SCAPE 2019

33rd Annual Meeting
of the Scandinavian Association
of Pollination Ecology

24 – 27 October

Backagården, Höör, Sweden

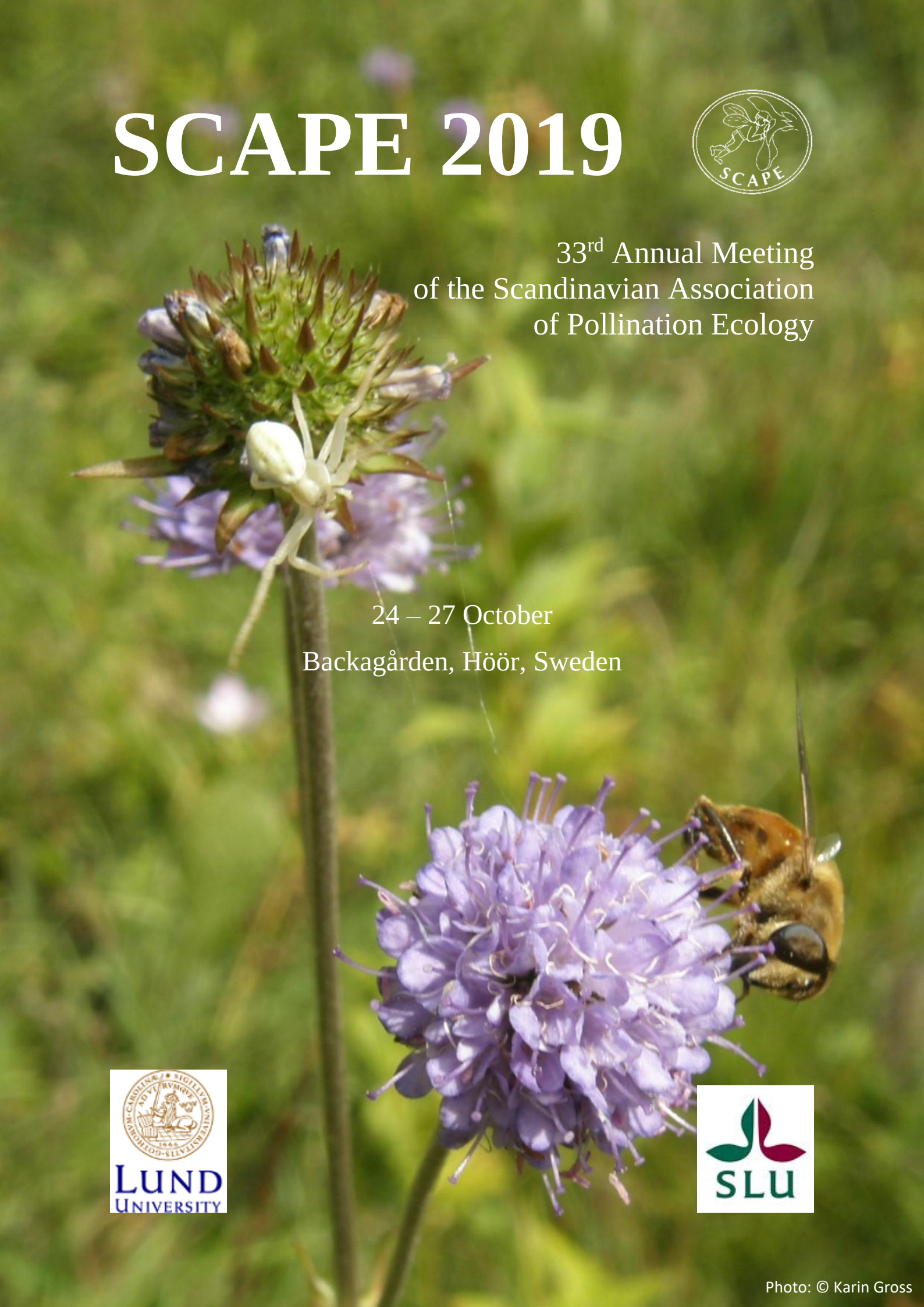


Photo: © Karin Gross

PROGRAMME

Thursday 24 October

16.00-18.00	Registration	
18.00-19.00	Supper	
	1st session (chair: Magne Friberg)	
19.00-19.05	Organizers	Welcome
19.05-19.15	J Poll Ecol/Nord J Bot	Special issue information
19.15-19.30	Yannick Klomber	O.01 The role of floral traits as predictor of pollinators along elevation and season on Mount Cameroon
19.30-19.45	Elżbieta Rożej-Pabijan	O.02 Impact of invasive *Rosa rugosa* on pollinator species composition of coastal sand dunes
19.45-20.00	Theodora Petanidou	O.03 Some things we know about the bees of the Aegean Archipelago
20.00-20.15	Comfort break	
20.15-20.30	Saskia Klumpers	O.04 The role of bee diversity for size-specific interaction patterns in grasslands of South Africa
20.30-20.45	Ainhoa Magrach	O.05 Understanding the functional role of migratory hummingbirds in plant-hummingbird interactions along a latitudinal gradient
20.45-21.00	Rocio Perez-Barrales	O.06 Does different pollinator preference solve reproductive conflicts between co-flowering species?
21.05-	Networking/socialising/sauna	

Friday 25 October

07.00-09.00	Breakfast/sauna	
	2nd session (chair: Ola Olsson)	
09.00-09.45	Rachael Winfree	K.01 Bee conservation in the eastern USA
09.45-09.50	Short break	
09.50-10.05	Björn Klatt	O.07 Extreme weather causes unexpected provision of pollination services
10.05-10.10	Irene Bottero	F.08 Influence of floral resources availability on pollinator abundance in Irish farmland
10.10-10.15	Julie Weissmann	F.09 Urban pollinators - Solitary bees in Freising
10.15-10.45	Coffee break	
	3rd session (chair: Nina Sletvold)	
10.45-11.00	Maria Gabriela Gutierrez de Camargo	O.10 Why be equal? Ecological relationships between co-occurrent species with similar floral display
11.00-11.15	Alison Scott-Brown	O.11 Linking soil environment to insect-plant mutualisms in a temperate, nitrophilous tree species
11.15-11.30	Casper van der Kooi	O.12 Spectral tuning of flower coloration to pollinator vision
11.30-11.45	Alexander de Gouveia	O.13 Sunbirds of a feather: Pollinator partitioning within the morphologically diverse *Cotyledon orbiculata* L. complex (Crassulaceae) in South Africa
11.45-11.50	Amy Parachnowitsch	F.14 Natural selection on floral traits of two *Penstemon* species
11.50-11.55	Nina Joffard	F.15 Floral trait differentiation in the *Anacamptis coriophora* group: phenotypic selection on scents, but not on colour
11.55-12.00	Jeff Ollerton	F.16 Butterflies, bumblebees and hoverflies are equally effective as pollinators of *Knautia arvensis* (Caprifoliaceae), a generalist plant species with compound inflorescences
12.00-13.15	Lunch	
	4th session (chair: Amy Parachnowitsch)	
13.15-13-30	Agnes Dellinger	O.17 Bees are inefficient pollinators in cloud forests - investigating pollinator shifts in Merianieae
13.30-13.45	Jurene Kemp	O.18 Poricidal anthers as pollen dispensers
13.45-14.00	Sara Leonhardt	O.19 Pollination from the bees' perspective: do bees use nutritional cues to select pollen?
14.00-14.15	Jeffrey D W Karron	O.20 Pollination, paternity and mating portfolios in a hermaphroditic plant
14.15-14.20	Marie V Henriksen	F.21 Plant-pollinator interactions in cultural landscapes during urbanisation
14.20-14.25	Dara Stanley	F.22 The importance of native honeybees in wild plant communities; the case of a South African biodiversity hotspot
14.25-14.30	Maria Blasi Romero	F.23 Evaluating the predictive performance of models explaining pollinator abundance in mass-flowering crops
14.30-16.15	Poster-session with coffee and cake	P.01-P.53
	5th session (chair: Øystein Opedal)	
16.15-16.30	Johan Ekroos	O.24 High land--use intensity in grasslands constrains wild bee species richness in Europe
16.30-16.45	Maxime Eeraerts	O.25 Honey bees vs non-*Apis* bees: pollination performance and response to bee abundance in sweet cherry orchards
16.45-17.00	Pawel Kolano	O.26 Investigating the effects of the neonicotinoid pesticide clothianidin on bumblebee foraging using an automated monitoring system
17.00-17.15	Nigel Raine	O.27 Assessing the risks and impacts of exposure to systemic insecticides for solitary, ground-nesting squash bees
17.15-17.30	Henrik Smith	O.28 Scale-dependent mitigation of pollination loss
18.00-19.30	Supper	
	6th session (chair: Karin Gross)	
19.30-19.45	Stefan Dötterl	O.29 VIP guests on flower scent parties at night: more than just moths and bats
19.45-20.00	Salena Helmreich	O.30 Hearing insects with light
20.00-20.15	Jonas Kuppler	O.31 Do plants eavesdrop on floral volatiles? Plant-plant communication beyond herbivore-induced volatiles
20.15-late	Networking/socialising/sauna	

Saturday 26 October

07.00-09.00	Breakfast/sauna	
	7th session (chair: Åsa Lankinen)	
09.00-09.45	Sharon Strauss	K.02 Reproductive interference rather than resource competition as a force determining local coexistence
09.45-09.50	Short break	
09.50-10.05	James Thomson	O.32 What makes a good year for fruit set in an early-flowering lily?
10.05-10.10	Graciela Rusch	F.33 Resource use among bumblebees and honeybees across spatial and temporal scales in Norway.
10.10-10.15	Judit Linka	F.34 Pollination by intoxication – how alkaloids influence bumblebees' pollinating behaviour
10.15-10.45	Coffee break	
	8th session (chair: Jane Stout)	
10.45-11.00	Sarah Arnold	O.35 Looking up for bees: pollination in smallholder legume crops, and the importance of trees in field margins
11.00-11.15	Chloé Raderschall	O.36 Diversified farming systems at field- and landscape scales for pollination in faba beans
11.15-11.30	Lisette van Kolfschoten	O.37 Grassland management for meadow birds in the Netherlands is unfavourable for pollinators
11.30-11.45	Michelle Larkin	O.38 Does management at a local or landscape scale impact pollinator communities in semi-natural grasslands?
11.45-12.00	Elisa Rigosi	O.39 The cholinergic pesticide imidacloprid impairs motion-sensitive neurons in the pollinator fly *Eristalis*
12.00-13.00	Lunch	
13.00-14.30	Excursion	
	9th session (chair: Lina Herbertsson)	
14.40-14.55	Philipp Wolfgang Eckerter	O.40 Influence of spatio-temporal pollen availability on pollinators and their function in agricultural landscapes
14.55-15.00	Elena Zioga	F.41 Pesticide residues in nectar and pollen collected from plants: A preview.
15.00-15.05	Knut Hessen	F.42 The distribution of insect pollinators in an oil palm plantation
15.05-15.10	Marcos Méndez	F.43 Is floral longevity depending on flower size, climate or phylogeny?
15.10-15.15	Veronica Hederström	F.44 Combined effects of pollen viability and pollinator efficiency on seed set in red clover cultivars
15.15-14.45	Coffee break	
	10th session (chair: Marcos Méndez)	
15.45-16.00	Kate Gallagher	O.45 Testing the role of floral neighborhood density and phenology on floral trait evolution
16.00-16.15	Shuxuan Jing	O.46 Different pollination approaches to compare seed set of diploid and tetraploid red clover (*Trifolium pratense* L.)
16.15-16.30	Jakub Štenc	O.47 Changes in pollinator behaviour under different plant spatial aggregation
16.30-16.45	Oz Barazani	O.48 The ecological significance of phenotypic differentiation in floral attraction traits in populations of *Eruca sativa* in Israel
16.45-17.00	Lilach Hadany	O.49 Flowers respond to pollinator sound within minutes by increasing nectar sugar concentration
17.00-17.15	Comfort break	
	11th session (chair: Jon Ågren)	
17.15-17.30	Christopher Mackin	O.50 Pollinator mediated evolution of floral traits in *Digitalis purpurea* after range expansion
17.30-17.45	Anina Knauer	O.51 Pollinator behavior and resource limitation maintain honest floral signalling
17.45-18.00	Eva Gfrerer	O.52 Phenotypic selection on floral scent in deceptive *Arum maculatum*
18.00-18.15	Katherine Burns	O.53 Don't forget about the flies! Public perceptions around pollinator conservation in Ireland
18.15-18.30	Yuval Sapir	O.54 Pollinator preference for intermediate floral size in a night-sheltering pollination system is and its association with heat reward
18.30-19.30	Getting ready…	
19.30-21.30	Conference dinner	
21.30-late	Party	

Sunday 27 October

07.00-09.45	Breakfast and check-out
10.00-10.45	SCAPE discussion, social media group, etc.
10.45-	End of SCAPE 2019

K.01 Bee conservation in the eastern USA

Rachael Winfree

Department of Ecology, Evolution, and Natural Resources, Rutgers University, New Brunswick, New Jersey, United States of America

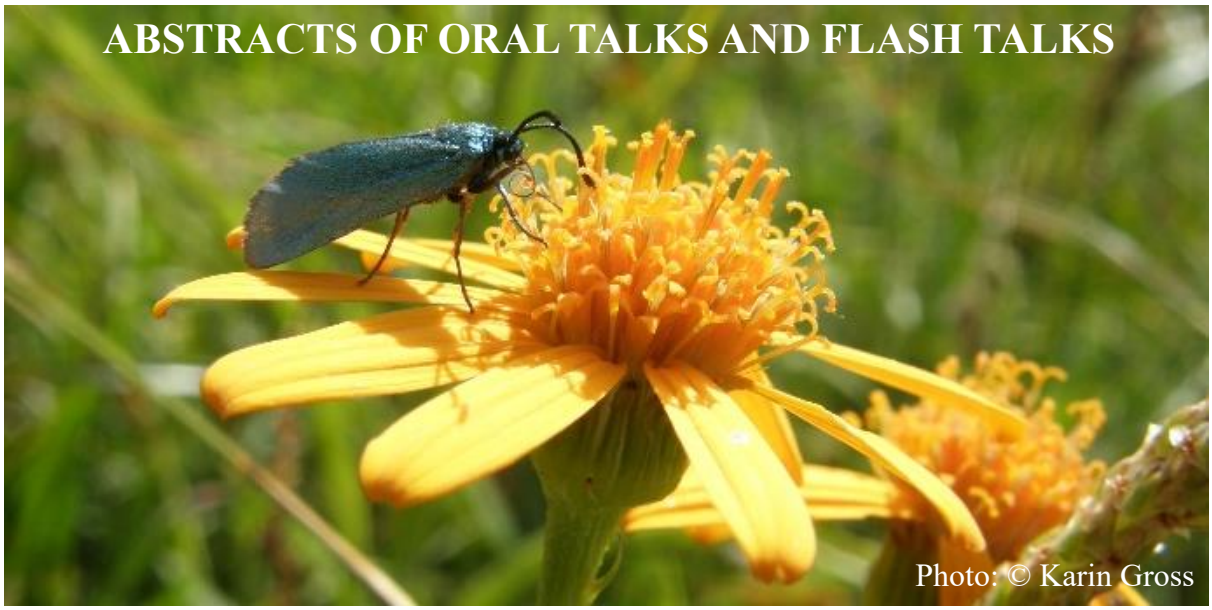
In this talk I will share what I know about bee conservation in the region where I do my research, the eastern USA. To some extent, the talk will tell the story of the conservation side of my research program, from my first field project with bees in 2003 to the present. This 16-year period in my own career parallels an incredible growth of the scientific community working on wild bees from a conservation perspective, so the talk will reflect that story as well. I will conclude by discussing what I think are the big questions in bee biodiversity and pollination from a large-scale perspective and their overlap with the research problems that my lab group is trying to solve now.

K.02 Reproductive interference rather than resource competition as a force determining local coexistence

Sharon Strauss

Department of Evolution and Ecology, University of California Davis, United States of America

I will discuss evidence on the role of reproductive interference in shaping coexistence and floral traits across a range of systems.



Thursday 24 October, 1st session

O.01 The role of floral traits as predictor of pollinators along elevation and season on Mount Cameroon

Yannick Klomberg[1], J. Mertens[1], Robert Tropek[1,2], Jiří Hodeček[1], Štěpán Janeček[1]

[1] Department of Ecology, Faculty of Science, Charles University, Prague, Czechia
[2] Institute of Entomology, Biology Centre CAS, Ceske Budejovice, Czechia

Flowering plants are expected to phenotypically converge in response to comparable selective pressures by the functional groups of pollinators, possibly resulting in pollination syndromes. However, there are still uncertainties about the conditions potentially influencing this predictability of pollination systems, as well as the role and efficiency of specific traits in attraction of specific pollinators. Therefore, we studied plant-pollinator interactions at four elevations from lowland to montane forest of Mount Cameroon in both wet and dry season. 217 plant species flowering in all strata and elevations were video-recorded resulting in a huge dataset of 1,209 recordings with >46,000 plant–visitor interactions. Showing for example shifts from predominantly bee to fly and bird visitation from dry to wet season in higher elevations. 25 floral traits (e.g. shape, colour and nectar characteristics) were measured in all flowering plants in order to distinguish the role of specific floral traits in the attraction of individual functional groups of visitors. Results of regression trees and non-parametric regression suggest that visitor limiting traits, being shape, size and tube width/length, play an important role in predicting potential pollinators. The best predicted were hymenopterans and lepidopterans. Using a trained regression tree model, the pollinators of specific plant species can be predicted relatively accurately across elevations and seasons. The general predictability of pollinators slightly increases towards higher elevations, while there is no systematic effect of season, although the predictability often differs inter-seasonally in each elevation.

O.02 Impact of invasive *Rosa rugosa* on pollinator species composition of coastal sand dunes

Elżbieta Rożej-Pabijan[1], Irena Grześ[2], Anna Stefanowicz[3], Marcin Woch[1]

[1] Institute of Biology, Pedagogical University of Kraków, Kraków, Poland
[2] Department of Environmental Zoology, Institute of Animal Sciences, Agricultural University, Kraków, Poland
[3] W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland

Dune habitats are highly susceptible to change from both natural and human-induced factors. One of the factors is invasion of *Rosa rugosa* that results in fragmentation of dune landscapes and changes vegetation to monospecific shrubs rich in flowers long in season. Shrubs can attract pollinators, however many pollinators are specialized toward host plants and need an open sandy area as a nesting site. The aim of our study was to compare pollinator faunas of *R. rugosa* patches and adjacent native sand dunes. The study was performed at 25 matched pair plots (invaded, uninvaded) at the Polish coast of the Baltic Sea. We checked pollinator species composition (bees and butterflies), by sweep netting and pitfall trapping and determined visitation rates on both plot types during fieldwork. Higher overall pollinator diversity, 20 species, was found on uninvaded dune plots while invaded plots contained 14 species. Uninvaded dune plots had 65 % of species in common with invaded plots, indicating that dune pollinator species use *R. rugosa* as an important but not the only source of nectar and pollen. On uninvaded plots several species of dune specialist bee species were found. Increased abundance and visitation rate of generalist pollinators was observed on invaded plots and was on average three times higher than on dune plots. The results indicate that *R. rugosa* invasion affects pollinator sand dune communities by promoting generalist pollinators and eliminating sand dune specialists.

O.03 Some things we know about the bees of the Aegean Archipelago

Theodora Petanidou

Departement of Geography, University of the Aegean, Greece

Despite its apparent simplicity, the Aegean is a very complex world. This complexity results basically from its extraordinarily high diversity in all kinds of beings, including plants and insects. Understanding the essence of the complex world of the Aegean constitutes a challenging multi-task effort involving many researchers worldwide. My lab's systematic research on the pollinators (with particular focus on bees and hoverflies) of the Archipelago started in 2004, focusing mainly on their diversity, pollination services they provide, as well as the particular threats these pollinators face in the Aegean. The systematic work carried out so far covers >250 sites in 25 Aegean islands, with extra comparative work carried out on other islands and mainland areas. In my talk I will tackle a few main results of the above investigation which is still ongoing. Our approach, using classical observation and molecular ecology, as well as novel holistic tools (e.g. ecological network analysis), covers ecological, biogeographical, and conservation/restoration aspects. The talk will be organized in three umbrella-issues: (i) diversity and biogeography co-considering functional aspects of the plant–pollinator system; (ii) global threats (e.g. global warming threatening synchronization of pollination partners and nectar reward availability, as well as frequency and intensity of fires); and (iii) conservation vis-à-vis traditional management in the Aegean (e.g. grazing).

O.04 The role of bee diversity for size-specific interaction patterns in grasslands of South Africa

Saskia Klumpers, Steven Johnson

School of Life Sciences, University of KwaZulu-Natal, Scottsville, Pietermaritzburg, South Africa

Size-matching between pollinator proboscis length and floral nectar tube depth of interacting species plays a crucial role in both pollination ecology and evolution. Community composition, specifically pollinator diversity, may affect species generalization degree and consequently the degree of size-matching. An increase in pollinator diversity may increase interspecific resource competition. Consequently, species may be more specialized which may lead to better size-matching. We investigated how bee diversity affected generalization degree and size-matching of *Amegilla natalensis*, a keystone long-tongued bee species in the grasslands of South Africa. We asked the following questions: (1) Is the average proboscis length of bees in a community related to the average nectar tube depth of flowers and are these traits related to bee diversity? (2) Are plants species that are visited by *A. natalensis* characterized by specific traits? And (3) does bee diversity affect generalization degree of *A. natalensis* and the average nectar tube depth of the flowers that it visits? We found that the average proboscis length of bees in a community was positively related to the average nectar tube depth of the flowers. Both traits were negatively related to bee diversity. *A. natalensis* visited flowers that were pink, blue or white and had deep nectar tubes (> 6 mm). In communities with a greater bee diversity, *A. natalensis* was more specialized and visited on average deeper-tubed flowers which better matched the length of its proboscis. Our results show that floral nectar tube depth distribution closely match bee proboscis length distribution within plant–bee communities. More diverse bee communities have a higher proportion of short-tongued bees. Therefore, for a long-tongued bee, an increase in bee diversity increases its specialization and leads to better size-matching. Consequently it highlights the possible role of species diversity for the facilitation of coevolution between plants and pollinators.

O.05 Understanding the functional role of migratory hummingbirds in plant-hummingbird interactions along a latitudinal gradient

Ainhoa Magrach

Basque Centre for Climate Change, BC3, Leioa, Spain

Predicting how species, communities and ecosystems will respond to global environmental change remains a key scientific challenge. Much progress has been done in understanding how species interact and assemble into complex networks. However, the dynamic nature of these species assemblages and the role of biodiversity in shaping them remain poorly understood. To fill these gaps, we evaluated structural changes in plant-hummingbird interaction networks within communities harboring resident and migratory hummingbird species along a latitudinal gradient of increasing species diversity from central Mexico to Alaska. We surveyed plant and hummingbird communities in the presence and absence of the migratory species to evaluate changes in species functional roles and community structure. Our results show a greater niche overlap within the more diverse areas, which allows resident species to take over the role of the migrant species in its absence. Contrastingly, we find that the migrant, behaves as a more specialized species within less diverse areas, monopolizing the most abundant resources and leading resident species to feed on less abundant resources. In the absence of the migrant species, its role is however not fully covered by resident species, resulting in communities that are less robust to further perturbations. These results have important implications for community persistence given expected changes in the migratory ranges of many species.

O.06 Does different pollinator preference solve reproductive conflicts between co-flowering species?

Rocio Perez-Barrales

School of Biological Sciences, University of Portsmouth, Portsmouth, United Kingdom

Pollinator preference, behaviour and flowering phenology regulate intra- and interspecific visitation in plant communities. In the Brazilian Cerrado, *Palicourea* species flower together between October and February during the rainy season. We investigated pollinator preference in co-flowering *Palicourea* species in the Cerrado in order to decipher mechanisms allowing co-flowering while reducing (potential) reproductive conflicts associated with pollinator sharing. We first studied pollinator behaviour to describe the level of pollinator sharing between *P. coriacea* and *P. officinalis* at different moments of the flowering season. In *P. coriaceae*, we then investigated pollen delivery and pollen deposition in single species and co-flowering patches. Our results showed that *Bombus atratus* was the main visitor to both species, but during the co-flowering period visitation increased in monospecific patches of *P. coriacea* as opposed to patches with both species. Avoidance of co-flowering patches might be related to nectar accessibility, which might be limited by the longer flower tube in *P. officinalis* compared to *P. coriacea*. This in turn resulted in an increase of pollen delivery in monospecific stands, while pollen deposition on the stigmas increased in co-flowering patches. Taken together, the results revealed a combination of strategies that reduce potential reproductive costs associated with co-flowering.

Friday 25 October, 2nd session

O.07 Extreme weather causes unexpected provision of pollination services

Björn Klatt

Department of Biology, Biodiversity Unit, Lund University, Lund, Sweden

Climate change is threatening the structural and functional stability of both aquatic and terrestrial ecosystems. In particular, the increased frequency and intensity of extreme weather events can result in ecological surprises which makes it difficult to predict the consequences of climate change on biodiversity and thereby on ecosystem services. In a mesocosm experiment, we show how an extreme weather event resulted in unexpected interactions between bumblebees in an agricultural ecosystem and floating algal mats in an aquatic ecosystem – with consequences for bumblebee colony development and pollination services. More specifically, bumblebee colonies grew larger when bees could use algal mats as rafts to access water. In contrast, colonies were lighter and crop yield was higher when bees had no access to water due to the absence of floating algal mats. Bumblebees without access to water spent longer time visiting flowers when the access to water was limited. We hypothesise that by spending longer time collecting nectar, bumblebees also satisfied their water needs, which resulted in increased bee-flower interactions, better pollination and thus higher crop yield. Our findings exemplify how extreme weather events can drive complex and unpredictable responses of organismal behaviour, and that interactions between terrestrial and aquatic environments can be an important factor for the provision of ecosystem services under future climate change.

F.08 Influence of floral resources availability on pollinator abundance in Irish farmland

Irene Bottero, Simon Hodge, Jane Stout

Trinity College Dublin, Dublin, Ireland

In Ireland, the main pollinators are managed bees, solitary bees, bumble bees and hover flies. More than half of both bumble bees and solitary bees are in decline. A cause of pollinators decline has been identified in the habitat degradation and intensification of agriculture. In Ireland, more than the 60% of the landscape is farmed, and the east part of the country is mainly composed of intensively managed crop and pasture lands. The shift from the semi-natural habitat into a landscape characterised by an intensive agriculture implies an alteration in the vegetation that might affect the availability of food resources for pollinators, with repercussion on their density, behaviour and movements. In this context, and as part of the EU-funded PoshBee project, we aimed to investigate if the end of the flowering period of the entomophilous, mass-flowering crops affected pollinator communities. Our hypothesis was that, due to the fact that the flowering period of the crops is the main resources of food for pollinators in the Irish agricultural landscape, the insect communities changed during and after the blossoming. In order to test our hypothesis, six oilseed rape crops and five apple orchard sites were selected throughout Ireland, and their pollinator populations were recorded during and after the crop flowering period. Furthermore, in order to better investigate the important role of the boundaries of agricultural fields in terms of provision of food, we also recorded the abundance and richness of floral resources along the margins, as well as the floral species that the individuals were feeding on. In this presentation, we will outline our preliminary findings.

F.09 Urban pollinators - Solitary bees in Freising

Julie Weissmann, Hanno Schäfer

Plant Biodiversity Research Group, Technical University of Munich, Munich, Germany

The project uses a holistic approach integrating pollinators, plants and people in a large town and aims to answer three main questions: 1) How important are urban habitats for applied bee conservation? 2) How relevant is bee diversity for urban fruit crop pollination? 3) How can urban citizens become involved in urban bee research? The study was carried out in a large town in southern Germany. Occurrence data of target specialized bee species was collected on existing and newly established flower patches throughout the city. Flower visitors were recorded through systematic observations on rosaceous fruit crops flowering throughout the season. Students and citizen scientist were trained to perform pollination observations on fruit crops and search for selected target bee species. Occurring and newly introduced food sources are used by some of the specialized and therefore particularly vulnerable bee species. The crop flower visitor community composition varied strongly throughout the season and between plant species. Participation by urban citizens in bee identification trainings was high, the contribution through observation reports was low. We conclude that 1) cities can contribute to target species conservation for some specialized bee species; 2) an urban food security perspective highlights the importance of protecting diverse bee communities in urban environments; 3) participative approaches in urban bee research have an educational impact but taxonomic difficulties raise specific challenges for citizen scientists.

Friday 25 October, 3rd session

O.10 Why be equal? Ecological relationships between co-occurrent species with similar floral display

Maria Gabriela Gutierrez de Camargo[1], Klaus Lunau[2], Montserrat Arista Palmero[3], Leonor Patrícia Cerdeira Morellato[1]

[1] Institute of Biosciences, Department of Botany, Phenology Lab, UNESP - São Paulo State University, Rio Claro, São Paulo, Brazil

[2] Department Biology, Institute of Sensory Ecology, Heinrich-Heine-University Düsseldorf, Düsseldorf, Germany

[3] Faculty of Biology, Department of Vegetal Biology and Ecology, University of Sevilla, Sevilla, Spain

Within a community, while plants present flowering times and spatial distributions to favour pollination success and avoid interspecific competition, pollinators look forward optimizing their food search. In this context, bees' floral constancy can be advantageous for both, plants and pollinators. Since floral constancy depends on the bees' ability to discriminate floral signals, it is expected that co-occurrent plant species will diverge in their floral displays or present temporal segregation of flowering to avoid heterospecific pollen deposition. For groups of co-occurrent taxonomically related species with highly similar floral display we investigated if the flower colours can be distinguished by bees (colour loci distance in the bee colour space) and how their flowers are displayed in time (flowering phenology). We intend to infer possible ecological relationships among these species which allow their co-occurrence in space and look for cues of signal standardization. We analysed 12 groups of species, six from the Brazilian campo rupestre vegetation and six from Spanish Mediterranean shrublands. Among the species of each studied group almost no flowers can be discriminated by bees in order to maintain floral constancy, confirming the similar display for foraging bees. Based on our preliminary phenological results, different temporal patterns were observed between and among groups. Mainly for the temperate groups, which are more constrained by a rest season, some species overlapped their flowering peaks and can be under competition or facilitation selective pressures. However, some species presented a tendency of sequential flowering and, besides avoiding interspecific competition, may facilitate each other by signal standardization, maintaining a reliable visual signal for bees over time in the shared space. More detailed analysis is necessary to understand the ecological relationships allowing the coexistence of species with similar flower displays.

O.11 Linking soil environment to insect-plant mutualisms in a temperate, nitrophilous tree species

Alison Scott-Brown, M. -J.R. Howes, G.C. Kite, J.H. Martin, P.C. Stevenson

Royal Botanic Gardens, Kew, United Kingdom

The concept of thrips as pollinating insects in temperate regions is rarely considered as thrips are more frequently regarded to be destructive florivores. Taking an integrative approach to studying thrips behaviour and floral chemistry we provide insights into the ambiguous pollination strategies of *Sambucus nigra* L. (common elder) and provide evidence that suggests that the relationship between *S. nigra* and *Thrips major* is mutualistic. Understanding what drives mutualisms between plants and insects can provide the basis for studying more complex relationships between land-use change and plant health and reproduction strategies, particularly as mutualism can rapidly revert to antagonism if ecological conditions change. For example, availability of NO3- and NH4+ can alter the expression of specialised floral secondary metabolites and volatile organic compounds that influence a range of ecological functions such

as pollinator behaviour, herbivore defence and adaptation to environmental stress. Using gas- and liquid-chromatography coupled with mass spectrometry in conjunction with insect monitoring and morphological analysis of floral tissues we explored whether soil chemistry alters floral traits of *S. nigra* at three sites; arable, dairy and a conservation site of special scientific interest (SSSI), each with a distinct soil chemistry profile. Our study showed that while pollen chemistry favoured pollinating thrips in plants in arable and SSSI locations, floral morphological traits associated with resource availability were enhanced in dairy farm plants, resulting in similar numbers of thrips visiting flowers in arable and dairy sites. The methods developed through this study enable an efficient and timely mechanism for identifying and communicating how environmental changes such as application of soil improvers used in agriculture can potentially alter floral traits of common native hedgerow species which are important food sources for insect pollinators, impacting their behaviour and populations at a time when some key pollinating species are in decline.

O.12 Spectral tuning of flower coloration to pollinator vision

Casper van der Kooi

University of Groningen, The Netherlands

Flowers display vivid colours to entice pollinators. Whereas the pigmentary aspects of flower coloration (e.g. synthesis, molecular biology and evolution of floral pigments) have been widely studied, the optics, i.e. the interaction of light with the flower's interior components, remain largely unstudied. It remains further unknown how floral visual signals are tuned to pollinators with different visual systems, such as bees, butterflies and birds. Here, I present results from a large-scale comparative study on flowers of species-pairs with contrasting pollination systems. First results suggest convergent evolution of floral visual signals to pollinator vision along three different routes, which all result in high visibility to respective pollinators: (i) the type of floral pigment evolves to yield hues that are most conspicuous to the main pollinator; (ii) the amount of pigment evolves such that it yields the highest saturation ("purity") possible for the specific pigment; (iii) the amount of light reflected ("brightness") increases upon switches from diurnal to nocturnal pollination. These three lines of evidence suggest that the optical properties of flowers convergently evolve via different means to yield the highest salience to pollinators.

O.13 Sunbirds of a feather: Pollinator partitioning within the morphologically diverse *Cotyledon orbiculata* L. complex (Crassulaceae) in South Africa

Alexander de Gouveia, Tracey L. Nowell, Craig I Peter

Department of Botany, Rhodes University, Grahamstown, South Africa

Cotyledon L. (Crassulaceae) is a small genus (11 species) of succulent shrubs that is largely endemic to South Africa. The most widespread of the species, *Cotyledon orbiculata* L., exhibits considerable morphological variation across its range, particularly amongst its flowers, signifying pollinator partitioning. In terms of reproductive traits, the pendulous red, orange or yellow flowers vary in corolla tube length and width, the degree to which the stamens and styles are exerted, and in the volume of nectar available. Peak flowering occurs in spring and summer, and different forms of *C. orbiculata* appear to have non-overlapping flowering times, especially when sympatric. The suite of floral traits found in *C. orbiculata*, is consistent with ornithophily, more specifically, sunbird pollination, and the variation therein suggests partitioning within the

sunbird guild based on their size and behaviour. We studied the pollination biology of different forms of *C. orbiculata* in order to test a hypothesis of pollinator-mediated differentiation in this species complex. We aimed to address the following specific questions: 1) Is the variation in floral morphology across *C. orbiculata* continuous or is there evidence that discrete floral clusters are maintained? 2) Are different of floral forms of *C. orbiculata* separated temporally? 3) Do different sunbird species visit different floral forms preferentially? Field observations and data collection were carried out at multiple sites across the Eastern Cape, Western Cape, and Northern Cape provinces in South Africa. Sunbird visitation was quantified using Bushnell® HD Trophy CamTM camera traps and by direct observation. Variation in floral morphology was measured using multivariate analysis of measurements of the gynoecium, androecium, corolla, and calyx. Information on flowering phenology was collated from herbarium specimens and field visits and analysed as circular data to assess degree of overlap between forms. Nectar volume was recorded using microcapillary tubes (ringcaps®, Hirschmann® Laborgerate), and nectar concentration was determined using an Atago® refractometer. Malachite (*Nectarinia famosa* L.), Greater Double-Collared (*Cinnyris afer* L.), and Southern Double-Collared (*Cinnyris chalybeus* L.) Sunbirds were found pollinating *C. orbiculata*. Analyses of floral morphometric data identifies three discrete clusters within the forms of *C. orbiculata* sampled - corolla tube length, corolla lobe length, and filament length, account for most of the variation. All three mentioned-species of sunbirds pollinated flowers having the longest corolla tube length (19.28–36.67 mm), while the Greater Double-Collard Sunbird was found pollinating flowers with medium (13.65–20.70 mm) and small (9.09–12.81 mm) corolla tubes. Average nectar volume was most abundant in flowers with the longest corolla tubes (22.65 µL), compared to flowers with the smallest corolla tubes (1.81 µL). Phenology patterns do not correlate with morphometric and nectar data sets and is year-round and non-overlapping. Findings from this study provides a new insight into the pollination biology of *C. orbiculata*: 1) That nectar-producing flowers are readily available to entice a variety of sunbirds year-round. 2) Flowers are non-competing, thus, as the flowering period ends for one flower, the next one starts to flower, thus, ensuring constant sunbird visitation. 3) That sunbird diversity, for a flower, is correlated to nectar volume and flower size. 4) That there may be more species within the *C. orbiculata* complex than initially anticipated.

F.14 Natural selection on floral traits of two *Penstemon* species

Kaushalya Rathnayake[1], Amy Parachnowitsch[1,2]

[1] University of New Brunswick, Canada
[2] Uppsala University, Sweden

Natural selection on floral traits is fairly commonly observed, however much of the focus has been on visual signals. We measured floral traits of two *Penstemon* species in the Colorado Rockies to ask whether selection on visual or olfactory signals is more prevalent and whether these two bee-pollinated plants experience similar selection pressures. Both *P. strictus* and *P. mensarum* are typical purple flowers common for bee-pollination, and we will compare these species to previously studied *P. digitalis* where selection on scent was stronger than many visual signals but unlike these species have mostly white corollas.

F.15 Floral trait differentiation in the *Anacamptis coriophora* group: phenotypic selection on scents, but not on colour

Nina Joffard[1], Iris Le Roncé[2], Julien Renoult[2], Bruno Buatois[2], Laurent Dormont[2], Bertrand Schatz[2]

[1] EBC, University of Uppsala, Sweden
[2] Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), Montpellier, France

Divergent selective pressures imposed upon floral traits may promote floral divergence and speciation in flowering plants. However, whether current divergent selection contributes to the maintenance of floral trait differentiation among closely related plant taxa remains to be tested. In this study, we compared floral phenotypes, pollinator guilds and selective pressures imposed upon floral traits among three closely related orchid taxa, namely *Anacamptis coriophora* subsp. *coriophora*, *A. fragrans* and *A. coriophora* subsp. *martrinii*. We showed that these three taxa were characterised by different floral colours and scents, with two predominant compounds per taxon, one shared among all three taxa and one taxon-specific. Floral display size was positively correlated with fruit set in most populations, while we found no apparent link between floral colour and female reproductive success. We detected positive selection on several taxon-specific compounds in *A. fragrans*, whereas no selection was found on floral volatiles of *A. coriophora*. Our results suggest that present-day phenotypic selection contributes to the maintenance of chemical differentiation between *A. coriophora* and *A. fragrans*, but that other evolutionary forces likely drove floral colour divergence in this orchid group.

F.16 Butterflies, bumblebees and hoverflies are equally effective as pollinators of *Knautia arvensis* (Caprifoliaceae), a generalist plant species with compound inflorescences

Jeff Ollerton[1], Emma Coulthard[2], Sam Tarrant[3], Fergus Chadwick[4], James Woolford[5], André Rodrigo Rech[6]

[1] University of Northampton, United Kingdom
[2] Manchester Metropolitan University, United Kingdom
[3] RSPB, United Kingdom
[4] University of Glasgow, United Kingdom
[5] University of Northampton, United Kingdom
[6] Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil

Interactions among plants and pollinators vary on a continuum from complete specialization (a single pollinator species for a given plant species) to highly generalised (different functional groups of pollinators perform equivalent services for a given plant species). Moreover, these interactions vary in time and space, giving rise to complex ecological scenarios. Despite this, there is a long-held assumption that bees, particularly large ones such as bumblebees (*Bombus* spp.), are usually the most effective pollinators of generalist plants. We tested this assumption by studying how the relative importance of different groups of pollinators of *Knautia arvensis* (L.) Coult. (Caprifoliaceae: Dipsacoideae) varied across years and flower density in the same population. The main questions were: 1. Are the principal groups of pollinators of *K. arvensis* consistent in their relative abundance over time? 2. How effective are these groups at pollinating this plant? We studied low and high density populations of *Knautia arvensis* in Northampton, UK. To assess pollinator importance, we exposed virgin inflorescences to single visits by different types of pollinators and then combined the effectiveness (proportion of stigmas with pollen after a single visit) of each pollinator group with the proportional visitation frequency in five different years. We also compared pollinator behaviour (time spent on flowers and flight distance between visits). The relative importance of each pollinator group varied considerably

between years. Different groups varied in flight distances between flower visits, and all were influenced by flower density, with shorter average flights in high-density patches. Butterflies were the best pollinators in terms of the proportion of stigmas pollinated and flight distance between flower visits, although their variable frequency prevented them from being the most important pollinators in all years. Our results reinforce the adaptive value of generalised pollination strategies when variation in relative abundance of different types of pollinators is considered.

Friday 25 October, 4th session

O.17 Bees are inefficient pollinators in cloud forests - investigating pollinator shifts in Merianieae

Agnes Dellinger[1], Rocio Pérez-Barrales[2], Diana Fernández-Fernández[3], Jürg Schönenberger[1]

[1] Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria
[2] University of Portsmouth, United Kingdom
[3] Instituto Nacional de Biodiversidad, Ecuador

Changes in pollination efficiency are thought to be the main driver of shifts in reproductive strategies in plants relying on pollination by animals. Such changes may occur when plants colonize new habitats, abiotic environmental conditions change or new pollinators appear. Environmental conditions and pollinator communities differ along altitudinal gradients and species which grow in lowland habitats often differ in their pollination strategy from closely related species which have colonized montane habitats. In particular, numerous Neotropical plant clades show a consistent shift directionality from bee to vertebrate pollination associated with growth at high elevations. Surprisingly, the underlying assumption that these pollinator shifts arose from a reduced efficiency of bee pollinators in mountain ecosystems has rarely been tested in the field. Using Merianieae (Melastomataceae) as study system, we test the hypothesis that bees are less efficient pollinators at high elevations than vertebrates, hence leading to repeated shifts from bee to vertebrate pollination. We employ manual pollination experiments, pollinator observations and measure pollen transfer (pollen export and pollen deposition) in six Merianieae species pollinated by either bees, passerine birds or mixed assemblages of vertebrates. Furthermore, we comparatively study selected floral traits crucial for pollen transfer in 47 Merianieae species to understand how pollen transfer is optimized in the different pollination systems. Our results confirm that bees are highly inefficient pollinators in montane cloud forests as bee-pollinated plants were strongly pollen limited. Vertebrate pollinators were significantly more efficient in transferring pollen, even when visitation rates were low. Employing different vertebrate pollinator groups (e.g. hummingbirds and bats) maximized pollen transfer in Merianieae. Certain floral adaptations to increase pollen transfer, such as enlarged stamen pores, bigger stigmatic areas or changes in pollen release mechanisms, associated with pollinator shifts.

O.18 Poricidal anthers as pollen dispensers

Jurene Kemp

University of Stirling, Stirling, United Kingdom

The buzz pollination syndrome, where sonicating bees extract pollen from poricidal anthers, has evolved independently across 65 plant families. Despite the prevalence of this syndrome, the function of poricidal anthers remains poorly understood. One possible function is that poricidal anthers act as dispensing mechanisms that gradually release pollen, and thus influence pollinator visitation and pollen deposition rates. We assessed whether poricidal anthers of various Solanum species gradually dispense pollen by applying simulated bee vibrations to flowers. If the gradual release of pollen is an adaptation to pollinators, we would expect the pollen release rate to vary with species' reliance on pollinators. We tested this and found that species with low pollinator reliance (i.e. selfing species) released most of their pollen after one or few simulated bee visits, whereas those reliant on pollinators released their pollen more gradually across multiple simulated visits. This suggests that the dispensing mechanism is an adaptation to pollinators. Because different bee taxa produce different vibrations, we tested how changes in vibration velocity influence pollen dispensing rates. Low velocity vibrations resulted in a reduction in total pollen released, and pollen was dispensed more gradually than when high velocity vibrations were applied. Male fitness modelling revealed that low velocity vibrations do not necessarily reduce fitness, as long as visitors have low diminishing returns and high visitation rates. In contrast, high velocity vibrations resulted in high male fitness after few visits, but only when there were no or few diminishing returns. Additionally, high velocity vibrations always resulted in higher pollen reward for pollinators than low velocity vibrations. This suggests that bees that produce either high or low velocity vibrations can act as effective pollen exporters of buzz pollinated plants, as long as visitation rates are high, but only bees that produce high velocity vibrations receive large pollen rewards.

O.19 Pollination from the bees' perspective: do bees use nutritional cues to select pollen?

Sara Leonhardt[1], Fabian Ruedenauer[1], Johannes Spaethe[2]

[1] Department of Zoology III, University of Würzburg, Würzburg, Germany
[2] Department of Zoology II, University of Würzburg, Würzburg, Germany

Bees are highly important pollinators of many plant species. In return for their service, they obtain their main food resources, i.e. pollen and nectar. While nectar represents an essential source of sugar and thus energy, pollen provides bees with all other essential macro- and many micronutrients, e.g. protein, fat or sterols. The nutritional quality of pollen therefore has a major influence on the bees' development, health and reproductive fitness. Given the high importance of pollen nutritional quality, we assumed that bees should pay close attention to nutritional cues in pollen in order to select and consume pollen which best meet their nutritional needs. We therefore investigated the role of different nutritional cues for pollen collection in bumblebees (Apidae: *Bombus terrestris*) and honeybees (*Apis mellifera*) through a combination of different behavioral assays and chemical analyses of resources. We found that bumblebees prioritized lipid perception when assessing pollen appropriateness and generally selected pollen of comparatively lower fat content, while totally ignoring its amino acid and sterol content. In contrast, honeybees payed attention to both pollen fatty acid and pollen amino acid content. Interestingly, foraging decisions appeared to ultimately affect colony fitness, as fatty pollen severely decreased the survival and reproductive fitness of bumblebees.

O.20 Pollination, paternity and mating portfolios in a hermaphroditic plant

Jeffrey D W Karron

Department of Biological Sciences, University of Wisconsin-Milwaukee, United States of America

When pollen carryover is limited, a hermaphroditic plant may mate with different partners through male and female function. We characterized mating portfolios in *Mimulus ringens*, a hermaphroditic, bumblebee-pollinated plant native to central and eastern North America. Nearly every sampled seed could be assigned to a single sire. We used this information to quantify the overlap in mating through dual sex functions, which can be presented as a pair of bipartite networks. Mate diversity is high within fruits, but there was almost no overlap in mates between the two sexual functions. This finding might help explain the maintenance of hermaphroditism under conditions that would otherwise favor the evolution of separate sexes.

F.21 Plant-pollinator interactions in cultural landscapes during urbanisation

Marie V. Henriksen, Line Johansen

Norwegian Institute of Bioeconomy Research, Norway

Land use change from semi-natural habitats into urban areas poses a threat to both local and global diversity of species and their interactions. The BE(E) DIVERSE project aims to provide knowledge to help safeguard biodiversity in cultural landscapes during urbanisation with focus on plants and key pollinators (bees and hoverflies) and their interactions in Trondheim, Norway. The function of semi-natural grasslands as hot spots for grassland specialist plants and insect pollinated plants in the urban landscape was examined, as well as the potential for other nature types to function as stepping stones for pollinators and their plant resources. Plants surveys revealed semi-natural grassland as hot spot habitats for both habitat specialists and insect pollinated plants while road verges were particularly rich in insect pollinated plants and therefore have the potential to function as stepping stones for pollinators. Flowering plants, pollinators and their interactions were then sampled at 14 sites along gradients of increasing urbanisation with each site containing both a hot spot (semi-natural grasslands) and potential stepping stone (road verges) habitat within a 500m radius. Three times during the summer, floral resource abundance and pollinator diversity was estimated along a 100m transect. Plant-pollinator interactions were sampled as pollen collected from the bodies of bees and hoverflies. The effect of urbanisation and land use on distribution patterns on plants and pollinators will be quantified in a joint species distribution model while the effects on plant-pollinator interactions will be assessed in a pollen transport network. This will help inform urban land use planning to maintain and restore biodiversity of plant and pollinators.

F.22 The importance of native honeybees in wild plant communities; the case of a South African biodiversity hotspot

Dara A. Stanley[1], Simangele Msweli[2], Steven D. Johnson[2]

[1] School of Agriculture and Food Science, University College Dublin, Dublin 4, Ireland
[2] School of Life Sciences, University of KwaZulu-Natal, Scottsville, Pietermaritzburg, South Africa

Western honeybees (*Apis mellifera* L.), native to Europe and Africa, have been transported worldwide and are now one of the most important global crop pollinator species. Although the relative contribution of honeybees to global crop pollination is increasingly recognised, relatively little is known about their importance as pollinators in wild plant communities. The

only remaining significant wild and unmanaged western honeybee populations are in Africa. We investigated the importance of honeybees as pollinators of diverse wild plant communities in the Maputaland-Pondoland-Albany Biodiversity hotspot in South Africa. Honeybees visited a large proportion of flowering plant species within these two communities (40% and 35%) and also provided a substantial proportion of visits to the plants they visited (40% and 32% respectively). However, when pollinator importance indices (based on abundance, pollen loads, fidelity and efficiency) were calculated for a subset of plants, honeybees were only important pollinators of 29% of the plants they visited. Our data provide a first step in determining the importance of honeybees as pollinators in wild plant communities, and the potential impacts of honeybee declines on these highly diverse grassland ecosystems.

F.23 Evaluating the predictive performance of models explaining pollinator abundance in mass-flowering crops

Maria Blasi Romero, Yann Clough

Centre for Environmental and Climate Research (CEC), Lund University, Sweden

Modelling pollinators is a way to identify priorities and problems on how to deal between pollination and biodiversity conservation. Global models that can predict bee responses in the landscape are needed to develop better agro-environment policies that will help to mitigate the loss of these ecosystem services agents. However, the existing knowledge for ecological predictions on ecosystem services generally comes from other regions, and therefore it restricts the ability to make use of the existing knowledge to inform policy and management. Knowing to what degree models are transferable is a prerequisite to increase ecological understanding. We used existing data on bumblebee and solitary bee abundance at different regions and spatial scales, and high-resolution land use information. Data includes pollinator observations in focal oilseed rape fields in 4 different countries (Sweden, Germany, The Netherlands, and the UK), data from different years (2011, 2012, 2013), and different studies (4 different studies). In this study, we assessed the contribution of land-use variables to the prediction of wild pollinator abundance in oilseed rape, the consistency in the effects, and the transferability of these models between countries and years.

Friday 25 October, 5th session

O.24 High land--use intensity in grasslands constrains wild bee species richness in Europe

Johan Ekroos, Henrik G Smith

Centre for Environmental and Climate research (CEC), Lund University, Sweden

An increasing number of studies find negative relations between bee species richness and simplification of agricultural landscapes, but the role of land-use intensity in focal grasslands, and its relative importance compared to landscape simplification is less well-known. In particular, it is not known if common species, which are the dominant crop-visiting species, are more robust to increasing land-use intensity than rare species. We compared the effects of nitrogen inputs, as a proxy for land-use intensity, and proportion of natural and semi-natural habitat, as a measure of landscape complexity, on total bee species richness, rare species richness and dominant crop-visiting species richness. We used data from five European

countries, consisting of 282 grasslands, covering the entire range of low intensity, no-input systems, to high-input grasslands, with more than 400 kg N/ha applied per year. We found strong negative impacts of increasing land-use intensity on total bee species richness across Europe. The richness of rare bee species was not significantly related to increasing land-use intensity, whereas dominant crop-visiting species richness was significantly reduced by increasing land-use intensity. Based on species accumulation curves, grasslands with no nitrogen inputs had higher total bee richness and higher shares of rare species compared with sites with high nitrogen inputs (>125 kg N/ha/year). Finally, we found no effects of increasing landscape complexity on bee species richness. Our results highlight the importance of retaining grasslands characterised by low land-use intensity across agricultural landscapes to promote the conservation of wild bees.

O.25 Honey bees vs non-*Apis* bees: pollination performance and response to bee abundance in sweet cherry orchards

Maxime Eeraerts, Guy Smagghe, Ivan Meeus

Department of Plant and Crops, Ghent University, Belgium

Previous studies have highlighted the contribution of wild pollinators to sweet cherry production (Eeraerts et al., 2017; Eeraerts et al., 2019). Pollination performance of honey bees and other pollinators and interspecific interactions might explain the added value of pollinator diversity. In our study we focused on the foraging behaviour (flower visitation rate, probability of tree change, probability of row change and contact with the floral stigma) and pollination efficiency (fruit set of flowers that received only one visit) of honey bees and non-*Apis* bees in sweet cherry orchards in Belgium. The influence of honey bee abundance and non-*Apis* bee abundance on the foraging behaviour was also investigated. Single visit pollination efficiency on sweet cherry was higher for both mason bees and solitary bees compared to bumble bees and honey bees. Visitation rate of bumble bees and mason bees was higher compared to other solitary bees and honey bees, the latter also visiting more flowers per minute than solitary bees. Mason bees and bumble bees showed a higher probability of changing trees in the same row and a higher probability of changing trees between rows, respectively, compared to both solitary bees and honey bees. We also found that the probability that honey bees change trees between rows increased with increasing non-*Apis* bee abundance. Foraging behaviour of non-*Apis* bees was not influenced by honey bee abundance of non-*Apis* bee abundance. Our results highlight the higher pollination performance of non-*Apis* bees, especially that of mason bees and other solitary bees. We also conclude a facilitative component of non-*Apis* bees to crop pollination. Management to support species with high pollination efficiency and effective foraging behaviour for specific crops will promote crop pollination.

O.26 Investigating the effects of the neonicotinoid pesticide clothianidin on bumblebee foraging using an automated monitoring system

Pawel Kolano[1], Katrine Borgå[2], Anders Nielsen[1]

[1] Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biosciences, University of Oslo, Norway

[2] Section for Aquatic Biology and Toxicology (AQUA), Department of Biosciences, University of Oslo, Norway

Bumblebees are important pollinators at high latitudes. Recent studies have shown that currently 46% of European bumblebee species have declining populations. This has caused concerns for the sustainability of bumblebee populations and the ecosystem service they provide both in wild plant communities and to entomophilous crops. The aim of this project

was to design a monitoring system for tracking foraging bouts of individual bumblebees. The system consisted of a nest box and a dedicated camera box as an entrance/exit. Each worker bumblebee was equipped with a 2mm x 2mm data matrix (bCode, Tim Gernat) on its back. A data matrix much like a QR-code is a variation of a two-dimensional barcode. A computer with a camera and motion detection software controlled the system, taking a series of pictures each time it detected motion, i.e. when a bumblebee left or entered the hive. I used a tailored software (bTools) to scan each picture for bCodes. The software returns a text string containing the ID of the bumblebee(s) found in the picture and the exact time the picture was taken. By using these timestamps I was able to generate data on activity patterns, i.e. number and lengths of foraging bouts, on an individual level.

Using this system I tested how different sub-lethal doses of the neonicotinoid pesticide clothianidin affected foraging behaviour on individual bumblebees. Preliminary results suggest that exposure to field-realistic doses of clothianidin significantly increases foraging bout length. More through results will be presented, both on the individual and hive level.

O.27 Assessing the risks and impacts of exposure to systemic insecticides for solitary, ground-nesting squash bees

D. Susan Willis Chan[1], Ryan S. Prosser[1], Jose L. Rodríguez-Gil[2], Nigel E. Raine[1]

[1] School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada
[2] Department of Biology, University of Ottawa, Ottawa, Ontario, Canada

Ground-nesting solitary bees comprise around 70% of bee species in temperate climates. In these species, female bees contact relatively large amounts of soil as they excavate their nests. Using the hoary squash bee (*Peponapis pruinosa*) as a model species, we evaluated the risk to adult female ground-nesting bees of exposure to lethal doses of systemic insecticide residues (three neonicotinoids: clothianidin, thiamethoxam and imidacloprid, and the anthranilic diamide: chlorantraniliprole) in agricultural soil in Ontario, Canada. To do this, we sampled agricultural soil prior to insecticide application and during the bee-active period (July-August). These samples were analyzed for insecticide residues, and residue concentrations were plotted to produce an environmental exposure distribution for each insecticide. The probability of exceeding lethal endpoints was determined by comparing three LD50 benchmarks to the distribution curve. We found substantial risk to ground-nesting bees of exposure to lethal doses of clothianidin, thiamethoxam, and imidacloprid residues in agricultural soil using our squash bee model. Minimal exposure risk was found for chlorantraniliprole. In parallel to our risk assessment, we investigated the impacts of insecticide application practices for cucurbit growers on the behaviour and reproduction of squash bees. We introduced mated adult female squash bees into twelve net-covered hoop-houses containing blooming squash. Squash plants in each hoop-house were treated with one insecticide (either imidacloprid, thiamethoxam or chlorantraniliprole) or were untreated controls. We found significant sublethal impacts of exposure to imidacloprid on pollen foraging, nesting behaviour and reproduction of female squash bees, with no significant differences apparent for bees exposed to squash plants treated with either thiamethoxam or chlorantraniliprole. Our results show that in future risk assessments should include exposure impacts from pesticides in soil to be protective for ground-nesting bees, and that field-realistic levels of imidacloprid exposure could be significantly affecting foraging and reproduction of these important pollinators.

O.28 Scale-dependent mitigation of pollination

Henrik Smith

Centre for Environmental and Climate Research (CEC), Lund University, Sweden

Ongoing agricultural intensification and landscape simplification negatively impact wild pollinators and the pollination service they provide to both crops and wild plants. As a result, there is currently a strong focus on how to benefit pollinator populations in agricultural landscapes, by e.g. preserving semi-natural habitats or providing supplemental flower resources in the form of flower strips. However, not all pollinators are the same, neither in terms of how they react to landscape change and mitigation measures, nor in what services they provide. Using recent research in our group, we demonstrate the implication for pollinators and pollination. Combining modelling and empirical field studies, we demonstrate (i) how spatio-temporal availability of food and nesting resources act as spatial ecological filter for bees, (ii) the scales at which mitigation of loss of flower resources affect pollinators, (iii) how competitive interactions modify the responses of individual species, and (iv) how this may explain how wild flower pollinated by generalist and specialist pollinators, respectively, are differentially affected by contemporary landscape simplification. We discuss our results in relation to where and when pollinator mitigation measures should be implemented to preserve pollination as a service.

Friday 25 October, 6th session

O.29 VIP guests on flower scent parties at night: more than just moths and bats

Stefan Dötterl[1], Isabel Alves dos Santos[2], Guaraci Duran Cordeiro[1], Florian Etl[3], Robert R. Junker[1], Andreas Jürgens[4], Jette Knudsen[5], Cristiane Krug[6], Artur Maia[7], Reisla Oliveira[8], Samuel Prieto Benitez[9], Clemens Schlindwein[8]

[1] Paris-Lodron-University of Salzburg, Austria
[2] University of São Paulo, Brazil
[3] University of Vienna, Austria
[4] Technische Universität Darmstadt, Germany
[5] Nattaro Labs AB, Lund, Sweden
[6] Empresa Brazileira de Pesquisa Agropecuária (Embrapa) Amazônia Ocidental, Manaus, Brazil
[7] Universidade Federal de Pernambuco, Recife, Brazil
[8] Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
[9] Universidad Rey Juan Carlos-ESCET., Madrid, Spain)

Nocturnal pollinators mainly use olfactory cues to find appropriate host plants. Floral scents of plants pollinated by bats and moths as well as specific compounds attractive for such pollinators are studied since decades. Much less is known about the chemical ecology of pollination systems involving other nocturnal pollinators, such as scarab beetles (Cyclocephalini) and nocturnal bees. In the last few years, we extensively studied the chemical communication of scarab and nocturnal bee pollination systems and in the present paper, we will ask whether the floral scents are similar or different to scents described from plants pollinated by moths and bats. More specifically, we test the hypothesis that there are distinct floral scent syndromes at night, with scents grouping according to the four groups of pollinators (moths, bats, scarab beetles, bees). We also tested for phylogenetic effects on scent patterns. We overall found differences in scent according to pollinator group, but also some obvious overlap between some groups, and that phylogeny explains a part of overall and within syndrome variations. Our data also show, that, despite the recent advances, more data are needed to better understand the ecology and evolution of floral scent.

O.30 Hearing insects with light

Salena Helmreich

FaunaPhotonics, Denmark

We present a new technique for automated monitoring of pollinators and other flying insects using a light-based sensor. Quantifying insect behavior has always been very labor-intensive work requiring netting, trapping and/or visual observations. This severely limits the amount of information that can be collected for scientific research or base farming decisions on. We have developed an optical sensor capable of collecting, analyzing, and uploading non-intrusive insect recordings in real-time over extended periods. The instrument illuminates an air volume with invisible infra-red light and records the back-scattered light from passing insects. From the recorded signal, we can extract multiple parameters such as wing beat frequency, size, body to wing ratio, etc. The technique works at distances from 1 to 500 meters and allows unprecedented time resolution when studying insect behavior. The sensor is currently able to count as well as cluster and identify insects down to genus or even species level by using an automated intelligence system. We have shown that on a typical evening in Tanzania, 10 000 insect flight observations can be recorded in an hour. Our primary focus, as of late, has been concluding a recent bee field trial in Denmark – further demonstrating our ability to distinguish between honeybees and several Nordic bumblebee populations – as well as our continued work with oilseed rape insect populations.

O.31 Do plants eavesdrop on floral volatiles? Plant-plant communication beyond herbivore-induced volatiles

Jonas Kuppler[1], Amy L Parachnowitsch[2]

[1] Institute of Evolutionary Ecology & Conservation Genomics, Ulm University, Ulm, Germany
[2] Department of Biology, University of New Brunswick, Fredericton, New Brunswick, Canada

Volatile organic compounds (VOC) emitted in response to herbivory can be detect by neighbouring plant individuals which may lead to phenotypic changes and increase herbivore resistance. For plant individuals, it could be also advantageous to detect other VOC such as floral scent. Detecting the presence of neighbouring flowering conspecifics could allow plant individuals to precisely synchronize flowering and increase attractiveness for pollinators and thus increasing the likelihood of cross-pollination. To test this idea, we explored if conspecific floral volatiles can induce phenotypic changes in flowers such as flower opening rate, nectar volume and sugar concentration using a diverse set of model organisms. We could show that exposure to flowering conspecifics resulted in phenotypic changes such as increased flower opening rate while plants exposed to floral scent of conspecifics showed no changes. Therefore, we discuss ecological implications for flowering plants of our findings and future directions.

Saturday 26 October, 7th session

O.32 What makes a good year for fruit set in an early-flowering lily?

James D. Thomson, Barbara A. Thomson

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

We have conducted supplemental pollinations in a single subalpine population of *Erythronium grandiflorum* for 26 years. Contrary to an earlier publication, there is no tendency for pollination to deteriorate over this period. Within seasons, early-flowering cohorts consistently have lower fruit set, due both to inadequate pollination by bumble bee queens and to frost damage. The best years are those that follow previous summers with plentiful rain and previous winters with deep snowpack that produce late springs.

F.33 Resource use among bumblebees and honeybees across spatial and temporal scales in Norway

Rakel Blaalid, Sondre Dahle, Graciela Rusch, Frode Fossøy.

Norwegian Institute for Nature Research (NINA), Norway

Abstract: The assessment of the flower resources used by pollinators can help understand several aspects of plant-pollinator interactions of significance for the conservation of plants and pollinators and for the ecosystem services they generate. However, there are still major knowledge gaps about the ecology of plant-pollinator interactions such as foraging distances of pollinators, host-specificity, and the phenology of flowering and pollinator activity. These factors are challenging and time consuming to assess with observational field assessments. DNA metabarcoding opens a wide range of opportunities for addressing these ecological questions. We present a study where we have combined field observations of flower visitation and pan-trap data with DNA metabarcoding of pollen from domestic bee-hives. We surveyed 120 highly urban to moderately urban areas in Oslo in 2017 and collected pollen from 17 beehives in the time period June-September to investigate the recourse use of wild and domestic pollinators. Among the 47 bee species included in the results, honeybees are the dominating species in terms of flower visitation rate. Based on the pollen DNA barcoding we found that the resource use of honey bees is skewed towards typical garden plants, often rich in resources. We also found sharp shifts in pollen composition during the season. However, there is variation among hives in both plant groups and the amount of pollen gathered, indicating strong spatial differences in resource availability in Oslo.

F.34 Pollination by intoxication – how alkaloids influence bumblebees' pollinating behaviour

Judit Linka

University of Greenwich, United Kingdom

Many flowering plants produce alkaloids which are present in different parts of the plants and in the nectar. Through the alkaloids within the nectar the behaviour of pollinators can be modified to the benefit of the plant. I'm interested how these naturally occurring alkaloids, primarily glaucine and caffeine influence the primary robbing behaviour of bumble bees. Initial results with glaucine indicate, contrary to expectations that this alkaloid doesn't deter buff tailed

bumble bees from primary robbing. Further experiments are investigating how caffeine alters the primary robbing behaviour of buff tailed bumble bees on *Linaria vulgaris*. Parallel with these lab experiments I am undertaking field observations of Salvia 'Hot Lips' flowers which are commonly primary robbed by buff tailed bumble bees.

Saturday 26 October, 8th session

O.35 Looking up for bees: pollination in smallholder legume crops, and the importance of trees in field margins

Sarah E J Arnold[1], Filemon Elisante[2], Yolice Tembo[3], Prisila A. Mkenda[2], Steven R Belmain[1], Patrick A Ndakidemi[1], Geoff M Gurr[4], Philip C. Stevenson[1,5]

[1] Natural Resources Institute, University of Greenwich, United Kingdom
[2] Nelson Mandela African Institution of Science and Technology, Tanzania
[3] Lilongwe University of Agriculture and Natural Resources, Malawi
[4] Charles Sturt University, Australia
[5] Royal Botanic Gardens, Kew, United Kingdom

Common bean (*Phaseolus vulgaris*) is an essential source of protein for many low-income households in Eastern and Southern Africa, and also benefits from insect pollination. We investigated the extent of its pollinator-dependence and the identity of its flower visitors on smallholder bean farms in Tanzania and Malawi. Using flower-visitor surveys we also evaluated the interactions between those potential and other plants growing on smallholder farms and particularly in the field margins. We anticipated that plant species richness on and around smallholder farms would positively influence abundance and diversity of flower visiting guilds and support increased visitation by key groups to bean flowers. Plants had around 25% more pods per plant and beans per pod when open pollinated compared to pollinator-excluded. Tanzanian fields in general had higher plant species richness and more complex flower visitor networks. Many of the most frequently visited field margin plants were non native species, though some have medicinal or natural pesticidal properties that may be beneficial to households. However, overall there was not a significant relationship between plant species richness on farms and most network parameters, flower visitor measures or visits to the crop flowers. However, the species richness of trees in and around bean fields was positively predictive of higher visitation rates to the crop. Trees on East African farms are often nectar-rich species and may provide a food source at times of year that the herb layer has been cut, burned or ploughed in. As the trees are often also leguminous species they may confer multiple benefits for smallholder farmers and wider biodiversity.

O.36 Diversified farming systems at field- and landscape scales for pollination in faba beans

Chloé Raderschall[1], Ola Lundin[1], Riccardo Bommarco[1], Sandra Lindström[2]

[1] SLU, Uppsala, Sweden
[2] Hushållningssällskapet, Kristianstad, Sweden

The intensification of food production has led to transformation of natural habitats into agricultural fields. The resulting homogenisation of the landscape has been accompanied by a stark decline in pollinators, which provide an essential ecosystem service to agriculture. During my PhD I assess diversification strategies at different spatial scales for their potential to reverse

the negative impacts of intensive agriculture on pollinator abundances and to increase pollination and yield. At landscape scale, we assessed if crop diversity (i.e. increasing the number and evenness of crops grown) benefits pollinators and faba bean pollination by providing more food and habitat resources. We selected 14 faba bean fields in Scania along independent gradients of crop diversity and proportion semi-natural habitat (SNH). We found higher pollinator densities with increasing SNH. Furthermore, insect pollinated plants produced 27% more yield, yet this pollination benefit was reduced with increasing SNH. In landscapes with higher crop diversity, pollinators were observed pollinating legitimately more often compared to robbing nectar or visiting extra floral nectaries. At field scale, we assessed the effects of annually sown flower strips and managed honey bee hives on wild pollinators, crop pollination and yield. Flower strips sown along fields can act as a resource bridge when flowering crops are scarce. Yet, a better understanding is needed of the dynamics of pollinators between flower strips and flowering focal crops such as faba beans. Similarly, added honeybee hives potentially augment pollination and yield but the impact of managed honey bees on wild pollinators requires further research. I will introduce our experimental design and discuss preliminary data on pollinator abundances in fields with/without flowers trips and/ or honey bee hives.

O.37 Grassland management for meadow birds in the Netherlands is unfavourable for pollinators

Lisette van Kolfschoten

Naturalis Biodiversity Center, The Netherlands

Agricultural intensification and loss of semi-natural grassland have caused widespread loss of pollinator species in open habitats around the world. To reverse the decline, management regimes have been implemented, varying widely in effectiveness. In addition, the Netherlands has established nature reserves in which semi-natural grasslands are restored and are often managed for specific groups of species, e.g. meadow birds or plants. The effects of such measures on insect biodiversity are not well known. This study assesses the relationships between management regime, floral abundance and diversity and pollinator communities in three common semi-natural grassland management regimes: (1) wet hay meadows, (2) herb rich grasslands and (3) meadow bird grasslands. The results show that, first of all, meadow bird grasslands have lower pollinator abundance and diversity and a less unique pollinator assemblage than both other grassland-types. Second, flower abundance has a positive effect on pollinator abundance. Third, complete mowing has a strong negative effect on both pollinator abundance and species richness while partly mowing does not. These results show that meadow-bird grasslands are a comparatively unfavourable habitat for bees, hoverflies and butterflies but with applying a different mowing regime the imbalance could be remediated.

O.38 Does management at a local or landscape scale impact pollinator communities in semi-natural grasslands?

Michelle Larkin[1], Dara A. Stanley[2]

[1] Botany & Plant Science, Ryan Institute and School of Natural Sciences, National University of Ireland Galway, Ireland

[2] School of Agriculture and Food Science, University College Dublin, Ireland

Agricultural intensification is one of the primary drivers of global pollinator decline, leading to concerns over the pollination of many wild flowers and commercially important crops. Agri-environmental schemes were introduced to mitigate biodiversity declines by offering financial incentives to farmers to protect and enhance biodiversity on their farms. However, these schemes have had varying levels of success as a) traditionally farmers are paid for applying measures regardless of environmental outcomes and b) schemes are often applied at a local scale when biodiversity conservation may need a wider landscape scale approach. A potential solution is to use results based agri-environment schemes where farmers are paid for conservation outcomes, and try to implement these schemes at a landscape scale. The aim of this study was to investigate local and landscape drivers of pollinator diversity in species rich grasslands in Ireland, using a results based agri-environment scheme (The Burren Programme) as a case study in the Burren region in the west of Ireland. Insect pollinators were sampled in 23 fields with varying conservation scores within the scheme in either high intensity (≥65% improved grassland) or low intensity (≥ 65% semi-natural grassland) landscapes using transects and pan traps. We found that local factors were driving bumblebee community composition while hoverfly and butterfly communities were influenced at the landscape scale. The results from this study will help understand the role of local and landscape factors in pollinator conservation and inform agri-environmental planning, and will advise whether there are any modifications to the existing Burren Programme which would benefit pollinators.

O.39 The cholinergic pesticide imidacloprid impairs motion-sensitive neurons in the pollinator fly *Eristalis tenax*

Elisa Rigosi, David C. O'Carroll

Department of Biology, Lund University, Lund, Sweden

Insect pollinators are key species for natural ecosystems and the human economy. Common agrochemicals, such as imidacloprid (IMI), are currently major threats for the survival of pollinators both in rural and urban environments. This insecticide acts pharmacologically as an agonist of acetylcholine receptors (nAChR). The majority of studies on the sub-lethal effects of IMI conducted in the last decade have focused on bee species. Among other effects, bees exposed to sub-lethal doses of IMI revealed altered foraging behaviours and navigation. But while the impairment in foraging and flight activities during navigation might be affected by a disruption in visual processing, the effect of neonicotinoids on the visual system of pollinators has been largely overlooked. Nevertheless, immunostaining has revealed widespread nAChR expression in proximity to a well-known population of motion sensitive neurons in the third optic ganglia, the lobula plate tangential cells (LPTCs). We thus performed *in vivo* recording from LPTCs in a widely used model for insect visual neurophysiology, the hoverfly, *Eristalis tenax*, which is also an important pollinator in its own right. We performed electrophysiological recordings while the animal was constantly perfused and the brain haemolymph exposed to either 3.9 μM IMI or its vehicle. Presenting wide-field moving stimuli in different directions and with increasing contrast we found that IMI exposure caused increased spontaneous responses, impaired contrast sensitivity and reduced direction selectivity of LPTCs. These results provide new insights into the neurophysiological impact of cholinergic pesticides and

open the door for employing the same experimental approach to other part of the visual system to unravel where along the visual processing these impairments occur.

Saturday 26 October, 9th session

O.40 Influence of spatio-temporal pollen availability on pollinators and their function in agricultural landscapes

Philipp Wolfgang Eckerter[1], Lars Albus[1], Farnaz Faramarzi[1], Sharumathi Natarajan[1], Erika Gobet[2], Willy Tinner[2], Christopher Bause[3], Thomas Eltz[3], Matthias Albrecht[4], Felix Herzog[4], Martin H. Entling[1]

[1] iES Landau, Institute for Environmental Sciences, University of Koblenz-Landau, Landau/Pfalz, Germany
[2] Institute of Plant Science and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland
[3] Department of Animal Ecology, Evolution and Biodiversity, Ruhr-Universität Bochum, Bochum, Germany
[4] Agricultural Landscapes and Biodiversity, Agroscope, Zürich, Switzerland

Wild pollinators depend on pollen and nectar for their survival and reproduction. Thus, a high availability of floral resources in crop and non-crop habitats is expected to enhance pollinators and their services to insect-pollinated crops. However, the specific use of floral resources and their availability at the landscape scale have rarely been considered in studies on crop pollination. In addition, while resources available before the focal crop are expected to boost beneficial insect densities and hence ecosystem services, flowers available simultaneously to the focal crop may attract beneficial insects away from it and thus reduce ecosystem services. To investigate effects of the type, amount and timing of alternative resources on pollinators and their services, we conducted experiments in 24 landscape around Landau (Germany) between 2016 to 2019. Pollen use over the cropping season was determined for *Bombus terrestris*, *Osmia cornuta* and *Osmia bicornis*, three important pollinators. We measured yield of *Vicia faba* phytometers, colony development of *B. terrestris* and colonization rate of *Osmia* nests along the landscape gradient. The diet of each pollinator species was dominated by a sequence of specific pollen types over the season. However, the analyses so far suggest that the availability of these dominant resources did not provide a strong explanation of pollinator density or fitness. Nevertheless, we found that higher pollen availability early in the season lead to more seeds per pod in *Vicia faba*. For *Bombus terrestris*, early pollen availability increased both with the amount of flowering crops and with the amount of semi-natural habitat. Overall, our results confirm that the timing of alternative floral resource availability is important for crop pollination services. However, the lack of a simple relationship of pollinators and the availability of specific resources complicates efforts to manage landscapes for pollination services.

F.41 Pesticide residues in nectar and pollen collected from plants: A preview.

Elena Zioga[1], Blánaid White[2], Jane Stout[1]

[1] Botany, School of Natural Sciences, Trinity College Dublin, Dublin, Republic of Ireland,
[2] School of Chemical Sciences, Dublin City University, Dublin, Republic of Ireland

The exposure to pesticides (fungicides, herbicides and insecticides) is a significant stressor for bees and other pollinators, and has recently been the focus of intensive debate and research. Specifically, the dietary exposure through consumption of contaminated pollen and nectar is

considered significant, as it presents the highest index of the likelihood of pesticide exposure across all the bee species. Although the residues found on those matrices directly collected from plants were found to be higher compared to those collected by the bees (before they enter in the hive), the actual risk that multiple pesticide residues might pose to non-target species is difficult to assess due to the lack of clear evidence of their precise exposure. Moreover, the amounts of pesticide residues in nectar and pollen may be highly variable, since studies in this field are influenced by various factors, including the crop type, the application method, the chemical properties of a compound and the abiotic environmental factors. To consolidate the existing knowledge of the field-realistic residues detected in pollen and nectar directly collected from plants, we performed a systematic literature review of studies over the past 50 years (1968-2018), and we will discuss the results of this analysis which indicate that even though pollen was the matrix evaluated the most, nectar seems to be more contaminated. The majority of pesticides were detected in the family of Asteraceae, and even though the compounds that were evaluated the most belong to the category of neonicotinoids (insecticides), the group of fungicides prevailed upon the rest pesticide categories.

F.42 The distribution of insect pollinators in an oil palm plantation

Knut Hessen[1], Anne Krag Brysting[2], Douglas Sheil[3], Anders Nielsen[2]

[1] University of Oslo, Oslo, Norway
[2] Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biosciences, University of Oslo, Norway
[3] Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Campus Ås, Norway

Oil palm plantations cover approximately 10% of the world´s permanent croplands, with Indonesia accounting for more than 53% (33.5 Mt) of global palm oil production. Oil palm is one of the world's most rapidly expanding crops and there continues to be an increase in vegetable oil and biofuel demands. Expansion of agricultural monocultures negatively affects all aspects of biodiversity including insects. Insects are the most important pollinator for tropical plant species, pollinating approximately 98-99% of all plants in this biome.

The oil palm company, PT Austindo Nusantara Jaya, is relatively conservation minded. One of the company`s goals is to keep patches of so called "high conservation value forest" left inside their plantations. This study focused on one of their plantations, a 16,620 hectares area in Ketapang, West Kalimantan, Indonesia, run by PT Kayung Agro Lestari (KAL). This plantation holds several small patches of "close to native forest". The aim of the study is to assess whether there is an increase in pollinator density and diversity in relation to forest patch proximity. I collected insect pollinators by use of pan traps placed at understory vegetation height from June to October 2017. I sampled around two forest patches and in two control sites situated about 2 km from any forest. The data collected in this study should allow managers to make more informed decisions concerning insect pollinator conservation in relation to oil palm plantation establishment, management and development.

Some preliminary results from this and another study, focusing on pollinator distribution in the same area, will be presented.

F.43 Is floral longevity depending on flower size, climate or phylogeny?

Noemí Pérez, Rubén Torices, Marcos Méndez

Area of Biodiversity and Conservation, Universidad Rey Juan Carlos, Móstoles (Madrid), Spain

Floral longevity is a key component of floral display. Individual fitness benefits from higher floral longevity due to higher floral display or more visits by pollinators, but keeping flowers open can entail costs, particularly in warm climates and/or large flowers. Using a literature search, we gathered information on floral longevity of 177 plant species from 55 families. When possible we also compiled information on geographic coordinates, habitat and floral length/diameter. Floral longevity ranged from minutes to ca. one month. We did not find any correlation between floral longevity and latitude or habitat. We found a negative correlation between log floral longevity and floral size, that held even after phylogenetic correction. There was a significant phylogenetic signal ($K = 0.14$) indicating that related species tend to have floral longevities more similar than expected from their phylogenetic relatedness. This signal is remarkable due to the low number of species of the same family in our data set and indicates that floral longevity could be a conserved trait at the family level.

F.44 Combined effects of pollen viability and pollinator efficiency on seed set in red clover cultivars

Veronica Hederström

Swedish University of Agricultural Sciences, Sweden

Clover seed is used in the agricultural sector for animal fodder production and provision of green manure. Availability of organic clover seed is vital for the organic farming sector. However, poor and variable seed set is a persistent problem, particularly among tetraploid red clover cultivars. As clover rarely self-pollinates, pollen transfer by insect pollinators is necessary for good seed set. This in turn, depends on the density and pollination efficiency of pollinators. Long-tongued bumblebees may be most valuable for ensuring a high seed set in red clover, but recent studies have demonstrated dramatic shifts in density and composition of bumblebee communities towards more short-tongued species with higher propensity towards nectar robbing. This could lead to lower pollination rates, especially in tetraploids, which have larger flowers with deeper corolla tubes. In addition, studies suggest that pollen germination and fertilization potential is lower in tetraploid red clover. Pollinator communities will be affected by location and season, and thus there could be a strong interaction between ploidy, geographic locality, and flower phenology, with some cultivars being especially sensitive. In this study we have tried to determine the effects of these factors, including interactions between pollinator community composition and clover cultivar, as well as variation in pollen viability among cultivars and its contribution to low seed set. For different red clover cultivars we investigated floral shape, nectar volume, pollen germination success and pollinator behaviour. Furthermore, we investigated seed set and the amount of pollen deposited on the flower stigma after visitation by 8 different pollinator species with 3 tongue lengths: short (< 8mm), medium (8-9 mm) and long (> 9 mm).

Saturday 26 October, 10th session

O.45 Testing the role of floral neighborhood density and phenology on floral trait evolution

Kate Gallagher, Yuval Sapir

Tel Aviv University, Israel

In Israel, the Royal Irises (Iris section *Oncocyclus*) come in all colors of the rainbow. These self-incompatible flowers rely primarily on pollination by male *Eucera* bees in a night-sheltering system. In this system, bees that sleep in irises emerge earlier in the morning to forage than ground-sleeping bees (Sapir et al., 2006). Therefore, we asked whether the strength of selection on floral traits could vary depending on the floral neighborhood density and phenology of a given focal plant? We hypothesized that if irises are rare in an area, bees may not exert strong selection on floral traits because they would rather sleep in any flower regardless of its size or color. However, if irises are common, as they would be during peak flowering or in dense clusters, then we might detect stronger selection on floral traits because bees have the opportunity to be more selective. Here we present results from our study testing this hypothesis, using the *Iris petrana* population in Yeruham. In 2019, we set up 40 plots using stratified random sampling based on iris population density. Throughout season, we selected two flowering focal plants per plot each week, and for each focal plant we measured floral traits including color and size, as well as the density of co-flowering irises and overall diversity of the co-flowering floral neighborhood. At the end of the season, we collected fruit and seed set data as measures of fitness. This study provides a novel insight to the evolution of flower color, a key trait in the interaction of plants with their environment, and in particular whether fine-scale temporal and spatial variation in selection on floral traits could be a mechanism maintaining continuous floral color polymorphism in the Royal Irises.

O.46 Different pollination approaches to compare seed set of diploid and tetraploid red clover (*Trifolium pratense* L.)

Shuxuan Jing, Birte Boelt, Per Kryger

Aarhus University, Denmark

Tetraploid red clover offers high forage production performances, but the low seed yield is limiting the commercial exploitation. We investigated the causes of the low seed yield of tetraploid red clover by comparing diploid and tetraploid red clover at the level of pollination and seed set per floret. Different pollination approaches were studied covering hand pollination, honey bees in confined environment and bumble bees under open field conditions. In all experiment the plant material was cv. Rajah (2x) and cv. Amos (4x). We found that bumble bees (especially Bombus pascuorum) are the dominant pollinators in open field conditions with high abundance and floret-visit speed. In the cage study, surprisingly, similar or even higher frequencies of honey bees were observed visiting tetraploid red clover compared to diploid red clover. We further suggested that increasing honey bees to high numbers may decrease the seed set of red clover, due to the preference of honey bees visiting already tripped florets.

O.47 Changes in pollinator behaviour under different plant spatial aggregation

Jakub Štenc, Klára Koupilová, Zdeněk Janovský

Department of Botany, Charles University, Czech Republic

Flowering plants are typically aggregated in space. Moreover, the individuals within a cluster of flowers are often closely related due to either clonal growth or limited seed dispersal. Pollinator foraging strategies differ among major pollinator functional groups and are likely to generate different visitation behaviour under different plant spatial aggregations. The main aim of this study was to investigate differences in visitation behaviour of pollinator functional groups under different levels of spatial aggregation of flowers. We observed pollinator behaviour in arrays of potted plants arranged in four clusters. We manipulated distance between clusters (near/far) and spacing of plants within clusters (loose/dense). Five common meadow species were used for observations in order to cover all major pollinator groups. Butterflies and hymenopterans were most prone to fly between clusters and on average every fifth or seventh visited plant was from a different cluster than the previous ones and probability of flying between the clusters increased, if the clusters were near to each other. On the other hand, syrphids and other dipterans, tended to fly between clusters much less (on average only every twentieth or tenth visited plant, respectively). Probability of syrphids and other diptera flying between plant clusters increased if the plants in clusters were loosely spaced, but did not differ with the distance of clusters from each other. Our results indicate that pollinator functional groups differ not only in their preferences for flowers and carry-over effectiveness, but also in probability of carrying pollen outside the local plant cluster. This could have profound impacts on plant mating structure and also reproductive success of self-incompatible plant species.

O.48 The ecological significance of phenotypic differentiation in floral attraction traits in populations of *Eruca sativa* in Israel

Oz Barazani[1], Sharoni Shafir[2]

[1] Institute of Plant Sciences, Agricultural Research Organization, Israel
[2] B. Triwaks Bee Research Center, Department of Entomology, The Hebrew University of Jerusalem, Faculty of Agriculture, Food, and the Environment, Rehovot, Israel

Plants of *Eruca sativa* (Brassicaceae) from desert and Mediterranean populations in Israel differ in flower color and size. In the conspecific desert habitat, the population has higher abundance of flowers with cream color and longer petals, whereas in the Mediterranean habitat, with a more heterogeneous annual plant community, the population has higher abundance of flowers with yellow and shorter petals. Choice experiments with honey bees, the main pollinator in the natural habitat in Israel, confirmed our hypothesis that they are more attracted to the yellow flower morph than to the cream one. In addition, a proboscis extension response test indicated that honey bees are able to discriminate between flower scents of the two morphs. The advantage of the yellow color morph in attracting pollinators may explain its dominance among plants of the Mediterranean population, where plants are more exposed to inter-specific competition over pollinators.

O.49 Flowers respond to pollinator sound within minutes by increasing nectar sugar concentration

Lilach Hadany, Marine Veits, Itzhak Khait, Uri Obolski, Eyal Zinger, Arjan Boonman, Aya Goldshtein, Kfir Saban, Rya Seltzer, Udi Ben-Dor, Paz Estlein, Areej Kabat, Dor Peretz, Ittai Ratzersdorfer, Slava Krylov, Daniel Chamovitz, Yuval Sapir, Yossi Yovel

Tel Aviv University, Israel

Can plants hear their pollinators and respond to them rapidly? We show that *Oenothera drummondii* flowers, exposed to playback sound of a pollinator or to synthetic sound signals at similar frequencies, produce sweeter nectar within 3 min, potentially increasing the chances of cross pollination. We found that the flowers vibrated mechanically in response to these sounds, suggesting a plausible mechanism where the flower serves as an auditory sensory organ. Both the vibration and the nectar response were frequency-specific: the flowers responded and vibrated to pollinator sounds, but not to higher frequency sound. Our results document for the first time that plants can rapidly respond to pollinator sounds in an ecologically relevant way. Potential implications include plant resource allocation, the evolution of flower shape and the evolution of pollinators sound. Finally, our results suggest that plants may be affected by other sounds as well, including anthropogenic ones.

Saturday 26 October, 11th session

O.50 Pollinator mediated evolution of floral Traits in *Digitalis purpurea* after range expansion

Christopher R Mackin[1], Balfour NJ, Peña JF, Blanco MA, Castellanos MC

[1] University of Sussex, United Kingdom

Evolution of novel floral form can occur when plants experience a change in their pollinators, such as when they extend their range into novel environments. Understanding how variation in the pollinator community visiting a plant and exerting natural selection on its floral traits can help us understand floral evolution and could help predict how plants will respond to environmental change. This study investigates floral variation and patterns of natural selection in the biennial herb *Digitalis purpurea* (common foxglove) by comparing native populations in the UK with naturalised populations in tropical mountains in Colombia and Costa Rica. Pollinator censuses in 11 populations and tests for the pollinating ability of each species indicate differences in the pollinator assemblage between continents, including visitation by hummingbirds and long-tongued bumblebees. In parallel, we found variation in floral morphology, particularly in the size of the proximal portion of the corolla tube, where a constriction restricts access to nectar to visitors with long mouth parts. We found consistent directional selection for larger proximal corolla tubes in the naturalised non-native populations, while no selection on corollas (directional, or otherwise) was present in two native European localities. We discuss potential explanations for these patterns in the light of adaptation to new pollinator environments.

O.51 Pollinator behavior and resource limitation maintain honest floral signalling

Anina Knauer

Agroscope, Switzerland

In many communication systems, signal-receivers profit from honest signals that indicate the signaller's quality, whereas low quality signallers should profit from cheating. Under such a conflict of interests between signallers and signal-receivers, the maintenance of honest signals presents a puzzle. In theory, honesty can represent an optimal strategy or be maintained by a constraint, but the actual mechanisms have been studied in few systems only. Here, we investigate honest signalling in a plant species, *Brassica rapa*, that advertises nectar amounts to pollinators by two honest floral signals; corolla size and the floral volatile phenylacetaldehyde. In a series of seven experiments we tested for physiological constraints and pollinator behaviors related to honest floral signals and rewards. While honest floral signals were associated with pollinator attraction, bees' flower visitation time depended on nectar amounts and increased the number of seeds that flowers developed. Further, honest floral signals and the seed set after hand pollination both increased after soil fertilization indicating nutrient limitation in the traits and a potential trade-off in resource allocation. Finally, by incorporating these results into a mathematical model, we showed that honest signalling in *B. rapa* is maintained by a combination of pollinator behavior and resource limitation causing differential benefits of nectar production.

O.52 Phenotypic selection on floral scent in deceptive *Arum maculatum*

Eva Gfrerer[1], Danae Laina[1], Marc Gibernau[2], Anja C Hörger[1], Hans-Peter Comes[1], Stefan Dötterl[1]

[1] University of Salzburg, Department of Biosciences, Salzburg, Austria
[2] Université de Corse Pascal Paoli, Laboratoire des Sciences Pour l'Environnement, Ajaccio, Corsica

Floral scent is a key mediator in plant-pollinator interactions, and as such sensitive to selection imposed by its pollinators. When environmental conditions, such as the pollinator community, differ in the range of the plant´s distribution, the selection pressures might vary geographically. By chemically mimicking an oviposition site, the common woodland plant *Arum maculatum* L. (Araceae) attracts and deceives its pollinating moth flies (Psychodidae) with its floral scents. The species composition and sex ratio of the attracted flies exhibit a strong geographical pattern north vs. south of the Alps, and the different fly species are known to have different olfactory preferences. Thus, our goals are i) to assess if floral scent in *A. maculatum* differs among populations north and south of the Alps, ii) if floral scent is under selection, and iii) if this selection is geographically structured. To address these goals, we collected floral scent and fruit/seed set from a total of 240 plants from six populations north and five populations south of the Alps. We show that floral scents of *Arum maculatum* are highly complex and differ within and among populations north and south of the Alps. Further, we will present results on correlations between floral scent and fitness data, either considering or not the regional context. Overall, this is one of the few studies that tested for β-selection on floral scents and contributes to our understanding of intraspecific variation in floral signals.

O.53 Don't forget about the flies! Public perceptions around pollinator conservation in Ireland

Katherine L.W. Burns[1,2], Úna Fitzpatrick[3], Dara A. Stanley[1,2]

[1] School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 2, Ireland
[2] Earth Institute, University College Dublin, Belfield, Dublin 2, Ireland
[3] National Biodiversity Data Centre, Beechfield House, Waterford Institute of Technology West Campus, Carriganore, Co. Waterford, Ireland

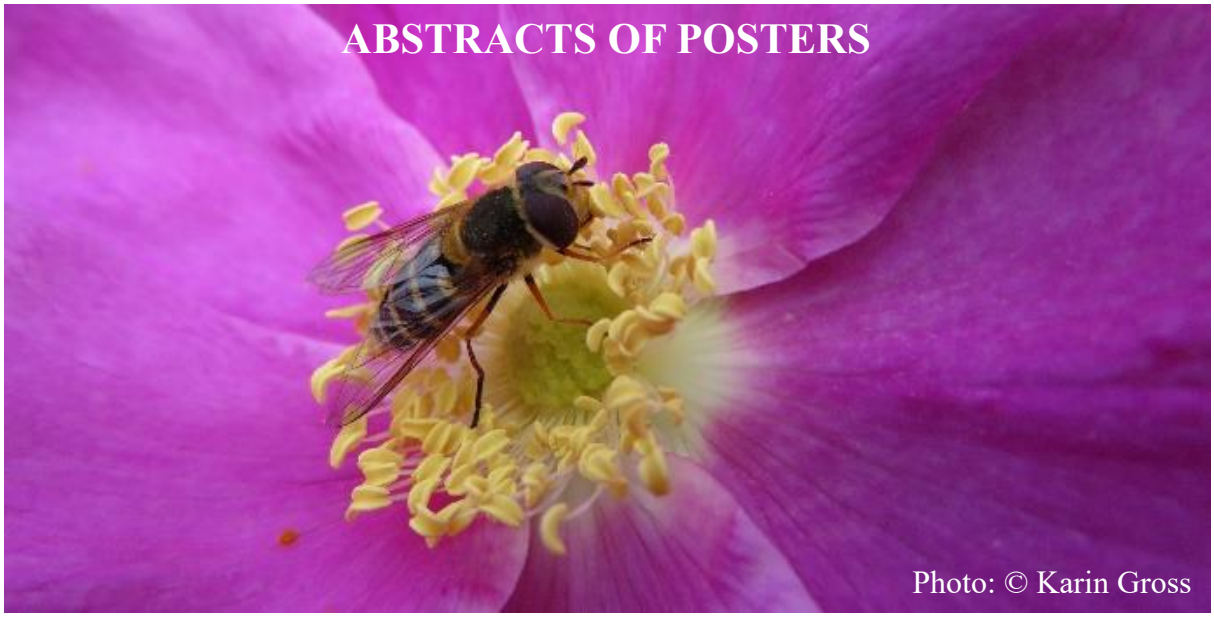
Media coverage of pollinator decline has resulted in a growing amount of public concern and interest in the topic of pollinator conservation. This emerging interest in pollinators presents an opportunity for future citizen involvement in the protection and promotion of global pollinator populations. However, despite a growing interest in pollinator conservation, there may be a lack of public understanding about the importance and identification of insect pollinators, especially with relation to non-honeybees. In an effort to support current conservation initiatives and action plans for pollinator conservation, and further inform new educational materials and engagement strategies, we used Ireland as a case study to determine how pollinators, pollination services, and pollinator decline are currently perceived by Irish citizens. We designed and distributed a citizen survey, "What's the Buzz? Public Views of Pollinating Insects in Ireland," to 613 participants to determine perceptions and understanding around the identification, importance, decline, and conservation of Irish pollinators. Our findings indicate that the Irish public is aware that pollinators are declining and understand the main causes, and most participants indicated that they are already carrying out actions to protect pollinators. However, the majority of survey participants underestimated the number of bee species in Ireland and were unable to identify certain common pollinators, such as flies and solitary bees. Many were also unaware of the importance of non-bee pollinators, such as flies and wasps, to the pollination of Irish crops and wildflowers. Our findings indicate that future educational measures should highlight the identification of solitary bees and non-bee pollinators and their importance to pollination services, to ensure a holistic approach to pollinator conservation.

O.54 Pollinator preference for intermediate floral size in a night-sheltering pollination system is and its association with heat reward

Yuval Sapir[1], M. Kate Gallagher[1], Omer Bar[1], Ilan Koren[2]

[1] Tel Aviv University, Israel
[2] Weizmann Institute of Science, Israel

Animal pollinators exert selective pressure on plants they pollinate. Pollinator-mediated selection is typically associated with traits that increase the visibility, attractiveness and utility of flowers to their pollinators. Although *Oncocyclus* irises are large and showy, they do not produce a nectar reward. They are, however, completely self-incompatible and depend on night-sheltering *Eucera* bees for pollination. This night-sheltering system is putatively associated with a heat reward, which enables bees that sleep in the pollination tunnels to emerge earlier in the morning than their ground-nesting counterparts. In this study, we used artificial iris flowers in six size classes to ask (1) whether pollinators select on flower size in irises and (2) if so, do their choices among flowers of different sizes correspond with the potential heat reward? We found that pollinators prefer intermediate-sized flowers and that intermediate-sized flowers warm faster at sunrise than other flower sizes. These data suggest that pollinator preference for intermediate sized flowers may be associated with the heat reward offered by these dark-colored irises to night-sheltering bees. This work offers new avenues of research using artificial flowers in natural systems to disentangle the traits under pollinator-mediated selection, and specifically whether a preference for intermediate sized flowers, in this system, is a learned preference based on the heat reward.



P.01 Accumulation and effects of the neonicotinoid insecticide clothianidin in bumblebees (*Bombus terrestris*)

Malin Røyset Aarønes

University of Oslo, Norway

Neonicotinoids can cause lethal and sublethal effects in bumblebees, with exposure trough pollen and nectar collected from treated crops. However, the bioaccumulative potential of these neonicotinoids has not been studied before. Our study aimed to assess the accumulation of clothianidin, a neonicotinoid, in bumblebee workers and the queen, and assess whether the accumulation could cause a change in mortality, brood production, nectar consumption, and storage of food. Bumblebee colonies (*Bombus terrestris*, n = 48) were exposed to field-realistic concentrations of clothianidin through nectar, with concentrations ranging from 1 µg/L to 13 µg/L, in a chronic exposure regime lasting nine days. Clothianidin showed a dose-response accumulation in the head (<0.2 – 2.17 µg/kg) and body (<0.2 – 3.17 µg/kg) of workers, and in the body (<0.2 – 2.49 µg/kg) of the queen, although the concentration was below that measured in the nectar (BAF = 0.2). Exposure did not cause a change in mortality or brood production, but showed a trend of a hormeotic response in nectar consumption and a negative dose-response trend in the proportion of empty honeypots. Accumulation in the head and body, as well as changes in nectar consumption and food storage, have the potential to cause long-term detrimental effects on brood production and mortality.

P.02 Pollinators enhance crop yield and shorten the growing season by modulating plant functional traits: A comparison of 23 canola varieties

George C. Adamidis[1,2], Ralph V. Cartar[1], Andony P. Melathopoulos[3], Stephen F. Pernal[4], Shelley E. Hoover[5]

[1] Department of Biological Sciences, University of Calgary, Calgary, Canada
[2] Institute of Ecology and Evolution, University of Bern, Switzerland
[3] Department of Horticulture, Oregon State University, Corvallis, OR, United States of America
[4] Agriculture and Agri-Food Canada, Beaverlodge Research Farm, Beaverlodge, AB, Canada
[5] Alberta Agriculture and Forestry, Lethbridge, AB, Canada

Insect pollination of flowers should change the within-season allocation of resources in plants. But the nature of this life-history response, particularly regarding allocation to roots,

photosynthetic structures, and flowers, is empirically unresolved. This study uses a greenhouse experiment to investigate the effect of insect pollination on the yield of 23 varieties of a globally important crop—canola (*Brassica napus*). Overall, insect pollination modified the functional characteristics (flower timing, flower effort, plant size & shape, seed packaging, root biomass) of canola crops, increasing yield quantity and quality, and pollinator dependence. Yield and pollinator dependence were defined by strong trait trade-offs, which ranged from more pollinator-dependent plants favouring early reproductive effort, to less pollinator-dependent canola plants favouring a prolonged phenology with smaller plant size and lower seed quality. Yield decreased with pollinator dependence in the absence of pollinators. The current preference for hybrid varieties will increase yield compared to open-pollinated varieties, but, even so, pollinators typically enhance yield of both. Our study elucidates the mechanisms through which insect pollination alters the character and function of a globally important crop, supporting optimization of yield via intensification of insect pollination, and highlights the beneficial (fitness) effects of insect pollination early in the season.

P.03 Herbivory-induced reduction on community-wide pollination services

Luis Aguirre

University of Massachusetts, Amherst, United States of America

Pollination is an ecological phenomenon of great importance in natural communities, but little is known about the effects that trophic interactions have on this process at the community level. In many plants, deposition of conspecific pollen is imperative for reproduction and is tied directly to the behavior of their pollinators. In turn, pollinator behavior is determined by floral traits. However, many floral traits often respond negatively to herbivory attacks. The aims of this project are to determine how herbivory to a dominant plant species affects pollinator behavior, and how these changes affect reproduction in undamaged neighboring species. Here, we performed a natural experiment in a milkweed-dominated community in which we simulated herbivory to milkweeds by removing foliar tissue and applying jasmonic acid. We compared pollinator behavior in herbivory and control plots by analyzing pollen loads of floral visitors as to determine degrees of floral fidelity. We also measured the quality of pollination services to undamaged neighboring plants by assessing pollen deposition and seed production in undamaged neighboring plant species. Our results indicate that herbivory to a dominant plant species has community wide effects on pollination services. We observed a drastic change in the composition of pollinators visiting flowering plant species. Similarly, our results indicate that herbivory to the dominant plant species has negative effects on the reproduction of neighboring plants. We observed reductions in conspecific pollen deposition on three neighboring plant species. In *V. cracca,* reduced pollen deposition correlated with a notable reduction in seeds per fruit. These observations provide evidence corroborating the hypothesis that herbivory alters pollinator behavior and reduces plant reproduction at the community level. The reductions in pollination highlight the drastic role that herbivory can have in a community through indirect effects.

P.04 Pollinator diversity reduces pollination deficits through complementarity in thermal community niches

Matthias Albrecht

Agroscope, Switzerland

The role of pollinator diversity in stabilizing crop pollination services and yield under climate change and increased weather variability remains poorly understood. Niche complementarity and increased response diversity of diverse crop pollinator communities resulting in broadened

thermal community niches of crop pollinators could be particularly important to buffer pollination of early-flowering crops against high temperature variation in temperate production regions. We therefore investigated the impact of the thermal community niche of pollinators of early flowering sweet cherry relative to other potential explanatory variables in mitigating pollination deficits and on final crop yield across 48 intensively managed cherry orchards in Switzerland. A high variation in pollination deficits was observed across orchards, with an average deficit of 10% less fruit set of open-pollinated compared to supplementary hand-pollinated cherry flowers. Thermal community niche was the strongest predictor of the observed variation in pollination deficits and cherry yield among the studied potential drivers: enhanced community niche was associated with significantly reduced pollination deficits and increased final cherry yield. Our findings provide strong arguments for growers to invest in measures to maintain high levels of wild pollinator diversity on their farms.

P.05 Biodiversity of plants and pollinators in forested agricultural areas, can EUs agrilcultural policy affect it?

Georg Andersson, Yann Clough

Centre for Environmental and Climate Research (CEC), Lund University, Sweden

The European Common Agricultural policy, which is to be reformed soon, have been criticized for the low efficiency of reaching environmental goals. One of these is preserving biodiversity and also enhancing ecosystem functions, such as pollination. Our goal is to understand how agricultural support to farmers can affect the biodiversity in farmland in the forested areas in Sweden. This first step examined the biodiversity and abundance of pollinators depending on habitat, landscape type and forest cover in these areas.

P.06 Floral signalling variation, herbivory resistance and pollen limitation in the alpine rock-cress *Arabis alpina*

Sotiria Boutsi, Hampus Petrén, Magne Friberg

Department of Biology, Lund University, Sweden

Interactions between plants and the surrounding community of pollinators and herbivores are central for shaping plant ecology and evolution. These interactions may contribute to intraspecific variation and local adaptation among different populations of a plant species. Increased knowledge of how local populations might vary in traits important for plant-insect interactions and how this variation is affected by various biotic and abiotic factors is important, not the least in alpine environments that are predicted to be especially vulnerable to anthropogenic change. In my master's degree project, I use the alpine plant *Arabis alpina* (Brassicaceae), which is a model organism for both population genetics of alpine plants and the evolution of the selfing syndrome. However, so far only few studies have investigated the ecology and evolution of its biotic interactions. In my study, I will experimentally assess the presence of pollen limitation in 12 different self-incompatible Italian and Greek *A. alpina* populations. I will also test whether variation in pollen limitation among populations is associated with differences in floral signalling, herbivory resistance, population size or altitude, and identify potential evidence for inbreeding depression in small populations. Furthermore, I aim to investigate regional variation in floral signalling among these and potentially other populations, grown in the greenhouse, by analysing variation in floral scent, floral morphology, nectar composition and potentially plant defence traits. Given the drastic insect decline of the past decades, studies exploring the dependence of plants on their pollinators and the potential for local variation in such interactions, can provide valuable insight into the future of ecological communities.

P.07 Driven by mutualists? How declines in pollinators impact plant communities and ecosystem functioning

Yann Clough

Centre for Environmental and Climate Research (CEC), Lund University, Sweden

Declines in pollinator availability – both in terms of abundance and species richness – causes concern not only for crop yields but also for the maintenance of pollination of wild plants, 80% of which are dependent on insects for pollination. In Europe, patches of semi-natural habitat embedded within a matrix of intensively used agricultural land may be particularly exposed, given the severe declines in insect biomass and diversity that have reported from such sites. Yet, we know surprisingly little about the effects of changes in pollinator availability on plant communities. Here, I first present an assessment of the effect of land-use intensity at the landscape scale on the degree to which plant communities are dominated by plants depend on pollinators. In that study we demonstrate consistent negative impacts of higher land-use intensity on the average dependence of plants on pollination (community-weighted mean pollinator dependence) in grasslands across Europe, when controlling for the local habitat quality of the focal grasslands showing that semi-natural grasslands in arable farming areas have less pollinator-dependent plants. Secondly, I discuss how the strength of this effect is likely to depend on pressure by herbivory and factors such as nutrient availability, using findings from common garden experiments and drawing upon a review of studies from theoretical and empirical ecology. Finally, I present a recently funded research programme, DrivenByPollinators, which aims at disentangling the effects of insects on plant communities and ecosystem functioning in landscapes of southern Sweden over the next five years.

P.08 Nocturnal bee pollination mediated by floral scents in Brazil

Guaraci D Cordeiro[1], Cristiane Krug[2], Mardiore Pinheiro[3], Claudia I Silva[4], Reisla Oliveira[5], Irmgard Schäffler[1], Theo Mota[5], Clemens Schlindwein[5], Isabel Alves dos Santos[4], Stefan Dötterl[1]

[1] University of Salzburg, Austria
[2] Embrapa - Amazonia Ocidental, Manaus, Brazil
[3] Universidade Federal da Fronteira Sul, Brazil
[4] University of São Paulo, Brazil
[5] Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

Nocturnal pollination is mainly guided by floral scents. This is well documented for plants pollinated by bats, moths, and beetles, whereas the communication between nocturnal bees and their host plants remain poorly understood. We used a multidisciplinary approach to investigate the pollination and chemical communication between nocturnal bees and their host plants: cambuci (*Campomanesia phaea*, Myrtaceae), a fruit crop from the Atlantic Forest, jacarandá-do-cerrado (*Macherium opacum*, Fabaceae), a commom tree from Cerrado, and guaraná (*Paullinia cupana*, Sapindaceae), a fruit crop from the Amazon. We found that all three plant species depend on animal pollen vectors and open their flowers at night. Nocturnal bees of the genera *Megalopta*, *Megommation*, *Ptiloglossa*, and *Zikanapis* were the only effective (cambuci) or the most important (jacarandá-do-cerrado, guaraná) pollinators, with different bee species observed at the different plant species. The flowers of cambuci released 14 volatile compounds, mainly 2-phenylethanol, 1-octanol, 1-hexanol, and benzyl alcohol. In field bioassays at night, nocturnal bee pollinators were attracted by a synthetic scent blend of these compounds. Jacarandá-do-cerrado released 94 floral compounds, with the terpenoids α-copaene, α-terpineol, and β-myrcene being most abundant. Guaraná flowers emitted (E)-β-ocimene, linalool, and derivatives thereof (linalool oxides, lilac aldehyde, lilac alcohol) as most abundant compounds. A synthetic scent mixture resembling the scent of the flowers successfully attracted *Megalopta* bee pollinators at night. Our study highlights that nocturnal bees are the main

pollinators of these plants, and that these bees, comparable to moths, bats, and nocturnal beetles, use floral scent cues to find their host plants. We also show that the scents of plants pollinated by nocturnal bees are highly variable and that the bees seem to be generalists that respond to various compounds.

P.09 Species and alien species

Tina D'Hertefeldt[1], Helena Hanson[2], Bente Eriksen, Cecilia Fredriksson[3], Johanna Alkan Olsson[2], Carina Sjöholm[3], Niklas Vareman[4]

[1] Department of Biology, Biodiversity Unite, Lund University, Sweden
[2] Centre for Environmental and Climate Research (CEC), Lund University, Sweden
[3] Department of Service Management and Service Studies, Lund University, Sweden
[4] VBE, Lund University, Sweden

Through the recent attention on Invasive Alien Species and their effects on biodiversity, plants are now at the center of a new discourse in society. Trade and transport are known to be the main routes for introduction of invasive alien species and invasive species are one of the top-five threats to global biodiversity loss. At the same time, there is a need for introducing new plant species in a changing climate. This poster reports from a recently started project that aims to discuss the concept of invasive alien plants in a cross-disciplinary setting, with Sweden as a case study.

P.10 Wild bee and floral diversity co-vary in response to the direct and indirect impacts of land use

Christophe Dominik

Helmholtz Centre for Environmental Research, Germany

Wild pollinators and flowering plants in agricultural landscapes are threatened by habitat loss. While pollinators and insect-pollinated plants closely interact, it is still unclear how species richness and functional diversity of these two groups influence each other and how they respond to land use change. In this study, data from 24 agricultural landscapes in seven European countries were used to investigate the effect of landscape composition and habitat richness on species richness and functional diversity of wild bees and insect-pollinated plants. The relationships between the diversity of bees and flowering plants were characterized and indirect effects of landscape on bees and plants mediated by these relationships were identified. Increasing cover of arable land negatively affected flowering plant species richness, while increasing habitat richness positively affected the species richness and functional diversity of bees. In contrast, the functional diversity of insect-pollinated plants (when corrected for species richness) was unaffected by landscape composition, and habitat richness showed little relation to bee functional diversity. Additionally, bee species richness positively affected plant species richness and bee functional diversity were positively affected by both species richness and functional diversity of plants. The relationships between flowering plant and bee diversity were modulated by the indirect effects of landscape characteristics on the biotic communities. In conclusion, these findings demonstrate that landscape properties affect plant and bee communities in both direct and indirect ways. The interconnection between the diversities of wild bees and insect-pollinated plants increases the risk for parallel declines, extinctions, and functional depletion. This study highlights the necessity of considering the interplay between interacting species groups when assessing the response of entire communities to land use changes.

P.11 Strip-cropping of insect pollinated crops: Can crop diversity enhance vegetable production?

Natasha Holland, Yoko L. Dupont

Aarhus University, Denmark

The demand for organic vegetables is increasing rapidly but cannot be met by current agronomic methods. Alternative methods, which enhance biodiversity and ecosystem services including pollination, are currently under development. In SureVeg (a Core Organic Co-fund funded project), we tested strip-cropping systems, i.e. a diversified cropping system in which alternating rows of different vegetable crops are sown. It is hypothesized that strip-cropping will provide floral resources during an extended period, supporting agroecosystem services provided by beneficial insects, including natural biological control and insect pollination. In the current study, we investigated a cropping system involving two insect pollinated crops: hokkaido pumpkin and faba beans, in addition to wild-flower strips. The study focused on pollination and fruit set of hokkaido pumpkin. The experimental set-up was established as an on-farm experiment hosted by an organic farm (Skiftekær Øko, Denmark), and included three fields: (1) hokkaido mono-culture (2) hokkaido mono-culture with flower strips and (3) strip cropped hokkaido pumpkin and faba bean and flower strips. In all fields, numbers of flowers and number and identity of flower-visiting insects were counted in transect walks carried out 2-3 times during the flowering season. Honeybees (*Apis mellifera*) were the main visitors, while bumblebees (*Bombus* spp) visited the flowers to a lesser extent. Pollinator abundances differed temporally and across different fields. Fruit weight was significantly higher in the strip cropped and flower strip hokkaido fields than the pure hokkaido field without flower strips. However, as the study did not include replicated fields, it cannot be concluded if other factors than cropping practice may have affected pollination and fruit set in hokkaido pumpkins. Furthermore, due to extreme drought in 2018, results may not reflect normal flowering and crop yield.

P.12 Integrating the management of pests and pollinators

Paul Egan[1], Lynn Dicks[2], Heikki Hokkanen[3], Johan Stenberg[1]

[1] Swedish University of Agricultural Sciences, Sweden
[2] University of East Anglia, United Kingdom
[3] University of Eastern Finland, Finland

To reduce the harmful impacts of pesticides on pollinators, policy makers and experts have increasingly turned to Integrated Pest Management (IPM). However, the extent to which non-pesticide IPM practices can also prove harmful to pollinators – and their ecosystem service – remains underappreciated. We articulate an urgent need to define more comprehensive approaches to IPM that show compatibility with crop pollination goals – but also vice versa. In this respect, we propose a first systematic framework for Integrated Pest and Pollinator Management (IPPM). Novel monitoring metrics (e.g. pollinator action thresholds) and a decision support tool (Pepo jEIL – ippm.shinyapps.io/server) are further introduced to operationalize IPPM.

P.13 The foraging behaviour of bumblebees in relation to landscape context

Janna Einöder

Utrecht University, Netherlands

Plant-pollinator interactions, among others between bumblebees and plants, are one of the most important mutualistic relationships globally maintaining both ecosystem functions and human food security. The mutualistic relationship between plants and bees might change when the

environment changes, potentially leading to ecosystems disfunctions and food insecurity. To enable successful conservation measures, these often-complex interactions and relationships between species need to be understood better. In this study, we have therefore zoomed in on one of these crucial interactions: the foraging behaviour of bumblebees on wild plants in relation to landscape context and plant ecology. Bumblebees are central place foragers and are thought to follow an economically optimised way when foraging derived from the optimal foraging theory. Hence, bumblebees want to maximise high-reward visits while minimising their travel and search time as well as distance from the nest. By the aid of an event recorder software installed on a tablet, detailed behaviour of the bumblebees could be tracked resulting in over 70.000 observations from 800 bumblebees throughout the sampling sites. Tracked behaviour, for instance, was how much time they spent on each flower, plant or in the patch as well as if and how much pollen load they had and what they were foraging on (nectar/pollen). Additionally, it was studied if and under what circumstances bumblebees decided to change plant species, hence how strong their flower constancy was. The data is still being analysed, however, some trends for parts of the analyses become apparent: Optimal foraging theory is applied by some but not all bumblebee species and seems to be more influenced by the local scale than the landscape context. Hence, time in patches increased with patch quality but not with landscape quality. Daytime seem to affect foraging with bumblebees showing a higher time in patch in the afternoon than in the morning and increased wind speed decreased the bumblebees' time in patch. We will continue to analyse the data to get deeper insights in the distinct behaviour of different bumblebee species as well as their flower constancy strategies.

P.14 The role of commercial ornamental plant varieties in supporting pollinator populations

Emily Erickson[1], H M Patch[1], S Adams[2], L Russo[3], V Wojcik[4], C M Grozinger[1]

[1] Pennsylvania State University, United States of America
[2] Penn State Extension, United States of America
[3] University of Tennessee, Knoxville, United States of America
[4] Pollinator Partnership, United States of America

One of the major factors underpinning pollinator decline is the reduction in the diversity and abundance of flowering plant species. In urban and suburban areas, ornamental plants are commonly planted and could provide foraging resources for pollinator populations. However, their role in supporting pollinator biodiversity is not well established, and the few studies examining the attractiveness of these plants for pollinators have been conducted in urban areas which had a distinct pollinator community. In this study, we monitored pollinator visitation patterns to 50 ornamental annual and perennial plant cultivars over four years at two semi-natural sites in Pennsylvania, USA. We found that many cultivars vary in attractiveness based on time and year. Moreover, we observed only polylectic bee species visiting plants, despite the presence of oligolectic species in the background population. We conclude that the utility of ornamentals depends on environmental context: while their role in supporting a complex pollinator community is limited, they may provide long-lasting supplemental foraging resources in urban and suburban environments. Additionally, we found significant variation among cultivars in visitor abundance. Many of these cultivated varieties have a long history of artificial selection on floral traits such as color, shape, scent, and resource production, and this selection may have uncoupled traits that typically co-evolve to attract specific functional groups of pollinators. We are conducting choice assays using *Bombus impatiens* foragers to determine the relative influence of floral visual and chemical advertisement and nutritional reward on mediating patterns of pollinator attraction to these cultivated varieties. Overall, these studies (1) evaluate the potential of ornamental plants in supporting pollinator communities, (2) determine which plant features shape plant-pollinator interactions, and (3) assist growers to incorporate pollinator health into breeding and production practices.

P.15 Involving people to protect wild bees and other pollinators in the Mediterranean. Presentation of the project "LIFE 4 POLLINATORS"

Marta Galloni[1], Laura Bortolotti[2], Luis Navarro[3], Theodora Petanidou[4], Anna Traveset[5]

[1] Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy
[2] Council for Agricultural Research and Economics, Bologna, Italy
[3] Department of Plant Biology and Soil Sciences, University of Vigo, Vigo, Spain
[4] Department of Geography, University of the Aegean, Mytilene, Greece
[5] CSIC - Mediterranean Institute for Advanced Studies, Balearic Islands, Spain

Wild pollinators are the core of our ecosystems and their populations are declining dramatically in the last decades: land-use change, intensive agricultural management and pesticide use, all anthropogenic, are among the main causes. Out of the 1,965 species of wild bees reported in the European Red List of Bees, 9% are threatened with extinction, while 55.6% are indicated as "data deficient": this lack of information regards in particular the Mediterranean basin (including Italy, Spain and Greece), which is considered as a "biodiversity hotspot" for conservation priorities. Public awareness on the role of wild pollinators needs to be improved especially in Mediterranean countries, where most of the existing awareness-raising initiatives still focus exclusively on honeybees. At the same time, agri-environmental measures have not been implemented at an adequate scale to compensate for the losses of suitable pollinator habitats. We present here the project: "Involving people to protect wild bees and other pollinators in the Mediterranean" (LIFE 4 POLLINATORS), recently submitted within the LIFE Governance and Information EU funding Programme. The main aim of the project is to gain environmental benefits by improving pollinator conservation, through the creation of a virtuous circuit that leads to a progressive change in practices across the Mediterranean region. In order to achieve this ambitious goal, the project has set a number of more specific objectives that foster education and dissemination, the implementation of citizen science approaches, and improved environmental governance. The partnership is built to cover a wide area of the Mediterranean region and its biological diversity, and to involve different actors ranging from the scientific perspective to key stakeholders, competent authorities and civil society.

P.16 Polyploidy, genetic leakage, reproductive success, and a geographic mosaic of specialized and generalized pollinators

Karin Gross[1], Malin Undin[2], Jodie Lilley[3], John N Thompson[4], Magne Friberg[1]

[1] Department of Biology, Biodiversity Unit, Lund University, Sweden
[2] Massey University, New Zealand
[3] University of Manchester, United Kingdom
[4] Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, United States of America

Polyploidization, or whole-genome duplication, is an important mechanism of diversification in flowering plants. Even though it causes immediate strong reproductive isolation among different ploidy lineages, the isolation is often not complete. Polyploidy has also been shown to affect plant phenotype and the interaction with other organisms, such as pollinators. Here, we ask how hybrid crosses between different ploidy lineages affect reproductive success and floral trait diversification and how the novel variation is related to pollination by specialized and generalized pollinators. We assess the strength of reproductive isolation and the potential for genetic leakage among different ploidy types as well as the interaction dynamics with specialized and generalized pollinators in the woodland star (*Lithophragma bolanderi*). Recent studies have revealed that this species exhibits an incomparably high variation in floral traits and is composed of multiple ploidy types. It is pollinated by the highly specialized seed parasite *Greya politella* but also by generalized pollinators. We conducted a large-scale greenhouse crossing experiment within and between populations of different ploidy types. In addition, we assessed reproductive success in more than 20 natural populations across the entire distribution

range of *L. bolanderi*. We present data on the seed set and germination rate of crosses within and between different ploidy lineages and the population pollination success in relation to the extent of pollination by the specialized pollinator *G. politella* and to plant ploidy-level. Such results provide the basis for our understanding of the mechanisms by which polyploidy affects diversification and how polyploid lineages can establish and coexist with their diploid progenitors.

P.17 Effects of polyploidy and reproductive strategies on resource allocation and plant-insect interactions

Andrés Romero Bravo[1], Karin Gross[1], John N Thompson[2], Kristina Karlsson Green[3], Anna Runemark[1], Magne Friberg[1]

[1] Lund University, Sweden
[2] University of California, Santa Cruz, USA
[3] Swedish University of Agricultural Sciences, Sweden

Pollination, one of the most widespread form of plant-insect interaction, plays a central role in angiosperm and pollinator diversification by driving and shaping the existing genetic diversity. The most dramatic process generating this genetic diversity is polyploidization. Polyploidization is the duplication of the chromosome set and can result from one single genome (autopolyploidization) or from hybridization processes involving genomes of different taxa (allopolyploidization). Newly formed polyploid lineages (neopolyploids) usually face strong reproductive isolation from their diploid progenitors. The successful establishment of polyploid lineages is more likely to happen in lineages relying on asexual reproduction than in those conserving sexual reproduction. In this project, we investigate the evolutionary origin of polyploid lineages and the investment into different reproductive strategies in *Lithophragma bolanderi*, a plant species previously shown to consist of a geographic mosaic of several ploidy levels. We will perform a phylogenetic analysis on 29 different populations of *L. bolanderi* including also 9 other species in the genus to identify potential allopolyploidization events occurred along the evolutionary history of this taxon. In order to elucidate whether polyploid lineages of *L. bolanderi* depend on asexual reproduction, investing more resources in bulbil production than in sexual reproduction, reproductive strategies of different ploidy types will be characterized in a common garden experiment. We will compare bulbil weights from hand-pollinated plants (simulation of resource allocation into sexual reproduction) with those from a control group (simulation of resource allocation into asexual reproduction). Together, this combined approaches will help to disentangle the evolutionary history of the species and will provide new insights into how polyploidization events affect plant-insect interactions and coevolution.

P.18 An analysis of the effects of increased Carbon Dioxide on the protein and amino acid concentrations of pollen from *Brassica rapa* and *Arabidopsis thaliana*.

Emma Harrison, Perry Mitchell, Michael Taylor, Jennifer Roecklein-Canfield

Simmons University, Boston, MA and Littleton High School, Littleton, MA

Colony Collapse Disorder (CCD) is a phenomenon in which worker bees disappear from the hive, leaving only the queen and immature bees. Incidents of CCD around the world pose an immense threat to global food security and economic growth. Theories regarding the cause of CCD include increased exposure to pesticides, pests and parasites, and habitat destruction. Additionally, poor nutrition is hypothesized to cause the death of worker bees associated with CCD. In this regard, some preliminary studies have shown that higher CO2 levels in the atmosphere, an imminent prediction of climate change, decrease the protein content in pollen and alter the essential amino acids that are crucial to bee nutrition. This implicates increased

CO2 levels as a contributing factor to the malnutrition of bees and thus to the prevalence of CCD. To test this hypothesis, we grew *Brassica rapa* and *Arabidopsis thaliana* in both high and standard CO2 environments. We analyzed the protein and essential amino acid content of the pollen from both plants using HPLC and GCMS and we report our findings here. Preliminary studies showed a moderate decrease in protein in *Brassica rapa* and we undertake here a more in-depth study into how high CO2 affects the protein and amino acid content in pollen.

P.19 Pollination in apple orchards – effects of pesticides and vegetation diversity

Bjørn Arild Hatteland[1,2], S J Hegland[3], M Stenrød[4]

[1] Department of Invertebrate Pests and Weeds in Forestry, Agriculture and Horticulture, Norwegian Institute for Bioeconomy Research (NIBIO), Norway
[2] Department of Biological Sciences, University of Bergen, Norway
[3] Department of Environmental Sciences, Western Norway University of Applied Sciences, Norway
[4] Department of Pesticides and Natural Products Chemistry, Norwegian Institute for Bioeconomy Research (NIBIO), Norway

The EU directive 2009/128/EC sets rules for pest management including sustainable use of pesticides. For agriculture, it means that all growers need to adopt to integrated pest management to reduce the use of pesticides. Currently, two studies are running in Norway evaluating the pesticide regulations in fruit production as well as investigating negative effects of insecticides on pollinating insects. The latter is explored by field experiments looking at the timing of insecticide (thiakloprid – neonicotinoid) treatments and possible effects on pollinator activity and pollination. In addition, bees are sampled to analyse traces of the insecticide post-treatment. We also study pollination in apple orchards as a result of diversity and abundance of bees as well as effects of vegetation diversity in the surrounding landscape. Finally, these studies are connected to the global project on pollinating insects in apple orchards; "Climate change and its effects on pollination services (CLIPS)". Pollinators are sampled using both netting and pan traps in two different fruit production regions in Norway. Here we present the study design and some preliminary results.

P.20 Effect of air temperature on bumblebee behavior on drought stressed plants

Rebecca Julia Höfer, Manfred Ayasse, Jonas Kuppler

Institute of Evolutionary Ecology and Conservation Genomics, Ulm University, Ulm, Germany

Climate change leads to increasing temperatures and reduced precipitation or extreme drought events. These can induce phenotypic alterations in plants and change flower visitors behavior, which in combination may alter trait-mediated flower-visitor interactions. In a wind tunnel experiment, we tested if different air temperatures modulate the behavior of *Bombus terrestris* in response to watered or drought stressed *Sinapis arvensis* plants. Further, we explored whether changes in behavior are linked to phenotypic changes in floral traits. We found that bumblebees did not preferred watered or drought stressed plants and the behavior did not differ between both groups. This can be explained by the similar floral trait expressions of watered and drought stressed plants. However, different temperatures resulted in behavioral changes of bumblebees such as finding the plants earlier at higher temperatures. In conclusion, our results indicate that plants can buffer floral trait expressions against short-term drought events to potentially maintain pollinator visitations, which were affected by air temperature. Therefore, simultaneously consider behavioral changes of pollinator and plant phenotypic expression in respond to temperature or precipitation can provide a more detailed picture how plant-pollinator interactions are altered by climate change.

P.21 Intraspecific variation of inflorescence characters: a plastic response to climate?

Gróa Valgerður Ingimundardóttir, Mikael Hedrén, Nils Cronberg, Torbjörn Tyler, Stefan Andersson

Department of Biology, Lund University, Sweden

Autumn hawkbit, *Scorzoneroides autumnalis*, grows in a wide range of habitats in Europe, from the Pyrenees up to the northernmost reaches of Scandinavia. The species is highly variable and has several described varieties and ecotypes. In the Nordic countries, four varieties have been commonly recognized: var. *pratensis, taraxaci, asperior* and *salinus.* Some of the most important features used to distinguish between varieties have been the colour and hairiness of the involucral bracts, and the number of capitula. Plants with dark, hairy and few capitula (e.g. var. *taraxaci*) are particularly known from colder climate or alpine habitats whereas var. *salinus*, for example, is known from coastal meadows and is described to have hairless capitula. We have collected individuals of *Scorzoneroides autumnalis* from various habitats throughout Scandinavia and from Iceland, and grown them in a common garden in Lund, Sweden. In the common garden, we have over 70 populations representing several different coastal, alpine and ruderal habitats. Our preliminary field observations as well as studies of herbarium specimens from the Nordic countries, suggest that colour and hairiness of the involucral bracts, as well as the size and number of capitula, are environmentally plastic and appear to be related to trends in climate, with capitula being fewer, larger, hairier and darker in colder regions. Because dark coloration, hairiness and large flower-size are known to facilitate heat retention and insect visitation in other species, we hypothesize that *S. autumnalis* benefits from investing in these features under colder conditions. Studies are being planned to test this hypothesis.

P.22 Flora-wide trends in pollinator visitation – the role of plant life-history and mating system

Zdeněk Janovský

Department of Botany, Faculty of Science, Charles University, Benátská 2, Prague 2, Czech Republic

Over the more than 150 years of research, a vast amount of data on pollinator visitation has been collected. Simultaneously, our knowledge of plant mating systems and generally life histories has greatly improved since the times of works of Knuth, MacLeod, Burkle and Willis. Do plants with particular life-history traits attract distinct pollinator assemblages? In order to answer this question, I compiled a database of pollinator observations for plants growing in Central and Northwest Europe from published literature. Since the sampling effort was not distributed homogeneously among the plant species, I included only species with at least 25 pollinator individuals recorded and reclassified their visitors into one of thirteen pollinator functional groups. Merging the pollinator database with the already existing databases on plant life histories and mating systems resulted in ca 200 species with known pollinator assemblages and life-history traits. Hoverflies and bumblebees were the two most abundant pollinator groups. Bumblebees on one hand hoverflies with muscid flies constituted the main gradient of variation in pollinator assemblages. Honeybees, butterflies and beetles dominated pollinator spectra of a small proportion of plants, but otherwise were rather infrequent. Solitary bees were rather thinly spread among the plant species, dominating pollinator assemblages of only few plant species. Hymenopterans frequented much more non-clonal perennials as compared to annuals and clonal perennials dominated by dipterans. Solitary bees and butterflies visited more often outcrossers especially those with some self-incompatibility mechanism. Beetles made up a larger proportion of pollinator assemblage only in frequently selfing plant species probably due to sparseness of visits by other pollinator groups. At a flora-wide level it seems, that the need of non-clonal perennials to invest more into outcrossing has led them to invest more into attracting more specific pollinators.

P.23 Floral evolution in two closely related orchid species: secondary evolution of pre-zygotic barriers?

Nina Joffard, Nina Sletvold

EBC, Uppsala University, Sweden

When closely-related plant species coexist, competition for pollinators and selection against interspecific pollen transfer may promote pollination niche differentiation and floral divergence. Therefore, one may expect selection to maximize floral divergence between closely related plants in mixed compared to pure populations. Moreover, this process should be mirrored by a stronger phenotypic differentiation in mixed compared to pure populations (i.e. character displacement). In this project, we will compare flowering phenology, morphology and floral scent chemistry between two closely-related co-occurring orchid species in mixed versus pure populations to search for the signature of reinforcement.

P.24 The effect of pollination boxes, a means to increase densities of *Eladobius kamerunicus*, in an oil palm plantation in Indonesia

Lynn Jørgensen[1], Anne Krag Brysting[1], Douglas Sheil[2], Anders Nielsen[1]

[1] Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biosciences, University of Oslo, Norway

[2] Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Campus Ås, Norway

My research was conducted in the oil palm plantation PT.Ketapang Agro Lestari (PT.KAL), in West Kalimantan, Indonesia.The oil palm (*Elaeis guineensis*) is a monoecious species, producing both male and female inflorescences at the same palm. The male inflorescence emits a strong anis-like scent during anthesis, attracting the pollinating African weevil *Elaeidobius kamerunicus*. *E. kamerunicus* feed on and deposit eggs inside male inflorescences in anthesis. During their visit to male flowers, weevils become covered with pollen grains which are subsequently transferred to female inflorescences that also emit an anis-scent, but do not produce any pollinator rewards. PT.KAL is testing a concept called “pollination boxes”, aiming to increase oil yields through increasing local weevil populations and thereby increasing pollination. Plantation workers manually collect and transfer post-anthesized male inflorescences to pollination boxes, each inflorescence potentially holding up to 3000 weevil eggs and larvae. The objective of my research is to examine the effect of pollination boxes on the relative abundance of weevils. I established transects at different locations within the plantation, each transect consisting of four sampling points located between 5-400m from the pollination boxes. I collected six random spikelets per inflorescence to assess the relative weevil abundance at each sampling point. Preliminary results suggest that distance to pollination boxes does not have a significant effect on relative weevil abundance. I also recorded the number of inflorescences, their sex, and their state of development in 24 palm trees surrounding each sampling point. I will further examine the effect of local inflorescence availability, and weather data, to evaluate the effect these variables may have on the relative abundance of weevils, and relate these data to yield data from the company.

P.25 Do bumblebees adapt to anthropogenic change in landscape and climate?

Cecilia Kardum Hjort

Department of Biology, Lund University, Sweden

Since there has been a conceptual shift in our view of evolution, suggesting that a rapid adaptation to environmental change may be more common than previously thought, the aim of

my project is to use bumblebees as a model organism to investigate the opportunities for genetic and morphological local adaptation due to landscape simplification and climate change.

P.26 Evaluating indirect effects of climate change on pollinators and pollination services through pesticide exposure

Jessica Knapp, Theresia Widhalm, Björn K Klatt, Ullrika Sahlin, Maj Rundlöf

Lund University, Sweden, Post-doc, Oral presentation, Poster, Flash talk

Increased precipitation and a warmer climate are expected to intensify pest pressure and therefore, pesticide use. However, relatively little is known about the non-target effects of pesticides on bees and the pollination services that they provide. This is particularly true of the likely trade-off between the negative effects of pesticide exposure and the positive effects of improved flower quality. Therefore, across a gradient of landscape complexity, we aimed to quantify pesticide exposure in the pollen and nectar collected by honeybees and bumblebees (the risks), as well as the amount of pollen and nectar produced by our focal crop, red clover (the benefits). These findings will be related to the health and population success of sentinel bumblebee colonies at our study sites and, ultimately, to the pollination of red clover. With this data, we use existing bee models to predict population level effects of pesticide use and the likely impact that this will have on red clover seed yield. These findings will provide policy makers, land managers and farmers with a better understanding of the potential impacts that common management practices have, especially under predicted warmer climates.

P.27 Structures of flower surfaces in plants with contrasting pollination systems

Marjan Kraaij

University of Groningen, The Netherlands

The surfaces of flowers come in different shapes and have different functions, but how they evolved remains largely unknown. Floral micro-texture can be a cue to insects, and increases in surface roughness by means of conical epidermal cells may facilitate flower handling by flower-landing insect pollinators. How epidermal cell shape and structure evolved with regard to the pollination system remains unknown. Here, we investigate the floral epidermal structure and shape in X species-pairs of Y families with contrasting pollination systems. We test whether flowers pollinated by (flower-landing) bees or flies feature more structured (rougher) surfaces than flowers pollinated by (non-landing) hawkmoths or birds and flowers that self-pollinate. In contrast to earlier studies, we find no evidence of co-evolution of flower surface and pollination system. The height, aspect ratio and overall roughness of floral epidermal cells varies between plant genera, but is not correlated with pollination system at large. Intriguingly however, we find that the upper (adaxial) flower surface that surrounds the reproductive organs and often constitutes the floral display is markedly more structured than the lower (abaxial) surface. We conclude that conical epidermal cells probably play a role in plant reproduction other than to provide grip to insects, such as hydrophobicity or improving the visual signal.

P.28 Can sexual selection cause divergence in mating system-related floral traits?

Åsa Lankinen[1], Maria Strandh[2]

[1] Plant Protection Biology, SLU Alnarp, Sweden
[2] Department of Biology, Lund University, Sweden

The wide diversity of floral traits seen among plants is shaped by neutral and selective evolutionary processes. In outcrossing species, sexual selection from competing pollen donors is expected to be important for shaping mating system-related traits but empirical evidence is

scarce. In a previous evaluation of experimental evolution lines crossed with either one or two pollen donors (monogamous, M, or polyandrous, P, lines) at early floral stages in mixed-mating *Collinsia heterophylla* (Plantaginaceae), P evolved enhanced pollen competitive ability and reduced maternal seed set compared to M, in accordance with sexually antagonistic evolution of pollen. Here, we asked whether the presence of sexual selection during pollen competition affects mating system-related floral traits in the same lines. We compared flowering start, timing of anther-stigma contact (as an indication of timing of self-pollination), timing of stigma receptivity and first seed set between M and P, and with a source line, S (starting material). The first three traits are later in outcrossers than in selfers of *Collinsia*. The last trait was expected to be earlier in P than in M resulting from sexual selection for early seed siring of pollen. Artificial polyandry for four generations resulted in later flowering start and later anther-stigma contact in P compared to M, and the latter trait was intermediate in S. Thus, P appeared more 'outcrossing' than M. Timing of stigma receptivity did not differ between lines. First seed set was earlier in P than in M, as expected from sexual selection. Our results from *C. heterophylla* experimental evolution lines suggest that a component of sexual selection during outcross pollination could enhance the patterns of floral divergence commonly found between outcrossers and selfers.

P.29 Why be equal? Ecological relationships between co-occurrent species with similar floral displays

Klaus-Rudolf Lunau[1], Zong-Xin Ren[2], Xiao-Qing Fan[2], Graham H. Pyke[3], Judith Trunschke[2], Hong Wang[2]

[1] Institute of Sensory Ecology, Heinrich-Heine-University Düsseldorf, Germany
[2] Kunming Institute of Botany, CAS, Kunming, China
[3] University of Technology Sydney, Australia

The visual signalling of pollen and anthers, and pollen- and anther-mimicking structures constitutes a very speciose mimicry system in flowering plants that are pollinated by pollen eating or pollen collecting animals like hoverflies and bees. By contrast, visual signalling of nectar and nectaries as well as false nectaries are rare among flowering plants. Here, we report on visual indication of nectar and nectaries found in a survey of flower colour diversity along an altitudinal gradient at the Yulong Snow Mountain in Yunnan (China). Using false colour photography we revealed small but conspicuous ultraviolet reflecting structures in the surrounding of the otherwise UV-absorbing central area of some flowers. The false colour photos are merged from a UV-photo and the blue and green channels of a colour photo while discarding the red channel, and thereby present the floral colour pattern as seen by UV-sensitive but red-insensitive bees. Visually conspicuous nectar and nectaries were found for example on the dark disc of *Saxifraga melanocentra* and *Codonopsis graminifoli*, the protuberances on the petals of *Saxifraga wallichiana*, and *S. sinomontana*, the staminodes of *Parnassia wightiana*, and *Trollius yunnanensis*, the unfolded petals *Anaphalis nepalensis*, the green floral guides of *Solanum lyratum*, and the black floral guides of *Momordica cochinchinensis*. The shared features of these structures are evident in the UV due to a glossy surface, the conspicuous colour contrast on the false colour photo, and the proximity to nectaries. We present evidence for the hypothesis that glistening surfaces on central areas of flowers indicate the presence of nectar and nectaries and function as visual nectar guides.

P.30 Effects of enemy community composition and drought on defense trait selection in woodland strawberry along a latitudinal gradient

Anne Muola[1,2], Martijn L. Vandegehuchte[3], Johan A. Stenberg[2]

[1] Biodiversity Unit, University of Turku, Finland
[2] Department of Plant Protection Biology, Swedish University of Agricultural Sciences, Sweden
[3] Department of Biology, Ghent University, Belgium

Human-induced changes in the community complexity alter the strength of ecological interactions. Here, we focus on interactions between woodland strawberry (*Fragaria vesca*) and its natural enemies. As most plants, woodland strawberry has to defend itself against multiple enemies. In general, plants with fewer enemies are thought to invest less in defense and, therefore, more in growth and reproduction. However, several plant species have actually found to evolve higher defense levels if the enemy community becomes less complex. A novel, largely untested hypothesis suggests that multiple attackers often exert opposing selection on defense traits, preventing the plant from evolving successful defenses against multitude of enemies. Escape from complex enemy communities may enable the plant to adapt to selection imposed by fewer fitness-impacting species. The ability of a plant to efficiently defend itself is known to depend also on environmental stress. One of the major stressors resulting from climate change is summer droughts, which are predicted to increase both in frequency and severity. While our knowledge about the influence of enemy community complexity on plant defense evolution is limited, we understand even less how the effect of natural enemies on the ability of plants to evolve effective defenses interacts with abiotic stressors. To address these knowledge gaps, we are setting up a large-scale experiment along a latitudinal gradient in Europe stretching from the Mediterranean to the Northern Scandinavia. In each of the five common gardens we have 16 woodland strawberry genotypes from all across Europe in two treatments, control and drought.

P.31 Inferring gene flow in a spatially structured population of *Primula farinosa*

Etsuko Nonaka

University of Jyväskylä, Finland

Landscape structure plays an important role in organizing biological diversity in landscapes by mediating evolutionary and ecological processes. Organisms interact with landscape structure to determine how they move about in their habitat to gather resources. As a result, such interactions can determine functional connectivity, the degree at which organisms connect populations and habitat elements in the landscape by movement and gene flow. Functional connectivity is crucial for determining spatial population and genetic structure of spatially structured populations. Using well-studied populations of an insect-pollinated, self-incompatible herb, *Primula farinosa*, as a concrete example, this project aims to theoretically and mechanistically link movement behavior of pollinators, the pattern of pollen flow, and landscape structure. It will utilize both genomic analysis and mathematical modeling approaches. We plan to genotype for dense SNP markers two generations of plants collected from multiple local population clusters found in Stora Alvaret in Öland, Sweden. Two-generation analyses will be conducted to assign a potential source population of pollen to offspring of sampled mothers whose genotype will be known. We also hope to quantify relative contribution of pollen and seeds to gene flow in the population using organelle DNA. Based on the information from these analyses, we will develop and parameterize mathematical models of pollinator movement to infer pollen flow between local plant populations in the landscape.

P.32 Quantitative pollen analysis using artificial intelligence

Ola Olsson

Department of Biology, Biodiversity Unit, Lund University, Sweden

We have developed a system for computer based, quantitative pollen analysis, using a Tensorflow based deep learning algorithm. The system relies on standard preparation of pollen samples in fuchsine gel on microscope slides, which are scanned at 0.25 μm resolution. We use a pollen library with over 200 plant species, which we have collected, prepared, and scanned. Individual pollen grains are labelled with species identity, and the algorithm is trained to identify these. The accuracy of the trained model is high, F1=90%, when identifying the same pollen images it was trained on. When identifying pollen in other samples accuracy is sometimes still quite impressive, but with some images much lower. We are currently (31 August, 2019) in a stage where we try to improve accuracy and reliability by various methods, and expect that soon (before 24 October, 2019…) we will have an efficient and trustworthy method, which can enhance efficiency of pollen analysis radically. Compiling a pollen library takes some time (but is probably needed regardless of method), and labelling pollen grains for training might take a few hours per species. Training the model as such usually takes less than two days. Once this is done, analysis of samples is quick and cheap: several pollen slides can be prepared per hour, scanning them takes 5-20 minutes per slide (of which only a few minutes need to be supervised), and then the AI analyses images in an automated manner; it counts and identifies ca 1500 pollen (or one typical sample) per hour (i.e. some 150-200 samples per week), and returns a tidy data file with the result, which are fully possible to cross-validate manually.

P.33 Using hierarchical joint models to study pollinator-mediated reproductive interactions

Øystein Opedal

Research Centre for Ecological Change, University of Helsinki, Finland

Pollinator-mediated reproductive interactions among coflowering plant species are prime examples of how species interactions may affect fitness and community assembly. Despite considerable interest in these issues, statistical methods for assessing signal of reproductive interactions in observational data on coflowering species are currently lacking. I will present a flexible method for quantifying potential reproductive interactions among coflowering plant species using the hierarchical latent-variable joint models implemented in the Hierarchical Modelling of Species Communities (HMSC) framework. The method accommodates any measure of reproductive success, including pollinator visitation, stigma pollen loads, and seed set.

P.34 Precision pollination of strawberries using chemical lures to attract syrphid species

Caroline Ponsonby

University of Greenwich; Olombria, United Kingdom

Some 39% of insect visitations to globally important food crops are by insects other than bees and their importance is deeply understated in commercial pollination services. To better understand how to manipulate Syrphid (hoverfly) species in order to optimise their commercial pollinating potential, the effectiveness of semiochemical attractants in luring hoverflies to flowering soft fruit has been assessed. In vitro bioassays utilising Y-tube olfactometers, aerial arena and wind tunnel experiments were used to identify chemical compounds suitable for use in lures for semi-field trials. Results are still pending but early indications show great potential in their application for soft and top fruit pollination. Myophily can complement pre-existing

bee pollinators and under certain circumstances, could replace them when used in conjunction with precision pollination monitoring systems designed by Olombria.

P.35 Effect of mass flowering crops on bumblebee communities in wild flower edges

Laura Riggi

SLU Uppsala, Sweden

Mass flowering crops can have a considerable effect on the flow of ecosystem services due to the large pulse of resources they provide. While the amount of floral resources is important for determining how many wild pollinators an area can sustain, an equally important – and relatively poorly investigated – factor is the timing of these resources. Bumblebees require a continuous, steady floral supply throughout the season to keep the colony running. Previous study have shown that periods of nectar surplus (i.e. spring bloom) are not enough to counteract the negative effects on bumblebees of low nectar resources later in the season (i.e. summer gap July - September). Late blooming mass flowering crops such as red clover (i.e. July – August) can be expected to benefit bumblebees and the services they provide. To test this we visited wild flower transects for bumblebees in landscapes with and without red clover crops during and after blooming in 2019. To test for pollination services at each site we measured fruit set in potted strawberries and beans. Current available data consists of over 3000-recorded bumblebee-flower interactions across 240 wild flower transects in Skåne. We aim to present preliminary results and hope to discuss hypotheses and methods during the poster session.

P.36 Assessing the effect of domestic honey bees on wild pollinators in heathland using camera monitoring

Hjalte Ro-Poulsen

University of Copenhagen, Denmark

The potential risk of mass-introduction of honey bees in natural and semi-natural habitats has concerned conservationist around the world. In Denmark, it has been heatedly debated during the past years, if competition between honeybees and wild bees in natural areas is a concern. Heathlands are among Special Areas of Conservation (SACs) and important habitat for flower-visiting insects during late summer, when the wide expanses of *Calluna vulgaris* are blooming. This further makes heathlands a popular destination for migratory beekeepers to set up hives. On Harrild heath, Denmark (1300 ha heathland) up to 450 hives are placed in different densities within the heathland during the flowering of *C. vulgaris*. In this study, we investigate the effect of mass introduction of commercial honey bees on wild pollinators (bees, hoverflies and butterflies). We use time-lapse camera-monitoring of *C. vulgaris* flowerbeds, in order to quantify visitation rates of honeybees and other flower-visiting insects throughout the flowering season. A total of 30 cameras were distributed around the heathland, encompassing locations in various distances from apiaries. Each camera was set to take a photo 40-45 cm distance from a flowerbed, every 60 seconds between 8h-18h. Using cameras to survey pollinators makes it possible to monitor many plots simultaneously and at a time-scale, which is not possible to do manually. This will provide new insight of the pollination dynamics and interactions of commercial honey bees and wild pollinators on heathlands.

P.37 Bees use fat to assess pollen quality

Fabian Ruedenauer[1], Johannes Spaethe[2], Sara Leonhardt[1]

[1] Department of Zoology III, University of Würzburg, Würzburg, Germany
[2] Department of Zoology II, University of Würzburg, Würzburg, Germany

Malnutrition is named a main reason for current bee population declines. Plant nectar and pollen are the only source of nutrients for almost all bee species. However, due to the variety of plants a bee has access to, it can be challenging to find the optimal diet. Several mechanisms could help bees to overcome this challenge, among them direct quality assessment at the flower, feedback on quality from the colony to the foragers or learned cues. Many species mainly use only one nutrient they regulate. We used chemotactile conditioning of the proboscis extension response (PER) to find out (1) whether bees can differentiate between different pollen species and (2) which nutrients they are able to taste and feeding assays to find out (3) which nutrients bees use to assess the pollen quality and how this influences their survival and reproduction and (4) whether the pollen they received as larvae is preferred due to learned cues preimaginally. Honeybees (*Apis mellifera*) and bumblebees (*Bombus terrestris*) were able to differentiate between pollen species. Additionally, bumblebees were able to perceive amino acids in water, but not in pollen, where instead they were able to perceive fatty acids. Accordingly, in the feeding assays they did not consume different amounts of pollen with different proportions of amino acids, but consumed less pollen with higher fatty acid contents, which decreased their survival, likely due to undereating other nutrients. Hence, bumblebees seem to regulate the fat content of pollen. Preimaginally learned cues, however, seem to play a subordinate role.

P.38 Why so different? The diversity and factors affecting nectar composition in populations of a rare plant *Polemonium caeruleum* L. in Poland.

Justyna Ryniewicz[1], Katarzyna Roguz[1], Mateusz Skłodowski[1], Andrzej Bajguz[2] Marcin Zych[1]

[1] Botanic Garden, Faculty of Biology, University of Warsaw, Warsaw, Poland
[2] Department of Plant Biochemistry and Toxicology, Institute of Biology, Faculty of Biology and Chemistry, University of Bialystok, Bialystok, Poland

Polemonium caeruleum is a red-listed, boreal plant species with SW limit range in Poland. Flowers of this plant are visited by a broad spectrum of insects, indicating generalist pollination system. We chose 14 populations of *P. caeruleum* to our study, distributed across Poland. Experiments conducted in years 2014 to 2018 showed that populations differ in terms of seed production and frequency of insect visits. We speculated that nectar composition may be one of the factors involved in shaping those features. In 2018 we collected nectar samples from populations of *P. caeruleum* involved in our study. Sugars and amino acids (AAs) content was determined using high-performance liquid chromatography (HPLC). We found that nectar composition, regarding both sugars and AAs, is highly variable across populations. In contrast to previous studies, our findings demonstrate that the most common AAs and sugars in nectar of *P. caeruleum* were, respectively, glutamine and glutamic acid, and sucrose or fructose. Additionally, we have also specified some basic habitat parameters: habitat fertility (nitrogen, potassium and phosphorus content) and soil properties, for each of the population, that could explain the recorded differences. The project was supported financially by the Polish National Science Centre grant no. 2014/15/B/NZ8/00249 (to MZ).

P.39 Light at night – can it affect reproductive success of insect-pollinated plants?

Justyna Ryniewicz, Marcin Zych

Botanic Garden, Faculty of Biology, University of Warsaw, Warsaw, Poland

Increasing light pollution during last decades seems to be a factor that significantly affects many groups of organisms and disturbs interactions between them. Also in the case of pollinators, the presence of artificial light at night can have a negative effect, influencing pollination services. In order to assess the impact of artificial night light on the reproductive success of insect-pollinated plants in 2019 we conducted a field experiment. We applied LED light, characterized by a broad spectrum of emitting wavelengths. As a research site we chose a meadow in the immediate vicinity of primeval Białowieża Forest, where the degree of light pollution is negligible. For the study we chose three plant species, characterized by different flower morphology and pollination biology: Aquilegia vulgaris pollinated predominantly by bumblebees active during the day, *Saponaria officinalis* moth-pollinated species, and *Cosmos bipinnatus*, a generalist species pollinated by a wide spectrum of insects. We set two experimental plots, where potted plants were exposed to pollinators: control site (natural day/light conditions), and experimental site with installed lightning at night. Within each site, we set a four-variant experiment to assess whether the presence of night LED light indirectly affects plant reproductive success (seed set) by influencing pollinators behavior. The project was supported financially by the University of Warsaw grant no. DSM 7600-33 (to JR).

P.40 Assessing market and non-market values of pollination services in Ireland

Jane C. Stout, James Murphy, Saorla Kavanagh

Trinity College Dublin, Ireland

The Pollival project used pollinators and pollination services, which have public and political appeal, as a case study for assessing the market and non-market values of ecosystem services. To assess market values, we used agricultural food crop production and trade data (UN FAO) and published data on the degree of pollinator dependence for each crop. From these data, the global value of animal pollination to crop production was estimated at €158–412 billion. Using the same approach, the annual value of animal pollination to home-produced crops in Ireland was estimated to be €20–59 million per year. However, given the importance of international trade in animal-pollinated crops, and the fact that Ireland imports more than it produces of these crops, global animal pollinator decline could result in an increased trade deficit for these crops. Four economic scenarios predicted the cost of pollinator loss to Ireland at between €153 and €843 million per year. Thus, the risk of pollinator loss globally will have local market impacts in Ireland, in terms of increased food prices and an increased trade deficit in animal-pollinated crops. Scaling up to global level, this approach illustrates that pollinator loss can have differential impacts on national economies depending on the national balance of trade for animal-pollinated crops.

In order to understand public perception of the importance of pollination services, and how they are valued by Irish society, we conducted national surveys. Of the 1000 randomly selected, representative respondents, the majority were aware that bees were in decline in Ireland, that it is important to protect bees and the benefits they provide, and that protecting the environment may require funding through taxation. On average, respondents indicated they were willing to pay an average of €4–6 per month (and up to €10) to protect bees and the flowers they pollinate, but further research will be required to develop a robust estimate of the willingness to pay for pollinator conservation. A second survey, carried out with a national newspaper showed also showed that more than half of respondents agreed that protecting pollinators may require funding through taxation, and most preferred the introduction of tariffs on products that harm pollinators and fines for actions that damage the places that pollinators live, breed or eat.

Taken together, our results suggest that both the market and the non-market values of pollinators in Ireland are currently underestimated. There are many approaches to the valuation of ecosystem services, but market studies using analysis of global supply chains, and non-market approaches using methods such as willingness to pay, can reveal more about the monetary value of pollinators to the Irish economy. For a more holistic approach to assessing the values associated with pollination services, incorporating monetary and non-monetary approaches, a framework incorporating economic, social and health values of pollination services is required. By understanding and communicating the monetary and non-monetisable values of key ecosystem services, such as pollination, a better appreciation of natural capital can be developed for both policy and planning decisions at many levels across multiple sectors.

P.41 Does among-population variation in floral scent in *Arabis alpina* relate to phylogeographic history?

Kajsa Svensson, Hampus Petrén, Anna Runemark, Magne Friberg

Department of Biology, Lund University, Sweden

Understanding the evolutionary processes behind population differentiation is an important topic in biology. In the perennial arctic-alpine herb *Arabis alpina* (Brassicaceae) previous research show that different European populations vary strikingly in the composition of floral scent, a trait known to play an important role in plant-insect interactions. In my study, I use genomic data from six *A. alpina* populations in Italy and Greece with varying scent profiles and try to identify if similarity in scent correspond to their phylogenetic relationship. In addition to identifying the phylogenetic relationship among these six populations, I also examine population differentiation and structure. My results show that all populations, except from the two Greek ones, are genetically differentiated from each other with varying magnitude, and that the differentiation rate was generally not related to similarity in scent. Furthermore, the phylogenetic and population structure analysis reveal that some populations with low similarity in scent are more closely related to each other than to other populations with a higher similarity in scent. Taken together, my results suggest that the spatial pattern of scent variation among these populations is not a result of phylogenetic relationship or genetic drift. Instead, the pattern may be a result of local adaptation, for example driven by plant-insect interactions, demonstrating how local selection in different populations may cause strong differentiation in floral scent phenotypes.

P.42 Insights from experimental hybridization on floral trait inheritance and reproductive isolation in self-compatible and self-incompatible *Arabis alpina* L. (Brassicaceae)

Hanna Thosteman

Department of Biology, Lund University, Sweden

One of the main challenges in evolutionary ecology is to identify the factors and agents that drive diversification. Two of the most diverse groups of organisms on earth are plants and insects, and evidence strongly suggests that the diversification of both groups is driven by the interactions between them. One fruitful way for understanding how these interactions evolve and diversify is to identify systems of closely related species, or different intraspecific populations, where it is possible to investigate the same traits subject to different types of selection pressure. In the present study I measured flower size, anther orientation and herkogamy as well as floral scent emission rate and composition of alpine rock-cress *Arabis alpina* L. (Brassicaceae) to identify in what way they are affected by inbreeding and hybridization between self-compatible (SC) and self-incompatible (SI) populations. These

populations differ from being completely depending on pollinator attraction for reproduction (SI-populations) to being almost autogamous (SC-populations with the ability to self-pollinate). A germination test revealed strong reproductive isolation between populations of different mating systems, with less than 10% of seeds produced in crosses between mating systems germinating, whereas 80-90% of seeds produced by crosses within-mating systems germinated. I found an effect of cross direction on flower size and floral scent composition, suggesting a potential presence of cytonuclear incompatibility between SC and SI populations. Furthermore, I discovered a loss of co-inheritance between flower size and total scent emission rate as individuals of different mating systems are crossed, suggesting that the two traits are not genetically connected. My findings constitute a foundation for future studies targeted to unravel the genetic background of floral trait variation in *A. alpina*. However, the discovery of strong reproductive isolation between SC and SI *A. alpina* indicate a potential need for reconsideration of the species classification and a necessity to split this species into two taxa.

P.43 Role of butterflies and hawkmoths in pollination networks on Mount Cameroon

Jan E.J. Mertens[1], Lucas Brisson[1,2], Yannick G. Klomberg[1], Vincent Maicher[1,3], Stepan Janecek[1], Robert Tropek[1,3],

[1] Faculty of Science, Charles University, Prague, Czech Republic
[2] Université de Poitiers, Poitiers Cedex, France
[3] Biology Centre, Czech Academy of Science, České Budejovice, Czech Republic

Butterflies and hawkmoths are common flower visitors, but not much is known about environmental factors affecting their visitation rates and preferences. We studied how elevation and season influence role of butterflies and hawkmoths in pollination networks on Mount Cameroon, West Africa. We also tested which floral traits are crucial for butterflies and hawkmoths preferences. We video-recorded all flowering plants (>1200 plants of 217 species) at four elevations (650–2200 m asl), during both dry and wet season. All plants were video-recorded continuously for 24h and were checked afterwards for flower visitors. All butterflies and hawkmoths were identified to (morpho)species and their touches with reproductive organs and feeding behaviour were recorded. One third of the observed plant species across the whole gradient is visited by butterflies and/or hawkmoths, for a total of 743 individual flower visits by butterflies and hawkmoths. Butterfly visitation frequency and species richness decreased at higher elevations and during wet season. Hawkmoths seemed to play a more important role as pollinators at the higher elevations where butterfly visits were scarce (dry season) or absent (wet season). All networks were highly specialised with insignificant differences among elevations, seasons, and lepidopteran families. The pollination networks were more connected and less modular at higher elevations and during wet season. We also showed that butterflies and hawkmoths with longer proboscides preferred flowers with longer tubes. Similarly, larger species visited larger flowers. Hawkmoths and skippers surprisingly preferred similar flowers of large size and with long tubes, unlike other butterfly families. Only hawkmoths, skippers and papilionids preferred flowers rich for nectar sugars.

P.44 Pollination and plant reproduction above the tree line: the dominance of Diptera and increased selfing revisited

Judith Trunschke[1], Zong-Xin Ren[1], Klaus Lunau[2], Graham Pyke[3], Hong Wang[1]

[1] Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China
[2] Institute of Sensory Ecology, Heinrich-Heine-University, Düsseldorf, Germany
[3] University of Technology Sydney, Ultimo, NSW, Australia; and Macquarie University, NSW, Australia

Plant-pollinator interactions in alpine habitats have been of great interest to both plant ecologists and entomologists because of the demanding environment characterizing living at

high elevation. Since Müller´s (1881) first report on insect pollination of alpine plants a tremendous literature characterizes pollination in mountain habitats as being scarce and unpredictable, dominated by a fly pollinator community in line with often less conspicuous flowers, or alternatively, a high rate of self-pollination. Yet, this picture has largely emerged from a majority of studies conducted in the European Alps, Rocky Mountains and Andes while data from the Himalaya - home to the world´s highest peaks and a center of biodiversity - are largely missing. We explored the floral and pollinator species richness and functional diversity as well as plant reproductive success in three alpine plant communities in the eastern Himalayas in Yunnan, SW China, occurring at elevations of 3900 m, 4200 m and 4600 m a.s.l., respectively. In contrast to observations in other alpine regions, our data suggest that bumblebees and the native honeybee *Apis cerana* are the most important flower visitors while Diptera are nearly absent. Further, the majority of plant species show apparent floral morphological features that suggest a prevention of self-pollination, and thus, a strong dependence on these visitors for pollen transfer and seed production. Moreover, some of the species provide substantial amounts of pollen and nectar, which can support large bumblebee populations. In conclusion, we suggest that pollination by bees is increasingly important in these high mountain plant communities in the southeastern Himalaya. The unique environmental conditions of this region (formed by tree lines reaching beyond 4000 m a.s.l., high UV-radiation, summer rain seasonality) may explain this dominance of bumblebees compared to other mountain regions, but further research is needed to understand why flies are so rare.

P.45 What abiotic and biotic factors influence reproductive output the alpine species *Ranunculus acris*?

Linn Vasssvik[1], Aud Halbritter[2], Anne Krag Brysting[1], Vigdis Vandvik[2], Anders Nielsen[1]

[1] Center for Ecological and Evolutionary Synthesis (CEES), Department of Bioscience, University of Oslo, Norway

[2] Ecological and Environmental Change Research Group (EECRG), Department of Biology, University of Bergen, Norway

Reproductive output in alpine *Ranunculus acris* depend on abiotic and biotic factors. Alpine topography creates microhabitats for plants, where abiotic factors, like temperature and precipitation, play a big role in creating this heterogeneity. Snow cover, where it accumulates and the timing of snowmelt, are important drivers of the timing of life history events for plants. The initiation of flowering, the length of the growing season and the production of above ground biomass are all influenced by timing of snowmelt. These abiotic factors also affect the number of plant abundance and the number of pollinators available.

This study investigates abiotic and biotic factors influencing reproductive output in alpine *Ranunculus acris*. I established 10 snowmelt gradients at Finse, southern alpine Norway, each gradient containing three stages (early, mid and late) representing three different timing of snowmelt. Different abiotic factors were measured along this gradient: timing of snowmelt and temperature. The total amount of *R. acris* plant biomass produced was weighed and abundance of *R. acris* individuals where counted throughout the growing season. In addition, a hand pollination experiment, to test for pollen limitation, was conducted. Seed mass (g) and seed:ovule ratio (n seeds produced / (n seeds produced + unfertilized ovules)) was used as measures of reproductive output.

In the two years of this study the general trend was that a higher seed mass was produced in the early snowmelt stage, and decreasing in the later snowmelt stages, and that a higher plant biomass resulted in heavier seeds. However, in the second year of the study higher temperatures also resulted in higher seed mass, and a higher plant abundance in the surrounding vegetation had a decreasing effect on seed mass. Seed mass was not affected by pollen limitation. I found no relationship between seed:ovule ratio and any of the abiotic or biotic factors measured.

My results show that *R. acris* growing in areas with an earlier snowmelt have a higher seed mass, which means more seeds are produced due to more time for fertilization and seed maturation. There is also less competition from the surrounding vegetation for nutrition and pollinators, which was also confirmed in the second year of the study, where higher plant abundance led to a lower seed mass. Biomass production is highly dependent on abiotic factors, like temperature, soil nutrition and soil moisture. Even though temperature only had a direct effect on seed mass in the second year of the study, indirect effects on seed mass from abiotic factors through the plant's biomass could be just as important.

This study highlights that alpine ecosystems are complex and that several factors, both biotic and abiotic, might have an important role in determining seed mass in *R. acris*.

P.46 The evolution of floral visual signals upon switches in pollination systems

Linda Verloop

University of Groningen, The Netherlands

The diversification of visual signals in flowers are largely driven by the interaction of flowers with pollinators. Pollinators (bees, birds, nocturnal moths and bats) see differently, and because flowers adjust their colors to the vision of their pollinators, visual signals of flowers differ depending on its pollinator. Pollinators of plants may shift during evolution and as a consequence the colors of flowers also shift. I study how coloration has evolved following transitions in pollination groups. I found evidence of convergent evolution of floral pigment absorbance spectra for pollination systems. Furthermore, I study how the optical principles of the petals' light reflecting structures have evolved and to what extent this was driven by pollinators. In line with our hypotheses, preliminary results suggest that nocturnal flowers are more efficient and effective reflectors than diurnal flowers, that is, flowers pollinated at night have anatomies that enhance light reflection.

P.47 The importance of trees for bumblebees in semi-natural grasslands; explaining biodiversity, ecosystem services and rarity

Maarten Vervoort

Lund University, Sweden

Changes in the agricultural landscape have caused declines in bumblebee diversity and abundance. Conservation efforts have been implemented, but it is necessary to expand our knowledge about the bumblebees' ecology and its requirements to reverse the ongoing population declines. This study investigates the importance of trees within semi-natural grasslands to provide a high-quality habitat for bumblebees. Species richness and the abundance of bumblebees was measured in 34 semi-natural grasslands in southern Sweden. In addition, I quantified the presence of tree habitat in these grasslands and determined the relevance of food resources provided by trees. I found that the species richness of bumblebees is positively affected and that bumblebee abundance is negatively affected by the presence of trees. Furthermore, rare species increase in abundance and common species decrease in abundance as a result of increasing tree presence. Here, it is also shown that the provision of food resources by trees is explaining the significant effects on species richness and abundance of bumblebees. Based on my results, I suggest that trees can promote biodiversity but can also reduce ecosystem services. These findings also suggest that resource-providing trees are important for certain species bumblebees and therefore could explain rarity in bumblebees. Trees, when implemented correctly, improve habitat quality and benefit bumblebee presence in agricultural habitats.

P.48 Applying the natural capital management framework to wildflower meadows

Cian White, Jane Stout

School of Natural Sciences, Trinity College Dublin, Ireland

Land managers are increasingly expected to manage landscapes for multiple benefits and purposes. Yet, despite proliferation of frameworks linking natural capital to ecosystem services, there remains little guidance for how management actions can improve ecosystem service provision. As ecosystem services cannot be directly manipulated, management actions must be targeted at natural capital stocks. Here I extend the Natural Capital Management Framework which explicitly links natural capital stocks to ecosystem service provision and identifies manageable natural capital stocks as the critical intervention point. Wildflower meadows and three services they deliver are used to demonstrate the utility of the framework. When managing for ecosystem services it is useful to consider ecosystem service providers; the set of species which contribute to the supply of all services. The ecosystem service provider set can be divided into subsets based on response traits, traits which determine how a species responds to a management intervention. Grouping the ecosystem service providers by response traits produces species cohorts which respond similarly to a management intervention and can be considered a manageable natural capital stock. A natural capital stock has three dimensions in which it can be manipulated: quantity, quality and spatial configuration. Manipulating one dimension of a stock reveals how it modulates the flow of ecosystem services, describing a dimension – ecosystem service supply relationship. Elucidating these relationships is an important task in the context of designing management strategies efficiently. I consider the floral community of wildflower meadows as a natural capital stock grouped by response traits, and investigate how two dimensions of the stock, quantity and quality, modulate the supply of three ecosystem services, preservation of rare species, pollination and psychological well-being.

P.49 Measuring pollination services in red clover fields

Theresia Widhalm, Jessica Knapp, Maj Rundlöf

Lund University, Sweden

Pollination services are of crucial importance for biodiversity conservation as well as agricultural production because a majority of flowering plants depend on animals for reproduction. However, multiple environmental stressors are currently affecting pollinators, and declines have been recorded throughout the world. The resulting potential lack in pollination services can be quantified by measuring the difference between optimal and current levels of pollination; the pollination deficit. We determined the pollinator dependency and pollination deficit in conventionally and organically managed red clover (*Trifolium pratense*) cultivated for seed production. Due to the large number of clover cultivars grown by farmers, we measured each cultivars level of pollinator dependence as the amount of yield under animal pollinator exclosure conditions. To quantify the pollination deficit, we implemented open pollination and maximised pollination as treatment levels; the latter being a combination of open pollination and hand pollination. Furthermore, as hand-pollinating clover under field conditions is a novel approach, we measured the effectiveness of our method by controlling for potential effects of parts of the hand pollination process not directly linked to pollen transfer. We used three additional pollination treatments (wing petal removal only, wing petal removal under animal pollinator exclosure, hand pollination under animal pollinator exclosure) as experimental controls of the maximised pollination treatment described above. Here, we report on the methodology for quantifying pollinator dependence and pollination deficit in red clover under field conditions. Our methods can be used to better understand how impacts of different management practices affect pollination and seed production in red clover.

P.50 Population dynamics of the butterfly *Pyrgus armoricanus* after translocation beyond its northern range margin

Theresia Widhalm[1], Yoan Fourcade[2], Thomas Frank[3], Erik Öckinger[2]

[1] Lund University, Sweden
[2] SLU Uppsala, Sweden
[3] BOKU Vienna, Austria

Translocation experiments can be used to study the factors limiting species' distributions and to infer potential drivers of successful colonisation during range shifts. To study the expansion dynamics of the butterfly *Pyrgus armoricanus* in southern Sweden and to find out whether its distribution was limited by climate, translocation experiments were carried out within and 50-60 km beyond its natural range margin. Populations were monitored for eight years following the translocation. Although most translocation attempts failed, *P. armoricanus* was able to survive in two sites north of its current range limit. One of them eventually led to expansion and establishment of a viable metapopulation. Translocation success appeared to be independent of latitude, suggesting that climate is not the main factor determining the current northern distribution limits of this butterfly. Population growth and secondary spread in the expanding population was positively related to patch area, connectivity and negatively related to barriers to dispersal. Local habitat quality seemed to be less important, although microclimate may play a role in colonisation success. The limited success of the translocation and the importance of a well-connected patch network suggest that the current distribution of *P. armoricanus* is limited by its low dispersal ability combined with the fragmentation of its habitat, making it unlikely to track its changing climatic niche. Assisted migration could be an effective tool for such species, but long-term evidence for its effectiveness is not yet available.

P.51 Trees a better predictor for solitary bee fitness than semi-natural habitat- and oilseed rape availability

Johanna Yourstone, Melanie Karlsson, Melanie Karlsson, Björn Klatt, Ola Olsson, Henrik Smith

Lund University, Sweden

Declines in wild pollinators, such as bees, constitute a threat to both wild plants and crop production. To be able to mitigate bee declines it is important to understand how bees respond to e.g. a lower availability of wild flowers growing in semi-natural habitats, and a varying availability of extremely resource-rich, but ephemeral, mass-flowering crops in modern simplified agricultural landscapes. In our study we focused on the cavity-nesting solitary bee *Osmia bicornis*. We investigated if and at what spatial scale the species is benefitted by the mass-flowering crop oilseed rape, as well as by the availability of semi-natural habitats and trees in a modern agricultural landscape. We also aimed to investigate the diet of the bee in relation to available resources. Our study was set in 12 areas that varied in their extent of semi-natural habitats and tree abundance in southern Sweden. In each area we placed trap nests loaded with cocoons of *O. bicornis* at about 0, 300 and 1000 m distance from nearest oilseed rape field. We sampled pollen from the bee nests and assessed the bees' reproduction success. We also made detailed surveys of semi-natural habitats and trees within 500 m from each nest. We found that the amount of semi-natural habitats was not related to the reproduction success of *O. bicornis*, while both oilseed rape and the amount of trees were positively related to the reproduction. The pollen samples showed that *O. bicornis* mainly collected oak and other tree species pollen in the beginning of the nesting season, turning to mainly buttercup and other grassland species later on. Our results highlight the hitherto overlooked importance of trees to wild bees, which deserves further investigation in order to plan accurate conservation actions for bees in modern agricultural landscapes.

P.52 Untangling temporal and spatial dynamics in a plant-butterfly ecological network

Konstantina Zografou[1,2], Mark T Swartz[3], Virginia P Tilden[1,3], Erika N McKinney[1,3], Julie A Eckenrode[1,3], Brent J Sewall[1]

[1] Department of Biology, Temple University, Philadelphia, Pennsylvania, United States of America
[2] Institute for Ecology and Evolution, University of Bern, Bern, Switzerland
[3] The Pennsylvania Department of Military and Veterans Affairs, Fort Indiantown Gap National Guard Training Center, Annville, United States of America

A framework to study plant-animal mutualisms is ecological networks. Although studies on networks have returned important insights into the complex structure of natural communities, relatively little is known about the temporal dynamics of species interaction networks. This obscures our understanding of how natural communities respond to global environmental change. To come closer to a more comprehensive understanding of world we studied the temporal and spatial dynamics of a butterfly-plant network (2007-2017). Across years, we found network structure (connectance, specialization, nestedness) to remain consistent. In contrast, we revealed strong instability for temporal dynamics of species and their interactions together with a bimodal variation in temporal persistence for butterflies. Bimodality corresponded to sporadic and stable species that differ in their level of persistence in the network. Topological maps of species temporal persistence and linkage level revealed the existence of two distinct regions of "interest" as sporadic-specialists and stable-generalists and signs for a third one, largely occupied by invasive plant species. A unique pattern of increasing butterflies, plants and interactions in July-August (middle months) and connectance and specialization index in June-September (border months) was assessed at the finest grade temporal scale, among seasons. Spatially, only one site was found to differ significantly from the rest of the study system. Incorporating seasonal variation in our analytical framework, it has greatly improved our understanding on the network structuring yielding September, as the month with the highest connectivity and network specialization. Our study has consistent evidence that mutualistic webs are highly dynamic entities, but also exposes the source of temporal variability that if taken into consideration, will greatly improve our ability to understand of how nature evolves to ongoing changes.