarcity and biodiversity loss. Thus, the implementation of sustainable agronomic practices such as cover crops that have been shown the potential to increase soil organic matter, field productivity, soil nitrogen availability and possibly increase biodiversity depending on plant species used is important. VALMEDALM project objective is to empower local almond production of the Mediterranean through the implementation of intercropping practices as an integrated strategy aligned with economic and social aspects, as well as sustainable principles towards an adaptation to climate change. For that, eight demo sites were implemented in five Mediterranean countries where will be identified intercropping practices and promote its implementation across the Mediterranean; evaluate the effect of intercropping practices in pests and weed control; assess the nutritional and functional properties of almonds and associated crops; assess the economic, social, and environmental impacts of the tested methodologies; and promote training and knowledge transfer towards local farmers and farmer associations.
This project will contribute to the adoption of sustainable and productive agricultural systems based on plants diversity, to increase farmers income and competitiveness of small producers in the Mediterranean markets.

*Keywords:* almond, intercropping, Mediterranean region

# EVALUATION OF THE NUTRITIONAL PROPERTIES AND MINERAL COMPOSITION OF ALMONDS INTERCROPPED WITH CHICKPEAS AND CLOVER IN DIFFERENT IRRIGATION SYSTEMS IN NORTHEASTERN PORTUGAL

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Crop diversification in almond orchards is a useful strategy to improve the quality of the ecosystem, prevent erosion through sustainable maintenance, mitigate the effects of climate change and improve soil quality. Despite these benefits, research on the effects of water stress on almond quality remains limited, and a deeper understanding of plant biochemical responses is needed to maintain almond production and quality. The objective of this study is to evaluate the nutritional and mineral composition of almonds, focusing on the benefits of intercropping under different irrigation systems. Using Official Methodologies of Food Analysis, the centesimal composition and total energy value of almond samples were determined. The results show that almonds from non-irrigated systems had a higher protein content, with significant differences observed between almonds from intercropped systems. Ash content was higher in samples from irrigated systems, especially in chickpeas. The fat content did not differ significantly among intercropped cultivars, although the irrigated control samples had the highest amount. In terms of mineral content, the copper content was significantly higher in irrigated intercrops. The manganese content was higher in irrigated almonds intercropped with chickpeas. The potassium content was higher in irrigated almonds intercropped with clover, and the calcium content was also higher in irrigated almonds intercropped chickpeas and clover compared to the control. In conclusion, crop diversification in agroforestry systems combined with efficient irrigation management improves the nutritional quality of almonds. This approach not only supports sustainable agricultural practices, but also fulfills the twin goals of food security and environmental protection. Further research to optimize these systems could bring even greater benefits for agricultural productivity and environmental sustainability.
*Keywords:* almonds, intercropping, mineral content, nutritional quality.

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# EVALUATION OF ALMOND TREE' FERTILITY WHEN THE SOIL IS SUBJECTED TO DIFFERENT MAINTENANCE SYSTEMS AND DIFFERENT WATER CONDITIONS

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In the Trás-os-Montes region, different soil management practices are used in the almond groves, with tillage being the most common practice, especially among small almond producers. The use of cover crops has become increasingly common. We conducted this work with the aim of assessing the fertility of the soil in the almond grove when subjected to different soil maintenance systems and different water conditions. The trials took place between 2022 and 2024 in two almond groves (non-irrigated and irrigated) in full production in Corujas and in a young irrigated almond grove in Argozelo. Each trial was divided into three treatments with three replicates of five almond trees each: with chickpeas, short-cycle clover and tilled soil. The soil was sampled with a probe at a depth of 20 cm on each tree (15 samples/treatment). The results of the analyses show that the soil in all three almond groves has a silty loam texture and a pH ($H_2O$) of 5. Potassium ($K_2O$) increased in all treatments in the irrigated almond grove, most significantly in the tillage treatment, where it increased
from 133.00 mg/kg to 195.05 mg/kg. In terms of organic matter, the non-irrigated almond grove had higher values, ranging from 1.78% to 4.43% in the chickpea treatment. In the assessment of micronutrients, a gradual increase in Fe levels was observed in the almond trees in full production over the sampling period, which was more evident in the irrigated almond grove in the clover treatment, increasing from 29.69 mg/kg to 111.63 mg/kg.

*Keywords*: treatments, intercropping, cover, input, nutrients, sustainability.

*Acknowledgement*: VALMEDALM Project - Valorization of Mediterranean almond groves through the use of integrated intercropping strategies

# AGROFORESTRY ALMOND ORCHARDS TO ASSESS INTERACTIONS BETWEEN TREES AND CROPS UNDER THE MEDITERRANEAN CLIMATE IN MOROCCO

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The practice of intercropping trees and crops on the same land simultaneously has been proposed to have multuple benefits. Several publications have appeared in recent years condidering sustainable agriculture practices as a preservation of biodiversity. We conduct this study in an almond agroforestry system where we examined the influence of intercrop practice in weed management during February 2024. The experiment was laid out in an intercrop design with three replications per leguminous species. The study included 18 plots in total. The weed management was evaluated by different means that are weed species and abundance presence by counting the different species of weeds and weighing them above ground biomass. Our findings indicate that, belonging to 9 different species, 201 weeds were counted in 3 random square meters in *Fava bean* intercrop and 207 weeds were counted in another 3 random square meters in *Lentil* intercrop. Thus, belonging to 10 different species, the results showed that 166 weeds were counted in 3 random square meters in *Fava bean* monoculture and 180 weeds were counted in another 3 random square meters in *Lentil* monoculture. Furthermore, the average of weeds per square meter was calculated to be 68 for intercrops and 58 for monocultures. In terms of drying weight, 50.35 g and 97.96 g were the average of weeds in intercrops and monocultures, respectively. Overall, significant variation was found among weeds abundance and weed dried weights. In conclusion, the results reported here will be contributed to future comparative studies in leguminous intercrops.

*Keywords*: leguminous, almond orchard, weed, agroforestry, management

# THE EFFECT OF WATER SALINITY ON TRANSPIRATION AND PHOTOCHEMISTRY IN *Citrus unshiu* Marc. 'IWASAKI' IN CROATIA

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The global climate has undergone rapid changes over the last two decades, affecting all sectors worldwide, including agriculture. Rising sea levels contribute to elevated salinity, exacerbated by secondary salinization from irrigation, which poses challenges to commercial agriculture with salt-sensitive plants such as citrus production in Croatia. An experiment was conducted with the mandarin cultivar Iwasaki over two growing seasons (2023 and 2024) at two locations in the Neretva Valley, Vidrice and Bostanac, Croatia, where irrigation water differed in terms of salt concentration. The average electrical conductivity (EC) of irrigation water in Vidrice was 5132 µS $cm^{-1}$ in 2023 and 5549 µS $cm^{-1}$ in 2024, while in Bostanac it was 685 µS $cm^{-1}$ in 2023 and 747 µS $cm^{-1}$ in 2024. Stomatal conductance (gsw), transpiration (E), and chlorophyll fluorescence parameters—quantum efficiency of photosystem II (PhiPS2) and relative electron transport rate (ETR)—were measured with an LI-600 porometer/fluorometer. A higher average gsw value (0.085 mol $m^{-2}s^{-1}$) was measured in Bostanac than inVidrice (0.026 mol $m^{-2}s^{-1}$) in 2023, while there was no significant difference between the sites in 2024. Higher values for both PhiPS2 and ETR were observed in Bostanac in both years, although the difference was more pronounced in 2023. These results emphasise the significant impact of irrigation water EC on stomatal conductance and photochemical efficiency of mandarins.

*Keywords*: climate change, salinity, mandarin, stomatal conductance, fluorescence

# EFFECTIVE REMOVAL OF SYNTHETIC DYE CRYSTAL VIOLET USING ACTIVATED CARBON FROM ORANGE BIOMASS

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In this work, the use of activated carbon from orange seeds, orange peels and their mixtures for the removal of C.I. Basic Violet 14 (Crystal Violet) from aqueous solutions was investigated. Crystal Violet is a synthetic dye known for its deep purple color and long-term stability in water. Activated carbon produced from orange seeds (*Citrus sinensis*) and orange peels (*C. sinensis*) is an environmentally friendly and sustainable material with significant adsorptive properties. In this study, both materials underwent a carbonization and activation process to increase their porosity and surface area. Adsorption tests of Crystal Violet dye were conducted at various pH values and concentrations. The results showed that activated carbon from orange seeds demonstrated high efficiency in removing Crystal Violet, while the mixture of activated carbon from seeds and peels provided better results compared to the individual types. The combination of both types of activated carbon allowed for a synergistic effect that enhanced the adsorption capacity. These findings indicate the potential of orange-derived activated carbon as a sustainable solution for the treatment of wastewater containing synthetic dyes and provide insight into the effectiveness of different biomass sources in pollutant removal.

*Keywords*: activated carbon, Crystal Violet, orange peels, orange seeds, wastewater

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# ROLE OF THE BLACK SOLDIER FLY IN ORGANIC WASTE MANAGEMENT AND PRODUCTION OF BIOFERTILIZER FOR FAVA BEAN CULTIVATION

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Bioconversion of organic waste using black soldier fly (BSF) larvae represents a new agroecological approach to valorize agricultural by-products for animal feed and thus strengthen the resilience of agricultural systems. A variety of agricultural by-products were identified, collected and chemically characterized to highlight the importance of this insect for organic waste management and as feed ingredients for breeding BSF insects for chicken feed. The organic by-products were collected from the market in Ain Taoujdate, Morocco, for insect feeding. Field trials were conducted to assess the effects of BSF insect frass on the fava bean growth. Six treatments were evaluated based on the N content in the insect frass and the amount used as reference for the fava bean crop: negative and positive controls, 25, 50, 100 and 200%, corresponding to 1.09, 2.18, 4.35 and 8.7 tons frass/ha, respectively. Morphological, agronomic and physiological parameters such as seed germination, plant development, yield and height, flowering time, root and shoot dry mass, leaf count, leaf area and chlorophyll content were evaluated. Samples were prepared and dehydrated to carry out analyzes of humidity, ash, protein and lipid content. The results showed a great variability in the nutritional composition of the by-products tested, resulting in variability in the rate of bioconversion by insects, with a high content of physico-chemical elements of insect frass used as biofertilizer for crop, particularly N content. Our results emphasize the effectiveness of using BSF insect meal for optimal growth of fava bean under Moroccan climatic conditions.

*Keywords:* organic waste management, BSF, nutritional composition, biofertilization, fava bean crop.

*Acknowledgment:* Financial support for this research has been provided by the Ministry of Higher Education of Morocco (ADVAGROMED project) and PRIMA, a program supported by the European Union (CIPROMED project, under grant agreement No 2231).

# PREVALENCE AND ANTIBIOTIC RESISTANCE DETERMINANTS OF CARBAPENEM-RESISTANT *Acinetobacter baumannii* FROM WASTEWATER TREATMENT PLANTS IN SPLIT, CROATIA

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*Acinetobacter baumannii* has emerged as a major opportunistic pathogen and an important source of hospital-acquired infections. In response to the increasing incidence of carbapenem-resistant *A. baumannii* (CRAB) infections, the World Health Organization (WHO) classified it as a critical threat in its 2017 list of priority pathogens and maintained this classification in the updated 2024 list, underscoring its persistent and serious threat to public health. While *A. baumannii* is frequently isolated from patients and hospitals, there is limited data on its spread outside the hospital environment. Therefore, this study investigated the occurrence and antimicrobial susceptibility of CRAB in the influent and effluent of two wastewater treatment plants (WWTPs) in Split. A total of 39 *A. baumannii* isolates were identified from 336 Gram-negative bacterial isolates. Susceptibility testing of 14 antimicrobials revealed that 18% of the *A. baumannii* isolates were CRAB, i.e. they exhibited multidrug or even extensive drug resistance. The isolates were found in the influent and effluent of the Katalinića Brig WWTP, while one was isolated from the influent of the Stupe WWTP. The higher incidence of CRAB in the Katalinića Brig WWTP is probably related to hospital wastewater, as this is the only plant that treats hospital wastewater. To exclude clonal relatedness between the isolates, pulsed-field gel electrophoresis was performed and four isolates were selected for whole genome sequencing. The potential leakage of these 'critical priority' pathogens into coastal waters raises concerns, indicating that WWTPs may serve as reservoirs for this pathogen outside hospital environments.

*Keywords*: carbapenem-resistant *Acinetobacter baumannii*, whole genome sequencing, wastewater treatment plants, Croatia

# OLIVE PITS AS ECO-FRIENDLY SORBENT FOR TREATMENT OF ZINC(II)-CONTAMINATED WATER

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Due to the increasingly intensive agricultural and food production, a large quantity of by-products is created all over the world. In order to protect the environment and preserve natural resources, it is necessary to utilize the by-products. Since olive cultivation represents a significant economic potential in Dalmatia's agricultural production, the idea of this preliminary study was to use olive pits as low-cost sorbent for the treatment of zinc(II)-contaminated water. In this way, the overall costs of water treatment could be reduced while achieving the same goals of the circular economy. The removal of zinc(II) from aqueous solutions containing ≈ 0.5 mmol/L, 1.5 mmol/L and 3.0 mmol/L zinc was carried out in a batch mode on the laboratory shaker at 230 rpm, at a solid/liquid ratio of 1/100, at room temperature and for 24 h. The capacity of the olive pits obtained was in the range of 0.030-0.064 mmol/g, with a removal efficiency of 24.2% to 64.6%. The capacity was highest at the highest initial zinc(II) concentration due to the higher concentration gradient, while the best removal efficiency was obtained at the lowest zinc(II) content. The sorption capacity and removal efficiency of raw olive pits were also compared with the values after cold extraction with n-hexane and ethanol. The sorption properties of olive pits after extraction increased slightly, suggesting that they can be used for water treatment even after extraction of valuable bioactive compounds. Finally, the maximum removal efficiency of ≈ 65% achieved indicates that olive pits are a promising material for zinc removal, especially at lower zinc concentrations.

*Keywords*: olive pits, low-cost sorbent, circular economy, zinc, wastewater treatment

# SORPTION OF COPPER, COBALT AND NICKEL IONS FROM TERNARY SOLUTIONS ON THE ZEOLITE 13X

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The demand for global water resources is increasing as the human population grows, leading to higher costs and stricter regulations. The higher the demand for water resources, the higher the pressure on natural resources and the higher the damage to the environment, posing a major threat to the sustainability of economic development. The wastewater generated by industry represents a risk to human health, which is why it must be treated before being discharged into the environment. The sorption of copper, cobalt and nickel ions on zeolite 13X was studied as a function of different initial concentrations of heavy metal ions from the ternary solutions. The experiments were conducted in batch reactors at a constant temperature of 27 °C and a stirring speed of 200 rpm for 72 h. The sorbed amount of copper and cobalt ions increases with the increase in the initial concentration of the selected ions in the ternary solutions, while in the case of nickel ions it varies with the increase in the initial concentration. The highest amount of heavy metals sorbed from the solutions corresponded to copper ions with a value of $q_e$ = 1.496 mmol/g at an initial concentration of $c_0$ = 35.006 mmol/L. The sorption efficiency of zeolite 13X for all heavy metal ions (copper, cobalt and nickel ions) from the ternary solutions decreases as the initial concentrations are increased. The experiments conducted showed that the best sorption efficiency was achieved for the removal of copper ions and was ≈ 95% for the lowest initial concentration of copper ions in the ternary solution. The results obtained were also tested using various isotherm models.

*Keywords*: sorption, copper ions, cobalt ions, nickel ions, zeolite 13X, isotherm models

# FTIR ANALYSIS OF THE RECYCLED CELLULOSE FROM THE LABORTORY WASTE MATERIALS VIA REGENERATION PROCESS

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With the continuous development of society, a large amount of waste is produced from various sources, which has a negative impact on all material resources. Therefore, the recycling of waste and the production of renewable materials is essential. Cellulose, as the most abundant renewable material, can also be negatively impacted by these uncontrollable waste streams. It is mainly used for the production of fibres, films or different cellulose derivatives. Cellulose has not yet reached its full application potential as its processing is very complex. However, this can be addressed through various chemical modifications that can lead to the sustainable production of recycled cellulose materials. Samples of waste cellulosic materials, and laboratory cotton wool and paper, were subjected to the cuprammonium regeneration process under different regeneration conditions to produce cuprammonium rayon fibres. The regeneration time and the concentration of sulphuric acid were changed. Fourier transform infrared spectroscopy (FTIR) was used to determine characteristic absorption bands and the crystallinity index (CI). The analysis is also related to the physical characteristics of the fibres as a result of the regeneration process. The FTIR analysis confirmed the successful regeneration of cellulose from both cellulose wastes and its dependence on the regeneration time and the concentration of sulphuric acid. The optimal conditions for the regeneration of cellulose from cotton wool was 8 minutes in 1 M sulphuric acid and from cotton paper was 4 minutes in 1 M sulphuric acid. In addition, investigation showed that the regeneration process should be further optimized for more compact cellulose waste.

*Keywords*: waste cellulose materials, cellulose regeneration, FTIR analysis, crystallinity index

# CONVERSION OF ROCKROSE (*Cistus ladanifer* L.) SCRUBLAND INTO BIODIVERSE PASTURES

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Pastures in the Mediterranean region are crucial for the preservation of local agriculture and biodiversity. Well-managed pastures improve soil structure and fertility, reduce erosion and improve water retention. This is especially important in a region with hot and dry summers and mild and wet winters. These agricultural systems play a crucial role in sequestering carbon, therefore contributing significantly to climate change mitigation efforts. In addition, the Mediterranean pastures are crucial for the conservation of endemic plant species and habitats for various wildlife species.
Quinta do Freixo (Algarve, Portugal) with an area of around 800 hectares, is dedicated to sustainable agriculture and promotes ecological, economic and social sustainability. In addition to organic agriculture production, the farm also processes agricultural food and offers rural tourism experiences. On this farm, dense shrubland of rockrose (*Cistus ladanifer* L.) are converted into pastures using a holistic method that includes mechanical cutting of the shrubs, spreading biodiverse hay and grazing with Campaniça sheep (1000 sheep/hectare). As part of the project "Revitalgarve: Revitalization of rural areas" (PRR-C05-i03-I-000237), these pastures are monitored through regular measurements of dry matter production, nutritional value analysis and floristic composition in the restored areas. This approach has contributed to the development of species-rich pastures, rich in legumes and grasses and characterized by high protein, high fiber content and excellent digestibility. In addition, the control of shrublands through this practice maintains biodiversity and reduces the risk of wildfires by effectively managing fuel loads.

*Keywords*: Dry matter production, ecological restoration, grasses, **s**heep, legumes.

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# MACROPHYTE COMMUNITIES IN THE NORTHERN ADRIATIC SEA: LONG-TERM CHANGES AND THE NEED OF NEW TOOLS FOR MONITORING

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Macrophytes, i.e. seagrasses and large-sized marine macroalgae, play a key role in coastal ecosystems, where they are the main primary producers and provide numerous valuable ecosystem services (biodiversity repositories, nursery habitats, food provision, sediment retention, protection from coastal erosion). In the northern Adriatic area, forests formed by large brown seaweeds (*Cystoseira s.l.*) and seagrass meadows (*Cymodocea nodosa*, *Nanozostera noltei*, *Zostera marina*) are the main macrophyte communities. Unfortunately, over the last decades these ecosystems have undergone a large-scale regression. Rarefaction and local extinctions of macrophytes in some regions (Conero Riviera, western Istrian coast) are documented by literature data and herbarium specimens, although detailed distribution maps are available only for a few species and localities. Given the enclosed nature of the Adriatic Sea, it is expected that the effects of climate change on these communities will be more severe in this basin than in other parts of the Mediterranean. Therefore, accurate monitoring is necessary to assess temporal changes in their distribution and coverage and inform actions for their conservation and restoration. The Brigantine project (Interreg Italy-Croatia ITHR0200237) aims to provide innovative tools for monitoring of benthic habitats in the northern Adriatic and measuring environmental variables that affect their distribution. The project aims to deliver an autonomous monitoring vessel capable of collecting chemico-physical and multispectral data in monitoring procedures. Combination of cross-border multidisciplinary expertise will allow to test the vessel in the field and adapt it to real-world conditions typical of northern Adriatic coastal habitats.

*Keywords*: Adriatic Sea, autonomous vessel, conservation, macrophytes, monitoring, sensors.

# MONITORING OF INVASIVE ALIEN PLANT SPECIES IN THE BREGANA RIVER AREA

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Invasive alien species (IAS) are a subgroup of alien species whose introduction or spread can seriously threaten biodiversity and the associated ecosystem services. Invasive alien species pose an increasing challenge, not only to environmental protection, but also to human health and the global economy. Collecting data, maintaining databases on alien species and educating the public are important components of invasive alien species management. Public institutions that manage protected nature areas and ecological network sites play a crucial role in monitoring the status of IAS. The public Institution Zeleni prsten of Zagreb County is one of the partners in the LIFE OrnamentalIAS project, which deals with invasive alien ornamental plants. The project involves 10 partners, eight from Slovenia and two from Croatia. The project deals with ornamental plant species on three levels: prevention, early detection – rapid response and management of introduction pathways. In Croatia, the area along the Bregana River was included, which is part of the Natura 2000 ecological network and covers an area of around 17 hectares. Particular attention was paid to mapping species from the EU list of IAS such as Himalayan balsam (*Impatiens glandulifera* Royle) and ornamental plants that have begun to spread in the wild, such as the Butterfly bush (*Buddleja davidii* Franch.). The former has begun to spread intensively in the Bregana River region in recent years. The paper presents the results of monitoring of some invasive plant species and the possibilities of removing certain species.

*Keywords*: invasive alien plants, biodiversity, LIFE OrnamentalIAS, *Impatiens glandulifera*

# ABUNDANCE AND DIVERSITY OF SOIL ARTHROPODS IN NON-IRRIGATED AND IRRIGATED ALMOND GROVES IN THE TRÁS-OS-MONTES REGION (PORTUGAL)

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In this work, the edaphic fauna of the almond grove was evaluated in 2023. The experimental trial took place in two almond groves in full production, one non-irrigated and the other irrigated, located in Corujas. Each trial was divided into three treatments: covered with chickpeas, short-cycle clover and tilled soil (15 trees/treatment). Three pitfall traps/treatment were placed 30 meters apart. Each trap contained a solution of ethylene glycol diluted to 50%. Arthropods were collected monthly and the individuals present in each sample were sorted and identified in the laboratory.
The results showed that the pitfall traps captured a total of 1041 and 2597 edaphic arthropods in the irrigated and non-irrigated almond groves respectively, belonging to nine different taxonomic groups: Formicidae, Coleoptera, Araneae, Acari, Collembola, Hemiptera, Dermaptera, Orthoptera. The soil arthropods were dominated by Formicidae, with 54.56% and 80.13% in the irrigated and non-irrigated almond groves respectively. The highest abundance of arthropods was found in the short-cycle clover treatment, with around 56.78% and 58.14% of the total number of individuals captured in the irrigated and non-irrigated almond groves, respectively. The abundance of soil arthropods was higher in non-irrigated almond groves. It was concluded that the type of cover crop influences the abundance and diversity of arthropods in the soil, with short-cycle clover standing out as the most bio-diverse cover.

*Keywords:* cover, clover, arthropods, , biodiversity, soil, almond grove

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# RESEARCH ON THE BIOLOGICAL CHARACTERISTICS OF THE SPECIES *Aleurocanthus spiniferus* (QUINTANCE, 1903) IN THE CLIMATIC CONDITIONS OF THE DUBROVNIK-NERETVA COUNTY

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The orange spiny whitefly, *Aleurocanthus spiniferus* (Quaintance, 1903), is an economically important pest of citrus fruit. In Croatia, *A. spiniferus* was first detected on *Citrus aurantium* L. in Split, in 2012 and subsequently eradicated. No new findings were reported from 2013 to 2018. In September 2018, as part of a special monitoring of quarantine species of whiteflies of the genus *Aleurocanthus* Quaintance & Baker, 1914, in Dubrovnik-Neretva County, the first positive finding of the species *A. spiniferus* was detected in a mandarin orchard during a visual inspection. In the following years, the pest then spread to the northwest, reaching Split-Dalmatia County, Šibenik-Knin County and, in 2023, Primorje-Gorski Kotar County (island of Krk). From 2020 to 2022, the population dynamics and development of the pest under natural conditions were monitored in Dubrovnik-Neretva County. In 2020, the development cycle lasted between 41 and 105 days, while in 2021 it was between 49 and 93 days. The climate analysis showed that it was 1.6 °C warmer in 2020 than in 2021, with higher maximum temperatures and no precipitation, which slowed down the development of the pest. The adult developmental stages were recorded during November in both years of the study. In the future, recording the adult stages of *A. spiniferus* during the winter months could provide indications of changes in climatic factors and the ability of the species to survive the winter months. Global warming, particularly in the Mediterranean basin, increases the risk of introduction and spread of new alien species due to favorable climatic conditions and abundance of host plants.

*Keywords:* whitefly, *Aleurocanthus spiniferus*, Dubrovnik-Neretva county, global warming, climate change

# RECOVERY OF BURNED AREAS IN NATURAL PARK OF SERRA DA ESTRELA: THE POWER OF NATIVE PLANTS

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The preservation and restoration of mountain regions is crucial due to their role as a reservoir for biodiversity, a source of freshwater and an ecosystem service for the world's population. The FLoRE project (S1/2.7/F0042), funded by INTERREG-SUDOE, is a consortium of 8 international partners from the SUDOE region that proposes and deploys Nature-based Solutions (NbS) to combat ecosystem degradation through the use of seeds of native wild herbaceous plants. Launched in 2024, the project also aims also to demonstrate the economic and organizational viability of a change in the implementation of ecological restoration solutions, through the involvement of multiple actors and stakeholders of the deployed solution. The project will produce a literature review on this topic and a toolkit to facilitate access to existing knowledge, apply the solution in practice, assess its impact and finally develop a medium- term strategy to engage all interested parties. As part of FLoRE, we are conducting activities to restore an area damaged by a forest fire in the Municipality of Manteigas, which is part of one of the most relevant natural biodiversity reservoirs in Portugal, the Serra da Estrela Natural Park (PNSE). In August 2022, over 22 000 hectares of agricultural fields and forests were destroyed by wildfires in the PNSE. A pilot area will be established where NbS based on seeds of herbaceous native plants will be tested for their suitability to promote ecosystem revitalization, actively involving local authorities, nature and environmental protection associations and the local population to facilitate their introduction.

*Keywords*: Ecosystem restoration, native plants, Serra da Estrela Natural Park, wildfires

# UNVEALING THE EFFECTS OF SOIL RESTORATION MEASURES ON ARTHROPOD ABUNDANCE IN A PORTUGUESE NORTHEASTERN FOREST

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Forest disturbances such as wildfire, changes in land use such as the abandonment of forests change the physical-chemical-biological properties of the soil. After a disturbance, remedial measures must be taken to prevent soil degradation. It is known that different groups of soil arthropods react differently to forest management practices, so soil-dwelling species can be used as bioindicators for the evaluation of forest restoration measures. In a fire-prone forest area in Vimioso in north-eastern Portugal, soil amendments were applied to prevent wildfires and avoid desertification. The amendments applied were compost, donkey manure and a mixture of woodchips, obtained from a local waste composting plant. The aim of this study was to investigate the impact of these amendments on arthropod abundance. Arthropod samples were collected in autmn, winter and spring (2023-2024) using pitfall traps. The most abundant arthropods collected were Arachnida, Coleoptera, Diptera and Formicidae, with the highest abundance in autumn. Donkey manure significantly increased the abundance of all arthropods except Formicidae, which showed no preference for particular supplements. Woodchips were the least attractive to the arthropods. These results emphasize the potential of using donkey manure as an effective soil amendment to improve arthropod abundance and promote ecosystem recovery in fire-prone areas. However, further research is needed to better understand the long-term effects of these strategies.

*Keywords:* Arthropods, bioindicators, forest disturbance, compost, soil amendment.

*BEST POSTER REWARD 3rd PLACE*

# PROTECTION AND SUSTAINABILITY OF BIOLOGICAL DIVERSITY IN THE SEA AND ON THE ISLANDS OF DALMATIA

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The three aspects of protection in the coastal eastern Adriatic, Croatia were analysed. 1) Management of protected areas such as the island Lastovo archipelago (southern Adriatic). The oligotrophic Adriatic Sea is characterized by strong water column stratification in summer that inhibits vertical mixing and nutrient supply to the euphotic zone , as well as low productivity. Lastovo is one of small number of islands globally where island trapped waves (ITWs) are observed during the stratified season. They are resonantly driven around the island by diurnal tides and winds. Such transient physical forcing enhances nutrient fluxes and creates localized higher net primary production, maintain specific marine plankton community and benthic life. Our findings reveal the matching phase of light and ITWs indicating that the ITWs effect on primary production is greatly driven by light. 2) Protection of shallow coastal habitats. Tourism accelerates construction on the seashores. The greatest environmental damage is caused by artificial beaches that prevent the maintenance of complex food webs and thus seriously threaten the functioning of the marine ecosystems. 3) Protection of primary vegetation (maquis with holm oak) and soil from erosion on the dry northern Dalmatian islands. This area is the driest in Croatia, where the growth of the maquis is the slowest. On the abandoned agricultural areas, the Aleppo pine is spreading and changing the microclimatic characteristics and properties of the soil, leading to more frequent fires, the collapse of drywalls and faster soil erosion. The shallow Adriatic Sea is rapidly threatened by climate change, so coordinated protection of both marine and terrestrial ecosystems is needed.

*Keywords:* Lastovo, Island trapped waves, artificial beaches, food web damages, maquis, holm oak.

# GLANDULAR AND NON-GLANDULAR TRICHOMES AND ANTIPHYTOVIRAL ACTIVITY OF *Inula spiraeifolia* L.

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*Inula spiraeifolia* L. (Asteraceae) is a sub-Mediterranean species native to southern and eastern Europe. Within the subtribe Inulinae, *Inula* L. (ca. 100 species) is one of the most important genera. As no single morphological feature ubiquitous to the genus *Inula* has been identified so far, this group is taxonomically problematic. In this study, we analysed the trichomes on the leaves of *I. spiraeifolia* by light microscopy, which may provide further taxonomic value and might have an ecological function. We identified three types of non-glandular trichomes: i) tiny, multicellular, erect trichomes with long, narrow and sharply pointed apical cell; ii) multicellular trichomes inclined towards the organ surface with linearly arranged basal cells that are wider in the lower part and prozenchymatous cells in the upper part; iii) branched trichomes with short basal part. Glandular trichomes are less numerous on the leaf surface and have a short stalk and a round glandular cell filled with secretory substances. Recently, new biological activities of aromatic plants have been demonstrated, showing their potential for daily life. As a non-toxic and environmentally friendly aqueous solution of volatile compounds, hydrosols of various aromatic plants are increasingly becoming the focus of scientific research. In this study, we demonstrated for the first time the moderate antiphytoviral potential of the hydrosol of *I. spiraeifolia* on local host plants infected with tobacco mosaic virus (TMV). These results provide new morphological data useful for distinguishing *I. spiraeifolia* from other species of the genus *Inula* and indicate new biological activities that show that this plant deserves further attention.

*Keywords:* antiphytoviral activity, glandular trichomes, hydrosol, *Inula spiraeifolia*, non-glandular trichomes

*Acknowledgments:* This research was supported by the institutional project “Hidden Treasures of Dalmatia - Biology and Biological Activity of Selected Plant Species”, funded by the Faculty of Science, University of Split.

# SPATIAL AND TEMPORAL ANALYSIS OF SEA SURFACE HEIGHT VARIATIONS IN THE MEDITERRANEAN SEA USING NEURAL GAS AND THEIR LINK TO BIOLOGICAL PARAMETERS

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This study examines changes in Sea Surface Height (SSH) across the Mediterranean Sea over a 30-year period, from 1988 to 2020, using a machine learning technique Neural Gas. The study also connects temporal and spatial SSH changes with biologically important oceanographic parameters, such as chlorophyll and nutrient concentrations. Data were obtained from the Copernicus Marine Service.The results show differences in the spatial anomaly distribution of SSH across the Mediterranean. The method successfully detected SSH patterns associated with the Bimodal Oscillating System (BiOS). For example, the Adriatic Sea exhibited distinct seasonal variations, with lower SSH during winter months and higher SSH in summer, reflecting its sensitivity to climatic factors and local hydrodynamics.The analysis also identified a relationship between SSH and nutrient levels, showing that regions with higher concentrations of nutrients, such as ammonia, nitrate, and phosphate, often correspond to areas with SSH anomalies. For instance, high nutrient concentrations were observed in the northern Adriatic Sea and along the coastlines of North Africa, which may contribute to localized SSH increases due to enhanced biological activity, such as phytoplankton blooms. Additionally, chlorophyll concentrations demonstrated a clear seasonal cycle, with higher levels in spring and summer, further influencing SSH variations.This research underscores the complex interactions between physical and biological processes in the Mediterranean Sea. The findings emphasize the importance of using advanced techniques like Neural Gas to better understand temporal and spatial changes in SSH, which is critical for assessing the impacts of climate change and human activities on marine ecosystems.

*Keywords*: Mediterranean Sea, Sea Surface Height, Neural Gas, BiOS, Copernicus Marine Service, nutrient anomalies, chlorophyll.

# TWO DECADES OF OCEANOGRAPHIC AND CATCH DATA COLLECTION USING FISHING VESSELS TO MODEL THE SPATIO-TEMPORAL DISTRIBUTION OF SMALL PELAGICS IN THE ADRIATIC SEA: PRELIMINARY RESULTS

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The Adriatic Sea represents one of the most productive areas of the entire Mediterranean basin, with anchovy (*Engraulis encrasicolus*) being among the main targets of fishery. The spatio-temporal distribution of Anchovy within this sub-basin is influenced by the peculiar oceanographic conditions, together with the specific exploitation patterns of the Adriatic fleets targeting these resources.
Two decades (2003-2023) of catches per unit effort of Anchovy have been made available through continuous collection of data derived from the Fishery Observing System (FOS) and the Adriatic Fishery & Oceanography Observing System infrastructure (AdriFOOS), implemented by CNR-IRBIM. These systems exploit commercial fishing vessels operating in the Adriatic Sea as Vessels of Opportunity, to collect a variety of data in near real time. These systems provide in-situ environmental data through sensors installed on fishing gears, along with geo-referenced catch data supplied by fishermen through a dedicated interface. The specific characteristics of each fishing vessel of the monitored fleet, targeting small pelagics, are also available as a proxies of exploitation efficiency.
The aim of this study is to build quantitative models, allowing high flexibility and handling of non-linear relationships (e.g., Generalized Additive Models), to detect and characterize the contribution of environmental and anthropogenic drivers to Anchovy's distribution in the Adriatic Sea. We provide useful hints about the application of near real-time data collection using fishing vessels, encouraging the use of such tools to increase the amount and the reliability of available fishery-dependent data, to optimize the monitoring of commercially relevant fish species.

*Keywords*: Small pelagic fish, Adriatic Sea, Fishery Observing Systems, Generalized Additive Models, Spatio-temporal dynamics

*BEST POSTER REWARD 2nd PLACE*

# THE MICROBIOME OF FARMED MUSSEL *Mytilus galloprovincialis* IN THE ESTUARY OF KRKA RIVER

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The Mediterranean mussel *Mytilus galloprovincialis* is the most important shellfish species in Croatian marine aquaculture, reaching a total production of 1.006 tonnes in 2022. As filter feeders, mussels accumulate microbial organisms from the environment, making them an integral part of their physiology and a potential source of advanced functions such as resistance to pathogens, immune responses, detoxification mechanisms, nutrient utilization, but also disease. In addition, one of the risks in mussel production is the presence of pathogens and coliform bacteria, which is strictly monitored. In this study, the entire microbial community of the gills and hepatopancreas of farmed mussels in the Krka River estuary in 2022/2023 was analyzed by the DNA metabarcoding method using the variable region V4-V5 of the 16S rRNA gene. The bioinformatic analyses revealed the largest contribution of Proteobacteria (monthly average of 52.6% - 91.7% in the gills and 16.6% - 75.7% in the hepatopancreas), Bacteroidota (gills 8% - 45.1%, hepatopancreas 8% - 28.4%), while Firmicutes occurred only in fall and winter as a significant proportion of the hepatopancreatic microbiota (0.9% - 66.6%), with considerable interindividual variability. At the family level, most represented were Comamonadaceae, Weeksellaceae and Xanthomonadaceae in both tissues. Of the possible foodborne pathogenic genera that sporadically exceeded a monthly average relative proportion of > 1% in the hepatopancreas, *Vibrio, Clostridium* and a group referred to as *Escherichia-Shigella* were recorded. The data provide an important basis for the understanding of mussel physiology and the development of tools for early warning systems, biomonitoring and the traceability of marine products.

*Keywords*: *Mytilus galloprovincialis*, microbiome, hepatopancreas, gills, Krka River estuary, aquaculture

*Acknowledgments:* This research was supported by the Ministry of Agriculture of the Republic of Croatia through Operational Program for Maritime Affairs and Fisheries for the period 2014-2020 and the European Union through the European Fund for Maritime Affairs and Fisheries, under project INNODAGNJA.

# DIET AND FEEDING HABITS OF THE MEDITERRANEAN HAKE, *Merluccius merluccius* (LINNAEUS, 1758) IN THE SOUTHERN TYRRHENIAN SEA (MEDITERRANEAN SEA)

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The european hake, *Merluccius merluccius* (Linnaeus, 1758) is one of the most important demersal fisheries resources in the Mediterranean sea. This species is a crucial component of the ecosystem, since it facilitates energy transfer from lower to higher trophic levels. Its ecological role has been studied through stomach content analysis on samples caught during the MEDITS (International bottom Trawl Survey in the Mediterranean), an experimental trawling survey carried out in December 2023 in the southern and central Tyrrhenian sea (GSA 10). Vacuity index (%VI), frequency of occurrence (%F), percentage of abundance composition (%N), percentage of biomass composition (%W) and index of relative importance (%IRI) were calculated and used to describe the trophic status of this species. In total, 220 specimens were sampled. Not considering the 90 everted ones, 130 stomachs have been taken and analyzed and, out of them, 54 were found to be empty (vacuity index = 41.54 %). Teleosts were the major group in the stomach contents (%IRI = 77.11), followed by crustaceans (%IRI = 22.67) and, to a lesser extent, by cephalopods (%IRI = 0.01). Informations on hake's feeding ecology as provided by this study contribute to improved ecosystem understanding and conservation efforts.

*Keywords*: *Merluccius merluccius*, ecology, trophic levels, Tyrrhenian sea, stomach content analysis

# ISOLATION AND MORPHOLOGICAL CHARACTERIZATION OF A *Vibrio gigantis* BACTERIOPHAGE

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*Vibrio gigantis* has been isolated from various marine species, including aquatic invertebrates and finfish. It is considered an emerging bacterial pathogen that may threaten European sea bass production. The aim of the research is to identify a potential candidate for phage therapy against vibriosis caused by *V. gigantis* in aquaculture, as phage therapy is considered a promising alternative to antibiotics for controlling infectious diseases. The bacteriophage was isolated from the marine environment using the enrichment culture method based on a double-layer agar overlay assay. Morphological characterization was performed using transmission electron microscopy. The isolated bacteriophage exhibits a distinct morphology reminiscent of myoiruses. It has an icosahedral capsid with a diameter of 68.87 ± 4.65 nm and a long, contractile tail, resulting in a total length of 215.87 ± 9.8 nm and a width of 20.29 ± 0.5 nm. These dimensions provide insight into its physical structure and possible interactions with host bacteria, suggesting both lytic and lysogenic infection cycle in the host cell. Given its potential, phage therapy with *V. gigantis* represents a promising alternative to antibiotics in aquaculture, addressing concerns about antibiotic resistance and promoting sustainable practices. With its ability to fight infections in all marine species, the phage offers hope for improved disease management and reduced mortality rates, representing a significant advance for aquaculture. Further research of its characteristics and application could lead to effective measures to combat vibriosis and improve the health of the marine ecosystem.

*Keywords*: *Vibrio gigantis*, bacteriophage, isolation, morphological characterization, phage therapy, aquaculture

# GENDER DETERMINATION IN THE MEDITERRANEAN MUSSEL *Mytilus galloprovincialis* (BIVALVIA: MYTILIDAE) BASED ON THE COLORATION OF THE GONAD TISSUE

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The coloration of gonadal tissue has been proposed as a reliable indicator of gender and allows for visual sex determination. Male mytilids usually have milky white gonads, while females are orange in color. It is known that carotenoid pigments, which are responsible for the orange color, are involved in the defense against oxidative stress. Males could therefore also have high concentrations of carotenoids depending on their position in the mussel bed and their reproductive cycle, which could lead to incorrect gender determination by color-based approaches. Studies have been conducted to determine the reliability of sex determination based on color by comparing the results with those of histology. Both methods were applied to mussels from a polluted rocky coast in the intertidal and a mussel farm in the subtidal. Histological staining showed that males predominated at both sites. This result contrasts with the higher frequency of females at both sites, as indicated by the color of the gonads. Thus, we conclude that determining the number of individuals of a particular sex based on gonad color alone may lead to erroneous results. From the results, we conclude that sex determination based on color is not sufficiently reliable and therefore a histological examination is required.

*Keywords*: mytilids, gender determination, gonadal tissue coloration, histology

# THE IUCN GLOBAL STANDARD FOR NATURE-BASED SOLUTIONS AND BIVALVE FARMING

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The work presents the results of the analyses of the application of the IUCN (International Union for Conservation of Nature) Global Standard for Nature-based Solutions in bivalve farming. The results showed the integration of the principles of Nature-based Solutions (NbS) into bivalve farming, including the benefits and challenges associated with such integration. A particular focus was placed on Integrated Multi-Trophic Aquaculture (IMTA) systems, where intensive aquaculture practises require innovative approaches to ensure the sustainability and conservation of natural resources. Understanding the role of bivalves in nutrient uptake and eutrophication reduction is crucial to understand the environmental impact of bivalve farming.

*Keywords:* farming, bivalves, IMTA systems, nature-based solutions, environment, sustainability

# OCTOCORALLIA FORESTS HAVE THE POTENTIAL TO BE BOTH A BIODIVERSITY HOTSPOT AND A NURSERY AREA FOR ELASMOBRANCH

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Do octocorallia forests not only contribute to biodiversity, but also serve as breeding grounds for elasmobranchs? During the experimental trawl survey planned to investigate descriptor 6 of the Marine Strategy Framework Directive (MSFD; 2008/56/CE) carried out in the Gulf of Patti (Central-Southern Tyrrhenian Sea) in october 2023, 30 egg-capsules of *Raja miraletus* (Linnaeus, 1758) were found with a frequency of occurrence of 55% and always with the co-occurrence of octocorallia colonies of *Spinimuricea klavareni* (Carpine & Grasshoff, 1975) (N/Km$^2$=81.97) and/or of *Funiculina quadrangularis* (Pallas, 1766) (N/Km$^2$=21.39). Octocorallia forests, characteristic of shelf-edge detritic bottom (DL), are rare or in decrease. They can be found in habitats not-impacted by fishing activity, as is the case of the Gulf of Patti which is closed to trawling since 1990 up to 500 m deep. Here, capsules were only once found attached to one of the branches of a colony of *S. klavareni*, but the constant presence of elasmobranchs eggs and octocorallia suggests that, as already demonstrated in other Italian coasts, coral forests are not only biodiversity hotspots, but they can also be nurseries for some elasmobranchs. In fact, some marine organisms such as gorgonians, have the ability to give three-dimensionality to the seabed, representing a center of attraction for several species, such as fish of significant commercial interest or vulnerable organisms, like *Ophiacantha setosa* (Bruzelius, 1805) or *Astrospartus mediterraneus* (Risso, 1826), which find food, shelter and/or breeding grounds in these habitats. The protection of the habitats created by these gorgonians is a priority.

*Keywords*: Octocorallia, biodiversity hotspot, nursery, elasmobranch eggs, essential fish habitats.

# DE NOVO PLASMID ASSEMBLY FROM CARBAPENEM RESISTANT ENTEROBACTERIACEAE IN CENTRAL ADRIATIC SEA

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Carbapenem-resistant Enterobacteriaceae (CRE) are classified as a critical priority by the World Health Organization (WHO) due to their ability to transmit resistance genes. Factors such as inadequate infection control, high antimicrobial usage, and ineffective environmental surveillance contribute to the global burden of CRE, resulting in increased morbidity, mortality and costs. In our previous study, we investigated the occurrence and diversity of CRE in the marine environment of the central Adriatic Sea. In 38 isolates isolated from the public beach of Trstenik and the Jadro estuary, we detected different carbapenemase genes, including *bla*$_{\text{KPC-2}}$, *bla*$_{\text{OXA-48}}$, and *bla*$_{\text{VIM-1}}$. Therefore, in this study, we performed a *de novo* assembly of eight plasmids. Notably, *bla*$_{\text{KPC-2}}$ was detected on 6 plasmids and *bla*$_{\text{VIM-1}}$ on one plasmid. The plasmids carried up to five *bla* genes, including *bla*$_{\text{TEM-1}}$, *bla*$_{\text{OXA-10}}$, *bla*$_{\text{OKP-B}}$ and *bla*$_{\text{GES-1}}$, in addition to the carbapenemase genes. The *bla*$_{\text{VIM-1}}$-carrying plasmid was the first report of the *bla*$_{\text{VIM-1}}$ gene in *Enterobacter asburiae* in a marine environment. The *E. asburiae* isolate also harbored *bla*$_{\text{KPC-2}}$ on a separate conjugative plasmid, that contained multiple antibiotic resistance genes (ARGs) and virulence factors, including those for aminoglycoside, tetracycline and quinolone resistance. Furthermore, sequencing of the conjugative *bla*$_{\text{KPC-2}}$-bearing plasmid in multidrug-resistant (MDR) *E. bugandensis* and extensively drug resistant (XDR) *E. coli* identified plasmid replicons such as IncP6 and IncR as key vehicles for ARG dissemination. In addition, plasmid analysis of XDR *K. pneumoniae* isolate highlighted the role of IncFIB plasmids in the environmental spread of *bla*$_{\text{KPC-2}}$ in the environment. This underscores the critical role of conjugative plasmids in horizontal gene transfer between CRE and highlights the public health threat posed by MDR and XDR bacteria in marine ecosystems, likely related to antropogenic activities and sewage disposal.

*Keywords*: carbapenemase-producing Enterobacteriacae, marine environment, whole plasmid sequencing, Adriatic Sea, Croatia

# DEPTH-DEPENDENT DIETARY INFLUENCE ON THE GUT MICROBIOME OF NORWAY LOBSTER (*Nephrops norvegicus*) FROM THE CENTRAL ADRIATIC SEA (MEDITERRANEAN SEA)

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Norway lobster, *Nephrops norvegicus*, is a benthic burrowing crustacean widely distributed on the continental shelf of Atlantic Ocean, Mediterranean and Black Sea. This species has great commercial importance within the Mediterranean basin, especially in Adriatic Sea. Pomo/Jabuka Pits represent the main fishing grounds. The microbiome of *N. norvegicus* and of the surrounding environment (sea water and sediment) were assessed through 16S rRNA gene high-throughput sequencing, taking into account different depth. The samples were collected through scientific trawling surveys conducted in the Pomo/Jabuka Pits area, in 2019 and 2023. Eighty samples were examined for the gut microbiome, 382 samples for stomach content to assess the diet. Alpha diversity (ASV, Amplicon Sequence Variants) of gut microbiome significantly varied according to depth and was distinct from the surrounding environmental microbiomes. Gut hosted specific microbiome, with 77% of the ASVs being exclusive. Despite not showing significant differences in terms of community composition, at greater depths , the gut microbiome was mainly characterised by Fusobacteriota, while, at shallower depth, it exhibited communities dominated by Synechococcales and characterised by Rhodobacteriales and Rhizobiales. Stomach content analyses showed that *N. norvegicus* primarily consumes crustaceans, fish, and cephalopods in terms of prey biomass (%W). Significantly different patterns were observed depending on depth. *Iridonida speciosa* notably dominates the diet at greater depths. At lower depths, a more diversified diet was observed, with a notable contribution from *I. speciosa* alongside significant levels of Osteichthyes, Cephalopoda, and Peracarida. The significant differences found in the diet may have influenced the gut microbial communities.

*Keywords: Nephrops norvegicus*, Adriatic Sea, microbiome, feeding ecology, gut bacteria, diet

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