SCAPE 2022

36th Annual Meeting of the
Scandinavian Association for Pollination Ecology

13-16 October
Gimo, Sweden

Main Building
Registration
All meals

Conference building

Lodging in buildings 1, 2, 3, 5, 6, and 9

Sauna in Sjöstugan (red building by the lake, encircled)

Programme overview

	THURSDAY 13 OCTOBER		
15:30			REGISTRATION
18:00			DINNER
19:30	Organisers		Welcome and information
19:45		P01-P11	POSTER presentation I
21:00			SAUNA (Sjöstugan) / SOCIALISING (Conference building)
	FRIDAY 14 OCTOBER		
07:00			BREAKFAST
			Chair: Magne Friberg
08:30	Ethan Newman	T01	Structural anther mimics improve reproductive success through dishonest signalling that enhances
			both attraction and the morphological fit of pollinators with flowers
08:45	Douglas Moore	T02	Signals from flowers with morphologically distinct anthers and their influence on pollinators
09:00	Monika Lipinska	T03	Pollination syndromes in the Neotropical orchid subtribe Maxillariinae Benth.
09:15	Pamela Santana	T04	Coevolution in mutualistic networks
09:30	Katrina Degenhardt	T05	Reproductive ecology of buzz pollinated *Primula meadia*
09:45			COFFEE 30 min
			Chair: Marcos Mendez
10:15	Svenja Horstmann	T06	Are bumblebees and butterflies in linear infrastructure habitats affected by landscape history ?
10:30	Veronica Hederström	T07	Effects of surrounding land-use on pollinator availability and flower visitation in semi-natural grasslands
10:45	Bjørn Arild Hatteland	T08	Diversity and phenology of bees visiting apple orchards and effects of the surrounding landscape in Norway
11:00	Ola Olsson	T09	Landscape effects on resource competition in bumblebees
			Minibreak 15 min
			Chair: Mario Vallejo-Marin
11:30	Felipe Torres-Vanegas	T10	Pollinator foraging tactics have divergent consequences for plant mating systems
11:45	Katarzyna Roguz	T11	Always on the safe side. Autonomous selfing in *Fritillaria persica* L. - how much pollen stays on the stigma and
			what is the role of the potential pollinators in pollen transfer
12:00	Upuli Wickramaarachchi	T12	Effects of mating system specific- herbivory induced secondary metabolism on pollinator visitation and behaviour
12:15	Kai-Hsiu Chen	T13	Why do some hermaphroditic species produce male-only flowers?
12:30			LUNCH 90 min
14:00	**Nathan Muchhala**	**INV**	**Actinomorphy to zygomorphy: effects of floral symmetry on pollination, diversification, and abundance**
			Minibreak 15 min
			Chair: Paolo Biella
15:15	Hedda Barfod Ørbæk	T14-F	Bilberry fruit and seed production in a hand-pollination experiment along an elevational gradient in Sogn, Norway
15:20	Jørund Johansen	T15-F	The foraging preference and behavior of managed and wild bees in apple and pear orchards
15:25	Eleanor Kent	T16	Commercial bumblebees for blueberry crop pollination supplement their pollen diet from the wider landscape
15:40	Linn Vassvik	T17	Pollination and potential pollen deficits in Norwegian apple orchards
15:55	Imogen Ryan	T18	To honeybee or not to honeybee? Informing honeybee stocking densities on commercial farms
16:10			COFFEE 30 min
			Chair: Åsa Lankinen
16:40	Sunayana Sajith	T19	Cost-effectiveness of alternative pollination strategies for strawberries in a protected cropping environment
16:55	Edith Villa Galaviz	T20	What makes a good pollinator in British strawberry fields?
17:10	Kedar Devkota	T21	Pollination services are resilient to an extreme climatic event and mitigate crop yield declines
17:25	Cassandra Vogel	T22	Pumpkin fruit set is limited by herbivory and low pollinator richness in a tropical smallholder agricultural landscap
17:40	Carolin Mayer		Latest news and development of the Journal of Pollination Ecology
			Minibreak 15 min
18:00		P12-P17	POSTER presentation II
19:00			DINNER
20:30			SAUNA (Sjöstugan) / SOCIALISING (Main building)

	SATURDAY 15 OCTOBER		
07:00			BREAKFAST
			Chair: Marcin Zych
08:30	Wilhelm Osterman	T23	Plant pollinator dependency for seed production in Arctic ecosystems
08:45	Mikko Tiusanen	T24	Shifting phenology and niche overlap in flowering plants and their pollinators along an elevational gradient
09:00	Guillermo Gómez	T25	Tales from Africa: Sunbird-plant interactions on Mt. Cameroon
09:15	Lisette van Kolfschoten	T26	Rising temperatures threaten pollinators of fig trees - keystone resources of tropical forests
09:30	Aafke Oldenbeuving	T27	Field traps and volatiles, inferring how a fig wasp chooses her host
09:45			COFFEE 30 min
			Chair: Renate Wesselingh
10:15	Isabel Kilian	T28	Assessing the plant-pollinator network of caraway (*Carum carvi* L.)
10:30	Emelie Ellis	T29	Multi-city study reveals negative effects of urbanisation on bees, hoverflies and moths
10:45	Merijn Moens	T30	Modelling plant-pollinator and parasitic relations in species distribution models
11:00	Océane Bartholomée	T31	Pollinator functional traits: a global overview of their diversity and their use
			Minibreak 15 min
			Chair: Jon Ågren
11:30	Ada Wroblewska	T32	The role of food-deception strategy in reproductive output of *Dactylorhiza* orchids
11:45	Thomas Rupp	T33	Telling lies to flies - deceptive strategies in fly-pollinated *Aristolochia* trap-flowers
12:00	Andrés Romero-Bravo	T34	The role of plasticity and heritability in rapid floral evolution
12:15	Rachel Spigler	T35	Considering the importance of floral longevity in understanding pollinator-mediated selection on attractive traits
12:30			LUNCH + WALK
			Chair: Ola Olsson
15:00	Benjamin Fuchs	T36	Can herbicide residues in soil affect plant signaling to pollinators and predatory insects?
15:15	Linzi Jay Thompson	T37	Opposing effects of a fungicide on bumblebee colonies
15:30	Alison O'Reilly	T38	Widely used insecticides impact the foraging behaviour and pollination services delivered by solitary mason bees (*Osmia bicornis*)
15:45	Peter Lampert	T39	Developing action aompetence for insect preservation
16:00	Saorla Kavanagh	T40	Protecting farmland pollinators
			COFFEE 30 min
			Chair: Nina Sletvold
16:45	Karin Gross	T41	Direct effects of whole-genome duplications of floral traits in the coevolving, nursery pollinated *Lithophragma bolanderi* (Saxifragaceae)
17:00	Katherine Eisen	T42	Flower size, not floral scent, may function as an honest signal in a generalist-pollinated plant
17:15	Mario Vallejo-Marin	T43	Can bee vibrations remove pollen from non-buzz-pollinated flowers?
17:30	Jeff Ollerton	T44	Representing pollinators and pollination in large data sets: an introduction to the new WorldFAIR project
17:45	Jon Ågren	T45	Enchanted by *Calypso*: selection via female and male function in a deceptive orchid
19:00			DINNER
21:00			SAUNA (Sjöstugan) / SOCIALISING (Main building)
	SUNDAY 16 OCTOBER		
08:00			BREAKFAST
10:00			DEPARTURE

Organising committee:
Jon Ågren
Nina Sletvold
Lisette van Kolfschoten

UPPSALA UNIVERSITET

SCAPE

Invited speaker

Actinomorphy to zygomorphy: effects of floral symmetry on pollination, diversification, and abundance

NATHAN MUCHHALA

Dept. of Biology, University of Missouri - St. Louis, Missouri, USA

While the ancestral symmetry of angiosperm flowers is actinomorphic (radial symmetry), hundreds of lineages have independently evolved zygomorphic flowers (bilateral symmetry). Such shifts are associated with more specialized pollination systems, and lead to significant increases in diversification rates. But what are the actual benefits of zygomorphic flowers for a plant? One little-tested assumption is that zygomorphy maximizes pollen transfer by allowing flowers to place pollen in a more precise and repeatable way on pollinator's bodies. If so, floral orientation should be much more important for zygomorphic versus actinomorphic flowers. Experimental manipulations support this idea: when flower positions are altered, zygomorphic flowers quickly readjust, bending stems or pedicels to return to the original position, while actinomorphic flowers show little response. To further explore the effects of zygomorphy on pollination, we performed flight cage experiments with nectar-feeding bats and artificial flowers, testing how floral symmetry and orientation affect pollen removal and transfer. For each flower, four anthers were placed either all of the way around the opening (actinomorphic) or together at one side of the opening (zygomorphic). Nearly twice as much pollen was transferred between zygomorphic flowers, but only when angled at 45°, causing pollen to be consistently placed on the tops of bats' heads. When flowers were positioned flat (pointed upwards), bats approached from many different angles, and zygomorphic flowers performed no better than actinomorphic ones in terms of pollen transfer. Together, results suggest that shifts to zygomorphy allow more specialized pollination systems which, with the correct floral orientation, maximize pollen transfer success. In the final part of the talk, I explore why such specialized pollination is associated with increased diversification rates, presenting evidence that in fact zygomorphy acts to decrease extinction rates rather than (as often assumed) acting to increase speciation rates.

T01

Structural anther mimics improve reproductive success through dishonest signalling that enhances both attraction and the morphological fit of pollinators with flowers

ETHAN NEWMAN, KATHARINE KHOURY, SANDY VAN NIEKERK, CRAIG PETER

Dept. of Botany, Rhodes University - Makhanda, Eastern Cape, South Africa

Numerous studies have identified traits associated with pollen mimicry, however, the processes underlying floral deception remains poorly documented for these structures. We studied the importance of attraction and mechanical fit of anther mimics in *Tritonia laxifolia* (Iridaceae) and their relative contributions to reproductive success. To determine anther mimics role in pollinator attraction, we offered bees' binary preferences to flowers painted with UV absorbent and reflecting paint. We also conducted preference experiments between flowers with excised anther mimics and unmanipulated controls, from which mechanical fit was assessed using single visits. Anther mimics effects on female reproductive success was determined using similar treatments,

but on rooted plants. Bees preferred UV absorbent over UV reflecting anther mimics. Preference for flowers with and without the three-dimensional structures was equal. Single visits resulted in more pollen deposition on unmanipulated controls over flowers with their anther mimics excised, which was directly linked to pollen-collecting behaviour. Controls with unmanipulated anther mimics experienced more seed set than those with their anther mimics excised. This study provides insights into pollinator-mediated selection on deceptive floral signals and shows that three-dimensional anther mimics increases reproductive success through both attraction and pollen collecting behaviours that improves the fit between flowers and pollinators.

T02

Signals from flowers with morphologically distinct anthers and their influence on pollinators

C. DOUGLAS MOORE, DAVID J. PRITCHARD, MARIO VALLEJO-MARIN

Biological Sciences, University of Stirling – Stirling, UK

Plants attract pollinators using an array of signals operating on different senses, i.e. sight and smell. Many pollinators consume pollen, thus their nutritional needs conflict directly with the reproductive needs of plants. Heterantherous plants have overcome this conflict by evolving distinct anther types which specialize in the function of either pollination or feeding pollinators. However, how the distinct anthers contribute to the overall signalling effect of heterantherous flowers, influencing pollinator attraction and behaviour, has been little studied. Here we explore how scent from different floral parts interact to influence pollinators, and test the hypothesis that heteranthery extends beyond morphology to olfactory signals. We compared the choices and behaviours of free-flying pollinators (*Bombus terrestris*) foraging for pollen on artificial flower arrays treated with scent extracts from different organs of a heterantherous flower (*Solanum rostratum*) and quantitively explore differences of the olfactory signals emitted. Scents produced by the anthers were preferred by bees, stimulating longer floral visits and more pollen collecting behaviour than corolla scents. Within the androecium, bees were more attracted to scents of feeding anthers than pollinating anthers but exhibit no behavioural differences. These results show that specialization in heterantherous flowers extends beyond morphology to the signals they produce, and we suggest that the coordination of signals between floral organs improves reproductive success.

T03

Pollination syndromes in the Neotropical orchid subtribe Maxillariinae Benth.

MONIKA M. LIPIŃSKA, AGNIESZKA K. KOWALKOWSKA, ŁUKASZ P. HALIŃSKI, DARIUSZ L. SZLACHETKO

Dept. Plant Taxonomy and Nature Conservation, University of Gdańsk – Gdańsk, Poland

Orchids, by most accounts the largest plant family, are one of the most advanced groups of plants in terms of adaptation to different forms of zoogamy. They are renowned for their great diversity of pollination syndromes. Specific features such as flower morphology, color, nectar production, and odor presence are considered to determine the suitability for pollination among different groups of animals. Although the complexity of the pollination systems is usually higher than floral morphology initially would suggest. Maxillariinae Benth. is a large, megadiverse subtribe of ca.

800-1000 species with an exclusively Neotropical distribution range. Pollination biology of most of its representatives remains either entirely unknown or presumed solely on the floral morphology since there are no field records of pollination events for most species. Bee pollination syndrome seems to be the most common among Maxillariinae, however, other syndromes such as pseudocopulation or ornithophily, have also been described. In our research, we are dedicated to investigating floral attractants by means of scanning (SEM) and transmission microscopy (TEM), histochemical and chemical analyses (GC-MS), and whenever possible combining obtained results with the field observation.

T04

Coevolution in mutualistic networks

PAMELA C. SANTANA; BRUCE ANDERSON; ANA PAULA APRÍGIO ASSIS; FLORENT GRENIER; ALLAN ELLIS; PAULO ROBERTO GUIMARÃES JÚNIOR

Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo - São Paulo, Brazil

Mutualistic interactions affect individual fitness and species trait evolution. As a consequence, mutualisms may facilitate reciprocal selection and drive coevolutionary dynamics. A fundamental fact of most mutualistic interactions is that the fitness consequences of mutualism often vary across interacting individuals and populations, generating asymmetries. Two asymmetries are likely to impact coevolutionary dynamics: i) Fitness asymmetries - differences in the strength of selection imposed by pairwise interactions; and ii) Specialization asymmetry - differences in specialization and dependence across partners. As evolutionary effects cascade through the network of interacting species, the phenotypic patterns at the community level are expected to be influenced by these asymmetries. Because several traits mediate most mutualistic interactions, these traits might be under distinct asymmetries. Here, using a mathematical coevolutionary model combined with empirical data (floral features, trait functionality, and network structure) from a specialized pollination community in South Africa, we investigated the consequences of fitness and specialization asymmetries on the coevolutionary dynamics of mutualistic networks. Our results suggest that asymmetries may play an important role in the phenotypic outcomes of coevolution. Selection asymmetries may change the amount of trait evolution each species experiences during the coevolutionary process and affect trait matching patterns. At the community level, selection asymmetries may fuel trait disparity in the network and determine which species changes more through the coevolutionary dynamics. Our results indicate that asymmetries may generate convergence of specific functional traits among some guild members and in only one guild of species.

T05

Reproductive ecology of buzz pollinated *Primula meadia*

KATRINA DEGENHARDT, JEFF KARRON, DOROTHY CHRISTOPHER, RICHARD RUSH, RANDY MITCHELL

Biological Sciences, University of Wisconsin-Milwaukee – Milwaukee, Wisconsin, USA

Buzz pollination represents a classic example of convergent evolution of floral form and function across unrelated lineages. In the genus *Primula* there was a single origin of buzz pollination in North America, comprising 17 species. These nectarless species often flower in spring when *Bombus* queens are searching for nest sites, and are primarily foraging for nectar rather than for

pollen. Our research focuses on the reproductive biology of *Primula meadia*, which is distributed in prairies across eastern and central North America. Although *Primula meadia* occurs at high abundance at some sites, we hypothesized that dependence on pollen-foraging bees might limit reproductive success in this species. At our wet prairie study sites *Primula meadia* is pollinated by queens of 5 *Bombus* species, as well as by halictids (*Augochlorella*). We use slow motion macro videography to document the dynamics of buzz pollination and pollen transport. We also show that *Primula meadia* is severely pollen limited at each of our study sites, with pollen supplemented flowers producing 2-3 times as many seeds as open pollinated flowers. Our future research will address temporal and geographic variation in pollen limitation in this species.

T06

Are bumblebees and butterflies in linear infrastructure habitats affected by landscape history?

SVENJA HORSTMANN

Dept. of Ecology, Swedish Agricultural University – Uppsala, Sweden

Grassland habitats along linear infrastructures, such as those in road verges or power-line corridors, have gained attention as potential supplementary or replacement habitats for species suffering from the widespread loss of traditionally managed semi-natural grasslands. However, it can take time for species to colonise new habitats, and both the historical and the current landscape composition can impact their colonisation rate. For two types of linear infrastructure habitats, road verges and power line corridors, we analysed the effects of time since habitat establishment and the current and historical land cover in the surrounding landscape on the species richness of plants, butterflies and bumblebees. We found a higher plant richness along older roads, and that butterfly and bumblebee richness were positively related to plant richness, independent of the road age. Plant richness was higher in power line corridors that were established on former grasslands than on forests. Butterfly richness was lower in power line corridors with higher proportions of potentially suitable habitats in the surrounding. While species with slow dispersal rates such as plants can take longer to settle in new habitats, mobile species such as flying insects are often found to react more directly. However, herbivorous and pollinating insects depend on the availability of plant resources, and therefore their arrival in a new habitat can be indirectly delayed. Provided there is continued appropriate management, our results show that species richness in linear infrastructure habitats can be expected to increase in the future.

T07

Effects of surrounding land-use on pollinator availability and flower visitation in semi-natural grasslands

VERONICA HEDERSTRÖM, THERESIA KRAUS, YUANYUAN QUAN, YANN CLOUGH

Centre for Environmental and Climate Science, Lund University. – Lund, Sweden

In many regions across the globe, pollinators have been negatively impacted by intensification of agricultural management, loss of natural habitat, and habitat fragmentation. This raises concerns about the persistence of plant species dependent on insect pollination for their reproduction. Using an experimental setup consisting of 18 semi-natural grasslands along a land-use intensity gradient, we link surrounding land-use to pollinator availability. Preliminary results from 2 years of plant-insect observations suggest, as can be expected, that the response to landscape composition

differed among insect groups. Flower visits from bumblebees and butterflies were positively related to the proportion arable crops as well as to mass flowering crops, and negatively related to the proportion leys within 1 km from the focal area. The opposite result was seen for beetles, with a similar trend for solitary bees. Visits from beetles and moths were positively related, whereas visits from hoverflies and other flies were negatively related to the proportion permanent grasslands in the surrounding 1 km. This suggests that effects of landscape context on plant reproduction will differ based on identity of pollinators visiting a plant. We are currently looking into trait-specific responses to land-use for these insect groups, and analyzing pan trap, seed-set, biomass and plant community survey data to understand how land-use driven pollinator-assembly-change impacts plant community composition and ecosystem functioning.

T08

Diversity and phenology of bees visiting apple orchards and effects of the surrounding landscape in Norway

BJØRN ARILD HATTELAND, SANDRA KAASEN VESTHEIM, JØRUND JOHANSEN, MAREN K. HALVORSEN, SILJE M.M. HØYDAL, STEIN JOAR HEGLAND, JOSEPH CHIPPERFIELD, MARKUS SYDENHAM, ANDERS NIELSEN

Norwegian Institute of Bioeconomy Research (NIBIO), Dept. of Invertebrate Pests and Weeds in Forestry, Agriculture and Horticulture - Bergen, Norway

Managed honeybees are typically applied in apple orchards in Norway, although wild bees are also present. Here we present data on bees collected in the latter years in apple and pear orchards comparing our findings with historical records from the 1950-70s. Preliminary data on bumble bee phenology will also be presented in terms of ratios between queens and workers during spring. We also mapped vegetation in the close vicinity of the orchards as well as used landscape elements as explanatory variables of solitary bees and bumble bees. Semi-natural habitats seem to increase the abundance and diversity of wild bees visiting apple orchards in Norway. We found that the abundance and diversity of solitary bees were related to the proportion of forest cover, forest edges and flower-rich patches on the local scale (<500 m from orchards). Bumblebee abundance and richness on the other hand seem to be more related to the proportion of pastures surrounding the orchards on scales from 500-2000 m.

T09

Landscape effects on resource competition in bumblebees

ISABELLA BLOMLÖF, JOHANNA YOURSTONE, OLA OLSSON

Dept. of Biology, Lund University – Lund, Sweden

We studied the pollen foraging of bumblebees in high-quality and low-quality landscapes. Individual bumblebees tend to forage on only a small number of flowers during any one foraging trip. This is likely due to costs or constraints related to the information processing required to exploit each flower species and could also have to do with how flowers are aggregated in the landscape. In a rich landscape, where many highly rewarding flower species are abundant, the individual forager should benefit from specializing on a few or just a single flower species. However, different individuals should specialize on different flower species, to achieve resource partitioning. In a poor landscape, the reverse should be true. We thus hypothesized that the diets among individuals should overlap more in poor landscapes, and that the diet breadth of individual

bumblebee workers should be wider in poor landscapes. We analysed pollen samples from the corbiculae of ca 500 individuals of seven bumblebee species, using a deep learning automated pollen analysis method. The data generally supported our hypotheses, although there was also an effect of the local patch quality, such that e.g. individuals foraging in flower strips of *Phacelia tanacetifolia* specialized nearly entirely on that species, even though the flower strips occurred in generally poor landscapes. However, in general we conclude that in high quality landscapes, individuals had narrower diets and less overlap among individuals. This should allow them both to forage more efficiently and avoid competition within and among species.

T10

Pollinator foraging tactics have divergent consequences for plant mating systems

FELIPE TORRES-VANEGAS, ADAM HADLEY, URS KORMANN, F. ANDREW JONES, MATTHEW BETTS, HELENE WAGNER

Ecology and Evolutionary Biology, University of Toronto – Toronto, Canada

Resolving the consequences of pollinator foraging behaviour for plant mating systems is a fundamental challenge in evolutionary ecology. Pollinators may adopt particular foraging tactics: complete trapline foraging (repeated movements along a fixed route), sample-and-shift trapline foraging (a variable route that incorporates information from previous experiences), and territorial foraging (stochastic movements within a restricted area). Studies that integrate these pollinator foraging tactics with plant mating systems are generally lacking. We investigate the consequences of particular pollinator foraging tactics for *Heliconia tortuosa.* We combine parentage and sibship inference analysis with simulation modeling to: (1) estimate mating system parameters; (2) infer the foraging tactic adopted by the pollinators; and (3) quantify the impact of pollinator foraging tactics on mating system parameters. We found high outcrossing rates, ubiquitous multiple paternity, and a pronounced departure from near-neighbour mating. We also found that plants repeatedly receive pollen from a series of particular donors. We infer that the pollinators primarily adopt complete trapline foraging and occasionally engage in sample-and-shift trapline foraging. This enhances multiple paternity without a substantial increase in near-neighbour mating. The particular pollinator foraging tactics have divergent consequences for multiple paternity and near-neighbour mating. Thus, pollinator foraging behaviour is an important driver of the ecology and evolution of plant mating systems.

T11

Always on the safe side. Autonomous selfing in *Fritillaria persica* L. - how much pollen stays on the stigma and what is the role of the potential pollinators in pollen transfer

KATARZYNA ROGUZ, EMILIA STASIAK, BARBARA PŁASKONKA, YUVAL SAPIR, MARCIN ZYCH

Botanical Garden, Faculty of Biology, University of Warsaw - Warsaw, Poland

Understanding the reproductive biology of a given species is crucial for predicting population development and for efficient conservation activities. One of the interesting mechanisms in plant reproductive biology is autonomous selfing, which occurs usually when anthers touch stigmas or when pollen falls onto the stigma of the same flower. Typically, this ability involves innovations

in flower morphology and development, *e.g.*, changes in the size or in the arrangement of reproductive elements. We studied the ability of autonomous selfing in two natural populations of *Fritillaria persica* L. (Liliaceae) in Israel in spring 2022. *Fritillaria persica* is a geophyte, with big green or purple inflorescence. In bell-shaped flowers of this species anthers move towards the style while anthesis and finally deposit pollen on the stigma. With the use of quantum dots we tracked pollen deposited autonomously on the stigma and pollen transfer within and among inflorescences. To better understand the reproductive system of *F. persica* we also tested the potential for self-pollination and plant-pollinator interaction. Our results show that the plant is self-compatible and pollen grains deposited autonomously on the stigma are often numerous and may play an important role in pollination. Less than half of the spontaneously deposited pollen stayed on the stigma, so we assume that it may play a dual role: (i) reproductive assurance and (ii) pollen presentation. Our data also show that pollinators were more active in the eucalyptus forest, where we found *Apis mellifera* beehives, than in the Judaean Desert.

T12

Effect of plant mating system on herbivory-induced secondary metabolism and pollination

UPULI I. WICKRAMAARACHCHI, STUART A. CAMPBELL

School of Biosciences, University of Sheffield - Sheffield, UK

Flowering plants depend on intimate relationships with pollinators for successful reproduction. Attack by herbivores has been shown to cause repellence of pollinators, suggesting an ecological cost of induced plant secondary metabolites. However, the extent to which this ecological cost varies among plants remains less understood. We hypothesised that a plant's mating system should modulate pollination costs and induced responses, with obligately insect-pollinated plants (outcrossers) exhibiting higher costs and less inducible floral traits compared to less pollinator-reliant plants (selfers). We tested this hypothesis in a wild tomato, *Solanum habrochaites*, in which there are obligately outcrossing and independently derived selfing populations, and evaluated the effect of simulated herbivory (methyl jasmonate, MeJA application) on emission of floral volatile organic compounds (VOCs), behaviour of pollinators (*Bombus terrestris*) and plant fitness. In free-flying choice experiments with 10 populations, simulated herbivory significantly reduced the attractiveness of selfing plants to bumblebees; however, contrary to predictions, MeJA-treated plants from outcrossing populations were significantly more attractive to pollinators. Preference differences were accompanied by contrasting effects on behaviours like buzzing and grooming and time spent on each plant. Floral scent analysis revealed that, despite population variation in VOC composition and emission, there were consistent effects of mating system on floral scent cues, and contrasting effects of MeJA application between mating systems. Our results suggest that mating systems may play a key role in the effect of plant stress on pollinator behaviour. We discuss these mating system specific phenotypic changes in terms of insect pollination and convergent adaptation of floral scent.

T13

Why do some hermaphroditic species produce male-only flowers?

KAIHSIU CHEN, JOHN R. PANNELL

Dept. of Ecology and Evolution, University of Lausanne – Lausanne, Switzerland

The individuals of some angiosperms produce both hermaphroditic and male flowers (i.e., they are 'andromonoecious'), a sexual system that has evolved numerous times and is estimated to comprise around 4% of species. Two main hypotheses have been proposed to account for andromonoecy: the advantage of flexible resource allocation between male and female functions as a result of a variable proportion of male flowers; and the advantage of enhancing male siring success through male-flower production when ovule availability is high. In this talk, I will draw on observations of the phenology and sex allocation of the perennial protogynous herb, *Pulsatilla alpina,* in which small individuals usually devote their reproduction solely to early-flowered male flowers. Our data point to the importance of both hypothesized advantages for androdioecy. On the one hand, we find evidence for substantial additional costs of female reproduction associated with the production of elongated floral stalks for seed dispersal by wind, costs not invested for male flowers. On the other hand, the short flowering season under strong protogyny leads to a decrease in ovule availability over the course of the flowering season, likely favouring the production of male flowers early in the season. Together, these two features of the reproductive system of *P. alpina* select for both the size- and time-dependent sex allocation observed in the species. I will argue that andromonoecy in other perennial, ditochomous, and wind-dispersed herbs, such as many species in the Liliaceae and Apiaceae, is likely to have evolved for similar reasons.

T14-Flash

Reproduction and pollination in Bilberry *(Vaccinium myrtillus*) along elevational gradients in western Norway

MARK GILLESPIE, STEIN JOAR HEGLAND, BJØRN ARILD HATTELAND, AUD HALBRITTER, HEDDA ØRBÆK

Dept. of Biological Sciences, University of Bergen – Bergen, Norway

Climate change affects species distributions and abundances, as well as driving changes in species phenological events. Plant-pollinator mutualisms may be vulnerable to such changes, as disruptionof the overlap in temporal timing or spatial distribution can alter interaction opportunities between them. It is still unclear whether these relationships are resilient under novel climatic conditions. Bilberry (*Vaccinium myrtillus*) is a functional important species in boreal ecosystems. The species is both outcrossed by insects and selfpollinated, however, the overall importance of pollination on bilberry reproduction is not fully understood. This study used both observational and experimental approaches to investigate bilberry phenology and reproduction in relation to temperature, snowmelt, and pollination, over two growing seasons (2020 and 2021), along two elevational gradients from the sub-montane zone to the subalpine zone in western Norway. Bilberry phenology advanced with increasing temperature and snowmelt along both gradients, and bilberry flowering was in synchrony with pollinator activity across all sites. Interestingly, while the number of flowers, fruits, ovules, and seed weight decreased with elevation, fruit set was higher at subalpine sites. Seed set varied between sites, with contrasting patterns between the gradients. Fruit production was higher along the gradient with the highest

pollinator abundance, however no clear sign of pollen limitation was found in hand cross-pollinated flowers compared to open-pollinated flowers across elevations.

T15-Flash

The foraging preference and behavior of managed and wild bees in apple and pear orchards

JØRUND JOHANSEN

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Effective pollinators are essential for the sexual reproduction of many important crops, especially for fruit crops that require cross-pollination with compatible cultivars to bear optimal fruit. To ensure pollination, managed honeybee hives are often placed in fruit orchards, as honeybees are flower constant generalists that can effectively pollinate a wide variety of crops. Wild pollinators are, however, often more effective pollinators on a per visit basis, and they can provide pollination insurance if honeybee colonies fail. In Norway, the relative importance of different pollinator groups has received little attention. In this study, I compared the visitation frequency and foraging behavior of managed honeybees and wild bees in two fruit orchards producing apple and pear fruit. I found that honeybees likely are the most important pollinators of pear flowers in the study area, due to their superior visitation frequency compared to wild bees. However, bumblebees may be more important for apple pollination. I found that bumblebees were similar to honeybees in their visitation frequency to apple flowers, in addition to being faster foragers, due to their lower handling times and search times. This enables them to visit more flowers per minute than honeybees, potentially moving more compatible pollen between flowers.

T16

Commercial bumblebees for blueberry crop pollination supplement their pollen diet from the wider landscape

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Commercial bumblebees (*Bombus terrestris*) are used to supplement the pollination services carried out by wild pollinators in highbush blueberry crops (*Vaccinium corymbosum)* grown in the UK. The extent to which commercial bumblebees forage in the wider landscape, beyond the crop, is unknown. We studied the foraging choices of *B. terrestris* colonies imported into blueberry fields throughout the crop flowering season (March to May) in four UK farms, and conducted floral surveys in a 1km radius around the farms every two weeks. Using a new molecular approach, Reverse Metagenomics, we identified the plant taxa from the bee-collected pollen and assessed whether they exhibited preference or avoidance for certain taxa based on their abundance in the landscape. Bees were found to collect pollen from blueberry flowers but heavily supplemented their pollen diet with other floral resources in the landscape. Flowering trees such as willow were visited more than would be expected based on their availability, highlighting their importance as an early spring pollen resource. These findings provide evidence for the requirement of diverse floral communities for agricultural and environmental purposes.

T17

Pollination and potential pollen deficits in Norwegian apple orchards

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Apples rely on insect pollinators for optimal yield and quality. Managed honeybees are commonly used in apple orchards and contribute greatly to pollination services. However, wild pollinators have often shown to be more efficient pollinators of crops including apples. Insufficient pollination may reduce seed set and quality of apples, reducing the potential revenue for farmers. Pollen limitation and 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 limitation is 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 limitation 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. In this presentation I will present some preliminary results from the first field season.

T18

To honeybee or not to honeybee? Informing honeybee stocking densities on commercial farms

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Both managed and wild pollinators provide important pollination services to commercial fruit crops, improving yield and yield stability. Although it is often pollinator species diversity that ensures stable pollination service provision, the emphasis has often been on abundance in farmed landscapes with the popularisation of managed pollinators for pollination service provision to crops. However, there is little empirical evidence for required stocking densities of managed pollinators, or advice on discerning the need for managed pollinators at all. Overstocking honey bees or managed bumblebees can be detrimental to wild pollinator conservation, as well as to crop production, where high visitation rates damage flowers. It is therefore important that managed pollinators are implemented only when needed, and not as standard practice. Decisions about when to deploy managed pollinators require detailed contextual information about the existing pollination service supply and demand for each crop. Working in a commercial raspberry system in the UK, we used "single-visit" studies and timed flower counts to quantify pollinator efficiencies and visitation rates. We found evidence supporting the reduction of honeybee stocking densities and the potential for wild pollinators to provide the required pollination service in the absence of managed pollinators. This evidence can help optimise farm management practices to promote wild pollinator conservation, whilst still ensuring high fruit yields.

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. The three methods are: 1) stingless bees, 2) hand pollination, 3) no assisted pollination. These were used in glasshouse experiments 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

What makes a good pollinator in British strawberry fields?

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Conservation management of insect species and floral resources is essential for safeguarding crop pollination. Nevertheless, for many crops, it is unclear which insects are likely to be the most important pollinators, what traits define their importance, or what resources these insects require beyond crop plants. A common assumption is that insects that visit crops more frequently also carry the most pollen and hence make the most significant contribution to pollination. Few studies, however, have compared estimations of pollinator importance based on flower visits and pollen transport, making it difficult to gauge the need for collecting pollen-transport data versus easier-to-obtain visit data. We used British strawberry crops as a case study to test whether our perception of pollinator importance and the traits that define it will vary with the method used to define them: visitor frequency or pollen load. We also describe the importance of wildflowers as resources of pollinators of strawberry. We found that honeybees, bumblebees, and hoverflies species are likely to be key pollinators of strawberries. Likewise, relative specialization, long active periods, and abundance were traits defining pollinator's importance of this crop. Most insects visiting strawberry also carried pollen of wild plants, suggesting a dependency on different flower resources. Overall, we observed similar results when predicting importance based on visitation or pollen-transport data, although visitation underestimates pollen transport by bees. Hence,

identifying essential pollinators or pollinator traits based on visitation data will reach the same general conclusions as those using pollen transport data, at least in monoculture crop systems.

T21

Pollination services are resilient to an extreme climatic event and mitigate crop yield declines

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Extreme climatic events pose a threat to pollinators and their ecosystem services to agriculture. Yet little remains known on how pollinator communities respond to many climate shocks, and experimental studies on crop pollination remain worryingly absent. Here we examined the effects of an extreme flooding event on pollinator communities in Nepal, and conducted insect exclusion experiments to quantify pollination services to two globally-important crops (oilseed mustard and buckwheat). We found that flooding led to lower pollinator abundance and significantly altered community composition. While social bees (*Apis florea, A. cerana, A. dorsata, and A. mellifera*) did not show large changes, flooding effects were instead stronger and more consistent for solitary bee species – and in particular mining and ground nesting guilds (*Halictus, Lasioglossum, Andrena* spp.). Despite these impacts, pollinator services to both crops remained resilient to flooding. Buckwheat in particular incurred significant yield loss due to flooding. However, owing to the resilience of pollination services, pollinators made a proportionally greater contribution to realised yield in flooded fields (54.1 %) than in non-flooded fields (36.1 %). Our study provides insight into how extreme events such as flooding can disrupt pollinator communities, but also how pollination services can show resilience to such shocks, and buffer against yield loss. We suggest an urgent need to incorporate pollination into strategies for agricultural climate adaptation and disaster risk reduction, and call for more studies on the response of pollination services to extreme climatic events, as they increase in frequency under climate change.

T22

Pumpkin fruit set is limited by herbivory and low pollinator richness in a tropical smallholder agricultural landscape

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Agroecology is proposed as a sustainable alternative to conventional agricultural practices, but little is known about the benefits of diversification of these practices for pollination and pest control services. The presence of pollinators and pests in crop fields is shaped by surrounding landscapes and local field management. Landscapes and agricultural practices in sub-Saharan Africa are rapidly changing, yet the region is underrepresented in studies about how landscapes and management affect pollinators, herbivory and ultimately crop yields. On 24 smallholder farms in Malawi, 12 which used manual pest removal and 12 that did not, located along independent gradients of semi-natural habitat and number of agroecological soil practices, we investigated the effects of land-use on flower visitors and pest damage of pumpkin, a pollinator-dependent crop. An increasing semi-natural habitat cover in the landscape decreased honeybee abundance but increased the abundance and species richness of other bees and had no effect on flower herbivory.

Additionally, the implementation of manual pest removal negatively affected flower visitors, but the use an increased number of agroecological soil management practices had positive effects on flower visitors and no effect on herbivory. Using a full-factorial hand pollination and exclusion experiment we found that both pollinator limitation and herbivory constrained fruit set, but not fruit quality of pumpkins. Moreover, increasing flower visitor species richness improved pumpkin fruit set. We recommend improved protection of remaining semi-natural habitats and increasing soil agroecological practices to ensure pollination services on Malawian smallholder farms.

T23

Plant pollinator dependency for seed production in Arctic ecosystems

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A majority of the worlds plant species rely on attracting insects for outcrossing and seed production. However, cold ecosystems, at high latitude in particular, often experience low diversity of pollinating insects, sometimes with entire taxonomic groups absent. This impoverished insect biodiversity could prevent the establishment of some plant species. Given that absent groups of pollinators, such as bees, are important for a large proportion of plants in their reproduction, the current (and historic) state of insect diversity can have a large impact on plant community composition. As a consequence, the warming effect of climate change, which often is elevated in colder ecosystems, could facilitate the establishment of novel plant species by introduction of introduction of insect species. The goal in this project is to compare plant communities at different latitudes with respect to their reproductive strategies and their pollination in order to understand how pollinators how pollinator composition and diversity shape plant communities. We present data from one of our sites in Jämtland, Sweden, using pollinator-exclusion experiments from 20 plants species. One third of the plant species were completely autogamous, while in the remaining species we find that pollen limitation is relatively widespread. Finally, our preliminary results suggest that the functional group of insect visitor correlates with the reproductive mode of plant, indicating that fly pollination is more often associated with self-pollination by autogamy. We discuss the implications of our preliminary results on species redistribution and plant community change due to climate change.

T24

Shifting phenology and niche overlap in flowering plants and their pollinators along an elevational gradient

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It is important that species match in time with their interaction partners. Climatic conditions alter phenology of species and emerging changes may threaten the synchrony of biotic interactions. However, how phenological synchrony between communities of plants and their pollinators reacts to changing environment remains unknown. Here, we recorded communities and phenology of flowering plants and pollinators on herb-rich meadows along an elevational gradient in Switzerland. We show that shifting conditions along the gradient change flowering plants and pollinators in terms of community composition, phenology, and niche overlap. We observed a

decline in the number of flowers, flowering species, and insects with increasing elevation. Flowering phenology was delayed by on average 1.4 days per 100-meter increase in elevation. However, the species-specific responses varied substantially. Within late-flowering species the phenology overlap in flowering times was higher at low elevations, while early-flowering species experienced higher overlap at high elevations. This indicates a potential shift in trade-off between the biotic and abiotic controls of the timing of flowering along the elevation gradient. Meanwhile, the phenology of flowering and insect activity were better synchronized at higher elevations, as pollinators showed increasing temporal overlap with the flowering community. Our findings offer a mechanism through which plant communities may change under warming climate: The trade-off between abiotic and biotic controls of flowering time. As a result, late-flowering species may spread towards higher altitudes and latitudes as they have an increasing advantage in longer seasons when their reproductive strategies become more favorable.

T25

Tales from Africa: Sunbird-plant interactions on Mt. Cameroon

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In recent times the level of specialization or generalization of plant pollinator interactions have been of interest for researchers. In this sense elevational gradients represent an extraordinarily suitable study system, enabling researchers to test hypotheses on the effects of complex environmental factors on specialization-generalization. Our research group is focused on the pollination systems present on Mt. Cameroon, Cameroon. We have studied how sunbirds and visited plants interact with each other. Moreover, we are interested in the temporal variation on sunbird-plants interactions, and how this affects the pollination networks. Additionally, we have challenged the concept of bird pollination syndrome to see if it is a good predictor of plant visitation. For this purpose, we combined data on insect visitation together with data on bird visitation. We demonstrated that although the bird pollination syndrome is a good predictor of bird visitation, birds are mainly driven by the nectar reward. Finally, we have explored the presence of trait-matching between the sunbirds and their floral resources. We have measured or collected floral pollinator attraction traits, plant morphological traits and plants' life forms, Bird traits were collected from the literature. We demonstrate that bill-tube length relationship is an important factor behind the observed interactions. Moreover, also our data suggests that trait matching becomes more important during the rainy season.

T26

Rising temperatures threaten pollinators of fig trees - keystone resources of tropical forests

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Pollinating insects are decreasing worldwide in abundance, biomass and species richness, affecting the plants that rely on pollinators for fruit production and seed set. Insects are often sensitive to high temperatures. Projected temperature increases may therefore severely affect pollinator fitness and thereby plants that rely on insect pollinators. The effect of higher

temperatures on the lifespan of pollinators is often not possible to test in an ecologically relevant way but with the highly specialized pollinating fig wasp, this is possible. In a few previous studies from China and Australia, increasing temperatures dramatically decreased fig wasp lifespan. Are these grim results generalizable to fig mutualisms globally? Here we use survival experiments to determine the effect of increasing temperature on the lifespan of Neotropical fig wasps associated with five common Panamanian *Ficus* species. Experimental temperatures were based on the current daytime mean temperature of 26.8°C (2SD: 21.6-31.7°C) and the predicted local temperature increase of 1 - 4°C by the end of the 21st century. We found that all tested pollinator wasp species had a significantly shorter lifespan in 30°C, 32°C, 34°C and 36°C compared to the current diurnal mean temperature of 26°C. At 36°C pollinator median lifespan decreased to merely 2 – 10 hours (6-19% of their median lifespan at 26°C). Unless wasps can adapt, such a dramatic reduction in lifespan is expected to reduce the number of pollinators that successfully disperse to flowering fig trees, and may therefore jeopardize both fruit set and eventually survival of the mutualism.

T27

Combining field sampling, genetics, and volatile chemistry to understand specificity and its breakdown in the fig wasp pollination mutualism

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Figs (genus *Ficus,* > 700 species) are pollinated by wasp species that are largely specific to their host species. The minute fig pollinator wasps locate and recognize a receptive fig host from large distances. Host recognition and species specificity seem to be based in part by species-specific blends of volatile organic compounds emitted by flowering figs. However, comparisons between fig and pollinator phylogenies suggest a degree of host shifting that is not consistent with strict host specificity. These evolutionary patterns require a host-choice mechanism that enforces specificity to fig species, and leaves room for 'mistakes'. In my talk I discuss data that we collected in the rainforest in Central-Panama using sticky traps, DNA-barcoding, volatile traps, and GC-MS analyses. We compare wasp capture rates at trees that do and do not belong the genus *Ficus*, and within the genus across different phases of the reproductive cycle. Indeed, fig pollinators arrive abundantly at their usual hosts when they are receptive, but we also find pollinators at other host species, and at hosts that have no figs. Based on these results we suggest a host-choice mechanism that could underlie both species specificity and flexible host-choice, in which not only floral volatiles, but also leaf volatiles play a role. Also, I present preliminary comparisons of the volatile organic compounds and discuss whether these support the proposed mechanism. Again, I compare across fig species and across reproductive phase.

T28

Assessing the plant-pollinator network of caraway (*Carum carvi* L.)

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Despite of pollination being a crucial ecosystem service and critical for angiosperm diversity, most studies in agro-ecosystems have focused on only a few taxa. Nonetheless, in the light of an increased multifactorial pollination decline, closer examination of all implicated species is now crucial. Here, we present the plant-pollinator network of caraway in a Central European agricultural landscape focusing on *Brachycera* (Diptera) and non-honeybee *Hymenoptera*. Caraway is a crop species which is gaining importance in Europe, especially as a medical plant. The qualitative assessment of insect-plant interactions was done via morphological and DNA barcoding identifications of insect specimens and pollen loads (metabarcoding in the case of pollen loads). In total, 121 insect species across 33 families were found to carry caraway pollen, including many non-wild bee and non-hoverfly species, showing a wide taxonomic range of potential pollinators. The potential pollinators were linked to 139 plant taxa of different taxonomic level illustrated in the complexity of the network. Moreover, there are distinct qualitative differences between the interactions of *Brachycera* and *Hymenoptera*, suggesting complementary roles of both taxa. Furthermore, intraday differences in taxa diversity indicate the necessity to collect insects and pollen at different day intervals to understand whole networks. Finally, our results show the potential of caraway as a complementary food source for a wide diversity of flying insects outside of the main flowering period.

T29

Multi-city study reveals negative effects of urbanisation on bees, hoverflies and moths

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Pollinating insect diversity is declining globally due to land-use change. Urbanisation may be a key driver of insect declines, but the effects of urban densification on insect pollinator communities within complex urban landscapes remains poorly understood, particularly for important non-bee pollinators such as flies and moths. We conducted a large multi-city assessment of wild bee, hoverfly and moth diversity and abundance along replicate urbanisation gradients, focusing on community agricultural green spaces (allotments). We show that despite significant variation among cities in the densities of greenspaces, their habitat configuration and connectivity and landscape diversity, there was a decline of insect species richness across all insect taxa as urbanisation increased. These results highlight the significant threats posed by increasing urbanisation, but highlight the context-dependent benefits of urban greenspaces in supporting insect pollinators.

T30

Modelling plant-pollinator and parasitic relations in species distribution models

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The number of publications that use species distribution models (SDMs) has increased massively in the last thirty years, and these SDMs find their use in numerous ecological applications. Classical SDMs are primarily based on climate, land use and other abiotic variables, but the implementation of biotic interactions that play a key role in the ecology of many species still remains a challenge. We modelled the distribution of 194 bee species in the Netherlands, using a total of thirty climate, land use and soil variables. We compared the biotic interactions, which consisted of visited plants and bee hosts of cleptoparasitic bees, at different resolutions and taxonomic levels. We found that general models improved significantly when interacting species (plants and parasite hosts) were included and this effect was strongest for cleptoparasitic bees. We also found that the importance of biotic variables peaks at different spatial resolutions for the cleptoparasitic and oligolectic bees. Food plants and hosts with smaller distribution ranges are more important in explaining the distribution of the modeled species compared to those with larger distribution ranges. We encourage researchers to include pollinator interactions found in the literature or databases, in their SDMs, provided that both resolution and different evaluation methods, including null-models, are considered and are ecologically supported.

T31

Pollinator functional traits: a global overview of their diversity and their use

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Functional traits are increasingly used to understand pollinators' responses to multivariate global changes. Although this approach depends on identifying and describing potentially important functional traits, there is no comprehensive overview of their use in insect pollinator studies. We address this knowledge gap by systematically identifying and reviewing studies explicitly using functional traits as effect and response traits, focusing on *Hymenoptera*, *Lepidoptera*, and *Diptera.* Among the >200 identified studies, bees was the most studied taxon, while studies on *Diptera* were rare. The most commonly studied traits related to body size and diet. Traits were often taxon-specific, highlighting the difficulty of designing a shared trait framework across taxa. The studies were mainly carried out in an agricultural context in temperate regions. Most studies focused on the consequences of global change, with a particular emphasis on landscape simplification and fragmentation. The use of a wider array of traits, including *e.g.* physiological and sensory traits, based on hypotheses of mechanistic links with environmental pressures, may increase the value of trait-based approaches. For better understanding of the generalities in trait-global change relationships, current taxonomic, habitat and geographic biases should be counteracted by focusing more on *e.g. Diptera*, the global South, and forest ecosystems.

T32

The role of food-deception strategy in reproductive output of *Dactylorhiza* orchids

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The around one-thirds of all known orchids do not produce rewards to attract the pollinators. This group of plant developed the deceptive strategy, in which the 'naïve' pollinators are cheated by various floral signals and in consequence it may contribute to different effect of reproductive output. The evolution of deception in orchids cannot be explained by a single mechanism, as the different selective pressures favouring this strategy are highly context-dependent. Therefore, we revealed the impact of several factors such as (1) floral display of *Dactylorhiza* plants, (2) pollinia removal, (3) flowering period, and (4) time of flowering and unit density of the co-flowering rewarding taxa on female success during 2014-2017 in nine populations of *D. majalis*, *D. incarnata* var. *incarnata* and *D. fuchsii*. We also calculated the selection gradients. Then, we investigated the inbreeding depression index (δ), pollen limitations and population genetic structure of three *Dactylorhiza* taxa using AFLP markers. Our survey showed that in early flowering *D. majalis*, positive and strong directional selection on high of inflorescence, flower number, and spur length was supported. We did not observe or note only the week directional selection in populations two other orchids. In all taxa, the removed pollinia from the lower and middle parts of inflorescence, the type of pollination (out-crossing, selfing), but not the flower position on inflorescence played the most important role in shaping of fruit set. Our findings indicated, as the first in the literature, that the level of female reproduction in a given year and population depended on a group of co-flowering rewarding plants composed from magnet and competitive plants to the *Dactylorhiza*. Almost all populations suffered from inbreeding depression, and had a significant strong genetic structure, but we showed that inbred seeds germinated equal like a outbred ones.

T33

Telling lies to flies - deceptive strategies in fly-pollinated *Aristolochia* trap-flowers

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Deceptive flowers trick pollinators into visiting them by advertising a reward, which they do not provide. Numerous deceptive plants are pollinated by Diptera and rely on floral scent for attracting these insects. Apart from sapromyiophilous pollination systems, the chemical ecology of such interactions remains largely unstudied. We worked on seven Mediterranean *Aristolochia* species (Aristolochiaceae), which are pollinated by the dipteran families Phoridae, Drosophilidae and Chloropidae. Their sophisticated trap flowers temporarily imprison their pollinators and release them loaded with pollen. To resolve the mechanisms of pollinator attraction and deceptive

strategies, we identified pollinators and applied chemical-analytical methods, chemical synthesis, electroantennography, and behavioral field assays. We show that the floral scent blends differ strongly among the studied species and consist of only a small number of compounds, including widespread, rare, and novel floral volatiles. The scents of the different *Aristolochia* species resemble fermenting fruits (acetoin and derivatives), alarm pheromones of bugs (aliphatic esters), invertebrate carrion (sulfides and pyrazines), as well as possibly sex pheromones of Phoridae (known and novel aliphatic compounds). Our results suggest that the studied *Aristolochia* species exploit various deceptive strategies, including chemical mimicry of food-sources of (kleptoparasitic) flies, oviposition sites, and possibly sexual deception.

T34

The role of plasticity and heritability in rapid floral evolution

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Rapid adaptive change is a key process during the colonisation of new environments. At the same time, phenotypic plasticity can provide flexibility to cope with new conditions and even jump-start adaptive change. Introduced plant species are greatly dependent on their ability to maintain seed production under different environmental conditions. In species reliant on animal pollination this may imply rapidly adapting to new pollinator regimes. In the Americas, naturalised populations of *Digitalis purpurea* have adapted their floral morphology to a new pollinator guild that includes hummingbirds in around just 85 generations. However, we have not observed changes in nectar traits. Here we aim to understand how heritable variation and phenotypic plasticity allow or preclude rapid adaptive change in both morphological and nectar traits. In a common-garden setup using a nested full-sib, half-sib mating design with both native and non-native populations, we analysed heritability and plasticity of both groups of floral traits in an F2 generation. We quantified within-genotype plasticity using the Phenotypic Dissimilarity Index (PhD) and compared it between nectar and morphological traits as well as between populations. Heritability was calculated using a MCMCglmm Bayesian approach and compared between groups of traits and populations. Our results reveal that nectar shows higher plasticity than morphological floral traits. Conversely, heritability of morphological traits seems to be higher than that of nectar traits. Overall, we see no evidence to support that floral traits are more plastic in the non-native populations. We hypothesise that longer periods of time will be needed for adaptive change to occur in nectar traits.

T35

Considering the importance of floral longevity in understanding pollinator-mediated selection on attractive traits

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Floral traits are often assumed to be under selection by pollinators—certainly, among species, less so certainly within species. Studies that manipulate the pollination environment by increasing or decreasing pollination rates (or both) present one way to decipher whether floral traits are under pollinator-mediated selection within populations. Interestingly, these studies often find weak pollinator-mediated selection. Explanations for such weak selection (or our ability to detect it)

include the role of antagonists and abiotic factors, limited phenotypic variation within populations, and greater importance of traits related to efficiency vs. attraction. However, a key trait that is often overlooked and could play a role in ameliorating pollinator-mediated selection on attractive traits is floral longevity. That is, if less attractive flowers can live long enough to buy additional time for pollen export and import when pollinator visitation rates are low, they may be able to achieve fitness rivaling more attractive plants (all else equal…though things are rarely all else equal). I will share results from a study investigating pollinator-mediated selection on floral traits in the biennial *Sabatia angularis* (Gentianceae). We experimentally manipulated pollination in the field and compared selection gradients on traits related to attraction in manipulated versus control plants. We also measured rates of pollen deposition in reduced-visitation and control groups and compared these to floral longevity. I speculate that under certain circumstance, longer floral lifespans could weaken pollinator-mediated selection on attractive traits and thus contribute to the maintenance of their variation within populations.

T36

Can herbicide residues in soil affect plant signaling to pollinators and predatory insects?

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We are in a biodiversity crisis with insects particularly in trouble. Global change factors, including the increasing use of agrochemicals are detrimental to insect biodiversity in agricultural ecosystems. Glyphosate has become the best-selling herbicide. It disrupts the shikimate metabolic pathway and thereby blocks the production of aromatic amino acids, which are the basis for several plant metabolites essential in plant-insect interactions. Glyphosate is exponentially used and residues are reported in soils from diverse habitats, but their effects on plants and cascading effects on species interactions and insect biodiversity are largely unknown. In common-garden and greenhouse studies we analyze the effects of herbicide residues in soil on plant physiological processes, with particular focus on metabolites with a role in signaling to interacting species, such as microbes, herbivores, predatory insects and pollinators. We showed that glyphosate residues (GR) in soil alter phytohormone concentrations in oat and potato plants, which reflected in their frequency of herbivore-damaged leaves. Furthermore, the extent of herbivore damage was independent of plant size in strawberry plants growing in GR soil, indicating a disrupted biosynthesis of defense compounds. Endophytic fungi, which execute plant defense in many cool-season grasses, reduced the biosynthesis of insecticidal alkaloids in plants growing in GR soil, leading to an increase in aphid herbivore populations. Our results indicate that herbicide residues in soil can fundamentally change plant-insect interactions, which may contribute to insect biodiversity decline.

T37

Opposing effects of a fungicide on bumblebee colonies

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Pesticide use can have negative impacts on pollinators, including bumblebees. Fungicides and herbicides are not designed to target insects and therefore little is known about their potential

implications for bees. Here we investigated how a commonly used fungicide and herbicide at a field relevant dose, can affect bumblebees at the colony level with regard to their: weight, production, activity and pollen loads across two experiments. Exposure to herbicide consistently had no effect on weight, activity or production, but the fungicide had context-dependent effects on colony weight, with a reduction in foraging activity that may have been caused by reduced foraging provisioning. Exposure to a fungicide resulted in a decrease in weight as well as a decrease in the number of bees returning pollen to the colony four weeks after exposure, in one experiment, but had no effect in the other. We also observed that these affects only occurred weeks after exposure, and there were no immediate effects of the fungicide. These results are important to consider in risk assessment and may have important implications for mitigation strategies.

T38

Widely used insecticides impact the foraging behaviour and pollination services delivered by solitary mason bees (*Osmia bicornis*)

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Wild solitary bees are important pollinators of crops and wild plants and threats to their decline poses a risk to the sustained provision of the crucial services they provide. There is some evidence to suggest that exposure to field realistic levels of insecticides can affect solitary bee health. However, there is a significant knowledge gap on how this may affect their foraging behaviour beyond a lab setting, and importantly, how it affects the important pollination services they provide. We exposed solitary mason bees (*Osmia bicornis*) to two widely used insecticide compounds; lambda-cyhalothrin (pyrethroid) and acetamiprid (neonicotinoid), in a semi-field exclusion cage setting via sprayed apple trees at the recommended spray rate for each compound. The results indicate that repeated exposure to either insecticide significantly reduces the proportion of apples produced after pollination by these bees. Similarly, exposed bees showed significant changes in their foraging behaviour and their floral interactions. These results show that field-realistic exposure to two widely used insecticide compounds can have short-term sublethal effects on behaviour and the pollination services they provide to apple, a crop of global economic importance. The implications of these findings pose threats to the sustained provision of important food crops worldwide, in addition to the healthy functioning of natural ecosystems. This highlights the importance of moving the risk assessment of insecticides towards a more field realistic scenario and assessing sublethal effects on wild bees.

T39

Developing Action Competence for Insect Preservation (DACIP)

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The decline of pollinators and other insects is a current environmental issue. Although the awareness of the problem is growing during the last years, an implementation gap between this awareness and concrete actions of citizens is observable. Our educational design research project "Developing Action Competence for Insect Preservation (DACIP)" aims to close this implementation gap. The project shall improve the theoretical understanding of citizens' competences to support insects in their daily lives. To achieve this aim, we developed an

educational framework (Action Competence for Insect Preservation = ACIP) and a corresponding quantitative research scale to measure citizens' self-perceived competences to support insects. The ACIP-framework helps educators to teach about the topic of insect conservation in an action-oriented way. The framework includes two main types of actions: direct actions and indirect actions, which both contribute to mitigate insect declines. The new research scale enables the assessment of individuals self-perceived action competences and shows a broad spectrum of potential applications in formal and informal education settings, as well as in scientific outreach activities. At the SCAPE conference, we will focus on the new ACIP-framework, the corresponding quantitative scale and the results from the piloting of the scale. In addition, we will outline how the ACIP-framework can be used to design teaching or science outreach interventions for pollinator/insect preservation. Finally, we will discuss how our project contributes to overcome implementation gaps in insect preservation on a large scale.

T40

Protecting Farmland Pollinators

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Farmers in Ireland recognise the importance of pollinators, but farmland has experienced wide-scale loss of wild pollinators over the last fifty years. In Ireland, one third of our 100 wild bee species are threatened with extinction. The National Biodiversity Data Centre is working with a group of forty farmers to come up with a method that will support all farms across Ireland to be more pollinator friendly. In consultation with farmers, we have created a scorecard that allows each farm to receive pollinator points each year and, each year farmers receive a results-based payment that relates to the points. What the preliminary results show is that some Irish farms remain incredibly biodiversity friendly, while others have great potential to improve their biodiversity value. Twenty-five farmers have increased their score between this year and last (9 tillage, 7 dairy, 5 beef, and 4 mixed). Each farmer created several nest sites for above ground cavity nesting bees and below ground mining bees. Within months some of these nest sites were occupied. The pollinator score helps farmers to understand how pollinator friendly their farm is, and identify what simple, low-cost actions they can take to work towards improving their score in a way that does not negatively affect productivity. It is important to show that those farms that have a higher pollinator score do have more pollinators and more biodiversity. This will create a clear evidence-based for the approach. Surveys were carried out in 2020 to test this. Forty species of bee and sixty-one species of hoverfly were identified across the forty farms.

T41

Effects of whole-genome duplications on floral traits in the coevolving, nursery pollinated *Lithophragma bolanderi* (Saxifragaceae)

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Whole-genome duplications (polyploidizations) are common in flowering plants and have profound implications on their evolution and diversification. Mixed-ploidy species are an ideal system to study how whole-genome duplications affect plant phenotypes, such as floral traits, and, thus, also the plants' interaction landscape with pollinators and herbivores. Several studies have

shown that in established polyploids floral traits as well as interactions with pollinators and herbivores differ from those in conspecific diploids. However, such differences between established polyploids and diploids are a combination of direct effects of whole-genome duplications and subsequent evolutionary processes. Here, we quantified floral traits of established polyploids and diploids grown in a large-scale greenhouse common garden and of neo-polyploids synthetically generated from diploids to assess the direct effects of a whole-genome duplication on floral traits in the plant *Lithophragma bolanderi* (Saxifragaceae). This species exhibits an exceptionally high variation in floral traits and comprises three major ploidy types – diploids, tetraploids, hexaploids. It is pollinated by the highly specialized seed parasite *Greya politella* (Prodoxidae) and, in some populations, also by more generalist pollinators. We present data on the covariation of floral traits with ploidy types across and within populations and on changes in floral traits in synthetically generated polyploids compared to their diploid progenitors. Together our results provide novel insights into the effects of whole-genome duplications on floral traits and how these could affect the plants' interaction landscape with pollinators and herbivores.

T42

Flower size, not floral scent, may function as an honest signal in a generalist-pollinated plant

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In flowering plants that produce a concealed reward, pollinator foraging preferences should generate selection for traits that are correlated with rewards and thus serve as "honest signals." The strength of selection for honest signals could vary across traits and populations, due to variation in pollinator communities, pollinator preferences, or plant mating system. We investigated whether flower size and floral scent could function as an honest signal of floral rewards and be subject to pollinator-mediated selection in *Arabis alpina*, an arctic-alpine herb. An emerging model system for ecological genomics and the evolution of life history traits, *A. alpina* exhibits variation in flower size, floral scent, and plant mating system, and is visited by a diverse array of insects. We examined variation in relationships between flower size, floral scent, and nectar volume in plants from 29 populations in a greenhouse common garden. We also estimated pollen limitation, which is related to the opportunity for selection, in 12 natural populations. We found that both across and within self-compatible and self-incompatible populations, larger flowers generally produced more nectar. In contrast, volatile emission rate was not associated with nectar volume. Pollen limitation was detected in six populations. Our results suggest that selection for floral traits that serve as honest signals of floral rewards can vary across trait types and populations. Aspects of floral morphology may be particularly likely to function as honest signals because of phenotypic integration and modularity of floral structures, while floral scent may function primarily as a long-distance pollinator attractant.

T43

Can bee vibrations remove pollen from non-buzz-pollinated flowers?

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Bees use vibrations to remove pollen from flowers that usually have dry pollen and tubular anthers (poricidal anthers), giving rise to the phenomenon of buzz pollination. But bees much more rarely apply vibrations (floral buzzes) to flowers with laterally dehiscent anthers and relatively sticky pollen. Although floral vibrations are the most effective method to remove pollen from poricidal anthers, little is known about the extent to which floral vibrations remove pollen from other types of flowers. Here we present the results of an experiment designed to compare how bee-like vibrations remove pollen from poricidal and non-poricidal flowers using species in the families Solanaceae and Brassicaceae.

T44

Representing pollinators and pollination in large data sets: an introduction to the new WorldFAIR project

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"WorldFAIR: Global cooperation on FAIR data policy and practice" is a two-year project which started in June 2022, funded by the European Commission through its Horizon Europe Framework Programme and coordinated by CODATA, the Committee on Data of the International Science Council. The aim is to develop case studies that illustrate how to advance implementation of the FAIR data principles, i.e. Findable – Accessible – Interoperable – Reusable. One of the case studies is on agricultural pollination. Until recently, most databases of plant-pollinator interactions were typically compilations of observations that an interaction has occurred, i.e., animal 'x' has visited flower 'y'. Though fine as a first approximation of which animals may be important pollinators to a plant, it does not provide any information about the outcome of the interaction that is important for farmers: pollination, followed by seed and fruit production. If databases of agricultural pollinators are to be useful for farming and conservation efforts, for example by targeting resources to support pollinators in farmland, then it's crucial that information about pollination is added to databases using controlled vocabularies that are agreed upon by the community of pollination ecologists and agronomists. This is beginning to happen but there is still much work to be done, especially decisions about the depth of information that is required for different audiences and how to best represent this information in a database. For more details about WorldFAIR see: https://codata.org/worldfair-global-cooperation-on-fair-data-policy-and-practice-a-major-two-year-project-starts-today/

T45

Enchanted by Calypso: selection via female and male function in a deceptive orchid

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Because most plants are hermaphroditic, a full characterization of selection on floral traits requires that effects not only on female, but also on male reproductive success are considered. Several arguments have been formulated to suggest that selection on floral display may be stronger via male than via female function. However, few studies have been able to document effects of floral morphology on realized male reproductive success. Here we report from an ongoing analysis of how floral morphology affects pollen export, pollen receipt and fruit production in the deceptive orchid *Calypso bulbosa*.

POSTERS

P01

Evaluating red clover pollination and seed yield in farmer studies and field trials

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Forage and green fodder plants are grown on 1.1 million hectares of arable land, making it the largest crop in Sweden. A major part of protein produced in forage comes from forage legumes that fixate nitrogen, where red clover is the most commonly used species in Sweden. Seed yield in insect-pollinated red clover is extremely variable, which could lead to deficiency in the availability in red clover seed. The underlying reason for this variation is not fully known but could include factors related to pollination services, cultivation or varieties. In a study performed across farms in southern Sweden, the link between pollinator abundance and seed yield was unclear. However, in a small field trial study at six sites across Sweden, seed yield increased with number of pollinators and was influenced by cultivar. Both studies showed a strong link between number of flower heads and pollinator abundance. To better understand differences between cultivars in seed yield and important traits influencing pollinator abundance, such as flower head abundance, we plan large-scale field trials at three sites over two years. A preliminary analysis suggested that number of flower heads can be evaluated using drones and picture analysis, allowing large data collections. The field trial data will also help linking cultivar differences to genetic differences, which in turn can be important for future plant breeding of red clover.

P02

Seed production in red clover - a study on pollinators across regions

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Red clover (*Trifolium pratense* L.) is an important crop in many temperate parts of the world and valuable as fodder for cattle due to its high protein content. Red clover is naturally diploid but to improve vegetative strength and green mass yield, breeding of tetraploid red clover cultivars is common. Seed yield from tetraploid cultivars, however, is variable and suboptimal compared to diploid cultivars. Red clover reproduction is dependent on pollination mainly by bees and bumblebees. Some studies suggest that the difference in seed yield between diploids and tetraploids is that the short-tongued pollinators that are dominating many of the agricultural landscapes today prefer diploid over tetraploid cultivars. To understand better the link between pollinator availability and seed yield, we studied pollinator abundance, species presence and seed yield in three tetraploid and one diploid cultivars at six field trials across Sweden, from Umeå in the north to Svalöv in the south, over two years. Northern Sweden is known to have a higher diversity of bumblebees. The results showed no preference among pollinators between red clover cultivars, but inflorescence density was of great importance for pollinator abundance. Seed yield was consistently higher in the north than in the south. While pollinator abundance had some influence on seed yield, we also found consistent cultivar differences, suggesting a genetic component. In conclusion, this study strengthens the importance of pollinators for seed production in red clover but also indicates that other factors such as genetic differences need to be further investigated.

P03

Genomic screening for increased seed yield in red clover

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Red clover is commonly used as a forage crop and of major importance for Swedish agriculture. One challenge in red clover cultivation is that seed yield of some cultivars are generally low or varies between years, causing problems for farmers that grow red clover for seed production. One of the goals in red clover breeding programs is therefore to increase the seed yield. The reasons for low seed yield are not yet fully known, but one commonly discussed hypothesis are pollinator deficiency. Red clover is an outcrossing plant, dependent on pollinators for seed set. Therefore, many studies have investigated the role of pollinator abundance and efficiency. The results are ambiguous and it is not clear to what extent low seed yield is caused by pollinator deficiency. Other explanations need to be investigated, for example genetic factors. In this project our aim is to link genetic markers to seed yield among red clover cultivars. A large scale field trial study spanning over two years (2023 and 2024) and conducted at three sites, including ca 400 different cultivars, will evaluate seed yield and analyse it together with genomic data. The results can help streamline plant breeding programs where the use of genetic markers might decrease the time it takes to breed a new cultivar with several years. In addition, the results will hopefully add further knowledge to what lies behind varying seed yield in red clover.

P04

Monitoring pollinators in agricultural landscapes: A pilot study for Sweden

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Farming practices and habitat loss are among the most important threats to pollinators in agricultural landscapes. The current decline of diversity in such landscapes is well documented and changes in the ways we manage our agricultural landscapes are often proposed to mitigate this trend. In such line, the new Common Agricultural Policy (CAP) by the European Union has to preserve landscapes and biodiversity as one of its main objectives. However, to reach that goal it is crucial to evaluate the effectiveness of these new farming practices on biodiversity. In other to follow the effects of such measures on pollinators in the Swedish agricultural landscapes we propose a long-term monitoring program that would evaluate such effects and monitor changes in four main pollinator groups: butterflies, hoverflies, bumblebees and solitary bees. Here, we present results from a pilot study where we tested a sampling design that would benefit from existing parallel monitoring programs and that would help us follow the effects of the new CAP measures on pollinators in Sweden.

P05

Preserving mobile insects in semi-natural grasslands – Minding the Matrix

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To mitigate loss of farmland biodiversity, including insect pollinators, much effort has been spent on preserving and managing semi-natural grasslands. However, our ability to reverse current negative trends using only this approach is limited. In addition, semi-natural grasslands are today mostly managed by grazing instead of mowing, resulting in a lack of critical floral resources for many insects particularly during the summer. Hence, floral resources in the surrounding landscapes may be critically important for the persistence of flower-dependent insects in grasslands. We take an alternative approach and investigate if proper management of the surrounding landscape can enhance the conservation value of grasslands for flower-visiting mobile insects. In Sweden, almost half of the agricultural land is used for ley production, which opens for a potential complementary/supplementary food resource in the form of flowering clover and alfalfa, common ley legumes. Using a variety of empirical approaches, we focus on consequences of the availability and management of leys that produce nectar and pollen resources from blooming ley legumes. Presenting the first preliminary results from field data, we assess whether legume rich leys could potentially increase the conservation value of semi-natural grasslands for increased benefits to biodiversity.

P06

The state of pollinators in urban landscapes

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Urbanization has wide implications for pollinator diversity and abundance. The ongoing modifications of natural land are increasing the need to protect green spaces in urban and sub-urban areas. The benefits of such conservation can have a positive effect on for instance other animals, plants, air quality, mental health and nearby agricultural land. I will mainly explore correlations between different levels of urbanization, pollinator communities and floral resources. My fieldwork was conducted in 2021 and 2022, passively collecting pollinators by pan traps and vane traps. Information about location and coordinates, weather, plant diversity and abundance were noted for each site. The results are not ready until summer 2023, so I will present my preliminary results by comparing samples from last year with old records. These records are extracted from bumblebee surveys done by the Norwegian scientist Astrid Løken, in the 1950's until the 1980's. When comparing the results from last year with Løken's research, I found that the abundance of *Bombus lucorum* and *Bombus jonellus* have been dramatically reduced over the past 70 years. Also, the general diversity of bumblebees was much higher in Løken's data than in my results. These findings lead me to predict that this year's sampling will also show limited diversity and abundance of bumblebees, and possibly of other species such as hoverflies and bees.

P07

Road verges - suitable replacement habitats or ecological traps for pollinating insects?

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Pollinator decline is affecting pollination and ecosystem services worldwide. Several factors, and interaction between these, are thought to explain this decline. One of the main suggested explanations is the decrease of available nesting and foraging habitats due to agricultural intensification and infrastructure expansion. So, how could we turn this negative trend around? Roads are boarded with road verges which, with tailored management, could host a variation of grassland species that were previously common in the landscape. As road verges cover an increasing part of the landscape, they could constitute a habitat type that there is a shortage of today. On the other hand, traffic exposure could result in roads acting as ecological traps for pollinators such as bees. Our aim is to investigate if flower rich road verges benefit bee populations, and if a potential benefit depends on the characteristics of the road with a focus on traffic speed and volume. We will study reproduction, flower visitation, pollen collection and health in bees close to roads with different traffic volumes to answer the questions of if and where road verges are beneficial to bees and useful for pollinator conservation.

P08

Disentangling the effects of urbanization on the faceted ecology of urban pollination

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Several of the ecological components assuring the pollination ecosystem service are deeply influenced by the environmental transitions posed by urban areas. By focusing on urbanization, this poster shows the main researches from Milan and Maldives addressing aspects of pollinator and pollination ecology. In landscapes degraded by urbanization, the effects of patch fragmentation and climatic alteration on the biodiversity of pollinators have been studied with morphologic and genetic characterizations, and DNA barcoding proved to be a very efficient tool. Moreover, a fundamental aspect for pollinator survival is the nutritional ecology of pollinator foraging, a topic that has investigated by profiling the pollen and nectar macronutrients in several urban context. Furthermore, to describe urban pollinator health, wing morphometry has been applied across the Milan urbanization gradient to quantify variations on wing size and asymmetry, indicators of altered flight performance and development stability, with potential consequences for the pollination service. Further aspects of the ecosystem service have been addressed. To quantify plant-pollinator interactions in the urban context, the pollen transported by pollinators has been identified with DNA metabarcoding indicating plant use by pollinators. In addition, to understand if pollination mode shapes the nutritional properties of proximity food, cross- and auto-pollinated strawberries and cowpeas were processed to find nutrient classes, bioactive and antioxidant properties influenced by the pollination treatment. Overall, these studies are enriching our understanding of the urban pollination service.

P09

Stoichiometry, floral diversity and caloric value of pollen collected by *Osmia bicornis* in agricultural landscape

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The evolution, ecology and diversity of bees may be shaped by the nutritional quality of their larval food (pollen), which is used to build an adult body. Moreover, nutritional needs may differ between sexes, posing sex-specific nutritional constraints on organisms. We have, however, limited knowledge on nutritional constraints posed on wild pollinators, experiencing life stage and sexual conflict in nutritional needs, additionally complicated by nutritionally diverse landscapes they inhabit. Here, we studied the biogeochemical niche of the solitary bee *Osmia bicornis*, considering species composition, stoichiometry (concentrations and proportions C, N, P, S, Na, K, Mg, Fe, Cu, and Zn) and caloric value of pollen loads consumed by female and male larvae in agricultural landscape. We collected pollen from twelve *O. bicornis* nests located on the perimeters of oilseed rape fields of different size to represent different oilseed rape coverage (ORC, 6-65%) and landscape structure within a circle area of 500 m radius around the nest. Our results showed that the caloric value of the pollen loads was driven by landscape diversity. Female larvae consumed a higher proportion of *Brassica napus* and *Quercus* and a lower proportion of Poaceae, *Salix*, *Prunus*, and *Acer* than males. This was correlated with higher concentrations of C, N, S, P, Cu, Fe, higher *C:N*, and higher caloric value of food of female larvae. Specific landscape characteristics, including ORC, determined pollen N, S and Fe concentrations and *C:N*.

P10

Bees on steroids: perception, regulation and fitness effects

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Pollination of many flowering plants depends on insects. To attract pollinators, flowers offer rewards such as pollen and nectar. Bee pollinators nearly completely rely on those rewards as their nutrient source. While nectar provides mainly carbohydrates, pollen provides all other essential micro- and macronutrients (e.g. proteins, sterols, etc.). Many nutrients, like sterols, are important for bee development, but cannot be synthesized by the bees themselves. They have to be sourced externally via pollen. However, pollen composition varies greatly across plant taxa with subsequent effects on bee health, development and reproductive fitness. We conducted feeding (i) and behavioral conditioning (PER) (ii) experiments using pollen differing in sterol content to answer two questions: (i) Does variation in pollen sterol content affect longevity and reproduction in bumble bees? (ii) Can they perceive sterols in pollen via their antennae prior to consumption? We show that *Bombus terrestris* workers perceive several sterols (β-sitosterol, cholestenone, cholesterol, desmosterol, stigmasterol) with their antennae, but cannot differentiate between them. They further were unable to differentiate between different sterol concentrations in pollen. Additionally, neither pollen consumption, brood development nor worker longevity were affected by different sterol concentrations. Our findings suggest that naturally occurring sterol concentrations in pollen might fully support nutritional requirements by bees. Thus, there is no need for sterol perception in pollen.

P11

The effects of glyphosate-based herbicides on foraging behavior of pollinators

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The abundance of insect pollinators is decreasing globally, which may have serious impacts on the environment and economy. There are several possible reasons for the ongoing pollinator decline, with one of them being the intense use of pesticides. Glyphosate [N-(phosphomethyl)-glycine] is the most commonly used non-selective herbicide world-wide that inhibits the enzyme 5-enolpyruvyl-3-shikimate phosphate synthase (EPSPS). EPSPS is an essential enzyme in the shikimate pathway found in all green plants and without ESPSP a plant cannot produce essential amino acids and will eventually die. Glyphosate is extremely efficient, inexpensive and it has been claimed to be safe for non-target organisms (e.g., animals). However, recent studies have shown that glyphosate has negative effects on non-target organisms such as insect pollinators via their intestinal microbiota. Glyphosate also alters chemical communication in plants, with potential consequences for plant-pollinator interaction. Moreover, commercial glyphosate-based herbicides (GBHs) contain a lot of other co-formulants, which can be even more harmful for the non-target organisms than glyphosate. So far these nuisances of GBHs on pollinators are still poorly known. I will present the outline of my PhD thesis that focuses on the direct and indirect effects of GBHs on pollinators by using both field and laboratory experiments. I will also present preliminary results on the effects of GBHs on bumblebees and their foraging behavior.

P12

The complex floral signal – a way to attract pollinators, used by the small orchid *Malaxis monophyllos*

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Many plant species have evolved a complex floral signal in order to ensure pollination efficiency. This can be particularly adaptive during prolonged orchid flowering, and may point towards a strategy of hedging bets, enabling pollination even if the preferred pollinators are lacking. Thus we used combined analyses of anatomical flower structure, volatile composition and flower-visiting insect behavior in order to characterize features that can attract pollinators of the small, rare orchid *Malaxis monophyllos*, an important element of regional biodiversity. During two seasons of field observations, we found that only small Diptera (e.g. mosquitos, drosophilids and fungus gnats) were interested in the flowers of *M. monophyllos*. These results were reflected in flower features that combined well with the pollination system engaging dipterans. Firstly, the analyses of floral scent (SPME+GCMS) revealed substantial concentrations of aliphatic compounds, i.a. 1-octen-3-ol and 1-octanol, which conditioned the mushroom-like scent, together with a substantial fraction of alkanes, some of which have been previously described as sex-mimicry and aggregation pheromones in the deceptive systems of orchids. The anatomical structure exhibits a highly diverse cell cuticle surface and pronounced metabolic and secretory activity of the epidermal and subepidermal cells from all parts of the labellum. Moreover, our study provides evidence for putatively subsequent decoys connected with raphides and luminescence, as well as lipid secretion limited to the area behind the column. In general, our integrative approach points to the fragrant and visual signals of M. monophyllos flowers, with the presence of possible rewards in terms of nectar, fungus or microbes. These results reveal a few new issues that seem valuable in explaining the evolution of Diptera-specific pollination systems in orchids.

P13

Who can be trusted? Signaling of the floral reward in selected *Iris* and *Phlomis* species

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Floral display size can be viewed as a signal of reward, sent by flowers and received by pollinators. As pollinators visit flowers for rewards, they should prefer honest floral signals, which indicate reward properties. Flowers that have large corollas generally produce more nectar, and attract more pollinators, than small flowers. Here we tested the relationship between the visual advertisement, measured as petal size, and the quantity of the food reward offered in flowers representing *Iris* and *Phlomis* genera. Both genera have a fairly similar flower structure and both are visited mostly by *Apis mellifera* and bumblebees. The size of *Phlomis* flowers was not correlated with nectar volume or concentration. However, we found a correlation between petal size and nectar volume in case of one of the *Iris* species. Flower size in *Iris spuria*, the smallest

studied *Iris*, was correlated with the amount of nectar produced in the flower, which suggests the honest reward signaling of *I. spuria*.

P14

Dressed for success! Plants' ability to adjust to changed temperature

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Autumn hawkbit, *Scorzoneroides autumnalis*, grows in a wide variety of habitats in Europe from the Pyrenees up to the northernmost parts of Scandinavia. The species is highly polymorphic and has been divided into several varieties and ecotypes. The most important features used to distinguish different variants are the colour and hairiness of the involucral bracts, and the number of capitula. Plants with dark, hairy and few capitula, for example var. taraxaci, are known from colder climate or alpine habitats, whereas those with hairless capitula, for example var. salinus, have been reported from coastal meadows. We have collected plants of *S. autumnalis* from over 70 populations representing several different coastal, alpine and ruderal habitats throughout Scandinavia and from Iceland, and grown them in a common garden at Lund University, Sweden. In a recent temperature gradient experiment, we used plants from 20 different crosses, placed in each of four climate chambers, to determine the effect of temperature on traits reflecting the number and morphology of capitula. Field observations, herbarium data and the results from the temperature gradient experiment, strongly suggest that colour and hairiness of the involucral bracts, as well as the size and number of capitula, are environmentally-plastic and much affected by temperature, with capitula being fewer, larger, hairier, and darker for plants grown under low temperatures. Because dark coloration, dense hairiness and large flower size are known to facilitate heat retention and insect visitation in other species, we hypothesize that plants of *S. autumnalis*, especially those from northern or alpine areas, benefit from possessing these features under cool conditions and that they can be easily achieved by phenotypic plasticity in most populations.

P15

Geographic variation in pollinator and coflowering community in Italian populations of *Arabis alpina*

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A recent revelation is the presence of ample population-level variation in floral scent bouquets among populations of the same species. In some cases, like in the self-incompatible herb *Arabis alpina* in central Italy, floral scent variation can differ starkly between populations that are both genetically and geographically close, indicating the presence of local adaptation. Pollinator-mediated selection is one major driving force behind floral evolution. If floral scent variation among *A. alpina* populations is driven by varying selection on the floral scent bouquet from each local pollinator community, we predict that these communities should vary at a local scale among different *A. alpina* populations. Further, not every flower in a coflowering community is expected to contribute the same draw to local pollinators. When considering what could drive the diversification of floral scent, we should consider that there may not only be differing communities

of pollinators driving the floral scents, but also differing competitive or interactive influences by other angiosperms. It could be that *A. alpina* plays a different role in different localised ecosystems, depending on the preference of pollinators to other angiosperms. This poster exhibits the preliminary results of an investigation into (i) the pollinator communities associated with *A. alpina* of differing scent profiles in central Italy, as well as (ii) a study investigating patterns of pollinator preference in the *A. alpina* co-flowering community network.

P16

Effects of human disturbances on pollinator-mediated plant-plant interactions via interspecific pollen transfer

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Many interactions are common among species of pollinator sharing, these interactions may influence on plant reproductive performance vary from positive (facilitation), neutral, to negative (competition) via interspecific pollen transfer. However, in the Qinghai-Tibet Plateau, empirical studies designed to assess the effectiveness of different grazing regimes rarely consider specific ecosystem functions, such as pollination. Due to climate change and overgrazing, alpine meadows are seriously degradation, and ungrazed during the plant growing season is the main way to apply management regime for the restoration of degraded grassland. In this context, it is still unclear whether floral abundance or floral trait diversity is the main factor affecting interspecific pollen transfer. In this study, we investigated the effects of different grazed regimes on pollinator-mediated plant-plant interactions though pollen transfer networks, and explored mechanism of interspecific pollen transfer, and plant reproductive fitness in the alpine meadow. After adopting the ungrazed regime, the overall quantitative effects of pollinator-mediated interspecific interactions on the receptor species are mainly positive and neutral, with no negative effects. Moreover, the positive effects of quantitative effects on pairwise donor- receptor are increased, and the negative effects are reduced in ungrazed communities. These effects changes corresponded with higher quantity and quality of pollen deposition in ungrazed communities, and plants with floral traits similar to the hub-species can benefit from pollinators mediated IPT, which ultimately ensure the plant reproductive success. This suggests that the benefits of pollinator-mediated interactions among plants seemed to over than the cost of conspecific pollen loss associated to pollinator sharing.

P17

Where and what kind? Planning urban flower meadows to support bee diversity

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Urban flower meadows are increasingly common green spaces in many cities. Apart from their positive influence on people's well-being, they lead to a reduction in air pollution, positively influence bioretention and support biodiversity, especially by improving the living conditions of bees. The establishment of this kind of greenery is dependent on different environmental factors e.g. soil, humidity, availability of the site and residents' preferences, which are not always compatible with the requirements of bees. Thus, we created a project in which the one of the main aims was to answer the question: what features of urban flower meadows are the most important in supporting bees, especially wild bee species? For this purpose we sampled bees from 55 urban flower meadows in three cities in Poland, and used exploratory analysis based on the characteristics of the meadows and their surroundings. We widely characterized meadows according to their structure and availability of resources (i.e. species of plants, flower units, color and ground cover heterogeneity). We also asked how big the urban meadow should be, and where it should be placed in order to optimally enhance the abundance and richness of this important group of pollinators. Specifically, an abundance of bees responded positively to the number of flowering units and to the blue/yellow color of flowers. The opposite trend was shown by meadow area and frequency of diaphytes (crops, ornamental plants), despite the lack of statistical significance. Increase in the cover of continuous urban fabric in the vicinity benefited both species richness and abundance of wild bee communities on urban meadows. Further, increased cover of industrial areas, pastures and green urban areas were positively correlated with bee abundance. To summarize, our results show that both heterogeneity of floral resources of urban meadows and diversity of the urban environments in their surroundings positively influence bee abundance and species richness.