# SCAPE 2017

## - the 31st annual meeting of the Scandinavian Pollination Ecologists

October 26th – 29th

*@ Reenskaug hotell, Drøbak (Norway)*

UiO : Life Science
University of Oslo

# PROGRAM

## Thursday 26th

17.00 - 18.00 – registration

18.00 - 18.45 – soup

18.45 - 18.55 – welcome

18.55 - 19.55 – 1st session. CHEMISTRY. Chair: Stein Joar Hegland

18.55 - 19.10. **Pollen protein content drives bee community preference for an invasive thistle over five native plant species -** Laura Russo

19.10 - 19.25. **Sub-lethal effects of imidacloprid, a neonicotinoid insecticide, on bumblebees (*Bombus terrestris*)** – Julie Sørlie Paus-Knudsen

19.25 - 19.40. **Pollen metabarcoding unravels long-distance migrations in the Painted Lady Butterfly -** Tomasz Suchan, Gerard Talavera, Michał Ronikier & Roger Vila

19.40 - 19.55. **"Investigating the relationship between landscape composition and honey chemistry" (Ireland)** - Saorla Kavanagh, Jane Stout & Blánaid White

19.55 - 20.15 – break

20.15 - 21.00 – 2nd session. ECOLOGY. Chair: Anders Nielsen

20.15 - 20.30. **Sex in a big city – what influences reproductive success of Warsaw's urban meadows? -** Katarzyna Roguz, Marcin Zych & Michał Chiliński

20.30 - 20.45. **Plant-pollinator interactions in northern Norway** – Lisa Lunde Fagerli

20.45 - 21.00. **Improvement of floral resources for urban pollinators by ground cover plants: a case of *Geranium* species**- Marzena Masierowska, Ernest Stawiarz & Robert Rozwałka

21.00 – socializing

# Friday 27th

## 07.00 - 09.15 – breakfast

## 09.15 - 10.30 – 1st session. ECOLOGY. Chair: Eirik Søvik

09.15 - 09.30. **What triggers flowering in the long-lived monocarpic island endemic *Aeonium urbicum* (Crassulaceae)? –** Jeff Ollerton

09.30 - 09.45. **Is asymmetry a relevant but ignored property of dependence measures? A case study on bacteria communities associated with flowers. -** Robert R. Junker & Wolfgang Trutschnig

09.45 -10.00. **Does floral herbivory reduce pollination-mediated fitness in shelter rewarding Royal Irises? -** Mahua Ghara, Christina Ewerhardy, Gil Yardeni, Mor Matzliach & Yuval Sapir

10.00 - 10.15. **The importance of co-pollination for seed-set in a nursery pollination system – a multi-population study -** Malin Undin, Karin Gross, John N. Thompson & Magne Friberg

## 10.15 - 10.45 – coffee break

## 10.45 - 12.00 – 2nd session. EVOLUTION. Chair: Jeff Ollerton

10.45 - 11.00. **Assisted evolution of flowering onset** – Jose M. Iriondo

11.00 - 11.15. **Contrasting selection by functionally different pollinators within and between phenotypically divergent plant populations** - Bruce Anderson, Ethan Newman & Allan Ellis

11.15 - 11.30. **A novel hypotheses for the evolution of heteranthery** - Kathleen Kay & Tania Jogesh

11.30 -11.45. **Ecological speciation between two close related *Erysimum* species with diverging mating system strategies** - Mohamed Abdelaziz

11.45- 12.00. **The evolvability of flowers: quantifying the evolutionary potential of pollination and mating systems -** Øystein H. Opedal

## 12.00 - 13.30 – lunch

## 13.30 - 14.30 – 3rd session. EVOLUTION. Chair: Nina Sletvold

13.30 -13.45. **What drives speciation? Tracking South African pollinators using genotyping plus meta-barcoding** – Tonya Lander

13.45-14.00. **Floral evolution in a mixed ploidy and mixed scent type population of the nursery pollinated *Lithophragma bolanderi* (Saxifragaceae) -** Karin Gross, Malin Undin, John N. Thompson & Magne Friberg

14.00-14.15. **Pollinator-mediated selection and functional fit of spur length in long-spurred and short-spurred populations of the orchid *Platanthera bifolia*** - Judith Trunschke, Nina Sletvold & Jon Ågren

14.15-14.30. **Selection on flower colour in a deceptive species: facilitation or negative frequency-dependence?** – Nina Sletvold

## 14.30 - 14.45 – coffee break

## 14.45 . 16.00 – poster session (13 posters) Chair: Jon Ågren

**Consequences of climate change for disrupted plant-pollinator interactions** – Linn Vassvik, Anders Nielsen, Anne Brysting, Aud Halbritter & Vigdis Vandvik
**The genetic basis of post-zygotic hybridization barriers between *Arabidopsis lyrata* and *A. arenosa*** Johannessen I.M., Hornslien K.S., Krabberød A.K., Bramsiepe J., Bjerkan K.N., Brysting A.K. & Grini P.E.
**Color Vision and Color Preference in the Flower-visiting Hoverfly *Eristalis tenax* -** Lina An, Alexander Neimann & Klaus Lunau
**Following in the footsteps of Linnè: resampling his trails** - Amy L Parachnowitsch, Emy Vu, Ida Brisvåg, María Hurtado de Mendoza & Ignasi Bartomeus
**Correlation Between Hedgerow Features and Pollinating and Pest Controlling Insect Visitors -** Sarah Gabel & Jane Stout
**Results-Based Agri-Environmental Payment Schemes: Investigating the Impacts on Pollinator Diversity in Burren Grasslands -** Michelle Larkin & Dara A. Stanley
**The multi-scaled habitat preferences of the Blue Calamintha Bee** - Katherine L. Burns, Mark Deyrup & Eric S. Menges
**Native honeybees as flower visitors and pollinators in wild plant communities -** Dara A. Stanley & Steven D. Johnson
**Want some strawberries? The interactive effects of herbivores and pollinators on plant fitness** - Anne Muola, Lisa Malm, Robert Glinwood, Amy Parachnowitsch & Johan Stenberg
**The Energetic Costs of Floral Scent Production** - Victoria Luizzi, Hampus Petrén, & Magne Friberg
**Efficiency of pollinators: a preliminary review of first visit data -** Lorenzo, C.; Méndez, M.
**The Pollination Ecology of the Polymorphic Centranthus ruber (L.) DC in Ireland** - Alison O'Reilly, John A. N. Parnell & Jane C. Stout

## 16.00 - 17.00 – snack n' nap break

## 17.00 - 18.00 – 5th session. COLOUR. Chair: Ingvild Asmervik

17.00-17.15. **On the optical principles and evolution of flower colouration** – Van der Kooi

17.15-17.30. **Does petal colour predict style length in Crocus species?** – Klaus Lonau

17.30-17.45. **Colour preferences in social bees -** Sarah Banysch, Sebastian Koethe & Klaus Lunau

17.45-18.00. **Keep the old, attract the new: floral color change by plants for a full exploitation of site-faithful pollinators -** Kazuharu Ohashi, Miki F. Suzuki, Takashi T. Makino & Kentaro Arikawa

## 18.00 - 19.30 – dinner

## 19.30 - 20.15 – 6th session. APPROACHES. Chair: Dara Stanley

19.30-19.45. **POLLIVAL: A natural capital based approach to value pollination services -** James T. Murphy & Jane C. Stout

19.45-20.00. **How a cognitive approach can help answering questions on pollination: the case of floral polymorphism in deceptive orchids -** João Marcelo R. B. V. Aguiar, Ana Carolina Roselino, Martin Giurfa & Marlies Sazima

20.00-20.15. **Perceived Diversity – A novel approach to investigate taxon-specific colour diversity -** Martin Lechleitner & Robert R. Junker

## 20.15 - 23.30 – cocktail break

# Saturday 28th

## 08.00 - 09.30 – breakfast

## 09.30 - 10.15 – 1st session. NETWORKS. Chair: Marcos Mendez

09.30 -09.45. **Pollinator diurnal activity patterns and small-scale plant co-flowering patterns largely determine the structure of plant-pollinator network -** Zdeněk Janovský, Christian F. Damgaard, Eva Matoušková & Lukáš Jánošík

09.45-10.00. **Key plant loss in pollination networks and the conservation of hubs -** Paolo Biella, Asma Akter, Jeff Ollerton, Stepan Janecek, Jana Jersakova & Jan Klecka

10.00-10.15. **Beyond random and forbidden interactions in plant-pollinator networks: how nectar reward and optimizing energy gain structure interactions among subalpine Asteraceae and their flower-visitors** - Saskia G.T. Klumpers, Peter G.L. Klinkhamer & Martina Stang

## 10.15 - 13.00 – excursion

## 13.00 - 14.00 – lunch

## 14.00 - 15.15 – 2nd session. LIMITATION. Chair: Jane Stout

14.00-14.15. **Patterns of reproductive isolation and floral scent variation among populations with varying mating systems in *Arabis alpina* -** Hampus Petrén, Per Toräng, Jon Ågren & Magne Friberg

14.15-14.30. **Nutrient availability affects floral scent much less than other floral and vegetative traits in Lithophragma bolanderi -** Mia T. Waters, Magne Friberg & John N. Thompson

14.30-14.45. **Variation in pollen limitation in a boreal pine forest in North-Eastern Poland** – Mateusz Sklodowski

14.45-15.00. **Variation in insect visitor assemblage and pollen limitation in Polish populations of a rare plant *Polemonium caeruleum* L. (Polemoniaceae) –** Justyna Ryniewicz

15.00-15.15. **Mechanical exclusion of some but not all bees in the Bladder Senna *Colutea arborescens* -**Maximilian Raden, Petra Wester & Klaus Lunau

## 15.15 - 15.30 – coffee break

## 15.30 - 16.30 – 3rd session. CLIMATE. Chair: Tommy Lennartsson

15.30-15.45. **Pollinator-mediated, indirect effects of climate on plant performance in alpine communities -** Sarah K. Richman, Christopher A. Johnson, Laura Stefan & Jonathan M. Levine

15.45-16.00. **Altered flowering phenology of bilberry and lingonberry as response to simulated warming and herbivory** - Mark Gillespie & Stein Joar Hegland

16.00-16.15. **Influence of microclimatic heterogeneity on alpine plant and flower visitor diversity -** Lisa-Maria Ohler, Martin Lechleitner & Robert R. Junker

16.15-16.30. **Vertical stratification of plant-flower visitor interactions** - Jan Klečka, Jiří Hadrava, Pavla Kolouškova

## 16.30 - 17.00 – snack break

## 17.00 - 17.15 – break

## 17.15 - 18.00 – 4th session. AGRICULTURE. Chair: Marcin Zych

17.15-17.30. **The interplay of climate and land use change affects the distribution of EU bumblebees** - Leon Marshall

17.30-17.45. **Effects of agricultural intensification on pollination services in shea parklands of Burkina Faso** - Aoife Delaney, Cath Tayleur, Juliet Vickery, Elaine Marshall, Adama Nana, Assita Dambele, Frank Gnane Lirasse, Jane Stout.

17.45-18.00. **Impact of managed honey bee (*Apis mellifera*) on the activity of native floral visitors in a boreal forest ecosystem in NE Poland**. – Anna Szacillo

18.00 - 19.30 – get ready…

19.30 - 21.30 – conference dinner (w/ entertainment)

21.30 - ? – beer and socializing at Tollboden

## Sunday 29th

08.00 - 10.00 – breakfast

10.00- 11.00 – check-out

11.00 -12.30 – famous last words

Fare-thee-well! Au revoir! Hasta luego! Auf Wiedersehen!

**På gjensyn!**

# THURSDAY – 1ST SESSION

**Pollen protein content drives bee community preference for an invasive thistle over five native plant species**

Laura Russo[1,2], Anthony Vaudo[2], C. Jacob Fisher[2], Christina Grozinger[2] and Katriona Shea[2]

*Trinity College Dublin[1], Penn State University[2]*

Our previous work has shown that an invasive thistle, *Carduus acanthoides*, is strongly preferred by bee communities of agroecosystems in central Pennsylvania. Our objective for this study was to determine what traits of this plant allowed it to preferentially attract pollinators compared to four confamilial native species and one native legume. We established 30 2x2m experimental plots with a controlled background density of five native annuals, then divided these plots into six blocks, composed of five experimental treatments. These treatments involved the invasion of the thistle into the plant community at two different timings (early and late in the summer) and intensities (high and low abundance), as well as a control plot which was not invaded and comprised only the five native plant species. We measured bee visitation to each plant species throughout the summer by collecting bees in the morning and afternoon, as well as plant traits including: above-ground biomass, number of flowers, size of floral display, and pollen protein, sugar, and lipid content. We chose to contrast this invasive thistle to four native asters and one native legume because asters are generally considered to have poor quality and legumes to have high quality pollen.

Although all treatment plots (with the thistle) had a higher total number of bee visits than control plots across the summer, we found no effect of experimental treatment on the rate of visitation (number of bees per flower per minute) to the native plant species. Within a given plant species, we found the number of flowers was a significant predictor of bee visitation; however, this trend was no longer significant when we looked across different plant species. In other words, the number of flowers did not predict bee preference for different plant species. The above-ground biomass, size of the floral display, pollen sugar content, and pollen lipid content were also not significant predictors of bee preference among different flower species. We found a statistically significant and strong ($R^2$ = 0.9) correlation between the average protein content of each plant species' pollen and rate of visitation. The unusually high protein content of the thistle pollen may allow it to compete for pollinators with closely related native species. In addition, the high protein and low lipid content is very similar to the protein:lipid ratios of legumes, previously found to be a strong predictor of bumblebee visitation, while providing a higher protein concentration.

# Sub-lethal effects of imidacloprid, a neonicotinoid insecticide, on bumblebees (*Bombus terrestris*)

Julie Sørlie Paus-Knudsen

*Center for Ecological and Evolutionary Synthesis, University of Oslo*

Pollinators are under threat from several drivers, and there are concerns regarding their ability to maintain the ecosystem service they provide. One of the threats that has received increased attention lately is neonicotinoids: a group of systemic neuro-active pesticides that disturb the transmission of signals in the insect´s nervous system. Neonicotinoids are the most widely used pesticides in the world, and protect a variety of crops against invertebrate pest. Despite being used in relatively small quantities, several studies have shown sub-lethal effects of neonicotinoids on honeybees (*Apis mellifera*) exposed to neonicotinoids. However, there is still a lack of knowledge on the effects on other important pollinators. A wide range of ecological and physiological traits vary decisively among bee species, indicating that studies on honeybees may not provide satisfactory predictions of the effects on other bee species.

The present study aimed to develop a new experimental method to quantify the sub-lethal effects of imidacloprid on bumblebee colonies (*Bombus terrestris*). More specifically the aim was to determine how dietary exposure to imidacloprid affects learning, and consequently the ability to forage and thus pollinate, in a non-*Apis* species. Bumblebees were exposed to three different dosages of imidacloprid through artificial nectar (sugar water), ranging from realistic field levels (1 μg/L and 10 μg/L) to distinctly higher levels (100 μg/L) in a chronic exposure regime, lasting for eight days. Bumblebees not exposed to imidacloprid were used as control. To assess whether imidacloprid influences learning, the bumblebees were tested systematically in a flying arena containing nectar-filled (rewarding) and water-filled (unrewarding) artificial flowers of two different colors. The bumblebees were tracked by cameras, allowing for analysis of the trajectory of bees. In particular, the learning behavior was quantified (how well bees discriminate between rewarding and non-rewarding flowers) and pollination efficiency (flowers visited during a foraging bout). In addition, the health of the colonies was assessed after exposure to imidacloprid by counting the surviving bumblebees in different developing stages. To assess food intake the number of honeypots were counted, and the amount of nectar consumed during the exposure period were measured.

This study shows the successful application of a new method to track bumblebee behavior. Further, the study shows that learning, locomotor activity, survival and food consumption are negatively affected in a dose-dependent manner when bumblebees are exposed to imidacloprid. Moreover, both the behavioral results and the results assessing the health of the colony show that field-realistic doses of imidacloprid have sub-lethal effects on bumblebees.

# Pollen metabarcoding unravels long-distance migrations in the Painted Lady Butterfly

Tomasz Suchan[1*], Gerard Talavera[2*], Michał Ronikier[1], Roger Vila[2]

[1]*W. Szafer Institute of Botany, Polish Academy of Sciences, ul. Lubicz 46, 31-512 Kraków, Poland*
[2]*Institut de Biologia Evolutiva (CSIC-Universitat Pompeu Fabra), Passeig Marítim de la Barceloneta, 37, 08003 Barcelona, Spain*
[*]*equal contribution*

The painted lady butterfly, *Vanessa cardui*, undertakes annual migrations between Europe and Africa, but the extent of these migrations is still insufficiently understood. Recent observations indicate that autumn migrants may travel from Europe, cross the Mediterranean, the Sahara, the Sahel, and travel far south to the Sub-Saharan Africa – achieving the longest migratory flight ever recorded by a butterfly in a single generation. In the spring, the specimens originating from Africa undertake a migration back to Europe. Until recently, all these migrants were believed to originate from the North Africa, as the flights from Maghreb to Europe were well documented. Whereas the spring migrations from the Sub-Saharan Africa to Europe are also possible remains an open question. Here we present the first application of pollen metabarcoding in a study of insect migrations. We collected butterflies crossing the Mediterranean during the spring migration and identified pollen deposited on the insects' bodies by ITS2 metabarcoding. By classifying the obtained sequences and comparing the distributions of identified taxons we could trace the origin of migrants. As expected, most of the identified plant taxons had Mediterranean or north-African distribution, but the presence of several Sub-Saharan species points to the possibility of long-distance dispersal of *Vanessa cardui* during the spring migrations. Plant metabarcoding can be thus used as a practical method for tracking long-distance insect migrations.

Saorla Kavanagh[1], Jane Stout[2], Blánaid White[1]

*[1]School of Chemical Sciences, Dublin City University (DCU)*
*[2]Department of Botany, Trinity College Dublin (TCD)*

The relationship between landscape composition and honey chemistry has not yet been explored. Honey contains biologically active compounds with potential antioxidative, antibacterial and anticarcinogenic effects. These compounds are beneficial not only to human health but also to bee health.

The aim of this research is to investigate the relationship between landscape composition and honey chemistry.

A total of 131 honey samples were obtained from beekeepers across the island of Ireland. The landscape composition around each hive site was determined using the CORINE Land Cover 2012 database and quantified to a 5 km radius. The phenolic composition of each honey sample was identified and quantified using HPLC-UV.

An analysis of bioactive compounds in Irish honey comparing profiles among geographical regions and harvest times using univariate and multivariate techniques was carried out and the results will be presented and discussed.

Preliminary results suggest that the composition of the surrounding landscape impacts the composition and concentration of phenols in honey. This study has shown that there is a significant difference in the phenolic composition between honeys from predominantly rural areas compared to honeys from predominantly urban areas.

# THURSDAY – 2ND SESSION

**Sex in a big city – what influences reproductive success of Warsaw's urban meadows?**

Katarzyna Roguz[1], Marcin Zych[1], Michał Chiliński[1]

[1]*Botanic Garden, Faculty of Biology, University of Warsaw, Poland*

Dynamic urban development is inextricably linked to a habitat alteration and its fragmentation. Growing cities occupy larger areas of natural landscape and this trend is expected to continue. Such changes are usually very negative, but they also fuel growing interest in the role of urban environment as a wildlife refugium. Green enclaves within cities are perceived as asylum for protected species and ecosystems services, e.g. pollination process. Increasingly popular way of improving the biodiversity of city areas are urban meadows planed in the city area. Such "green infrastructure" is a source of high quality nectar and pollen for pollinators, available during the whole growing season. It might also constitute an ecological corridor penetrating dense mosaic of buildings. Knowing its potentially important role in biodiversity conservation we decided to investigate the reproductive success of meadow plants. In this study we also assessed the attractiveness of Warsaw's meadows to flower visitors taking into account negative factors like habitat fragmentation or air pollution. Preliminary results show that Warsaw's meadows are very attractive to several groups of pollinators and that studied plants (*Echium vulgare* L., *Linum usitatissimum* L.) are not pollen limited.

**Plant-pollinator interactions in northern Norway.**

Lisa Lunde Fagerli[1], Anne Krag Brysting[1], Bård-Jørgen Bårdsen[2] and Anders Nielsen[1]

[1]*Center for Ecological and Evolutionary Synthesis, University of Oslo, Norway*
[2]*NINA, Tromsø*

Plant-pollinator interactions represent an important ecosystem service. Areas north of the polar circle are subject to harsh and heterogeneous environmental conditions that pose challenges to the native biota. Even though the summer is short and cold, the light conditions are optimal, as it never gets dark. The plant-pollinator communities in high-latitude areas are not well studied, but is characterized by the dominance of flies and bumblebees as pollinators. However, the alternating climate may result in seasonal fluctuations of pollinator availability. Self-pollination, anemophily and a generalized flower morphology are therefore common plant strategies to ensure reproduction.

For two successive seasons, I studied a plant-pollinator system in a subarctic area in northern Norway. My fieldwork was conducted at different sites at Reinøya (69°53′33″N), an island with a steep ascent and low tree-line (*ca*. 360 m a.s.l.). During the summer of 2016, I recorded flower visits in an elevation gradient from 0 to 300. Seed set was recorded for the three focal plant species *Melampyrum sylvaticum*, *M. pratense* and *Cornus suecica*. The following summer, I conducted a bagging experiment on the two *Melampyrum* species to assess their abilities to self-pollinate. In addition, I studied diurnal patterns of pollinator activity in a meadow. There was an overwhelming dominance of black flies visiting most flower species. However, the efficiency of these insects as pollinators can be questioned as the *Melampyrum* species produced seeds when pollinators were excluded. I observed no difference in flower visits or seed set along the elevation gradient. Interestingly, pollinators were not active during the night, even though light and environmental conditions were satisfactory.

In this talk I will share experiences from the fieldwork, present some preliminary results and discuss how my observations may give new insights on the plant-pollinator system of a subarctic site.

# Improvement of floral resources for urban pollinators by ground cover plants: a case of *Geranium* species

Marzena Masierowska[1], Ernest Stawiarz[1], Robert Rozwałka[2]

[1]*Dept. of Botany, University of Life Sciences in Lublin*
[2]*Dept. of Zoology, Maria Skłodowska-Curie University in Lublin*

Hardy *Geranium* species, hybrids and cultivars are widely grown in naturalistic and forest parks, and gardens. Our research aims towards understanding the contribution of herbaceous ground cover plants: *Geranium macrorrhizum*, *G. platypetalum* and *G. sanguineum*, as a food source for urban pollinators. We focused on (a) floral phenology and abundance, (b) temporal distribution of the floral resources produced by them, and (c) abundance of nectar and pollen flow, which are essential to predict the effect of urban herbs on the abundance and diversity of pollinating insects. Moreover, the spectrum and activity of insect flower-visitors (d) was monitored.

The investigation was conducted in the Botanical Garden of Maria Skłodowska-Curie University, Lublin, Poland (N - 51°16', E - 22°30'; 200 m a. s. l.) in the years 2004 – 2014.

The flowering season of the studied species began in May and continued up to 7.5 weeks. The highest number of flowers was formed on *G. macrorrhizum*, the lowest —1.8-times less— on *G. sanguineum*.

Regarding pollen and nectar flow, again *G. macrorrhizum* appeared to be the best producer. The pollen yield was 25.87 mg/10 flowers and 5.09 g × $m^{-2}$, on average. Values of nectar amount/10 flowers and total sugar mass secreted in nectar/10 flowers of this species were up to 5x higher than those obtained for *G. platypetalum* and *G. sanguineum*. The estimated total sugar nectar yield × $m^{-2}$ in *G. macrorrhizum* was up to 10x higher when compared to that calculated for the other species. The sugar nectar concentration was high in all investigated species.

The principal visitors in all species were Hymenoptera. The highest visiting rate was observed for *G. macrorrhizum* and *G. platypetalum*. The insects gathered mainly nectar.

In conclusion, our results show that herbaceous ground cover plants can play an important role in improving food resources for Hymenoptera in urban ecosystems.

# FRIDAY – 1ST SESSION

**What triggers flowering in the long-lived monocarpic island endemic *Aeonium urbicum* (Crassulaceae)?**

Jeff Ollerton

*University of Northampton*

Long-lived monocarpy is a plant reproductive strategy in which individuals grow for a number of years before finally flowering, setting seed, and then dying. It is a strategy that is particularly common on oceanic islands. Although there has been much research on the evolution of monocarpy, little work has been undertaken to understand the environmental cues that trigger flowering in these long-lived individuals. Given that each year of vegetative growth provides additional resources that can be used for reproduction, why do individuals "choose" to flower when they do? The genus *Aeonium* (Crassulaceae) has undergone a species radiation in the Canary Islands and monocarpy has evolved a number of times during that diversification. On Tenerife *Aeonium urbicum* is a particularly common monocarpic species of bare lava fields and cliff faces that grows for between 5 and at least 15 years before finally flowering. This species has been the focus of a long-term investigation involving students and staff at the University of Northampton. The first eleven years of data from this study will be presented in order to answer the question: what triggers flowering in the long-lived monocarpic island endemic *Aeonium urbicum*?

**Is asymmetry a relevant but ignored property of dependence measures? A case study on bacteria communities associated with flowers.**

Robert R. Junker[1] and Wolfgang Trutschnig[1]

[1]*University of Salzburg*

Species' abundances often do not vary independently of each other. Abundances of mutualistic partners can be expected to be positively correlated, whereas the abundances of competitors may show a negative correlation. Such linear or at least monotone associations are well reflected by Pearson's *R* or Spearman's *rho* that quantify the strength of associations. Additional dependence measures are available allowing to identify non-linear relationships in community data. However, all of these dependence measures are symmetric (i.e. mutual), implying that the influence of variable *X* on variable *Y* coincides with the influence of *Y* on *X*. However, in many types of interactions one species may be more dependent on another species than *vice versa*. For example, specialized herbivores depend more on certain plant species than *vice versa*, or epiphytic bacteria may be more dependent on their plant hosts than *vice versa*. In order to fill that gap, we implemented an asymmetric copula-based dependence measure *acdm*, which allows us to detect dependencies of any functional type and – for the first time – the asymmetry in dependence between two random variables.

We will discuss the theoretical and ecological relevance of asymmetry in dependence measures. Additionally, using a data set bacteria associated with flowers we will provide fundamentally new insights into the nature of associations between flowers and bacteria.

# Does floral herbivory reduce pollination-mediated fitness in shelter rewarding Royal Irises?

Mahua Ghara[1], Christina Ewerhardy[2], Gil Yardeni[1,3], Mor Matzliach[1], Yuval Sapir[1]

*[1]The Botanical Garden, School of Plant Science and Food Security, Tel Aviv University, Tel Aviv 69978, Israel*
*[2]Albrecht von Haller Institute of Plant Sciences, University of Göttingen, DE-37073 Göttingen, Germany*
*[3]Current address: Department of Botany and Biodiversity Research, University of Vienna, A-1030 Vienna, Austria*

Florivory, the damage to flowers by herbivores, can make flowers less attractive to pollinators. Even when pollinated, flower consumed by florivores may fail to produce fruit or will produce lower seed set. Despite the widespread evidence of florivory across ecosystems and plant taxa, only a few studies tested experimentally the interaction of florivory and pollination by manipulative study. We studied the effect of two levels of florivory on both pollinator visitation and reproductive success over two flowering seasons in three *Iris* species. We hypothesized that florivory will reduce pollen deposition due to reduced attractiveness to pollinators, and that fruiting probability and seed set will depend on the extent of florivory. We performed artificial florivory treatments, representing high, low, and no florivory (control) in two experiments. In the first experiment, each of the three floral units of the same flower was subject to either low, high or no artificial florivory, after which we counted the number of pollen grains present on the stigma. In the second experiment, three flowers of the same plant were treated and were further recorded for fruit and seed production. Surprisingly, and against our hypotheses, in all three species no significant effect was found among and between florivory treatments and control, neither in pollen grain deposited nor in fruit and seed set. The results undermine the assumption that flower herbivory is necessarily antagonistic interaction and suggests that florivores are not strong selection agents on floral reproductive biology in the *Oncocyclus* irises.

# The importance of co-pollination for seed-set in a nursery pollination system – a multi-population study

Malin Undin[1], Karin Gross[1], John N. Thompson[2] & Magne Friberg[1,3]

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According to the geographic mosaic theory of coevolution, interactions between the same interacting species can have shifting outcomes when occurring in different environments. Several recent studies indicate that one important factor affecting the coevolutionary outcome is the local presence or absence of additional interacting species. For example, the interaction between Woodland stars (*Lithophragma* spp., Saxifragaceae) and the highly specialized pollinating floral parasite moth species *Greya politella* (Prodoxidae), has been shown to be affected both by the local presence of other *Greya* species and, in some *Lithophragma parviflorum* populations, by a high abundance of bombyliid flies and solitary bees. In the other *Greya*-pollinated *Lithophragma* species, the interaction has traditionally been considered more specific and less affected by co-pollinators. However, recent data report tremendous among- and within-species variation in several floral traits of documented importance for *Greya* moth pollination. This contrasts with predictions from coevolutionary theory, which suggest that selection should act stabilizing on traits of importance for tight mutualisms. Here, we utilize a unique feature of the *Lithophragma-Greya* pollination ecology: the possibility to score the contribution of *G. politella* pollination post-flowering. To investigate the importance of *G. politella* for seed set across the Sierra Nevadan range of *Lithophragma bolanderi*, we collected developing capsules from nine *L. bolanderi* populations, and found that the proportion of fruits with traces of *G. politella* oviposition ranged from 0 to 0.95. We coupled these data with detailed laboratory pollination efficacy experiments, and repeated field censuses, using plants and moths from two of the nine populations. Thereby, we determined the *Greya* moth contribution to pollination during nectaring, and detected among-population variation in visitation rate by more generalized pollinators (solitary bees, other lepidopterans). Together, our results show (**i**) that the importance of *G. politella* pollination varies dramatically among *L. bolanderi* populations, (**ii**) that nectaring *Greya* moths are only weakly contributing to pollination, and (**iii**) that the contribution from generalist co-pollinators is spatially variable, and quite substantial in some populations. This suggests that the large among-population variation in the floral display traits of *L. bolanderi* could be generated by a selection mosaic brought about by pollinators other than *G. politella*.

# FRIDAY 2ND SESSION

**Assisted evolution of flowering onset**

Jose M. Iriondo

*Universidad Rey Juan Carlos, Madrid, Spain*

Humans are unconsciously imposing selective pressures on flowering phenology in plant species across the planet as a result of global change. The effects of such massive intervention may be important but have not yet been assessed. In this context, could deliberate human-assisted evolution of phenological traits be used in selected cases to mitigate the effects of climate warming? The purpose of EVA project is to assess the use of the evolutionary forces of selection and gene flow as tools to increase the resilience of populations of species affected by climate change. The research focuses on the modification of flowering onset, a trait of great adaptive relevance in the context of climate warming. Studies are under way on two species of contrasting life cycle and reproductive system to assess the efficacy of these tools on species with different life history traits. In parallel, the genetic risks associated to these actions will be evaluated through the study of potential genetic and phenotypic responses correlated to flowering onset, which may also affect the fitness of individuals. Obtained results will delimit the viability of these actions and the conditions needed for their application.

**Contrasting selection by functionally different pollinators within and between phenotypically divergent plant populations**

Bruce Anderson, Ethan Newman, Allan Ellis

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- Geographically variable selection mediated by different pollinators is an important driver of floral divergence and speciation in plants, yet only a handful of studies have shown pollinator-mediated selection to be heterogeneous within and among populations. Here we investigate the form and strength of pollinator-mediated selection on mechanical fit floral traits in two different plant species visited by different functional pollinator types across their ranges.
- By allowing single visits by different pollinators, we were able to estimate the form and strength of selection components exerted by different functional pollinator types within and between populations using cubic splines.
- We demonstrate that fitness surfaces differ strongly when pollinators are functionally different but that fitness surfaces are similar when pollinators are functionally similar. Floral morphology associated with high fitness was closely matched with the morphology of pollinators that exerted strong selection, but not with the morphology of the pollinators that exerted weak selection.
- Our study provides rare details of selection on floral traits driven by multiple pollinators within and between populations and challenges researchers to think beyond the simplistic evolutionary models which only consider the most effective pollinator.

**A novel hypotheses for the evolution of heteranthery**

Kathleen Kay and Tania Jogesh[1]

[1]*University of California Santa Cruz*

*[Regarding plants] with two kinds of anthers...I am very low about them, and have wasted enormous labour over them, and cannot yet get a glimpse of the meaning of the parts. C. Darwin to J. D. Hooker, October 14, 1862*

Heteranthery, the presence of two or more types of stamens within the same flower, is common among bee-pollinated plants and typically involves one set of easily-accessible, brightly-colored stamens and another set of relatively cryptic stamens displaced from the center of the flower. Although heteranthery confounded Darwin, it is now commonly accepted that dimorphic stamens represent a division of labor between the feeding and pollinating functions of flowers that use pollen as a bee reward. Nevertheless, the division of labor hypothesis has been tested in only a few systems and has received mixed support. We examine the macroevolution of heteranthery across the evening primrose family (Onagraceae) and the genus *Clarkia.* We find that heteranthery is indeed associated with bee pollination and is commonly lost with transitions to moth pollination or self-fertilization. We then examine two heterantherous *Clarkia* species to test 1) whether one set of stamens is cryptic to bees whereas the other is conspicuous, 2) whether bees primarily collect pollen from the conspicuous stamens, and 3) whether pollen from the cryptic stamens is more likely to be deposited on stigmas. Although one set of anthers appears to be cryptic to bees, we do not find any division of labor between cryptic and conspicuous anthers. Instead, we find that cryptic anthers are held in reserve until conspicuous anthers are depleted by bee visitors, at which point they move into a central position in the flower, release their pollen, and are also depleted by bee visitors. As this strategy appears to have no effect on female fitness (seed production), we hypothesize that, in this system, heteranthery combined with timing differences and anther movement represents a pollen dosing strategy to maximize male fitness over many bee visits. We find similar patterns for anther crypsis, timing and movement in several other heterantherous *Clarkia* species, suggesting that gradual pollen presentation may be a common explanation for heteranthery.

**Ecological speciation between two close related *Erysimum* species with diverging mating system strategies**

Mohamed Abdelaziz

*Department of Genetics. University of Granada. Spain*

*Erysimum wilczekianum* and *E. incnum* are two close related species that become in contact in the Middle Atlas Mountains. Both species are phenotypically very similar, but they show the flower size as most distinctive character. In the present work we carried out different field experimental approaches and greenhouse experiments to evaluate the selective pressures acting on both species and how they could influence the rise of reproductive barriers between them. We sampled over 400 individuals in nature and over 500 were used in greenhouse controlled-crosses. Flower traits were significantly selected in *Erysimum wilczekianum* by means of the generalist assemblage of pollinators visiting them. However, *E. incanum* did not attract any pollinator to their flowers and only plant size traits were under significant selective pressures. We also found a strong pre-zigotic reproductive barrier by the pollinators associated to the reduction of floral reward in *E. incanum*. However, the post-zigotic reproductive barrier between these species was incomplete and asymmetric, being *E. incanum* the species tolerating the inter-specific pollen load. The different selective pressures acting on both species would be the major force driving the evolutionary divergence between them. And even when both species have not lost completely their ability to interbreed, that is reduced, pushing them to an achieved ecological specieation scenario.

# The evolvability of flowers: quantifying the evolutionary potential of pollination and mating systems

Øystein H. Opedal[1]

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Trait evolvabilities are central to predicting the short-term evolutionary potential of populations, and hence their ability to adapt to changing environments. In the event of a community turnover, population decline, or complete disappearance of pollinators, animal-pollinated plants may respond by adapting to novel pollinators or by changing their mating system. I quantify and evaluate the evolvability of floral traits involved in plant-pollinator interactions. Special attention is given to the evolvability of herkogamy, a key floral trait associated with variation in mating systems. I compiled genetic-variance estimates for a variety of floral traits, computed evolvabilities, and compared these among trait groups and against the evolvabilities of vegetative traits. When measured in percentage of its own size, the median evolvability of herkogamy was an order of magnitude greater than the evolvability of other floral size measurements, and was generally not strongly constrained by genetic covariance between its components (pistil and stamen lengths). To test whether evolvabilities depend on mating systems, I also compared evolvabilities among species differing in their mating systems. Median evolvabilities were similar across mating systems, with a tendency towards reduction for some trait groups in highly selfing species. I conclude that most floral traits, and especially herkogamy, has the potential to evolve rapidly in response to changing environments. This suggests that the extensive variation in floral traits commonly observed among closely related populations and species may result from rapid adaptive tracking of fitness optima determined by variation in pollinator communities or other selective factors.

# FRIDAY 3RD SESSION

**Floral evolution in a mixed ploidy and mixed scent type population of the nursery pollinated *Lithophragma bolanderi* (Saxifragaceae)**

Karin Gross[1], Malin Undin[1], John N. Thompson[2] & Magne Friberg[1,3]

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Floral traits are amazingly diverse not only among species but often also among populations within species and even within populations. The diversification must have included both processes that generate diversity and processes that selectively and divergently filter this diversity. Studies on pollinated-mediated selection on floral traits like colour, size, or morphology have generated multiple textbook examples of the natural selection process, but much less attention has been paid to understand the evolution of floral chemistry, in particular floral scent. Here, we attempt to study both the origin of floral scent diversity through polyploidisation, and its filtering of floral scent diversity through natural selection in the woodland star (*Lithophragma bolanderi*). This species exhibits an incomparably high among-population variation in floral morphology and scent and is composed of multiple cytotypes. It is pollinated by the highly specialised pollinating seed parasite *Greya politella* but also by more generalised pollinators. We found one *L. bolanderi* population composed of two chemotypes, two main cytotypes, and with approx. 50% of the pollinated flowers being pollinated by ovipositing *G. politella* and approx. 50% by other visitors. We present data on how floral traits differ between chemotypes and cytotypes and how this is linked to reproductive success and pollination by different pollinators. These results not only provide insights into evolutionary dynamics within populations but also into how different cytotypes can establish and persist in mixed-ploidy populations.

**Pollinator-mediated selection and functional fit of spur length in long-spurred and short-spurred populations of the orchid *Platanthera bifolia***

Judith Trunschke, Nina Sletvold and Jon Ågren

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The length of floral spurs and tubes should determine the functional fit between pollinators and floral reproductive organs, and thereby, the efficiency of pollen transfer. Because of the consequences for seed production spur length can be hypothesized to be under strong selection and adapted to local pollinator assemblages with variable tongue lengths. In the present study, we documented phenotypic and pollinator-mediated selection in two long-spurred woodland and two short-spurred grassland populations of the hawkmoth-pollinated orchid *Platanthera bifolia* on the island Öland, SE Sweden. In addition, we experimentally quantified the functional relationship of spur length and pollen removal and pollen deposition, and tested whether it varies between the two ecotypes. Taken together, the data suggest that spur length is of adaptive significance, but that natural variation does not influence the magnitude of pollen transfer and is not target of pollinator-mediated selection in the year of study.

# FRIDAY – POSTER SESSION

**The genetic basis of post-zygotic hybridization barriers between *Arabidopsis lyrata* and *A. arenosa***

Johannessen I.M., Hornslien K.S., Krabberød A.K., Bramsiepe J., Bjerkan K.N., Brysting A.K., Grini P.E.

*University of Oslo, Department of Biosciences, Section of Genetics and Evolutionary Biology, Oslo, Norway*

The favored species concept focuses on the reproductive isolation between species, although in the world of plants the exceptions are numerous. In my project, I investigate post-zygotic hybridization barriers between two *Arabidopsis* species, with the aim of understanding the genetic basis of the barrier.

We have shown that the post-zygotic hybridization barrier between *Arabidopsis lyrata* and *A. arenosa* is linked to the event of endosperm cellularization (Lafon-Placette et al. 2017). In diploid and incompatible interploidy crosses between the two species, we see either early or late/no cellularization. Failing to make the switch from the phase of bulking up energy to the phase of feeding the embryo, which is the purpose of cellularization, results in non-germinating seeds. The crosses between diploid *A. lyrata* to tetraploid *A. arenosa* are completely incompatible. However, we did find that by crossing diploid *A. arenosa* to tetraploid *A. lyrata*, we got seeds with normal looking endosperm and endosperm cellularization, and close to 100 % germinating rate, showing a complete bypass of the barrier between the two species.

Leading up to this point, the work has been based on plant crossings and a variety of seed analysis using microscopes and performing seed measurements. The current focus of my work is to identify genes involved in this endosperm-based hybridization barrier. From Illumina sequencing of RNA from developing seeds, I have acquired transcriptomes from seeds from crosses within species, at both diploid and tetraploid level, and from diploid hybrid seeds and interploidy interspecies seeds. We are currently working on assembling and annotating the transcriptomes.

Learning more about post-zygotic plant hybridization barriers can help us understand: 1) How diverging populations form reproductive barriers on the way to become separate species, 2) Why some species can be crossed and produce fertile offspring while others cannot. And in the future, we may potentially be able to manipulate interspecies crosses due to knowledge of barrier genes.

Lafon-Placette, C., I. M. Johannessen, K. S. Hornslien, M. F. Ali, K. N. Bjerkan, J. Bramsiepe, et al. (2017). "Endosperm-based hybridization barriers explain the pattern of gene flow between Arabidopsis lyrata and Arabidopsis arenosa in Central Europe." **PNAS 114**(6): E1027-E1035.

**Consequences of climate change for disrupted plant-pollinator interactions**

Linn Vassvik[1], Anders Nielsen[1], Anne Brysting[1], Aud Halbritter[2] and Vigdis Vandvik[2]

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Pollinators provide an important ecosystem service and it is therefore crucial to understand their response to a climate change. Many pollinators dependent on temporal synchrony with their host plants and therefore can an asynchrony in shifts in phenology of both plants and insects disrupt such interactions. Recent climate warming is associated with phenologcial advances in plant and animal species and there is now growing evidence that temporal mismatches between plants and animals occur. An important question will therefore be: "What are consequences for disrupted plant-pollinator interactions?" and "Will an increase in mismatch between plants and their pollinators decrease reproductive output and affect population viability?"

This study was carried out at Finse, Hardangervidda mountain plateau. 30 locations were selected along 10 snowmelt gradients. Each snowmelt gradient had an early, mid and late snowmelt stage. Phenology on *Ranunculus acris* and visiting pollinators (mainly Dipteran) were monitored throughout the season. Some of the plants were hand-pollinated to assess the effect of pollen limitation.

**Color Vision and Color Preference in the Flower-visiting Hoverfly *Eristalis tenax***

Lina An, Alexander Neimann & Klaus Lunau

*Heinrich-Heine-Universitaet Duesseldorf*

Color signals enable insects to reliably detect and recognize important objects such as food sources, hosts or mating partners. Like most other pollinating insects, hoverflies use color signals to seek nectar and pollen from flowers. It is well known that inexperienced and experienced *Eristalis tenax* males and females prefer yellow over other color hues. In this study we compared the flies' color preference for landing and for proboscis reaction. *Eristalis tenax* flies were successfully trained to approach and land on artificial flowers of other colors than yellow. Interestingly this choice is biased: the flies' innate preference for yellow is still detectable in flies trained to non-yellow colors. Moreover, the flies avoid to land on dark colors and prefer brighter colors over trained darker colors. Learning is restricted to approach and landing, since the innate preference of the proboscis reflex for yellow colors in *Eristalis tenax* cannot be altered by training. The meaning of these findings for visiting flowers in the field is discussed, particularly whether the yellow color stimuli that trigger landing and proboscis reflex are identical or not.

**Efficiency of pollinators: a preliminary review of first visit data**

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Pollinators are needed for successful reproduction in a large portion of angiosperms and are assumed to have influenced the evolution of floral morphology. However, not all pollinators contribute equally to reproductive success of plants. Two components, "quantity" and "quality", of pollinator influence on plant reproduction have traditionally been considered. While a lot of information exists on the quantitative component, based on visitation rate, the qualitative component has been less explored. Single visit experiments, which estimate the amount of pollen deposited on virgin stigmas after a single visit by a known pollinator, are a common method to assess pollinator quality. Over 80 papers have reported single visit data. We report preliminary data of an ongoing review of this literature, showing that Hymenoptera (excluding wasps and ants) and birds, were the most efficient pollinators, i.e. offered the highest quality of visits. Nevertheless, the quality of the pollinators was dependent on the match between pollinator and flower morphology. Using the accessibility index of Stang, a shift in pollinator quality was detected from simple, accessible flowers towards complex, unaccessible flowers. As the degree of complexity of the flowers increased, the quality rank of Hymenoptera and birds increased.

# Want some strawberries? The interactive effects of herbivores and pollinators on plant fitness

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Herbivores can affect plant reproduction both directly and indirectly. Direct effects of herbivory result from consumption of plant tissues which may either directly destroy reproductive structures but also cause resource limitation, and, consequently, decrease the resources available for reproduction. Indirect effects of herbivory are due to corruption of the visual and olfactory signals that plants use to attract pollinators leading eventually to pollination limitation. Understanding the underlying mechanisms of how plant-herbivore-pollinator-interactions can affect plant fitness has important implications for agriculture, especially for insect-pollinated crops. Here, I present results from investigations studying the effects of herbivores and pollinators on the fitness of woodland strawberry (*Fragaria vesca*). Strawberry Leaf Beetles (SLB) feed both on strawberry leaves and flowers. In general, leaf damage is relatively well tolerated. However, after a certain threshold SLB-damage on leaves decreases both current and future sexual reproduction while clonal reproduction remains unaffected. Florivory by SLB leads to lower pollination success which, in turn, results in smaller fruits with more deformations. In addition to indirect effects, SLB-damaged flowers produce smaller fruits even when they are hand pollinated, showing that florivory also has substantial direct effects on yield, independent of pollination. So far, our results demonstrate that SLB damage has not only direct negative effects on plant fitness but also that it interferes with pollination. Further studies are needed to test whether variation in plant resistance affects, not only the herbivores, but also pollinators.

**The Pollination Ecology of the Polymorphic *Centranthus ruber* (L.) DC in Ireland**

Alison O'Reilly, John A. N. Parnell and Jane C. Stout

*Botany, School of Natural Sciences, Trinity College Dublin, Republic of Ireland*

Centranthus ruber (L.) DC is a non-native plant that is naturalised in Ireland. It's now widely spread, growing abundantly on walls and roadsides and is potentially invasive. *C. ruber* shows flower colour polymorphism with pink, red and white flowered populations, however, nothing is known about how flower colour may affect *C. ruber's* pollination ecology.

Controlled pollination treatments were applied to test the breeding system of white and pink *C. ruber* colour morphs, and to determine whether differences in pollination success exist between the two colour morphs. Breeding system treatments included bagged and open pollination, to test for spontaneous and faciliated self-pollination, geitonogamy, xenogamy and natural levels of pollination. All seeds from these treatments were tested for differences in germination success. No significant difference was found in seed set between the pink and white colour morphs for any treatment, however, a significant difference between bagged and open treatments suggests that *C. ruber* plants are not capable of spontaneous self-pollination, and produce fewer seeds, which have a lower germination success, when artificially self-fertilized. Pollen samples were tested for pollen viability and starch content which showed an overall high mean percentage of viability and low mean percentage starch content for each colour morph.

Observations of insect visitors to *C. ruber* flowers were conducted over a 10-day period to determine the visitation rates and foraging rates for all three colour morphs. There was no significant variation in the visitation rates to the different coloured morphs, but white flowers attracted a slightly different composition of insect visitors. The high foraging rates by bees indicated that they may be more efficient at transferring pollen than hoverflies. Style length was measured for each colour morph at two floral growth stages, which showed white morphs had significantly longer styles during the female phase.

These results suggest that *C. ruber* plants are insect-dependent for sexual reproduction and are a source of high quality rewards for native pollinators. These findings may be crucial for future management schemes to control the spread of *C. ruber* populations and pollinator conservation.

**The multi-scaled habitat preferences of the Blue Calamintha Bee**

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The ecosystem service of pollination, provided by wild pollinators, is essential to the function of ecological communities. Many populations of native pollinators are in decline due to habitat loss, which may have substantial impacts on the health of ecosystems. The Blue Calamintha Bee, *Osmia calaminthae,* is a specialist species of bee native to only four sites, all in Highlands County, Florida, USA on the Lake Wales Ridge. It has been petitioned to be listed on the federal List of Endangered and Threatened Wildlife (U.S. Fish and Wildlife Service) which, if granted, would allow it to receive protections provided by the Endangered Species Act. The bee specializes on the endemic woody mint, Ashe's Calamint, *Calamintha ashei,* but little else is known about its range and habitat requirements. We attempted to characterize the habitat preferences of the Blue Calamintha Bee through observational methods at multiple spatial scales. We chose six plots on three different properties where the Blue Calamintha Bee has been observed in the past and spent 18 hours observing pollinators during the peak bloom period of Ashe's Calamint. Additionally, line-transect vegetation surveys and flowering plant surveys were conducted at each of the eighteen sites. In the study areas in which the Blue Calamintha Bee was observed foraging, the percentage of shrub cover was less than that of sites where the bee is no longer present. This information suggests that the Blue Calamintha Bee may require an open foraging area, as opposed to a habitat with denser vegetation. Additionally, honeybees were the most active flower visitor of Ashe's Calamint at all three sites, indicating likely competitive interactions. Our results suggest that management should aim at preserving open scrub with fewer shrubs and refrain from the application of honeybees to sites where the Blue Calamintha Bee is known to be active.

# Correlation Between Hedgerow Features and Pollinating and Pest Controlling Insect Visitors

Sarah Gabel and Jane Stout

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Agricultural land is an important habitat for insects, as agriculture takes up over 60% of land cover in Ireland. And hedgerows, highly prevalent in the Irish landscape and particularly farmed land, allow the movement of insects and provide food and shelter from the elements. These insects can be both beneficial to the farmer – such as pollinators and pest controllers – or harmful – such as aphids and other herbivorous insects. This study was dedicated to investigating how certain hedgerow features may correlate with the abundance and diversity of pollinators, pest controllers, and aphid pests across nine organic oat crops. The hedgerows were assessed for tree and shrub vegetation, dimensions, and other key features once during the field season. Insect and floral surveys were conducted three times at each site between June and August. Insect surveying was done using pan traps and timed walks and hand-searches along transects, and floral surveying was done by counting floral units along the same transects. The collected data showed the plants that flying insects visited during they survey, as well as the bees (pollinators) and hoverflies (pollinators and pest controllers) caught in oat crops and hedgerows using netting and pan trapping.

**Results-Based Agri-Environmental Payment Schemes: Investigating the Impacts on Pollinator Diversity in Burren Grasslands.**

Michelle Larkin & Dara A. Stanley

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Pollinators provide a vital ecosystem service by ensuring the successful pollination and reproduction of both wild flowers and many commercially important crops such as Oilseed Rape and Coffee. It is estimated that pollinators contribute €153 billion annually to the global economy and an estimated €53 million per annum to the Irish economy. Despite this, pollinators are experiencing an increasing global population decline as a result of agricultural intensification, spread of parasites and disease, and climate change. Due to increasing concerns of biodiversity declines across the agricultural landscape agri-environmental schemes (AES) have been introduced to mitigate any further declines. AES primary focus is to encourage farmers and other landowners to protect and enhance biodiversity by offering financial incentives. However, traditionally farmers are only paid for applying measures, and as a result these schemes have experienced varying levels of success. A new Results-Based Agri-Environmental Payment Scheme has been developed in the Burren region in Ireland, and has experienced high levels of success in conserving and enhancing both habitat quality and diversity as farmers are rewarded based on the environmental results they deliver. However, diversity in this scheme is assessed using plant indicator "scores" and the effects of this Results-Based Scheme on pollinators and the services they provide have not been extensively studied. The principal objective of this project is to study how insect pollinators (i.e. bees, hoverflies and butterflies) are effected by a Results-Based Scheme in the Burren, and whether there are any modifications to the existing scheme which would benefit pollinators. A survey of pollinators was conducted across 23 farms in the Burren of varying biodiversity scores, using transects and pan trapping. Preliminary results from this work are discussed, and will be useful in understanding the ecology of rarer pollinating species, and in informing agri-environmental measures and pollinator conservation.

**Native honeybees as flower visitors and pollinators in wild plant communities**

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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 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 27 %) and also provided a substantial proportion of visits to the plants they visited (40% and 34% 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 25% 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.

# The Energetic Costs of Floral Scent Production

Victoria Luizzi, Hampus Petrén, and Magne Friberg

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Flowers produce a variety of volatile organic compounds that have been shown to function in pollinator attraction and herbivore deterrence. It is often assumed that these volatiles are costly to produce, and costs are commonly invoked to explain observations such as the loss of fragrance associated with the transition to self-pollinating or the shutdown of scent production during times of low pollinator activity. However, the existence of production costs has yet to be convincingly demonstrated. This proposed study will ask whether there is an energetic cost of producing floral volatiles manifested in reduced fitness in the absence of pollinators in individuals that naturally produce more fragrance. Individuals of *Arabis alpina* from both outcrossing populations and mixed-mating (outcrossing and selfing) populations will be grown in a 2 x 2 design of high and low nutrients and high and low water availability, as costs are sometimes easier to observe under stress. Volatile production and size (used as a proxy for fitness) will be measured for all individuals after flowering. Individuals with naturally variable levels of volatile production will be compared within treatments to test whether there is a negative correlation between volatile emission and fitness in the absence of pollinators. Any plasticity in volatile production will also be detected through comparison between treatments. The results of this work will contribute to a basic understanding of the ecology and evolution of floral scent and will aid in predicting responses of volatiles to environmental changes.

**Following in the footsteps of Linnè: resampling his trails**

Amy L Parachnowitsch, Emy Vu, Ida Brisvåg, María Hurtado de Mendoza, Ignasi Bartomeus

*Uppsala University*

Earth's biota has experienced radical changes since 1750, but those changes are often difficult to quantify due to the lack of baseline data. Linné was a pioneer in recording local biodiversity, including his "Herbationes Upsaliensis", which include all plant species present in 8 transects around the city of Uppsala. Resampling these trails provides a perfect opportunity to see how city development and agricultural intensification has changed local plant biodiversity. Here we present an updated survey of the reconstructed historical transects and compare current plant diversity with historical data.

# FRIDAY – 5TH SESSION

**On the optical principles and evolution of flower colouration**

Casper von der Kooi

*University of Lausanne*

Plants attract pollinators by displaying distinctly coloured flowers. The colouration of flowers is due to the wavelength-selective absorption by pigments and light scattering by the petal interior. Whereas the chemical properties and evolution of floral pigments have received considerable scientific attention, the optics, i.e. the complex interaction of light with the inner floral components, has so far received much less attention. Using a wide array of physical techniques, anatomical studies and optical models, we recently studied the optical properties of flowers.

In this talk, I show that light scattering is crucial for maximising the flower's conspicuousness to pollinators. I outline the different anatomical traits and their optical properties found in many species, and discuss some special cases. The consequences of anatomical changes to the flower's visual signals are interpreted with a "pollinator-subjective view" using established vision models. Finally, I will discuss a recently started large-scale comparative study on the optical properties of flowers with different pollination syndromes.

**Key publications**

Van der Kooi et al. 2016 *Proceedings B*; doi 10.1098/rspb.2016.0429

Van der Kooi et al. 2017 *Interface*; doi 10.1098/rsif.2016.0933

Van der Kooi et al. 2014 *New Phytologist*; doi 10.1111/nph.12808

**Does petal colour predict style length in Crocus species?**

Klaus Lunau, Jessica Bossems, Sabine Konzmann, Dörte Harpke

*Heinrich-Heine-Universitat Duesseldorf, Germany*

Many flowers display colour patterns. The central and smaller part of floral colour patterns is often yellow and UV-absorbing and caused by the colour of pollen, anthers, or floral guides. This yellow and UV-absorbing central colour is combined with contrasting peripheral colours. Yellow flowers thus often have an ultraviolet bull's eye. There are, however, some noteworthy exceptions. Yellow bee-pollinated Crocus-flowers are obviously constrained in their pigmentation and obviously unable to produce yellow, UV-reflecting petal colours. We have analysed the colour patterns of most Crocus species and found that far most yellow Crocus species display no colour pattern, but completely absorb ultraviolet light. Most blue and white Crocus flowers, including the saffron crocus, possess yellow elongated styles which offer a landing platform for bees that thereby cross-pollinate the flowers. By contrast yellow Crocus flowers possess significantly shorter styles. This character is interpreted as a consequence of the flowers' colouration and explained by the limited abilities to produce yellow and UV-reflecting petals.

**Colour preferences in social bees**

Sarah Banysch, Sebastian Koethe, Klaus Lunau

*Heinrich-Heine-Universitaet Duesseldorf, Germany*

For many melittophilous plants, the flowers' colour is a crucial factor for pollinator attraction and antagonists' exclusion. Colour preferences of naïve bees have been studied mostly in bumblebees using workers which have been raised in the laboratory and thus have no experience with flowers except for the pollen used for feeding the larvae.
This talk will present the results of colour preference tests with two Brazilian stingless bee species (*Melipona bicolor, Partamona helleri*) using free-flying workers and a newly developed experimental setting. The sets of colour stimuli were made of pressed mixtures of pigment powders. Thereby, this set-up enables the variation of intensity, dominant wavelength and spectral purity of the flower dummies.
The results indicate that *M. bicolor* exhibits only weak preferences for distinct colour parameters, whereas *P. helleri* prefers colours of high spectral purity over less spectral pure ones. Influence of previous experience of the tested *P. helleri* workers can be excluded.
Along with the outcome of the colour preference tests, obstacles and problems faced while training and working with stingless bees will be illustrated, as well as some contextual comparison with the well-studied model species *Apis mellifera* and *Bombus terrestris*.

The work's aim hereby contributes to a better understanding of Meliponines perception of colour information.

**Keep the old, attract the new: floral color change by plants for a full exploitation of site-faithful pollinators**

Kazuharu Ohashi, Miki F. Suzuki, Takashi T. Makino (Univ. of Tsukuba), and Kentaro Arikawa (Sokendai-Hayama)

Floral color change—the retention of old, nonreproductive, rewardless, but unwilted flowers in an altered color—has been suggested as an adaptive strategy for plants to attract pollinators from a distance with an increased display while minimizing pollinator visits to nonreproductive, rewardless flowers using distinct coloration. However, considering that most visually oriented pollinators would respond similarly to these aspects of floral display, the reason for low prevalence of floral color change in nature is unclear. Here we briefly review our recent studies aiming to provide evolutionary explanations for the sporadic distribution of floral color change in angiosperms. First, based on spectral data for 219 flower species, we show that pollinators with UV-sensitive eyes can see color changes of flowers more often than humans. We then present the results from phylogenetically independent analyses suggesting that the occurrence of floral color change is consistently correlated with bee pollination. A plausible explanation for the association between floral color change and bee pollination may lie in the behavioral characteristics of bees—their tendency to forage within small areas and learn to make frequent returns to profitable plants or patches. As our laboratory experiments with bumble bees illustrate, plants with discolored old flowers receive persistent return visits from resident foragers by presenting a useful color guide to rewarding flowers, as well as they could attract the passersby by increasing the size of an entire display. Thus, floral color change can be considered as a strategy to fully exploit site-faithful pollinators such as bumble bees, by maintaining experienced foragers while attracting inexperienced ones. Moreover, our field data on *Weigela* suggest that such an exploitation of site-faithful pollinators by floral color change pays off only in multi-species plant communities, where plants need to avoid interspecific competition or heterospecific pollen transfer. More studies are needed to clarify whether our findings could be extended to other systems.

# FRIDAY – 6TH SESSION

**POLLIVAL: A natural capital based approach to value pollination services**

James T. Murphy[1] & Jane C. Stout[1,2]

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[2]*Trinity Centre for Biodiversity Research, Trinity College Dublin, Dublin 2, Ireland.*

Assessing and evaluating natural capital and ecosystem services which flow from it are key national environmental research priorities enabling integration of natural capital into decision-making processes and the sustainable use of natural resources. A new project (POLLIVAL) aims to develop national and European capacity in evaluation of ecosystem services using pollination as a case study. By integrating market and non-market values, assessing current status and identifying drivers of future change, the project will develop a model system to enable evaluation of other forms of natural capital for decision-making and planning processes. The objectives of the project are: 1. To identify best practice to evaluate the current market values of pollination services in Ireland. 2. To develop methods to assess non-market values. 3. To integrate the implications of land use change (driven by various processes including environmental change, policy change and consumer behaviour) on the value of pollination services in Ireland. The project will integrate approaches from natural, social and economic sciences and will involve consultation with experts and integration of expert knowledge, data-gathering (from a range of sources, including collection of novel ecological data sets), development of methods, and modelling of future scenarios.

# How a cognitive approach can help answering questions on pollination: the case of floral polymorphism in deceptive orchids

João Marcelo R. B. V. Aguiar[1,2], Ana Carolina Roselino[3], Martin Giurfa[1], Marlies Sazima[2]

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Bees forage for food (nectar or pollen) available in flowers and use different floral cues such as color, shape and fragrance, to identify and locate these food resources. In this foraging context, bees learn to associate floral cues with the presence of food reward. Yet, not all insect-visited flowers offer this reward. Many cases of flower polymorphism have been documented for orchids pollinated trough generalized food deception. It was suggested that floral polymorphism in species pollinated trough generalized food deception promotes more visits to flowers by disrupting the learning process of the pollinators. We tested this hypothesis by focusing on the case of the polymorphic deceptive orchid *Ionopsis utricularioides*, which varies in color and odor fragrance, and by assessing the learning and generalization capabilities of bees trained with color and odor signals. We first trained free flying *Scaptotrigona* aff. *depilis* (Meliponini) bees to visit a setup with artificial flowers that were manipulated in color and presence of sugar reward during the experiments. We found that, when bees are presented to a setup of artificial flowers with different colors with no sugar reward, simulating the deceptive polymorphic flowers, they have their learning process disrupted, visiting more flowers until learning that all of the stimuli presented are signals for absence of reward. To study whether honeybees can detect and discriminate the olfactory variation present *I. utricularioides*, in particular the various pairs of isomers of the same fragrant molecules, we used the olfactory conditioning of the Proboscis Extension Response (PER), which allow training a bee to an odor paired with sucrose and test its generalization capabilities for structural variants of the odor trained. We found that when bees are trained to differentiate odorants, they were able to discriminated between structural and stereoisomers. We also found that the major component of a floral fragrance can be overshadowed by minor components, in a way that the bees can perceive an odorant mixture, such as the floral bouquet, based not mainly by the most common fragrant compound, as we expected, but by other minor compounds that can be more salient for the bee. Taken together, our findings show that evaluating pollination trough the "eyes and noses" of pollinators can lead us to a more complete understanding of insect-flower interactions, and to comprehensive analyses of complex problems in pollination studies such as generalized food deception by polymorphic flowers.

# Perceived Diversity – A novel approach to investigate taxon-specific colour diversity

Martin Lechleitner and Robert R. Junker

*University of Salzburg, Department of Ecology and Evolution, Austria*

Communication via colours is crucial for many ecological interactions, e.g. in pollination. Pairwise interactions between plants and pollinators usually occur within a community, which means that all flower colours displayed in a community may be integrated into foraging decisions. Thus, the functional diversity of a plant community calculated based on colours may provide valuable information on resource availability, foraging patterns and the resilience of communities. Due to the taxon-specific equipment with visual receptors the perceived diversity may differ between taxa, which should be considered in the evaluation of ecological processes.

We introduce a novel approach 'Perceived Diversity' that allows to quantify the colour diversity of communities under consideration of animal taxon-specific visual systems. Our approach links distances between colour spectra with the salience of colours as perceived by several flower visitor taxa defined as the contrast of the flower colour to a green background based on the visual model of Vorobyev & Osorio (1998). Besides the quantification of the species-specific functional diversity of colours, we implemented a graphical output 'perceptional landscape' that visualizes the distribution of salience-values in a colour space, which facilitates the comparison across flower-visitor taxa.

Using data of flower colours sampled along an elevational gradient in the Austrian Alps we tested the performance of our approach. We found that flower communities of alpine pastures appear more diverse for pollinators adapted to alpine environments than for lowland species. This result suggests a co-evolution of plants and pollinators allowing the animals to reduce handling times and plants to more reliably receive conspecific pollen.

Our approach can be used flexibly for various systems and will provide new insights into colour-mediated interactions involving more than two partners.

Vorobyev M. & Osorio D. (1998): Receptor noise as a determinant of colour thresholds. Proceedings of the Royal Society of London B: Biological Sciences 265(1394): 351-358.

# SATURDAY – 1ST SESSION

**Pollinator diurnal activity patterns and small-scale plant co-flowering patterns largely determine the structure of plant-pollinator network**

Zdeněk Janovský[1,2], Christian F. Damgaard[3], Eva Matoušková[4], Lukáš Jánošík[1]

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[4]*Dept. of Zoology, Charles University in Prague*

Pollination networks are a valuable tool for description of communities of plants and pollinators, but they necessarily homogenise over the sampled site and sampling period. Yet from pollinator's viewpoint, such sites are largely heterogeneous and a pollinator can perceive only a tiny proportion of it at a time, within which it can choose flowers to visit (or decide to move over a larger distance). Do these sensoric constraints modify importantly pollinator's visitation behaviour? Similarly, a plant is mainly interested in pollinators' visits in times when it releases pollen or possesses receptive stigmas. How does its pollinator spectrum in times of "activity" differ from the overall spectrum?

For this purpose, we observed a spatially and temporally well-resolved pollination network from a single site followed by a Bayesian analysis of pollinator behaviour. We modelled pollinator visitation as a two-stage process where the pollinator first chooses a patch to visit and only then, it chooses among the flowers. Thus, we obtained posterior probabilities of pollinator visits on a given plant species at a given position at the site at a given point in time.

Both predictable variation in pollinator diurnal activity and spatial differences in flower composition had large influence on pollinator spectra experienced by the plants at different sectors of the meadow. Moreover, the observed pollinator visitation diurnal patterns matched patterns of pollen release for ten of the key plant species in the system. In some plant species, only overall pollinator abundance tracked plant attractiveness (measured as amount of pollen available) while in others there was a turnover in species spectrum with some pollinators visiting the plant only for nectar in times when they almost did not contribute to its pollination.

**Key plant loss in pollination networks and the conservation of hubs**

Paolo Biella*, Asma Akter, Jeff Ollerton, Stepan Janecek, Jana Jersakova, Jan Klecka

**PhD student at: Department of Zoology, Faculty of Science, University of South Bohemia, Ceske Budejovice, Czech Republic Institute of Entomology, Biology Centre of the Academy of Sciences of the Czech Republic, Ceske Budejovice, Czech Republic*

Networks of interactions are rarely considered in conservation planning. However, network analysis could be an effective way to detect the key species ("hubs") that play an important role in cohesiveness of such networks. Features of such hubs will be shown from two montane Northern Apennine grasslands in Italy. Yet, it is still not clear how networks react when key species are lost in a natural environment. Therefore, plant hubs were experimentally removed from two grassland sites in the Czech Republic. We tested how such plant loss affected pollination in terms of flower-visitation rate by insects and pollen deposition in the surviving community. This experiment showed some direct and indirect effects of species loss in pollination networks. The key species of networks are important components and they could be taken into account for conservation or management of sites. Hubs could help to preserve the greatest number of interactions and thus possibly support many other species.

# Beyond random and forbidden interactions in plant-pollinator networks: how nectar reward and optimizing energy gain structure interactions among subalpine Asteraceae and their flower-visitors

Saskia G.T. Klumpers, Peter G.L. Klinkhamer & Martina Stang

*Leiden University*

In recent years, plant-pollinator community studies have shown general interaction patterns such as asymmetry (generalist pollinators interact with specialist plants and vice versa) and nestedness (a core group of generalists interacts with each other and a few specialists mostly interact with generalists). These interaction patterns are often explained by random foraging behaviour of pollinators, sometimes in combination with the existence of forbidden interactions. Forbidden interactions imply that plants are not visited by certain pollinators, due to a mismatch in either phenology or morphology. Surprisingly, although nectar reward and foraging efficiency are two of the most likely aspects to determine pollinator foraging behaviour, we lack knowledge on how these aspects affect the type- and number of interaction partners and consequently plant-pollinator network structure.

Here we investigated whether, in addition to species abundance and morphological traits, nectar reward and pollinator foraging efficiency can explain species generalization degree and plant-pollinator interaction patterns, such as asymmetry, nestedness and size-matching between the nectar tube depth of flowers and the proboscis length of their pollinators. In addition, we used our result to investigate the ways plants can mitigate the risk that in a particular year there are insufficient numbers of pollinators to ensure pollination. We specifically hypothesized that plants can either be generalized on pollinators which are prone to temporal fluctuations or specialized on pollinators which are less prone to temporal fluctuations, which will result in equal visitation rates. In other words, plants might face a pollinator species number (SN) – species predictability (SP) trade-off. To this end, we used a three year dataset to analyze the interactions of subalpine Asteraceae species, co-occuring in the Colorado Rocky Mountains, and their pollinators.

# SATURDAY – 2ND SESSION

**Patterns of reproductive isolation and floral scent variation among populations with varying mating systems in *Arabis alpine***

Hampus Petrén[1,2], Per Toräng[1], Jon Ågren[1] & Magne Friberg[1,2]

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Self-compatible plants have a reduced need to attract pollinators for reproduction, which typically results in a reduction of floral display and decreased production of floral scent (the selfing syndrome). In various species, like the cruciferous plant alpine rock-cress (*Arabis alpina*), some populations are self-incompatible outcrossers, whereas other populations are self-compatible and, at least in the northern European population, highly selfing. As a consequence, the level of floral signalling in a single population should largely mirror the mating system of that population and the between population variation regarding such signals should be high. Furthermore, populations more different from each other in regard to mating system could also show higher levels of reproductive isolation when crossed, as compared to populations with similar mating systems, as a result of increased parental conflict between individuals with different mating systems. As a part of my doctoral studies, I explore the differentiation between European populations of *A. alpina* with regard to both floral signalling and reproductive isolation with the goal of understanding the importance of these factors in diversification of plant-insect interactions, in the differentiation of populations and, hence, ultimately for speciation.

# Nutrient availability affects floral scent much less than other floral and vegetative traits in *Lithophragma bolanderi*

Mia T. Waters[1], Magne Friberg[2], and John N. Thompson[1]

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Natural selection can favor either traits that are consistently expressed across environments or
that vary in predictable ways in response to environmental variation. Because plants have modular designs, many morphological traits differ considerably under different environmental conditions. Some traits, however, such as those used to attract coevolved pollinators, may be under stabilizing selection within populations if particular traits or trait combinations are important for attracting local pollinators. We tested the relative plasticity of plant traits in *Lithophragma bolanderi* (Saxifragaceae), which is tightly coevolved with host-specific *Greya* moth pollinators (Prodoxidae). We focused on the emission of floral scent, which is a variable trait of documented importance for this interaction. We subjected pairs of multiple seed-families of two *L. bolanderi* populations to a high and a low nutrient treatment, and evaluated how nutrient availability affected the floral scent variation relative to other vegetative and reproductive traits. The floral volatile composition and the per-flower emission rate differed significantly between populations but were unaffected by nutrient treatment. Yet morphologically, the plants in the low-nutrient treatment produced fewer leaves, scapes, and flowers than plants in the high-nutrient group, and had leaves lighter in color. Thus, the results reveal a strong genetic component both to scent composition and emission level. These results indicate that reproductive traits important to coevolving interactions, such as the floral scent of *L. bolanderi*, may be locally specialized and more canalized than other traits important for plant fitness. We are now currently investigating the genetics of variation in *Lithophragma* floral scent, using crosses among populations with different scent bouquets to assess how variation is expressed between parents with highly different scent profiles, their hybrids, and backcrosses. These results will allow us to make a preliminary estimate of the minimum number of genes involved in the expression of floral scent, and to start assessing the phenotypic and genetic correlations in expression of different groups of chemical compounds that contribute to floral scent bouquets.

**Variation in pollen limitation in a boreal pine forest in North-Eastern Poland**

Mateusz Skłodowski

*University of Warsaw Botanic Garden*

One of the consequences of the honey bee introduction into the natural environment may be change in the plants seed set. This, in turn, could be the effect of changing pollen limitation level. According to recent opinions pollen limitation (PL), i.e. a reduction in plant seed set due to inadequate quantity or quality of available pollen, may be an important driver of the evolution of plant reproductive strategies. However, little is known on the extent and variation of pollen limitation levels in many natural populations and also on the extent to which honey bee affects PL in various environments. Here we present the results of pollen limitation experiments conducted over two years in several populations of two native (*Hypericum perforatum* and *Campanula persicifolia*) and one invasive (*Impatiens parviflora*) zoogamous plant species occurring in semi-natural pine forests in Wigry National Park (NE Poland). Our paper discusses the observed variation also with regard to variable population density of honey bee.

**Variation in insect visitor assemblage and pollen limitation in Polish populations of a rare plant *Polemonium caeruleum* L. (Polemoniaceae)**

Justyna RYNIEWICZ[1], Katarzyna ROGUZ[1], Emilia BRZOSKO[2], Beata OSTROWIECKA[2], Izabela TAŁAŁAJ[2], Ada WRÓBLEWSKA[2], Edyta JERMAKOWICZ[2], Paweł MIRSKI2 & Marcin ZYCH[1]

[1] *Botanic Garden, Faculty of Biology, University of Warsaw, Warsaw, Poland*
[2] *Department of Plant Ecology, University of Białystok, Poland*

*Polemonium caeruleum* is a rare species from Polish Red Book of Plants. Flowers of *P. caeruleum* are hermaphrodite, dichogamous and protandrous, pollinated mainly by bumblebees and honeybees, although visits of insects from other taxonomic orders also are recorded. It is a boreal species and in Poland it reaches its SW limit range. This plant often grows in small and isolated populations. *P. caeruleum* reproduces only by seeds and appropriate insect species composition and abundance is necessary for its survival. Under the influence of several factors (mainly agricultural treatments) number of individuals of this plant in some Polish populations decreases, which may result in reduction of the number of pollinator visits and consequently limitation in seed production.

In years 2014 - 2017 we conducted pollination experiment to test our hypothesis of pollen limitation among populations of *P. caeruleum* and check if the generally observed drop in population size is related to the reproductive performance of the plants. Our research considered 7 - 15 populations, depending on year, distributed throughout the country. We also evaluate frequency of insect visits in each population (years 2015 - 2017).

We found, that in almost all of the study population P. caeruleum is not pollen limited. Frequency of insect visits influences seed production, but it is not necessarily associated with pollen limitation index. Our results also show large temporal and spatial variation in insect visitor assemblages

**Mechanical exclusion of some but not all bees in the Bladder Senna *Colutea arborescens***

Maximilian Raden, Petra Wester & Klaus Lunau

*Institute for sensory ecology, Duesseldorf, Germany*

Many angiosperm flowers use floral filters to narrow the spectrum of flower visitors. The blossoms of the Bladder Senna *Colutea arborescens* (Fabeceae) possess stiff keels that have to be pressed open for access towards nectar and pollen. The aim of this study is to examine interactions between flowers of *Colutea arborescens* and its pollinators using measurements of the forces needed to open the flowers as well as the forces of potentially and actually pollinating bee species. We found that large and heavy bees, e.g. the carpenter bee *Xylocopa* sp. open the flowers due to their weight; megachilid bees, e.g. small and lightweight *Megachile ericetorum* bees handle the flowers with proper technique to get access to nectar and pollen; by contrast, honeybees and bumblebees were unable to legitimately visit the flowers. The flower morphology favours pollen deposition on the dorsal abdomen in *Xylocopa* and on the lateral abdomen in *Megachile* bees. These findings are discussed in the context of the pollen dilemma which is the phenomenon that bees are not only good pollen vectors, but also collect large amounts of pollen that are no longer available for pollination.

# SATURDAY – 3RD SESSION

**Pollinator-mediated, indirect effects of climate on plant performance in alpine communities**

Sarah K. Richman[1,2], Christopher A. Johnson[2], Laura Stefan[2], Jonathan M. Levine[2]

[1]*Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ, USA*
[2]*Department of Environmental System Sciences, Institute of Integrative Biology, ETH-Zürich, Switzerland*

Global climate change is expected to alter ecological communities through changes in species' local abundances and geographic ranges. Species' range shifts are thought to drive novel species interactions as species migrate at different rates in response to changes in climate. Plant-pollinator communities are expected to be particularly susceptible to interaction decoupling due to the different speeds at which plants and pollinators are able to migrate to "track" climate change. We examined the effect of climate-driven changes in pollinator communities on plant reproductive success in the Swiss Alps by transplanting high-elevation plant communities along an elevation gradient, observing subsequent pollinator visitation, and measuring female reproductive success. While we found species-specific effects of warming on pollinator visitation rates, two overall results emerge. First, all plant species received increased visitation under intermediate warming, which we attribute to high pollinator diversity observed at these temperatures. Second, all species suffered reduced reproductive output at high levels of warming, regardless of pollinator visitation rate. Our results demonstrate that while small increases in global temperature may benefit plant species due to increased pollinator activity, these benefits disappear under more extreme warming predicted by global climate models.

# Altered flowering phenology of bilberry and lingonberry as response to simulated warming and herbivory

Mark Gillespie and Stein Joar Hegland

*Western Norway University of Applied Sciences, Faculty of Science and Engineering, Campus Sogndal*

Flowering phenology and abundance is central to plant reproduction and pollination interactions. Alteration of flowering start, peak, duration and abundance caused by climate change or other drivers may change the mutualistic interactions between plants and pollinators. This may have cascading effects on other animals, for example birds, that feed on berry resources.

Along a climatic (altitudinal) gradient we simulated the combined impacts of increased temperatures and herbivore attack on flowering and reproduction of *Vaccinium myrtillus* (bilberry) and *Vaccinium vitis-idaea* (lingonberry). We selected open southfaced sites in boreal forest dominated by bilberry at ca. 100, 500 and 900 m.a.s.l. (hereafter termed "low", "intermediate" and "high") spanning the natural altitudinal range of these species in this climatic region. At each site, 6 blocks were established wherein 4 plots were randomly placed. Open top chambers (OTCs), that typically raise the temperature by 1-2 degrees, were placed in two of the plots from April to October. One OTC-plot and one ambient plot were then treated with Methyljasmonate (MeJA) to simulate herbivore attack by induced defence responses in the plants.

We measured first flowering dates, the number of flowers, length of flowering period, peak flowering and flowering abundance. Berries were also counted and weighed. We hypothesized that flowering start, peak flowering and length of flowering should be linearly related to the climate gradient, but that all variables should be positively affected (i.e. flowering should start and peak earlier, and that flowering would last longer and have higher abundance) by OTCs, negatively by herbivore treatment and that there would be an additional effect of the combined treatment. As bilberry and lingonberry are near their optimum at the intermediate site, we hypothesized that flowering abundance and berry production variables would be highest at this site and that these variables would be most negatively affected by OTC- treatment in the low site and most positively at the high site.

Preliminary results indicate that flowering variables were tightly linked to the climatic gradient. The OTC-treatment had less effect on most flowering variables than we expected. In contrast, we found a negative effect of OTCs on berry weight at the low site in the first year and a positive effect at the medium site. Both of these effects were not significant in the second year. Herbivore-treatment had the largest effect on flowering and reproductive variables; MeJA-treatment delayed flowering start and decreased the length of flowering period and flowering abundance irrespective of placement along the climate gradient.

# Influence of microclimatic heterogeneity on alpine plant and flower visitor diversity

Lisa-Maria Ohler, Martin Lechleitner, Robert R. Junker

*Department of Ecology and Evolution. University Salzburg, Austria*

High-alpine plant species are commonly assumed to be particularly endangered by climate warming and are expected to migrate upwards to escape rising atmospheric temperatures. Alpine landscapes are characterized by a heterogeneous topography creating microclimatic refugia due to different exposures of solar radiation. Soil temperatures deviate from air temperatures and are crucial for the life of alpine plants potentially affecting alpine plant diversity as well as insect-plant interactions. We investigated microclimatic differences in soil temperatures of several 2.25 $m^2$ plots on a topographically heterogeneous high alpine pasture in the Austrian Alps. Soil temperature and surface temperature heterogeneity was highly variable between the plots. Plant species diversity was higher on warmer and more heterogenous plots. Plant species composition also responded to microclimatic heterogeneity. The diversity of flower visitors was increased on plots with higher plant diversity (i.e. warmer plots). Microclimatic heterogeneity thus influences plant alpha- and beta-diversity and indirectly affects the distribution of flower visitors. Our study thus clearly supports the notion that microclimatic refugia have the potential to buffer negative effects of climate warming on alpine plant communities.

# Vertical stratification of plant-flower visitor interactions

Jan Klečka[1], Jiří Hadrava[1,2], Pavla Kolouškova[1]

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[2]*Department of Zoology, Faculty of Science, Charles University, Prague, Czech* Republic

Interactions between plants and insect flower visitors vary in time and space at different scales. A neglected aspect of small-scale variation of plant-flower visitor interactions is the role of vertical position of flowers. We conducted two experiments in a dry grassland to study vertical stratification of plant-flower visitor interactions.

In the first experiment, we observed flower visitors on cut inflorescences of *Centaurea scabiosa* and *Inula salicina* placed at different heights above the ground in two types of surrounding vegetation: low and high. Even at such a small-scale, we detected highly significant shift in total visitation rate of inflorescences in response to their vertical position. In low vegetation, inflorescences close to the ground were visited more frequently, while in high vegetation, inflorescences placed higher received more visits. Moreover, we found major differences in the composition of the flower visitor community on flowers at different heights.

In the second experiment, we measured flower visitation rate in inflorescences of *Salvia verticillata* growing at different heights. Flower visitation rate increased markedly with inflorescence height. We later harvested seeds to test whether there was a corresponding difference in seed production.

Overall, our results demonstrate strong vertical stratification of plant-flower visitor interactions at the scale of mere decimetres, which may have a number of ecological and evolutionary implications.

# SATURDAY – 4TH SESSION

## THE INTERPLAY OF CLIMATE AND LAND USE CHANGE AFFECTS THE DISTRIBUTION OF EU BUMBLEBEES

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Bumblebees in Europe have been in steady decline since the 1900s. This decline is expected to continue with climate change as the main driver. However, at the local scale, land use and land cover (LULC) change strongly affects the occurrence of bumblebees. At present, LULC change is rarely included in models of future distributions of species. This study's objective is to compare the roles of dynamic LULC change and climate change on the projected distribution patterns of 48 European bumblebee species for three change scenarios until 2100 at the scales of Europe, and Belgium, Netherlands and Luxembourg (BENELUX). We compared three types of models: (1) only climate covariates, (2) climate and static LULC covariates and (3) climate and dynamic LULC covariates. The climate and LULC change scenarios used in the models include, extreme growth applied strategy (GRAS), business as might be usual (BAMBU) and sustainable European development goals (SEDG). We analysed model performance, range gain/loss and the shift in range limits for all bumblebees. Overall, model performance improved with the introduction of LULC covariates. Dynamic models projected less range loss and gain than climate-only projections, and greater range loss and gain than static models. Overall, there is considerable variation in species responses and effects were most pronounced at the BENELUX scale. The majority of species were predicted to lose considerable range, particularly under the extreme growth scenario (GRAS; overall mean: 64% ± 34). Model simulations project a number of local extinctions and considerable range loss at the BENELUX scale (overall mean: 56% ± 39). Therefore, we recommend species-specific modelling to understand how LULC and climate interact in future modelling. The efficacy of dynamic LULC change should improve with higher thematic and spatial resolution. Nevertheless, current broad scale representations of change in major land use classes impact modelled future distribution patterns.

**Effects of agricultural intensification on pollination services in shea parklands of Burkina Faso**

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Shea parkland is a form of agroforestry which is common in the Sudano-Sahelian zone of West Africa. It is present in 13 West African countries and is the dominant agricultural landscape in Burkina Faso. Pressure due to climate change, rising populations and migration have resulted in parklands with an increasing proportion of land under cultivation and reductions in fallow areas, as well as fragmentation of wood and scrub habitats. Shea (*Vitellaria paradoxa*) is pollinated by insects, and loss and fragmentation of natural habitats has been observed to affect insect-mediated pollination services elsewhere. Here, we aimed to determine whether landscape factors affect insect pollination services and yield of shea trees in parklands in southern Burkina Faso. We recorded density of shea trees, tree and shrub diversity and flower herbivory at ten 1ha sites in the Centre-Sud region and mapped cultivated areas and human habitations within 1km of each site. We counted flower visitors to shea within the sites and assigned them to functional groups based on morphological features. We also investigated pollination limitation by comparing fruit set of hand pollinated flowers with flowers left open to natural pollination. We then assessed whether pollination limitation and flower visitors differed depending on landscape characteristics. Preliminary results will be presented. This research will provide information going towards recommendations for agricultural practices in shea parklands, and therefore contribute to the food security and income of subsistence farmers in an underdeveloped region.

**Impact of managed honey bee (*Apis mellifera*) on the activity of native floral visitors in a boreal forest ecosystem in NE Poland.**

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Appearance of new species in a stable ecosystem may influence structure and stability of plant-pollinator relationships. Managed honey bee (*Apis mellifera*) is one of the most widespread insect that is intentionally or unintentionally introduced into many pollination networks around the world. There is an increasing interest in recent years in the role of honey bees in natural ecosystems, with some of the studies showing negative influence of A. mellifera on native pollinators. However, little is known about that from Europe. Our study was conducted in Wigierski National Park (NE Poland), where honey bee does not occur. Using nine plots and three indicator plants (*Campanula persicifolia*, *Hypericum perforatum*, *Impatiens parviflora*), we recorded activity of floral visitors. Initially, in 2016 we set observations of only natural pollinators, while in 2017 we put hives in six experimental sites (we differentiated number of hives per site – 3 per site, 1 per site and control without hives). We compared frequency of each visitor morphogroup (bumblebees, honey bees, solitary bees, hoverflies, butterflies and others) in order to test how the presence of honeybees influences behaviour of native floral visitors.