Book of Abstracts

IV International young researchers Conference on Invasive Species

Vigo

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IV International young researchers Conference on Invasive Species

IyrCIS – 2024 Proceedings

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and organized by

the Institute of Botany of the Czech Academy of Sciences and

the Department of Plant Biology and Soil Sciences – Universidade de Vigo.

Edited by

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(EN) WELCOME

Welcome to the *International Young Researchers Conference on Invasive Species* **(IyrCIS – 2024)!** We are delighted to provide this unique and complimentary platform for young researchers to collaborate, innovate, and exchange knowledge in the field of invasive species.

Our world is grappling with significant challenges posed by invasive species, affecting ecosystems, biodiversity, and human societies. Your participation is crucial as we tackle these issues head-on, exploring fresh ideas, sharing groundbreaking research, and developing effective strategies for managing and mitigating invasive species.

This conference offers an exciting opportunity to explore a wide range of topics, from the ecological and economic impacts of invasive species to the latest advancements in monitoring, prevention, and control methods. We are honoured to have four presentations by young experts, but already proven researchers, who will share their valuable knowledge and experience.

We aim for this conference to inspire collaboration and drive impactful research. Together, let's embark on this exciting journey to delve into the intricate world of invasive species and chart a path towards a sustainable future.

To enhance your experience, we have curated a social program that complements the academic sessions. Join us for virtual excursions to the breathtaking locations of Galicia in Northwestern Spain and immerse yourself in the beauty of the Cathedral of Santiago (Santiago de Compostela – Galicia, Spain). Enjoy two concerts inspired by traditional Galician music, featuring the renowned musician Carlos Núñez and the talented band Tanxugueiras.

- Visit Galicia (link)
- Visit to the Cathedral of Santiago de Compostela (link)
- Concert by Carlos Núñez (link)
- Concert by Tanxugueiras (link)

We look forward to a conference filled with inspiration, collaboration, and impactful discoveries. Welcome to IyrCIS – 2024! Your participation and the dedicated efforts of the organizing and scientific committees have made this event a reality.

Luís González,

on behalf of the Scientific and Organizing committee.

(ES) BIENVENIDOS

¡Bienvenidos al *Congreso Internacional de Jóvenes Investigadores sobre Especies Invasoras* **(IyrCIS - 2024)!** Estamos encantados de ofrecer esta plataforma única y complementaria para que los jóvenes investigadores colaboren, innoven e intercambien conocimientos en el campo de las especies invasoras.

Nuestro mundo se enfrenta a importantes retos planteados por las especies invasoras, que afectan a los ecosistemas, la biodiversidad y las sociedades humanas. Tu participación es crucial para hacer frente a estos problemas, explorando nuevas ideas, compartiendo investigaciones pioneras y desarrollando estrategias eficaces para gestionar y mitigar las especies invasoras.

Esta conferencia ofrece una oportunidad apasionante de explorar una amplia gama de temas, desde las repercusiones ecológicas y económicas de las especies invasoras hasta los últimos avances en métodos de seguimiento, prevención y control. Tenemos el honor de contar con cuatro ponencias a cargo de expertos jóvenes, pero ya acreditados investigadores, que compartirán sus valiosos conocimientos y experiencia.

Pretendemos que este congreso inspire la colaboración e impulse una investigación de impacto. Emprendamos juntos este apasionante viaje para adentrarnos en el intrincado mundo de las especies invasoras y trazar el camino hacia un futuro sostenible.

Para mejorar tu experiencia, hemos elaborado un programa social que complementa las sesiones académicas. Acompáñanos en excursiones virtuales a los impresionantes parajes de Galicia, en el noroeste de España, y sumérgete en la belleza de la Catedral de Santiago (Santiago de Compostela - Galicia, España). Disfruta de dos conciertos inspirados en la música tradicional gallega, protagonizados por el renombrado músico Carlos Núñez y el talentoso grupo Tanxugueiras.

- Visit Galicia (link)
- Visit to the Cathedral of Santiago de Compostela (link)
- Concert by Carlos Núñez (link)
- Concert by Tanxugueiras (link)

Esperamos un congreso lleno de inspiración, colaboración y descubrimientos impactantes. ¡Bienvenidos a IyrCIS - 2024! Tu participación y el esfuerzo dedicado por los comités organizador y científico han hecho realidad este evento.

Luís González,

en nombre del Comité Científico y Organizador.

(GL) BENVIDOS

Benvido ao *Congreso Internacional de Novos Investigadores sobre Especies Invasoras* **(IyrCIS - 2024)!** Estamos encantados de ofrecer esta plataforma única e complementaria para que os mozos investigadores colaboren, innoven e intercambien coñecementos no campo das especies invasoras.

O noso mundo enfróntase a importantes desafíos que presentan as especies invasoras, que afectan aos ecosistemas, á biodiversidade e ás sociedades humanas. A túa participación é fundamental para abordar estes problemas explorando novas ideas, compartindo investigacións pioneiras e desenvolvendo estratexias eficaces para xestionar e mitigar as especies invasoras.

Esta conferencia ofrece unha oportunidade emocionante para explorar unha ampla gama de temas, desde os impactos ecolóxicos e económicos das especies invasoras ata os últimos avances en métodos de seguimento, prevención e control. Temos a honra de contar con catro ponencias de expertos novos, pero investigadores xa acreditados, que compartirán o seu valioso coñecemento e experiencia.

Pretendemos que esta conferencia inspire a colaboración e promova unha investigación de impacto. Embarquemos xuntos nesta emocionante viaxe para afondar no intrincado mundo das especies invasoras e trazar o camiño cara a un futuro sostible.

Para mellorar a túa experiencia, elaboramos un programa social que complementa as sesións académicas. Acompáñanos en excursións virtuais ás impresionantes paisaxes de Galicia, no noroeste de España, e mergúllate na beleza da Catedral de Santiago (Santiago de Compostela - Galicia, España). Goza de dous concertos inspirados na música tradicional galega, protagonizados polo recoñecido músico Carlos Núñez e o talentoso grupo Tanxugueiras.

- Visit Galicia (link)
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- Concert by Carlos Núñez (link)
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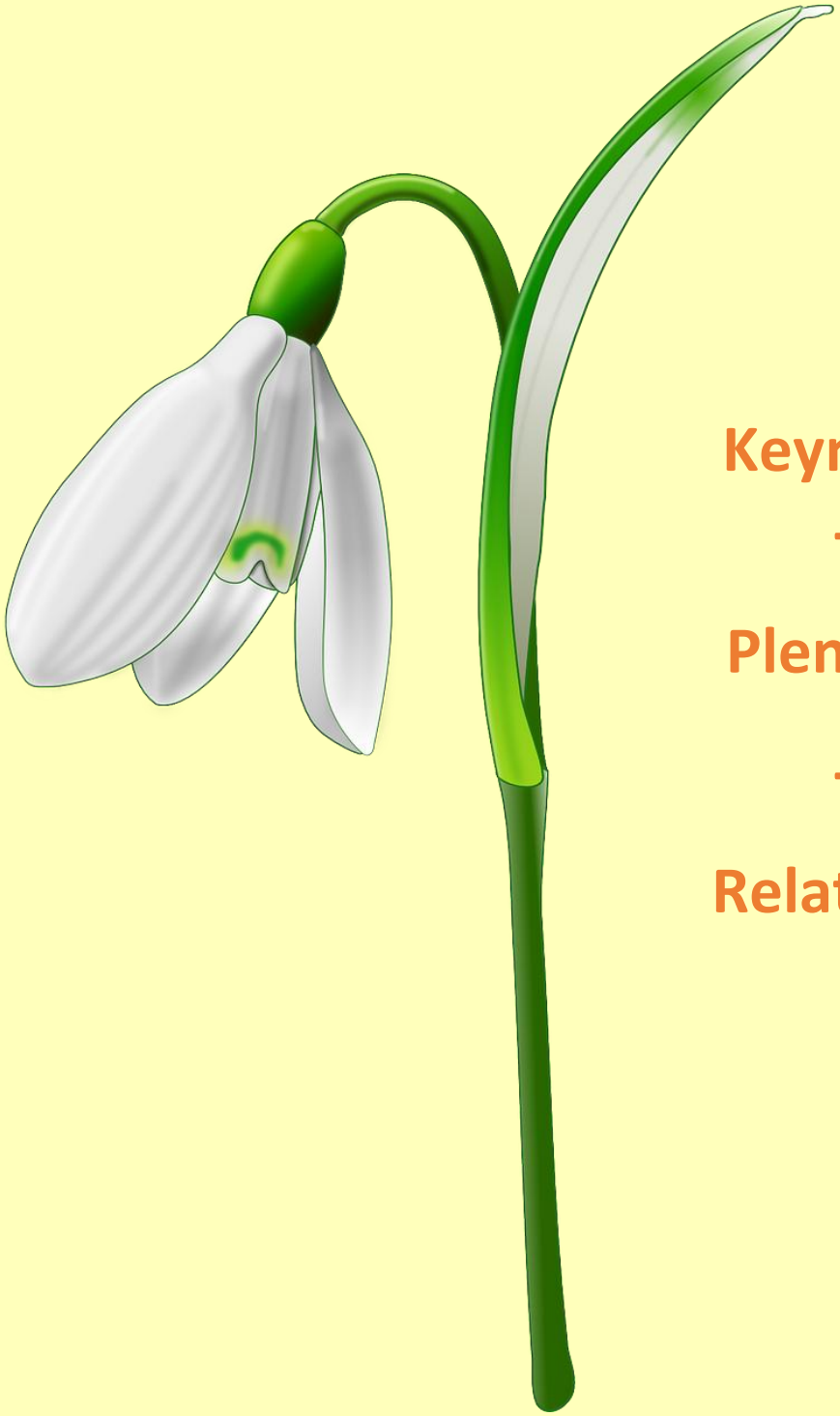
Agardamos unha conferencia chea de inspiración, colaboración e descubrimentos impactantes. Benvido ao IyrCIS - 2024! A vosa participación e o esforzo dedicado polo comité organizador e científico fixeron que este evento sexa unha realidade.

Luís González,

en nome do Comité Científico e Organizador.

Content – Contenido – Contido



Keynotes

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Plenarias

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Relatorios

How plant-soil interactions drive and respond to invasions – insights from Australian Acacias

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The negative impacts of invasive alien species on native biodiversity are widely reported. However, our understanding of these impacts comes largely from the aboveground components of invaded ecosystems. Recently, ecologists have begun to appreciate the impacts of invasive species on the unseen majority: microbial communities. Microbes are crucial in shaping native plant communities and, therefore, in influencing the success of introduced alien species. In this talk I delve into the relationships between invasive Australian Acacia species (wattles) and mutualistic nitrogen-fixing rhizobia and whole soil microbial communities to reveal important ecological dynamics of wattle invasiveness as well as ecological impacts on native plant species.

In regions like South Africa, various wattle species exhibit differing levels of invasiveness while sharing the same rhizobia. Phylogenetic studies reveal that these bacteria have been introduced alongside their host plants from Australia. So, what are the implications of these co-invasions for native biodiversity? Analysis of ecological networks indicates that wattles and native legumes form distinct rhizobium associations. Consequently, specialist native legumes, which form associations with only specific rhizobia, suffer more from wattle invasion compared to generalist native legumes. While some native legumes can selectively restrict exotic rhizobia, dense wattle thickets homogenise soil rhizobial communities, creating positive feedback loops that favor invasive wattle growth.

I will also discuss broader impacts on soil microbial communities under acacia invasion and how they lead to reduced diversity and complexity in these communities. Finally, I will illustrate that an understanding of the dynamics of plant-microbial interactions is crucial for effective ecological restoration.

Keywords: *Acacia*, invasive trees, mutualisms, restoration, rhizobia, soil microbial communities

Climate change and non-native species in protected areas

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Invasive species significantly affect biodiversity and ecosystem services, but understanding these impacts across broad spatial scales is challenging. Our research has shown that the level of invasion of Europe's protected areas depends on the time since the park's establishment, its accessibility and type of management. Only a quarter of Europe's marine and terrestrial areas protected over the last century have been colonized by the 100 worst invasive species, despite offering climatically suitable conditions for invasion. Invasive species were rare in long-established national parks and nature reserves, which are actively protected and often located in remote and pristine regions with very low human density. In contrast, the richness of invasive species is high in the more recently designated Natura 2000 sites, which are subject to high human accessibility. This situation may change in the future, since our models anticipate important shifts in species ranges toward the north and east of Europe.
In Spain, we identified over 200 NNS across the network of National Parks, including 68 listed in national NNS regulations. Distribution models suggest that rising minimum temperatures could enable NNS to expand in latitude and altitude within the parks, particularly in high-mountain areas. Species like the barbary sheep, water hyacinth and largemouth bass may particularly benefit from global warming.
This research underscores the importance of aligning management strategies with international biodiversity targets, it is thus essential to: i) coordinate conservation efforts across competent administrations (national and regional), ii) integrate resources and expertise in a unified strategy against invasion across the network and iii) enhance divulgation and public awareness. This comprehensive approach is vital for addressing the complex challenges posed by invasive species in the context of global change.

Keywords: ecosystem services, Natura2000, climate change, prioritization, risk management

AI and big data for invasion biology: find, model and forecast invader's secrets

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Invasion biology is experiencing a transformative shift, propelled by the integration of artificial intelligence (AI) and big data. The exponential growth of AI applications in ecology has led to significant advancements in understanding and managing invasive species. This talk will begin with an introduction to the fundamental principles of machine learning, deep learning, and generative AI, followed by recent case studies in invasion biology. By leveraging satellite imagery and machine learning algorithms, we can detect and monitor the spread of invasive species with unprecedented accuracy and efficiency. These advanced methods not only allow early detection but also facilitate real-time tracking of invasion dynamics across large and remote landscapes. Furthermore, the combination of remote sensing and AI extends beyond automated invader identification to monitoring stress responses, estimating population densities, and forecasting species growth under future climatic conditions. One of the focal points will be the application of AI and remote sensing in monitoring the demographic dynamics of invasive plants. I will highlight innovative, cost-effective technologies and open databases that promise to revolutionize our understanding and management of biological invasions. The talk will also offer practical advice on incorporating AI into ecological research, including tips for getting started and navigating common challenges. To conclude, I will address critical considerations when using AI in ecology, emphasizing the importance of diversity and representation in data and models. This will open a discussion on ethical implications and best practices, encouraging a holistic and responsible approach to AI applications in invasion biology.

Keywords: artificial intelligence, machine learning, plant demography, remote sensing, species distribution models

Monitoring biological invasions in the Mediterranean: citizen science, morphological, and molecular analyses

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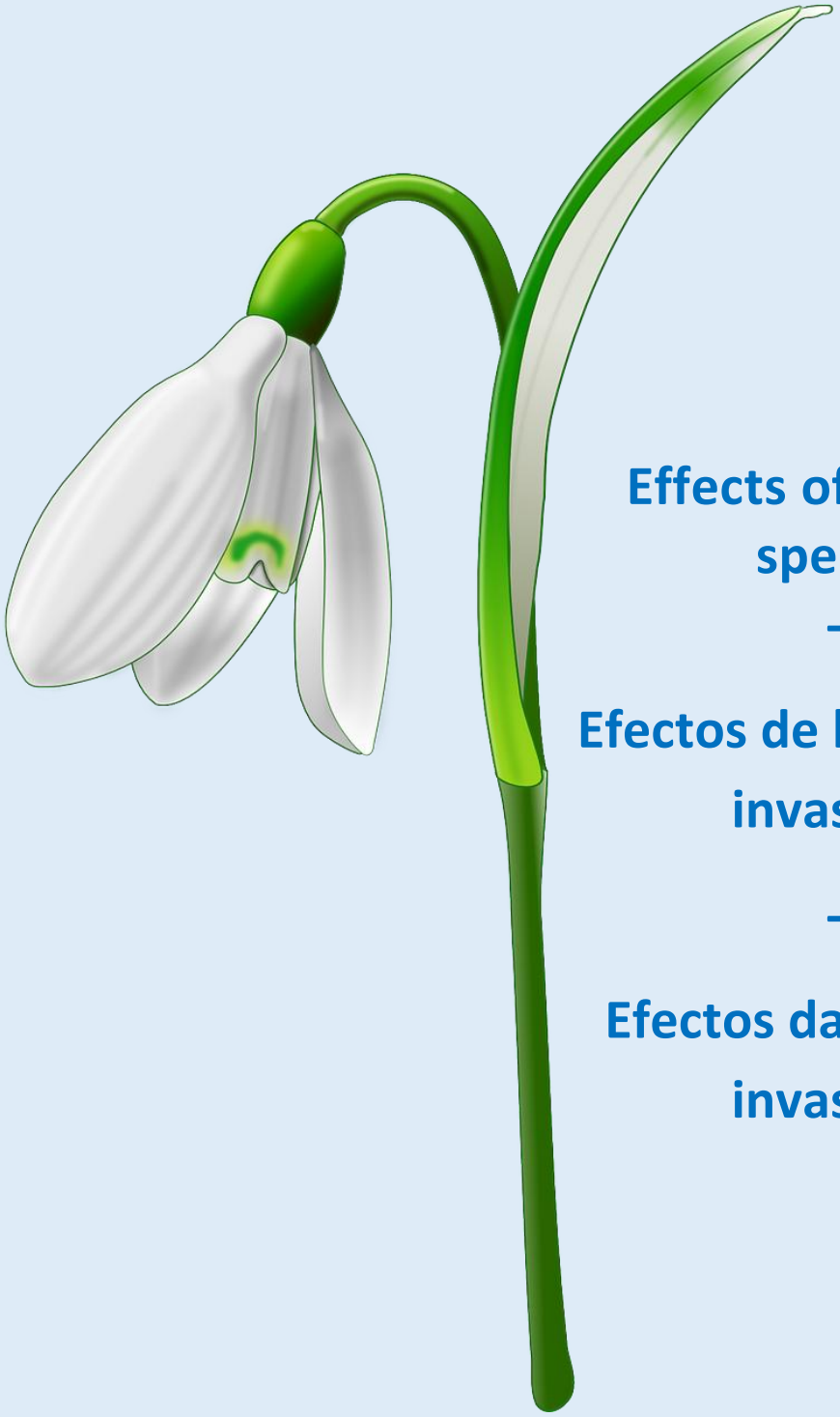
The Mediterranean Sea, a unique biodiversity hotspot, hosts several thousand marine species. However, climate warming and increasing human activities are expected to cause severe changes in the next years: a rapid increase of thermophilic and non-indigenous species will occur alongside a decrease of native ones. The Mediterranean's huge fish diversity, encompassing over 700 species, is particularly sensitive to these environmental fluctuations. Indeed, some species are undergoing a drastic decline, while others are rapidly expanding their range. The two main routes of introduction are the Suez Canal, an artificial waterway opened in 1869, and the Strait of Gibraltar, a natural connection with the Atlantic Ocean. Species entering from the Red Sea through the Suez Canal are considered 'alien' due to human intervention, while those arriving via the Strait of Gibraltar are part of a natural expansion and, therefore, native (or neonative). A sound approach to study and monitor these species is the combination of citizen science, morphological, and molecular analyses to gain a complete understanding of fish distribution and population dynamics. Within the AlienFish project, we evaluate the benefits (and limitations) of each method: (i) citizen science can provide huge amounts of data, otherwise inaccessible to researchers; (ii) morphological analyses can allow comparisons for species that are difficult to identify and for which DNA sequences are lacking; (iii) molecular data can elucidate the phylogeographic origin of the populations. One interesting example regards the presence of sea chubs (*Kyphosus* spp.) in the basin, which has long been debated due the high phenotypic similarity between *Kyphosus vaigiensis* and *Kyphosus sectatrix*. This combined approach sheds light on the presence of sea chubs in the Mediterranean and clarifies their population dynamics, providing insights into the potential impacts of their expansion. In conclusion, integrating these three methods gives the most robust results for studying invasive species.

Keywords: alien fishes, citizen science, Mediterranean, molecular analyses, monitoring invasions



Effects of invasive species

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Efectos de las especies invasoras

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Efectos das especies invasoras

Effect of exotic floral resources on urban butterflies in relation to trophic specialization

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Urbanization is an important driver of global biodiversity loss. Cities include a substantial number of exotic flowers in detriment of native ones. Exotic flowers abundance is known to negatively affect species with high trophic specialisation in wild areas. However, whether and how the abundance of exotic flowers affects animal species in urban ecosystems is still poorly known. We tested if the availability of exotic and native floral resources affected the presence and abundance of butterfly species in urban gardens, and how the strength of this effect related to the degree of each butterfly species trophic specialization (SSI). We gathered the availability of floral resources via field work, and the abundances of 28 butterfly species via a citizen science project in 13 gardens distributed across Barcelona city (Spain) during 2023 and 2024. First, we tested the effect of the abundance of exotic and native flowers on the presence and abundance for each butterfly species, in separated generalized linear mixed models. The obtained coefficients were then related to the butterfly's species SSI via linear mixed models. Exotic and native floral resources did not affect the presence or the abundance of butterflies in urban ecosystems in relation to the SSI. However, the SSI values of the studied species were generally low (mean SSI = 0.78, range 0.41-1.25) in contrast with the natural butterfly community from same bioclimatic region (mean SSI = 1.24, range 0.41-4.23). According to these results, exotic flora in urban gardens is a suitable resource for all urban butterflies regardless of their trophic preferences. Nevertheless, butterfly species with very high SSI values (range 1.25 4.23) were not observed in urban gardens. This lack of diversity regarding trophic preferences may indicate a negative effect of the urban ecosystem yet to be studied. Information in this area of knowledge is necessary in order to implement an urban green space management strategy that promotes biodiversity.

Keywords: urban greenspaces, exotic flora, urban butterflies, trophic specialization

Native biogeographic realms influence the global distribution and potential impact of invasive alien species in mountain regions

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Invasive alien species (IAS) are a significant threat to mountain regions' biodiversity and ecosystem integrity worldwide. This study uses native biogeographic realms (ecozones) as a framework to map and understand the global distribution and potential impact of IAS on terrestrial and aquatic ecosystems in mountain regions. We critically screened peer-reviewed studies to build a global dataset on the reported ecological impacts of IAS in mountain regions. Then, we calculated the cumulative impact of IAS on mountain ranges by native ecozone using a standardized methodology that incorporates GBIF occurrences in the invaded mountain ranges and land cover information. Using a Tweedie's compound Gamma-Poisson Generalized Linear Model (GLM), we tested whether resulting cumulative impact values in mountain regions are influenced by (a) the native ecozones of IAS and (b) the location of the invaded mountain ranges themselves, revealing a significant effect of both variables. Additionally, through cartographic exploration of resulting cumulative impact values by native ecozone, we found that IAS of Palearctic origin have invaded and potentially impacted more mountain regions worldwide. They are present in mountain ranges across North America, South America, South Africa, the Himalayas, Oceania, and also in non-native regions throughout Europe. This pattern could be attributed to historical trends of human-mediated introductions, transportation and trade, favourable climatic conditions, habitat disruption, and the unique ecological characteristics of these IAS, among other contributing factors. Our results highlight the complex ecological connections between the origin of IAS and the invaded mountain ranges they inhabit, suggesting that the native ecozone of IAS influences both their potential for spread and the extent of their impact on mountains worldwide. Further research is needed to elucidate these intricate aspects.

Keywords: Invasive alien species, mountain regions, native biogeographic realms, ecozones, cumulative impact

Invasion history and status of *Mytella strigata* (Hanley, 1843) in Indian Waters

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The invasive mussel *Mytella strigata* was initially documented in Indian waters in 2019, notably appearing in the Cochin backwaters of Kerala. This study aims to compile and analyze the invasion history and ecological impacts of *M. strigata* in Indian waters since its initial introduction thorough literature search and analysis of relevant studies. It particularly focuses on studies that document the species' effects on native ecosystems. *M. strigata* is native to the Pacific and Atlantic coasts of tropical America, ranging from the Gulf of California to Ecuador along the eastern Pacific coast. Its introduction to Indian waters is attributed to anthropogenic activities, particularly associated with ship traffic, potentially facilitating transport through ballast water or hull fouling. This species has demonstrated significant invasive prowess, establishing populations in various global regions, including the Indian River Lagoon in Florida, USA, first observed in 2004, and subsequently spreading to Florida, South Carolina, Georgia, Southeast Asia, the Philippines, Singapore, Thailand, and Hong Kong. Along the Indian coastline, it has notably proliferated along the southwest coast, including the estuarine and marine areas of Vembanad Lake, Kadinamkulam, Paravur, Edava-Nadayar, Ashtamudi Lake, Kayamkulam, Chettuva, and the Ponnani region of Kerala state. Additionally, it has spread to the Ennore Creek, Pulicat Lake, and the Gulf of Mannar region of Tamil Nadu state on the southeast coast of India. This proliferation results in dense aggregations on substrates such as rocks and wood within the intertidal zone. The invasive success of *M. strigata* can be attributed to its phenotypic plasticity, rapid reproductive rate, and thermal tolerance. Concerns have been raised regarding its ecological impacts, including competitive interactions with native commercially important species such as *Perna viridis*, alterations of planktonic communities, and potential disruptions to fisheries and marine ecosystems. Additionally, studies have noted that massive fouling in fish culture cages significantly affects water quality within the cages due to reduced water circulation. In light of these findings, it is suggested that continued research and effective management strategies be prioritized to mitigate the adverse ecological impacts of *Mytella strigata* on Indian marine ecosystems.

Keywords: invasive mussel, indian waters, anthropogenic activities, ecological impacts, southwest coast

Biological invasions in Morocco: which species and at what cost?

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Biological invasions pose significant economic threats globally, yet accurate cost estimates are particularly limited for African countries. In some regions, such as Morocco, there is no official information on the invasive alien species present. To address this gap, we present the first comprehensive analysis of the potential costs of biological invasions in Morocco. First, we conducted a global survey using scientific and grey literature, as well as consultations with national experts and stakeholders. This survey identified 551 invasive species in Morocco, accounting for approximately 1.76% of the country's plant and animal biodiversity. Second, utilizing the *InvaCost* database, we obtained cost data for the 12 most common invasive species with available cost information from other countries. By calculating the annual cost for each species and extrapolating based on their prevalence (number of occurrences) in Morocco, we estimate the annual economic impact of these invasive species to be $1.61 billion. This estimate likely underestimates the true economic burden, as it is based on only 2% (12 out of 551) of the invasive species present in Morocco. Despite the challenges of extrapolating cost data from other regions, the economic implications of invasive species damage underscore the urgent need for targeted management and policy interventions. Effective strategies, such as early detection, rapid response, and integrated control measures, are crucial to minimize the spread of invasive species and reduce their economic impact on agriculture, ecosystems, and human well-being.

Keywords: Invasive species, Economic impacts, Management strategies, Morocco, Biological invasions, InvaCost

The effect of the invasive Argentine ant venom in amphibian of its native and invaded range

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The Argentine ant, *Linepithema humile*, ranks among the foremost global invaders. Recently it has been described that its venom is lethal to juvenile amphibians in invaded areas, such as in Spain, a previously overlooked impact. Under the novel weapons hypothesis and the invader competitive ability hypothesis, we predict that the venom of the invasive ant will not impact the amphibian in the ant native range. Alternatively, the venom can affect amphibian in both ant ranges, but without population effects in the ant native range given differences in ant density.

Twenty juveniles of three amphibian species (*Rhinella arenarum*, *Odontophrynus asper*, and *Boana pulchella)* inhabiting the native range of *L. humile* were exposed to the toxins of *L. humile*, by applying increasing doses of a prepared ant mash into their backs for 10 minutes to detect the toxic dose (TD), while controls were exposed to water. We measured the immediate physiological effects on amphibians, mainly paralysis, and conducted short and medium-term follow-ups of their growth and survival. We evaluated clinically individuals at 1 hour and 24 hours post-treatment, and ten individuals of each species were selected for a 15-day follow-up.

The Argentine ant venom induced paralysis on all native amphibian species and caused varying survival rates depending on the species. While *O. asper* exhibited higher sensitivity to the venom (TD= 108.39 ants/g toadlet) compared to *B. pulchella* (TD= 171.30 ants/g toadlet) and *R. arenarum* (TD= 225.39 ants/g toadlet), the survival rate of *B. pulchella* was the lowest (20%), whereas it was higher in *R. arenarum* (60%) and *O. asper* (100%).

We compare this first report of the Argentine ant venom impacting amphibians within the ant native range with the results in the invaded range, and highlight the potential impact of *L. humile* venom in the invaded areas. Studying invasive species in their native range is paramount to understand their potential impacts and to comprehend how their invasion mechanisms could operate in invaded areas.

Keywords: chemical weapon, invasive species, *Linepithema humile,* predator-prey relationships, toxic dose, amphibian decline, iridomyrmecin

Comparing the effects of a native and a non-native species on soil nutrient pools in coastal and sand dunes in southern Chile

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Coastal sand dunes are very important habitats for specialist species. Besides the extreme environmental conditions in these ecosystems, native and non-native species with invasive behavior often establish in these poorly covered soils. In coastal sand dunes in southern Chile, the colonization of the native *Gunnera tinctoria* (GT) and the invasion of the non-native *Ulex europaeus* (UE), both N-fixing species, formed large and dense patches that accumulated substantial amounts of above and belowground biomass. Consequently, nutrient enrichment and changes in soil stocks were expected. This study compared the effects of the establishment of the two above mentioned species in the soil carbon (C), nitrogen (N) and phosphorus (P).

Results showed that C stocks increase under both colonizer and invasive species, and the main accumulation was observed at first 10 cm of the top layer of soil. Notwithstanding, GT accumulates significantly more C than UE (27.8 and 18.2 Mg ha-1 respectively), compared to 8.7 Mg ha-1 of the native dune plant communities.

Contrary to expectations, this study did not find a significant increase in soil N stock (0.7 Tn ha-1) due to UE invasion, but a significant reduction in available plant N (~17 mg kg-1) was found under these patches. Meanwhile, GT colonization showed a significant increase in N concentration (~25 mg kg-1) and soil stock (1.1 Mg ha-1) compared to UE invasion and resident dune plant communities (~19 mg kg-1 and 0.4 Mg ha-1, respectively). No significant differences in soil P stocks were found.

It is concluded that the invasive species studied are modifying the availability of nutrients in sand dunes, with potentially negative consequences for the conservation of specialist species pre-adapted to previous sand dune conditions.

Keywords: *Gunnera tinctoria, Ulex europaeus,* carbon stocks, nitrogen stocks, phosphorus stocks

Community and ecosystem impacts of woody plant invasion in the Shola-Grasslands of the Nilgiris

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The higher elevations of the Nilgiris Biosphere Reserve are home to the Shola-Grassland ecosystem - a mosaic of evergreen stunted forests (locally called sholas), dominated by C_3 woody species, in sheltered folds and valleys, embedded in a matrix of grasslands, dominated by C_4 grasses, in exposed sloped and hilltops. Here, from the 1830s to 1937, colonial forest officials planted more than 40 alien plant species, some of which still cover large tracts of the landscape (e.g., *Eucalyptus globulus*, *Pinus patula*), while some Nitrogen-fixing woody species are invasive in the grasslands (*Acacia mearnsii*, *Cytisus scoparius*, *Ulex europaeus*). The area occupied by these invasives and exotic plantations has doubled in the Nilgiris from 1973 to 2017, while the area occupied by grasslands has decreased by around 60% in the same time period. We studied the ecosystem and community impacts of these invasive and exotic plantations on the native grasslands. We used *in-situ* mineralization tubes to understand the impacts of invasion on soil Nitrogen cycling, and used data collected from the outlets of different catchments with different invasion intensities to understand impacts of invasion on nutrient and sediment outflow. Further, we also investigated the differences in vegetation composition of the understorey of invaded and planted areas as compared to the native grasslands.

We found that invasion by N-fixing woody plants is elevating soil nitrogen concentrations, and increasing the export of nitrates from the ecosystem. Additionally, this invasion not only decreases the grassland vegetation diversity, but also shifts this vegetation from being dominated by C_4 grasses to being dominated by C_3 grasses (many of which are invasive grasses themselves). These results have implications not only as to the importance of grassland restoration, but also towards conceptualizing how restoration could be done. This talk will attempt to highlight how invasive N-fixing plants and exotic plantations are threatening a tropical forest-grassland mosaic ecosystem, and how studies on the impacts of such invasions can help guide the management of these ecosystems.

Keywords: forest-grassland mosaics, nitrogen-fixation, woody encroachment, nutrient cycling, vegetation patterns

Assessing and predicting the impacts of two range-expanding predators, the whelks *Mexacanthina lugubris* and *Acanthinucella spirata*, along the North American Pacific Coast

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Global change is causing a widespread redistribution of species, which itself can have severe ecological consequences. As predators redistribute, they are expected to negatively impact prey populations in the novel, recipient communities. Invasion biology theory suggests that these impacts can be predicted by either the abundance of the novel predator in the recipient community or the impacts on prey in the predator's historic range. However, these expectations are largely untested in range-shifting species. We manipulated the abundances of two predators undergoing poleward redistributions, the whelks *Mexacanthina lugubris* and *Acanthinucella spirata*, in their respective historic and novel ranges and assessed (1) whether consumption of prey (acorn barnacles and mussels) was related to predator abundance and (2) whether impacts on prey in novel communities mirrored those in the historic communities. We found that impacts on prey varied by predator-prey combination, with *Acanthinucella* displaying clearer abundance-associated effects on barnacles than *Mexacanthina*, but that impacts generally scaled linearly with the abundance of predators. Additionally, for both species, we found that predation impacts in the historic range generally predicted the impacts in the expanded range, with some potential for increased impact in the expanded range. Our results therefore suggest that impacts on prey generally increase with predator abundance but may vary by prey species and that impacts in the predator's native range are useful indicators of impacts in novel communities.

Keywords: range-shift, expansion, quantify, predict, framework

Invasion process

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Proceso de invasión

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Proceso de invasión

The mother of millions: unvelling a new invasive complex in the mediterranean basin

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Invasive alien species pose a significant threat to global biodiversity, and ornamental plant trade is one of the primary causes of introducing alien plants. One such plant is *Kalanchoe* ×*houghtonii* (Crassulaceae), a purpoted artificial hybrid created from the crossing between *K. daigremontiana* and *K. tubiflora*. The two parental species are native to Madagascar, but together with the hybrid have become naturalised and a threat in several regions worldwide, particularly in Mediterranean climate areas.

Kalanchoe ×*houghtonii* has four morphotypes, two of which are of known synthetic origin, and the other two which may occur naturally and could be derived from spontaneous gene flow between sympatric populations of the parentals. Reproduction is primarily promoted by propagules produced by the plant. From the cytogenetic point of view, *K. tubiflora* is tetraploid (2n=4*x*=68), while *K. daigremontiana* is diploid (2n=2*x* =34). For the hybrids, there are at least two cytotypes, a triploid (2n=3*x*= 51) and a tetraploid (2n=4*x*= 68).

This study aims to elucidate the interplay between invasiveness, cytotype, and genetic diversity in *Kalanchoe* x*houghtonii*. We sampled individuals from several wild locations of the Mediterranean basin, and we complemented the sampling with herbarium and cultivar samples from different regions of the globe. We performed whole genome sequencing and analysed the plastid and nuclear genomes – including the repetitive DNA content and the diversity of ribosomal DNAs – to infer the genomic composition of the hybrid complex. To better understand the contribution of each parental species in the different hybrid cytotypes, we enhanced the study with fluorescent *in situ* hybridisation (FISH) using 18S and 5S ribosomal DNA probes. By combining genomics (including plastome assemblies, 35S and 5S ribosomal DNA networks, nuclear BUSCO gene phylogeny, and determining the genomic structure of the nuclear DNA of the different hybrid morphotypes) and cytogenetics, we aim to provide a holistic understanding of the evolutionary history and invasiveness of this new and aggressive hybrid complex in Mediterranean habitats.

Keywords: cytogenomics, BUSCO genes, FISH, invasiveness, Mediterranean basin, plastomes, ribosomal DNA

Deciphering the key to the success of invasive Asteraceae in mainland Spain

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Biological invasions are one of the main challenges facing biodiversity conservation, as they are one of the major causes of species extinctions. Spain is becoming one of the areas with the greatest rates of entry and expansion of invasive alien species (IAS), which is likely the result of the country's high rate of habitat destruction, its large diversity of climates and landscapes, and its key role as a global commercial/transportation hub and a leading touristic destination.

Darwin posed two hypotheses to explain the establishment success of alien species (AS) in a new range: the "pre-adaptation" hypothesis or "Darwin's naturalization" hypothesis. On the one hand, the pre-adaptation hypothesis argues that AS closely related to native species would be more likely to become established because they might share adaptations to local environmental conditions. On the other hand, the naturalization hypothesis maintains that phylogenetically more distantly related AS could succeed by establishing in empty ecological niches. Both hypotheses assume a correlation between phylogenetic distance and ecological distance.

This project aims to determine the ecological and evolutionary dynamics that led to the success of AS in peninsular Spain, thus being able to solve the "Darwin's naturalization conundrum" at a regional scale and the risk and impact of AS on native biodiversity on the composition, diversity, and structure of plant communities in Spain. Those objectives will be attained by studying the phylogenetic distance (Phylogenetic approaches: ML and LPP) and ecological distance by niche overlapping (Schoener's D index) between invasive species and the native community. The risk will be assessed by e.g., implementing EICAT and the effect of the presence of AS by analizing vegetation inventories. The focus will be on the subfamily Asteroideae, the one with the highest number of AS within the Asteraceae family, and the most diverse in Spain. The results of this study may ultimately lead to improved knowledge and management of IAS.

Keywords: alien species, climatic niche, ecological distance, naturalization hypothesis, phylogenetic distance, pre-adaptation hypothesis

Recent invasion of Ponto-Caspian amphipods in the Masurian Lakeland associated with human leisure activities

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Non-indigenous species (NIS) contribute to the decrease of native species' diversity on a local and global scale. One of Europe's most significant donors of freshwater invasions is the Ponto-Caspian Region. Following the construction of artificial canals connecting isolated waterbodies and the resulting heavy boat traffic, the Ponto-Caspian Amphipoda started to spread in Europe. Four amphipod species: *Dikerogammarus haemobaphes*, *Dikerogammarus villosus*, *Pontogammarus robustoides* and *Chaetogammarus ischnus* have invaded the Masurian Lakeland (North-eastern Poland). Based on the literature and our data, we studied their distribution in 22 lakes in the region during the years 2001–2016. We analysed their distribution against several water quality parameters and levels of anthropogenic pressure. Our results also present the first records of two new invaders, *D. villosus* and *C. ischnus*, in the studied area. We show that the relative abundance and frequency of these two species rapidly increase and, simultaneously, the populations of the earlier invaders, i.e., *D. haemobaphes* and *P. robustoides*, decrease. The native species – *Gammarus lacustris* – seems to be negatively affected by NIS richness, as well as by the proximity of towns. The spread of NIS in the lakes appears to be facilitated by boating and the lower complexity of the shoreline. Our study shows how anthropogenic pressure, especially tourism, can facilitate bioinvasion, jeopardising native biodiversity unless appropriate regulations are implemented.

Keywords: assemblage succession, biological invasions, lakes, propagule pressure, recreational boating, time series, tourist pressure

Overlooked expansion? The case of two millipedes in Poland

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The expansion of myriapod species outside their native range in Europe is a well-known phenomenon, although well-studied only in the western part of the continent. Our study reports the fast recent eastward range extension of *Polydesmus angustus*, from Germany to Poland, where its new eastern limit of distribution species is probably the Vistula River course. Records come from seven localities in different parts of Poland. Additionally, we analyzed records of *P. angustus* from Poland on the iNaturalist platform. Ten of the collected specimens were used for molecular analysis. We confirm the species occupies disturbed, anthropogenic habitats, confirming its human-mediated dispersal scenario. Furthermore, we discuss the potential competition with its closest native relative, *Polydesmus complanatus*. We also point out that in the case of taxonomic groups containing externally similar species, the verification of citizen science-based records by specialists examining morphological details of specimens and, if possible, by DNA barcodes, is necessary for reliable insight into the range extension of alien species. We also show, using the example of *Ophiodesmus albonanus*, that in the face of climate change, even thermophilic species previously recorded only in greenhouses can colonise outdoor habitats.

Keywords: diplopoda, range extension, anthropogenic habitats, DNA barcoding, citizen science

Why and when? Introduction pathways and time of first record of alien species in Argentina

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Biological invasions are considered a crucial component of global change. Alien species invasion success depends on environmental conditions, specific functional traits and the time elapsed since the arrival of the first diaspores. In Argentina, the families with the highest proportion of alien species already or potentially invasive are Asteraceae (24%) and Fabaceae (23%). Our objective is to describe the relationship between different categories of alien species from these two predominant families and their native range, introduction pathways and time of first record in Argentina. We hypothesize that already problematic species arrive before the potentially problematic species because of the time lag between the invasion phases. Also, we conjecture that the introduction pathway is associated with the native range because of the commercial links between countries. We categorized 198 Asteraceae and Fabaceae species introduced in Argentina as 'currently problematic', 'potentially problematic' and 'non-problematic'. Through bibliographic search for each species, those with publications highlighting negative impacts in Argentina were classified as 'currently problematic', while those with negative impacts elsewhere but not yet in Argentina were deemed 'potentially problematic'. Data concerning native range, introduction pathways and time of first record was obtained from a bibliographic review and regional floras and herbaria. Although most of the problematic species has been first recorded before 1950, we found no difference with potentially problematic species as we hypothesized, suggesting other traits or the native communities drive invasiveness. While European species represent most of the problematic species, there has been a notable rise in the proportion of agricultural Asian species over the last century. We incorporated the date of first registration into the analysis, as a proxy of date of introduction, which is a key aspect of the invasion dynamics, but very rarely studied.

Keywords: Asteraceae, Fabaceae, exotic, invasion

Travelling riverside blues: long-distance migration of the invasive Atlantic blue crab

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The Atlantic blue crab (*Callinectes sapidus* Rathbun, 1896) has invaded coasts and estuaries across Europe and Northern Africa, causing severe ecological and socioeconomic impacts. The life cycle of the blue crab often involves migratory movements between marine waters, estuaries and upstream freshwater environments. While upstream migration of the blue crab is well known in its native range, it has been very sparsely analysed in invaded areas.

We report long-distance migration events in the Iberian Peninsula and use a global database to assess the probability of blue crab occurrence in relation to distance from the sea. We exemplify the potential impacts of the blue crab on fresh waters by overlapping its probability of occurrence with that of the critically endangered European eel (*Anguilla anguilla* Linnaeus, 1758). Finally, we evaluate the blocking effect of dam barriers on the upstream spread of the invasion.

Invasive blue crab populations have been detected at 108 km from the sea in the Guadalquivir River (the farthest distance reported outside its native range), 71 km in the Guadiana River, and 53 km in the Ebro River. Although the probability of blue crab occurrence decreases steeply in the first few upstream kilometres, it remains concerning within a dozen kilometres from the river mouth. The invasive potential of the blue crab significantly overlaps (63%) with the Iberian range of the European eel. The effect of dams on the potential invasion of freshwater systems was limited (13%).

The migratory behaviour of the blue crab poses a new threat to freshwater species, particularly those inhabiting coastal streams and migratory species artificially restricted to coastal areas by the blocking effects of barriers. Our findings highlight the need to expand our understanding of the impacts of this invasion on inland waters.

Keywords: Dams, European eel, freshwaters, migratory corridors, reproductive migration

Native and invasive seaweeds of ports and nearby coast of the northern of Spain

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Seaweeds play an important role in maintaining the optimal environmental conditions of ecosystems as marine major primary producers. They can be classified as red, green, and brown algae based on their structure and phylogenetic relationships, but also based on their origin as native species if they are naturally found in an environment, alien species when they been introduced by accident or intentionally into areas outside their native range or cryptogenic species if they have uncertain origins. Ports are the main entry point for marine invasive species, as these are dispersed via ballast water and biofouling and then, they can spread along the coastline. Thus, we aim to taxonomically identify seaweeds species found in ports and nearby coasts of Asturias (Biscay Bay, northern Spain) to determine whether there exist similarity in the native, cryptogenic or invasive species composition of their communities. Four different ports each of them with different traffic ratios (East of Cabo Peñas: Gijón and Lastres; West: Avilés and Cudillero) and four coastal locations were sampled during six months. A total of 431 samples were collected and morphologically identified, 115 corresponding to ports and 316 to their nearby beaches. Two invasive species were found in two ports (*Asparagopsis armata* and *Sargassum muticum*) while an additional one was found in the coastal area (*Chondria coerulescens*), despite of the fact that ports are the main entrance of invasive seaweeds. However, it should be highlighted that higher seaweed richness was found in ports with the most maritime influence such as Gijón. Misidentification rate of invasive species as native or cryptogenic will be calculated by molecular methods. Therefore, molecular analysis should also be included to verify species and invasive species management.

Keywords: seaweeds, invasive species, Biscay Bay, ports

Database on the global human-mediated introduction of vector mosquitoes

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Mosquitoes (Culicidae) have a significant impact on global public health. With over 3,726 identified species, many of them transmit vector-borne diseases (VBD) like malaria, dengue fever, yellow fever, chikungunya, and zika, resulting in at least 700,000 annual deaths. Introducing mosquito species, facilitated by global trade, human activities, climate change and urbanisation, allows their rapid spread into new areas and can affect native species, ecosystems and human activities. Recognising when a species becomes invasive is crucial, as any species introduced to a new area can potentially become invasive. Invasive mosquito vectors contribute to transmitting and spreading VBDs by transmitting new pathogens or altering existing transmission cycles. Therefore, monitoring the occurrence, spread, and early detection of invasive species is essential for effective disease control. While some species are well-documented, there may be unrecognised species that have the potential to cause severe disease outbreaks. Existing biodiversity databases have limitations, including data gaps, validation issues, and the absence of additional information, such as introduction pathways and origins. Through an extensive search of scientific articles, we comprehensively analysed the global distribution patterns of non-native mosquito species that serve as vectors for human diseases, compiling their first records in new regions along with information on their origins and introduction pathways. Our results show that of the 186 mosquito species that transmit diseases to humans in the wild *Aedes aegypti* (Linnaeus, 1762), *A. albopictus* (Skuse 1895) and *Culex quinquefasciatus* (Say, 1823) are the most commonly introduced species, but a total of 45 species from 19 subgenera have been introduced to regions outside their native range. Nearly half of the first records in new regions occurred after 1950. By analysing the temporal and geographic distribution patterns of these introduced species, our study provides valuable insights into the potential spread of disease and supports ongoing disease prevention and control efforts.

Keywords: vector mosquitoes, invasive alien species, vector-borne diseases, dispersal pathways, vector surveillance

Management

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Manejo

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Manexo

Field surveys and phylogenetics narrow the search for a suitable biological control agent for Guinea grass (*Megathyrsus maximus*)

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South Africa is a net donor of invasive species – especially grasses – to the rest of the world. One such species is Guinea grass (*Megathyrsus maximus*), a tall-statured C4 grass whose native range spans most of sub-Saharan Africa. Intentionally exported for centuries for its grazing value, it has become a near-global invasive. Texas, USA is the first territory to initiate a biological control program for Guinea grass, targeting an invasive population of the grass whose genetic origins have been traced to South Africa. Surveys done in South Africa by researchers at the Centre for Biological Control have identified several species of cecid midges (Diptera: Cecidomyiidae) as candidate biological control agents for Guinea grass. Multiple stem-galling taxa (gall midges) and seed-feeding taxa (seed midges) exist, all currently undescribed or in the process of being described. The adults are delicate and short-lived, while the larvae and pupae are heavily parasitized by a wide range of wasp taxa. These and other aspects of their biology have made it challenging to develop cultures for laboratory host-specificity testing of Texan grass species in quarantine. The situation is particularly complicated for the seed midges, which require a host plant with developing seedheads, and are morphologically similar to seed midges reared from several grasses related to Guinea grass. Findings from field host range surveys and phylogenetic analyses are used as alternative, dual lines of evidence for the existence of distinct host-specific species that have the potential to control Guinea grass in Texas.

Keywords: biocontrol, grassland, invasive alien plants, invasive species, Poaceae, phylogeny

Invasion of *Hieracium pilosella* in the Fuegian Steppe: risk assessment and detection of invadable areas using satellite imagery

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Hieracium pilosella L. is an invasive plant in grasslands worldwide, including Argentina, where it is currently found in the Fuegian Steppe. This invasion poses a threat to the pastoral systems of the region, as it can alter the diversity of native vegetation and decrease the biomass of forage value in grasslands. Although widely distributed in the region, its coverage in natural communities is still low, indicating early stages of invasion. Faced with the potential impacts of the invasion, this study addresses two methodologies useful for the management of the invader. First, we applied the Australian Weed Risk Assessment (AWRA) protocol to determine the invasive potential of *Hieracium pilosella* in the Fuegian Steppe and identify the factors contributing to this potential. The results indicated a high invasive potential, supported by 96% of responses, with an equal proportion of impacts in both agricultural and natural environments, where dispersal capacity was the attribute with the greatest contribution to invasive potential. On the other hand, we evaluated the detection of potentially invasible areas using remote sensing and GIS techniques, focusing on disturbed areas, which are most susceptible to invasion according to previous studies. For this, we employed a disturbance detection methodology in grasslands based on the Disturbance Index, using Landsat images on the Google Earth Engine platform. The methodology demonstrated great potential for detecting sites with predominance of bare soil associated with oilfield locations and areas with intensive livestock use. Given the high invasive potential of the species in the region, urgent measures are recommended to stop its expansion and eradicate new populations. In this regard, this study provides a methodology with potential to detect sites identified as disturbed, to guide eradication measures of new populations in these highly vulnerable sites to invasion, which may serve as a propagule bank and promote its expansion.

Keywords: AWRA protocol, disturbances, grasslands, invasive detection, remote sensing

Microhabitat selection, population structure and trapping efficacy of the invasive atlantic blue crab *Callinectes sapidus* in a hypersaline mediterranean coastal lagoon

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This analysis investigated the population structure and habitat selection of the Atlantic blue crab (*Callinectes sapidus*) in the hypersaline coastal lagoon of the Mar Menor (SE Spain), as well as the effectiveness of different capture methods. Data collection was carried out for two years, from November 2021 to September 2023, in an intertidal and transitional zone known as *Las Encañizadas*, located between the Mar Menor lagoon and the Mediterranean Sea. Different types of traps were tested, including fyke nets, collapsible cylindrical traps, flat bee-hive traps and minnow traps. These were installed in different habitats: *Cymodocea nodosa* meadows, *Caulerpa prolifera* meadows and bare substrate, and physico-chemical habitat variables were measured. Catch success was assessed as catch per unit effort (CPUEs) by sex and size. Most catches were of adult and sub-adult crabs, peaking in summer, with the largest crabs found in November. A significant correlation was found between crab size, habitat and trap efficiency.

Sex ratios varied between sectors, influencing settlement areas and spawning corridors. Physico-chemical and biological habitat factors affected crab abundance by size, with mud positively affecting juveniles and adults, while depth had a negative impact on juveniles and subadults. Biological parameters influenced sub-adult and adult abundance, with a preference for bare substrates and *Cymodocea nodosa* meadows. Fyke nets proved to be the most effective, followed by simple traps. The analysis indicated that trap type significantly affected catchability based on crab size and sex, with subadults and males preferring fyke nets. The effect of sex was particularly pronounced in female fyke nets catches. The findings provide an integrated view of the biology of the species and optimal harvesting methodologies, allowing the design of time and location prioritised management strategies to ensure efficiency and cost-effectiveness.

Keywords: *Callinectes sapidus*, capturability, habitat, population, intertidal.

Effectiveness of the control method for the invasive *Arctotheca calendula* on the coast of A Mariña, Lugo

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Invasive exotic plants are one of the main threats to biodiversity conservation worldwide. In recent years, the coastal ecosystems of the northwest of the province of Lugo have been highly affected by the invasion of the capeweed, *Arctotheca calendula* (L.) Levyns, especially on coastal dunes, marshes and cliffs. This is a species from the Región del Cabo (Sudáfrica) whose expansion is closely linked to human activities, so the large influx of tourism in the recent years may be closely related to its spreading.

This research project assesses the negative impact that the capeweed has in the area, as well as the evolution it has had over the last nine years of management of this species. The space occupied by *A. calendula* in 2015, when eradication measures were started by the competent administration, is compared to the space currently occupied in 2024 in order to assess the effectiveness of the measures taken. These consisted of a manual and mechanical eradication during the flowering season of all the individuals present in the surroundings of As Catedrais beach.

The results achieved in the eradication plan carried out since 2015 were not what had been expected, as since then the species has tripled its populations. Our results allowed to highlight the great importance that vehicles have in spreading this invasive species, as well as the need to carry out an adequate management proposal. In order to achieve a successful management plan, this must include a series of complementary actions to the eradication measures to prevent the spreading of the *Arctotheca calendula* in the As Catedrais beach Natural Monument, so that the work carried out is more effective.

Keywords: *Arctotheca calendula*, invasive plants, capeweed, Galician northern coast, eradication, coastal vegetation

Elucidating the role of an *Austropuccinia psidii* effector protein during myrtle rust infection

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Myrtle rust is caused by the invasive fungus, *Austropuccinia psidii*, originally found in Brazil, and is incredibly infectious and physically devastating to Myrtaceae plants. The disease was first detected in New Zealand in 2017 and continues to spread rapidly across the country. The presence of the disease in Australia has already caused major declines in Myrtaceae populations (e.g., eucalyptus in Queensland) and now threatens Aotearoa-New Zealand natives, including taonga species such as pōhutukawa (*Metrosideros excelsa*), mānuka (*Leptospermum scoparium*) and rātā (*Metrosideros umbellata*). Localised extinctions of myrtle plants have already begun to occur in Aotearoa. Transcript experiments have identified several proteins expressed during the first 24-48 hours of infection by *A. psidii* on mānuka. This expression pattern is a signature of their important role in the successful infection of plant cells. In other plant pathogens these 'effector proteins' are known to manipulate the host plant's cellular processes to boost pathogen fitness. Here, we aim to elucidate the role of the *A. psidii* effector protein, AP1260, during infection through bioinformatic and biophysical analysis. Sequence homology and predictions of AP1260's structure and cellular localisation were made and used to compare to later biophysical analysis. Biophysical studies sought to determine its physical characteristics in solution. These included analytical ultracentrifugation, fluorescence spectroscopy, circular dichroism, small-angle X-ray scattering, and nuclear magnetic resonance. Functional analysis of AP1260 used agrobacterium-mediated transformation of *Nicotiana benthamiana* and yeast-two-hybrid to determine its localisation and in planta interaction partners. The results obtained in this study represent the first studies of an *A. psidii* effector protein. Characterisation of AP1260 improves the knowledge of the mechanisms of *A. psidii* infection and may uncover methods to interfere with its function, making its characterisation critical to the biosecurity of nations with Myrtaceae populations. The outcomes of this research may lead to the development of a novel and effective method to treat and control myrtle rust.

Keywords: myrtle rust, *Austropuccinia psidii*, structure and function, protein

Recovering native ant communities by removing suitable conditions for the invasive Argentine ant

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Invasive alien species are key drivers of biodiversity loss, causing ecological disruptions and massive economic impacts due to both their direct damage and subsequent management costs. Management often lags behind invasion due to delayed impact perception. Ants, particularly the Argentine ant, *Linepithema humile*, are widespread invaders impacting ecosystems and economic sectors. Its population grew for decades in Doñana Biological Reserve (Spain), spreading from the research buildings that offer protection against high temperatures, to natural habitats with similar conditions. We assessed management actions to control its spread, using long-term monitoring and habitat modification. By replacing concrete with wood in fences, we aimed to reduce the favorable conditions for the invasive ant and promote the recovery of the native ant community. Our study evaluates these interventions' effectiveness and their impact on the invasion process by using pitfall traps and baits at different distances of the buildings. The management actions significantly affected the ant community structure from the restored habitat, and no changes happened in the control site. The distance from human constructions also influenced ant communities. The Argentine ant's success at baits was significantly influenced by temperature and worker number, with higher success when temperatures decreased and worker numbers were high. Conversely, the endemic ant *Cataglyphis* spp., which are one of the most thermophilic ones, succeeded more often at higher temperatures. Post-management, *Cataglyphis* spp. abundance increased in the restored habitat, particularly away from human constructions, while remained low in the control site. The local management of replacing a fence controlled the invasion, but did not eradicate the Argentine ant from the restored habitat. Together with post-invasion management, higher temperatures could decrease Argentine ant abundance; however, in the absence of a formal eradication plan from the authorities, the Argentine ant will remain in local spots spread along the Doñana Biological Reserve.

Keywords: habitat restoration, anthropization, *Linepithema humile*, protected area, native faune

Chemical treatments on invasive bivalve, *Corbicula fluminea*

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The Asian clam *Corbicula fluminea* is a native aquatic species in Eastern Asia and Africa but has become one of the most ecologically and economically harmful invasive species in aquatic ecosystems in Europe, North America, South America. Due to their natural characteristics as a hermaphroditic species with high fecundity and dispersal capacity, Asian clams are extremely difficult to eradicate once they have infiltrated a waterbody. This is an emerging issue for states in the Northeastern United States as Asian clams expand their range farther North due to climate change. There has been extensive research conducted to develop chemical treatments to reactively control invasive mollusc populations and proactively prevent their further spread. However, treatments are mostly targeted toward biofouling bivalves in industrial settings. A comprehensive review of Asian clam chemical treatments used in open water systems was performed to evaluate molluscicides and identify toxicity ranges of emerging treatments that maximize Asian clam mortality and minimize negative impact to water quality and non-target species. The potential chemical applications in Asian clam control and management are summarized in this report to assist resource managers and practitioners on invasive Asian clam management.

Keywords: Asian clam, chemical treatment, invasive species, *Corbicula fluminea*, bivalve mollusc, Molluscicide, management, toxicity

Biological control of invasive plants species: exploring the potential of pathogenic microorganisms

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Invasive plant species exert profound and wide-ranging effects on ecosystem functioning and associated biota. Their impacts span various landscapes, from encroaching upon residential areas or competing with agricultural crops to altering ecosystem processes including promoting fire, depleting soil nutrients and degrading critical habitat for endangered species. Biological control offers an effective means for reducing the impacts of invasive plants with lower risk of negative impacts. Invasive grasses, while often considered as unsuitable for biocontrol, are increasingly seen as appropriate targets for biocontrol development. Although plant pathogens have received less attention than the use of specialist arthropods to reduce weed populations, agents such as fungi and bacteria can offer advantages under certain circumstances. In work conducted in Brazil, six isolates of *Streptomyces* spp. obtained from diseased potato plants were evaluated as potential biological control agents against *Eleusine indica* (L.) Gaertn. Both in vitro and in vivo experiments were conducted to assess their efficacy. Eight treatments were administered, comprising six distinct *Streptomyces* isolates, autoclaved distilled water, and the herbicide glyphosate. The in vitro assays were conducted in Petri dishes containing 30 seeds each, covered with two layers of germination paper moistened with 5 ml of the respective treatment. The results revealed that all isolates inhibited seed germination to a similar extent as the herbicide, being statistically equal. Subsequent greenhouse trials involved the application of the same treatments to E. indica seedlings. The findings demonstrated that the various *Streptomyces* isolates influenced seedling growth parameters, including height, fresh biomass, chlorophyll content, and dry mass. We are now investigating both *Streptomyces* isolates and plant pathogens isolated from *Ipomoea* sp. for their own control. We are currently exploring potential pathogens of *Arundo donax* L. in North America that could potentially be applied for a biocontrol of this widely introduced and hard to control perennial grass.

Keywords: biological control, environmental impacts, invasive species, pathogens

A review of biological control for the invasive tree-of-heaven, *Ailanthus altissima*

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Native to the forests of eastern Asia, *Ailanthus altissima* (tree-of-heaven) was introduced to Europe and the United States in the late 18th century as an ornamental tree, highly desired for its striking foliage and tolerance for human habitats. *Ailanthus altissima* is now found on every continent except Antarctica. The tree is considered invasive throughout its secondary ranges and is associated with reduced native biodiversity. Due to its abundant seed production, vegetative reproduction, and potent allelopathy, *A. altissima* invasions often lead to monocultures in highly disturbed areas, urban centers, and roadsides. Compounding the issue, *Ailanthus altissima* is also the preferred host of *Lycorma delicatula* (spotted lanternfly). Also native to eastern Asia, *L. delicatula* is a threat to vineyard and nursery industries in Korea, Japan, and the United States. Controlling populations of *A. altissima* is expected to slow the spread of *L. delicatula*. Biological controls for *A. altissima* are desired as conventional controls are often ineffective due to the tree's ability to resprout from stumps and lateral roots. In 2002, researchers in Pennsylvania, USA found *A. altissima* dying from a vascular wilt attributed to the cosmopolitan fungus *Verticillium nonalfalfae*. Two decades of research have demonstrated high rates of virulence and host specificity of certain strains of *V. nonalfalfae* for *A. altissima*. Work is ongoing to develop *V. nonalfalfae* as a commercial bioherbicide in the United States. This work is a review of Verticillium wilt in *Ailanthus altissima* and its potential as a biological control.

Keywords: biocontrol, pathogen, *Ailanthus altissima*, *Lycorma delicatula*, *Verticillium*

The history of an invasion: the mimosa in Froxán

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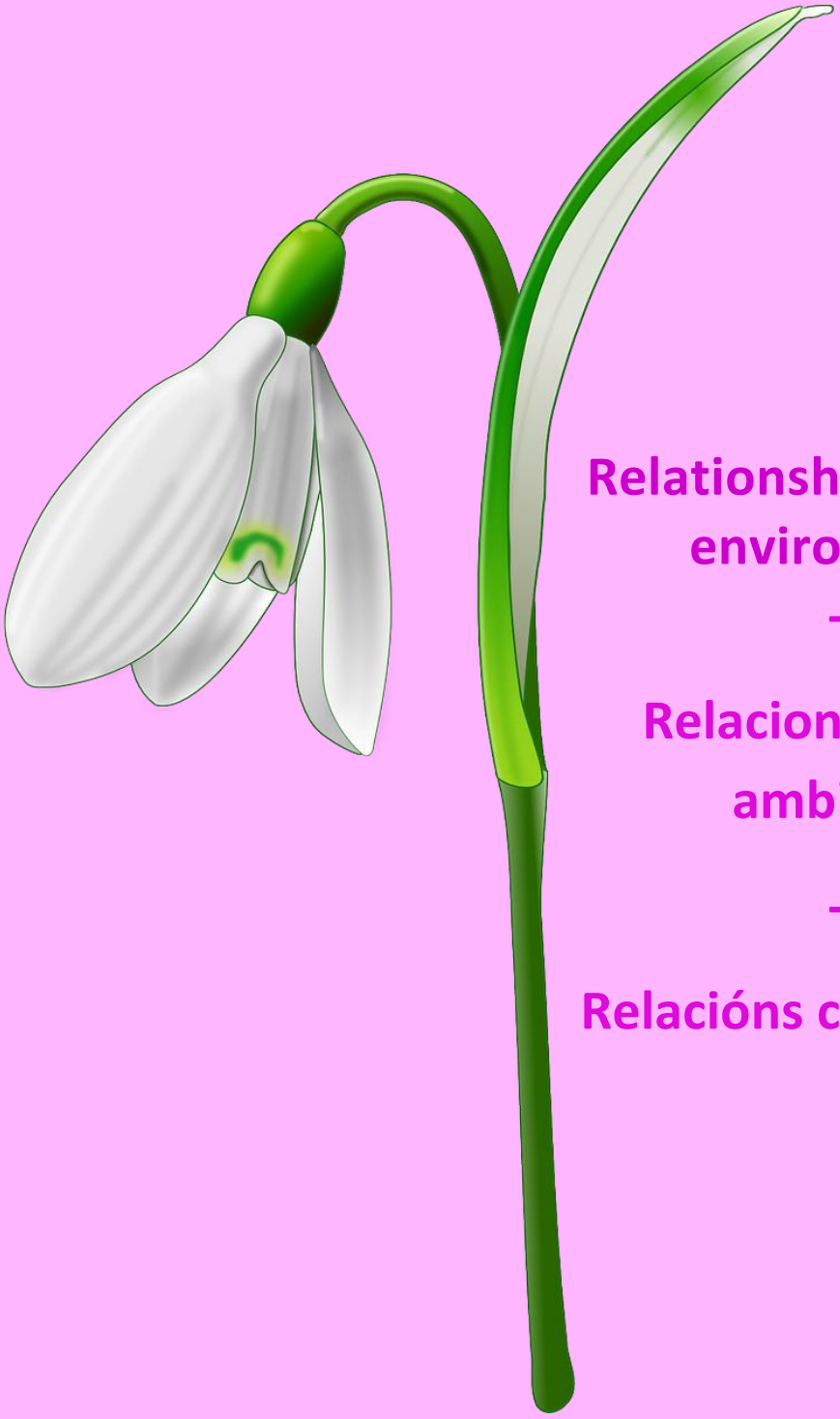
The Australian invasive species *Acacia dealbata* demonstrates to be highly invasive within Galician ecosystems. Initially introduced in Portugal during the 19th century, its rapid proliferation is intricately related with various anthropogenic factors. This study delves into the impact and management of *A. dealbata* in Galician ecosystems, with a specific focus on the "Comunidade de Montes de Froxán" serving as a case of study.

Primarily, we have discerned several characteristics which contribute to *A. dealbata's* invasive success enabling its adept colonization of diverse habitats across Galicia. Its impact on ecosystems is substantial, manifesting consequences such as diminished biodiversity, disruption or alteration of nutrient cycles and heightened susceptibility to forest fires.

Within the confines of the "Comunidade de Montes de Froxán", control strategies have been implemented to ameliorate the effects of the invasion and control the species proliferation. These measures involve the eradication of invasive populations and promote the natural regeneration of native species. The successful outcomes highlight the significance of addressing the issue of biological invasions through a synergistic combination of scientific research, active management, community involvement and perseverance in the proposed measures. Collaboration remains essential to develop effective control and restoration strategies in the affected ecosystems.

Keywords: *Acacia dealbata*, biological invasions, control, management, environmental impact



Relationship with the environment

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Relaciones con el ambiente

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Relacións co ambiente

Niche shifts in non-native plants are more closely related to native niche breadth than to plant traits and human-driven introduction history

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Despite that climate matching has been the gold standard in predicting the areas of invasion of non-native species, one central question, with implications for effective management, is which factors modulate niche shifts. Because plants introduced through the same introduction pathway (gardening, agriculture, forestry, unintentional) tend to share some features of the introduction process and biological attributes, niche shifts might be influenced by how and when species of particular attributes have been introduced. However, we lack an integrative test of how niche shifts are modulated by introduction pathways, minimum residence time, growth form, and niche breadth in the native range. In this work, we compared the climatic niches between the native (global) and invaded ranges (mainland Spain), through ordination and kernel smoothers. We calculated niche shift components (overlap, abandonment, unfilling, stability, expansion, pioneering), for a set of 164 plant species. Niche shift components were then related to a plant's introduction pathway, minimum residence time, growth form, and native climatic niche breadth and minimum residence time. Niche stability accounted for more than half of niche occupancy in 90% of species, while around 60% of species showed some degree of niche shift. The climatic niche shifted the least for annual and perennial herbs, plants introduced a long time ago, and those with great native climatic niche breadth. Introduction pathways had a non-significant effect. Niche shifts were not explained by interactions of minimum residence time with introduction pathways nor with growth form. Native climatic niche breadth was the most important correlate of niche shift components. Our results indicate that niche shifts of non-native plants in the invaded range are more dependent on their ability to cope with broad climatic conditions rather than on growth form and to introduction history.

Keywords: growth form, introduction pathway, minimum residence time, niche conservatism, niche shift

Diversity and distribution patterns of invasive alien plants in mainland Portugal

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Mainland Portugal has over 700 alien plant species, of which nearly 100 are considered invasive. While previous works have mapped and analyzed the distribution of some of these species, the distribution and drivers of the entire spectrum of invasive plant taxa across the country remain unassessed. In this work, we mapped the species richness of known invasive plants across mainland Portugal and analyzed distinct aspects of their spatial distribution, using municipalities as units of analysis aiming to support decision-making in management.
We compiled occurrence records for 97 terrestrial and aquatic vascular plants included in the list of invasive alien species of Union concern (Regulation EU No. 1143/2014) and the Portuguese national list (Decree-Law No. 92/2019). Six different sources were used to compile the presence records of the invasive plants. A generalized least squares regression model was used to assess relationships between the richness of invasive plants and a set of 28 variables representing environmental and human factors. A k-means clustering analysis was performed to identify groups of species exhibiting similar distributions.
Littoral municipalities, with higher accessibility to major urban centres of national or regional relevance, have significantly higher invasive plant richness. In addition, higher values of municipality area, sampling effort, density of protected areas, and number of plant nurseries and aquarophilia stores showed a positive association with the number of invasive plant species. Four groups of species were identified based on their distribution patterns: widespread species, moderately widespread, species primarily found along the littoral, and species with narrow ranges.
Generally, in mainland Portugal, littoral municipalities and those near urban centres face increased pressure from plant invasions. National and local-level prevention and monitoring initiatives should primarily focus on these areas to mitigate the impacts of the ongoing spread of invasive plants.

Keywords: invasion patterns, invasive alien plants, invasibility, specific richness

Assessing the role of non-native species and artificial water bodies on the trophic and functional niche of Mediterranean freshwater fish communities

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Habitat alterations and the introduction of non-native species have many ecological impacts, including biodiversity loss and a deterioration of ecosystem functioning. However, the effects of these combined stressors on the community trophic web and functional niche are not completely clear. Here, we investigated how artificial ecosystems (i.e. reservoirs) and non-native species influence the trophic and functional niche space of freshwater fish communities. To do so, we used carbon and nitrogen stable isotope and abundance data to compute a set of isotopic, trait and functional metrics over 13 fish communities sampled in 12 ecosystems in Türkiye. We show that in reservoirs, fish were more similar in their trophic niche compared to lakes, where the trophic niche was more variable due to higher habitat complexity. However, there were no differences in the trait and functional metrics between the two ecosystem types, suggesting a higher prey diversity than assumed in reservoirs. We also found that the number of non-native species did not affect the trophic niche space, nor the trait or functional space occupied by the fish community. This indicates that non-native species tended to overlap their trophic niche with native species while occupying empty functional niches in the recipient community functional space. Similarly, the proportion of non-native species did not affect any trophic, trait, or functional metric, suggesting that changes in community composition were not reflected in changes in the community niche space. Moreover, we found that trait richness, but not functional richness, was positively related to the isotopic niche width and diversity, indicating that a wider occupied trait niche space corresponded with a wider occupied trophic niche and lesser interspecific similarity. Our findings underscore the complexity of ecological relationships within freshwater ecosystems and highlight the need for comprehensive management strategies to mitigate the impacts of human activities and biological invasions.

Keywords: Stable isotope analysis, functional ecology, functional traits, isotopic niche, functional niche, fish assemblage

Physiological differences between populations of *Carpobrotus* sp. pl. subjected to stress

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In the genus *Carpobrotus* we find different species of invasive plants present in the five continents of the Earth. In Galicia we can find this succulent mat-forming plant in different beaches like Samil, Rons, A Lanzada, Corrubedo, Sabón and As Catedrais. Apparently, they look very similar, but genetically they may be different. For example, we know that Samil and Rons are from two different genetic clusters. However, little is known about how two different genetic clusters react to different types of abiotic stresses. Therefore, the aim of this study is to assess the influence of abiotic stress on different genetic groups, thus achieving a better understanding of the adaptation of the genus *Carpobrotus* to these conditions.

For this purpose, the behavior of two populations with different genetic clusters was compared: the population of Samil (Vigo), and the population of Rons (O Grove). To do so 200 individuals (100 individuals per population) were subjected, after a period of acclimatization, to two different treatments: salinity (plants were watered with a 0.5 molar NaCl solution), and drought (plants were not watered); a third group remained untreated as controls. 20 of those plants were subjected only to the acclimatization treatment, while 180 were subjected to different stress intensities: 60 to mild stress, 60 to severe stress and 60 to a recovery period after the stress in which they were watered normally. For these plants we measured their photosynthetic activity (ϕII, ϕNO and ϕNPQ), biometric parameters such as aerial length and weight, number of whorls and root length and weight. Moreover, we measured photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) using their leaves.

Keywords: *Carpobrotus*, invasive plants, photosynthetic pigments, abiotic stress, drought, salinity

Are invaders smarter? Individual cognition vs social information in invasive and native ants

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Introducing invasive species poses significant ecological challenges in new environments, demanding adaptive strategies for their survival. It was proposed that eusocial insects could overcome these challenges using social information rather than individual cognition. This could allow the colony to avoid the costs necessary to produce and maintain individual behavioural and neural plasticity in the thousands of colony members. We hypothesised that highly invasive introduced species with a high numerosity of colony members would rely more on social information. In contrast, native species –less numerous and more adapted to the environmental conditions- would be more specialised and dependent on their cognitive skills. We tested problem-solving strategies in ant workers of invasive (*Linepithema humile* (Gustav Mayr, 1868); N= 186) and native (*Tapinoma erraticum* (Latreille, 1798); N= 188) species of the same subfamily (Dolichoderinae) co-occurring in northwest Spain. Workers were divided into three treatments according to the methods used in the tests: with social information ((Z)-9-hexadecenal pheromone as proxy), without social information (ethanol) and control (no problem-solving). Problem-solving tests were designed based on mechanisms needed to adapt to new environments: exploration (exploring an empty arena), neophobia (interaction with a novel object) and maze-solving ability. Age-controlled focal individuals were tested five times over five consecutive days to establish a pattern of their behaviour. The brains of the focal individuals were subsequently extracted after the fifth test. They were analysed using a confocal microscope to compare microglomureli density in the Mushroom Bodies and Central Complex (the area that processes mechanosensory and visual information) and the changes in brain volumetry. Our study highlights the different behavioural strategies and the trade-off between neural development and social information use between invasive and native ants. Our findings provide a new dimension for developing management plans and open research lines focusing on comparative neuroethology.

Keywords: behaviour, social information, individual cognition, problem-solving, neuroethology

Could predation by pumas limit a population of feral horses?

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Animal populations are regulated by bottom-up and top-down effects. Predators can affect the population dynamics and behaviour of large herbivores, including feral invasives, causing top down-regulation. The geographic range of the puma (*Puma concolor*) in Argentina suffered a major contraction in the 19th century due to direct persecution by livestock ranchers and to the advance of the agricultural frontier, which led to its functional extinction in the Pampean grasslands. Changes in land use over the last twenty years may have allowed the puma to recolonize different areas of its distribution range and to increase its local abundance. This seem to be the case at Tornquist Provincial Park, a nature reserve that also hosts a population of feral horses (*Equus caballus*). In 1942 five horses were introduced in the reserve and since then, the population has increased, favoured by the very scarce predators and the almost total absence of any type of management, reaching twenty-seven adult horses per square kilometer in 2022. During the last three years we noticed an increase in puma sightings and also several cases of foal carcases with signs of predation compatible with puma attack. In this work, we compare the survival of females of different ages and adult female fecundity among years with evidences of puma presence and predator activity (2022-2024) versus previous data from seasons without puma (1995-2002). Foal mortality was significantly higher in the recent years, and population growth rate (λ) was 1, what means its size was stable. Our results suggest that puma predation in the area may be limiting the feral horse population and so helping to reduce its harmful effects on the native ecosystem. This role of predators should be considered in the planning of management of feral horses and others invasive alien herbivores.

Keywords: predation, biological invasions, feral horses, natural grasslands, top-down effects

Importance of seed dispersal by ants in the invasion of alien species

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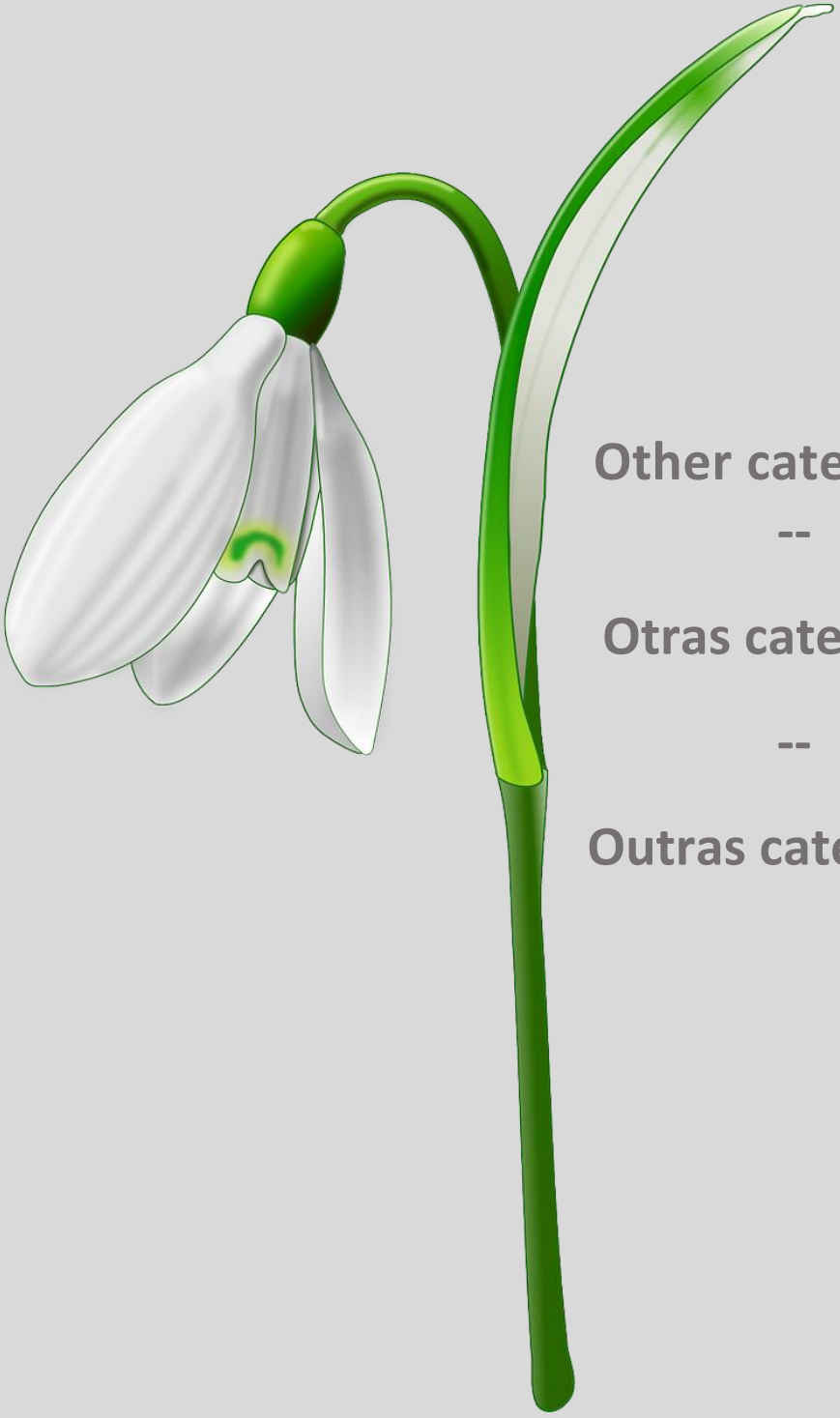
Invasive alien species can establish mutualistic interactions that are key to their spread in invaded areas. Among them, seed dispersal facilitates the propagation and establishment of invasive plants. Ants are the most important invertebrates dispersing exotic seeds, facilitating their colonization of new areas via transport of seeds to enriched sites, and increasing germination via seed manipulation. To determine the importance of seed dispersal by ants in plant invasion, we performed a global review to: (i) evaluate the contribution of myrmecochory phases to the propagation and establishment stages of invasive plants, (ii) establish diet type of ants that interact with seeds of invasive species, and (iii) determine the role of elaiosomes in dispersal by native ants. We further determined dispersal rates and manipulation by the *Dorymyrmex tener*, an ant native to Patagonia, by offering exotic seeds with and without elaiosome in field experiments, and evaluated the effects of seed manipulation and nest substrate on seedling emergence and growth in greenhouses. We found that 96% of the articles on the contribution of ants to plant invasion evaluated the propagation stage, and only half studied the propagation and establishment together. Most of the ants involved had generalist diets and in 79% of the studies the interaction was mediated by elaiosome bearing seeds. The presence of the elaiosome was key to removal of *Carduus thoermeri* and *Cytisus scoparius* seeds in field experiments. The effect of seed manipulation and dispersal to nest soil favored emergence, growth and/or seedling establishment of both species. In conclusion, dispersing ants favor invasive plants during spread, with higher dispersing rates for elaiosome-bearing seeds, and during plant establishment, increasing chances of seed germination and arrival to high quality sites. Our results suggest that managing invasive plants with elaiosome-bearing seeds requires to consider the potential ant dispersing community.

Keywords: ants, *Carduus thoermeri, Cytisus scoparius, Dorymyrmex tener,* elaiosome, invasive plants, myrmecochory, Patagonia



Other categories

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Otras categorías

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Outras categorías

Taming the terminological tempest in invasion science

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Standardised terminology in science is important for clarity of interpretation and communication. In invasion science – a dynamic and rapidly evolving discipline – the proliferation of technical terminology has lacked a standardised framework for its development. The result is a convoluted and inconsistent usage of terminology, with various discrepancies in descriptions of damage and interventions. A standardised framework is therefore needed for a clear, universally applicable, and consistent terminology to promote more effective communication across researchers, stakeholders, and policymakers. Inconsistencies in terminology stem from the exponential increase in scientific publications on the patterns and processes of biological invasions authored by experts from various disciplines and countries since the 1990s, as well as publications by legislators and policymakers focusing on practical applications, regulations, and management of resources. Aligning and standardising terminology across stakeholders remains a challenge in invasion science. Here, we review and evaluate the multiple terms used in invasion science (e.g. 'non-native', 'alien', 'invasive' or 'invader', 'exotic', 'non-indigenous', 'naturalised', 'pest') to propose a more simplified and standardised terminology. The streamlined framework we propose and translate into 28 other languages is based on the terms (i) 'non-native', denoting species transported beyond their natural biogeographic range, (ii) 'established non-native', i.e. those non-native species that have established self-sustaining populations in their new location(s) in the wild, and (iii) 'invasive non-native' – populations of established non-native species that have recently spread or are spreading rapidly in their invaded range actively or passively with or without human mediation. We also highlight the importance of conceptualising 'spread' for classifying invasiveness and 'impact' for management. Finally, we propose a protocol for classifying populations based on (i) dispersal mechanism, (ii) species origin, (iii) population status, and (iv) impact. Collectively and without introducing new terminology, the framework that we present aims to facilitate effective communication and collaboration in invasion science and management of non-native species.

Keywords: biological invasion, classification, communication, non-English language, non-native, polysemy, synonymy

Science vs. Law, when social aspects hinder invasive species management

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Achieving effective management of invasive exotic species requires harmonization among scientific inquiry, public administration, and legal frameworks. The scientific community plays a crucial role in advising state, regional, and local governments on necessary actions for preventing, rapidly detecting, controlling, or eradicating specific species within designated areas.

However, the alignment of scientific, social, and political interests is not always seamless, leading to regulatory measures aimed at protecting nature and managing invasive alien species, which may not optimally fulfill this purpose. Internationally, tools like Inventories of Invasive Alien Species often seem to serve as excuses for eliminating bothersome species rather than achieving their intended goals. Examples such as including donkeys or dogs in the Dominican Republic, domestic cats in Poland due to their negative impacts on the primary sector, and hippos in Colombia highlight this issue.

In Spain, a legal mechanism called "naturalized species" has been established, granting protection to species introduced before the creation of the Inventory. This mechanism aims to mitigate the Inventory's effects on socially or economically significant species, making it legal to release catalogued species like rainbow trout, American crayfish, and black bass.

Hence, while scientific research on invasive alien species and their impacts is crucial, it's equally vital to translate this knowledge into legal and political contexts to raise awareness about the risks of governmental actions and prevent malicious distortions of environmental law. Inadequate environmental education in this area has led to the current management situation, underscoring the need for a comprehensive strategy for citizens and policymakers to address the ecological and, specially, socio-economic impacts of effectively managing invasive alien species.

Keywords: invasive alien species, environmental protection, environmental law, public administration, environmental education

Stakeholder's perception and participation in invasive alien plant species management in the protected areas of southern lowland Nepal

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Invasive Alien Plant Species (IAPS) pose significant threats to ecosystems, including protected areas (PAs). Effective management planning needs to take into account the stakeholder's diverse perspectives and involvement. This study investigated the perception and participation of stakeholders in the management of invasive species in the five PAs of southern lowland Nepal to enhance our understanding of their roles and contributions. Utilizing social - survey methods, i.e., Key Informant Interview (KII) and Focus Group Discussion (FGD), we explored proficiency of their knowledge on IAPS, identified problematic species and their ecological and socio-economic impacts, and documented IAPS management practices. Altogether, 28 persons comprising 20 park staffs and 8 community members were interviewed as key informants, and 29 FGDs were organized with total 180 participants consisting 83% men and 17% women. The KII was done with technical staff of PAs and leadership of Buffer Zone Management Committee whereas the FGDs that consists of 5-10 people were done with the Buffer Zone Users' Committee (BZUCs) members and other local peoples. Data was analyzed using the descriptive statistics such as frequencies and percentages as well as by scoring. Our data revealed that 93% people were not aware of the nature of IAPS whereas only 7% were aware of it. According to the respondents, four globally worst IAPS found in Nepal (i.e., *Mikania micrantha, Chromolaena odorata, Lantana camara, Pontederia crassipes*) had been increasing in recent years. According to the FGDs participants, *Mikania micrantha* was the most problematic IAPS in natural ecosystems followed by *Lantana camara* and *Chromolaena odorata* whereas in agro-ecosystem and residential areas, *Ageratum houstonianum* was the most problematic species followed by *Argemone mexicana* and *Parthenium hysterophorus*. Extinction of populations of native species was the most frequently reported impact of IAPS. Utilization of the IAPS as food, fuelwood and as herbal medicine had been also reported. Manual uprooting was the most frequently implemented control measure. Lack of relevant information and funding were the major obstacles identified by the respondents for effective IAPS management. Improved awareness of local stakeholders through the flow of relevant information using their official communication channels and additional technical and financial supports can enhance effectiveness of the IAPS management, thereby reducing threats to native biodiversity and ecosystems in the PAs.

Keywords: biological invasions, key informant interview, focused group discussions, invasive species management, Tarai and Siwalik regions

Invasive species distribution models are strongly influenced by the choice of calibration area

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Biological invasions are a leading cause of biodiversity loss worldwide. So, it is crucial to identify areas with the highest probability of establishment for exotic species. Species distribution models (SDMs) represent an essential tool for this purpose but face many challenges that influence their accuracy. This project focused on evaluating the effect of various factors involved in the calibration and selection of SDM to predict the potential range of invasive species through virtual species simulations. Using bioclimatic variables, 100 virtual species were generated based on environmental suitability, spatial sampling bias, and accessible areas. A cellular automaton was programmed to define native and invasive areas. Five presence datasets were obtained for each species. SDMs were built using MaxEnt, varying the extent of calibration area, spatial thinning of occurrence records, predictor collinearity treatment, and MaxEnt regularization parameter (100 species x 5 replicates x 400 models). Model performance was assessed regarding functional accuracy and discrimination accuracy in the native and invasive range. Unbiased models were included for each species. Results show that larger calibration areas generally lead to higher functional accuracy, although performance varies across species. Unbiased models exhibited strong performance, while regular models displayed higher variability. Calibration area size was the most influential factor in terms of functional accuracy (explaining 50.5% and 18.1% of the variance in the native and invasive range), while regularization multiplier, predictor collinearity, and spatial thinning had minimal impact (4.1% explained variance combined in the native range and 4.6% in the invasive range). The correlation between functional and discrimination accuracy was relatively low, indicating that models performing well in one metric may not excel in the other. In conclusion, by demonstrating the substantial impact of calibration area size on model performance the study underscores the importance of this factor in SDM applications.

Keywords: species distribution models, virtual species, biological invasions, model extrapolation, model transferability

Species list -- Lista de especies -- Lista de especies

Acacia spp.

Acanthinucella spirata

Aedes aegypti

Aedes albopictus

Ageratum houstonianum

Ailanthus altissima

Arctotheca calendula

Argemone mexicana

Arundo donax

Asparagopsis armata

Austropuccinia psidii

Callinectes sapidus

Carpobrotus spp.

Chaetogammarus ischnus

Chondria coerulescens

Chromolaena odorata

Corbicula fluminea

Culex quinquefasciatus

Cytisus scoparius

Dikerogammarus haemobaphes

Dikerogammarus villosus

Eleusine indica

Eucalyptus globulus

Gunnera tinctoria

Hieracium pilosella

Ipomoea spp

Kalanchoe ×houghtonii

Kyphosus sectatrix

Kyphosus vaigiensis

Lantana camara

Linepithema humile

Lycorma delicatula

Megathyrsus maximus

Mexacanthina lugubris

Mikania micrantha

Mytella strigata

Parthenium hysterophorus.

Pinus patula

Polydesmus angustus

Pontederia crassipes

Pontogammarus robustoides

Sargassum muticum

Ulex europaeus

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