23rd Annual Meeting of the Scandinavian Association for Pollination Ecologists

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Program

Friday 23 October

16:00	Registration
18:20	Welcome
18:30	Dinner
19:30	Keynote — Mark van Kleunen: Baker's Law as a rule in invasion ecology
20:30	Posters Sauna

Saturday 24 October

7:30	Breakfast
	1st session — Chairperson Johan Ehrlén
8:40	Julie Lebeau: How do butterflies cope with a sudden limitation in nectar availability?
9:00	Manja Wendt: Ants too can smell it: The attractiveness of rewarded floral scents
9:20	Michael Werner: Pollen feeding by flower visiting insects
9:40	Miguel Munguía-Rosas: Exploring the adaptive value of flowering phenology: The relationship between flowering onset and synchrony with reproductive success in three British plant species
10:00	Daniel Wisbech Carstensen: Coexistence of two *Lichmera* honeyeaters on Lombok, Indonesia
10:20	Coffee
	2nd session — Chairperson Roosa Leimu
10:40	Keynote — Lynn Adler: Sex and food: The role of flowers for pollinators and herbivores
11:40	Paul Page: The role of floral traits in the nursery pollination of *Silene* by *Hadena bicruris*
12:00	Laurent Natalis: Ethological and physiological isolation between *Rhinanthus minor* and *R. angustifolius*: Where are the leaks?
12:20	Lunch
	3rd session — Chairperson Jon Ågren
14:00	Georg Andersson: Effects of farming practice and age of organic farms on pollination services
14:20	Eeva-Liisa Alanen: Differential responses of social bees and day-active Macrolepidoptera to long-term set-aside
14:40	Mariken Kjøhl: Potential effects of climate change on pollinator dependent crops
15:00	Coffee

4th session — Chairperson Marcos Méndez

15:30 Amparo Lázaro: Factors related to the inter-annual variation in plants' generalization levels within a community

15:50 Jens Olesen: Strong, long-term dynamics in ecological networks

16:10 Marcin Zych: Apiaceae pollination: How specialized can a generalist plant be?

16:30 Ana López Llandres: Floral predators affect the structure of pollination networks through their effects on the behaviour of pollinators

16:50 Yoko Dupont: Spatial and temporal stability of modularity and network keystone species in pollination networks

17:10 Pause

5th session — Chairperson Pia Mutikainen

17:30 Robert Junker: Alien ants on alien plants? What determines the distribution of nectar-feeding ants on flowers in Hawaii?

17:50 Christopher Kaiser-Bunbury: Are invasive plants detrimental to generalised native plant-pollinator interactions?

19:00 Dinner

21:00 Sauna, Leperdisco

Sunday 25 October

4:00 Summer time ends. Put your watch back one hour.

8:00 Breakfast

6th session — Chairperson Ørjan Totland

9:00 Nils Hasenbein: Pollination in fragmented ecosystems: Between competition and isolation

9:20 Anne Weber: Population size, pollination and selection on flowering phenology and floral display

9:40 Carolin Mayer: Population size effects on the pollination of *Comarum palustre* L. (Rosaceae)

10:00 Chris Kettle: Flower size variation supports tropical tree species coexistence in Borneo

10:20 Pause

7th session — Chairperson Tommy Lennartsson

10:40 Rebekka Lundgren: Experimental reduction in flower visitation does not cause high reduction in the reproduction of plant species in a Norwegian meadow

11:00 Jon Ågren: Context-dependent selection and the maintenance of variation in floral display

11:20 SCAPE 2010

11:30 Lunch

12:45 Departure from Seili

16:00 Arrival to Turku

Keynote speakers

Friday at 19:30

Baker's Law as a rule in invasion ecology

Mark van Kleunen

University of Bern, Switzerland

In 1955, Herbert Baker suggested that plants capable of uniparental reproduction should be more likely to establish populations after long-distance dispersal because such plants do not rely on the availability of mates and pollinators. Although this hypothesis has since become known as 'Baker's Law', many exceptions have been reported that casted doubt on its general validity. For example, the high frequencies of dioecious plant species on oceanic islands, suggests that obligate outcrossing may not be a major barrier to long-distance colonization of islands. However, a problem of studying historical colonization events is that we do not know which species reached islands but did not manage to colonize. Therefore, the study of more recent colonization events – alien plant invasions – may provide a good framework to test Baker's Law.

Here, I will give an overview of my work and the work of others on breeding systems of alien, invasive and non-invasive, plant species. I will show, using comparative multi-species studies, that in general self-compatible species and species capable of self-fertilization are more likely to naturalize (i.e. establish populations) and spread (i.e. become invasive) once introduced to new regions. Additionally, I will show, using case studies on several invasive species, that the high spread rate could be explained by the fact that species capable of self-fertilization suffer less from Allee effects. In conclusion, although Baker's Law may not be a law, most evidence indicates that it is a rule in invasion ecology.

Saturday at 10:40

Sex and food: The role of flowers for pollinators and herbivores

Lynn Adler

Department of Plant, Soil & Insect Sciences, University of Massachusetts, Amherst, USA

Plant-animal interactions are thought to have played a key role in the diversification of angiosperms, but plant-pollinator and plant-herbivore interactions have historically been studied independently. Flowers act as signals for mutualist pollinators, but such cues may also be used by a variety of floral antagonists including nectar robbers, florivores, and seed predators. Furthermore, many insects function as pollinating adults but have herbivorous larvae, providing the potential for mutualist interactions to have negative consequences if pollinators oviposit their offspring on preferred plants. The role of floral traits in determining the outcome of this interaction, ranging from pollination to herbivory, is largely unexplored outside of a few highly specialized systems. Furthermore, if traits such as defensive chemicals are correlated in leaves and floral tissue, it may be difficult for plants to evolve optimal solutions to conflicting selection pressures for attractive flowers and defended leaves. Here I present data from several systems examining the extent to which plants encounter conflicting tradeoffs between attracting pollinators while deterring herbivores, the role of plant traits in determining the outcome of interactions that range from pollination to herbivory, and the potential for conflicting selection pressure due to correlated traits across tissues. Examining the broad context in which traits evolve should provide a greater understanding of the ecology and evolution of plant attractive and resistance traits.

Oral presentations

1st session

How do butterflies cope with a sudden limitation in nectar availability?

Julie Lebeau, Renate Wesselingh and Hans Van Dyck

Biodiversity Research Centre, Université catholique de Louvain, Louvain-la-Neuve, Belgium

Maniola jurtina (meadow brown butterfly) is a common butterfly in European agricultural landscapes, feeding mainly on purple flowers, known to be nectar rich.

For this study, we were interested in the life-size experiment consisting of leaving an uncut edge in a mown meadow, which can be considered as a sudden limitation of most ecological resources, including nectar.

Based on the hypothesis of an increase in insect density in the uncut meadow edge, we investigated whether nectar was less available for butterflies and whether it influenced their flower choice.

Three experiments were conducted in summer 2009 in Southern Belgium. The first one aiming at establishing the increase in insect density took place in ten meadows and consisted in quantifying insects in transects before and after mowing. The second experiment consisted in recording visitation rates on standardized flowers, before and after mowing in a flower-rich meadow. It aimed at quantifying both visitation frequency and nectar left after half a day in the meadow. Simultaneously, the third experiment recorded flower preferences of the meadow brown butterfly in order to detect any change due to this sudden limitation in nectar availability.

Results of all three experiments will be presented and discussed.

Ants too can smell it: The attractiveness of rewarded floral scents

Manja Wendt and Michael Rostás

Department of Botany II – Ecophysiology and Vegetation Ecology, University of Würzburg, Germany

In their reproductive state, plants become transmitters of various signals that can be perceived and taken advantage of by nectar-searching insects. A specific scent can aid localising nectar-bearing flowers within an odorant environment. If the nectar turns out to be valuable, the scent may act as reinforcer in successive nectar foraging. Regarding perception and processing of odour signals there is innumerable literature available on honey bees and they show enormous learning abilities. Considerably less is known about the scent efficacy on other nectarivorous insects. Several ant species are frequent nectar collectors, but are also found to avoid flower visits of certain plant species. Thus, the question arises whether ants use flower scent when foraging. Considering that odour signals are very important in many other aspects of ant´s life, we expected a role for floral scent, too. Furthermore ants are well equipped for effective neuronal and behavioural processing of scent signals. Using a Y-maze fitted to provide floral scent we tested ants for their odour preferences. For this purpose we compared the answers of naive individuals with those of classically conditioned ants. Trained animals preferred the rewarded over the unrewarded flower bouquets. Our results show that ants can recognise and discriminate ecologically relevant odour which implies that they may use these abilities in a nectar foraging context. We also found, that re-training may reverse the preference for an odour, suggesting that ants are able to exploit the sequence of many appearing nectar sources over the flowering period in the field.

Pollen feeding by flower visiting insects

Michael Werner, C N Weiner, M Klug, M Jäger, S Z El-Damrawy, K-E Linsenmair and N Blüthgen

Department of Animal Ecology and Tropical Biology, University of Würzburg, Germany

Most flower visitors visit flowers to feed on nectar or pollen. Nectar feeding is well studied, and flower visitors use nectar mainly as an energy source. Ingestion of pollen can have different reasons and could happen accidently. For many flower visitors it is unclear if they ingest pollen and if they are able to digest it. Pollen is known to be difficult to digest because of its exine structure.

In our study we observed the condition of pollen in faeces of more than 160 insect species from 30 families and 5 different insect orders to ascertain if the pollen is digested. Pollen was found in faeces of all insect orders examined, but the total amount and the percentage of apparently digested pollen strongly differed between samples, as well as the number of different pollen types.

Insect groups characterised by large amounts of pollen in faeces and digestion rates included beetles, many calyptrate flies, Empididae and Syrphidae among others. In contrast, groups that probably accidently ingested the pollen involved Tachinidae and Stratiomyidae by nectar feeding. Some pollen types were more often digested (e.g. Rubiaceae) than others (e.g. *Plantago media*).

In experiments with the hover fly *Episyrphus balteatus*, we assessed the average foraging time span that a faeces sample may represent. Moreover, faeces samples originating from individuals collected on different grasslands were analysed whether they represent the composition of flower composition on each site.

Exploring the adaptive value of flowering phenology: The relationship between flowering onset and synchrony with reproductive success in three British plant species

Miguel A Munguía-Rosas[1,2], Jeff Ollerton[1] and Victor Parra-Tabla[2]

[1]University of Northampton, UK
[2] Universidad Autónoma de Yucatán, Mexico

One of the most important events during the life cycle of angiosperms is the start of flowering. As flowering onset frequently exhibits intrapopulation variation with an underlying genetic basis, it has been suggested that this trait should be optimized by natural selection. However, published empirical evidence is ambiguous and the extent of such optimization is controversial. The adaptive value of other phenological traits such as synchrony are also poorly understood. We studied the flowering phenology of three sympatric, unrelated plant species (*Mercurialis perennis*, *Arum maculatum* and *Tamus communis*) with contrasting pollination mode (wind and insects) and sexual system (monoecious and dioecious). We addressed the following questions: Is there any evidence of phenotypic selection on flowering time and synchrony of the species under study? Are these traits influenced in some extent by resource availability? To answer these questions we tracked flower and fruit production during field work in 2009. Preliminary results suggest that flowering time and synchrony is not being selected for in *M. perennis* (dioecious and wind pollinated) and there is directional selection on flowering time in *A. maculatum* (monoecious and insect pollinated). Using plant size as a surrogate of resource availability, our results also suggest that availability of resources partially explains variation in reproductive success and flowering time of *M. perennis*. The *Tamus communis* data set is currently being analyzed. It seems that pollen vector and sexual system influence the strength of selection. However a more systematic review of evidence is needed to draw a conclusion; to assess this matter we are conducting a quantitative review of literature.

Coexistence of two *Lichmera* honeyeaters on Lombok, Indonesia

Daniel Wisbech Carstensen

Section of Ecology and Genetics, Aarhus University, Denmark

According to classic niche theory morphologically and ecologically similar species should not be able to coexist because of intense competition. More or less overlapping distributions in space or time are however often seen for very similar species. This is the case for three nectarivorous birds on the island of Lombok, Indonesia. Here two closely related and very similar *Lichmera* honeyeaters and one *Cinnyris* sunbird coexist to some extent. Fieldwork was done to study if and how these species segregate ecologically, and what happens in areas where they coexist. It was found that the two honeyeaters was partially separated in altitude. In the zone of overlapping distributions, one species dominated forest habitats while the other dominated non-forest habitats. The sunbird, found at same altitude, was never observed in the forest, where honeyeaters were abundant, and was mostly observed in poor resource patches outside the forest.

2nd session

The role of floral traits in the nursery pollination of *Silene* by *Hadena bicruris*

Paul Page[1], Adrien Favre[1], Florian Schiestl[2], Alex Widmer[1] and Sophie Karrenberg[1]

[1] Integrative Biology, ETH Zürich, Switzerland
[2] Systematic Botany, University of Zürich, Switzerland

Floral traits such as scent and colour attract pollinators as well as predators but the effects of these signals are difficult to isolate. The nursery pollinator *Hadena bicruris* prefers white-flowering *Silene latifolia* over its close relative the red-flowering *S. dioica*. We investigated the relationship of capsule predation by *H. bicruris* to flower colour and night-emitted scent. We used 98 field-transplanted second-generation hybrids between *S. latifolia* and *S. dioica*, which exhibited strong trait segregation, as well as individuals of both species. Whiter flowers and stronger emission of methyl salicylate were good predictors of capsule predation indicating that they may function as attractants to *Hadena.* However, methyl salicylate was emitted by both species and odour compounds with strong differences between species, such as lilac aldehydes, were not associated with capsule predation. Thus, our findings suggest that species differences in flower colour but not in floral scent drive capsule predation by *H. bicruris* in this *Silene* species-pair system.

Ethological and physiological isolation between *Rhinanthus minor* and *R. angustifolius*: Where are the leaks?

Laurent Natalis and Renate A Wesselingh

Biodiversity Research Centre, Université catholique de Louvain, Louvain-la-Neuve, Belgium

Rhinanthus minor L. and *R. angustifolius* C.C. Gmelin (Orobanchaceae) are annual hemiparasitic plants pollinated by bumblebees and growing in very similar habitats. The flowering periods and geographical ranges of these species largely overlap in Europe, and where they co-occur, hybridization and introgression are found.

We try to understand the process of hybrid formation by exploring the ethological and physiological (post-pollination, pre-fertilization) borders between these two closely related species.

We compared pollen tube growth rates between conspecific and heterospecific pollen and tested whether a conspecific pollen advantage occurs after mixed pollinations, by identifying hybrid seeds by genotyping.

In the field, we quantified bumblebee species richness in natural populations as well as their reward-collecting behaviour and pollen uptake and deposit. We also tested the impact of one patchy spatial distribution of the two *Rhinanthus* species on the probabilities that individual bumblebees switch between the two species.

The results will be presented and their implications in the hybridization of *Rhinanthus* will be discussed.

3rd session

Effects of farming practice and age of organic farms on pollination services

Georg Andersson, Henrik Smith and Maj Rundlöf

Environmental sciences, Lund University, Sweden

Agricultural landscapes shape large parts of earth's ecosystems, and can be both a threat to and a promoter of biodiversity depending on the farming practice and/or intensification. During the last century there has been major intensification in agricultural landscapes and large declines in semi-natural habitats. This affects not only biodiversity but also the ecosystem functions such as pollination. To get a more general understanding of organisms and their interactions among them selves as well as with their environment, landscape ecology can be applied. Studies of landscape effects on biodiversity most often focus on the spatial distribution and quality of habitats, but the time-scale and ecosystem services is not equally well studied. How historical processes effects the configuration of biodiversity and ecosystem function is of great importance to more efficiently set up management to prevent further losses. Organic farming is one of the environmental schemes that has been argued to benefit biodiversity, but effects have been shown to depend on landscape context.

Here I present studies of the effects of landscape use intensity and farming practice on biodiversity and pollination. We used strawberries (*Fragaria ananassa*) in pots put out in field margins on farms differing in time since transition to organic farming.

Preliminary results show that strawberries are better pollinated in old organic farms than in young and also in organic compared with conventional farming.

Differential responses of social bees and day-active Macrolepidoptera to long-term set-aside

Eeva-Liisa Alanen[1], Mikko Kuussaari[1] and Terho Hyvönen[2]

[1] Research Programme for Biodiversity, Finnish Environment Institute, Helsinki, Finland
[2] Plant Production Research, MTT Agrifood Research Finland, Jokioinen, Finland

Pollinators are an important component of the functional biodiversity found in agroecosystems. However, the populations of many species are currently in decline, which is largely due to the intensification of agriculture. Effective measures are, therefore, needed to enhance pollinator populations and to secure pollination services both for wild plants and crops. We studied the response of abundance and species richness of four pollinator groups to one of the optional measures, the long-term set-aside with three different seed mixtures and two mowing treatments. The study was conducted as a field experiment in southern Finland, in the years of 2003-2008. The studied groups, in order of their decreasing importance as pollinators, were the honey bee, bumblebees (*Bombus* and *Psithyrus)*, butterflies and day-active moths. Social bees responded to the established set-asides faster than the butterflies and moths. Bumblebees were super-abundant during the first year of the experiment, which was mainly due to the abundant flowering of the annual plant *Phacelia tanacetifolia* in the treatments sown with meadow plants. Species richness of butterflies was found to respond faster than the species richness of moths. By the last two years of the experiment, mowing had benefited the studied groups, with the exception of moth species richness. Furthermore, a comparison with surrounding field margins showed their higher importance for the Macrolepidoptera than for the social bees.

Potential effects of climate change on pollinator dependent crops

Mariken Kjøhl, Anders Nielsen and Nils Christian Stenseth

Centre for Ecological and Evolutionary Synthesis, University of Oslo, Norway

Despite our increased awareness of potential negative effects of changed global climate on pollination services, there is striking paucity in studies on how the pollination of insect pollinated crops may change under climate change. A growing human population and food demand amplifies the importance of a broader understanding of the effects of future climate scenarios on pollinator dependent crops, which represent important nutritional and economic values. We have been asked by The Food and Agricultural Organization of the United Nations (FAO) to compile a review of existing knowledge on potential climate change impact on insect pollinated crops and their most important pollinators on a global scale. Studies of climate change effects on wild plant-pollinator systems reveal that phenological mismatches may occur when plants and pollinators responds to increased temperatures in contrasting ways. Due to the shortage of relevant studies we have also examined studies on climate change effects on wild plant-pollinator systems as well as studies on other environmental pressures, such as habitat fragmentation, invasive species and pesticide applications. We aim to draw inference from these studies on the potential effects of global change on pollinator dependent food production. We will also try to make recommendations on the recording and management of pollinator interactions data, including important environmental variables that could be included in observational records, such that the knowledge base on crop pollination and climate change is enhanced. Here we will present some preliminary results.

4th session

Factors related to the inter-annual variation in plants' generalization levels within a community

Amparo Lázaro[1], Anders Nielsen and Ørjan Totland

[1] Norwegian University of Life Sciences, Norway

The number of pollinators of a plant species is considered a measure of its ecological generalization and may have important evolutionary and ecological implications. Many pollination studies report inter-annual fluctuations in the composition of pollinators to particular species. However, the factors causing such variation are still poorly understood. Here, we investigate how plant and pollinator assemblages, and sampling effort influenced the inter-annual changes in the functional generalization level of the 20 most common plant species of a semi-natural meadow in southern Norway. We also studied the extent to which such changes were limited by flower shape and flowering phenology. Large inter-annual changes in generalization levels were common and there was no relationship between the generalization level one year and the following. Plants with different flower shapes and phonologies did not differ in the extent of inter-annual variation in generalization levels. Generalization level of particular plant species increased with flowering duration, sampling effort, and the abundance of managed honeybees in the community. Generalization level decreased with the flowering synchrony between the focal plant species and the rest of the plant community and with the focal species own abundance, which we attribute to interspecific competition for pollinator attraction and foraging decisions made by pollinators. Most studies do not consider the effect of the plant community on the generalization level of particular plant species. We show here that both pollinator and plant assemblages can affect the inter-annual variation in generalization levels of plant species. Studies like ours will help to understand how pollination interactions are structured at the community level as well as the ecological and evolutionary effects these inter-annual changes in generalization levels may have.

Strong, long-term dynamics in ecological networks

Jens M Olesen[1], Constantí Stefanescu[2] and Anna Traveset[3]

[1] Department of Biological Sciences, Aarhus University, Denmark
[2] Butterfly Monitoring Scheme, Museu Granollers-Ciències Naturals, Barcelona, Spain
[3] Institut Mediterrani d'Estudis Avançats (CSIC-UIB), Mallorca, Spain

Nature is organized into complex, dynamical networks of species and their interactions, influencing overall diversity and stability. However, studies are generally short-term and depict ecological networks as static structures only devoid of any dynamics. We studied the long-term (12-yrs) behaviour of a set of similar pollination networks, and their constituting species and links. The networks consisted of butterflies and their nectar plants. Species varied bimodally in their temporal permanence. Sporadic species being present only 1-2 years and stable species being present 11-12 years dominated the networks. Temporal permanence and linkage level of species, i.e. number of links to other species, defined two groups of species: Specialists varying a lot in their temporal permanence, and temporally stable species varying a lot in their linkage level. Both species and links had a strong temporal dynamics, except for a core of temporally stable generalists. The turnover of links of specialists was driven by the turnover of their species, whereas the turnover of links among generalists took place by rewiring. The strong temporal dynamics of both species and links is an astonishing feature of ecological networks, which somehow may contribute to their overall stability.

Apiaceae pollination: How specialized can a generalist plant be?

Marcin Zych and R Niemirski

University of Warsaw Botanic Garden, Warsaw, Poland

Plants of the family Apiaceae (=Umbelliferae) are usually placed among the species regarded 'promiscuous' in terms of pollination systems. In fact many of them may be characterized by wide range of flower visitors, however recent studies of this plant group suggest that the actual number of anthophilous taxa should not be equalized with the number of their efficient pollinators. Our studies of pollination biology of three common European taxa (Heracleum sphondylium subsp. sphondylium, H. sphondylium subsp. sibiricum, Angelica sylvestris) have shown that their key pollinators are restricted to a few dipteran groups (A. sylvestris) or even species (H. sphondylium), which suggests at least ecological specialization, and that a large proportion of flower visitors utilize flower resources but do not provide pollination service. Based on our results and new literature data we discuss the concept of specialization/generalization in pollination systems of the umbellifers and difficulties in determining their efficient pollinating agents.

Floral predators affect the structure of pollination networks through their effects on the behaviour of pollinators

Ana López Llandres

Department of Functional and Evolutionary Ecology, Estación Experimental de Zonas Áridas (CSIC), Spain

Floral predators have been neglected in ecological and evolutionary studies of pollination networks, despite their potential effects on plant-pollinator interactions. We compared visit rates of syrphids and bees to *Chrysanthemum segetum* patches with different levels of predation risk (with and without crab spiders) and nectar availability (rich and poor patches) throughout five consecutive days. Pollinators responded differently to the trade-off between predation risk and foraging success: bees preferred rich patches without spiders and avoided poor risky patches, while the number of syrphids was highest at poor risky patches. Because bees were more susceptible to predation than syrphids, our results confirm theoretical predictions that, in the presence of competition for resources, less susceptible pollinators should preferentially exploit riskier resources. Our study highlights the role of predators in determining the structure of pollination networks through their indirect effects on pollinators' behavior. Furthermore, since the association of predation risk with a particular flower affects the relative frequency with which pollinators visit the flower, floral predators may either reduce or increase plant fitness, imposing selective pressures on floral traits.

Spatial and temporal stability of modularity and network keystone species in pollination networks

Yoko L Dupont and Jens M Olesen

Section of Ecology and Genetics, Aarhus University, Denmark

Modularity is a non-random structure of networks, when the network tends to be organized into sub-groups of species interacting more tightly with one another than with species outside the sub-group. Modularity of networks is a property, which has received much interest, but has been little investigated, mainly due to lack of a powerful method. Recently, however, Guimerà and Amaral (2005 *Nature*) developed a new computational tool, functional cartography by simulated annealing (FCSA), an optimization technique, which can reliably identify modules. Applying this algorithm to 51 pollination networks, Olesen et al. (2007 *PNAS*) showed that all large networks (>150 species) are significantly modular. In the current study, we investigate the stability of modular structure in pollination networks from one habitat type (heathland) at three different sites, and in networks of different temporal scaling. We show that modularity is remarkably constant. Similar modules are found across sites, and modules are formed at an early stage, often remaining throughout the flowering season. Thus, modular organization of pollination networks is stable across space and time. This stability appears to be connected to the existence of a few (8-9) hub plant species. These are highly generalist plant species, which attract a large number of insect species. Modules mostly aggregate round one or two such hub plant species. Thus, hub plants may be regarded as network keystones.

5th session

Alien ants on alien plants?
What determines the distribution of nectar-feeding ants on flowers in Hawaii?

Robert R Junker[1], Curtis C Daehler[2] and Nico Blüthgen[1]

[1] Dep. of Animal Ecology & Tropical Biology Biozentrum, University of Würzburg, Germany
[2] University of Hawai'i, Honolulu, USA

The Hawaiian Islands, the most isolated terrestrial habitats worldwide, lacked several taxa prior to their introduction by humans. Ants were among those missing components but arrived in the last century. Invasions by ants were associated with severe ecosystem consequences. Since few native Hawaiian plants possess extrafloral nectaries and honeydew producing insects are not abundant, floral nectar may be an important source of sugar. Nectar larceny by ants, however, often interferes with pollination and leads to reduced seed set. Accordingly, many plant species protect their flowers by chemical or mechanical means against ant visits. We compared these defences of native and introduced plant species and tested their influence on the interaction strength between ants and flowers.

In a network approach, we found – based on the resources offered by flowers and the ants' abundance on sugar baits – that flowers of plants native to Hawaii were heavier exploited by ants than flowers of introduced plants. Mechanical barriers, repellent floral scent and unpalatable nectar occurred more often in introduced plant species and potentially provide non-exclusive explanations for this observation.

We hypothesise that plants which shared a long evolutionary history with often antagonistic ants were selected in order to protect their flowers against ants. Native Hawaiian plants were not exposed to this selective pressure and thus lack these ant-specific defences. The absence of mechanical barriers and ant-repellent scents may also correspond to adaptations on bird pollination which is common in Hawaiian ecosystems.

Are invasive plants detrimental to generalised native plant-pollinator interactions?

Christopher Kaiser-Bunbury

ETH Zürich, Switzerland

Introduced species on oceanic islands have displaced critically endangered plants from their natural habitat and created fragmented, small populations of endemics. On the Seychelles, such populations are mostly confined to granitic inselbergs where harsh abiotic conditions and isolated environment have provided some natural protection against introduced species. Inselberg species, however, may encounter strong reproductive constraints through disruption of their pollinator mutualisms by invasive plants. Quantitative network analysis was used to investigate the impact of invasive species on pollinator behaviour, native plant reproductive success and network stability. Based on the findings we assess the importance of considering pollination interactions in invasion processes and derive restoration recommendations.

6th session

Pollination in fragmented ecosystems: Between competition and isolation

Nils Hasenbein

Bielefeld University, Germany

Research on the effects of ecosystem fragmentation on pollination has still not provided conclusive data allowing to predict patterns of change in fragmented habitats. Especially for conservation efforts, a deeper understanding of underlying principles is needed. Results differing between study systems suggest that more case studies, especially in several tropical areas, are needed before general conclusions can be drawn. We present data on the pollination of Acanthus eminens and Acanthus pubescens in Kakamega Forest in western Kenya. The closely related shrubs grow inside mid-altitudinal rain forests and on forest edges, respectively, and both flower between october and january, being visited mainly by carpenter bees (Xylocopa). Due to forest fragmentation, distances between populations decrease. We are trying to assess whether the decreasing geographic isolation affects the species' reproduction, as well as if forest fragmentation itself has an effect on pollinator visitation rates and pollinator species composition of Acanthus eminens. Presented data include species composition and visitation frequencies in both forest and fragment populations of A. eminens and comparisons with observations on A. pubescens. Fruit set, seed set and seed viability are used as measures of reproductive success.

Population size, pollination and selection on flowering phenology and floral display

Anne Weber and Annette Kolb

Vegetation Ecology and Conservation Biology, University of Bremen, Germany

Habitat fragmentation may affect plant-pollinator interactions, and pollinators are known to act as selective agents on plant phenotypic traits. However, only little is known about how fragmentation influences patterns of selection on plant phenotypic traits via changes in pollinator availability. The major aim of this study was therefore to investigate whether habitat fragmentation affects pollinator-mediated selection on plant phenotypic traits, using the self-incom¬patible, perennial herb Phyteuma spicatum (Campanulaceae). Previous studies with this species suggested that small (but not large) populations are pollen-limited and that floral display traits affect pollinator behaviour. We first assessed the effects of habitat fragmentation on the strength and direction of phenotypic selection on inflorescence height, inflorescence size and flowering phenology by collecting data on trait-fitness relationships in 16 populations of varying size. To link differences in fitness to differences in pollination intensity, i.e. to test whether pollinators mediate trait selection, we used supplemental hand-pollination in a subset of six populations. We found among-population variation in linear selection on inflorescence height and size but not on flowering phenology. Differences in selection among populations, however, were not related to population size. The results of the hand-pollination experiment showed no strong pollen limitation in any of the populations, and seed production was not related to population size, both of which may be explained by good flowering and weather conditions during the study year. We conclude that there is varying selection on inflorescence traits, but that this is not affected by habitat fragmentation.

Population size effects on the pollination of *Comarum palustre* L. (Rosaceae)

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Fen species are considered rare plant species since their occurrence is confined to special habitats that are restricted in size and geographical range. Not only in the Ardennes in Belgium, where our study was performed, fen habitats are under destruction and plant species suffer from fragmentation and risk of extinction. Habitat fragmentation may not only reduce diversity of plant species but also diminish species richness and abundance of pollinator guilds. Furthermore, foraging behaviour of flower visiting insects could change finally disrupting plant-pollinator interactions. Reduced seed set and limited gene flow finally lead to inbreeding depression of isolated plant species.

In our study, we examine how population size effects the pollination and fruit set of *Comarum palustre* (Rosaceae). During 26 hours and 40 minutes of flower observation, 627 insects were observed in large and 270 in small populations. In small populations, only half as many flowers were visited during the same amount of time. Significantly less insects were visiting *C. palustre* flowers in small populations during 20min observation (Student's $t = 5,85$; $df = 78$; $p<0,01$).The most important visitors accounting for more than 50% of insects visiting in large but also in small populations were bumblebees with 2.5 more individuals visiting *C. palustre* in large stands (322 compared to 138). First experiments with supplemental pollination show that *C. palustre* suffers from pollen limitation in habitat fragments.

Flower size variation supports tropical tree species coexistence in Borneo

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Mechanisms that support high species richness of tropical tree communities remain poorly resolved, despite their implications for management and conservation of global biodiversity. We reveal the importance of pollination as a driver of species coexistence among twelve tropical tree species in Borneo. Flower production of small-flowered Dipterocarpaceae is two orders of magnitude greater than large-flowered species, but small-flowered trees also have smaller-sized pollinators, lower average pollen dispersal distances and lower mean pollination success than large-flowered species. Paternity analysis revealed that mating between related individuals was more frequent in a smaller-flowered species. Variation in flower size established a trade-off between flower number and pollination success that resulted in equivalent fruit production among species and gives rise to a mechanism that contributes to equalizing individual fecundity among species. This highlights the importance of maintaining pollinator communities and gene flow in order to sustain tropical tree species richness and its associated biodiversity.

7th session

Experimental reduction in flower visitation does not cause high reduction in the reproduction of plant species in a Norwegian meadow

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There is a growing concern whether recently documented pollinator decline will affect the reproduction of plant species and potentially drive a decline in plant populations. In this study we tested if an experimental reduction of flower visitation causes a reduction in seed set in the twenty most common insect-pollinated perennial herbs occurring in a species-rich semi-natural meadow in Norway. In addition, we assessed if the extend of the reduction in seed set was related to the degree of reproductive dependence of plant species on pollinators. To obtain a reduction in the number of flower visits, we placed 30 dome-shaped cages covered with fishnet in the community, and compared them with 30 naturally pollinated plots. We tested the capability of the study species to produce seeds in absence of insects using bagging experiments. We successfully reduced the flower visitation frequency in fourteen of the twenty study species. In those fourteen plant species the experiment on average reduced the flower visitation frequency by 60.8 % and the seed set by 17.4%. The reduction in visitation was not significantly related to the reduction in seed set. However, we found a positive significant relationship between the degree of reproductive dependence on pollinators and the reduction in seed set. Our results indicate that a high reduction in flower visitation does not necessarily cause a high reduction in seed set, and that plant species that are highly dependent on pollinators might be under more threat by pollinator decline.

Context-dependent selection and the maintenance of variation in floral display

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Spatiotemporal variation in interactions with mutualists and antagonists may result in variable selection on plant reproductive traits and contribute to the maintenance of genetic variation in floral display. In an ongoing study, we examine processes underlying variation in selection on scape length, which strongly influences floral display in the self-incompatible, perennial herb *Primula farinosa*. This plant is dimorphic for scape length and produces either a regular or a very short scape. Surveys of natural populations and field experiments show that the long-scaped morph has a higher pollination success, but is also subject to more intense seed predation and grazing than the short-scaped morph. The direction and strength of selection on scape morph varies among populations and years, and this variation can to a large extent be explained by spatial and temporal variation in interactions with pollinators, seed predators and grazers. Recent experiments suggest that both mutualists and antagonists may mediate frequency-dependent selection on scape morph, and that frequency-dependence can vary from positive to negative with rare-morph advantage depending on the relative strength of these interactions. Taken together, the results show that interactions with pollinators, seed predators and grazers may contribute to the maintenance of genetic variation in floral display both by mediating divergent selection among populations and by causing negative frequency-dependent selection on plant stature within populations. The observed selection mosaic is the integrated result of spatial variation in these interactions, each affecting different components of fitness.

Posters

Restoration of pollination webs in native pine woodlands of Scotland

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Restoration ecology is faced with an increasing degradation of world's ecosystems due to human activities. To restore whole communities, the interactions between organisms must be considered, as restoration of a system to its proper state may require -for instance- reinstatement of key linkages related to food web structure. This approach demands a detailed understanding of ecological interactions at the level of community and above.

In managed pine forests, pollinator abundance and richness are strongly linked to abundance and diversity of floral resources available in the understory. These, in turn, are influenced by changes in canopy structure during the course of secondary succession.

In this context, the aims of the project are (1) to understand the influence of canopy age and structure on the assembly of plant-pollinator communities in managed secondary forests, and (2) to explore how this knowledge could aid the functional restoration of pollination webs. These aims are being addressed in the context of a large scale restoration program taking place in the Caledonian pine forests, a highly fragmented, highly endangered habitat of considerable ecological and historical value.

Historical decline of bumblebee diversity in red clover fields

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Once a common crop (before the 1950's), red clover (*Trifolium pratense*) has become rare in Denmark and other North European countries. Today, red clover is an important crop in organic farming. Pollination is almost exclusively by bees, especially long-tongued bumblebee species. Many species of bumblebees are declining, in particular extinctions and decline of species are prevalent from 1950's onwards. However, no studies document a quantitative, historical decline in bumblebee diversity.

In Scandinavia there is a long tradition of research on red clover breeding. In 1930, a prize was offered by the Royal Danish Academy of Sciences to investigate the importance of *Bombus* spp. in pollination of red clover and the distribution of bumblebees and their nests in Denmark. This resulted in at least two studies: Skovgaard (1936) and Stapel (1933). Both present detailed data on species richness and abundance of bumblebees in red clover fields. Using the same observation protocol, we repeated these studies in 2008-2009 using a total of 34 red clover fields in Denmark. Because bumblebee abundances varied through the season, we compared fields using data from the day having the maximum activity level (bumblebee individuals/ha/hour) for each field.

Bumblebee diversity varied among fields and years. Abundances observed in 2008 were not significantly different from the 1930's. However, abundances were lower in 2009. On the other hand, several species observed in the 1930's were never sighted in 2008-9. Currently, only four-five *Bombus* species are common in red clover fields. We are now investigating the effect of landscape configuration on diversity of bumblebees in the red clover fields.

Life-history strategies in *Armeria caespitosa*

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Analysis of life-history adjustments along environmental gradients is an efficient tool to improve our scarce knowledge of how plants can cope with changing environments. Such adjustments in traits like growth rate, reproductive effort, onset of reproduction, and longevity also imply demographic changes in plant populations. Studying both life-history traits and population demography along species elevation gradients could serve to understand how species range limits advance, stand or retreat under the current climate change. We used matrix models, LTRES and flowering probability curves to evaluate the population trend, the variation of life history traits, and the changes in flowering probability-plant size relationship of the Mediterranean high-mountain endemic *Armeria caespitosa* at the extremes of its elevation range in Sierra de Guadarrama.

Our results show that *A. caespitosa* has viable populations at the extremes of its altitudinal range due to plastic shifts in life-history strategies. The lowest population showed lower life expectancies and higher flowering probabilities of the small individuals than the highest population, where large plants were more frequent.

For *A. caespitosa* a faster life history in the lowest population may be a response to a warmer, more stochastic environment. Such plastic strategy may be crucial to face global change. All the evidences found here support the idea that differences in life-history strategies may be highly dependent on the growth conditions and such plasticity confers *A. caespitosa* an unknown capacity for a Mediterranean high-mountain species until now.

Cheaters in mutualism networks

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Most mutualistic network studies assume all species are mutualistic partners. Nonetheless, cheaters of mutualisms are widespread and their role in network organization is unclear. We evaluate the role of cheater species to network topology in two pollination networks (Malpighiaceae and Bignoniaceae) and their flower visitors. We expect that the removal or introduction of cheaters (reward robber animals) may influence network topology by changing nestedness and modularity if they interact with specific subsets of plants. We answered the questions: What are the differences and similarities in topology of the visitation, pollination and robbery networks especially with respect to modularity and nestedness? How are robber species distributed within networks? We did not find differences in the topology of Malpighiaceae networks, although the removal of robbers decreased connectance and nestedness values, whereas in Bignoniaceae, robbers' removal destroyed modularity. Therefore, cheaters influence network organization, increasing nestedness and modularity. The modularity formerly detected on pollinator networks may be generated by the inclusion of all flower visitors. Since cheaters are ubiquitous in ecological systems they may have an important influence on the topology of networks, affecting their dynamics.

Relationships between pollinator visitation, altitude, population size and reproductive success in alpine populations of *Leontodon autumnalis* var. *taraxaci*

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Very few alpine plant species are both self-incompatible and late-flowering, but *Leontodon autumnalis* var. *taraxaci* is a noteworthy exception. These traits, coupled with a low abundance of efficient pollinators in the alpine, suggest that the reproductive success of Leontodon should be strongly constrained by both pollinator availability and climatic conditions.

Here we examine how components of reproductive success in alpine *Leontodon* is related to altitude (as a proxy for climate conditions), pollinator visitation and population size, through a study of 21 *Leontodon* populations at Finse, south-west alpine Norway, during 2008. Pollinator frequency decreased with altitude, and preliminary results suggest that average seed set of populations decreased with altitude, implying that climatic conditions, especially temperature regimes, limit reproductive success in these populations. The average seed weight also decreased with altitude, indicating that seed development might be limited by shorter growing season or temperature regimes during the growing season. Population size did not affect pollinator frequency or reproductive success, but this might be biased by the fact that populations decreases in size with altitude. Demographic results for reproductive and unreproductive individuals show that about 30% in all populations reproduced during the season, and this was stable throughout the altitudal gradient.

Bombus hortorum as pollinators of two rare *Astragalus* species

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Astragalus alopecurus Pallas *(*syn. *Astragalus centralpinus* Braun-Blanquet) is a glacial relict listed in the Red Data Book and its IUCN category is Critically Endangered (CR) and grows on only one site in Bulgaria, a stony, grassy more or less open habitat on marbleized limestone in the coniferous belt at Beglika, Western Rhodopes Mts. This plant species occurs rather restrictedly elsewhere in Asia - China, former USSR, Middle East (Turkey) and Southern Europe – France, Italy (South Alps), former USSR. A total of 1319 flowers were excluded from pollinators and 99.6% of them did not set fruit so they were incapable for spontaneous self-pollination and dependent upon insects for pollen transport. Pollinators included *Bombus hortorum* (the most active) and *B. agrorum* workers, while *B. pratorum* and some others were recorded rarely.

Astragalus dasyanthus Pall. is a rare species for the Bulgarian flora, protected by the Biodiversity Law. Its conservation status is also assessed as Critically Endangered (CR). This plant occurs rather restrictedly elsewhere in Southern and Eastern Europe extending northwards to Hungary and Central Russia. One of the few populations in Bulgaria, which is located in mount Ruen, in the vicinity of Boboshevo, was studied. A total of 303 flowers were excluded form pollinators and only 9,9% of them produced fruits. The flowers were actively visited by bumblebees, predominantly *B. hortorum,* in 1995 2008 and 2009 and sporadically visited by carpenter bees (*Xylocopa* sp.). The main visitors in 2007 were *B. terrestris* L.

Bumblebees' behaviour was rather similar in the flowers of both *Astragalus* species, which although distantly related had similar flower morphology and size. A single foraging trip lasted 1-10 (rarely 12-15) minutes, with an about 6 flower heads for both locoweed species and usually half of these heads belonging to one and the same genet. Pollinators collected nectar, transferred the pollen sternotribically and demonstrated high flower constancy. Only a few of all observed workers actively collected pollen briefly (2-3 movements with front legs only) from the anthers and it happened after the nectar extraction in the same flower just before they left it. Most workers had full pollen baskets since they cleaned their face and transferred the pollen grains into the baskets while flying from flower to flower. Of all observations only once did bumblebees "desperately" collect nectar and the baskets were usually empty. It was on a very hot day (30°C) in the flowers of *A. dasyanthus.* There are several possible explanations for such behaviour e.g. colony development status, nectar quantity and concentration or bumblebees being dehydrated due to the heat, but further investigations need to be done to test these possibilities.

Colour preferences of flower-visiting insects

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Any given floral colour pattern provides colour contrast between it components, is made up of colours of a distinct brightness, hue and saturation, and has properties like ultraviolet reflection patterns which are invisible to humans. When flower-visiting insects are responsive to floral colour patterns they are attracted from some distance, guided towards the site of access to the reward, target landing sites, and extend their proboscis; each of these reactions may be triggered by different colour cues. The visual properties of colour patterns provide many cues; the flower-visiting insects, however, may be insensitive to some stimuli of floral colour patterns, or use only single or few cues for orientation due to their innate or learned preferences. Taking divergent colour vision systems into account, flower-visiting insects may respond to the green and colour contrast against the background and between the various components of the colour patterns. Moreover, they may respond to the intensity, dominant wavelength, and spectral purity of the floral colours, or to combinations of some of these cues. The talk gives some examples of color preferences in honeybees, bumblebees, and syrphid flies, and discusses the pitfalls for researches resulting from the possible mismatch between the recording of properties of floral colour pattern with human eyes, or spectrophotometers and the effective stimuli triggering behavioral reactions of flower-visiting insects. The interpretation of floral colour patterns becomes even more complicated when not only the attraction of pollinators is considered, but also the discouraging of illegitimate flower-visitors.

Local adaptation in *Primula farinosa*

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We study local adaptation in the perennial herb *Primula farinosa.* This species displays a scape length polymorphism on the island of Öland (Sweden), with a short-scaped morph close to the ground and a long-scaped morph. The proportion of the short-scaped morph varies among populations in the study area. On Öland, *P. farinosa* occurs on calcareous grassland grazed by cattle and sheep. These areas are characterized by a thin soil cover. They are often flooded during winter and spring and become very dry in the summer, creating a stressful environment for many species. In the field, we have observed variation among populations and scape morphs for rosette area, number of flowers and reproductive effort. Following drought years, differences in mortality in relation to soil depth has been observed. This spring, we have conducted reciprocal transplantations between 4 different localities, differing in mortality rate, soil depth, vegetation height and scape morph composition.

We will study local adaptation in life history traits, such as reproductive effort and age at first reproduction. We will also study the relative performance of the two different scape morphs in terms of survival, growth and reproductive patterns and under varying environmental conditions.

Are position effects on fruit size related to sexual system evolution? A phylogenetic test with the tribe Inuleae (Asteraceae)

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In Asteraceae, sex expression shows a positional pattern within the inflorescences. When unisexual flowers are present, female flowers are always placed in the outer positions within the capitulum, whereas male unisexual flowers are always placed in the innermost positions. Interestingly, this positional pattern within the capitulum has also been reported for fruit size in several hermaphroditic species, where outermost fruits are usually larger than the innermost ones. We tested if these positional effects on fruit size at the inflorescence level might turn in evolutionary time into position effects on floral gender. To assess this hypothesis we explored whether outer fruits are in fact larger than inner fruits, and whether the difference in size among outer and inner fruits was associated with the evolution of the sexual system in a monophyletic group of Asteraceae, the tribe Inuleae. Although there was not significative difference among outer and inner sizes for every analysed species, the evolutionary model of the standardized fruit size difference, measuring the magnitude of the difference in size among outer and inner fruits within each inflorescence, matched our expectations and the evolution of this trait was associated with the evolution of the sexual system. However, we found unexpected results on fruit size because the hermaphroditic species showed the largest fruit sizes. This pattern was explained as a consequence of the trade-off among fruit size and flower number.

Beyond wine: Exploring dominance in quantitative pollination networks

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Plant-pollinator networks often show a nested structure. This kind of structure entails a so called "asymmetric specialism", in which specialist pollinators mainly interact with generalist plants and vice versa, specialist plants with generalist pollinators. Most previous studies on network structure are based on qualitative (presence-absence) data. Information about the intensity of the interactions could modify current wisdom about nestedness patterns and asymmetric specialism if (a) most visits to generalist plants are payed by a few pollinator species (high dominance in the distribution of visits) and/or (b) the main pollinator of generalist plants is also a generalist. We tested these ideas using quantitative data of an alpine plant-pollinator network in N Spain. This network showed a significantly nested structure, both using qualitative or quantitative (WINE based) data. Dominance in the interactions significantly increased from generalist to specialist plants, indicating that specialist plants mainly interact with just a few pollinator species. This pattern agrees with generalizations derived from qualitative analysis of networks. Notwithstanding, the most frequent pollinator of both generalist and specialist plants was often a generalist insect, although not the most generalist pollinator of the network, suggesting that specialist pollinators have a relatively minor role in the network. This result departs from the expectations derived from a purely qualitative analysis of networks.

Costs of different ways of gender adjustment in *Buxus baleriaca*

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Gender adjustment in monoecious plants can be dependent on a number of factors, including architectural constraints and differential costs of floral structures. Usually, producing a perfect flower is cheaper than producing two separate male and female flowers because a perfect flower shares the cost of attractive structures for both gender functions. Nevertheless, depending on the cost of different floral structures it can be optimal for a species to produce non-fruiting perfect flowers, male flowers or female flowers. We propose that this kind of reasoning can be also applied to the adjustment of sexual expression within a monoecious species. In some monoecious species, in which unisexual flowers are produced in complex units, male biased gender expression could be achieved by removing female flowers from such units, by adding male flowers or by reallocating into male flowers resources that would have been otherwise expended in a given amount of female flowers. In *Buxus balearica*, which produces inflorescences with a central female flower surrounded by mostly four male flowers, variation in phenotypic gender was actually achieved by a combination of (1) supression of the central female flower, (2) variation in number of male flowers in the cosexual inflorescences and (3) variation in number of male flowers in male inflorescences. A model showed that a given gender could be achieved through different combinations of the modifications 1-3 above mentioned. However, according to the model plants did not utilised the cheapest way of adjusting gender, probably due to developmental constraints.

Scaling down pollination networks from species to individuals: An individual-based network of *Apis mellifera* and *Cirsium arvense*

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Network theory has long been acknowledged as a sub-discipline in pollination biology. In a traditional pollination-network, animal pollinator species together with the pollinated plant species constitute the nodes in the network. Species are linked in a network when *individuals* of an animal species visit the *individuals* of a plant species. Thus, every node in a species-species interaction network encompasses a network of interacting individuals. However, very few studies have investigated the structure of networks at the level of individuals. We explore a pollination-network by scaling down from species to individuals. In other words, the nodes in our network are composed of individuals. We examined global network parameters such as size, connectance, nestedness, modularity, centralization, in addition to local network properties, including linkage level, degree distribution, eigenvector and dependencies for every interacting pair of plant and bee. The data was obtained by marking several honey bee (*Apis mellifera*) individuals and several thistle (*Cirsium arvense*) stems ("individuals") in a meadow, whereupon visitation between marked bees and plants was registered. The network was highly nested, not significantly modular, had a truncated degree distribution and a slightly left skewed asymmetry. Furthermore, link structure was influenced by number of flower heads, plant height and spatial location of the plants. Thus, network properties of the individual-based network, are in general similar to species-based pollination networks. A downscaling from species to individuals might allow us to understand community structure in a more detailed manner, and this study exemplifies, that the comprehension could be aided by network theory.

Early or late flowering: does it matter? Effect of different flowering strategies on reproductive success in *Rhinanthus angustifolius* C. C. Gmelin (Orobanchaceae)

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Flowering phenology is a key point in plant reproduction. Within a population, differences in flowering time can lead to differences among plants in conditions such as temperature and pollinator presence, which may affect reproductive success.

Rhinanthus angustifolius, an annual hemiparasitic plant of hay meadows, presents an interesting flowering strategy. The onset of flowering is not induced by photoperiod but rather seems to be genetically determined and correlated with the number of nodes under the inflorescence. In natural populations, we may find early flowering plants with few nodes as well as late flowering plants with a higher number of nodes under the first flower. Early flowering is advantageous in hay meadows: mowing means the end of life, since the plants are not able to regrow after mowing. Only fruits that have set sufficiently early will produce viable seeds.

But early flowering also has its disadvantages. The very first plants to flower need to attract pollinators (bumblebees), and low visitation rates are to be expected. In this study, we compared the first flowering plants with plants starting three weeks later in a semi-natural population in 2009. We used several indicators of reproductive success such as pollinator visitation rate, pollen deposition and fruit and seed set, and recorded flowering phenology for the population as a whole. We also counted the number of nodes in each group, to see if early flowering plants indeed had less nodes. The first results will be presented.

Pollinator-mediated selection on floral traits in the orchid *Gymnadenia conopsea*

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Phenotypic selection on floral display and flower morphology has been documented in several plant species, but few studies have established experimentally the agents of selection. Pollinator-mediated selection can be identified by comparing the strength of selection in open-pollinated control plants and in plants receiving supplemental hand-pollination. Here, we use this approach to examine selection on floral display through female function in the rewarding orchid *Gymnadenia conopsea* in a large population in central Norway. We quantified selection on plant height, number of flowers, corolla size and spur length using the product of number of fruits and mean fruit mass as an estimate of female reproductive success. Both fruit production and fruit mass were pollen-limited. There was directional selection for taller plants, more flowers, larger flowers and longer spurs. Supplemental hand-pollination reduced selection on spur length, but did not significantly affect selection on the other traits included in the analysis. No selection on spur length was detected among plants receiving supplemental hand-pollination. The results suggest that spur length affects pollination efficiency in *Gymnadenia conopsea*, and support Darwin's classic model of pollinator-mediated selection on spur length.

The impact of size threshold and census method on interaction probabilities in plant-pollinator networks

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The extent to which pollinators prefer to visit flowers that match their size is a long-standing question in pollination biology. Though close matching of proboscis length and flower tube depth is well known in symmetric one-to-one relationships, its importance is less clear for whole communities, which are often dominated by generalized and asymmetric interactions. In a previous paper we showed that the threshold imposed on proboscis length by tube depth can explain large parts of the observed degree of size matching in a community (Stang et al. 2009). Here we want to show in simple model calculations that this size threshold has a specific impact on the shape of the probability distribution of interactions, and in particular on the degree of size matching. As a basic principle in our modeling we assume pollinators to be distributed on all accessible plants with equal probability according to the relative abundance of those plants. Due to the size threshold, however, the related conditional probabilities result in a concentration of short-tongued pollinators on plants having shallow tubes, suggesting an apparent preference. Pollinators with a long proboscis, on the other hand, are expected to be evenly spread over a large range of available plants. We will show, however, that the latter group will also exhibit an apparent preference when certain census methods are used. So both size threshold and census method can mimic size matching due to preference, which might not in fact be present. We therefore suggest taking size thresholds as well as census method into account when calculating interaction probabilities and interpreting interaction patterns at the community level.

Impacts of bioenergy crops on plant-pollinator networks

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Pollinators and the services they provide are increasingly threatened by many factors including land use change and agricultural intensification. This study focuses on the impact of two bioenergy crops: the annual, high input, insect-pollinated Oilseed rape (*Brassica napus*) and perennial, low-input, wind-pollinated *Miscanthus giganteus*, on pollinators and the pollination services they provide in Ireland. We used plant-pollinator networks to examine the impacts of these energy crops, compared with the crops they replaced, on plant and pollinator communities and their interactions. Five replicate fields of each of five treatments (1. Oilseed rape, 2. *Miscanthus* planted on former arable fields, 3. *Miscanthus* planted on former grass fields, 4. wheat control and 5. grass control) were selected in SE Ireland: . Each of the 25 sites were visited three times during the May-August 2009 season. On each visit, four belt transects were walked in each site. Flower visitors of the orders Hymenoptera, Lepidoptera and Diptera (Syrphids) were recorded along with the plants they were seen visiting. Plant communities were characterised by recording all flowering species in 1x1m quadrats every 10m along the transects. Bipartite interaction networks were constructed and differences in network parameters were compared among treatments. This project is part of the SIMBIOSYS (Sectoral IMpacts on BIOdiversity and ecoSYStem services) project which is focusing on the sectors of energy crops, road building and landscaping and aquaculture in Ireland, and their affects on associated ecosystem services - www.simbiosys.ie.

Flower size and temperature differentially affect floral longevity in a Mediterranean shrub with large flowers along an altitudinal gradient

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In Mediterranean environments, floral longevity may be constrained by flower size and temperature due to increased maintenance costs. A survey of twelve species of Cistaceae, a characteristic Mediterranean family with large flowers, indicated that floral longevity was approx. 1 day independently of flower size. In an altitudinal gradient we also conducted an observational and an experimental study of the floral longevity in *Cistus ladanifer*, the species with the largest flowers in our study area. In spring 2009, we manipulated floral longevity by using bagged and pollination treatments in a total of six populations at two altitudes of 700 and 1200 m a.s.l. in Madrid province, Spain. Flower size significantly increased with altitude and floral longevity significantly decreased with increasing altitude but this was not due to differences in flower size. Experiment indicated that floral longevity differed between altitudes and was strongly related with pollen receipt. Shorter longevities at high altitude were due to higher temperatures rather than to larger flower sizes. This study shows that in Cistaceae floral size and longevity are not closely related, and that although floral longevity seems to be phylogenetically constrained within this family, it shows intraspecific variability in relation to temperature.

Land use intensity in grasslands: Changes in biodiversity, species composition and specialisation in flower-visitor networks

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The relationship between resource availability and biodiversity of consumers has gained particular attention with the increasing loss of species in recent decades. In this study we evaluate resource availability of extensively (low/unfertilised, mown once per year) and intensively used meadows (higher fertilisation, mown 2-4 times) before and after the first mowing in relation to network specialisation, species richness and composition of flower visitors.

In 2007, we studied 40 meadows, simultaneously sampling one extensively and one intensively used meadow. All actually flowering plant species and all flower-visitors were recorded on an area of 1000 m² per plot.

Species composition with regard to plants as well as to flower visitors differed between the two land use types. Extensively used meadows are significantly richer in bee, butterfly and plant species before the first mowing. They also showed higher numbers of plant-flower visitor interactions and flowering areas. In addition, higher Simpson's Diversity of plants and butterflies was recorded as well as higher individual numbers of butterflies. Interestingly, after the first mowing all these differences except the higher species richness of flowers on extensively used meadows disappeared.

We conclude that the management regime may strongly affect plant-flower visitor interactions. Differences in plant species composition may play an important role to diversity and species composition of some flower visitor groups, probably as more specialized flower visitors depend on certain plant species for survival and reproduction.

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