

# ECOFLOR 2026: Book of Abstracts



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Welcome to the ECOFLOR 2026 Book of Abstracts.

## Floral Evolution, Breeding Systems & Reproductive Success

### Pollinator-mediated floral evolution in the pollination-generalised plant *Viscaria vulgaris*

**Presenter:** Aarushi Susheel

**Affiliation:** Lund University

**Authors:** Aarushi Susheel, Felipe Torres-Vanegas, Ciara Dwyer, Yedra Garcia, Sophie Hecht, Magne Friberg & Øystein H. Opedal

Pollinator-mediated selection can lead to large variation in floral traits. This has been well researched in specialist systems, where one pollinator species interacts with a flowering species. In generalist systems, where one flowering plant interacts with several pollinator species, changes in the size and composition of the pollinator community can alter the patterns of selection acting on the plant. Through my PhD, I will study how a pollination-generalised flowering plant, *Viscaria vulgaris*, adapts to a functionally diverse pollinator community that varies both spatially and temporally. The study involves measurement of plant and pollinator phenotypes, pollinator visitation, pollinator effectiveness, and plant fitness. Combining these data with selection studies across multiple years in multiple populations, I aim to quantify the importance of functionally distinct pollinators in pollination and floral divergence. Initial data analysis has revealed functionally diverse pollinator assemblages within each plant population, along with evidence for phenotypic selection on floral traits. I plan to link these patterns by presenting findings from single-visit efficiency experiments and pollinator visitation rates to quantify the ‘importance’ of each pollinator in the local pollinator community of various populations. This would pave the way for constructing models that will assess the impact of functionally diverse pollinator assemblages on floral evolution.

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### When is selfing not an evolutionary dead-end?

**Presenter:** Øystein Opedal

**Affiliation:** Lund University

**Authors:** Øystein Opedal & Josselin Clo

Partial self-fertilization is a common reproductive strategy in flowering plants with important consequences for population demography and phenotypic evolution. While selfing has traditionally been thought to reduce adaptive potential, recent insights into the genetics of selfing

and the ecology of plant mating challenge this long-standing idea. We discuss the current state of Stebbins' dead-end hypothesis through the lens of recent quantitative-genetic models, and by considering variation in mating systems and evolutionary potential across species' ranges. While macroevolutionary transitions tend to proceed from outcrossing towards selfing, outcrossing rates appear to evolve readily among populations and congeners. There is limited evidence that selfing reduces adaptive potential (evolvability) as reflected in standing genetic variation of phenotypic traits, and that evolvability is reduced in the kinds of harsh environments often occupied by selfers. Although reversals from near-complete selfing toward outcrossing may remain challenging due to the population-genetic properties of selfing lineages, we propose that populations of mixed-mating species are often able to track variation in their reproductive environment through evolutionary changes in selfing rate. Thus, self-fertilization may not always represent an evolutionary dead end. We conclude by outlining a modern quantitative-genetic research programme aimed at better understanding the microevolutionary dynamics of plant mating systems.

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### **Pollinators and Plant Rarity: Variation in Pollinator Interactions and Reproductive Systems Across Rare and Widespread Plant Species**

**Presenter:** Sara M. Brito Lopes

**Affiliation:** Centre for Functional Ecology, University of Coimbra (CFE - UC)

**Authors:** Sara Brito Lopes, Hugo Gaspar, Pedro Lopes, Afonso Petronilho, Ana Afonso, Catarina Siopa, João Loureiro, Sílvia Castro

The current human-driven loss of biodiversity is accelerating, and plants are among the most affected groups, with an estimated 45% of angiosperms at risk of extinction. Understanding the drivers of rarity and threat is essential for predicting species persistence and for designing effective conservation plans that prioritise vulnerable taxa. Most angiosperms rely on animal pollination for successful reproduction making pollinator interactions a key component of their success. However, information on pollinator identity remains scarce for many species. In this study, we selected 14 congeneric species pairs, each consisting of one rare species (with varying conservation statuses) and one widespread relative. For all species, we conducted pollinator censuses and net-sweeping surveys to characterise their pollinator communities. We also performed controlled pollination experiments, including pollen supplementation and pollinator exclusion, to evaluate pollen limitation and pollinator dependence, respectively. Additionally, we quantified pollen/ovule ratios to infer the breeding system. With these data, it was possible to identify the pollinators of the studied species and to evaluate differences in visitation rates, pollinator diversity, pollen limitation and pollinator dependence between rare and widespread taxa, as well as among conservation categories. These insights are particularly relevant to inform the development of effective, evidence-based conservation strategies.

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## Integrated fitness pathways expose concealed habitat-loss impacts in sexually deceptive orchid

**Presenter:** Joshua Borràs

**Affiliation:** University of the Balearic Islands (UIB)

**Authors:** Joshua Borràs, Miquel Capó Yedra García, Øystein H. Opedal, Amparo Lázaro and Joana Cursach

Natural habitat loss is one of the main threats to biodiversity. Understanding how landscape degradation affects reproductive success is essential for plant conservation, especially for species involved in specialized pollination systems. We evaluated how habitat loss influences reproductive fitness in the sexually deceptive *Ophrys balearica* using two years of data from six populations, three in conserved and three in disturbed landscapes. We quantified herbivory affecting flowers and inflorescences, pollinaria removal and deposition, fruit production, plant traits, and the composition of co-flowering species. A path-analytical modelling framework tracked each reproductive stage to assess how habitat loss, herbivory and pollination shape reproductive output. Herbivory was the strongest constraint on reproductive fitness. Both herbivory and pollinator visitation were higher in disturbed landscapes, with visitation varying across sites and years with no differences in observed fitness. Floral display increased visitation and improved both male and female fitness components, although morphological traits explained little fitness variation once herbivory and visitation were accounted for. Overall, orchid populations in disturbed landscapes showed cumulative reductions in relative fitness when all reproductive stages were integrated. This study shows that habitat loss alters herbivore pressure and pollinator visitation, leading to reduced reproductive success in this sexually deceptive orchid.

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## Phylogeography of an invasion to track rapid floral evolution

**Presenter:** Maria Clara Castellanos

**Affiliation:** University of Sussex

**Authors:** Romero-Bravo, A., J. O'Flaherty, J. Green, L. Unwin & M.C. Castellanos

Recent plant range expansions where pollinators change provide a unique opportunity to study the potential and speed of floral adaptive change. We have been studying the common foxglove, *Digitalis purpurea*, to investigate convergent floral changes after the addition of hummingbirds as pollinators when naturalised in tropical mountains. In addition to our previous reports of

morphological changes, we now have new evidence of changes in nectar traits consistent with bird pollination. To confirm the convergent nature of these changes, here we use a phylogeographic approach to reconstruct the invasion of focal Colombian and Costa Rican populations from the native European range. We used genotyping-by-sequencing on individuals from eleven native populations in Europe and three populations in the introduced range. Our phylogeographic reconstruction points at Central Europe as the source of two recent and independent introduction events to South and Central America. Within the native range, population structure is consistent with a historic northward expansion from southern European populations and the colonisation of Norway from Britain across the North Sea. Our phylogeographic analysis provides the most comprehensive insight onto the colonisation history and the genetic relationships across populations of *Digitalis purpurea*, an emerging model species to study adaptive changes in novel pollinator environments.

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### **Beyond Seed Set: What Shapes Seed Quantity and Viability in Wild Plant Assemblages?**

**Presenter:** Estefanía Tobajas

**Affiliation:** BC3-Basque Centre For Climate Change-Klima Aldaketa Ikergai

**Authors:** Estefanía Tobajas, Luis J Chueca, Christian Gostout, Brais Hermosilla, Jennifer Rose, Xabier Salgado-Irazabal, Celia Baigorri, Montserrat Muriana, Jon Poza, Ainhoa Magrach.

Understanding the drivers of plant reproductive success is crucial for predicting population dynamics and ecosystem functioning. Reproductive success depends not only on the number of fruits and seeds produced, but also on the viability of these seeds, an aspect that is seldom considered in pollination studies. In this study, we investigated the factors influencing both seed production and seed viability within a diverse plant community. During 2024, we marked and collected fruits from multiple plant species across 16 sites in Gorbea Natural Park (N Spain), quantified their seed production, and assessed seed viability using tetrazolium staining. Preliminary results show that plant species richness has a positive effect on seed set, although the magnitude of this effect varies among species. We also find evidence of a trade-off between seed quantity and seed quality: fruits with more seeds tend to produce a lower proportion of viable seeds. Next steps will incorporate additional mechanisms, including temporal and resource use overlap among plant species, functional diversity, and pollinator community structure, to better understand the pathways shaping reproductive outcomes. Overall, this study highlights the value of integrating seed production and viability to understand plant reproductive success, and underscores the influence of community composition and biotic interactions on reproductive performance in natural plant communities.

## Habitat factors and traits shape plant- pollinator interactions in a semi-arid landscape

**Presenter:** Diana Michael

**Affiliation:** Ashoka University, Sonipat

**Authors:** Diana Michael, Kunjan Joshi, Shivani Krishna

Plant–pollinator interactions are central to understanding ecological processes that shape plant community reproductive success. Although species-level interactions help predict community stability, examining individual-level interactions of keystone species is crucial. This study investigates how habitat factors and floral traits influence pollinator interactions in *Maytenus senegalensis*, a dominant species in the semi-arid Aravalli Hills, India. We quantified flower production, nectar concentration, flower diameter, soil moisture, distance to habitat edge, and proportion of co-flowering conspecifics to assess their effects on pollinator visitation and reproductive success. We found variation in reproductive investment and a trade-off between flower production and reward quality: individuals producing more flowers had lower nectar sugar concentration. High flower production negatively affected reproductive success, likely due to increased within-plant visitation. *Eristalinus* and *Apis* were dominant pollinators, with Dipterans playing a key role in maintaining network stability. Higher conspecific neighbors reduced pollen deposition, indicating competition. Individual plants also showed varying specialization in their interaction niches, suggesting divergence driven by pollinator-mediated competition. Disturbances to plants with high pollinator connectance strongly affected network stability. Overall, our results show that microhabitat and neighborhood context shape individual interaction niches, with allocation trade-offs and conspecific competition jointly influencing pollination and fitness in semi-arid systems experiencing environmental change.

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## Gene expression plasticity across regulatory pathways for flowering time in *Arabidopsis thaliana*

**Presenter:** Patricia Roca Villanueva

**Affiliation:** University of Granada

**Authors:** Patricia Roca-Villanueva, Ana García Muñoz, Xavier Picó.

Gene expression plasticity can be defined as the ability of a single gene to adjust its expression in response to changes in the environment. Understanding how environmental cues affect gene expression plasticity in field conditions is a major challenge, which may help grasp the complexity of genotype-phenotype relationships. Nevertheless, gene expression plasticity in natural conditions has barely received attention due to the logistical complexity to estimate gene expression outdoors. In this study, we investigated how environmental conditions modulate the expression of flowering-related genes from all known regulatory pathways in natural

accessions of *Arabidopsis thaliana* across multiple timescales relevant for gene expression. Using generalized linear mixed models (GLMMs) on a previous whole-genome gene expression dataset obtained from locally-adapted accessions in natural conditions, we evaluated gene expression plasticity across diurnal (morning vs. afternoon), seasonal (across developmental stages: vegetative, inductive, and reproductive), and annual timescales (over two different years). Our analysis focused on a set of 306 known genes in *A. thaliana* related to flowering time to estimate their expression plasticity and to quantify the differences across accessions and various regulatory pathways. Overall, our work provides valuable insights to understand how genes and regulatory pathways for flowering respond to natural environmental variation to complete the vegetative-to-reproductive transition in plants, which is a major trait under strong selection in annuals and short-lived perennials.

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## Traits, Plasticity & Signals

### Flower economic spectrum: A key to understanding the floral diversity of alpine plants

**Presenter:** Lucie Holzbachová

**Affiliation:** Charles University Prague

**Authors:** Lucie Holzbachová, Petr Sklenář, Jakub Štenc

Flowers of zoogamous plant species are subject to combined selection pressures from abiotic and biotic factors, yet their impact on floral diversity has mostly been studied separately. The concept of the Flower Economic Spectrum (FES) has been recently proposed to understand the evolutionary phenotypic variation and diversity of functional traits in flowers that evolved under multiple selection factors. The world's mountainous regions are home to a large part of global biodiversity and mountain environments impose strong pressures on flowering, such as extreme climatic conditions and low abundance and diversity of pollinators. However, not all alpine regions share the same conditions. Tropical and temperate mountains differ in many important ecological factors that strongly influence generative plant reproduction. We studied more than 50 herbaceous and woody species from two mountain regions (Ecuador and the USA). The study examines the phenotypic variability of alpine flowers through the lens of the FES, i.e. relationship between flower longevity and investment into flower biomass (cost of flower production). Our preliminary results show a positive association between flower biomass investment and flower longevity, with differences in longevity patterns between the two alpine regions. Together, these findings provide empirical support for the proposed Flower Economic Spectrum.

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## Flower orientation influences wild pollinator behaviour: a field study on natural and artificial flowers

**Presenter:** Chiara Buonanno

**Affiliation:** University of Parma

**Authors:** Chiara Buonanno, Giannetti Daniele, Marta Barberis, Marta Galloni, Donato A. Grasso

The foraging activity of bees is a complex behaviour that depends, among other factors, on some physical features of flowers. Of particular importance are accessibility of floral rewards, floral proportions, symmetry and orientation. Several studies have investigated the effects of flower orientation using colonies of bees under experimental controlled condition. In the present study we performed field experiments employing both artificial and natural flowers (different species of the genus *Salvia*) characterized by zygomorphic symmetry. By altering the orientation of flowers, we analysed how different species of wild bees approached and interacted with them. The results showed that pollinators visiting artificial flowers, especially of family Halictidae, preferred those with a horizontal landing surface. Concerning real flowers, several species of Apidae visited significantly more flowers with natural orientation or those turned of 90°. Our results, including observations on insect approach and visiting methods, showed that even minor alterations in flower orientation can markedly affect pollinator behaviour, providing new perspectives into the ecological and evolutionary mechanisms shaping plant–pollinator interactions.

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## Floral Trait Thermal Plasticity in a Common Crop

**Presenter:** Lucy Unwin

**Affiliation:** University of Sussex

**Authors:** Unwin, L. A., Millerchip, E. K., Dadswell, C., Castellanos, M. C

Plasticity in floral traits, particularly those related to pollinator reward and attraction, can influence both the types of pollinators that visit a flower and the nature of those interactions. As flowers commonly exhibit suites of traits that align with pollinator preferences, environmentally driven (=plastic) changes in floral traits can alter plant-pollinator interactions in both crop and wild plants. Whilst floral nectar traits have frequently been cited as ‘highly plastic’, many studies do not measure true plasticity - that is, variation in trait expression across environments within the same genotype. Consequently, the true extent of plasticity in floral nectar traits remains poorly understood. Understanding this is central to predicting the resilience of plant–pollinator interactions in the face of environmental change. We used an experimental setup to measure plasticity in response to temperature in floral nectar volume,

flower size, and nectar sugar characteristics in the common bean *Phaseolus vulgaris* L., a globally important crop in the Fabaceae family. *P. vulgaris* individuals were grown in controlled greenhouse conditions, then allowed to flower at temperatures of 16, 23, and 30°C for 3-day periods. Individual plants experienced multiple temperature treatments to assess plasticity in floral traits. Both nectar volume and flower size show significant plasticity in response to temperature. For both traits, the response to temperature was quadratic, consistent with the presence of a thermal optimum. Interestingly, plants varied in their baseline nectar production, but the shape of the plastic response was highly consistent across plants, suggesting plant-level physiological control of this trait. For flower size, plastic responses were less consistent and there was variation across flowers within plants. Understanding the plasticity of floral traits in crop species provides key information on the potential to breed cultivars with stable reward production that can benefit both yields and pollinators.

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## Community Ecology, Networks & Niche Partitioning

### Effects of forest structural heterogeneity on hoverfly diversity and pollination potential.

**Presenter:** Clàudia Massó Estaje

**Affiliation:** University of Würzburg

**Authors:** Clàudia Massó Estaje, Anne Chao, Jörg Müller, Alice Claßen, Ingolf Steffan-Dewenter

Habitat homogenization from intensive forest management has reduced pollinator diversity, threatening forest regeneration and plant reproduction. Experimental evidence on how forest structural heterogeneity influences pollinator communities at the landscape scale, however, remains scarce. We tested whether enhancing structural heterogeneity through deadwood enrichment and canopy gap creation (Enhancement of Structural Beta Complexity, ESBC) promotes hoverfly diversity, key pollinators in temperate forests, and whether this effect is driven by local (  $\alpha$  ) diversity or species turnover (  $\beta$  diversity). Our large-scale forest experiment across 11 regions in Germany compared paired small forest landscapes (ESBC vs. control), comprising 234 patches sampled with pan traps across three seasons. Using incidence-based Hill numbers, we quantified taxonomic, functional, and phylogenetic diversity (TD, FD, PD) at  $\alpha$ ,  $\beta$ , and  $\gamma$  scales. Structurally heterogeneous landscapes supported higher  $\alpha$ -diversity across all biodiversity dimensions, particularly for taxonomic richness, suggesting that rare hoverfly species benefit most. Most diversity gains were driven by  $\beta$  rather than  $\gamma$  components. Our

findings provide experimental evidence that enhancing forest structural heterogeneity can restore multi-dimensional pollinator diversity, reinforcing its potential to sustain floral visitation networks and counteract biotic homogenization.

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### How is the buzz-pollination niche partitioned among co-flowering plants?

**Presenter:** Agnes Dellinger

**Affiliation:** University of Vienna

**Authors:** Benjamin Lazarus, Agnes S. Dellinger

Co-flowering plants may overlap or diverge in pollination niche, with traits related to pollinator attraction (e.g., color, scent) and fit (e.g., herkogamy) regarded as particularly important in mediating pollination niche position. Buzz-pollinated flowers are particularly interesting in this context since they have a third, invisible and understudied trait component determining niche position: their vibrational properties. Buzz-pollination is a functionally highly specialized pollination mechanism where large quantities of pollen can only be dislodged when bees apply vibrations in the range of 100-400 Hz to the flowers. Whether co-flowering, buzz-pollinated species are “tuned” to different bees, or rely on common strategies of niche partitioning such as differential attraction and fit, remains unclear. In my talk, I will explore these questions using community-level plant-pollinator interaction studies of the plant family Melastomataceae as a model. Melastomataceae are among the largest plant families worldwide (close to 6000 species), almost exclusively buzz-pollinated (96% of species, adaptive plateau) and multiple species are commonly co-flowering in diverse tropical habitats. Using comparative assessments of plant-pollinator interactions, single visit experiments and artificial vibration experiments (mimicking bees), we find that co-flowering Melastomataceae often overlap in their bee visitor assemblages, but that size-matching with bees (herkogamy) plays a critical role in niche differentiation. Our artificial vibration experiments further indicate that different species have different vibration optima, and that differential “tuning” may indeed be an important mechanism of pollination niche differentiation.

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### A multidimensional approach reveals pollination niche partitioning among terrestrial orchids

**Presenter:** Aurélien Caries

**Affiliation:** Lund University

**Authors:** Caries Aurélien, Friberg Magne, Opedal Øystein, García García Yedra

Pollinator-mediated reproductive interactions between co-flowering species are increasingly recognized for their role in community structure. Pollination traits, flowering phenology and spatial distribution are key axes of the pollination niche, yet few studies have assessed their combined effects on community assembly. We quantified pairwise overlap in pollination niches among 16 orchids, including rewarding and deceptive species, using floral traits related to pollinator attraction and pollination efficiency measured at two sites on Öland (Sweden). We collected flowering times and spatial co-occurrence data from a citizen-science database. At the local level, we compared the coefficient of variation per trait between pollination strategies (deceptive vs. rewarding) and trait values across sites. Most species pairs overlapped in at least one axis of the pollination niche. Typically, species with high overlap across multiple niche dimensions represented cases where the literature suggests pollinator niche partitioning. Three food-deceptive species overlapped strongly in niche space, despite sharing pollinators. While character displacement for unmeasured traits via competition may occur, we hypothesise that trait divergence may instead promote facilitation by maintaining pollinator deception and increasing visitation. Our findings highlight the complementary role of different niche dimensions in enhancing species coexistence and support emerging evidence that deceptive orchids may facilitate each other.

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### The impact of *Impatiens glandulifera* (Himalayan Balsam) on the pollination of the native *Stachys sylvatica* (Hedge Woundwort) in the UK

**Presenter:** Samira Ben-Menni Schuler

**Affiliation:** Universidad de Granada

**Authors:** Samira Ben-Menni Schuler, Laura Mary White, George Horn, Rocío Pérez-Barrales

Invasive plants can alter pollination dynamics by attracting shared pollinators away from native flora, potentially reducing reproductive success. *Impatiens glandulifera* (Himalayan balsam) is a widespread invader in the UK whose large, nectar-rich flowers attract bumblebees and may disrupt native pollination. We assessed its impact on the pollination of the native *Stachys sylvatica* through (1) observations in pristine and invaded sites and (2) an experimental introduction of *I. glandulifera* into an uninvaded habitat. Across natural sites, *S. sylvatica* stigmas in invaded areas received ~3.5 times less conspecific pollen than in pristine sites. In the introduction experiment, the arrival of *I. glandulifera* caused a rapid decline in conspecific pollen deposition, decreasing by ~80% within four days, while invasive pollen appeared on up to 70% of stigmas. Combined visitation and pollen data indicate that behavioural diversion of bumblebees better explains the reduction in conspecific pollen than heterospecific pollen deposition. Our results provide experimental evidence that *I. glandulifera* can swiftly disrupt native

pollination processes during early invasion stages, highlighting the vulnerability of co-flowering natives and the need for management strategies that limit Himalayan balsam establishment in sensitive riparian habitats. away from native flora, potentially reducing reproductive success. *Impatiens glandulifera* (Himalayan balsam) is a widespread invader in the UK whose large, nectar-rich flowers attract bumblebees and may disrupt native pollination. We assessed its impact on the pollination of the native *Stachys sylvatica* through (1) observations in pristine and invaded sites and (2) an experimental introduction of *I. glandulifera* into an uninvaded habitat. Across natural sites, *S. sylvatica* stigmas in invaded areas received ~3.5 times less conspecific pollen than in pristine sites. In the introduction experiment, the arrival of *I. glandulifera* caused a rapid decline in conspecific pollen deposition, decreasing by ~80% within four days, while invasive pollen appeared on up to 70% of stigmas. Combined visitation and pollen data indicate that behavioural diversion of bumblebees better explains the reduction in conspecific pollen than heterospecific pollen deposition. Our results provide experimental evidence that *I. glandulifera* can swiftly disrupt native pollination processes during early invasion stages, highlighting the vulnerability of co-flowering natives and the need for management strategies that limit Himalayan balsam establishment in sensitive riparian habitats.

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### Lower Disturbance Correlates with Higher Robustness and Reduced Connectance in Plant–Pollinator Networks in Es Trenc Natural Park (Mallorca)

**Presenter:** Fortunato Fulvio Bitonto

**Affiliation:** Alma Mater Studiorum - University of Bologna

**Authors:** Bitonto F. F., Serra P. E., Fuster Bejarano F. , Gutierrez R. , Galloni M. , Traveset A.

The Biodiversity Strategy for 2030 and the Nature Restoration Law require EU Member States to strengthen biodiversity monitoring and restore degraded ecosystems. In line with these, we conducted a plant–pollinator network assessment from March to June 2023 in two areas within the Es Trenc–Salobrar de Campos Natural Park (Mallorca, Spain): a human-impacted and a relatively undisturbed site. Pollinators were surveyed every two weeks along a mobile transect, collected with hand-nets, and identified to species level. Floral resources were evaluated using twelve randomly placed 1-m<sup>2</sup> plots per area per monitoring day. We recorded more than 1,500 insect individuals belonging to 120 species, including 20 bee species classified as Data Deficient, Nearly Threatened, or Endangered in the European IUCN Red List. Floral surveys documented over 1,300 flowering units from more than 50 plant species, including the endangered *Helianthemum caput-felis*. Network-level metrics indicated that the less disturbed site exhibited higher ecological robustness and lower connectance compared with the anthropized area, suggesting a more stable and resilient plant–pollinator system. These findings will be shared with the park authorities to help inform evidence-based conservation actions aimed at

supporting plant and pollinator communities, contributing to reducing the information gap in the Mediterranean Basin.

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### Modeling the structure of emerging plant-pollinator networks in a changing world

**Presenter:** Ignasi Bartomeus

**Affiliation:** EBD-CSIC

**Authors:** Ignasi Bartomeus, Nerea Montes.

While impacts of pressure-driven species losses on interaction networks have been identified, predicting effects of full species turnover, particularly considering colonisation of novel species, remains a critical

challenge. Here, we identify future turnover in species pools (lost and novel species) of local plant- pollinator networks at the EU level and projected future plant – pollinator assemblages. To assess the

consequences of turnover, we use existing interaction matching models to predict (novel) pairwise interaction probability and estimated abundance and upscale these relationships to the community level. We use a two-step approach that captures (i) the potential network of species interactions and (ii), how this structure redefines the final community dynamics, accounting for interaction rewiring due to competition.

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### How reliable are pollinator population trends? An interplay between duration, variability, and autocorrelation

**Presenter:** Julia G. de Aledo

**Affiliation:** Estación Biológica de Doñana

**Authors:** Julia G. de Aledo, François Duchenne, Ignasi Bartomeus

Pollinators are susceptible to anthropogenic influences including climate change, habitat loss, and agricultural intensification. While pollinators are key in providing ecosystem services, supporting ~85% of wild flowering plant species, detecting population changes remains a challenge. Existing models leave a gap in understanding fast-lived insect dynamics. In the currently available data, there is an over-representation of recent and short time series. Our goal is to evaluate the degree of robustness the available data can offer to assess trends. To do so, we analyze how statistical power and the probability of false positives are affected by key factors: duration,

slope, stochasticity, and temporal autocorrelation. Additionally, we aim to explore how these trends are compatible with the expectations of stable populations by developing a null-model approach. We found a 20% probability of detecting false positives with the available pollinator data. We propose practical thresholds (more than 10 years) for an acceptable statistical power (75%) to ensure trend inferences are robust enough. However, rigorous evaluation of trends leads to a mismatch between the need of long-term monitoring programs and the emergency of taking conservation actions. To shorten this distance, we provide a framework to test the compatibility of short observed changes with expected ecological stability of a reference population. This framework will introduce a complementary index to help understand the observed trends.

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### **Beetles (Coleoptera) are more than just inefficient mess-and-soil pollinators**

**Presenter:** David Peris

**Affiliation:** Institut Botànic de Barcelona, CSIC-CMCNB

**Authors:** David Peris

Beetles (Coleoptera) are often characterized as inefficient or incidental “mess- and-soil” pollinators: flower visitors that pollinate flowers while damaging them. However, growing evidence reveals their substantial and ancient role in the evolution of plant pollination systems. An estimated 20% of about 400,000 species of beetles (Coleoptera) are flower visitors. Cantharophilous plants exhibit traits—such as robust floral structures, thermogenesis, and strong, often spicy or fruity scents, protogynous flowers—specifically suited to beetle visitation. Beyond their contributions to basal angiosperms, beetles also participate in the pollination of economically significant crops. But more importantly, as one of the earliest insect lineages to interact with flowering plants, beetles have driven key floral adaptations through their diverse feeding behaviors, sensory ecology, and morphological variation. These findings highlight the complexity of beetle–flower mutualisms and underscore the importance of reevaluating beetles not as inefficient pollinators, but as key evolutionary agents that have shaped modern pollination ecology.

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### **Real world open pollinator communities shapes plant–pollinator networks across land-use gradients**

**Presenter:** Nerea Montes Pérez

**Affiliation:** Estación Biológica de Doñana - CSIC

**Authors:** Nerea Montes-Perez, Francisco Rodriguez-Sanchez, Ignasi Bartomeus

Over recent decades, agricultural intensification and habitat fragmentation have become major drivers of declines and local extinctions. Understanding how these pressures affect ecological dynamics is particularly crucial for plant–pollinator interaction networks, which sustain the essential ecosystem service of pollination. Previous research has shown that land- use intensification reduces plant and pollinator abundance and diversity, often favouring generalist species. Yet most of these studies typically treat communities as closed systems where species cannot be replaced after disturbance. This assumption may underestimate the capacity of ecological communities to persist and buffer environmental change. Here, we investigate how plant and pollinator abundance, species richness and key network properties shift along an agricultural gradient and compare these responses to expectations under a hypothetical closed-community scenario. We sampled plant–pollinator networks over one season across 30 sites spanning a land-use gradient in the Doñana Protected Area. Our study provides a framework to disentangle how community turnover and network reconfiguration contribute to the resilience of pollination systems in human-modified landscapes.

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## Alpine & Montane Ecology

### Reproductive strategies in plants of temperate and tropical alpine orobiomes

**Presenter:** Alptekin Koc

**Affiliation:** Charles University

**Authors:** Alptekin Koc

Pollinator composition varies considerably between tropical and temperate alpine areas. Due to the continuous vegetation period in the tropical alpine and them on average existing at higher altitudes than temperate alpine regions, their invertebrate pollinator density is far lower and mostly consists of flies. For temperate alpine habitats during the summer, their pollinator density is higher with a more varied pool of available pollinators than for the tropical counterpart. The question is: How do plants cope with these conditions? Plants do not always depend on pollinators for their sexual reproduction. They can also be completely autonomous by being selfers or even apomicts. With the differences in pollinators in mind, it would be assumable that there could be more autonomous species present in the tropical alpine compared to the temperate alpine. I investigated this aspect by doing pollination experiments of different treatments in the field in the tropical Andes and the temperate alpine Rocky Mountains. The resulting seed sets I used to determine if pollinators are essential for the local plant species reproduction and if they are pollen limited. The results can help with establishing focused conservational efforts for certain pollinator groups in these unique habitats.

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## Altitudinal variation in floral allometry and its relationship with pollinators along an altitudinal gradient of the tropical Andes of Bolivia

**Presenter:** Andrés Romero-Bravo

**Affiliation:** Lund University

**Authors:** Andrés Romero-Bravo, Øystein H. Opedal and Sissi Lozada-Gobilard

Flower traits are shaped by breeding systems and the biotic and abiotic factors defining the pollinator environment and may thus vary along environmental gradients. Environmental variation along altitudinal gradients is often associated with changes in plant and animal diversity, making such gradients ideal systems to study variation in flower traits and their relationship with pollinators. We measured flower traits related to advertisement and pollinator fit in 60 plant species and recorded their legitimate pollinators along an altitudinal gradient (400–4400 m) in the tropical Andes of Bolivia. Flower traits included flower size (advertisement), entrance diameter, flower length and anther-stigma distance (fit). We tested the intra-floral modularity hypothesis which predicts that traits regulating fit tend to be more canalized than those involved in advertising. Specifically, we asked whether canalization varies along the studied altitudinal gradient and across different groups of pollinators. To do so, we compared the allometric relationships of advertisement vs fit traits. Preliminary results show that fit traits are indeed more canalized without any significant change along the environmental gradient or pollinator groups, although bee-pollinated flowers seem to be more canalized than those relying on other pollinator groups, especially birds.

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## The importance of aiming high: bee diversity in the canopy of

a tropical montane forest

**Presenter:** Claudia Vigano

**Affiliation:** Freiburg

**Authors:** Clàudia Massó Estaje, Anne Chao, Jörg Müller, Alice Claßen, Ingolf Steffan-Dewenter

In the tropics, canopy tree species rely disproportionately on large Hymenoptera for pollination, but few studies have been designed to survey bees. This lack of data is likely due to the difficulties of sampling dense forest layers and reaching the canopy. In our work, we used tree-climbing techniques to access the canopy of a tropical montane forest in southern Ecuador.

There, at about 25 meters above the ground, on the branches of ten *Handroanthus chrysanthus* individuals, we placed non-scented blue vane traps to capture the diversity of bees attracted to the flowers of this mass-flowering species. Active on alternate weeks for 18 months, the traps collected the first documented records of bee diversity for the area. Of more than 2,000 individuals sampled, captures were dominated by Euglossini males. In addition, traps placed below the canopy layer, at around 10 meters, performed significantly worse, capturing ten times fewer individuals than the canopy traps. Our results show that even in mega-diverse forests, canopy bee assemblages can be dominated by a surprisingly narrow group of taxa. This underscores the ecological importance of accounting for vertical stratification and species' niche preferences when surveying tropical bee communities, which is essential for guiding conservation strategies.

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### High altitude pollinators

**Presenter:** Helena Pijálková

**Affiliation:** Faculty of Science, Charles University

**Authors:** Helena Pijálková, Tadeáš Ryšan, Lucie Holzbachová, Jakub Štenc, Alptekin Koc, Shannon Serpa, Nyika Campbell, Petr Sklenář, Álvaro Barragán, Sisimak Duchicela, Jiří Hadrava

Our present study compares two areas belonging to the Cordillera mountain range. Our aim is to provide an insight into the composition of pollinators, and which predictors might affect the seasonal variability in the pollinator communities. The alpine environment hosts many kinds of flowers, many of which rely on insect pollinators. Yet pollinators of alpine environments remain historically understudied, especially in the tropics. In the tropical Andes, highest altitudes are cold and windy, with temperatures at night falling below 0 °C. However, these conditions remain relatively stable throughout the year, with most prominent changes being driven by the seasonal differences in precipitation (rainy vs. dry season). In contrast, temperate alpine environment of Colorado Rocky Mountains has very short vegetational season, of about three months, when the biota must reproduce rather quickly. During this time of the year, the temperatures often exceed 15 °C. Due to these differences, we can expect both alpine environments to have very different pollinator communities. Both areas were dominated by the Diptera, however the changes in insect composition throughout the seasons differs greatly between the two areas, as a consequence of seasonal fluctuations in climate conditions and availability of floral sources.

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## Bee sampling methods along a tropical elevational gradient

**Presenter:** Pedro Alonso-Alonso

**Affiliation:** JMU Würzburg University (Germany)

**Authors:** Alonso-Alonso, Pedro

Despite their relevance as pollinators, bees (Hymenoptera: Anthophila) are not frequently sampled in the wet tropics, where bee research is mostly taxonomical, leaving ecology often aside. In the Neotropics, two groups have got most of the attention, Euglossini and Meliponini, due to their abundance, but also because ecologists know how to catch them. Most methods for collecting bees have been tested in temperate ecosystems and applied in tropical forests without testing their efficiency. We studied bees along an elevational gradient in SE Peru, in the tropical Andes aiming to understand the environmental drivers behind their diversity and abundance patterns. During 11 months of fieldwork, we completed 3 rounds of sampling in 26 locations. We covered the whole gradient from the open Polylepis woodland at 3500 to the lush amazonian Terra firme forests at 230 m asl. To optimize the bee sampling we used multiple methods, catching bees actively during transect-walks and attracting them with scents and also passively using different kinds of traps. Here we discuss the success of the different methods used to collect bees in the different kinds of forests found in the elevational gradient of the eastern slope of the tropical Andes.

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## Comparison of Mountain Pollination in Ecuador and the Colorado Rocky Mountains

**Presenter:** Tadeáš Ryšán

**Authors:** Tadeáš Ryšán, Helena Pijálková Lucie Holzbachová, Jakub Štenc, Shannon A. Serpa, Alptekin Koc, Petr Sklenář, Álvaro Barragán Nyika Campbell, Sisimak Duchicela, Jiří Hadrava

Mountain ecosystems impose environmental constraints, including temperature fluctuations, steep topography, and variable resource availability. Despite these challenges, they support communities with remarkably high biodiversity and a high degree of endemism. Adaptation to environmental adversity is a key driver of this diversity: species that persist in mountains must develop a range of physiological and ecological traits, from generalism to narrow specialism. But how do these environmental constraints influence the pollination relationships between plants and their pollinators? Do pollinator networks in tropical paramo, which have relatively stable climates but complex topography, tend to be more diverse and specialized than those in temperate mountains with shorter growing seasons, or is the opposite true? In our research, we investigated flowering plant and pollinator communities throughout the flowering season using pollination transects at Pichincha Volcano in Ecuador and Niwot Ridge, Colorado, USA.

Our goal was to determine how pollinator networks are structured and how they are influenced by the unique environmental challenges of high-mountain ecosystems. Using the pollination snapshot method, we recorded several thousand interactions over the entire growing season, exposing to different environments, so it can be triggered by both biotic and abiotic factors. A typical plastic response in plants occurs in response to herbivore attack with the induction of defenses, but the role of the herbivores as modulators of the plastic response of the plant to abiotic conditions has been seldom studied. In this study, we experimentally explore the effect of damage by florivores and folivores on the occurrence and intensity of floral phenotypic plasticity of *Moricandia arvensis* (Brassicaceae) under two contrasting abiotic conditions. In nature, this mustard species blooms in two contrasting environments, facing mild and wet conditions during spring, and hot and dry during summer. In response to these environmental changes, the same individual is plastic for floral traits. Our preliminary results show that plants attacked by each type of herbivores retain the capacity to flower during summer conditions, expressing plasticity for floral traits. These herbivores limit the plastic response of the plant to the abiotic conditions. This study highlights the complex interaction between biotic and abiotic stressors and their combined effect for the evolution of plasticity in *M. arvensis*.

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## Global Change: Climate, Pollution & Long-term Trends

### Resilience and Recovery of Floral and Nectar Traits under Acute Heat Stress

**Presenter:** Alba Edwards

**Affiliation:** University of Sussex

**Authors:** Alba Edwards, Lucy Unwin, Maria Clara Castellanos

Climate change is driving more intense and prolonged heatwaves, imposing acutely stressful conditions on organisms and ecosystem interactions. During heatwaves, flowering plants exhibit weakened physiological function and disrupted reproductive development. Thermal stress can further diminish the production of floral nectar, which is essential to pollinator attraction. As a consequence, heat-associated reproductive losses can have significant consequences for both wild and crop plants, which are vital for maintaining ecological stability and ensuring food security. In this study, I investigated the impacts of simulated heatwaves on floral and nectar traits in the common bean (*Phaseolus vulgaris*). Results here indicate that heatwaves can significantly alter flower and nectar production in the species. Exposure to an extreme 2-day heatwave (daytime 33°C) caused significant reductions in floral output, flower size, nectar volume and sugar concentration, with the latter of these traits expressing slow and incomplete recovery. These findings highlight how even short-lived severe heat events can negatively modify floral nectar traits, with prolonged effects. Future studies should adopt field-focused

approaches to address the outcomes of these diminished floral resources on pollinator foraging, to more intricately determine the consequences of acute heatwaves on plant reproductive success.

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### **Dedusting herbarium stigmas to uncover historical changes in plant–pollinator interactions**

**Presenter:** Macarena Marín Rodulfo

**Affiliation:** University of Granada

**Authors:** Macarena Marín-Rodulfo<sup>1</sup>, Ana Teresa Romero<sup>1</sup>, Angela Cano García<sup>1</sup>, Carmen Quesada<sup>2</sup>, Rocío Pérez-Barrales<sup>1</sup>

Herbarium collections have become invaluable archives for understanding ecological and evolutionary processes through time. In this study, we explore a novel use of herbarium material to analysing pollination interactions by examining pollen grains on stigmas in specimens of two *Linum* species with contrasting pollination systems, the generalised *L. narbonense* and the specialised *L. suffruticosum* s.l., collected across the Iberian Peninsula since 1899 to 2022. We sampled flowers from sheets from major Spanish herbaria (MA, BC, VAL, SEV, GDA) and store them in alcohol 50% to hydrate stigmas. Then, stigmas were mounted in fuchsin-stained glycerine jelly for microscopic observation and observed under x10 magnification to identify pollen grains to determine intraspecific pollen and heterospecific pollen at the family or morphotype level. Statistical analyses (GLMMs) using biodiversity indices reveal patterns of variation in pollen transfer and community composition through time and space and confirmed the magnitude of pollination specialization of the species under study. This study provides unprecedented insights into the historical dynamics of pollination interactions, as well as methodological basis for future studies using herbaria to investigate biotic interactions, contributing to the broader understanding of pollination ecology.

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### **Monitoring Biodiversity in the Genomics Era: Using herbaria to assess genetic diversity trends across time**

**Presenter:** Melissa Viveiros Moniz

**Affiliation:** University of Granada

**Authors:** Melissa Viveiros-Moniz, Ana García-Muñoz, Luis Matias, Mohamed Abdelaziz, Juan Viruel, A. Jesús Muñoz-Pajares

Climate change is having far-reaching consequences on all living beings, altering ecosystems, habitats, and biodiversity worldwide. Species distributions are shifting, with alpine plant species being particularly threatened. Traditional monitoring based on individual counts produce delayed signals of biodiversity loss and overlook the fact that genetic diversity is the fundamental basis for evolutionary processes. Here, we draw attention to the use of genetic diversity in monitoring schemes to anticipate negative trends in biodiversity by applying two fundamental methodologies: genomics and the use of herbarium specimens. Genomic approaches provide a vast amount of data without requiring previous knowledge of the organism, making them suitable for non-model species. Meanwhile, herbaria serve as excellent sources of plant material for comparative studies across time with their chronologically recorded collection data. Building on these approaches, we investigated temporal patterns of genetic diversity in endemic alpine plant species from Sierra Nevada, a region highly vulnerable to climate change. By combining next-generation sequencing with genomic analyses, we were able to estimate genetic diversity metrics for each taxon and track changes over time. Our study highlights the potential of combining genomics and historical collections to inform conservation strategies in the face of rapid environmental change.

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### **Effects of climate variability and landscape modifications on the long-term stability of butterfly communities and their pollination interactions**

**Presenter:** Olivia Gardella

**Affiliation:** IMEDEA - CSIC

**Authors:** Olivia Gardella, Pau Colom, Constantí Stefanescu, Jordi Corbera, Laura Blas & Amparo Lázaro

Understanding how climate and land-use changes affect pollinators and their interactions with plants is crucial for predicting ecosystem responses to anthropogenic pressures. Yet, the mechanisms underlying the stability of communities and interactions remain poorly understood. We assessed the effects of climate variability (mean and SD of annual temperature) and landscape modifications (% natural areas and landscape heterogeneity within 2-km buffers) on temporal community stability, species synchrony, and variance ratio (community variance/sum of population variances) of butterfly communities and interactions, using 30-year data from seven butterfly communities of the Catalan Butterfly Monitoring Scheme. Stability metrics, along with landscape and climate variables were calculated per site within 5-year windows across data series. We also considered species and interaction diversity as internal properties linked to stability. The percentage of natural habitats in the landscape promoted butterfly community stability, while temperature variability emerged as the main external driver of interaction instability. Furthermore,

landscape heterogeneity reduced interactions' variance ratio, suggesting that heterogeneous landscapes enhance interaction stability by reducing covariances among interactions. Notably, species and interaction stability strongly increased with diversity. Our findings highlight biodiversity's pivotal role in sustaining community stability and ecosystem functions, while cautioning against the destabilizing effects of climate change and land-use pressures.

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### **Three decades of butterfly–plant interaction turnover explained by climate and species loss**

**Presenter:** Pau Colom

**Affiliation:** CREAM

**Authors:** Pau Colom, Constantí Stefanescu, Jordi Corbera & Amparo Lázaro

Understanding the mechanisms behind interaction turnover over long-term periods is essential to predict how ecological networks respond to global change. We used a high-resolution dataset of butterfly–plant interactions spanning 13–29 years in seven Mediterranean communities to assess how climate fluctuations and community shifts shape interaction turnover and its components—species turnover and rewiring. Early in the time series, rewiring explained most interaction turnover, but its influence declined as species loss reduced the pool of shared partners between years. Consequently, species turnover became increasingly dominant, even though communities shifted toward butterfly species with generalist traits that promote rewiring. Nevertheless, rewiring intensified in years with stronger temperature fluctuations, when populations experienced greater shifts in phenology and abundance and were more likely to rewire. In the context of biodiversity loss, species turnover increasingly governs interaction dynamics, while the short-term flexibility provided by rewiring may collapse as communities become impoverished.

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### **Vulnerability of Oromediterranean pastures to ozone pollution and atmospheric nitrogen deposition: experimental approaches for analysing impacts on atmosphere-plant-insect interactions**

**Presenter:** Sara Campos Saelices

**Affiliation:** CIEMAT

**Authors:** Campos-Saelices, S., Prieto-Benítez, S., Bermejo-Bermejo, V., González-Fernández, I. & Cabrero-Sañudo, F.J.

Increased tropospheric ozone (O<sub>3</sub>) and atmospheric nitrogen (N) deposition are two environmental problems affecting high-mountain Mediterranean pastures. When both factors are considered, the critical thresholds defined for vegetation protection are exceeded in the area, constituting important stress factors for these communities. While few experimental O<sub>3</sub>-effects on the vegetative growth of species of these plant communities have been observed, its impact on flowering-related variables and reproductive capacity has been demonstrated. N-deposition can also affect pasture communities by altering their structure and species composition, as well as by modulating their O<sub>3</sub>-response. This thesis project presents an experimental design to investigate how an Oromediterranean pasture community, consisting of seven representative species, responds to the interaction between O<sub>3</sub> x N, considering four O<sub>3</sub>-levels, ranging from pre-industrial background values to those predicted throughout this century; and two N-levels, reproducing the ranges in the area. The experimental assay will be carried out at the CIEMAT Open Chamber Facility. The effects on variables related to growth and physiology will be analysed, especially those related to plant-pollinator relationship. Floral characteristics relating to pre- and post-pollination will be analysed, as well as pollination and floral-visitation rates. The effects on life expectancy and insect growth will be analysed using experimental pollinators.

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## Applied Pollination Ecology

### Monitoring pollinators in the long term: the example of butterflies and the European Butterfly Monitoring Schemes

**Presenter:** Constanti Stefanescu

**Affiliation:** NATURAL Sciences Museum of Granollers

**Authors:** Constantí Stefanescu and Andreu Ubach

In a world fully affected by global change, robust data are needed to diagnose with certainty trends in biodiversity and, very particularly, in the different groups of pollinating insects. In this context, butterflies have emerged as a model group with an enormously popular methodology for accurately monitoring populations on a large scale, the so-called Butterfly Monitoring Scheme. Based on a simple census method that has allowed these projects to be based on citizen science, BMSs have been implemented in most European countries and have become a very powerful tool for documenting trends in butterfly populations on the continent. These databases allow us to explore key aspects such as the impact of landscape change, local-scale management and climate change on these insects. With additional effort, it is also possible to obtain information about the mutualistic networks of butterflies and flowers, and how they change over time. This talk uses the Catalan BMS to exemplify some of these aspects. With

32 years of data, 193 butterfly species and more than 4 million individuals counted, it has become a reference for studying how Mediterranean ecosystems are changing. We conclude by exploring new horizons to include other pollinator groups in monitoring programs.

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### **Do spontaneous ground covers conserve wild pollinators and enhance crop pollination in apple orchards from northern Spain?**

**Presenter:** Ángel Plata Sánchez

**Affiliation:** Departamento Biología de Organismos y Sistemas, Universidad de Oviedo and Instituto Mixto de Investigación en Biodiversidad (CSIC-Uo-PA), Oviedo, Asturias, Spain

**Authors:** Ángel Plata, Teresa Moran-López, Marcos Miñarro, Daniel García

Promoting non-crop habitats in agroecosystems, such as ground cover vegetation within crops, may enhance pollinator abundance and diversity by providing resources that crops lack. These habitats may support broad pollinator conservation and supply pollinators that spill over to crops during bloom, enhancing pollination. However, they may also compete with crops for pollinators. Spill-over and retention can operate simultaneously, making them difficult to distinguish through approaches based on species occurrence. Apple orchards offer a valuable model for evaluating these processes, as apple yield depends on both pollinator abundance and diversity. In northern Spain, climatic conditions allow spontaneous ground cover vegetation to persist most of the year with minimal management, offering a cost-efficient opportunity for growers to promote ground covers. However, it remains unclear whether such ground covers effectively conserve wild pollinators and enhance apple pollination. Here, we characterize flower and pollinator communities in spontaneous ground covers of twenty-six Asturian apple orchards before, during, and after apple bloom, and compare them with pollinators visiting apple flowers. We then assess how flower abundance and diversity in ground covers shape pollinator communities both within the covers and on apple trees. Finally, we discuss approaches to infer whether ground covers drive pollinator spill-over and/or retention.

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### **Assessing nesting patterns of *Osmia* spp. in almond orchards across contrasting landscape contexts**

**Presenter:** Gabriel Arbona Taberner

**Affiliation:** Universitat de les Illes Balears

**Authors:** Gabriel Arbona, Cayetano Herrera, Andreu Juan, Anna Traveset, Mar Leza

The decline of wild pollinators threatens crop production, emphasizing the need to diversify pollination services beyond the managed honeybee. Solitary *Osmia* bees are promising alternative pollinators for early flowering crops due to their high foraging efficiency, ease of management, and the possibility of synchronizing their emergence with crop bloom. This study aimed to obtain *Osmia* cocoons from wild populations inhabiting almond orchards across Mallorca, representing contrasting landscape contexts, to examine the structural and ecological characteristics of their nests. Nesting aids made of natural reed bundles (300 cavities per site) were installed in 15 orchards. After the flight season, reeds were dissected and nest traits recorded. Nests and cocoons with distinct morphologies were detected. In total, 180 nests and 492 *Osmia* cocoons were obtained, with mixed-context orchards showing the highest occupation. Most nests were built in 6-mm reeds, though typically less than half of the cavity length was used. Nests with fewer than seven cells exhibited less consistent patterns in cell size and cocoon weight. Statistical analyses revealed that nest features and the presence of cleptoparasitic larvae had stronger effects on cocoon presence than landscape variables. These results provide key insights for optimizing *Osmia*-based pollination in almond orchards.

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### **Widespread pollination deficits in pear (*Pyrus communis* L.) orchards: the role of pollinators, landscape context and pesticide risk**

**Presenter:** Lucia Lenzi

**Affiliation:** University of Bologna

**Authors:** Lucia Lenzi, Arnau Xavier, Jordi Bosch, Adele Bordoni, Laura Zavatta, Serena Magagnoli, Agata Morelli, Fabio Sgolastra

European pear (*Pyrus communis* L.) is an important entomophilous crop, and most varieties are self-incompatible, therefore strongly dependent on insect pollinators. However, harsh conditions during bloom and low sugar content of nectar often lead to low pollinator visitation rates, causing shortfalls in production. Our aim was to assess pollination services, detect pollination deficits in pear orchards and analyze the effects of local factors (pesticide load, orchard management) and landscape factors (“pollinator-friendly” cover) on pollinators and pollination services. Our results confirm the dependence of fruit set on pollination (mean 37%). We also report significant pollination deficits across pear orchards (mean 31%), and low pollination service (mean 17%). Most flower visitors were honeybees and Diptera Muscidae, while wild bees were the least abundant group. However, “pollinator-friendly” cover (1.5 km) positively influenced wild bees’ visitation rate. Pollinators had no effect on pollination deficit, but higher bumblebee visits negatively affected seed set. Pear flowers were contaminated with at least four pesticides, and pesticide risk had a negative effect on fruit set. Our results indicate insufficient pollination services in pear orchards and raise concerns about the management of

pollination provision, highlighting the importance of semi-natural areas to boost wild bee visits and reduce pesticide pressure on pollinators.

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## Urban Pollination Ecology

### Thermal buffering ability of butterflies across urban and natural environments

**Presenter:** Ashley Tejeda Meneses

**Affiliation:** University of Barcelona

**Authors:** Ashley Tejeda Meneses, Pau Colom Montojo, Andrew Bladon & Yolanda Melero Cavero

Urbanization alters microclimates, potentially affecting pollinator activity and plant–pollinator interactions. We examined whether the thermoregulation of butterflies, key pollinators in Mediterranean ecosystems, is affected by urbanization. Specifically, we test if urban populations exhibit enhanced thermal buffering ability compared to natural ones, and whether this capacity predicts species persistence in cities. We conducted field surveys in urban parks and surrounding natural areas in Barcelona, recording air and thoracic temperature of butterflies, to quantify thermal buffering ability across species and populations. We did this during their flight period in the bioclimatic region (March–October) over two years. Preliminary analyses suggest inter- and intraspecific differences in thermal buffering. Some species show enhanced thermoregulation in urban areas, while others appear more vulnerable to urban heat. Variation between populations of the same species also indicates possible local adaptation or plasticity. Our results indicate that behavioral thermoregulation is a crucial mechanism for coping with urban heat islands and a key filter determining which butterfly species can thrive in them. Such information can help prioritize conservation actions and guide the management of urban green spaces. Understanding these patterns helps predict changes in pollination dynamics under urban warming, as butterfly activity influences floral visitation and plant reproduction.

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### Integrating conservation and public engagement through pollinator gardens: lessons from the Botanical Garden of Bologna

**Presenter:** Marta Barberis

**Affiliation:** University of Bologna

**Authors:** Marta Barberis, Fortunato Fulvio Bitonto, Nicola Herrmann Lothar, Ioannis Mondin, Costanza Viglianisi, Mariacristina Laureti, Martina Capacci, Silvia Del Vecchio, Umberto Mossetti, Laura Bortolotti, Annalisa Managlia, Marta Galloni

Pollinators play a crucial role in maintaining biodiversity and ensuring the productivity of natural and agricultural ecosystems. However, over the past decades, they have been declining due to habitat loss, pesticide use, and climate change. The implementation of pollinator gardens represents an effective action for restoring urban green spaces while raising public awareness about the topic. An example is represented by the Pollinator Garden established at the Botanical Garden of Bologna as part of the LIFE 4 Pollinators project (LIFE18 GIE/IT/000755). It includes nearly 80 nectar-rich species selected to ensure continuous floral resources throughout the seasons, organized in flowerbeds representative of the main floral morphologies (*sensu* Faegri and Van der Pijl). During the first two years following establishment, flower-insect interactions were monitored weekly from March to December by walking a transect running along the perimeter of each flowerbed. The no. of recorded interactions was 6868, observed during 78 monitoring days. Alongside, the total number of pollination units per plant was counted, for a total no. exceeding 124,000. Comparison of network indices revealed increased connectance, links per species, and nestedness. Here, we present the results obtained from network analysis, the concept beyond design, as well as challenges and opportunities encountered.

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## Citizen Science

### Easy pollinator learning with PreguntadoR

**Presenter:** Esther Funes-Ligero

**Affiliation:** Universidad de Granada (UGR)

**Authors:** Esther Funes-Ligero, Mohamed Abdelaziz, A. Jesús Muñoz-Pajares.

Learning how to identify pollinators is often hard for students. This key skill usually requires lot of time from teachers and repeated trips outside. To fix this problem in learning taxonomy, we created PreguntadoR, a special app built entirely with R for interactive learning. PreguntadoR takes the tough job of learning insect body parts and makes it quick and fun. We designed it to give users a structured, but very adaptable, place to gain both basic and advanced knowledge. The app uses game-like features with its different settings and personalized exercises. When users practice with specific tasks, they see the important visual signs and classification groups they need for correct identification over and over. This system makes sure the key differences in shapes stay in their memory fast. So, PreguntadoR serves as a

strong digital helper for teachers, supporting classes and independent study, and opens up the complex world of pollinator taxonomy for everyone.

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## Using Citizen Science to Expand Plant-Animal Interaction Data in the Pyrenees

**Presenter:** Oriane Hidalgo

**Affiliation:** Institut Botànic de Barcelona

**Authors:** Iván Pérez Lorenzo, Leonardo Platania, Luis Palazzesi, Jaume Pellicer, Oriane Hidalgo

Plant-animal mutualisms have strongly shaped the evolutionary trajectories of both lineages, yet research often centers on conspicuous pollination systems (e.g., orchids) and narrow spatio-temporal scales (e.g., single-site daytime monitoring). This bias is acute in the megadiverse, globally distributed family Asteraceae, perceived as generalist. In this context, citizen-science platforms could offer a complementary source of observations, though their usefulness for interaction ecology needs careful evaluation. Here, we assess the value of citizen-science records for studying interactions between Asteraceae and invertebrates (inc. Insecta, Arachnida and Gastropoda) in the Pyrenees. We built a curated dataset combining iNaturalist observations with targeted field sampling at monitored sites, currently encompassing c. 14,000 records of plant-animal interactions. We describe the taxonomic composition and spatial distribution of the dataset, and identify common sources of bias. We also illustrate practical applications, including generating reference lists of invertebrate species for training automated identification tools, and constructing plant-animal interaction networks. Our results show that reviewed citizen-science observations, when complemented with focused fieldwork, can substantially increase the amount and diversity of interaction data available. This integrated approach provides an efficient way to improve biodiversity monitoring and to support plant-focused analyses of interaction networks at multiple scales.

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## Pollination, herbivory, microbiota and pathogens

### Developing Functional Profiles for Wild and Managed Pollinator Gut Microbiomes

**Presenter:** Christian Gostout

**Affiliation:** BC3 Basque Center for Climate Change

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The gut microbiome of wild pollinators plays an important role in pollinator health and resilience. The composition of pollinator gut microbiota has been characterized using metabarcoding, and more recently, metagenomic approaches for a limited number of species, especially commercially used pollinators. These approaches have allowed the observation of changes in the composition of the gut microbiome in response to certain environmental factors, but the implications of these changes for gene expression and metabolic pathways, and in turn, pollinator health, are virtually unknown. We move beyond studies focused on the composition of gut microbiomes to focus on their functions using metatranscriptomic analyses of RNA extracted from the gut of the wild pollinator, *Bombus pascuorum*, and the managed species, *Apis mellifera*. We show that taxonomic profiles can be used to make initial inferences of function, and that metatranscriptomics can confirm functional expression. Across 122 specimens, we detected an overrepresentation of gene expression transcripts linked to specific metabolic pathways, including the breakdown of sugars and complex polysaccharides. Our study expands microbiome functional studies to wild pollinators, and creates new commentary on their interactions with managed species. We present an initial perspective on our study approach and outlook, including a look at preliminary results.

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## Pathogen Transmission Through the Bee–Flower Network in Urban Ecosystems

**Presenter:** Giovanni Cilia

**Affiliation:** CREA-AA

**Authors:** Giovanni Cilia, Dario Scalambra, Rosa Ranalli, Laura Zavatta, Marta Galloni

Urban environments, with their concentrated floral resources and complex pollinator communities, create plant–pollinator–pathogen networks that can facilitate pathogen transmission. This study investigated these interactions in two urban parks in Northern Italy by sampling wild bee females, their pollen loads, and the last visited flowers (377 samples per matrix, April–September 2024). Molecular analyses revealed that pathogens were deeply surrounded within the network structure: DWV (45.2%) and *Nosema ceranae* (41.3%) circulated across bees, flowers, and pollen, confirming the bidirectional movement of pathogens through shared floral resources. DWV reached 73.3% prevalence in bees and loads of  $3.6 \times 10^{12}$  copies, while *N. ceranae* was most common on flowers (41.5%) and in pollen (38.7%), indicating that flowers act as persistent environmental reservoirs. Seasonal patterns showed increased prevalence in bees during warm periods but stable pathogen abundance in flowers and pollen, suggesting continuous environmental contamination even when bee infection levels fluctuate. Pollen identification reconstructed individual foraging networks, revealing that bees visiting a richer

diversity of plant species had lower probabilities of pathogen presence and co-infection. Overall, these findings demonstrate that urban plant–pollinator networks function as tightly interconnected systems for pathogen exchange, highlighting the need to integrate pollinator health into urban ecological planning.

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### Unmasking microbial associations behind insect-attractant scents in the mucilage droplets of sticky carnivorous plants

**Presenter:** Celia Vaca Benito

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Nectar-dwelling microbes modify the floral scents that attract insect pollinators <sup>1,2</sup>. Similar to floral nectar, the mucilage droplets on the leaf-traps of sticky carnivorous plants (e.g., *Drosera*, *Drosophyllum*) emit olfactory signals – often mimicking floral or fruit scents – to lure prey insects <sup>3</sup>. Although bacteria and fungi have been documented in the mucilage of sundews (*Drosera* spp.) <sup>4</sup>, the microbiome of *Drosophyllum lusitanicum* has not been examined, nor has the potential contribution of these microbes to leaf-trap scent. We investigated the mucilage microbiomes of *Drosophyllum lusitanicum* (nine populations) and two *Drosera* species, *D. intermedia* (six populations) and *D. rotundifolia* (three populations), using metabarcoding of the 16S rRNA gene (bacteria) and the ITS region (fungi). We also characterized their volatilomes (volatile organic compound profiles) using direct thermal desorption–gas chromatography/mass spectrometry (TD-GC/MS) <sup>5</sup>. To assess links between scent profiles and microbial communities, we applied co-inertia analyses comparing PCoA ordinations of the bacterial and fungal datasets with those of the volatilome across all 18 populations. We found a significant common structure between the microbiome and the volatilome for fungi, but not for bacteria, suggesting that fungi may play a more prominent role in shaping the luring scent of the mucilage droplets in sticky carnivorous plants.

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### How do herbivores modulate floral phenotypic plasticity to abiotic conditions?

**Presenter:** Violeta Quiroga Álvarez

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Phenotypic plasticity is the ability of a genotype of producing alternative phenotypes when exposing to different environments, so it can be triggered by both biotic and abiotic factors. A typical plastic response in plants occurs in response to herbivore attack with the induction of defenses, but the role of the herbivores as modulators of the plastic response of the plant to abiotic conditions has been seldom studied. In this study, we experimentally explore the effect of damage by florivores and folivores on the occurrence and intensity of floral phenotypic plasticity of *Moricandia arvensis* (Brassicaceae) under two contrasting abiotic conditions. In nature, this mustard species blooms in two contrasting environments, facing mild and wet conditions during spring, and hot and dry during summer. In response to these environmental changes, the same individual is plastic for floral traits. Our preliminary results show that plants attacked by each type of herbivores retain the capacity to flower during summer conditions, expressing plasticity for floral traits. These herbivores limit the plastic response of the plant to the abiotic conditions. This study highlights the complex interaction between biotic and abiotic stressors and their combined effect for the evolution of plasticity in *M. arvensis*.

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