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Title of symposium

Pollination in the Anthropocene

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Session description

Pollinator loss is a major concern because pollination is essential for the reproduction of many wild plants and the maintenance of their genetic diversity. Pollinators also provide a vital ecosystem service through the pollination of many crops. To allow pollinator conservation in the Anthropocene, the recent IPBES report identified several policies that need to be addressed urgently.

Globally, the scientific community agrees that the destruction of natural habitats, land use intensification, climate change, various pollutions and biological invasions are the most prominent components of global change that influence biodiversity. Indeed, pollination emerges as a model to better understand the effects of global change on ecosystem functions, as it requires the simultaneous presence of plants and pollinators, and almost all the above-mentioned components of global change can alter this co-occurrence. However, these components have been approached as single-factor conservation problems, rather than interacting factors; and their combined effects on pollinator diversity and pollination services are still rarely studied.

Facing the great challenge of the current pollination crisis, our scientific community needs to propose methods to gather information and accurately evaluate the decline of plant-pollinator interactions. Also, the impact of current management practices, and the efficiency of conservation methods urgently needs to be assessed and discussed. Mutualisation and collective use of databases, methods to assess the ecosystem service of pollination, identification of highly threatened plant-pollinator interactions, and proposition of

operational actions … all have to be favored to pave the way for pollination resilience and conservation. This session will favour scientific exchanges on the present pollination crisis and the collective solutions for the protection of this crucial part of biodiversity.

Speakers

Invited speakers

MICHEZ Denis, University of Mons, Laboratory of Zoology, 20 place du parc, 7000 Mons, Belgium

"European Red List of Bees"

Extinction drivers vary in space and time, interact synergistically, and affect species and/or functional groups differently. One of the main challenges of the STEP project (*Status and trend of European pollinators*, EU funded FP7 project) was to assess how each bee species among the 1,965 species native in Europe is potentially experiencing a risk of extinction. Assessing the status of all European bees was a major task that required a coordinated large-scale effort involving specialists from across Europe, as well as a standardized framework of assessment. The STEP project collaborated with IUCN and applied the internationally recognized IUCN (International Union for Conservation of Nature) Red List procedures (www.iucnredlist.org) to guide the development of a Red Data Book for European bees. As the knowledge base for this assessment was both taxonomically and geographically incomplete, we involved the majority of the European bee expert community (i.e. taxonomists and ecologists). We also built a partnership with the European team of IUCN to coordinate and guide this process. A team of more than 40 experts participated in the development of the assessments and the review process for this first European bee Red List. The following information was collected for all the species: nomenclature, distribution, country records, population size and trend, preferred habitats, general ecology, modes of utilisation, major threats, ecosystem services provided and current and future conservation measures.

The first outcome was an updated checklist of European bees, which now includes 1,965 species. This is an important step forward as the last comprehensive list of European bees was published in 1901 by Friese. The team gathered all the available observations to produce detailed maps of 1,585 species including 2.5 million data points. These detailed maps allowed us to estimate the Extent of Occurrence (EEO) and Area of Occupancy (AOO) of each species. Of all the European native bees, 7 species were assessed as Critically Endangered, 46 as Endangered, 24 as Vulnerable, 101 as Near Threatened, 663 species as Least Concern, 1,101 as Data Deficient and 23 as Not Applicable. The main threats identified were habitat loss due to habitat loss as a result of agriculture intensification (e.g., changes in agricultural practices including the use of pesticides and fertilisers), urban development, increased frequency of fires and climate change.

Some life history traits were associated to the most threatened species: sociality (e.g. bumblebees), host-plant specialisation (e.g. bee species specialised in the pollen of teasel

family, Dipsacaceae) and habitat specialisation (e.g. bee species associated to coastal areas). The species richness of bees increases from north to south in Europe, with the highest species richness being found in the Mediterranean climate zone. The Iberian, Italian and Balkan peninsulas are important areas of species richness. The largest numbers of threatened species are located in South-Central Europe and the pattern of distribution of Data Deficient species is primarily concentrated in the Mediterranean region. The quality of the data available was highly variable across the various genera of wild bees. Some groups like leaf-cutting bees (i.e. genus *Megachile*) presented many taxonomic questions limiting the access to high quality data. Other groups like the majority of cleptoparasitic genera (i.e. cuckoo bees) are very rare and are seldom collected. Status and trends of the populations of these groups were impossible to assess based on the available data (i.e. resulting in a Data Deficient assessment).

For a small proportion of the species, the data included a large amount of historical data, allowing the team to characterise the trends in their populations. This was mainly possible for the Bumblebees (genus *Bombus*). For this group, 891,619 data points were compiled for the 68 species recorded in Europe. The assessment showed that, of the 68 bumblebees present in Europe 9 species have an increasing population trend (13.2%), 20 are stable (29.4%), 31 are decreasing (45.6%) and 8 (11.8%) are unknown.

Other speakers (speaker underlined):

Talk 1. PROFFIT Magali, LAPEYRE Benoit, BUATOIS Bruno, KJELLBERG Finn, STAUDT Michael, HOSSAERT-MCKEY Martine, Centre d'Ecologie Fonctionnelle et Evolutive (CEFE) UMR 5175, CNRS – Université de Montpellier – Université Paul Valéry – EPHE, 1919 Route de Mende, 34293 Montpellier cedex 5, France

"Ozone pollution, a major threat to plant-pollinator chemical communication?"

Volatile organic compounds (VOC) play a key role in the relationship between plants and their abiotic and biotic environments. For instance, pollinators usually rely on floral scents to locate their host plants. This chemical communication between plant and pollinator can be disturbed by exposure to pollutants such as ozone (O_3), whose levels have increased in the troposphere and are predicted to further increase over the coming decades. In the present study, we evaluated the impact of O_3 concentration on different steps of the chemical communication between the dioecious Mediterranean fig, *Ficus carica*, and its highly specific pollinating wasp, *Blastophaga psenes*. Firstly, using gas chromatography coupled with electroantennographic recordings and behavioral tests, we found that a particular ratio of three VOC is sufficient to attract *B. psenes* to the inflorescences of *F. carica*. Secondly, using gas chromatography coupled with mass spectrometry, we analyzed the VOC emitted by the inflorescences of *F. carica* in several localities in the French Mediterranean region. Our results revealed that the concentration of O_3 the day of collection affects significantly the VOC emitted by the inflorescences, particularly the VOC used by the pollinator to find its host plant. Finally, using tests in the laboratory, we observed that O_3 exposure affects

directly the detection of VOCs by antennae of *B. psenes* and its attraction towards the attractive mixture of VOC. These results demonstrate that O_3 pollution has the potential to alter the chemical communication between plants and pollinators, and therefore the crucial ecosystem services provided by pollinators.

Talk 2. VOGT-SCHILB Hélène [1,2,3], PRADEL Roger[1], GENIEZ Philippe[1], RICHARD Franck[1] & SCHATZ Bertrand[1]

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"Land uses changes and specialized pollination: the case of Mediterranean orchids"

The effects of global changes on biodiversity generally consist in a loss of species but also in a simplification of the interaction network. As a consequence, the specialized interactions are particularly threatened and are thus considered as sentinels of environmental changes. Orchids are particularly vulnerable to environmental changes due to their specialized interactions with pollinators and strong habitat requirements. Our goal here is to test whether their variation of presence is due either to their level of specialization in their pollination strategy or to changes in land uses. We used a diachronic survey of orchid communities in three Mediterranean regions (Provence-Alpes-Côte d'Azur, Languedoc-Roussillon and Corsica) in France to examine this question. Comparing data from two field surveys conducted ~25 years apart (1982-1984 and 2006-2014) at the same several tens of sites per region (184 sites in total), we evaluated the impact of increase in woody plant cover on (i) the richness and composition and (ii) local extinction/colonization dynamics of orchids. We applied a Bayesian multispecies site-occupancy model to each orchid species recorded in these sites to account for under-detection in estimating their dynamics. The woody plant cover increased in most sites in each of the three regions, but twice lesser in Corsica than in the two other regions. In the two continental regions, we found strong declines in species richness and changes in community composition of orchid communities. In the three regions, abundance of shade-intolerant species tended to decline more sharply than that of shade-requiring species. No effect of the level of specialization in the pollination strategy was detected in their diachronic variation of presence. Our results suggest that changes in land uses have a great effect in the dynamics of Mediterranean orchids regardless of their pollinator specificity.

Talk 3. ZANINOTTO Vincent, DAJOZ Isabelle, Institut d'Ecologie et des Sciences de l'Environnement de Paris, Sorbonne-Universités, 4 Place Jussieu, 75005 Paris

"Urban impacts on the phenology of plant-pollinator interactions"

As growing urbanization threatens land ecosystems, cities become a useful experimental system to study how the pollination function responds to global changes. In particular, how

global warming impacts on plant-pollinator interactions could be prefigured by the influence of the Urban Heat Island on the phenologies of plants and their pollinators. This study aims to assess the effects of experimental shifts in blossoming phenology on plant-pollinator interactions and plant reproductive success of two focal plant species with contrasted floral morphologies, *Sinapis alba* (Brassicaceae) and *Lotus corniculatus* (Fabaceae). To study how urbanity affects these responses, the experiment was carried out in parallel in urban and rural environments in the Ile-de-France region (France). Replicates of the same plant community were set up in both habitats, from March to July during two consecutive years (2017 and 2018). We expect plant-pollinator interactions to be more numerous in the urban environment at the beginning of the experiment, thanks to the urban heat island. We analyze the composition of the pollinator assemblage visiting the experimental plants between urban and rural habitats. Preliminary results suggest that, although the number of pollinator species visiting urban and rural plant communities is similar, rural assemblages are marked by the presence of specialist bees and the abundance of syrphid flies whereas the abundance of small solitary bees is higher in the city. This may lead to better reproductive success of *Sinapis alba* and *Lotus corniculatus* early in the season in the urban habitat. Overall, these results suggest that pollination response to experimental time shifts in blossoming differs between urban and rural habitats.

Talk 4. ROPARS Lise, GESLIN Benoît, AFFRE Laurence, Aix Marseille Univ, Univ Avignon, CNRS, IRD, IMBE, Marseille, France

"Toward a conciliation between the installation of honey bee colonies and the preservation of wild pollinators in the Calanques National Park"

According to the European Red List of bees, the French Mediterranean basin might harbor around 700 species of wild bees representing nearly 70% of the entire French Fauna. As pollinator decline is increasingly reported in agricultural environments, nature reserve can act as shelters for bees because of low pesticide exposure and high floral diversity throughout the year. In the other hand, land manager received numerous demands from beekeepers to install honey bee colonies in their natural reserves. Recently, concerns have raised regarding potential competition for floral resources between wild and honey bees in urban and semi-natural contexts. These studies emphasize that competition could be detrimental for the maintenance of wild pollinators which may jeopardize the pollination function.

In this context, our goals was to evaluate the potentiality of the Calanques National park to harbor a diverse wildlife while allowing the maintenance of beekeeping activities. We first quantified the amount of floral resources present in the main habitat of the park (shrubland, dominated by Rosmarinus officinalis, Thymus vulgaris, Cistus albidus, Cistus monspeliensis) within 17 sites located along a gradient of honey bee colonies density. Nectar and pollen were quantified and their production were mapped at the scale of the whole park. We estimated the amount of resources exploited by honey bee colonies and estimated the

resources available to wild bees. Ultimately, this method could be a good predictor of the resource quantity to help land managers to conciliate the installation of honey bee colonies and the conservation of the wild pollinating fauna.

Talk 5. DUCHENNE François [1,2], THEBAULT Elisa [1], DAUGERON Christophe[3], DELFOSSE Emmanuel[3], PORCHER Emmanuelle[2], TEULIERE Elsa[4], ELIAS Marianne[3], CERRETTI Pierfilippo[5] & FONTAINE Colin[2]

[1] Institute of Ecology and Environmental Sciences of Paris, IEES-Paris UMR7618 (CNRS, SU, IRD, INRA, UPEC, Paris Diderot), Sorbonne Université, 75005 Paris, France , [2] Centre d'Ecologie et des Sciences de la Conservation, UMR7204, (CNRS, MNHN, SU), Museum national d'Histoire naturelle, 75005 Paris, France,[3] Institut de Systématique, Evolution, Biodiversité, UMR 7205 (MNHN, XNRS,SU, EPHE), Museum national d'Histoire naturelle, Paris 75005, France, [4] École Normale Supérieure, 75005, Paris, [5] Dipartimento di Biologia e Biotecnologie 'Charles Darwin', Sapienza Università di Roma, Rome, Italy

"Flower visitors and global warming: evaluation of the phenological response at European scale"

Knowledge on the response of pollinators to climate change is currently mainly restricted to Lepidoptera in the UK and very few species of Hymenoptera in the USA. As a result, we know very little about the heterogeneity of responses among pollinator species and as a consequence, whether extrapolation from what we know is reasonable. Furthermore, our understanding of underlying mechanisms implicated in these changes remains very weak, despite being a key point to estimate vulnerability to climate change. Here, we assess the response to climate warming of more than 1500 species of flower visitor belonging to four insect orders – i.e. Coleoptera, Diptera, Hymenoptera and Lepidoptera – by analyzing a database of more than 13 million of occurrence data spread across western Europe and over 60 years. Our results indicate an average phenological shift of -0.13 days/year since 1960, a pattern matching the one of flowering phenology of European plant. Behind this general trend, our analysis reveals substantial variation in response among species, related to species taxonomy, traits and spatial repartition. Further, our results suggest that although phenotypic plasticity on the mean flight date is important for most species, the long-term temporal trend of the mean fly date seems mainly driven by an evolutionary response to rising temperature. Overall, our results indicate that the high prevalence of studies focused on the response of Lepidoptera only might be misleading if we are to understand the response of pollinator communities to climate warming.

Talk 6. MARTIN Gabrielle[a], FONTAINE Colin[a], ACCATINO Francesco[b], PORCHER Emmanuelle[a]

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“New indices for rapid assessment of pollination services based on crop yield data: France as a case study”

Local studies indicate that animal pollination is essential for crop productivity, but its effectiveness and temporal stability vary broadly across regions. However, there is no simple and rapid method to assess the pollination services over large areas. Here, we introduce two new indices to measure pollination effectiveness and temporal stability in farmland, the Pollination Services index and the index of Temporal Variation in Pollination Services, that only require readily available data, namely crop yield and crop pollinator dependence. The philosophy of these indices is to compare at a given site the standardized yield, or the temporal variation in yield, among crops that have different levels of dependence on animal pollinators for their production. We expect that where there is a shortage of pollinators, standardized crop yields should decrease, and temporal variation in crop yields should increase, with increasing dependence on pollinators. The Pollination Services Index in a given area is thus defined as the slope of the linear regression between standardized crop yield and crop pollinator dependence; the Temporal Variation in Pollination Services is defined as the slope of the linear regression between the inter-annual coefficient of variation of crop yield and crop pollinator dependence. We calculated these two indices in France, where we show extensive spatial variation in the estimated pollination services. We further show that this variation in Pollination Services index is negatively correlated to the index of Temporal Variation in Pollination Services, and positively correlated with habitat quality for pollinators and agricultural extensity. Despite a couple of limitations that deserve further attention, these indices may constitute promising, cost-effective tools to highlight regions of pollination deficit over large areas.