SCAPE 2023

37th Annual Meeting of the Scandinavian Association for Pollination Ecology

19-22 October 2023

Domain de Mozet
Rue du Tronquoy 2
5340 Mozet
Belgium

Organizing committee

- **Carolin Mayer**
  Journal of Pollination Ecology & Institute of Life, Earth and Environment, UNamur
- **Maxime Eeraerts**
  Forest and Nature Lab, UGhent
- **Renate Wesselingh**
  Earth & Life Institute, UCLouvain

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Venue map


vers la plaine de jeux
prairie
Sauna & bonfire
barbecue
sapinière
Registration
Conference room
Posters
terrain de foot
parking
nichoir
prairie
jardin
terrain de basket
tour XIe scle
hêtre
cabane
mini-ferme
nichoir
hêtre
Dining room
tri déchets
pétanque
terrasse
grotte préhistorique
friche
compost
Red shaded areas: bedrooms
station d'épuration
arrêts TEC ligne 42
vers le village et les grottes de Goyet
ferme Royer
la fermette
nichoir
ruches pédagogiques
feu de camp
rivière le Tronquoy
cabane sur l'eau "parage"

SCAPE 2023 CONFERENCE PROGRAMME

Thursday, October 19

16:00			Registration
			Belgian night (chair: Carolin Mayer)
18:30			Welcome
18:45	Arne Devriese	T1	Differential response of plant and insect pollinator communities to fragmentation in coastal dune slacks
19:00	Ivan Meeus	T2	AskBee: Tailoring garden planting to support bee conservation goals
19:15			Dinner
			Belgian night part 2 (chair: Carolin Mayer)
20:15	Guillaume Ghisbain	T3F	Wild bee conservation in Europe
20:22	Maarten Trekels	T4	Standardizing plant-pollinator data: the case of agricultural biodiversity
20:37	Natasha de Manicor	T5	Simultaneous warming disrupts plant-pollinator mutualisms
20:52	Louella Buydens	T6F	Bee pathogen prevalence within a biodiversity gradient
21:00			Belgian beer, sauna and bonfire

Friday, October 20

7:45			Breakfast
			Pollinators and flower traits (chair: Renate Wesselingh)
8:45	Océane Bartholomée	T7	Warm or bright, an exploration of the morphological traits explaining bumblebee habitat use
9:00	Felicitas Wolf	T8	Effects of altitude and land-use change on pollinator species diversity
9:15	Mathilde Dufay	K1	Evolution of floral traits mediated by pollinators
10:00			30 minute coffee break
			Nutrition and stressors (chair: Klaus Lunau)
10:30	Sara D. Leonhardt	T9F	Can we infer pollen quality and bee nutritional requirements from bee pollen loads?
10:37	Fabian A. Ruedenauer	T10F	Fatty acid profiles of pollen collected by different bee species
10:45	Marielle C. Schleifer	T11	Pollen fatty acids: perception, regulation and fitness effect on honey bees
11:00	Upuli I. Wickramaarachchi	T12	Effects of herbivory-induced stress on pollen quality and bee fitness
11:15	Alexandra Pardo-Domínguez	T13	Susceptibility to insecticides of commercial and wild *Bombus terrestris* subspecies and their hybrids
11:30			30 minute coffee break
12:00	Markus A. Kjær Sydenham	T14	Climatic conditions and landscape diversity predict plant-pollinator interactions and pollen deposition in bee-pollinated plants
12:15	Sangeetha Varma	T15	Dominance and identity of the dominant bee drive bee diversity on flowers
12:30	Olivia Bernhardsson	T16	The impact of honey bee density and apiary proximity on bumble bee foraging behavior depends on landscape-level forage availability
12:45	Bjørn A. Hatteland	T17	Bumble bee communities in open and overgrown heathlands in Western Norway
13:00	Samuel Boff	T18	Pollen diet of mason bees in agricultural areas with varying levels of organic farming
13:15			Lunch (13:30) and break

			Crops (chair: Ivan Meeus)
14:30	Sunayana Sajith	T19	Cost-effectiveness of alternative pollination strategies for strawberries in a protected cropping environment
14:45	Linn Vassvik	T20	Pollen deficits in Norwegian apple orchards
15:00	Paula Prucker	T21	Securing crop fruit set with biodiversity – the effect of wild floral resources on crop pollination under climate change
15:15	Clément Tourbez	T22	Variation in the pollen diet of managed bee species along climate gradient in agro-ecosystems
15:30	Lisa W. DeVetter	T23	Honey bee hive placement affects pesticide exposure but not pollination services in highbush blueberry systems
15:45			30 minute coffee break
			Flowers and Evolution (chair: Stein Joar Hegland)
16:15	Jeff Ollerton	T24	The pollination of flowers by birds: challenges for biologists
16:30	Guilermo Uceda Gómez	T25	Coping with altitude. Pollinator shifts across elevational gradients
16:45	Marianna Kaldra	T26	The 'marriage' of heterostylous plants gets more 'complicated' in an era of habitat loss and fragmentation
17:00	Katarzyna Roguz	T27	Flower coalition: integrated flower roles in Fritillaria persica inflorescence
17:15	Constantin Kopper	T28	Pollination syndromes in Melastomataceae, pollinator shifts and species richness explain patterns of disparity in an ancestrally buzz-bee pollinated family
17:30	Yedra Garcia	T29	Water deficit can change selection on floral traits: insights from the morning glory
17:45	Øystein H. Opedal	T30	The evolution of plant mating systems under fluctuating pollination reliability
18:00			Poster session (odd numbers)
19:00			Dinner
21:00			Sauna and bonfire

Saturday, October 21

7:30			Breakfast
			Conservation and management (chair: Maxime Eeraerts)
8:30	Carolin Mayer		JPE news
8:35	Marianne S. Torvanger	T31	Flower preference determines wild bee distributions along a latitudinal gradient
8:50	Laurian Parmentier	T32	Three-strip management: curved mowing as an innovative management method for perennial margins to enhance pollinator biodiversity
9:05	Reinier de Vries	T33	Pollinator responses to grassland productivity
9:20	Gabriella Bishop	T34	Bumble bees and solitary bees are limited by summer floral resources in agricultural landscapes
9:35			Quick break
			Conservation and management (chair: Maxime Eeraerts)
9:45	David Kleijn	K2	Does managing for pollination produce benefits for pollinator conservation?
10:30			30 min coffee break
			Botany and floral cues (chair: Marcos Mendez)
11:00	James D. Thomson	T35	How strong are links between pollination rates and plant demography?
11:15	Anna E-Vojtkó	T36	Reproductive form and function across South African *Oxalis* species
11:30	Felipe Torres-Vanegas	T37	Do pollinators exert phenotypic selection on floral traits in generalized plant-pollinator interactions? The case of *Viscaria vulgaris*.
11:45	Aarushi Susheel	T38	Insect communities in Italian *Arabis alpina* populations with diverging scent profiles

12:00	Jaakko O. Santeri Soininen	T39	*Geranium sylvaticum* maximizes pollination probability by sexually dimorphic flowers
12:15	Hanna Thosteman	T40	Floral scent and plant defence in *Arabis alpina*
12:30			Lunch and break
13:15			Break/walk
			Monitoring and conservation (chair: Jeff Ollerton)
14:30	Lucie Vézina	T41	Canadian bee-ecology and a changing climate: Distribution and diversity of solitary bees in Canada using DNA metabarcoding and community data
14:45	Aline C. Martins	T42	Contrasting patterns of foraging behavior in Neotropical stingless bees using pollen and honey metabarcoding
15:00	Susanne Butschkau	T43	Unveiling wild bee foraging preferences: Investigating pollen collection with visitation – and DNA-based networks across a land-use gradient
15:15	Will Glenny	T44	Plant selection for pollinator restoration in semi-natural ecosystems
15:30	Astrid E. Neumann	T45	Flower power is not enough: Which garden features affect pollinators in cities?
15:45	Kavya Mohan Nadumthottiyil	T46F	Pollen foraging by native social bees in a southern Indian habitat
15:52	Ola Olsson	T47F	Pollen analysis using automated image recognition and DNA barcoding compared
16:00			Coffee break
			Flower scent and color (chair: Paulo Biella)
16:30	Marketa Applova	T48	Floral economic spectrum traits are correlated with leaf traits: plants with “juicy“ leaves usually have “juicy“ flowers
16:45	Casper J. van der Kooi	T49	Flashy flowers: how glossy colours shine and confuse
17:00	Klaus Lunau	T50	Spectral purity or colour contrast as biologically relevant descriptors of flower colour signals for bees
17:15	Valerie Martin	T51	Scent emissions from a nectar yeast across different floral backgrounds and context-dependent effects of nectar yeast on bumblebee foraging behavior
17:30	Stuart Campbell	T52F	Strong and stable scent? Adaptive and nonadaptive drivers of floral volatile variation
17:40			Poster session 2 (even numbers)
19:00			Dinner
21:00			Sauna, bonfire and party

Sunday, October 21

8:00	Breakfast and goodbye
10:00	First bus to Namur
11:00	Second bus to Namur

KEYNOTE PRESENTATION ABSTRACTS

K1

Evolution of floral traits mediated by pollinators

Mathilde Dufay[1] & Isabelle De Cauwer[2]

[1]CEFE-CNRS, Université de Montpellier; [2]EEP, Université de Lille, France

Floral traits often function as an attractive signal to pollinators and can therefore impact plant reproductive success, through an effect on pollen receipt and/or export. In order to detect these effects of pollinator mediated-selection, and to distinguish it from other evolutionary forces, several methodologies can be used : (i) a description of traits variation (among individuals, among populations, if it applies, between sexual phenotypes), in order to hypothesize possible relationships between such variation in traits and some variation in selective pressures ; (ii) the study of floral traits effects on pollinator behaviour and (iii) selective gradient studies, which investigate correlations between traits and male and / or female individual reproductive success.

In this talk, I will present our research on two insect pollinated plant species that show contrasted life history traits (*Silene dioica*, a dioecious short-perennial with a generalist pollination system and *Chamaerops humilis*, a dioecious long perennial with an extremely specialized pollination system), and I will show how these different methodologies can be complementary for the study of floral traits evolution. We studied selective pressures mediated by pollinators on several traits (size and number of flowers, nectar, flowering phenology... in *S. dioica* ; quantity and composition of scents in *C. humilis*). Our aim was to understand how these selective pressures vary between male and female individuals, and whether they can vary among populations. Among other conclusions, we were able to verify that knowledge of the behavioural response of pollinators to floral traits alone does not always allow us to deduce the effects that these traits may have on the reproductive success of plants.

K2

Does managing for pollination produce benefits for pollinator conservation?

David Kleijn[1] & Jeroen Scheper[1]

[1]Plant Ecology and Nature Conservation Group, Wageningen University & Research, Wageningen, the Netherlands

Seed and fruit set of many crops and most wild plants depends heavily on the diversity of wild pollinator communities that visit their flowers. Because wild pollinator communities are under threat, this has inspired many initiatives that aim to increase wild pollinator diversity, especially in agricultural landscapes. Such initiatives could represent win-wins for biodiversity and farmers. Here we explore under what conditions there are synergies between crop pollination and pollinator conservation. We analyse which species are providing most of the pollination benefits, what their population trends are and whether they benefit from measures on farmland. We furthermore examine whether pollinator enhancing measures are profitable for farmers when the costs of their establishment are taken into account. We conclude that although, across the board, beneficial effects of pollinator enhancing measures in farmland are modest and rarely promote crop yield or the species most in need of conservation, carefully designed measures have the potential to significantly boost pollination and wild pollinators. Uptake of such measures by farmers critically depends on society's willingness to pay for their establishment, however, as they are rarely profitable.

ORAL PRESENTATION ABSTRACTS

T1

Differential response of plant and insect pollinator communities to fragmentation in coastal dune slacks

Arne Devriese[1], Sam Janssens, Rein Brys, Hans Jacquemyn

[1]KU Leuven, Belgium

Habitat destruction and fragmentation are one of the main drivers of pollinator decline and biodiversity loss in general. However, the exact effects of habitat fragmentation on pollinator communities are still poorly understood and it remains unclear which patch characteristics are most important in driving pollinator diversity and community composition. In this study, a total of nineteen fragmented dune slacks were studied to investigate the effects of patch area and connectivity on plant and pollinator diversity and community composition, and to test to what extent plant diversity had an impact on insect pollinator communities. Species richness of both plants and insects was significantly related to patch area, whereas patch connectivity only had a significant effect on plant diversity. Nestedness analyses showed that plant communities of small dune slacks were significantly nested within communities of large patches, but no such effects were found for insect communities. Turnover in pollinator communities was high and significantly related to the distance separating dune slacks. Cumulative species area curves showed that several small habitat patches harbored a higher plant and pollinator diversity than a few large patches, but effects were more pronounced for insects than for plants. However, some pollinator species were preferentially found in large and strongly connected habitat patches. Overall, our results show that protecting a large number of well-connected dune slacks and several large dune slacks will be essential to preserve well developed plant and insect communities and to maintain viable populations of pollinators in fragmented dune systems.

T2

AskBee: Tailoring garden planting to support bee conservation goals

Ivan Meeus[1]

[1]Department of Plants and Crops, Ghent University, Belgium

Eight percent of the surface area of Flanders consists of gardens, this area has potency for supporting rare bees. Furthermore, gardens offer the advantage of targeted intervention, unlike, for instance, Natura 2000 areas where stricter conservation goals for other species and habitat types apply. Through a location-specific approach, we can recommend specific plants for gardens to promote endangered bee populations. This approach should be data-driven, allowing us to identify suitable target species for a specific GPS point: (1) at the local level, we need to determine if the immediate vicinity of the garden is suitable for supporting bees; (2) at the landscape level, we must identify which populations are endangered but still present; (3) at the regional level, we need to make a balanced selection of target species to ensure all threatened species are supported. Once the target species is chosen, we must efficiently recommend the appropriate plants. Again, there are various options to do this, ranging from expert judgment to data-driven choices. With each methods having its own shortcomings and biases depending on available knowledge and databases. Here, I present a look under the hood of the AskBee application, on the choices we made, the weak and strong points, primarily to stimulate discussion on improvements and alternative approaches.

T3Flash

Wild bee conservation in Europe

Guillaume Ghisbain[1], Mira Boustani, Sara Reverté, Paolo Rosa, Denis Michez

[1]Laboratory of Zoology, Research Institute for Biosciences, University of Mons, Mons, Belgium

The current degradation of natural habitats constitutes an unprecedented threat in the history of humanity. One of the consequences of this ecological upheaval is the abrupt collapse of insect populations, a global phenomenon due to a combination of well-established anthropogenic disturbances. Among these declining organisms are wild bees, a group of pollinators ranked among the highest contributors to crop production value globally. In the current context of their large-scale decline, an update of the European Red List of bees is being prepared, in conjunction with an annotated inventory of these organisms at a continental scale. The preparation of updated taxonomic tools, including identification keys, is at the core of the efforts of European experts. In the long run, these projects will provide the necessary tools for an optimal development of knowledge about wild bees on a continental scale and invaluable support for their conservation.

T4

Standardizing plant-pollinator data: the case of agricultural biodiversity

Maarten Trekels[1]

[1]Meise Botanic Garden, Belgium

Gaining a deeper understanding of plant-pollinator interactions can provide crucial insights into the role they play in agrobiodiversity. Both wild and domesticated pollinators are delivering invaluable services to society, ranging from crop reproduction to maintaining healthy ecosystems. Agriculture can have large impacts on species interactions within a certain geographical area. However, many challenges remain in data availability of species interaction data. Although openly published datasets are becoming increasingly available in a standardized way, not all data sources are published as FAIR data. Since species interactions are highly dependent on the context, it is essential to liberate data on the interactions in local circumstances. A lot of the agronomic data is gathered from local initiatives and collaborations (see e.g. Honeybee Valley), which does not always result in the publication of datasets. Other data sources are not necessarily published in a way that they connect to digital knowledge resources, the so-called “dark data”. Essential use-cases in understanding the mechanisms behind interactions are potentially left unexplored. Within the Horizon Europe WorldFAIR project (https://worldfair-project.eu/), we explored the available data and analysed the FAIRness of them. This exercise highlights the need of a more streamlined approach on publishing plant-pollinator data. We also stress the importance of a standardized publishing model and link this to the ongoing efforts at the Global Biodiversity Information Facility (GBIF).

T5

Simultaneous warming disrupts plant-pollinator mutualisms

Natasha de Manincor[1], Alessandro Fisogni, Nicole E. Rafferty

[1]Laboratory of Zoology, Research Institute for Biosciences, University of Mons, Mons, Belgium

Climate change may disrupt plant–pollinator mutualisms by generating phenological asynchronies and by altering traits that shape interaction costs and benefits. Our knowledge is limited to studies that manipulate only one partner or focus on either phenological or trait-based mismatches. We assembled communities of three annual plants and a solitary bee prior to flowering and emergence to test how springtime warming affects phenologies, traits, interactions and reproductive output. Warming advanced community-level flowering onset, peak and end but did not alter bee emergence. Warmed plant communities produced fewer and smaller flowers with less, more-concentrated nectar, reducing attractiveness, and warmed bees were more generalized in their foraging, reducing their effectiveness. Plant–bee interactions were less frequent, shorter and peaked earlier under warming. As a result, warmed plants produced fewer, lighter seeds, indicating pollinator-mediated fitness costs. Climate change will perturb plant–pollinator mutualisms, causing wide-ranging effects on partner species and diminishing the ecosystem service they provide.

T6Flash

Bee pathogen prevalence within a biodiversity gradient

Louella Buydens[1], Niels Piot, Ivan Meeus, NutriB² project partners under the coordination of Sara Leonhardt

[1]Department of Plants and Crops, Ghent University, Belgium

Forage availability may shape pathogen prevalence in wild bees by affecting bee immunity or transmission via shared flower use. Bee pathogens are naturally occurring within populations, but the existing equilibrium may be disrupted due to the introduction of managed bees and reduced flower availability. This may alter the pathogen dynamics within and between bee hosts, which could result in pathogens becoming another driver of wild bee decline. During this project which is part of NutriB² (an EU-BiodivERsA research project), the link between plant diversity - as a measure of flower availability - and pathogen prevalence in wild bee species was investigated. Around 1400 wild bees were sampled during spring and early summer of 2020 and 2021 in 9 different locations in Belgium and 58 locations in Germany along a gradient of plant diversity. Among the species sampled were the solitary bees *Andrena haemorrhoa* and *Andrena nitida*, the partially semisocial species *Halictus scabiosae*, the primitively eusocial bees *Lasioglossum calceatum* and *Lasioglossum pauxillum* and several bumble bee species. Their RNA was extracted and screened with qPCR for the presence of viruses as well as unicellular pathogens. Furthermore, features of the observed plant-bee networks were compared across the plant diversity gradient in order to investigate possible bee pathogen transmission networks. Since our results did not show a universal link between plant diversity and pathogen prevalence, other proxies for forage availability based on land use heterogeneity and bee-collected pollen were investigated as well.

T7

Warm or bright, an exploration of the morphological traits explaining bumblebee habitat use

Océane Bartholomée[1], Vun Wen Jie, Paul Caplat, Henrik G. Smith, Emily Baird

[1]Lund University, Sweden

Functional ecology, through a mechanistic understanding of species-environmental relationships, provides the power to predict the impacts of global changes on biodiversity and ecosystem functioning. However, this understanding is still limited as most studies focus on few traits, often taken from existing measurements. Bumblebees are essential pollinators of high latitude/altitude ecosystems, particularly sensitive to climate change. In early spring they forage on a unique species – bilberry – in heterogeneous habitats – (hemi-)boreal forests. Such conditions are ideal to study species coexistence and their response to abiotic conditions, while excluding partitioning through exploitation of different floral resources. In bilberry-dominated forests, this study combined full-day monitoring of bumblebee communities, detailed functional trait measurements with joined species distribution modelling (JSDM). We found that bumblebee sub-genera differed in their morphological, sensory, and thermoregulatory traits (PCA). Variation in bumblebee community composition was explained by temperature, light intensity, time of observation, and bilberry flower density (RDA and NMDS). With JSDM, we showed that if temperature conditioned species occurrence, light intensity explained species abundance. These responses were supported by visual and thermoregulatory traits, but no specific trait-environmental variable relationship was identified. These results suggest that temperature acts as a first filter from the local species pool and that the present species partition along a light intensity gradient. This study extends upon previous findings of microhabitat partitioning as potential mechanisms underpinning bumblebee coexistence. It highlights the importance of including relevant functional traits when studying how species interact with their environment, particularly to improve our ability to predict consequences of global changes.

T8

Effects of altitude and land-use change on pollinator species diversity

Felicitas Wolf[1], Demetra Rakosy, Tiffany Marie Knight

[1]Martin-Luther-Universität / Deutsches Zentrum für integrative Biodiversitätsforschung (iDiv) Halle-Jena-Leipzig, Germany

Biodiversity is declining across the world, and there is an urgent need for a better understanding of the drivers that cause this change across different taxa and regions. Biodiversity research is well established in Western and Central Europe, but still lags behind in Eastern Europe, particularly for Diptera. Mesophilic semi-natural grasslands are global plant biodiversity hotspots, but less is known about their pollinator diversity, and how it varies across natural and anthropogenic gradients. To address this knowledge gap, we assessed pollinator species diversity in Romanian mesophilic meadows occurring along both an altitude and a land-use gradient. Both altitude and land-use can act as strong filters for species, leading to the expectation that pollinator species diversity would decrease with altitude and land-use intensity. However, pollinator groups are likely to respond differently to elevation and land-use change, depending, for example, on their tolerance to decreasing temperatures or increasing disturbance. In order to account for differences between taxa we assessed the variation in species diversity and composition across altitude and land-use gradients separately for Hymenoptera (Apoidea) and Diptera (Syrphidae and Tachinidae). Our research showed that pollinator species diversity was similar across the assessed elevation range, while traditional hay meadows tended to be more diverse than both abandoned and intensively grazed meadows. However, in both cases, these overall patterns masked some group-specific trends. We conclude that while both altitude and land-use change had a filtering effect on species, it is likely that land-use change may impact pollinators differently across different altitudes.

T9Flash

Can we infer pollen quality and bee nutritional requirements from bee pollen loads?

Sara D. Leonhardt[1]

[1]Plant-Insect-Interactions lab, Technical University of Munich, Germany

Wild bees are an important pollinator group in European landscapes. They largely depend on flower resources, in particular pollen, to raise their offspring and hence maintain their populations, because pollen provides most required macro-nutrients, such as protein and lipids, as well as micro-nutrients, e.g. sterols, minerals. The spectrum of plants used as pollen hosts is generally more restricted across bee species than the spectrum of plants used for nectar foraging. Moreover, different bee species can strongly differ in the spectrum of pollen plants used, indicating that they may differ in their nutritional requirements. However, knowledge on nutritional needs of wild bees are largely lacking. We suggest an indirect approach to infer nutritional needs of various wild bee species through integrating information on pollen spectra used (based on pollen metabarcoding of pollen loads) and on pollen chemical profiles (for now focusing on amino acids, fatty acids and sterols). To test this idea, we integrated information from field observations, pollen DNA metabarcoding, analytical chemistry, and network analyses to infer floral and nutritional niches of different wild bee species in relation to variable floral resource landscapes. Our findings provide first hints on variation and similarities in the nutritional niches of different wild bee species.

T10Flash

Fatty acid profiles of pollen collected by different bee species

Fabian A. Ruedenauer[1], Alejandra Parreño, Susanne Butschkau, Sophie Lauber, Stefanie Siebler, Sara D. Leonhardt

[1]Plant-Insect-Interactions lab, Technical University of Munich, Germany

Fat is a crucial dietary element in bees and is predominately consumed via pollen. The impact of different fatty acids on bee fitness is characterized by adverse as well as favorable effects, depending on the concentration. Low concentrations of unsaturated fatty acids, like oleic acid, have been demonstrated to positively affect cognitive abilities, while elevated concentrations have been linked to decreased bee longevity. Moreover, it is postulated that distinct bee species have a need for different fatty acids and varying fatty acid quantities in pollen. In this study, we conducted a DNA metabarcoding analysis of pollen loads from different bee species to determine the plant species from which they had been collected. Additionally, we have collected pollen from these specific plant species by hand and analyzed its fat content. By combining information about the proportion of pollen collected from each plant species by a bee species with the fatty acid profiles of these plants, we were able to create target fatty acid profiles for the various bee species. Our findings suggest that different bee species collect significantly different fatty acid profiles. Given the pivotal role of fatty acids in bee nutrition and the apparent ability of bees to perceive and differentiate between various fatty acids, bees may select pollen they collect based on its fatty acid composition, among other potentially influential factors.

T11

Pollen fatty acids: perception, regulation and fitness effect on honey bees

Marielle C. Schleifer[1], Fabian A. Ruedenauer, Sara D. Leonhardt, Johannes Spaethe

[1]Plant-Insect-Interactions lab, Technical University of Munich, Germany

For successful cross-pollination, the majority of flowering plants rely on insects and attract them by offering rewards, predominantly nectar and pollen. Bees specifically depend on pollen as their source of essential nutrients, including proteins, lipids, and sterols. Fatty acids, in particular, are important as a source of energy, for membrane structures and cellular integrity, and play a role in learning processes. Nevertheless, overconsumption of fatty acids can have adverse health effects. To explore the impact of fatty acids on the lifespan of newly hatched honey bee (*Apis mellifera*) workers, we investigated the perception of fatty acids by means of chemotactile proboscis extension response (PER) conditioning, and performed feeding experiments. Given the importance of fatty acids for bees, we hypothesized that honey bees can detect variations in the fatty acid content of pollen via their antennae, and that excessive consumption affect their longevity. Our findings reveal that *A. mellifera* can indeed detect both saturated and unsaturated fatty acids using their antennae. Moreover, they are able to distinguish between different single fatty acids and also between different concentrations of fatty acids in pollen. As hypothesized, higher concentrations of fatty acids in pollen were harmful and resulted in an increased mortality. Our results indicates that variations in pollen fatty acid concentration affects foraging preferences and fitness in honey bees. Notably, as we tested both natural concentrations and concentrations exceeding those typically found in pollen, our study suggests that honey bees must pay specific attention to the fatty acid content in pollen.

T12

Effects of herbivory-induced stress on pollen quality and bee fitness

Upuli I. Wickramaarachchi[1], Stuart A. Campbell

[1]Plants, Photosynthesis and Soil Cluster, School of Biosciences, University of Sheffield, UK

Attack by herbivorous insects causes plants to produce a wide array of defensive secondary metabolites, some of which cause repellence of pollinators, suggesting an ecological cost of induced plant responses. Though the ecological function of secondary metabolites in defence against herbivores is well established, their role in floral rewards (nectar and pollen) and their impact on pollinators remain poorly understood, particularly for pollen-consuming bees. Moreover, it remains unknown whether pollen secondary metabolites are induced by herbivory, and whether these induced responses are adaptive. Using the wild tomato, *Solanum habrochaites*, we tested the hypothesis that herbivory stress would induce pollen secondary metabolites, with negative *effects* on bee pollinators. We then compared obligately insect-pollinated tomato populations (outcrossers) with less pollinator-reliant populations (selfers), to test whether defence responses are lower in more pollinator-dependent plants. We evaluated the effect of simulated herbivory (methyl jasmonate, MeJA) on pollen biochemistry and honeybee (*Apis mellifera*) larval growth and survival. Pollen from induced plants significantly reduced the prepupal weight (pw) and survival, compared to controls. LC-MS analysis of pollen revealed that, despite population variation in metabolite composition and induction, there were consistent effects of mating system on defence-related secondary metabolites and contrasting induced floral responses between mating systems. Our results suggest that pollinators may be sensitive to the indirect effects of plant stress on pollen, and that these effects may have driven the evolution of pollen biochemistry and quality. We discuss these mating system-specific plant stresses in terms of pollinator fitness and convergent evolution of floral rewards.

T13

Susceptibility to insecticides of commercial and wild *Bombus terrestris* subspecies and their hybrids

Alexandra Pardo-Domínguez[1], Nuria Arranz, Lidia Blanco-Sánchez, Beatriz Beroiz, Concepción Ornosa, Pedro Hernández-Crespo, Félix Ortego, Gema P. Farinós

[1]Centro de Investigaciones Biológicas Margarita Salas, Applied Entomology for Human and Plant Health Group, Madrid, Spain

Pesticide regulation in the European Union requires risk assessment on bees, with a recent focus on wild species, including the buff-tailed bumblebee (*Bombus terrestris*). In Spain, there are two native subspecies: *B. terrestris* lusitanicus (BTL), which is widely distributed in the Iberian Peninsula, and *B. terrestris* terrestris (BTT), restricted to the Eastern Pyrenees. Domesticated BTT colonies are also commercialized in Spanish greenhouses, from which they can escape and breed with native BTL, generating hybrids. Our aim was to compare the susceptibility of *B. terrestris* workers to neonicotinoid and pyrethroid insecticides, depending on their subspecies (BTT, BTL or hybrids), by acute oral toxicity bioassays. We identified the subspecies and hybrids by the combination of both morphological and molecular methods on the collected queens and their offspring colonies. We verify the presence of BTT and hybrids in natural areas close to greenhouses where commercial colonies are used, indicating that they are colonizing places outside their natural distribution. In addition, we found hybrids in natural areas far away from greenhouses, suggesting that local hybridization is spreading. Bioassays were performed by treatment of individual workers with an LC50 and LC90 (previously estimated) of the neonicotinoids imidacloprid and thiacloprid and the pyrethroid deltamethrin. Preliminary analyses show that there are no significant differences in the susceptibility to these insecticides regarding the subspecies, and that the three insecticides reduce nectar consumption. We are currently determining the basal and insecticide-induced activity of detoxification enzymes in the tested individuals, in order to characterize potential metabolic differences among subspecies.

T14

Climatic conditions and landscape diversity predict plant-pollinator interactions and pollen deposition in bee-pollinated plants

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The pollination potential of wild plants depends on plant-pollinator interactions which are under pressure from climate change and landscape homogenization. Understanding the drivers of pollination potential is fundamental for our ability to predict how anthropogenic stressors affect plant biodiversity. Incorporating species-specific differences in plant affinities improves the realism of models of pollination potential for different plant species. However, whether the sum of predicted occurrence of pairwise interactions (viz. pollination potential) within a habitat, scales with pollen deposition has not been investigated. We sampled plant-bee interactions in 68 Scandinavian plant communities in landscapes of varying heterogeneity along a latitudinal temperature gradient of 4–8 C°, and estimated pollen deposition as the number of pollen grains on flowers of bee-pollinated plants within 27 of the plant communities. We show that plant-bee interactions, and the pollination potential, for bee-pollinated plants (viz. *Lotus corniculatus*, and *Vicia cracca*) in temperate plant communities in Scandinavia increase with landscape diversity, annual mean

temperature, plant abundance, and decrease with distances to sand-dominated soils. Furthermore, the pollen deposition in flowers increased with the predicted pollination-potential from our models, seemingly driven by effects of landscape diversity and plant abundance on plant-pollinator interaction frequencies. Our study illustrates that the pollination potential, and pollen deposition, for wild plants can be mapped based on spatial models of plant-pollinator interactions that incorporate species-specific differences in host-plant affinities. Maps of pollination-potential can be used to guide conservation and restoration planning.

T15

Dominance and identity of the dominant bee drive bee diversity on flowers

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Communities are characterized by the dominance of a few species, which are crucial for shaping communities. Bees compete for scarce resources, and offer an ideal system to study the effect of dominance on the diversity of bees. The effect of bee dominance is studied predominantly for the western honeybee, which can have negative effects in introduced sites. Solitary bees, stingless bees, native honeybees, and bumblebees can also be dominant on flowers. We test the hypothesis that dominance, regardless of the identity of the species, negatively influence diversity of bees on flowers. We analyzed 95,160 visits of 58 species of bees belonging to honeybees, solitary bees, and stingless bees on 59,211 flowers of 12 plant species across five years. Visitors were grouped into honeybees, solitary bees, and stingless bees. Proportion of the total abundance accounted by the most abundant species was considered as the estimate of dominance. Dominance negatively associated with richness and visitation rate of bees, but identity of bee functional group predicted the magnitude of the effects. Richness decreased with the dominance of honeybees and solitary bees, but not with the stingless bees. Visits of honeybees decreased when solitary bees dominated the visits. Visits of solitary bees decreased when honeybees or stingless bees dominated the flowers. We have shown that native bees of different functional groups can exert a similar negative effect on bee diversity in flowers like the invasive species do. Honeybees and stingless bees, though native in some parts, deteriorate bee diversity if augmented to ecosystems unnecessarily.

T16

The impact of honeybee density and apiary proximity on bumblebee foraging behavior depends on landscape-level forage availability

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Competition for resources between managed honeybees (*Apis mellifera*) and wild bees can potentially detrimentally impact the pollination of both crops and wild plants, leading to negative consequences on biodiversity and food security. To investigate if honeybees and wild bees share floral resources and how honeybee densities might affect wild bee foraging behavior we conducted an experimental field study in Sweden. We studied commercial bumblebees (*Bombus terrestris*), which served as a study species for wild bees, in semi-natural grasslands at different distances (0m, 500m, 1000m, 2000m) from large apiaries, assuming that the density of honeybees would decrease with distance. We assessed how possible competitive effects were modified by the surrounding landscape, amount of mass flowering oilseed rape and semi-natural habitat, and if these effects vary over the season. Honeybee densities was quantified in each grassland

through standardized transects and bumblebee foraging activity of each colony was measured. Through collecting and analyzing honeybee and bumblebee pollen we determined their diet. We found that resource competition was affected by hive proximity but the effect depended strongly on the seasonal variation in floral resources. High honeybee densities can alter bumblebee foraging behavior and change their foraging activity, diet breadth and niche overlap. Importantly, semi-natural habitat seem to have a mitigating effect on resource competition between honeybees and bumblebees. The conservation of these areas in agricultural landscapes are important to facilitate niche differentiation and should be considered in apiary management practices.

T17

Bumblebee communities in open and overgrown heathlands in Western Norway

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Coastal heathlands have been strongly reduced during the latter decades and is currently red-listed as an endangered vegetation type in Norway. Land-use changes, especially the abandonment of traditional farming practices, are known as important factors. Heather like *Calluna vulgaris* is known to attract many different pollinating insects, of which some that are strongly associated with heathlands. Here we investigated communities of bumblebees in open and overgrown heathlands in a UNESCO Biosphere Reserve in Western Norway. Pan traps and insect aerial nets were used to effectively capture pollinators in six study sites during June and August. A total of nine *Bombus* species were identified, with the most abundant being *B. lucorum* complex, *B. jonellus*, and *B. pascuorum*, which accounted for 71% of the individuals. Species composition varied between the sites. The overgrown heathlands typically had a higher abundance of common species like *B. pratorum*, while the red-listed species *B. muscorum* was recorded exclusively in open heathlands. Furthermore, *B. muscorum* was mainly active during the flowering period of *C. vulgaris*. *B. jonellus*, on the other hand, was more abundant in overgrown sites despite being mainly associated with Ericaceae, which may be due to the additional floral diversity and nesting sites found here. Further research should explore the potential impacts of landscape characteristics like fragmentation and management practices on bumblebees in heathlands. Habitat conservation is considered the most effective way to conserve insect pollinators and should be highlighted in policy-making decisions to maintain healthy populations.

T18

Pollen diet of mason bees in agricultural areas with varying levels of organic farming

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It is known that the availability of local resources for the larval provisioning of solitary bees can be influenced by the landscape. However, we still require more information on how elements of the landscape affect the diet of bees, considering a range of organic cropping in agricultural environments. To shed light on these questions, trap nests were introduced in farming environments with different levels of organic cropping. Males and females of the mason bee *Osmia bicornis*, coming from these nests, were measured. Moreover, the frass content mixed with uneaten pollen found inside the trap nests was identified, and the pollen diet and specialization index were studied in the context of the landscape elements and organic levels within a buffer zone with a radius of 500 m. The analyses of larval provision

showed that plant diversity is driven by the presence of meadows as well as areas set aside for agriculture. Furthermore, we found that females that provisioned the nests showed a higher specialization index in areas with fewer meadows. The results of this study showed that farming management associated with landscape influences the pollen diet of wild bees, and therefore, it is important for conservation purposes of wild bees in these environments.

T19

Cost-effectiveness of alternative pollination strategies for strawberries in a protected cropping environment

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The use of protected cropping began as a practice to grow out-of-season vegetables and small fruits. Simultaneously, efforts were made to pollinate crops grown in these protected cropping systems, since pollination is essential for many fruit and vegetable crops. Some of the most successful methods of pollination have been insect pollinators, such as bumblebees and stingless bees. In other cases, mechanical or hand pollination is also an option. In this study, we analyse the cost-effectiveness of three strategies for pollinating strawberries grown in a glasshouse: 1) stingless bees, 2) hand pollination, 3) no assisted pollination. These different methods were used in glasshouse experiments in Richmond (NSW, Australia) and the resultant fruits graded based on quality and then valued, based on the market price of each grade. The cost of pollination was based on the number of hives used for stingless bee pollination and number of hours spent (labour cost) for hand pollination. It was estimated that using stingless bees cost A$800 if hives were rented and A$1600 if purchased as a capital item for one crop rotation. For hand pollination, the total cost of labour was estimated at A$2276. Excluding the capital costs of the glass house and other common costs across methods, bee pollination produces A$6 of value for every dollar spent versus A$4.5-4.7 per dollar for hand pollination. Thus, stingless bee pollination in a protected cropping environment can be a cost-effective method to produce high quality fruits.

T20

Pollen deficits in Norwegian apple orchards

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Apples rely on insect pollinators for optimal yield and quality. Wild pollinators have often shown to be more efficient pollinators of apples, compared to the managed honeybee. Insufficient pollination may reduce seed set and quality of apples, reducing the potential revenue for farmers. Pollen deficits in apple orchards have been documented in several countries, however studies on this in Norway are lacking. We have therefore investigated whether pollen deficits are occurring in Norwegian orchards on three different spatial scales: within orchards, between orchards and cultivars, and finally on a regional scale. The assessment of pollen deficit is studied through a hand pollination experiment, where branches on apples trees in 18 orchards, divided over two regions and three apple varieties, received one out of three treatments: (1) hand pollination treatment, using supplemental pollination from closest capable apple tree, (2) natural pollination treatment, where the branch will receive pollen through pollinator visits, (3) and an exclusion treatment preventing pollinators from visiting the flowers. Results from 2022 show an overall pollen deficit in Norwegian apple orchards, with the deficit varying between the three tested cultivars, and being higher in eastern Norway.

T21

Securing crop fruit set with biodiversity – the effect of wild floral resources on crop pollination under climate change

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Changes in land use and climate have sent pollinators, like many insects, into worldwide decline. With most European crops depending at least partly on insect pollinators, human food production is supported by flower-visiting insects that could benefit from wild floral resources in arable landscapes. Thus, we tested the effects of wild flowers (flower strips, extensively managed fields) on insect pollination of strawberries. Following a space-for-time approach, data was collected in two climatically contrasting regions of Bavaria to predict the effectiveness of pollinator supporting measures under future climate conditions. Adjacent to each plot, we sampled visiting pollinators on flowers of potted phytometer plants, half of which were artificially drought-stressed beforehand, and analysed pollinator abundance and richness and fruit quality. We observed more flower visits of more diverse pollinators in response to adjacent flower resources under cooler regional climate, but not under warmer conditions. Flowers developed under drought were pollinated by fewer and less diverse pollinators with no effects of nearby flower resources. Irrespective of flower availability, insect pollination increased the weight of strawberry fruits developed from drought-stressed flowers. Plants pollinated under warmer regional climate produced heavier fruits of lower relative sugar content. These unexpected observations are possibly caused by functional differences between pollinator communities of the two regions, resulting in different pollination qualities. However, the results highlight the potential of insect pollination to buffer negative effects on fruit set under drought stress.

T22

Variation in the pollen diet of managed bee species along climate gradient in agro-ecosystems

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Pollination of crops by bees is one key ecosystem service to produce our food supplies. However, while the need for these resources is increasing, bees are experiencing global population declines. To face this mismatch, many growers introduce managed bee species to complement wild bee pollination. In this study, we compare the pollen diet of three European managed bee species (*Apis mellifera*, *Bombus terrestris* and *Osmia bicornis*) in agricultural landscapes along a climate gradient. Managed populations of each species were introduced into 128 sites across 8 European countries and two bee-pollinated crops, i.e., apple orchards and oil seed rape. Pollen loads were collected, and we developed palynological analyses to define the foraging preferences of the three species and to extrapolate their suitability as pollinators for both crops. We found that *A. mellifera* and *B. terrestris* had a wider pollen diet (i.e. collect pollen from a high number of plant families) than *O. bicornis*. Moreover, we found that unlike the other two bee species, *O. bicornis* foraged more on other plant families present in the landscape rather than on the two crop species. Across Europe, while apple pollen consumption was not affected by latitude, we found that *A. mellifera* increased its consumption of rapeseed pollen towards the south while the other two species decreased it. These results will contribute to select the most suitable bee species to promote pollination of cultivated species in Europe.

T23

Honey bee hive placement affects pesticide exposure but not pollination services in highbush blueberry systems

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Honey bees (*Apis mellifera*) provide essential pollination services in commercial highbush blueberry (*Vaccinium corymbosum*) production systems. Pollination deficits occur frequently, and most growers attempt to enhance pollination by placing hives adjacent to field edges. However, proximity of hives to field edges may increase honey bee exposure to pesticides and contribute to poor colony health often reported by beekeepers after blueberry pollination. The objective of this research was to compare two hive placement strategies on blueberry pollination and exposure of honey bee hives to pesticide drift. "Clumped" and "dispersed" hive placement treatments were compared at 25 farms across 3 states in the United States of America in 2021 and 2022. Clumping hives away from the field edge led to greater honey bee visitation rates under optimal pollination weather conditions, whereas fruit set, berry weight, and seed set were not affected by hive placement. Silicone bands were fixed onto the surfaces of hives to passively sample pesticides during the blueberry bloom period. Multiple pesticides were detected on the silicone bands with fungicides detected in the greatest concentrations, followed by herbicides, insecticides, and miticides. Pesticide concentrations on silicone bands were on average lower among hives in the clumped treatment, suggesting that hive placement further from the field edge results in less hive exposure to drift. Results from this study demonstrate clumping hives away from field edges can increase honey bee activity, maintain yield components, and reduce hive exposure to pesticides.

T24

The pollination of flowers by birds: challenges for biologists

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Relationships between flowers and birds have an evolutionary history stretching back at least 50 million years, and have been documented by indigenous cultures for more than a millennium and by scientists for over 300 years. Although we have learned a great deal about bird pollination during that time, much of that understanding comes from studies of a limited set of three bird families. Pollination by hummingbirds, honeyeaters and sunbirds is well recognised as being ecologically important and has driven the evolution of flower traits such as shape, size, colour and scent. However, at least 70 other families of birds belonging to 11 orders are known or suspected pollinators. This phylogenetic diversity challenges our understanding of how disparate bird biologies mould flower evolution and how these "other" birds fit into wider networks of plant-pollinators interactions. We currently estimate that bird pollinated flowers account for about 20,00 species, or less than 10% of angiosperm diversity. This is almost certainly an under-estimate because many bird-pollinated flowers do not fit our preconceived ideas about "ornithophilous" flowers traits. Insect pollination long predates bird pollination in the evolutionary history of the flowering plants, so another challenge is to understand the circumstances under which flowers switch from insects to birds. Explanations for the switch usually invoke the more effective long distance gene flow that birds can provide, but this is at odds with the observation that bird pollination often spurs the diversification of plant clades. Bird pollination, despite its familiarity, still raises many unanswered questions.

T25

Coping with altitude: pollinator shifts across elevational gradients

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Plant-bird pollination interactions constitute a fundamental ecological process that shapes biodiversity and ecosystem dynamics. In this sense elevational gradients represent an extraordinarily suitable study system, enabling researchers to test hypotheses on the effects of complex environmental factors on bird-plant interactions. Our research group is focused on the pollination systems present on Mt. Cameroon, Cameroon. In this study, we delve into the dynamics of the interaction between Hypericum revolutum, a key plant species, and its avian pollinators, examining the influence of elevation and seasonality on these interactions across an elevation range from 2200 m to 3800 m. Exclusively focused on grassland ecosystems, we chose Hypericum revolutum as our focal plant species due to its prominence in these ecosystems and its significance for avian pollinators. Our study involved field observations of plant-bird interactions over two seasons to capture the variability induced by seasonality. We showcase how the likelihood of a plant being visited reaches its highest point at mid-elevations, and how the probability further rises as the number of flowers increases until a certain threshold is exceeded. Furthermore, there is a distinct peak in pollinator visitation frequency at 2800 m, followed by a decline as elevation increases. We also identified a seasonal effect in both the probability of visitation and the frequency of visits, with lower values observed during the transition from the dry to the wet season.

T26

The ‘marriage’ of heterostylous plants gets more ‘complicated’ in an era of habitat loss and fragmentation

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Habitat loss and fragmentation are among the main reasons for recent widespread biodiversity loss. Among plants, insect-pollinated species are particularly affected, as they depend on pollinators to be able to exchange genes between different individuals and populations. This also includes species characterized by heterostyly – a unique reproductive system defined by the presence of two or more distinct floral morphs within a population, each with differing positioning of anthers and style. The spatial separation of reproductive organs restricts self-pollination and also favours cross-pollination between different morphs. Both floral morphs are usually needed in equal frequencies for securing optimal reproduction. However, as habitats become fragmented, heterostylous species can be affected in many ways. Reduced connectivity between habitat patches can impede the movement of pollinators between different populations and individuals, leading to reduced gene flow and genetic diversity. Reduction in population size can disrupt the morph ratio balance, resulting in fewer compatible mates. Small and isolated populations are also more vulnerable to genetic drift and inbreeding, which can reduce the populations’ adaptability to changing climatic and environmental conditions. Consequently, populations with a biased morph ratio might have an increased risk of extinction. In this talk, I will give an overview of recent studies which have investigated the consequences of habitat fragmentation on various heterostylous species from different plant families. Understanding the effects of habitat fragmentation can help us make better conservation efforts not only for heterostylous species but also for other insect-pollinated plants experiencing habitat fragmentation.

T27

Flower coalition: integrated flower roles in Fritillaria persica inflorescence

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Flowers are specialized organs that integrate various features to work together for reproductive success. This integration can extend to the inflorescence level, where flowers play distinct roles, contributing to reproductive success in dynamic environments. In our study, we explored the variability of flowers and their roles within the inflorescence of Fritillaria persica L., a geophyte native to the East Mediterranean region. Our findings reveal that in F. persica, flower features and the arrangement of reproductive parts within the inflorescence may demonstrate integrated roles at the inflorescence level, with bottom flowers primarily serving the female reproductive function, middle flowers function as a reassurance mechanism that facilitates spontaneous self-pollination, and top flowers performing the male reproductive function. However, preliminary results indicate that there is no difference in the availability of rewards among flowers from different inflorescence levels and that there is no correlation between flower features and the quantity of reward (nectar).

T28

Pollination syndromes in Melastomataceae, pollinator shifts and species richness explain patterns of disparity in an ancestrally buzz-bee pollinated family

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Pollination syndromes are defined as suites of floral traits, which have evolved repeatedly across angiosperms in adaptation to distinct functional pollinator groups. Several studies show support for the concept, while others raised concerns about their reliability. The large, pantropically distributed family Melastomataceae is dominated by buzz-bee pollination (95.5%), where pollen is released from tubular, poricidal anthers through vibrations. In eight (of 23) tribes, shifts to other syndromes have occurred. Shifts among functional pollinator groups, are regarded as a source of increased floral disparity. We recorded 44 functional floral traits across 411 species, spanning the whole family. We used machine learning algorithms to identify pollination syndromes for species with documented pollinators and employed these trained models to predict pollinators for species without observations. We ran ancestral character state estimation to determine directionality in pollinator shifts in Melastomataceae. Furthermore, we contrasted floral disparity among the different syndromes, biogeography, and tribes to evaluate the relative role of pollinator shifts in generating floral disparity. Our results indicate strong support for four well differentiated pollination syndromes within Melastomataceae: “buzz-bee”, “nectar-foraging vertebrate”, “food-body-foraging vertebrate”, and “generalist”. Pollination syndromes in Melastomataceae can be discriminated by six system specific floral traits of which reward type and pollen release mechanism are the two most important traits. Further, we found that the “buzz-bee” and “nectar-foraging vertebrate” syndromes are highly diverse and pollinator shifts contribute to floral disparity, which is not directly correlated with clade size. Finally, we reconstructed the “buzz-bee” syndrome as ancestral from which all other syndromes evolved repeatedly.

T29

Water deficit can change selection on floral traits: insights from the morning glory

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Understanding the effects of resource limitation on phenotypic selection on flowers is key to predict the evolution of plant-pollinator interactions under climate change. Two important resources predicted to decline with climate change are pollinators and water in the form of increased droughts. However, previous work has studied these selective agents separately and in the case of water deficit, studies are rare. Here, we use the common morning glory (Ipomoea purpurea) to investigate the effects of reduction in pollinator access and water availability on floral signals and nectar rewards and their effects on phenotypic selection on these traits. We conducted a manipulative experiment in a common garden, where we grew plants in three treatments: 1) pollinator restriction, 2) water reduction, and 3) unmanipulated control. Plants in pollinator restriction and control treatments were well-watered compared to water deficit. We found that in contrast to pollinator restriction, water deficit had strong effects altering floral signals and nectar rewards but also differed in the direction and strength of selection compared to control plants. Water deficit increased the opportunity for selection, and selection in this treatment favored lower nectar volumes and larger flowers, which might further alter pollinator visitation. Well-watered plants showed similar patterns of selection to increase nectar volume suggesting non-pollinator-mediated selection on nectar. Our study shows that floral traits may evolve in response to reduction in water access faster than to declines in pollinators and reinforces that abiotic factors can be important agents of selection on floral traits.

T30

The evolution of plant mating systems under fluctuating pollination reliability

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Self-fertilization has evolved frequently in flowering plants, but the eco-evolutionary forces driving this major evolutionary trend are not fully understood. If inbreeding depression is substantial, selfing should only evolve when outcrossing is not an option ("best of a bad job"). In contrast, if inbreeding depression is moderate (due to purging), selfing should often evolve even if outcrossing is sometimes an option ("best of both worlds"). The latter scenario is especially likely if selfing is delayed (i.e. occurs after the opportunity for outcrossing has passed). These scenarios yield different expectations for patterns of temporal variation in pollination reliability along gradients in mating system. If selfing evolves as a mechanism of reproductive assurance, we expect selfing to evolve in populations that experience either consistently or periodically low pollination reliability, while outcrossing evolves only in populations with consistently high pollination reliability. In contrast, if selfing is highly costly, selfing would be expected to evolve only in populations that experience consistently low pollination reliability. Long-term studies of the tropical vine Dalechampia suggests that selfing populations tend to occur in environments that experience less reliable pollination on average, and where pollination is more variable among years. This pattern suggests that selfing is favoured whenever pollination is sometimes unreliable, as expected under the reproductive-assurance hypothesis. In the event of increasing fluctuations in pollination reliability in the future, we expect more populations to evolve towards selfing, even if low pollination reliability occurs only periodically.

T31

Flower preference determines wild bee distributions along a latitudinal gradient

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Understanding how climatic conditions and land use intensity affect the functional composition of pollinator communities is essential for developing efficient conservation strategies. In central Europe, plants with 'bee-pollinated' tubular flowers have declined together with the functional guild of bees that pollinate them. However, it is not known if such declines are persistent across climatic and land use intensity gradients. Improving our understanding of how environmental condition shape the distribution of bee species with differing floral preferences can help devise region-specific conservation strategies. Here, we analyse over 7000 wild bee observations from structured surveys at 269 sites across Northern Europe to investigate how bees with different flower preferences are distributed across climatic and land use intensity gradients. Bees were assigned a continuous functional trait (flower preference score) with preference for short vs tubular flowers. We observe a northward shift in the functional composition in bee communities, where bees with preferences for tubular flowers had a higher likelihood of occurrence with cooler climates (increasing latitude), while bees with preference for radially symmetric flowers increased towards the warmer climates (decreasing latitude). These findings were consistent, also after removing bumblebees from the analyses. Our results illustrate that the functional composition in bee communities, in terms of flower-preference traits, depend to a large extent on climatic conditions. Hence, conservation actions such as the development of seed mixes for flower strips should be tailored to the regional species pool.

T32

Three-strip management: curved mowing as an innovative management method for perennial margins to enhance pollinator biodiversity

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Agri-environment schemes (AES) such as perennial flower margins are popular measures being installed in ago-environments. However, many of them soon miss their effect due to dominance of grasses through inadequate management. Here, cumulative nitrogen (N) depositions show a strong negative relationship, especially the number of flowering dicots to grasses, which has in turn a negative impact on insect communities. To enhance this, they need low-intensive forms of management that 1) counteract natural and anthropogenic succession and 2) better support all needs of inhabiting insects. While mowing is necessary to remove excess of litter, it is often the case that non-mown parts are better places (refugia) for insects and their larval stadia, thereby causing a management dilemma. To solve the management dilemma, I propose an innovative mowing method called Three-strip management. The basic idea behind this new mowing method is that variable curved mowing lines are applied instead of straight ones. As each new mowing cycle is varied in space, a more complex mowing pattern is generated which has a positive impact on the inhabiting insects. Implementing such a spatio-temporal variation during each mowing cycle, the goal is to create a multitude of diversity (microclimates and blossoming of flowers). In this presentation, this novel mowing method for margins is explained comparing Three-strip management with classical phased mowing management. Based on a 3-year case study on perennial margins installed in Flanders (Belgium), results of the new Three-strip management and the impact on pollinators (bees and butterflies) are presented and discussed.

T33

Pollinator responses to grassland productivity

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Grasslands form one of Europe's most important pollinator habitats, but land use intensification for forage production has strongly affected their species communities. To explore the potential for pollinator preservation on grasslands, we sampled pollinators and other invertebrates along a grassland productivity gradient in a diverse landscape in the south of the Netherlands. Each grassland held a 150m-transect where pollinator survey walks, flower counts and sweep netting were undertaken in May, June and July. Wild bee species richness and abundance correlate negatively to grassland productivity, but grassland productivity drives the income of farmers. This results in a trade-off between pollinator benefits and farmer benefits. Further public financial support may be needed to overcome this key barrier to pollinator-friendly land management. Yet this also requires more robust monitoring of realized ecological benefits. We explore the potential of flower richness as a generalizable indicator of grassland pollinators as well as other invertebrates, that can be measured effectively with remote sensing techniques.

T34

Bumblebees and solitary bees are limited by summer floral resources in agricultural landscapes

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The loss of floral resources is a leading cause of wild bee decline in agricultural landscapes, but little is known about the temporal aspects of floral resource limitation for both social and solitary bees. Understanding when floral resources are most needed is crucial for the optimal design of pollinator conservation measures. We surveyed bees and flowers in 160 semi-natural habitat patches multiple times per year (May-July) for five years. We identified the seasonality of floral resources and wild bees and examined inter- and intra-annual patterns of floral resource limitation at both local and landscape scales. Floral resource availability varied greatly across years, but generally peaked in late May, after which it declined and remained low for the rest of the season. Bumblebee and solitary bee abundances increased across the season, leading to stronger floral resource limitation for both groups later in the season. Bumblebee abundance was marginally positively associated with the cumulative amount of landscape-scale floral resources, as well as the floral resources of the previous year. Solitary bee abundance was only predicted by local-scale floral resources. Our results indicate that agri-environmental management should target the provision of summer floral resources for both social and solitary bees. Local-scale enhancement of floral resources can likely benefit solitary bees, but bumblebees probably require the management of floral resources at the landscape scale. Increasing the floral resources and the flowering period of herbaceous habitats that cover large proportions of the landscape, such as pastures, has the greatest potential to improve summer floral resources for bees.

T35

How strong are links between pollination rates and plant demography?

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Especially in popular and semi-popular literature, but also in professional reports and reviews, we are warned of impending pollination crises. Such warnings often rest on the proposition that any reduction in the contemporary pollination rate of a plant population will reduce its female reproductive rate, population size, or both. Although this simple logical chain is plausible, we argue that several common circumstances may commonly weaken it or render it inconsequential. These circumstances include incomplete dependence of seed output on pollination, vagaries in the ecology of recruitment from seed, and especially the costs of sexual reproduction in perennial plants. In the long-lived Erythronium grandiflorum, for example, making a single fruit reduces plant size by about 10%, reducing survival probability and flower production in the next season. Thus, incomplete pollination in one season is compensated by preservation of resources that support individual persistence and population persistence. For such plants, predictions of demographic consequences of incomplete pollination are likely to be directionally biased toward negative or even alarmist outcomes. More realistic predictions require us to replace the "simple logical chain" with a more complete “whole-ecology” analysis of a plant's intrinsic characteristics and its ecological circumstances.

T36

Reproductive form and function across South African Oxalis species

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For a plant, investing different amounts of resources into different types of organs might be advantageous for optimal fitness through maximizing plant growth, reproduction and survival. Thus, species use different strategies: (1) investment into low cost organs, that are fast growing and short lived or (2) into high cost slow growing organs that have a longer life span (fast-slow spectrum). Although each plant tissue type and associated functionality has its own costs and benefits, so far these so called ‘economic spectra’ have largely been explored for leaves and roots. Recently, the framework for a potential flower economic spectrum (FES) was proposed. Here, we aimed at testing the FES concept on South African Oxalis species, which, despite their recent evolutionary history are incredibly diverse in their traits. In this study, we (1) provide an overview of morphological and phenological variability across species and (2) examine resource allocation patterns across species above and belowground, but mainly focusing on the FES traits. We had the opportunity to grow more than 100 species of South African Oxalis in a common garden for one vegetation season and measure their investment into different organs by measuring various functional traits of the whole plant (height), the bulbs (weight) and leaves and flowers (number, longevity, specific area, dry matter content). One of the most interesting findings was a strong trade-off between investing into producing larger bulbs (vegetative reproduction) vs. producing expensive and long lasting flowers (sexual reproduction); which highlights a coordinated economic spectrum on the whole plant level.

T37

Do pollinators exert phenotypic selection on floral traits in generalized plant-pollinator interactions? The case of Viscaria vulgaris.

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Phenotypic selection on floral traits can diverge in response to spatial and temporal variation in the ecological context experienced by particular plant populations. However, there are a limited number of empirical studies that evaluate the role of spatial and temporal variation as a factor that can exert divergent consequences for the patterns of phenotypic selection on floral traits in generalized plant-pollinator interactions. In this study, we evaluated spatial and temporal variation in the strength and direction of phenotypic selection on floral traits at two *Viscaria vulgaris* populations located in southern Sweden. We complemented this phenotypic selection study with a temporal pollinator exclusion experiment to evaluate whether functionally distinct pollinators exert divergent patterns of phenotypic selection on floral traits. We observed positive and significant phenotypic selection on floral traits involved in the attraction of pollinators. Phenotypic selection on floral traits involved in the mechanics of pollen removal and deposition was limited. Overall, temporal variation produced the lowest difference in the estimated phenotypic selection gradients, followed by spatial variation. Variation among diurnal and nocturnal pollinators produced the greatest difference in the estimated phenotypic selection gradients. The strength and direction of phenotypic selection on floral traits in *Viscaria vulgaris* is comparable to other study systems with specialized plant-pollinator interactions. We underscore that functionally distinct pollinators can exert divergent consequences for the patterns of phenotypic selection on floral traits.

T38

Insect communities in Italian *Arabis alpina* populations with diverging scent profiles

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Most flowering plants require insect pollinators to increase their reproductive success. This dependence is one of the driving forces behind the speciation and diversification of angiosperms. The generalist herb, *Arabis alpina* L. (Brassicaceae) exhibits large intraspecific variation in composition of scent bouquets. Of particular interest is a geographically small area in central Italy, where this variation is prominent among populations that are genetically and geographically close. Such variation could be attributed to the preferences of the diverse insect visitors in different populations. Through pollinator observations, we measured the visitation rates of different insect species in 6 populations and compared the visiting insect communities across the different populations. We found that the communities were moderately distinct, with specific pollinators 'dominating' certain populations. Further analyses linking insect community and floral scent are pending. We also measured floral morphology and found great variation among populations, specifically in nectary depth. To explore potential correlations between insect and flower morphology, we correlated floral morphology measurements and insect proboscis measurements. We found indications of a positive correlation between the nectary depths of flowers and the proboscis lengths of the 'dominating' pollinator across populations, indicating a coevolutionary relationship between the insect community and *Arabis alpina*.

T39

Geranium sylvaticum maximizes pollination probability by sexually dimorphic flowers

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Sexual dimorphism in plants is most visible within populations of dioecious and gynodioecious species. Gynodioecious populations consist of female and hermaphrodite individuals. Females have lost their functional stamens, while hermaphrodites possess both female and male functions. Hermaphrodite flowers are characterized by being larger, showier, and more rewarding than female flowers. The difference between small female and large hermaphrodite flowers has been previously explained by various hypotheses, including the allocation of resources to produce more and higher quality offspring by females. However, a problem arises since females also require pollination for seed production, and reduced flower size reduces visitation rates. We propose a novel "pollination hypothesis" to attribute the size of the *Geranium sylvaticum* sexes as an adaptation to pollen receipt via pollinator behavior. We tested the hypothesis by video recording insect visitations in the flowers of different sexes and parameterized the contacts with reproductive organs by different insect groups. This allowed us to define pollination probabilities by the sexes via different insect groups. Pollen and stigma displays are linked by the pollinator. Based on our observations, the pollen display of hermaphrodites was compatible with the stigma display of females, unlike that of other hermaphrodites. According to these results, small-flowered females are adapted towards pollen receipt by affecting insect movements, and hermaphrodites attract more visitors than females but are not efficiently pollinated. Differential goals of the sexes are realized in terms of pollinator movements and drive *G. sylvaticum* evolution by creating directional selection pressure.

T40

Floral scent and plant defence in *Arabis alpina*

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One recent discovery is the presence of variation in floral scent among conspecific populations of plants involved in generalized pollination systems. Often, such variation is taken as evidence suggesting that the floral scent of different populations is moulded in different directions by pollinator mediated selection, due to e.g. variation in local pollinator communities. Pollinators are believed to drive the evolution of floral scent in several systems, and this theory can also be tested for *Arabis alpina*. However, one possibility is that floral scent may not be the target of selection and that pollinators are not the only agents shaping the evolution of the floral scent chemistry in this system. Many floral scent compounds share biosynthetic pathways with defence compounds. Thus, selection pressures that affect defence compounds could result in indirect selection on the floral scent compounds. Therefore, to determine if floral scent is free to evolve unrelated to other plant compounds it is important to investigate to what degree floral scent compounds are correlated to other plant compounds, especially those involved in plant defence. We extracted floral scent, constitutive foliar volatiles and glucosinolates from 23 populations of the perennial herb *Arabis alpina*. Thereby, we could assess the magnitude of interdependence among these compounds produced and emitted by different plant tissues. By comparing integration indices, we found that floral scent was largely not non-correlated with plant defence compounds in this species, and the geographically variable floral scent variation is thus likely the target of locally divergent selection pressures.

T41

Canadian bee-cology and a changing climate: Distribution and diversity of solitary bees in Canada using DNA metabarcoding and community data

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Solitary bees are an important part of Canadian ecosystems yet are understudied across much of Canada. Additionally, the climate is changing quickly with many potential consequences for cavity nesting bees. Understanding how Canadian bee communities are affected by the changing climatic conditions will help predict how communities may shift as ranges expand and contract. I am aiming to address the following research objectives: (1) What are distributions of cavity nesting bees in recent years? (2) How do changes in temperature and precipitation patterns affect the distribution of cavity nesting bees across Canada? (3) Do the sources of pollen and nectar provisions of cavity nesting bees change with differences in temperature and precipitation across Canada? I sampled several locations across Canada since 2019 using community data collected through the Bees@Schools program. I used DNA metabarcoding of each sample to identify the species of bees and the flowers whose pollen provisioned the nests. I gathered annual weather data from each site over the last 10 years to model the results and generate predictive distribution patterns in the changing climate. Results are currently pending but will be available by October 2023. This research will contribute to current knowledge of the distribution, diversity, and diets of Canadian bees. Generating plant-pollinator networks from the larvae and nest provisions is essential for effective conservation practices – especially as this longitudinal dataset becomes increasingly comprehensive and valuable for future analyses as the climate continues to change.

T42

Contrasting patterns of foraging behavior in Neotropical stingless bees using pollen and honey metabarcoding

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Stingless bees are major flower visitors in the tropics, but their foraging preferences and behavior are still poorly understood. Studying stingless bee interactions with angiosperms is methodologically challenging due to the high tropical plant diversity and inaccessibility of upper canopy flowers in forested habitats. Pollen DNA metabarcoding offers an opportunity of assessing floral visitation efficiently and was applied here to understand stingless bee floral resources spectra and foraging behavior. We analyzed pollen and honey from nests of three distantly related stingless bee species, with different body size and social behavior: *Melipona rufiventris*, *Scaptotrigona postica* and *Tetragonisca angustula*. Simultaneously, we evaluate the local floristic components through seventeen rapid botanical surveys conducted at different distances from the nests. We discovered a broad set of explored floral sources, with 46.3 plant species per bee species in honey samples and 53.67 in pollen samples. Plant families Myrtaceae, Asteraceae, Euphorbiaceae, Melastomataceae and Malpighiaceae dominated the records, indicating stingless bee preferences for abundant resources that flowers of these families provide in the region. Results also reinforce the preference of stingless bees for forest trees, even if only available at long distances. Our high-resolution results encourage future bee-plant studies using pollen and honey metabarcoding in hyper-diverse tropical environments.

T43

Unveiling Wild Bee Foraging Preferences: Investigating Pollen Collection with Visitation – and DNA-based Networks Across a Land-use Gradient

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Recent years have shown a rapid decline in wild bee populations, with land-use emerging as a prominent factor threatening plant-bee interactions along with other anthropogenic factors. The decline of wild bees is a threat to animal-pollinated plant species. Maintaining a diverse community of both bees and plants is essential to sustain the mutualistic relationship between them. To get a clearer picture of the foraging choices of wild bees within actively managed agricultural landscapes, we caught bees on plots differing in land-use intensity. All plots are integrated within the German Biodiversity Exploratories framework. We want to know how land-use affects variation in visitation - and plant-bee pollen networks. We hypothesize, (i) that observation networks are less specialized than pollen-based networks and that (ii) with increasing land-use intensity bees collect more flowering plant sources outside of plots. We present visitation vs. pollen-based interaction network results for bees sampled in 2020 and 2021 on a land-use gradient.

T44

Plant selection for pollinator restoration in semi-natural ecosystems

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Individual plant species play valuable roles in meeting restoration goals for pollinators. However, the selection of plant species for pollinator restoration is usually developed for agroecosystems, which experience frequent human interventions to ensure plant success. By contrast, semi-natural ecosystems are landscapes managed to meet diverse endgoals that range from provisioning ecosystem services to preserving biodiversity, and are frequently in remote locations. We created a framework to select plant species for pollinator habitat restoration in semi-natural ecosystems, and suggest that plants which can be produced in large quantities, are attractive to many pollinator species, occupy important positions in plant-pollinator interaction networks, and provide floral resources during times of resource bottlenecks, are most important for pollinator community restoration. We then observed plant-pollinator interactions to 23 focal plant species in naturally occurring communities across a large landscape in Montana, USA, and applied our framework to select the most important plant species for pollinator habitat restoration in semi-natural ecosystems. Focal plant species were divided into early-, middle-, and late-season flowering groups, and then ranked according to bee visitation rate and richness, the number of specialist bee species observed visiting a plant species, the frequency of occurrence in local communities, and phenophase duration. The rankings of each plant species were condensed into a composite score to aid land managers in selecting the plant species to best meet restoration goals. This study outlines a method that can be replicated by land managers from diverse regions to create a regionally-specific seed mix to achieve pollinator community restoration.

T45

Flower power is not enough: Which garden features affect pollinators in cities?

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While urbanization can have various impacts on insects depending on the habitat requirements of specific taxa, urban green spaces generally promote insect diversity and abundance. For pollinators, urban gardens represent particularly relevant types of urban green spaces, as they can harbour diverse nesting and food resources. Yet, little is known about the precise garden features that promote insect pollinators in cities. Our aim in this study was to show which features of urban community gardens affect (1) the diversity, richness and abundance of pollinators in general; and (2) the abundance of certain pollinator groups. Over two seasons, we recorded pollinators in 33 urban community gardens in two German cities (Munich and Berlin). We assessed flowering plant richness, open soil, deadwood and urbanisation surrounding the gardens as garden features and analysed their effects on pollinators using GLMMs. We found that flowering plant richness positively affected pollinator group diversity, richness and abundance. The effects of habitat features on single pollinator groups varied between all analysed taxa. E.g., deadwood only affected beetles, while higher urbanisation only positively affected the number of bumblebees. Our findings suggest that flowering plant richness is a good general feature to promote pollinators in urban gardens. To promote many different pollinator groups in urban gardens a diverse range of habitat features should be integrated as life cycles and habitat requirements differ between pollinator groups. Results of this study may be used to further develop evidence-based recommendations for gardens and other green spaces to actively support pollinators in cities.

T46Flash

Pollen foraging by native social bees in a southern Indian habitat

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Apis cerana and *Tetragonula iridipennis* are common social bees that pollinate a variety of plant species and are extensively reared for honey production in India. Both species are resource generalists, and previous studies indicate high constancy in pollen foraging in both these species. However, it is not known whether the hive-level specialisation and constancy change over time with changes in floral resource composition in the community. The two bee species differ in size, foraging range, colony size and active foraging hours, which can have an effect on the resources that they use. This study aims to examine pollen resource use by *T. iridipennis* and *A. cerana* over four months during peak flowering by identifying pollen collected from individual bees. Specifically, we ask: 1) Is there overlap in pollen resources used and to what extent? 2) Does overlap in pollen use vary with flower availability? 3) Is the diet breadth of *A. cerana* wider than *T. iridipennis* at the colony level and at the individual level? We found a very high degree of pollen constancy in *A. cerana* over the study period. Analyses are underway to understand the dietary overlap of these species over time.

T47Flash

Pollen analysis using automated image recognition and DNA barcoding compared

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We have compared the results of pollen analyses of the same samples using two different methods: automated image recognition using deep learning, and DNA barcoding. Approximately 120 corbicula pollen samples were collected from several species of bumblebees (*Bombus* spp.) and honeybees (*Apis mellifera*) in a field study design with faba bean fields (*Vicia faba*) and flower strips with mostly phacelia (*Phacelia tanacetifolia*) and clovers (*Trifolium* spp.), but also field margins with various weeds and shrubs including bramble and dewberry (*Rubus fruticosus* and *R. caesius*). We used rbcL and ITC2 markers for the DNA barcoding, which allowed us to identify plants to genus or species levels. The deep learning method can be tailored to analyse samples at any taxonomic resolution desired, provided reference training samples are available. However, in most cases it will not be reliable at the species level, but for morphologically similar groups consisting of several related species (in a few cases a whole family). Overall, the qualitative correspondence between the two methods was good, i.e. the same taxa were identified with both methods. The strengths of the DNA barcoding are the somewhat higher taxonomic resolution of the results and that available barcode reference libraries cover very many species. The strength of the image recognition is that it is quantitative, that it can be manually cross validated, and its low price (ca 3-4€ per sample).

T48

Floral economic spectrum traits are correlated with leaf traits: plants with “juicy“ leaves usually have “juicy“ flowers

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Plant economic spectrum expresses, in what function the plant invests certain amount of limited sources. There is the fast-slow continuum, that in one extreme consists of fast-growing and short-living plants and at the other extreme of slow-growing and long-living plants. Position on this continuum is usually estimated by measuring leaf traits, such as specific leaf area (SLA) and leaf dry matter content (LDMC). Recently, it was suggested that also flower traits can form their own economic spectrum, distinguishable by analogies of leaf traits, such as specific floral area (SFA) and floral dry matter content (FDMC), measured on flower petals. Here we asked if floral economic traits are independent of leaf economic traits. Thus, we conducted a field survey of 71 mostly meadow herbs from a wide range of families. The leaves and the flower petals were processed for specific leaf area, leaf dry matter content, specific floral area and floral dry matter content. The expected and well documented negative correlation between SLA and LDMC was confirmed in our data, but also found for the respective floral traits, i.e. between SFA and FDMC. Moreover, we found positive correlations across organs, i.e. between FDMC and LDMC, and between SLA and SFA, with the former the stronger of the two. Relatively strong relationship between LDMC and FDMC could be related to the dependence on soil water content of both organs. Correlations among all four studied traits imply that flowers and leaves are subjected to similar trade-offs, even though their functions are entirely different.

T49

Flashy flowers: how glossy colours shine and confuse

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Why are some organisms shiny, and others not? Shininess is found all over the tree of life, from butterflies to buttercups, from fishes to flies. The appearances of these taxa are dominated by a flash, a bright pulse of light that probably enhances long-range signal visibility. However, shiny colours come at a price, because the shine may undermine the ability to identify the object at close range. Colours with a matte appearance prevail in nature, but the very many independent origins of shiny colours across the tree of life hint at an adaptive benefit of shininess. What are these benefits and when do they arise? We have recently started addressing these questions in a plant-pollinator context. Using glossy/matte artificial flowers with different colours, we tested how glossiness determines the long-and short-distance visibility of these objects for bumblebees. We found that bumblebees exhibit an innate preference for matte over glossy stimuli, presumably because the visual signal of matte stimuli is constant with varying angles of observation/illumination. The strength of bee preference for matte stimuli is, however, dependent on the colour of the stimuli. In addition, we found that glossiness undermines fine colour discrimination. Altogether, our behavioural data hint at an ecological trade-off of glossiness, which explains why in some taxa glossy flowers have evolved repeatedly, whereas in other groups they are absent. I will contextualise our findings within a broader evolutionary framework, with particular reference to the evolution of the optical properties of flowers (e.g. buttercups and sexually deceptive species) and butterflies.

T50

Spectral purity or colour contrast as biologically relevant descriptors of flower colour signals for bees

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Flowers typically display salient visual signals to bees. The large peripheral corolla colour attracts bees from a distance, whereas the central floral guide directs an approaching bee towards rewards. Colour is a complex perception. Currently there is a debate about whether the attribute of colour contrast, or spectral purity, is the biologically relevant descriptor for flower signalling. These attributes are typically correlated descriptors of signalling observed in nature. However, colour contrast refers to a scalar that describes the precise magnitude of the perceptual distance between two respective colours, whereas spectral purity describes a vector specifically representing the colour difference of a potential target relative from an adaptation background like foliage. To understand what the biologically relevant descriptor is for why flowers evolve colours it is important to consider how bees process colour information. Evidence from behavioural tests with free-flying bumblebees approaching bi-coloured patterns (background vs corolla, and corolla vs floral guide) show that colour choices do take into account both signal magnitude, and direction. Honeybees and stingless bees in preference tests also prefer colours that are more spectrally pure, even when available presented stimuli are easily detected. The consequences for flower signalling are striking. Flowers evolved visual signals to attract bees from a distance using corolla colour that is contrasting to the background. As a bee approaches a flower the central floral guide becomes visible, and these signals are always of higher spectral purity to promote the bee to land, collect a reward, and enable plant pollination.

T51

Scent emissions from a nectar yeast across different floral backgrounds and context-dependent effects of nectar yeast on bumblebee foraging behavior

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In the intricate world of plant-pollinator interactions, a fascinating phenomenon emerges – nectar robbery. Nectar robbers infiltrate flowers of various angiosperms, puncturing petals near the nectary to consume nectar and often sidestepping their pollination duties. Secondary nectar robbers then exploit the holes left by their predecessors, further diminishing the nectar resources available to lure legitimate pollinators. This study delves into the role of *Metschnikowia reukaufii* (*Metschnikowia*), a nectar-specialist yeast isolated from robbed flowers, in shaping the floral phenotype of four distinct wildflower species and the foraging behavior of nectar-robbing vs. pollinating bumblebees. Our investigation uncovered the following insights: 1) Nectar Environments: *Metschnikowia* displays similarities in volatiles across different nectar environments. While a few of its volatiles are unique to specific nectar types, the majority of *Metshnikowia's* volatile compounds, as well as its effects on nectar pH, remain consistent. 2) Yeast Volatiles: *Metschnikowia* emits volatiles at concentrations lower than the overall flower bouquet, yet at levels detectable by both GCMS and bumblebee olfaction. Notably, *Metschnikowia* volatiles surpass plant volatiles in abundance within the nectar of our studied wildflower species. Evidence also suggests that *Metschnikowia* significantly alters the composition of plant-produced nectar volatiles. This may disrupt the ability of floral visitors to locate nectar based on plant cues. 3) Nectar Cues: Preliminary findings indicate that nectar robbers may rely more heavily on *Metschnikowia* cues for nectar location compared to pollinators. This might stem from nectar robbers' dependence on nectar cues and pollinators' reliance on petal cues for nectar discovery in flowers with enclosed nectaries.

T52Flash

Strong and stable scent? Adaptive and nonadaptive drivers of floral volatile variation

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Angiosperms exhibit spectacular diversity in floral traits that attract pollinators, and understanding the sources of this diversity is a central goal of pollination biology. However, of the wide range of morphological, colour and chemical traits that comprise floral displays, floral scent remains surprisingly poorly understood, particularly at larger spatial or phylogenetic scales. In this talk I will discuss two studies investigating the effects of reproductive strategy, biochemical constraints and environment on floral scent variation among species and populations that vary in their reliance on insect pollinators. In a comparative study of wild Solanaceae, GC-MS analysis of floral metabolites and phylogenetic models of trait evolution revealed convergent shifts in aromatic and terpenoid emissions in less pollinator-dependent species, and greater stability of scent composition in more insect-reliant taxa when exposed to biotic stress. Analysis of scent variation among populations suggests that pollinator limitation can cause rapid divergence in scent profiles. Flower and leaf volatiles were highly distinct, but a primary constraint on floral volatiles appeared to be the magnitude of the covariance between leaf and flower emissions. I will conclude with a conceptual framework for understanding floral scent regulation that emphasises the complex interplay of natural selection by insects, pleiotropy, phenotypic plasticity and phylogenetic history.

POSTER PRESENTATION ABSTRACTS

P1

BRASILICO-Worldwide Bee Monitoring Project: Phases I, II and III

Samuel Boff[1], Alberto Satta, Anja Dünnebeil, Anna Traveset, Andre Rech, Alan Eriksson, Aline C. Martins, Antonio Aguiar, Bo Dalsgaard, Breno Magalhães, Caio S. Ballarin, Camila Aoki, Cora Carmesin, Daniela Parizotto, Eunice Enríquez, Evandson J. dos Anjos Silva, Isadora Meneses Ramalho, Favizia Freitas de Oliveira, Fernanda Santos, Fernando Gonçalves, Hannah Burger, Henning Madsen, Ingrid Gomes, Juan Manuel Benitez Alvarez, Kemilly Silva Albuquerque, Laercio Peixoto do Amaral Neto, Lars Straub, Larysson Feitosa dos Santos, Luisa Carvalheiro, Manfred Ayasse, Maria Auxiliadora Milaneze Gutierres, Maria Cristina Gaglianone, Marina Muniz Moreira, Maureen Labarussias, Michela Pusceddu, Nayara Carvalho, Patricia Landaverde, Patricia Nunes-Silva, Pietro Maruyama, Rafael Beltran, Robert J. Paxton, Rodrigo Gonçalves, Sabrina Gurten, Thiago Mata Barreto, Vivian Freitas Maranhães, Marcelo Mello, Mauricio Fernández Otárola, Mohamed Shebl, Lucas Padula Abbade, Marcos Yudi Nagaoka Godoy, Luis Gustavo de Sousa Perugini, Vanessa Carolina de Sena Correia, Vincent Doublet, Wesley Dáttilo, Josué Raizer

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The Brasilico Worldwide Bee Monitoring Project aims to document bee communities in a standardized manner to assess the impact on them of local and landscape factors. It commenced as a citizen science initiative focused on monitoring bee populations in Brazil during the spring of 2020 amidst the COVID-19 pandemic. Since its inception, the project has expanded its network of collaborators within Brazil and across the globe. Presently, our monitoring efforts span beyond the borders of Brazil, encompassing both urban and rural areas in countries such as Costa Rica, El Salvador, Guatemala, Mexico, Germany, Switzerland, Spain, Italy, Denmark, and Egypt. Despite the challenges posed by analyzing data across highly variable latitudinal and longitudinal coordinates, our monitoring adheres to a unique protocol, concentrating solely on observations of bees during their interactions with basil flowers (*Ocimum* sp.). While tropical regions exhibit a higher diversity of bee species, visitation rates are found to be contingent upon the abundance of basil flowers. Currently, we are engaged in a comprehensive analysis of the role of various landscapes, which appear to exert a significant influence on bee community composition and visitation rates.

P2

Flower morphology in blueberry cultivars and its relation to flower visitors

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Highbush blueberry is a globally important fruit crop with growing demand, that depends on insect pollinators to produce market quality fruits. However, pollination is far from being a simple process and is affected by several interacting factors. Among these factors, flower morphology plays a key role in determining which visitors are pollinators, the visit rates, as well as the occurrence of nectar robbing. In this study, we seek to identify the main pollinators for several blueberry cultivars and relate pollinator visitation rates to flower morphology. For this, we

selected five individuals from each of 10 northern highbush cultivars, eight southern highbush cultivars and one rabbiteye cultivar. The study was conducted at an experimental field in Centro region, Portugal, and thus all cultivars were under the same growing conditions. Plant-pollinator interactions were obtained by direct observations, and visitor identity, as well as the number of flowers visited were recorded in 5 minutes periods distributed throughout the day. Flower morphological traits related to pollination such as corolla length and corolla opening were measured in 6 flowers per individual. The analysis of flower morphological traits shows variation among cultivars, with Chandler having the flowers with the longest corolla. Preliminary analysis of pollinator data shows three main pollinators, *Anthophora plumipes*, *Bombus terrestris* and *Apis mellifera*. Data also shows variation in the visitation rates of these pollinators among varieties. The implications for blueberry production are discussed.

P3

Climate change effect on flight times in a Batesian Mimicry complex

Blessing Chidinma Umeh[1], Gunnar Mikalsen Kvifte, Markus A.K. Sydenham, Michael Allen Patten

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Plant-pollinator communities thrive when the phenology of interacting species is in sync. There has been concern about how climate change alters interactions between plants and pollinators in space and time. Previous studies have focused on climate change as the driver of phenological changes in plants and pollinator groups. Little is known, about the effect of climate change on complex evolutionary interactions like the Batesian mimicry complex (where models with aposematic signals (bumblebees) are being mimicked by some harmless "mimics" (hoverflies, Diptera: Syrphidae) to evade predators). It is yet unknown if the phenological mismatches of the Batesian mimicry complex might undergo quick evolutionary adjustments under conditions related to climate change, enabling these pollinator groups to interact. Using temperature as a measure for climate change, this project aims to explore how the flight period of the bumblebee model and its mimic hoverflies has changed over time and across latitudes within the Scandinavian Peninsula (Norway and Sweden) using citizen science data from Artsdatabanken and Artspolen. We would expect the flight periods of both models and mimics to have advanced with time, with bumblebees advancing sooner than their mimic hoverflies and with more shift in the north compared to the southern latitudes. Understanding the evolutionary response to anthropogenic climate change is essential to evade climate-driven mismatches within the batesian mimicry complex.

P4

Wild pollinators in space and time: A spatiotemporal investigation of bumblebee population genomics

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Bumblebees have a wide-ranging distribution across various temperate habitats and pollinate a diverse array of plant species, many of which are pollinated predominantly by bumblebees. They are thus considered keystone pollinators, and recent population declines of several bumblebee species across the globe have been the source of growing alarm. The causes are believed to be a combination of anthropogenic factors, such as land-use change and urbanisation, leading to depletion of forage resources and widespread habitat fragmentation. Population genomics is a crucial tool for investigating the impacts of such threats on dispersal, genetic diversity and gene flow between populations. Here, we conduct a spatiotemporal population genomic analysis on three bumblebee species with contrasting biological traits:

Bombus lapidarius, a widespread generalist which is seemingly resilient to urban stressors; *Bombus pascuorum*, a significantly polymorphic bumblebee species commonly found in agricultural landscapes; and *Bombus consobrinus*, a mountainous forage specialist. To investigate the effect of land use change on the dispersal and spatial genomic differentiation of these functionally different bumblebees, we will conduct both fine-scale and coarse-scale population structure analyses across a mosaic of land-use types. Furthermore, we will assess the effects of continuous exposure to anthropogenic threats over time by drawing upon advances in ancient DNA (aDNA) methodology in order to carry out temporal comparisons of historical bumblebee genomes obtained from museum collections.

P5

Assessment of the resilience of plant-wild bee interaction networks in N2000 priority habitats in Wallonia.

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The worldwide concern over the decline of pollinators needs plans for the conservation of this pollination ecosystem service. National and regional plans first require a comprehensive assessment of the abundance and diversity of insect pollinators and of their floral resources, as well as an in-depth understanding of the dynamics and resilience of plant-pollinator networks. The aim of our project is to improve knowledge of floral resources and wild bee communities in Wallonia, particularly in Natura 2000 priority habitats on limestone substrates such as chalk grasslands. Our aim is to develop citizen science monitoring for the plant-bee communities in protected sites (nature preserves and national parks). Monitoring will be tested in partnership with volunteers (mainly Cercles des Naturalistes de Belgique). Identification keys for the common wild bees present in Belgium will be produced and used by volunteers. The second part of the project will test the robustness and resilience of the interaction networks in order to suggest practical actions for the restoration and management of these vulnerable habitats.

P6

Heterospecific Pollen on Plant Neighbors: Intensity and Trait Similarities

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Sharing pollinators causes positive (enhanced pollinator attraction) and negative (decreased pollinator attraction and/or heterospecific pollen deposition - HPD) effects on plants. These effects may be directly related to floral traits similarities between neighboring plants. Our objective was to understand the intensity of HPD and the impact of trait similarity on HPD between neighboring plants. We sampled 35 plots, with 2m² each, spaced at least ten meters in the Campos Rupestres, a highly biodiverse rocky outcrop vegetation in Brazil. We monitored plant blooming from September 2022 to March 2023 and measured floral traits (corolla, stamen and pistil length and corolla diameter) of the plants. Every three weeks, we collected stigmas from species within the plots, counting the heterospecific pollen (HP) and conspecific pollen (CP) on stigmas. From the 806 stigmas of 56 species, the majority received both CP (approximately 85%) and HP (about 55%), while only 22% received over ten HP grains. The HP/CP ratio averaged 0.1 per stigma. Six plant species received more HP than CP. The variation in HP proportions among species showed that 82% had a proportion less than or equal to 0.25 HP/CP, while 8% had a proportion greater than 0.5. Among the plots, two had a ratio greater

than 0.5, while 32 had a ratio lower than 0.25 HP/CP. Notably, trait similarity (coefficient of variation of each floral trait) was not related to HPD. Our results confirm the frequent occurrence of HPD and indicate the lack of association with floral trait similarities. Reproductive success data would strengthen these findings.

P7

Is there a relationship between heterospecific pollen deposition and pollen limitation at the community level? A case study with plant-hummingbird interactions from Brazil

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Heterospecific pollen deposition (HPD) is omnipresent in plant communities and is usually associated with pollinator sharing (generalization) and negative effects for plant fitness. On the other hand, very specialized pollination systems may be more likely to be disrupted or fail in pollen delivery when pollinator visits are scarce (Pollen Limitation - PL). We explore the HPD-PL relationship at the community level for plant-pollinator interactions. Data was collected between August/2017-July/2018 in Diamantina, Brazil. Stigmas were collected every month to evaluate the conspecific pollen deposition (CPD) and HPD in 31 species visited by hummingbirds. Attached pollen grains were identified, quantified and classified into conspecifics and heterospecifics. We calculated the intensity of CPD/DPH and DPH frequency (proportion of stigmas containing heterospecific pollen) per species. To estimate pollen limitation (PL), we compared supplementary cross pollination(PC) and natural pollination (NP, N= 30 flowers/species/treatment). The PL was estimated as ((PC – PN) / PN) for each species. The frequency of stigmas with heterospecific pollen was relatively high, with an average of 53% out of the 31 species. Although PL was generally low, most species (78%) had some degree of PL, and 22% had none. We found a negative relationship between PL and HPD intensity in such a way that the plant species that receive more heterospecific pollen exhibited lower LP. Therefore, the greater the intensity of HPD, the greater the fruit set obtained by natural pollination. Our results indicate benefits of generalization and facilitation in the highly diverse Campos Rupestres.

P8

To drop or not to drop: Investigating the link between insect-pollinator activity and June drop in Sweet Cherry (*Prunus avium*).

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Sweet cherry in the UK undergoes a natural process generally referred to as ‘Cherry run-off’ or ‘June drop’, during which immature fruit are abscised from the plant. The quantity of fruit lost annually to June drop is highly variable. These fluctuations in yields make cherry an unpredictable crop for farmers, driving the need to further investigate the causes of June drop to understand how this process can be mitigated. This study aimed to use high-definition time-lapse cameras to investigate plant-pollinator interactions on cherry trees and reveal what role pollinators have on fruit retention during June drop. Twelve cameras were used to record pollinator activity on flowering cherry trees for 17 days between 11am and 5pm, when pollinator activity is at its peak. The cameras were deployed within two distinct pollinator density treatments, high and low. The different densities were accomplished using commercial bumblebee colonies in

netted areas to simulate possible scenarios that can be found in cherry orchards. The recordings were compared to in-person observations to validate time-lapse cameras for pollinator studies. Preliminary analysis reveals that cameras in high-density areas captured more floral visits than those in low density areas, which is consistent with in-person observations. Preliminary results also indicate that trees in high density areas retained a higher proportion of fruit during the June drop than those in low density areas. This study will greatly contribute to the understanding of how remote monitoring can help identify fluctuations in pollinator activity levels and their subsequent role in fruit loss.

P9

Standardizing bee sampling: a systematic review of pan trapping and associated floral surveys

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A widely accepted method for sampling bees is the use of pan traps. This method allows simultaneous sampling of sites, and several methodological studies and conceptual frameworks offer guidance on its standardization. So far, it is unclear if bee studies use these standardized methodologies consistently so that results among studies are comparable. Furthermore, the effect of floral abundance around pan traps on the number of bees sampled with these traps is still under debate within the scientific community. We systematically searched for peer-reviewed studies in English, published until 2022 and listed in the Web of Science core collection, which used pan trapping for bee collection. We extracted details on trap characteristics and on the methodology used to sample flower abundance and diversity around traps. Out of 369 references in total, we extracted detailed information from 290 studies. These studies described similar methodologies for a few aspects such as trap color; other aspects (for example, sampling duration, filling level or trap solution composition) varied considerably among studies. Only a small subset of studies used floral abundance and/or diversity as an explanatory variable in their analyses. In comparison to botanical surveys, these studies often simplified floral sampling methods, probably due to sampling time constraints or efforts to synchronize floral and bee sampling periods. Correlations between floral indices and bee indices showed an ambiguous relationship. Our review highlights the value of incorporating floral context into pan-trapping studies and the need for standardized methods in future bee research.

P10

Mapping the genomics of Scandinavian wild bee populations on multiple geographical scales

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Insects are key ecosystem service providers, and loss of insect diversity and abundance is expected to have cascading effects on natural ecosystems and human welfare. Particularly alarming is the decline in wild pollinators, which is already limiting crop production. Bees are the most important group of animal pollinators, they represent a broad range of ecological traits and are in urgent need of conservation. They are also ideal ecological model species for studying the influence of functional traits on population connectivity at different spatial scales, as their community composition vary drastically along environmental gradients and their broad variation of functional ecological traits and life history strategies is well studied. Because bees don't tend to migrate long distances, their traits and genomic signatures may be expected to vary with habitat conditions, making habitat preference and functional traits possible predictors for

population structure and connectivity. In this project, we will combine functional ecology and habitat suitability data with genome-wide biodiversity estimates, to obtain insights into wild bee population connectivity on multiple geographical scales. By using species with varying functional traits and dispersal abilities, our models of connectivity may be fitted to a limited number of focal species or generalised to entire pollinator communities. Such novel population connectivity models, locating diversity hotspots and dispersal barriers, will provide essential basis for conservation efforts to mitigate the effects of human activities on insect decline.

P11

Polyploidy, a geographic mosaic in the interaction with specialized and generalized pollinators, and plant reproductive success

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Both polyploidization (whole-genome duplication) and geographic structures in species interactions are important drivers of floral diversification. Polyploidization causes immediate strong reproductive isolation among different ploidy lineages and newly emerged polyploid lineages are prone to minority cytotype exclusion. Increased reproductive success in polyploids has been suggested to help mitigate minority cytotype exclusion. Studies in a few systems in limited parts of the species' distribution range indicate that polyploidy affects interactions between plants and their pollinators and herbivores. Here, we assess the contribution of the specialized, seed parasitic pollinator *Greya politella* (Prodoxidae) and more generalized pollinators to the reproductive success of *Lithophragma bolanderi* (Saxifragaceae) and relate this to plant ploidy-level across its entire distribution range along the western foothills of the Sierra Nevada, California, as well as within a mixed-ploidy population. *L. bolanderi* comprises three major ploidy types (diploids, tetraploids and hexaploids). It coevolves with its specialized pollinator *G. politella*, which shows local adaptation in pollination efficacy, but it is also pollinated by more generalized pollinators in some populations. We evaluate here how overall fruit set and seed set varies with plant ploidy level and the extent of pollination by the specialized pollinator *G. politella*. The results suggest how a combination of polyploidy and a geographic mosaic in the interaction with specialized and generalized pollinators shape local and geographic variation in plant reproductive success and how polyploid lineages can establish and coexist with their diploid progenitors.

P12

Nectar-robbing along an elevational gradient in Western Norway

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Co-evolution of corolla tube length and pollinator tongue length has been discussed by ecologists for many years. While some flowering plants have evolved longer corolla tubes, some pollinator species have evolved longer tongues to collect nectar from these long-corolla flowers. One such specialized interaction happens between *Bombus consobrinus* and *Aconitum septentrionale*. This specialized interaction tends to be mutually beneficial, as both plant and pollinator are rewarded for their efforts. However, climate change, and shifts in pollinator phenology and species composition, pose potential threats to such specialized interactions by affecting the timing of flowering and pollinator activity. This can cause asynchrony between plant flowering and pollinator activity, potentially leading to reduced pollination efficiency

and reduced reproduction for the specialized plants. Changes in the species composition of pollinators can also introduce new interactions and competition for resources. Understanding the interplay between plant phenology and habitat choice is important for understanding wild pollinator's role in ecosystem functions. This study investigates the relationship between elevation and number of robbing holes on *Aconitum septentrionale*, using the number of robbing holes as a proxy for foraging behaviour of *Bombus wurflenii*, a nectar-robbing bumblebee species. Data was collected during the summer of 2023 along an elevational gradient in Western Norway, from below the tree line and into the alpine zone. The results will potentially have implications for conservation efforts, and give deeper insight into this plant-pollinator interaction.

P13

3-D pollination syndromes in *Aquilegia*

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Flowers of the genus *Aquilegia* are pentamerous and have two petaloid perianth whorls, of which the inner one is spurred; nevertheless, their morphology is highly diverse. In Asia and Europe pollinators are mostly bumblebees and bees, while in North America shifts to hummingbird and hawkmoth pollination have occurred. In earlier studies, typical bee, hummingbird or hawkmoth syndromes have been inferred for *Aquilegia* flowers, which we can largely confirm in our re-analysis of classical pollination syndromes. However, *Aquilegia* species are usually visited by a number of different pollen and nectar collectors, and some species seem to exhibit in mixed pollination systems. To better understand the floral evolution through pollinator-driven selection, we use X-ray computed tomography with the aim to identify 3-dimensional shape traits possibly resulting from the adaptation to one or more pollinators. Furthermore, we are complementing the study of anthetic flowers with a comparison of floral developmental sequences, among species with different pollination syndromes to fully understand floral trait divergence at a morphological level in these pollination syndromes

P14

Flower color polymorphism in the Peacock Anemone (*Anemone pavonina* LAM)

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The peacock anemone (*Anemone pavonina*) is an herbaceous plant native to the Mediterranean Region. As known from other species of the genus Anemone, different color morphs are found in *A. pavonina*. In Greece, populations on the slopes of Mount Olympus possess mainly red flowers at low elevations up to 1200m a.s.l. and purple flowers dominate at higher elevations. Furthermore, mixed-colored populations occur in the transition zone between 1000m and 1200m a.s.l. Red flowers only reflect light within the visible spectrum, but purple flowers are also blue-UV-reflecting. Beetles of the genus *Pygopleurus* are supposed to be the main pollinators of the red morph whereas purple flowers are probably pollinated by bees. In my PhD project I want to investigate what biotic and abiotic factors cause and maintain this color polymorphism. In 2022 and 2023, I conducted field experiments and found that *A. pavonina* is highly pollinator dependent and shows almost no seed set when insect pollination was excluded. Furthermore, insect pollination in red

flowers decreased with increasing elevation while pollination in purple individuals remained stable. Further experiments are planned to investigate the pollinator community, pollinator efficiency and temperature gradients.

P15

Climate warming decreases berry production in functionally important species

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Experiments along elevational gradients represent a unique possibility to understand climate and climate change impacts on species and their interactions. We simulated climate warming and increased herbivory attacks, by using open-top chambers and by inducing plant resistance with methyljasmonate-application, in dwarf-shrub dominated vegetation along tree elevations in temperate (100 masl), boreal (500 masl) and alpine (900 masl) bioclimates. We investigated vegetative and reproductive responses in two functionally important plant species bilberry (*Vaccinium myrtillus*) and lingonberry (*Vaccinium vitis-idaea*). We found that warming effects affected growth negatively for both species at low elevation, but positively at high elevation, whereas reproduction decreased at all elevations but only in bilberry. The plant resistance treatment decreased reproduction and herbivory levels in both species, but the combined treatment of warming and resistance only had synergistic negative effects on reproduction in bilberry. Plant growth responses to warming were thus elevation-dependent, whereas reproductive responses were species-dependent. Climate warming in combination with increased invertebrate herbivory may be particularly detrimental for bilberry reproduction, a result that may have many potential knock-on effects for the numerous of interacting species that rely on bilberry.

P16

Pollinating insects in urban and suburban areas of Bergen, Norway - a pilot project

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The wild pollinator fauna in and around Bergen, Norway has not been mapped since the 1970s. In recent years, increased attention has been given to measures that benefit pollinating insects from local, municipal and national actors. However, evaluation of the different measures require systematic monitoring of the pollinating insects. Knowledge on which species are present and their particular habitat requirements is needed to successfully support wild populations in the system. In addition, many of the proposed facilitation strategies in Norway might have limited effects, as they are typically focused on using generic insect hotels as well as relying on beekeeping as strategies to safeguard pollination in an urban setting. Our pilot study aims to (1) start initial mapping of wild bees present in urban and the sub-urban areas of Bergen, (2) establish stations where we initiate and investigate appropriate small scale measures that support local populations of wild bees, (3) inform and spread knowledge about the biodiversity of pollinating insects to the general public, through aesthetically pleasing and ecologically appropriate facilitation stations and, (4) investigate the applicability of established landscape models to predict habitats and corridors for pollinating insects.

P17

Effects of pollinator density on the patterns of selection on floral traits

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In most angiosperms, access to sexual partners is mediated by pollinators. If some floral traits confer an advantage in terms of pollinator attraction, and if this advantage translates into an advantage in terms of the number of offspring left to the next generation, then these floral traits should be under selection. With land use change, plant-pollinator interactions could be altered, potentially leading to an increase in pollen limitation. In this case, one possible prediction is that the selection of attractive floral traits should intensify within both sexual functions in an anthropized environment compared to a natural environment, which is more favorable to pollinators. However, the intensification of selection could differ between sexual functions, due to the numerical difference in gametes between them, a question as yet unstudied in the literature. In this study, we test this hypothesis in a dioecious species, Silene dioica. Six natural populations in northern France, located in two contrasting environments, a semi-natural environment and an agricultural environment, were studied. Within these sites, the floral traits and reproductive success of male and female plants were measured, in order to estimate and compare the selection exerted on these traits, between sexes and between environments. In addition, pollinator communities were characterized at each site, and hand pollination experiments were carried out to quantify pollen limitation. This poster presents the initial results of this study.

P18

Pollination of lingonberry *Vaccinium vitis-ideaea*

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Lingonberry (*Vaccinium vitis-idaea*, Ericaceae) is a common dwarf shrub in boreal forests. The annual lingonberry crop can be more than 30 kg per hectare and it is very important food for birds and mammals such as the brown bear. In economic terms, up to 10 million kg lingonberry is picked by humans in Finland. However, there is nearly no information on the pollinators of lingonberry. In this work, we explored the pollinators of lingonberry in middle boreal region in central Finland summer 2019 and 2020. Furthermore, in an experimental set-up, we studied the importance of farmed honeybee (*Apis mellifera*) as a potential pollinator of lingonberry. In eight sites, we established 8 x 50 cm x 50 cm plots that were (i) open pollinated (four plots per site) (ii) pollinated by insects smaller than bumble bees (2 plots per site) (iii) insect pollination was excluded (two plots per site). In half of the sites (n=4) we transferred honeybee hive next to the plots. Half of the sites (n=4) were known to be without honeybees. In all plots (n=64), we monitored insect visits on the lingberry flowers. Honeybees did not increase fruit set or berry weight, but increased seed abortion rate. The results highlight the importance of solitary bees (*Andrena* spp.) as lingonberry pollinators.

P19

Flower size as an honest signal in Royal Irises (*Iris* section Oncocyclus, Iridaceae)

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Flower traits such as flower size or color changes can act as honest signals of higher re-wards like nectar, but nothing is known for shelter-rewarding systems. Large flowers of Royal irises offer overnight shelter as reward to Eucera bees. A black patch might signal the entrance to the tunnel (shelter), and together with flower size, might act as honest signals. We hypothesize that larger flowers and black patches indicate larger tunnels, and larger tunnels would increase pollinator visits enhancing plant reproductive success. We measured seven species from a controlled environment, and two species from three natural populations varying in flower size. Fruit and seed set was assessed in these natural populations. We found a positive correlation between flower, patch size and tunnel volume, suggesting that flower and patch size act as honest signals, both under controlled conditions and in the wild. However, in the natural populations, this positive relationship and its effect on fitness was population-specific. Flower size increased fitness in YER *Iris petrana*, and interactions between flower/patch size and tunnel size, increased fitness in YER and *I. atropurpurea* NET populations. This suggests a positive selection on the honesty of the signal in these two populations. This study supports the hypothesis that pollinator-mediated selection leads to honest signaling of flower advertisement.

P20

Fine-Scale Bee Phenology and Apple Flowering in Hardanger, Western Norway

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Climate change has the potential to disrupt the relative timing of interacting species, such as plants and pollinators, leading to a possible alteration in their phenological synchrony. As such, global warming could lead to greater year-to-year variation of local environmental conditions, including phenological patterns. Following the biodiversity insurance hypothesis, a higher diversity of pollinators may serve as a possible buffer against phenological mismatches, offering ecological resilience in contrast to species-poor systems. In this study, we investigate the relationship between above-ground temperatures and the activity of bees pertaining to the flowering of the domesticated apple (*Malus domestica* x Borkh). Temperature acts as a crucial trigger for the emergence of wild bees, as well as being one of the main drivers of apple flower phenology. Furthermore, the relatively short flowering period of apple trees makes it a good model for phenological mismatches. By examining temperature and other within-season conditions, it is possible to investigate fine-scale phenological changes as well as local variability. The study was carried out in apple orchards in the Hardanger region, Western Norway, prior to, during, and after the mass flowering season of apple in 2022 and 2023. Preliminary results of pollinator diversity, phenology, and temperature recordings could provide crucial knowledge about local environmental dynamics and their ecological and agricultural implications.

P21

Pollen as Bee Medicine: Is Prevention Better than Cure?

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To face environmental stressors such as infection, animals may display behavioural plasticity to improve their physiological status through ingestion of specific food. In bees, the significance of medicating pollen may be limited by their ability to exploit it. Until now, studies have focused on the medicinal effects of pollen and nectar after forced-feeding experiments, overlooking spontaneous intake. Here, we explored the medicinal effects of different pollen on *Bombus terrestris* workers infected by the gut parasite *Crithidia bombi*. First, we used a forced-feeding experimental design allowing for the distinction between prophylactic and therapeutic effects of pollen, considering host tolerance and resistance. Then, we assessed whether bumble bees favoured medicating resources when infected to demonstrate potential self-medicative behaviour. We found that infected bumble bees had a lower fitness but higher resistance when forced to consume sunflower or heather pollen, and that infection dynamics was more gradual in therapeutic treatments. When given the choice between resources, infected workers did not target medicating pollen, nor did they consume more medicating pollen than uninfected ones. These results emphasize that the access to medicating resources could impede parasite dynamics, but that the cost–benefit trade-off could be detrimental when fitness is highly reduced.

P22

The predictive use of floral scents to identify pollinator mechanisms

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Floral traits have been extensively used to predict the pollinator guild identity of diverse plants. Whereas the relationship of floral shape and colour with pollinator guild has been extensively studied, that between floral scents and pollinator identity has been not explored deeply. Although floral shape and colour can help to predict the identity of the pollinator guild (i.e. bee, fly, moth, etc.), it may not be useful in plants shifting between closely related pollinator groups (e.g. different types of beetles). Here, I use the genus *Amorphophallus* (Araceae) and the family Orchidaceae, two plant groups that have been well sampled in terms of floral scent chemistry, to test the relationship between floral scent chemistry and pollinator identity. Based on species with known pollinators, we developed models based on floral scent chemistry which can predict the pollinator functional group identity in the analysed plants. In the case of *Amorphophallus*, sulphur compounds were the most important to discriminate between pollinator functional groups, aliphatic esters helped to identify potential non-yet-described pollination mechanisms. In orchids, both pollinator guilds and pollinator reward could be linked to floral scent chemistry. Interestingly, the most common compounds (e.g. linalool, ocimene) were the chemicals that helped at most to discriminate among pollinator guilds and rewards of orchid flowers. For both aroids and orchids, we reconstructed the evolution of the main chemicals in a phylogenetic tree, which helped to shed light on the potential evolution of plants and their pollinator shifts.

P23

Temperate food forests: a valuable novel habitat for pollinators?

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Worldwide, pollinator communities are in decline due to changes in land use and management intensity, climate change, pesticides and genetically modified crops, pollinator management and pathogens, and invasive alien species. Consequently, pollination as an ecosystem service is also under threat. Decreases in both wild pollinator communities and the pollination service have been observed across an array of habitat types, including croplands, grasslands, forests and urban areas. Recently, a potential novel habitat for pollinators is increasingly being created in the Western European landscape: food forests. Temperate food forests are multi-layered food production systems that are designed to emulate (mid-succession) woodlands. They are commonly expected to harbour great biodiversity. Indeed, temperate food forests' high plant diversity, structural diversity and presence of floral resources and their low management intensity suggest they could serve as a valuable habitat for wild pollinators. However, scientific evidence to back up this claim is currently lacking. With this study, we aim to assess the potential of this novel habitat for supporting pollinator biodiversity by comparing bee and syrphid communities in food forests with communities in three reference habitats: forests, grasslands and croplands. We hypothesise that abundance and diversity of bees and syrphids are highest in food forests, followed by grasslands, forests and croplands. Both proxies are thought to increase with the diversity of flowering plants and the number of flowers present in the studied habitat. Additionally, we hypothesise that community compositions in food forests are intermediate between those of forests and grasslands/croplands. In the SCAPE conference poster session, we present our study setup and some first observations.

P24

How does pollinator diversity affect gene flow and thereby fruit yield and quality in Norwegian apple orchards?

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Apple production is highly dependent of cross-pollination by insects, often using numerous cultivars or pollinizer trees. Furthermore, apple production is highly variable, and even more so facing climate change. Knowledge about which role the pollinator communities play in these systems may bring us closer to understanding why the between year variation is so large, and how to mitigate this variation. In this particular study, we will use state of the art genetic methods (Genotyping-by-sequencing) to investigate how the genes are transported within the orchards, and how this is affected by pollinator diversity and abundance. In turn, we will look into how the fruit quality and seed set is affected by the observed gene flow. The study sites, two in southern Norway and two in western Norway, represents the variation found in Norwegian apple production in terms of size of apple orchards, management practices, use of honey bee hives and proximity to semi-natural and natural habitat.

P25

The role of nocturnal pollinators in Norwegian Apple horticulture

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Malus domestica (apple) is an economically important fruit crop that relies on pollen transfer to achieve high yields and fruit quality. To date, most research on apple pollination has focused on diurnal insects such as bees and hoverflies. However, little is known about the contribution of nocturnal pollinators, such as moths, to apple pollination. I explored the diversity and abundance of nocturnal pollinators and assessed their role as pollinators in Norwegian apple horticulture. Research was conducted on three apple varieties (Aroma, Discovery, and Summer Red) during the apple flowering season during May 16–June 2, 2023, at two study sites in eastern Norway. To determine if nocturnal insects were present in the study sites during the flowering season, I placed one light trap at each site for eight nights. In total 22 specimens were collected: 16 moths, 4 bees, 1 fly and 1 crane fly. In addition, I placed stationary camera traps on flower clusters to monitor nocturnal pollination activity throughout the flowering period (approx. 45,000 photos total). Photos are still being analyzed. To better understand the relative contribution of nocturnal pollinators to apple production, I conducted a pollinator exclusion experiment where flowers were either accessible only during the day (sunrise to sunset), accessible only at night (sunset to sunrise), or not accessible to pollinators at all (control). Preliminary results suggest that flowers accessible to pollinators only during the day produced eight times as many apples as flowers accessible only at night. Future analyses will explore the quality of apples produced by diurnal and nocturnal pollinators.

P26

Exploring the head-space; can leaf volatiles attract fig pollinators?

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To better understand factors that might contribute to pollinator specificity, we captured in a previous study fig pollinating wasps at 13 *Ficus* species, sampling at different phases of the reproductive cycle of the host figs (e.g. trees with receptive inflorescences, or vegetative trees, bearing only leaves). The results indicated that not only floral volatiles but also leaf volatiles could play a role in host recognition and pollinator attraction. Here I present a first comparison of odour bouquets produced by fig leaves and fig flowers from *v popenoei*, and will reflect on the pollinator attracting potential of leaf volatiles.

P27

Pollinator dependency along the elevational gradient of the Nevado de Colima, Mexico

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Montane systems allow us to study the response of different organisms to changes in environmental conditions along an elevational gradient. In plants, these changes affect reproductive aspects such as reproductive success and availability of pollinators. In the context of climate change, understanding plant-pollinator relationships helps us to identify plant species at risk of extinction due to the general decline of pollinators. The objectives of the study are to identify patterns in the distribution and activity of the pollinator community, and assess the dependence of plants on pollinators and the capacity for autonomous reproduction as a function of elevation in different strata of the Nevado de Colima, covering elevations from 2400 to 3650 meters above sea level. Focal observations of flowering species were made to determine the community of floral visitors and their visit rates. To determine the dependence of pollinators on fruit set, differential reproductive success was compared between free-pollination and closed-pollination experiments. The capacity for autonomous reproduction was evaluated as the difference in fruit set produced without pollinators at different elevations. The pollinator community includes hummingbirds, bees, bumblebees, flies, and butterflies. According to previous studies, the abundance of pollinators decreases in high areas; however, we observed a bell-shaped distribution in the abundance of the whole pollinator community. There were differences between the dependence of pollinators in the high and low areas but between all strata.

P28

Plants and pollinators in the concrete jungle: unmasking urbanization's influence on flower features

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Urbanization is frequently cited as a primary factor contributing to the observed pollination crisis. The rapid global expansion of cities has severe potential consequences for biodiversity and ecosystem functioning. This dynamic growth has led to a significant increase in research focused on understanding the effects of urbanization on pollination. Cities host a significant diversity of local pollinator species, however, urban pollinator communities may exhibit unique characteristics. We have a unique chance to observe the evolution of a million-year-old interaction in a new environment (cities). There are no studies testing the potential impact of urban-related factors and pollinators on the evolution of floral traits. The aim of our study is to test the extent to which urban conditions modify the pollination process and whether the selection pressure exerted on plants by pollinators changes in urbanized areas. We focus on the pollination biology of the common native synanthropic plant Echium vulgare, which, due to its frequency, plays a potentially vital role in urban ecosystems. We investigate whether urban-related factors affect nectar characteristics, pollen deposition and transfer among populations, and pollinator activity.

P29

Can agroforestry practices be designed to support wild pollinators and crop performance? Insight from the agricultural landscapes of east province of Rwanda

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Global biodiversity is disappearing through food systems and the agricultural land use is a major driver of biodiversity losses and changes in ecosystem services. The pollinator declines in agricultural landscapes may impact society, economy and human well-fare, directly through degraded crop pollination, and in the long-term through declining biodiversity and ecosystem functioning and hence the impacts on crop yield and quality. In tropical Africa, a wide range of agroforestry practices exist, with an unknown impact on ecosystem services. Here, we examined the consequence of arthropod biodiversity on crop performance in agricultural landscapes of east drylands of Rwanda. Despite their extreme diversity, there are few scientific studies investigating arthropod biodiversity and associated ecosystem services in the study area. Furthermore, the fact that there is no information of the interaction between wild pollinators and trees and plants/crops in Rwanda, may lead to the underestimation of their economic value and lack of empirical evidence may lead to poor decision making with respect to their conservation in a rapidly changing world. This study aims at investigating the extent to which beans (*Phaseolus vulgaris*) depend on pollination, and whether local and landscape scale structure is linked with to visitation by wild pollinators, and hence crop yield. This study will also illustrate how the current agroforestry practices can be adjusted to stimulate the pollination services while providing numerous benefits to the landowners. Here, an emphasis will be on characteristics that inform farm management practices at both local and landscape scale.

P30

The impact of landscape features on pollination services provided to sweet cherry

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Agricultural landscapes can have detrimental impacts on pollinator communities, which play a crucial role in pollinator-dependent crops like sweet cherry (*Prunus avium*). The proximity to semi-natural habitats can mitigate these effects, as such habitats provide essential food and nesting resources to sustain pollinator communities. In this study, we assessed how the percentage of semi-natural habitats in sweet cherry orchards in the Centro region of Portugal influences pollinators. We conducted census observations in focal plants to record pollinator's visitation. Pollinators were identified at the genus level to evaluate the occurrence of the different groups of pollinators. The percentage of semi-natural habitat was calculated considering the total area of natural forests, shrublands and non-managed grasslands surrounding studied orchards in a 500-meter radius. The proportion of semi-natural habitat within a 500-meter radius of the orchards ranged from 6% to 33%. *Apis mellifera* was a frequent floral visitor in all orchards. Nevertheless, wild pollinators accounted for 49% of all pollinator visits. Pollinator richness was positively related to the percentage of semi-natural habitats, and pollinator abundance was positively impacted, although no statistical differences were observed in the latter. Our results show that agricultural areas with a lower percentage of pollinator-friendly habitats have a lower diversity of pollinators, with a non-significant reduction of pollinator abundance, which may lead to impairments in fruit production. Hence, implementing landscape-scale measures to conserve and protect semi-natural and natural areas becomes vital for pollinator-dependent crops such as sweet cherry.

P31

High rates of nectar depletion in summer grasslands indicate competitive conditions for pollinators

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Competition between pollinators for floral resources is a phenomenon of both basic and applied importance. While competition per se is difficult to measure under field conditions, it can be inferred indirectly through the measurement of floral resource depletion. In this study, we conducted a pollinator exclusion experiment to calculate nectar depletion rates in summer across 16 grassland sites in the Germany regions of Franconia and Saxony-Anhalt. Overall depletion rates were estimated at 95% in Franconia and 79% in Saxony-Anhalt, indicating strong nectar limitation and, by implication, competition between pollinators. Despite being ubiquitous in our study regions, honey bees were scarce at our sites at the time of nectar sampling. This demonstrates that wild pollinators alone are capable of massive nectar depletion, and the addition of managed honey bees to new areas may intensify already competitive conditions. Nevertheless, the manifest diversity of the pollinator communities at our sites indicates that other factors (e.g., nest site limitation, top-down pressures) can mitigate competitive exclusion even under conditions of extreme food limitation.

P32

Spatio-temporal patterns of invasive bee pastures, based on the knowledge of beekeepers

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Invasive alien plant species are altering floral resources of pollinators, including honey bees. Understanding their role has an interdisciplinary importance for ecology, conservation and economy. For example, invasive plants could be important in apiculture as bee pastures. Hence, investigating the opinions (i.e. ecological knowledge) of beekeepers about condition and spatio-temporal changes of such resources can help to understand invasion ecology. Therefore, we asked >400 beekeepers, by questionnaires, about their opinions on challenges, current condition, and expected future of bee pastures, within Hungary. Here, we focused on four invasive plants: black locust, false indigo, goldenrod, milkweed. The four investigated invasive bee pasture are important honey producers. Black locust, steadily, is the most important bee pasture, while false indigo and milkweed have regional importance and the latter is losing its importance, some beekeepers also avoid it. The pollen and nectar of goldenrod species are important winter food for honey bees since decades. For generations, beekeepers had to face to lost native bee pastures, replaced by these new, invasive plants. These species are also raising conflict between stakeholders, through threatening nature and agriculture. Beekeepers considered that the eradication of alien plants is the most problematic factors about the future of bee pastures, causing serious economic problems without alternative foraging resources. Furthermore, bee pastures could even be vulnerable to the forthcoming climate and environmental changes, so it is need to reveal past patterns and possible future scenarios in details, as well to involve all the stakeholders into discussions and collaborative knowledge-pooling about bee pastures.

P33

Bumblebees in relation to *Aconitum septentrionale* in Central Norway (Øyer)

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Pollination services by bumblebees are vitally important in boreal ecosystems. Over the last 80 years, substantial shifts in bumblebee community composition have been documented in other parts of Scandinavia with potential negative effects on the reproduction of the plants they pollinate. Astrid Løken studied the bumblebee community in Øyer over the summers of 1939-1941. Her recordings give us a unique snapshot of the bumblebee community in Central Norway 80 years ago. Løken monitored the bumblebee species in the area specifically those visiting *A. septentrionale*. Løken also observed the behavior of the bumblebees during the day and over the flowering season of *A. septentrionale*. My goal was to repeat Løken's field work to compare the bumblebee community 80 years ago with my observations of the current situation. The alpine area in Øyer, at an altitude of 900-1000 masl, has not been affected by habitat change, and is still used as pastures by local farmers, grazed by sheep and cattle. My fieldwork was carried out in four periods during the summer of 2023, each of a duration of four days; in late June, at the beginning and end of July, and mid-August. I identified bumblebees visiting *A. septentrionale* to species and registered their mode of collection on flowers. In addition I registered the flowering stage of *A. septentrionale* and weather conditions as these have been shown to affect bumblebee behavior. Species determination is about to be completed and thereby the comparison of the current bumblebee community is yet to be done.

P34

Impact of invasive plant species on wild bee conservation

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The Anthropocene is characterised by a major decline in pollinators, particularly affecting bees. Conversely, on the other side of the mutualism that lies behind the pollination activity, some plant species are taking advantage of anthropogenic activity to expand their distribution. These invasive plant species can modulate plant-pollinator interactions and therefore constitute a disturbance factor for communities. This poster summarises a PhD project that aims to characterise how invasive plant species alters the floral resource profile at the local landscape level, as well as their consequences on bee floral choices and fitness. To answer this question, we will study along an invasion gradient, the summer lilac (*Buddleja davidii*), an invasive species rich in floral resources. We will first describe how the diversity, abundance and quality of floral resources are affected. We will then investigate the repercussions of these changes on the interaction profile of bee species with the plant community using pollination networks. Finally, the consequences on bee fitness will be evaluated via an experimental approach with sentinel bumblebee individuals placed on the sites. In the current context of pollinator decline, the multidisciplinary approach of this project will make it possible to precisely characterise the impact of invasive species and help to define effective conservation strategies.

P35

Community-level response of plant-pollinator interactions

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The loss of area and connectivity of semi-natural habitats in Europe is threatening the functioning and resilience of plant-pollinator networks in these biodiversity hotspots. FuncNet is a Biodiversa+ project between Estonia, Belgium, Germany, Sweden and the Czech Republic for gaining knowledge about the effects of land use change on functional connectivity on plant-pollinator networks. As a part of this study, we aim to assess the structure of plant-pollinator metanetworks in response to the fragmentation of semi-natural grasslands. As the area and connectivity of semi-natural grasslands has been decreasing over the past century in Europe, other marginal landscape elements, such as road and ditch verges, power-line clear-cuts, can be vital for supporting insect-pollinated grassland plants and pollinators. However, mismatches in plant-pollinator interactions in response to landscape change have not been studied thoroughly before and are vital to understand in order to maintain important ecosystem functions. We aim to assess plant-pollinator networks in well-connected and fragmented landscape systems through observations, while also mapping the pollinator diversity and plant species composition within each fragment. In addition, pollen samples will be collected from pollinators for metabarcoding analyses to evaluate the floral availability for pollinators. The results will go towards giving recommendations to stakeholders for implementing biodiversity-friendly landscape management practises.

P36

Pollination mechanisms in *Vanilla* (Orchidaceae)

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Little is known about the pollination mechanisms of species belonging to the pantropical genus *Vanilla* (Orchidaceae). Both autonomous self-pollination and animal-mediated pollination mechanisms seem to exist amongst the *Vanilla* species, yet few studies provided real evidence on pollination events. Based on sporadic records, euglossine bees have been observed visiting flowers of Neotropical Vanilla species. Our research aimed at better understanding the pollinator attraction mechanism of two Neotropical species, *Vanilla pompona* and *Vanilla hartii.* We tested for nectar presence, analysed nectar composition, and examined floral fragrances. Furthermore, we identified floral visitors and documented their behaviour, quantified fruit set during two consecutive years, and compared morphological traits of both flowers and their visitors. We found that *Vanilla pompona* is pollinated by *Eulaema cingulata*, and displays a dual pollinator attraction mechanism that combines floral fragrance rewards with food deception to induce pollen removal. *Vanilla hartii* rewards its floral visitors with sucrose-rich nectar, and is pollinated by *Euglossa* species that morphologically fit with the flowers. Combining our results with an in-depth literature review, we presume that Neotropical *Vanilla* species belonging to the section Xanata are pollinated by Euglossini. Finally, an overview of the pollination mechanisms known so far provides insights into the potential evolution of reproductive strategies within this commercially important orchid genus.