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ABSTRACT BOOK

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EVOLUTION OF FLOWERS UNDER POLLINATOR CHANGE

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ABSTRACT

Plants that rely on animal pollination might require to rapidly adapt when exposed to new pollinator conditions. Change in pollination environments happens often as humans influence the ranges of plants and pollinators and is also a common feature in the long-term evolution of flowering plants. In this talk I will present a series of studies where we examine the capacity for rapid floral trait evolution under contrasting pollination situations. We focus on pollination biology, and measure natural selection as well as plasticity and quantitative genetic parameters of floral traits (heritability and evolvability) to understand their potential for evolution in response to change. In the recent trans-continental range expansion of common foxgloves (*Digitalis purpurea*) we demonstrate that populations naturalised in two regions of the Americas, after independent introduction only 85 generations ago, show evolution in corolla morphology that is consistent with the new pollinator guild that includes hummingbirds in addition to bumblebees. We explore why nectar traits do not show rapid change even though they can be expected to be under strong selection by hummingbirds. The tree tobacco (*Nicotiana glauca*) has lost all pollinators after another trans-continental expansion. In this case, we show how high levels of environmentally induced plastic variation in corolla traits in wild populations overrides potential evolution in response to selection for increased selfing. Finally, the Mediterranean gorse (*Ulex parviflorus*) has a stable pollination environment dominated by a single pollinator. We found how stabilizing selection and low trait heritability can explain lack of change in flowers in this species. Our results on the causes and constraints in floral evolution when exposed to novel or the loss of pollinators are particularly relevant in the current changing conditions, as well as important to understand the mechanisms behind the extraordinary diversity of flowers.

SO, YOU WANT TO STUDY ORCHID POLLINATION: MAXIMIZING OBSERVATIONS AND DATA SETS

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ABSTRACT

Orchid pollination *in situ* is often challenging due to a combination of their growth habit, demography, conservation status, pollen packaging, floral lifespan/cues, etc., compared to other lineages of flowering plants. Here, we review 5 interrelated categories that may limit the investigation of orchid pollinators and their flowers. We offer a series of classical and modern alternatives to better expand small data sets. These tools and protocols are appropriate when applied to species representing at least four of the five subfamilies in the Orchidaceae and their pollinia vectors.

A WALK OF 20 YEARS FOR BUMBLE BEE HEALTH: FROM RISK ASSESSMENT OF PESTICIDES TOWARDS ENTOMOVECTORING FOR ENHANCED POLLINATION AND BIOCONTROL

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ABSTRACT

In this paper, I describe the first efforts in the early 2000s with the design of standardized bioassays with use of micro-colonies to **assess** the risk to bumble bees (*Bombus terrestris*). Workers of *B. terrestris* are important pollinators of wildflowers and many crops in agriculture. In these tests, the workers were exposed to pesticides by exposure via contact or diet, and the resulting effects on worker survival and also sublethal reproductive effects of the nest were measured. With the development of for instance the neonicotinoid insecticides, their behavior effects on pollination services could also be assessed with an optimized design wherein the workers needed to learn foraging for food.

In continuation, I will describe the use of managed pollinators as disseminators of pollen and also biological control agents against plant pathogens. Examples in both open field and greenhouse settings are given to present the usefulness of this technology into more sustainable production systems and green agriculture.

OLIGOLECTY IN BEES: PREDICTABLE PLETHORA OR POISONOUS POLLEN?

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ABSTRACT

Worldwide, about 30% of bees are oligolectic, i.e., their larval pollen provisions consist for more than 90% of pollen of a single plant genus. While oligolecty is ancestral to bees, reversals from polylecty to oligolecty, as well as switches in specialisation to plant genera from different families, are common. The main driver of oligolecty is thought to be the presence of a superabundant resource, or a predictable plethora, coinciding with a short nest provisioning period. This is well supported, as is the notion that oligolectic bees face larger conservation threats than polylectic species.

However, increasing experimental and observational evidence indicates that the predominant pollen sources used by many oligolectic bees may be toxic to the larvae of co-occurring polylectic species, and even to polylectic congeners. Here, we will explore this evidence, some known aspects of toxicities, as well as the benefits for plants to produce toxic pollen. We argue that pollen toxicity, may be one of the main drivers for oligolecty, and may cause runaway selection for oligolecty through increased pollen availability.

The toxicity itself has consequences for visitation of bee species to native plants, introduced weeds and crops, and these play out on a global scale. We will use the insights to argue that the increasingly narrowing focus on the conservation of crop pollinating species may not be helpful and actually hinder true bee conservation. On the flipside, understanding pollen dietary requirements should form the basis for effective conservation and restoration efforts for endangered bees.

BEE PROTECTION- WHO, WHY, WHEN, HOW?
BEE HEALTH, PESTICIDES, TESTING AND RISK ASSESSMENT- HAZARD AND RISK TO BEES, INTERNATIONAL DEVELOPMENTS AND THE ROLE, ACHIEVEMENTS AND CHALLENGES OF THE ICPPR BEE PROTECTION GROUP

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ABSTRACT

Protecting bees is an important task for society, due to the high importance of pollination services for food production. There are several threats and stressors that my damage or stress bees. The role of pesticides for bee health is intensively and discussed controversial in different parts of the world, unsurprisingly, as there are some communalities but also enormous differences in pesticide use. In many countries of the world, plant protection products and biocides are used to control insect and fungal pests, or to control weeds in agricultural fields. Pesticides are regarded in many parts of the world as major threats for bees, leading to risks for bee health, causing sublethal to lethal effects on individual bees, colonies or bee populations, or resulting in residues in bee matrices and bee products. While use patterns, applications and techniques, risk assessment and risk management as well as active substances used vary greatly between countries, some strategies to assess and investigate side effects have been developed in working groups like the ICPPR Bee Protection Group. Mostly, official institutions require and rely on internationally validated test guidelines, which ensure reproducible results and reliability of the test system. In the last decade, in Europe, but also other parts of the world major efforts were undertaken to improve risk assessment strategies. Honey bees often serve as a surrogate, but method development also aims at incorporating wild bee species, which brings some challenges.

Overall, bee protection requires a combination of testing strategies, an appropriate risk assessment and also management of risks, considering local and regional possibilities to implement mitigation measures and use of appropriate machinery. In the talk, current international developments, new test methodologies, risk assessment strategies and also strategies to evaluate the use under realistic conditions, and assessment of the risks – including possibilities and constraints of bee poisoning incident investigation will be presented as well as future foreseeable challenges be addressed.

The ICP-PR Bee Protection Group serves as a forum for addressing challenges and uncertainties associated with protecting and enhancing the health of honey bees (Apis mellifera) and non-Apis bees and to provide a means of coordinating international research efforts within academia, government, and industry to develop suitable testing and evaluation methods for assessing exposure and effects of factors impacting bee health.

MOVING WITH YOUR MUTUALIST: PREDICTED CLIMATE-INDUCED MISMATCH BETWEEN PROTEACEAE SPECIES AND THEIR AVIAN POLLINATORS

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ABSTRACT

Climate change influences species distribution in space and time, but predicting locations where climate change may induce mismatches in the ranges of mutualistic partners will aid in the identification of vulnerable ecosystems. Here, we explore how climate change influences shifts in species ranges among mutualists. We used machine-learning algorithm to predict range shifts of 11 bird-pollinated Proteaceae species in the CFR and their two most important, endemic, pollinator bird species. We determined the proportion of overlap in the ranges of nectar-feeding birds and Proteaceae under current and future climate scenarios. Species ranges were projected to the year 2050 and 2070 using Representative Concentration Pathways (RCP) 4.5 and 8.5. The majority of Proteaceae species in our model are predicted to experience range contractions which ranged from 21% for *Protea neriifolia* under RCP 4.5 2050 to 59% for *P. laurifolia* under RCP 8.5 2070 climate scenarios. Only *Leucospermum cuneiforme* is predicted to expand its range under future climate scenarios. Cape sugarbird and orange-breasted sunbird are predicted to experience 22% and 45% range contraction, respectively, under RCP 8.5 2070 condition. Overlap in suitable ranges of Proteaceae species with Cape sugarbird and orange-breasted sunbird is predicted to decline by 42% and 44%, respectively, under the more extreme climate scenario. Individual Proteaceae species show varying range overlap with nectar-feeding birds, but most species do not track the range shift of nectar-feeding birds. In conclusion, climate change threatens species occupying the mountain range of the northern limit of the CFR. Predicted range mismatch of mutualists may have significant implications for the reproduction and persistence of Proteaceae under extreme climate scenarios. We suggest active monitoring of Proteaceae populations and nectar-feeding birds at their northern distribution limits, particularly so for highly threatened small-range species.

SOIL AND ATMOSPHERIC NUTRIENT ENRICHMENT ALTER HOW LARGER PLANT-POLLINATOR NETWORKS ORGANIZED ACROSS THE GLOBE

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ABSTRACT

Plant-pollinator networks have been shown to respond to environmental drivers and stressors, but a less studied factor but highly common is pollution. Atmospheric and soil nutrient enrichment are known to affect plant development, flowering phenology, and plant volatiles, which can affect animal behavior and potentially impact mutualistic interactions. We perform a metanalysis of plant-pollinator networks across the world to assess whether Nitrogen, Nitrogen dioxide, Phosphorus or Ozone can predict the structure of plant-pollinator networks, by considering the relative abundance of plants and pollinators and controlling by the network size. We consistently found pollutant concentrations to affect network structure namely generality and vulnerability, especially in large size communities. Increments of Nitrogen, a liming factor for plant growth, has resulted in highly generalized behavior of pollinators, but potentially associated to the loss of highly specific interactions, such as leguminous plants which are adapted to environments with low Nitrogen concentrations. On the other hand, ozone has reduced the community generality potentially through the reduction of plant attractiveness, remaining only those highly specialized interactions. Overall, we show that nutrient enrichment is highly pervasive negatively affecting native's communities, and potentially disrupting more specialized interactions through different mechanism. We call the attention on the use of fertilizer and ozone liberation into the atmosphere as more preserved environments may be experiencing alterations through environmental eutrophication due to human activities.

THE BUZZ ABOUT TOWN: THE EFFECTS OF URBANISATION ON BEE AND WASP COMMUNITIES IN CAPE TOWN, SOUTH AFRICA

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ABSTRACT

Bees and wasps provide essential ecosystem services by pollinating urban plants and foods. However, there are massive global declines in many insect groups, and little is known about the impacts of urbanisation on pollinators in rapidly urbanising areas of Africa. Within the Durbanville area of Cape Town, we investigated the effects of urbanisation and availability of floral resources on bee and wasp (pollinator) diversity, community composition, and nesting guild distribution across an urban-rural/natural gradient. Using pan traps, specimens were collected from 18 sites in austral spring 2019 and 2020. A total of 433 bee and 45 wasp specimens, comprising of 45 bee and 27 wasp morphospecies respectively were collected. Bees from the family Halictidae (particularly *Seladonia* and *Patellapis* species) were the most abundant. Except for *Apis mellifera*, all other bee species were solitary, and most (86.7%) collect pollen from flowers. Four different nesting guilds were identified, with the most common being ground-nesters (68.9%). Floral resources, rather than the degree of urbanisation, had a strong effect on pollinator diversity and community composition. This study supports the development of several cost-effective and achievable conservation initiatives, such as adopting no-mow periods during austral spring and developing small-scale bee-friendly floral-rich patches, which can be undertaken by existing municipal structures and private landowners alike. Suggested future studies include investigating the ways pollinator diversity and community composition is influenced by 1) individual floral species and characteristics, 2) the size, shape, and location of habitat/floral patches, and 3) the effects of urban warming.

DRIVERS OF DIVERSITY AND COMMUNITY STRUCTURE OF BEES IN AN AGROECOLOGICAL REGION OF ZIMBABWE

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ABSTRACT

Worldwide bees provide an important ecosystem service of plant pollination. Climate change and land-use changes are among drivers threatening bee survival. In developing countries, rural areas constitute a significant proportion of the country's land, but information is lacking on the status of bee populations.
This study investigated how weather variables and habitat-related factors influence the abundance, diversity, and distribution of bees across seasons in a farming rural area of Zimbabwe. Bees were systematically sampled in five habitat types across diverse landscapes and weather variables. Zero-inflated models, censored regression models, and PCAs were used to understand the influence of explanatory variables on bee community composition, abundance, and diversity.

Bee abundance was positively influenced by the number of plant species in flower ($p < .0001$). Bee abundance increased with increasing temperatures up to 28.5°C, but beyond this, temperature was negatively associated with bee abundance. Increasing wind speeds marginally decreased probability of finding bees. Bee diversity was highest in fields, homesteads, and natural woodlots compared with other habitats, and the contributions of the genus *Apis* were disproportionately high across all habitats. The genus *Megachile* was mostly associated with homesteads, while *Nomia* was associated with grasslands.

Our study suggests that some bee species could become more proliferous in certain habitats, thus compromising diversity and consequently ecosystem services. These results highlight the importance of setting aside bee-friendly habitats that can be refuge sites for species susceptible to land use changes.

RELATIONSHIP BETWEEN TEMPORAL DYNAMICS OF FLOWERS AND CLIMATE

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ABSTRACT

The cerrado is a Brazilian neotropical savanna and a biodiversity conservation hotspot. The interactions with floral visitors depend on the plant's reproductive strategies and climatic conditions. In the tropics, the relationships between climate change and reproductive phenology, and their consequences, are still understudied. Therefore, we assessed a long-term flowering phenology of a cerrado tree community, considering the start and peak dates, and the duration of animal-pollinated species, to answer: (i) Are there differences in the flowering between species that are dependent and independent of biotic pollination? (ii) Are these differences in flowering related with shifts on temperature and precipitation over time? We analysed a unique 15 years-long (2005-2019) monthly observation of woody cerrado phenology, of 10 plant species, separated in two groups: dependent of biotic pollination (N=5) and independent of biotic pollination (N=5). We built circular-linear models of phenology with precipitation and temperature. Most cerrado species showed a decrease of flowering duration over time, regardless the pollination dependence or independence from pollinators. Species depend on biotic pollination had a more severe decrease the flowering duration. We also found an overall positive relationship between the increase of temperature and the decrease of the duration of flowering. The flowering start and peak dates changed over time between the compared groups but were not related with the climate. Our results indicated that availability of flower resources is decreasing for pollinators in time across the cerrado species, which may lead to a mismatch between plants and pollinators, reduction of flower visitors and reproductive success.

BEE FUCNTIONAL TRAITS AND CLIMATE VARIABILITY DRIVE BEE PHENOLOGICAL PATTERNS IN TROPICAL AND SUBTROPICAL REGIONS

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ABSTRACT

Bee temporal activity in temperate regions is mainly imposed by the marked temperature seasonality throughout the year. In contrast, the bee phenological pattern in tropical and subtropical regions is expected to be more continuous, given the mild monthly temperatures and reduced variability over the year. In spite of such assumption, several tropical and subtropical bee species have shown different levels of seasonality, but the extrinsic and intrinsic factors explaining their phenological patterns are still poorly known. In this work, we review the phenological patterns of bee species across the Brazilian biomes and evaluate the relations with bee functional traits and the climate variability. Our results demonstrated that solitary, specialist and ground nesting bee species are more seasonal than eusocial and cavity nesting species. The bee seasonality increased both, interspecifically and intraspecifically, in sites with colder climates, but did not change in response to local precipitation regimes (humid sites vs. arid sites). Bee monthly activity was positively affected by monthly temperature whereas slightly negatively affected by monthly precipitation. The implications of these variable seasonal patterns and drivers on the possible bee responses to global warming are discussed.

UNDERSTANDING THE IMPACTS OF CLIMATE CHANGE ON LEPIDOPTERAN POLLINATOR COMMUNITIES: INSIGHTS FROM A 30-YEAR DATASET IN FINLAND

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ABSTRACT

Global warming poses a significant threat to pollinating insect communities. There is limited understanding of how individual species respond to climate change and how their responses contribute to community-level changes. Lepidoptera (both nocturnal moths and diurnal butterflies) contribute to multiple ecosystem functions. Acting as pollinators, herbivores and food for higher trophic levels, they contribute to both ecosystem services and disservices. Importantly, Lepidoptera have been shown to be particularly sensitive to land-use and climatic change due to their close and complex relationship to plants as both larvae and adults. Nonetheless, the extent to which the temperature responses of individual species vary with their traits (such as hibernation stage, host plant and habitat use) is poorly characterised – and how such species-specific responses reflect into community change with climate warming remains unknown. To address these knowledge gaps, we are currently examining the responses of Lepidopteran communities to warming climatic conditions in Finland using a comprehensive 30-year observational dataset for over 1,600 species. More specifically, we are analysing the relationship between species-specific traits and the Species Community Temperature Index (STI), and between STIs and changes in species relative representation in communities. Here, the latter change will contribute to shifts in the Community Temperature Index (CTI). Our approach allows us to uncover the factors driving current shifts in Finnish pollinator communities and provide a mechanistic understanding of shifts in the community-level trait distribution.

FIRE MAINTAINS COEXISTENCE OF DIVERGENT FLOWER FORMS

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ABSTRACT

Pollinators are known to generate divergence in floral form, but if this does not result in the utilization of different ecological niches, upon secondary contact divergent forms are unlikely to coexist in the long-term. *Lapeirousia anceps* corolla tubes have diverged in response to pollinators with different proboscis length, and at a secondary contact zone, long- and short-tubed plants appear to coexist without much geneflow between forms. It is unclear, however, whether these forms occupy different niches and if one form will outcompete the other.

We show that as the veld ages, the density of *L. anceps* plants, pollinator visitation rates and the relative abundance of long-tubed plants decrease. Patterns of selection on tube length also appear to shift temporally, suggesting that the short and long tubed plants may occupy different post-fire niches.

This illustrates how temporal heterogeneity of the environment caused by fire can promote divergence and coexistence of divergent forms. However, it also suggests that diversity may be threatened if natural disturbance regimes are changed or improperly managed due to climate change, grazing, or human induced fires.

ENHANCING APPLE POLLINATION UNDER NET

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ABSTRACT

Crops are increasingly grown under cover, which necessitates the use of managed pollinators, most often honey bees. However, compared to crops grown outdoors, the covers can negatively affect bee activity, hive health and pollination services. In netted apple orchards, pollination can be reduced by 30% compared to orchards out in the open.

To improve pollination services and retain strong hives, some growers open the net above the hive, or above some of the rows during flowering. However, this is labour intensive and involves risk, as it can expose the flowering trees to potential hailstorms and increase damage to the net. While the benefits are not well understood.

We compared the quality of apple pollination and hive health under open and closed nets. For pollination frequency, we compared visitation, fruit set, seed number and apple quality. For hive health we measured changes in hive size, the amount of pollen and number of pollen types collected by hives under open and closed nets.

We found that visitation and fruit set were higher when nets were opened, but we found no difference in seed number and apple quality. Hive health increased when the nets were open above the hive, and the bees collected more, and more species of pollen. However, under closed nets, the hives collected more apple pollen than under open nets. We conclude that opening the nets may benefit hive health but keeping them closed may result in improved apple pollination, because it enhances pollen foraging on the crop.

DEVELOPMENT OF POLLINATOR-FRIENDLY FLOWER MIXES TO SUPPORT CONSERVATION IN WEST AFRICAN URBAN GARDENS

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ABSTRACT

The provisioning of supplemental sources of floral resources through strategies such as planting pollinator-friendly flower mixes can support pollinator conservation by providing nutrition during periods when crops are not flowering. However, despite their potential conservation and food production benefits, pollinator-friendly flower mixes have not been developed for use in West Africa. Therefore, we developed and evaluated two pollinator-friendly flower mixes that could be used in West African urban gardens. To facilitate the efficient use of space in rapidly urbanizing environments, we developed an edible mix and a medicinal mix that will simultaneously provide resources for pollinators and people. Each mix was tested at three different planting densities: 60 cm, 30 cm, and 15 cm of distance between plants. Mixes were planted on February 3, 2023 in 2x2-m experimental plots at two experimental gardens. Each mix was replicated six times at each planting density. Seed mixes were then evaluated based on germination rates, vegetation cover, flower production, and pollinator visitation. Both flower mixes attracted pollinators including honey bees, wild bees, butterflies, wasps, and beetles. In the first three months after planting, stem density, vegetation cover, and flower density were highest in plots with the 15-cm planting density and lowest in plots with the 60-cm planting density. Pollinator visitation was highest in the 15-cm planting density plots for the medicinal mix and the 30-cm planting density plots for the edible mix. Both mixes appear to effectively attract pollinators and may be useful to urban gardeners wishing to increase their crop pollination rates.

MORPHOLOGICAL VARIATION OF BLUEBERRY FLOWERS AND POLLINATION

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ABSTRACT

Blueberry is widely cultivated and specific characteristics of its flowers such as the shape and size determine the success of pollination. However, in Brazil, the floral morphology of blueberry cultivars (*Vaccinium ashei*) grown and its impact on pollination has not been studied. In this study we investigated whether the floral morphology and pollen deposition differs between cultivars.

We measured five floral characteristics (corolla opening diameter; corolla width; corolla length; anther-stigma distance, stylet length) in 50 flowers of Bluebelle, Bluegem, Britteblue, Climax, Powderblue, Woodard and Delite, in two localities of Rio Grande do Sul (Veranópolis and Guaíba). To assess the impact of the floral morphology in pollination, we counted the number of pollen grains on the stigma of their flowers.

The Principal Component Analysis (PCA) indicated that the flowers of each cultivar presented a pattern of size and shape. MANOVA confirmed the differences in floral morphology between cultivars, except for the diameter of the corolla opening of flowers of Veranópolis orchard, which showed no difference. Flowers with smaller anther-stigma distances and greater corolla openings presented a greater number of pollen grains on the stigma.

Based on these results, we suggest that floral morphology influences blueberry pollination. Bluegem and Bluebelle flowers characteristics favour pollination, Delite flowers characteristics may limit it. We recommend that flower morphology is considered during the development of new cultivars and orchard planning.

UNDERSTANDING INSECT POLLINATOR DYNAMICS IN THE AGRICULTURAL HIGHLANDS OF GUATEMALA

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ABSTRACT

The importance and economic value of pollination for agricultural and natural systems has been emphasized by many studies in recent decades. Insects are the main pollinating animals, and bees are considered the most important group. Recent evidence points out the importance of wild bee populations in maintaining the pollinating process and the genetic diversity and productivity of natural and agricultural systems. Forest degradation, pesticide overuse, and habitat loss are factors that threaten pollinator populations. The adequate landscape management and the diversification of plant communities through changes in agricultural practices, are alternatives that can contribute to reducing the pollinator crisis. Although, the pollinator situation in tropical highlands has been scarcely studied.

During the last ten years, we have worked on understanding the relationship between land use, agricultural practices and environment on pollinator communities and pollination services in the Guatemalan highlands. We have addressed the subject from different perspectives: we evaluated the effect of landscape structure and land use on diversity and composition of bee populations, its plant-pollinator interactions, and the pollination service itself, measured as the reproductive success of the common turnip, Brassica rapa L. (Brassicaceae). We also assessed the effect of small-scale land use and practices on local pollinator communities. Overall, our results highlight the importance natural vegetation and non-intensive practices in maintaining viability of natural pollinator populations, their interactions, and the pollination service in agricultural areas of the tropical highlands.

INFLUENCE OF THE BEHAVIOR OF WILD BEES (HYMENOPTERA: APOIDEA) AND THE PRESENCE OF VIRUSES IN COFFEE PRODUCTION

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ABSTRACT

Many studies investigate how the diversity of floral visitors and changes in their communities affect coffee production. However, very few studies have focused on understanding how insects visiting behaviour and the presence of Honeybee virus affects coffee production, especially in Central America. Here we assessed how foraging behaviour (flower visitation-rate, collection time in flowers and contact stigma/anther) of honey and stingless bees and the presence of Honeybee virus affect coffee pollination (fruit set of flowers) in conventional and organic crops. We quantified the prevalence of honeybee virus, local floral resources, diversity of bees and recorded the behaviour of each of the most common species when visiting coffee flowers. We found that the managed honeybee *A. mellifera* and three wild bees *T. angustula*, *S. mexicana*, and *P. bilineata* are the principal floral visitors of coffee crops in Guatemala, whose total abundance but not richness was higher in agroecological areas. Regarding their behaviour, we observed that *P. bilineata* time spent on flowers were positively related with both fruit weight and fruit set, the average number of flowers visited by *P. bilineata* was also positively related to fruit set, while only the percentage of *A. mellifera* collecting pollen was positive related with fruit weight, suggesting that although *A. mellifera* is found in large quantities, wild bees are more efficient pollinators of coffee in the region. Regarding virus prevalence we found that only *A. mellifera* populations presented high prevalence emphasizing the importance of conserving wild pollinators to improve the production of cash crops.

FUTURE TRAJECTORY OF CROP POLLINATION SERVICE DEMAND IN SOUTH AFRICA NECESSITATES MONITORING OF *Apis mellifera* AND NATIVE POLLINATOR HABITAT

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ABSTRACT

South Africa is quite unique in Africa in the use of managed pollination services for the production of insect dependent crops, while simultaneously having a rich biodiversity. Furthermore, the European honey bee is both an indigenous pollinator species important in natural ecosystems, as well as a managed pollinator species offered as a formal market service. However, similar to global patterns, the production of insect dependent crops are increasing sharply. Due to favourable exchange rate and seasonal opportunities for fruit export, much of South Africa's insect dependent crop production is exported. Consequently, world demand for such high value crops is a strong driving force in South African agriculture. Recent changes in crops being grown include a proliferation of high value crops like blueberries and macadamias (e.g. plantings of macadamias have doubled from 2012 to 2020). Due to the availability of a formal managed pollination service, much of South Africa's crop pollination makes use of honey bee hive rental. However due to the rapid increase in pollinator dependent crop hectares, shortages in managed pollination services seem all but certain. This places stress on the pollination services and supporting ecological services (e.g., swarm trapping and forage use). The looming shortage requires urgent investment in increasing available managed honeybee colonies, which itself has biodiversity implications. Alternatively, conservation measures to ensure that natural vegetation is conserved in close proximity to orchards needs major improvement, which is not currently the case. Therefore, monitoring the state of managed and wild pollinator populations will now become increasingly important.

INCREASING YIELD OF HASS AVOCADO BY ADDING BUMBLE BEE (*Bombus terrestris*) TO THE ORCHARDS

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ABSTRACT

Inadequate pollination is a limiting factor to improve avocado yield. We examined whether adding bumblebees (BBs; ca. 10 hives/ha) to conventional honeybees (HB; 5 hives/ha) would improve 'Hass' avocado pollination and yields. A preliminary trial (2017) in an avocado orchard with four consecutive rows of 'Hass' followed by one row of 'Ettinger' serving as a pollenizer (20% 'Ettinger') showed a considerable increase in 'Hass' yield in rows adjacent to (up to 80 m from) the BB hives vs. distant rows (=controls). In 2018, the trials were extended to three additional orchards. A significant yield increase was obtained in the BB hive-adjacent trees compared to BB hive-distant ones. Similar results were obtained in the years 2019-2022, in experiments conducted through-out the country. The SNP analysis, to determine the parents of 'Hass' fruit at varying distances from the BB hives, showed no differences in the cross-pollination rate ('Hass' × 'Ettinger'). However, pollination rates and the number of germinating pollen grains per stigma decreased with distance from the hives and correlated to the negative gradient in yield. Experiments conducted in the years 2020-2022 to examine the positioning of the hives in the orchards showed that the maximum radius of action of the BB ranges from 50 to 70 m from the hives, so it is better to place them along the rows and not at the edges and in rows 50-70 m apart. Taken together, our data suggest that adding BB hives to 'Hass' avocado orchards, at ca. 10 hives/ha resulting in 0.5–1.0 BB visits/tree per min, increases pollination and, accordingly, total yield.

TEMPORAL AND SPATIAL VARIATIONS IN FLORAL ADVERTISEMENTS

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ABSTRACT

Plant-pollinator interactions are based on the existence of communication pathways, which comprise chemical and visual floral cues that can be perceived and interpreted by pollinators according to their sensorial abilities. These floral traits can vary temporally and spatially, and we are able to detect these changes by looking at them through time (from minutes to years) and space (from within flowers to landscape-scale).

Here, we bring an example of temporal and spatial variation in floral advertisements of a plant species, *Zeyheria montana* Mart. (Bignoniaceae), endemic from Brazilian Cerrado (savanna phytophysiognomy). This shrub is exclusively pollinated by hummingbirds in a latitudinal gradient across its geographic distribution. However, changes in floral traits, including chemical and visual advertisements, led to a pollinator diversification in a single locality in which medium-sized bees began to visit and pollinate the flowers.

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LANDSCAPE-SCALE STRUCTURING OF FLOWER COLOUR ACROSS POLLINATOR MOSAICS IN CAPE DAISIES

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ABSTRACT

The striking variation in Angiosperm flower colour is often attributed to divergent selection imposed by allopatrically distributed pollinators with different colour preferences. Despite its importance, the distributions of pollinators and their colour preferences are seldom quantified. The extensive mass-flowering daisy displays in Namaqualand, South Africa, exhibit striking flower colour convergence within communities, but also geographic flower colour turnover within species and genera. By quantifying the geographic pollinator mosaics across which daisy floral signals have diverged, and experimentally testing pollinator preferences for floral colour signals I investigate the drivers of floral signal divergence and convergence in Namaqua daisies. I show that landscape-scale turnover of dominant flower colours in daisy communities is strongly associated with largely non-overlapping distributions of dominant bee-fly pollinators with divergent flower colour preferences, suggesting the importance of pollinator shifts across strong qualitative pollinator mosaics for signal divergence. However, extensive divergence in floral signals, in response to selection imposed by different behaviours of the same pollinator, also occurs across more subtle gradients in the abundance of dominant pollinating fly species. The geographically structured diversification of floral colour signals across qualitative and quantitative pollinator mosaics that I show is perhaps unexpected given the classically generalist pollination phenotype of daisies. However, because of the dominance of single fly pollinators within communities, and the virtual absence of bees as pollinators, I suggest that Namaqua daisies function as pollination specialists despite their generalist phenotypes, thus facilitating differentiation of floral signaling by pollinator shifts and sexual deception.

DOES FLORIVORY AFFECT FLORAL SCENT EMISSION ALONG FLOWER LIFETIME?

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ABSTRACT

Plant-pollinator interactions require the prior establishment of communication pathways, which are modulated by chemical and visual cues. Among them, floral scent is essential to ensure successful pollination in various natural systems, but it can also be used by florivores to locate flowers and their resources of interest. Florivores may negatively impact scent emission directly, by feeding on areas responsible for volatile synthesis and emission, or indirectly, by inducing plant physiological responses that change floral scent traits. Thus, after florivory, flowers may no longer be attractive to pollinators or may even start to repel them, due to local short-term changes in floral scent emission.

Here, we selected seven plant species pollinated by bees, hummingbirds, hawkmoths, or butterflies, which have diverse florivore groups in a Neotropical savanna, to investigate whether damage by florivores alters the amount and composition of floral scent during flower lifetime, i.e., in a time interval inferior to 24 hours.

Despite variable florivory levels, we verified no reduction in the total amount of floral scent emitted in six species, but a reduction was observed in a hawkmoth-pollinated species. However, in none of the species did florivory affect scent composition during the flower lifetime. Overall, our data suggest that a stability in scent emission, even in a post-florivory scenario, may guarantee the maintenance of pollinator visitation despite the damages caused to the flowers by florivores.

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POLLINATION ECOTYPES: THE KEY ROLES OF FLOWER COLOUR, MORPHOLOGY AND SCENT CHEMISTRY IN POLLINATOR SHIFTS WITHIN THREE SOUTH AFRICAN PLANT SPECIES

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ABSTRACT

Pollination ecotypes, in which among-population differences in floral traits of species are associated with differences in pollination system, are ideal to study initial stages of floral divergence, enabling identification of floral traits under selection and of pollinator characteristics that drive divergence. I use three examples of pollination ecotypes in species from the South African flora, including two important horticultural species, to illustrate this.

Firstly, in distinct colour forms of the River Lily *Hesperantha coccinea* (Iridaceae), red and pink flowers of butterfly- and long-tongued fly ecotypes also differ in flower orientation and tube length, reflecting the demonstrated importance of colour for attraction of these pollinators and suggesting differences in feeding mechanics and behaviour that affect the mechanics of pollination.

Secondly, in two subspecies of the rare *Nerine bowdenii* (Amaryllidaceae), flowers are similar in colour and structure, but differences in flower size precisely mirror differences in dimensions of the respective long-proboscid fly pollinator species, emphasizing the importance of morphological matching between flowers and pollinators in pollinator-mediated adaptive divergence.

Finally, in pollination chemotypes of *Guthriea capensis* (Achariaceae), flowers are similar in morphology and appearance, but are characterized by highly distinctive scent chemistry, indicative of the importance of odour for attraction of lizard and rodent pollinators.

Together these studies illustrate the roles of pollinator sensory ecology, behaviour, and morphology in understanding the selective mechanisms underlying the evolution of variation in floral morphology and advertising traits among flowers.

THE ROLE OF SHORT-TONGUED FLIES AS POLLINATORS IN SOUTHERN AFRICAN HIGH ELEVATION SYSTEMS: A CASE STUDY OF *Crassula peploides* (CRASSULACEAE)

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ABSTRACT

True flies (Insecta: Diptera) are often regarded as pests, however, evidence increasingly indicates that they play an important role in pollination in natural systems, especially at high elevation. Fly pollination is frequently associated with foul smelling flowers, but this has hitherto only been documented in a relatively limited number of plant families. We studied the pollination system of the putrid-smelling flowers of *Crassula peploides* in the high elevation Drakensberg Mountain region.

Visitor observations and pollen load analyses revealed almost exclusive pollination by short-tongued flies, primarily species of the families Sarcophagidae, Tachinidae and Muscidae, although pollinator assemblages varied between localities and years. Preliminary morphospecies identifications were confirmed by DNA barcoding. Flower scent analysis using GC-MS showed that scent profiles of *C. peploides* are dominated by aliphatic acids, which potentially mediate attraction of flies to the flowers. To the human eye, flowers have white petals with a red base and a red gynoecium, contrasting with the gravel substrate. Flies were observed probing the flower surface systematically, indicating the potential presence of nectaries. Results provide the first evidence of functional specialization of foul-smelling flowers for pollination by short-tongued flies in Crassulaceae. Trait similarities with other, previously studied species at high elevation suggest the presence of a guild of small, unpleasant-smelling, usually white-flowered plant species pollinated by short-tongued flies. The intriguing dominance of acids in the floral scent of *C. peploides* merits further investigation as a potential indicator of mimicry. This study further highlights the importance of flies as pollinators, especially in alpine regions.

POLLINATOR-MEDIATED ADAPTIVE WANDERING IN A FLORALLY DIVERSE ANNUAL DAISY: *Dimorphotheca pluvialis-sinuata* (ASTERACEAE)

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ABSTRACT

Pollinator shifts, the divergent floral-phenotypic and ecological specialization of allopatric plant populations along spatial pollinator gradients, are the most frequently invoked drivers of floral divergence in the Cape. However, divergent floral adaptation may occur in the absence of fitness trade-offs between floral phenotypes, leading to phenotypically diverse but ecologically generalist flowers i.e. adaptive wandering. Focusing on three morphotypes of spring mass-flowering *Dimorphotheca pluvialis-sinuata* daisies, we quantified floral phenotypic divergence and trait integration, gradients of network and pollinator-use similarity and trait preferences of local pollinators to assess whether the pollinator-shift or adaptive wandering models explain floral diversification in the complex. Multivariate analyses of floral trait data suggest a strong correspondence with *a priori* morphotype designations, while comparison of field collections with specimens grown in a common garden suggest that floral traits are not sufficiently plastic to obscure the diagnosis of morphotypes. Quantitative network analyses revealed that visitor communities on *Dimorphotheca* were generally highly dissimilar, with weak visitor-species gradients inconsistently underlying the distribution of morphotypes. Contrary to expectations derived from pollinator-shifts, this suggests that pollinator distributional limits do not explain floral divergence and that these daisies are ecologically generalized. However, despite the apparent generalization of *Dimorphotheca,* indicator species analyses identified strong visitor affiliates with each of the three morphotypes. Experimental manipulation of ray colouration and disc appendage morphology with model inflorescences showed that these taxa preferred to visit models more closely resembling the native phenotype in each morphotype's distribution. However, overall trait preferences were weak, suggesting that floral divergence is unlikely to result in niche shifts that contribute to reproductive isolation. It therefore appears that patterns of divergence and pollinator use in *Dimorphotheca* are more closely aligned with the theoretical model of adaptive wandering than pollinator-shifts.

WHEN FLOWERS BLEED TO CHEAT – DECEPTIVE POLLINATION STRATEGIES IN SOUTH AFRICAN *Ceropegia* (APOCYNACEAE)

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ABSTRACT

The intriguing flowers in *Ceropegia* fascinate growers and botanists globally for their outstanding floral diversity and complexity including kettle-trap and non-trap flowers. Understanding the evolution and diversification of flowers in this group requires detailed insight into pollinator specificity, identification of cues for pollinator attraction, and presence of rewards. Emerging evidence suggests that multiple shifts between the two distinct flower types gave rise to diverse mimicry strategies, driven by a single, albeit functionally diverse pollinator group – flies.

Previously, studies have focussed on deceptive species with kettle-trap flowers in which floral chemistry plays a key role in attracting pollinators and mediating pollinator specificity. Many kettle-trap flowered species are pollinated by kleptoparasitic flies which suck blood from wounded or dead insects caught by predatory arthropods. The flies locate these food sources via volatiles released by the insects when attacked or wounded. Some kettle-trap flowers use these volatiles to lure kleptoparasitic flies into their rewardless flowers.

The remarkable strategy of kleptomyiophily seems widespread among *Ceropegia* kettle-trap flowers but was not known from non-trapping species ('*Brachystelma*' and the stapeliads) which generally use different strategies (carrion/dung mimicry) and attract different flies. We present the first case of kleptomyiophily in a non-trapping *Ceropegia* species and reveal a novel aspect of this strategy: secretion of fake haemolymph (protein and sugar containing liquid) from the corolla lobes. In deceptive kettle-trap flowers, prolonged physical confinement of pollinators promotes pollination; our novel findings suggest that in non-trapping flowers, rewards retain fly-pollinators on the flowers, replacing the function of the trap.

FLORAL DIVERSIFICATION DRIVEN BY A POLLINATOR SHIFT IN THE DUVERNOIA CLADE OF *Justicia*

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ABSTRACT

Floral divergence among sister taxa is often associated with pollinator shifts and can play a role in speciation. We investigated a potential case in Duvernoia clade of *Justicia* (Acanthaceae) which includes two species with markedly divergent floral morphology. Pollinator observations and pollen load analyses showed that *Justicia adhatodoides* is pollinated exclusively by large carpenter bees, while its sister taxon *Justicia aconitiflora* is pollinated exclusively by eumenid wasps. Floral morphology matches body and tongue morphology of these two insect groups, and this phenotypic matching mediates pollen transfer and access to nectar. Visual and olfactory signals of flowers, and possibly also the taste of nectar, likely play functional roles in pollination system specialization. To infer the direction of the pollinator shift in the Duvernoia clade, we are also studying pollination systems of the outgroups. This study provides a compelling new example of a transition between bee and wasp pollination, and highlights the combined effects of floral morphology, colour and scent on specialization in plant pollination systems.

CAN DROUGHT AFFECT FLORAL COLOUR OF BEES IN AN AGRICULTURAL POLLINATION SYSTEM?

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ABSTRACT

Recent IPCC predictions of climate change, including increased extreme rainfall and drought events, may put pollination interactions at risk. Changes in climatic conditions can affect floral traits, among them flower colour, which acts as visual signalling to pollinators. UN's 2030 Agenda has the goals of ensuring food production and ecosystem processes. However, these goals may be compromised if pollination is affected, as several crops are dependent on pollinators for fruit and seed production, which rely on floral signals to locate flowers.

We investigated whether variations in water availability, simulating a climate change scenario, could induce changes in flower colour of *Cucurbita pepo* L, a bee-pollinated crop. For that, we assigned plants to one of the following three treatments: a 30% reduction in rainfall, extreme drought events, and regular rainfall (control). Both drought scenarios simulate IPCC predictions for the next decades. We measured the reflectance of petals, stigmas and anthers of fresh flowers and used these data to generate colour loci in a colour hexagon vision model, representing the trichromatic vision of bees.

Extreme drought conditions affected floral colour, which might be related to the regulation of the synthesis of carotenoids that are known to confer yellow and orange pigmentation of flowers and are present in *Cucurbita*. However, those changes were not noticeable by bees, according to the visual sensitivity of *Bombus terrestris*, meaning that the visual communication between flower and pollinator, in terms of floral colour, may be maintained in this scenario.

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TRAP NESTING: AN EASY WAY TO CONSERVE LEAFCUTTER BEES FOR ENHANCED POLLINATION IN PIGEON PEA

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ABSTRACT

Pigeon pea (*Cajanus cajan*) is an often-cross pollinated pulse crop. Solitary bees (Megachilidae) were reported to be the major flower visitors, and visitation by *Megachile* spp increases the pollination and yield of the crop. Leafcutter bees construct their nests in natural pre-existing cavities using materials like leaf, mud, resin, and chewed plant tissues. Our studies were conducted at the experimental farm of ICAR-National Bureau of Agricultural Insect Resources, Yelahanka Campus at Bengaluru, Karnataka, India. We used bamboo trap nests (120 trap nests organized into ten different bundles each with 12 bamboo culms) of 10 mm diameter installed during the flowering stage to document the effect of providing shelter to leafcutter bees. Two plots of pigeon pea one installed with trap nests and another without trap nests were maintained. Four different species of leafcutter bees viz., *Megachile lanata*, *M. laticeps*, *M. disjuncta,* and *Coelioxys* sp. were found constructing nests. The percent pod set, number of seeds per pod, and test weight of seeds in plots installed with trap nests were significantly higher compared to that in the plots without trap nests. The provision of nesting structures in croplands will help leafcutter bees to have quick and easy access to shelter for nesting and foraging facilitating the conservation of these bees and enhancing pollination and yield in pigeon pea.

EVOLUTIONARILY INSPIRED SOLUTIONS TO THE CROP POLLINATION CRISIS

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ABSTRACT

The field of pollination ecology is strongly divided between applied research on crop pollination, and fundamental research that aims at understanding the function of flowers and the role of pollinators in driving their evolution. In this presentation we will outline how applied research on crop pollination can benefit from findings of fundamental pollination research, an area of science that is particularly strongly represented in South Africa. In particular, I will argue that the crop pollination crisis, which is perceived as a major threat to human food production, should not only be approached from an ecological point of view, but can also benefit from an evolutionary perspective. Throughout their evolutionary history, plants have successfully dealt with pollination crises numerous times by adapting to different pollinators. Insight into these 'pollinator shifts' can be used to (genetically) modify crop flowers to make them more suitable for local assemblages of wild pollinator species. This Darwinian perspective on solving applied problems is already widespread in other areas of agriculture, such as making crops resilient against climate change, and holds great potential for pollination too.

NON-PROTEIN AMINO ACIDS OF FLORAL NECTAR AFFECTS SURVIVAL AND LOCOMOTION OF POLLINATORS

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ABSTRACT

A large variety of animals exploit floral nectar as a food source and are engaged in pollination of numerous angiosperm species. Recently several secondary compounds have been detected in nectar and some of them affect the foraging behaviour of animals and potentially increase the benefits to the plant. One class of such compounds is the non-protein amino acids (NPAAs), i.e., amino acids that are not used for protein synthesis.

GABA (γ-aminobutyric acid) and β-alanine are among the most abundant and they were frequently found in floral nectar. Interestingly they are known to be important neurotransmitters in the insect nervous system. We performed experiments about the effects of these compounds on bumble bees (*Bombus terrestris*). Laboratory-reared insects fed artificial diets enriched with the two non-protein amino acids at low and high concentration and their survival and behavioral parameters have been assessed. GABA had a positive effect on insect's survival whereas β-alanine had a negative consequence on the same parameter. Bumble bees decrease the flying activity after feeding the low concentration GABA diet. They also increased their walking activity when fed the β-alanine diet at high concentration, while they increased their flying activity with the same solution at low concentration.

We tested also the possible effect of nectar-dwelling yeasts (*Metschnikowia gruesii*, *M. reukaufii* and *M. chrysoperlae*) on GABA concentration in nectar. Only *M. gruesii* and *M. reukafii* were able to drastically and quickly reduce GABA concentration. This result suggests that yeasts can interfere with the possible effect exerted by NPAAs on insect survival and behaviour.

NATIVE BEE COMMUNITIES IN AGROECOSYSTEMS OF THE LOWER MISSISSIPPI ALLUVIAL VALLEY, UNITED STATES

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ABSTRACT

Native bees (Hymenoptera: Anthophila) were sampled across the Delta region of Mississippi, part of the lower alluvial valley of the Mississippi River, to determine the biodiversity of native bees. Collections were made in commercial agricultural fields of cotton, corn, soybeans, along with additional samples taken from semi-natural habitats including former agricultural land enrolled in conservation programs. The native bee communities found in agricultural fields was dominated by generalist pollinators in the genera *Agapostemon, Augochloropsis, Halictus,* and *Lasioglossum* (Halictidae), and *Melissodes* (Apidae). We compared common species and communities of native bees between crop habitats under conventional agricultural management practices for the lower Mississippi Alluvial Valley region, including often heavy insecticide usage and tillage regimes, and habitats considered to be natural or semi natural with no little anthropogenic activities. Nonmetric multidimensional scaling (nMDS) indicated some differences between communities, but they were not significantly different. While cropland is generally highly managed and disturbed within the landscape, our data suggest that a community of common generalist native pollinators persists. Many of these common and frequently encountered species are also found in other cropping systems across North America.

THE ECONOMY OF POLLEN DISPERSAL IN FLOWERING PLANTS

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ABSTRACT

Mating success of flowering plants depends strongly on the efficiencies of pollen removal from flowers and its subsequent dispersal to conspecific stigmas. Based on the pollen fates for 241 plant species, the overall percentage of pollen removed from flowers varied up to two-fold according to type of pollen dispersal unit and was >80% for plants with granular monads or sectile (segmented) pollinia, but <45% for orchids and milkweeds with solid pollinia. The percentage of removed pollen reaching stigmas (pollen transfer efficiency, PTE) varied markedly and, on average, was 2.4% for species with granular monads, 10.4% for orchids with sectile pollinia, 18.7% for milkweeds with solid pollinia, and 27.0% for orchids with solid pollinia. The high PTE for orchids and milkweeds results from firm attachment systems (clips or glue) and lack of consumption when pollen is packaged in pollinaria (pollinia plus attachment device), as well as the potential for complete deposition of solid pollinia. The percentage of pollen produced that disperses to stigmas (relative pollen export) varies mostly with PTE among species. Species with specialized pollination or adaptations to a particular pollinator functional group do not realize distinctly greater pollen economy, though PTE tended to be lower in plants pollinated by animals, such as bees, that groom actively. Nectar production increases the probability that flowers receive pollen, but does not generally influence PTE. These findings confirm the key importance of floral traits, particularly pollen-packaging, for pollen dispersal outcomes and highlight the under-appreciated pollen-transfer effectiveness of non-hymenopteran pollinators.

AN IMPROVED INTERPRETATION OF HOLOCENE FOSSIL POLLEN ARCHIVES BASED ON THE UNDERSTANDING OF THE POLLEN VEGETATION RELATIONSHIP AND POLLINATION PATHWAYS IN THE SAVANNA BIOME OF THE GREATER KRUGER NATIONAL PARK, SOUTH AFRICA

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ABSTRACT

Pollen grains use diverse transportation pathways such as wind, water, insects, and animals. These diverse pollen transportation pathways and the quantity of pollen produced by various plant species affect the pollen assemblage richness and diversity in Quaternary pollen archives. This pollen vegetation relationship study explores the pollination pathways of wind and insects and evaluates the seasonal influences on the deposition or collection of pollen. This study was applied to honey samples and surface sediment samples from the Greater Kruger National Park in the Savanna biome. Comparative statistics (Anova and Rarefaction curves) were used to expose the proportion of insect (honeybees) and wind-transported pollen in both samples in addition to the influence seasonality has on different pollen deposition sites. This data was compared to a botanical survey of the surrounding vegetation. Honey samples reflected 85% of pollen from the surrounding vegetation compared to a 72 % representation by sediment samples. The surrounding vegetation that has not been proportionally represented by either honey and sediment samples correlates with the known low production rate of the plant species, for example, *Senegalia nigrescens* (54 %: vegetation, 1.68 %: sediment, and 0.84 %: honey). Pollen that was overrepresented in sediment and honey samples compared to the relative abundance in the surrounding vegetation, correlated to plants with high pollen production rates such as *Combretaceae* (2 %: vegetation, 21 %: sediment, and 61 %: honey). Overall honey samples reflected seasonal changes much more accurately than sediment samples, since pollen from honey is stored in the nectar and pollen from surface sediment samples accumulates on the soil and is susceptible to further transportation by wind. This further indicates that seasonal (monthly) vegetation fluctuations are tentatively accounted for by sediment samples. This debut study contributes to the improving accuracy in the transcription of pollen assemblage data to the interpretation or reconstruction of past environments in the Lowveld region, Savanna biome of southern Africa.

WHO IS THE BEST POLLINATOR? TRACKING THE POLLEN FATE OF A BUZZ POLLINATED PLANT

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ABSTRACT

Floral visitors differ in quality of pollen transfer, even acting as a thieve instead of a pollinator. Body size may be one trait that help predict the outcome of pollination: usually, large bees are considered more effective pollinators, while small bees act as pollen thieves. Our aim was to track pollen fate regarding the size and behavior of two different bee species. We hypothesized that small bee species are less efficient in pollen removal and deposition and have a less steep pollen carryover curve than larger bee species. To evaluate our hypothesis, we conducted fieldwork and pollination experiments. We found that small bees remove 1.7 times more pollen from anthers and deposited almost 1.5 times more pollen grains in the stigma of *C. latistipula* than large bees, but surprisingly, this did not into a higher plant fitness: while 88% of *B. morio* visits set fruits, only 66% of *Melipona* spp. set fruit. This may be explained by the morphological mismatch between bees' and flower size. We also found that the pollen carryover curve was steeper for large than for small bees, but the number of pollen grains deposited over multiple visits was higher for large bees. In sum, our results suggest that the flower visitor traits, such as size, could help us predict the outcome of plant-flower visitor interactions and dynamic of mutualism.

SOUTHERN AFROTEMPERATE FOREST TREE SPECIES HAVE GENERALIST, BUT DISTINCT, POLLINATOR COMMUNITIES PREDICTED BY FLORAL TRAITS

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ABSTRACT

The largest indigenous forest in southern Africa is confined to the eastern regions of the mega-diverse Cape Floristic Region. Despite an abundance of work on pollination in the fynbos biome, indigenous forests have been largely overlooked, with the most comprehensive notes on forest tree pollination dating back to 1926. The challenges of spatiotemporal variation in forest tree flowering and accessibility have seen pollination studies in undisturbed forest canopies being unevenly distributed across the globe, mostly restricted to areas where canopy cranes are in place and often covering northern temperate or tropical forest systems. Thus, southern Afrotemperate canopies represent two geographic gaps: southern temperate forests and Afromontane forests. Here, despite divergent phylogenies, the majority of canopy tree species produce a strikingly similar flower morphology of small, white flowers. We accessed flowering tree canopies, using rope pulling techniques, and observed flower visitors to four common canopy tree species in a large, undisturbed forest interior. A total of 144 hours of day- and night-time observations were captured. The most common flower visitor was the Cape honeybee (*Apis mellifera capensis*). However, dipteran, lepidopteran and non-bee hymenopteran species contributed significantly to flower visitation rates, with respective tree species showing statistically unique assemblages of flower visitors. Interestingly, temporal partitioning in flowering phenology was noted for focal tree species, as well as differences in measured floral traits. We conclude that tree species, despite being generalist in their interaction with flower visitors, support a rich diversity of insect species and have high conservation value.

THE INFLUENCE OF NECTAR ROBBERS IN SHAPING FLOWER COLOUR

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ABSTRACT

While the influence of pollinators in driving floral signals is relatively well known, the role of flower antagonists is less known. Flowers face a trade-off in attracting effective pollinators but avoiding antagonists such as nectar robbers; flower visitors that take nectar without pollinating the flowers. One solution is to produce signals (e.g. flower colours) that are detectable to pollinators but less detectable to nectar robbers. This is possible if the visual systems of these two flower visitor types differ, which is the case with birds and insects. Bird-pollinated *Erica* species in the Cape Floristic Region, South Africa, are pollinated by sunbirds and predominantly robbed by Hymenoptera. We applied visual modelling to 62 *Erica* species to test if bird-pollinated species are less conspicuous to bees than to birds. The results found this to be true for some metrics of colour discrimination and flower conspicuousness, but not all. We also tested the prediction that flower conspicuousness to bees is correlated to other bee-avoidance traits (corolla length and stickiness, and sepal size) but found no correlations. This study suggests that insect nectar robbers have contributed to shaping flower colour evolution in bird-pollinated species.

TOWARDS A CAUSAL UNDERSTANDING OF POLLINATION SUCCESS: EVALUATING A PATH ANALYSIS APPROACH TO COMPLEMENT THE POLLEN LIMITATION INDEX AND OTHER RATIO VARIABLES IN POLLINATION ECOLOGY

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ABSTRACT

Pollination success is an outcome of plant traits in combination with biotic and abiotic factors. However, the relative importance of these drivers has been obscured by the lack of an appropriate causal framework to relate drivers to each other and to pollination outcomes. This is because plant traits and pollination outcomes are quantified by a suite of ratio variables (indices) which normalise for maximum potential seed production, to allow comparison between species and populations. However, these indices are calculated from common ratio-elements, resulting in spurious correlations and thus precluding inclusion of multiple indices in a common causal framework. For example, the extent to which plant reproduction is limited by pollen receipt (pollen limitation) depends on the extent to which plants rely on pollen from other genetic individuals to make seed (self-incompatibility). The index of pollen limitation (PL) is often calculated using seed production following hand cross-pollination, which is also used to calculate the index of auto-fertility (AF). This prevents us from using AF as an explanatory variable in a comparative analysis of PL. We review the contributions of ratio variables to pollination biology and evaluate a path-analysis approach to relate plant traits and environmental variables to pollination success. Using this approach, we assess to what extent the lower proportion fruit set in trees relative to other growth forms can be attributed to differences in resource constraints versus auto-fertility versus pollen receipt from pollinators. This approach, which we have used in a multi-species study, is also promising for investigating causes of variation in reproductive success among populations within species.

GENERALIST POLLINATORS UNDERLIE THE FUNCTION AND EVOLUTION OF HETEROSTYLY: STUDIES ACROSS ALL ANGIOSPERM GENERA AND IN LINUM SPECIES

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ABSTRACT

Heterostylous plants promote cross-pollination between two distinct floral morphs with reciprocal positions of stigmas and anthers, an efficient mechanism for disassortative mating. Since their discovering by Charles Darwin, heterostyly and related stylar polymorphisms have been reported in an increasing number of taxa, up to 199 genera and 28 families in the latest reviews. Apparently, stylar polymorphisms have many independent origins in angiosperm lineages sharing similar floral traits such as actinomorphic and narrow-tubed flowers, suggesting a case of evolutionary convergence that has not been tested empirically. Such convergence has been functionally linked to long-tongued pollinators, which may be more efficient in disassortative pollen transfer. We performed exhaustive literature reviews to (i) update the number of stylar-polymorphic taxa, (ii) record six floral traits possibly associated with the evolution of this breeding system and (iii) retrieve available information on the pollinators of heterostylous taxa. We found 244 style-length polymorphic genera belonging to 34 families, notably expanding known cases by 20%. Phylogenetic and comparative analyses determined numerous independent origins of style-length polymorphism across the angiosperms. These gains were associated with actinomorphic, tubular flowers with a low number of stamens with filaments fused to the corolla, and a low number of carpels. We did not find an association with long-tongued pollinators. Instead, we found that a vast majority of heterostylous taxa have generalist pollination systems. Experimental trials of pollen transfer using heterostylous *Linum* flowers labelled with quantum dots showed that short-tongued generalist pollinators can efficiently promote disassortative pollen transfer.

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EVALUATION OF PLANT-POLLINATOR INTERACTIONS IN THE BRAZILIAN CERRADO

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ABSTRACT

The Brazilian Cerrado is the second largest biome in South America and is considered a biodiversity hotspot. Given the current global biodiversity crisis, plant-pollinator interactions are fundamental to ecosystem regulation and maintenance. Here, we conducted a data survey of plant-pollinator interactions in the Cerrado, adopting biodiversity data standards. A systematic review of the literature was carried out on the Web of Science and Dimensions platforms, up to March 2022, resulting in 99 references. We also included interactions recorded in the Cerrado by more than fifty scientists up to December 2022. The interaction database standard of the Brazilian Plant-Pollinator Interactions Network (REBIPP) was used to compile each interaction (http://db.rebipp.org.br/). We recorded 393 plant species interacting with 511 animal species, totaling 1,864 interactions, for which we developed a metanetwork. Among the 77 botanical families sampled, Fabaceae (19%), Rubiaceae (7%) and Malpighiaceae (7%) had the highest number of species. The animals were divided into 12 functional groups, with bees (52%) and birds (8%) being the most diverse and with the highest number of established interactions. This reinforces patterns found for local works in the Cerrado but also demonstrates the diversity of less frequent groups (e.g., bats, moths). This data will be included in the REBIPP database and can be used to support decision-making for the conservation of Cerrado. The results obtained here represent a joint effort by several researchers in the synthesis of knowledge and identification of information gaps for the Cerrado.

POLLINATION BIOLOGY OF ENANTIOSTYLOUS *Cyanella alba*: WHERE ARE THE BUZZ-POLLINATING BEES?

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ABSTRACT

Flowers interact with pollinators and have evolved diverse forms to enhance outbreeding. One such innovation is enantiostyly ('mirror-image flowers') where styles are deflected either left (L), or right (R) of the flower's midline. This asymmetry is usually accompanied by heteranthery, specialization of anthers for feeding and pollinating function. Pollinating anthers are reciprocally positioned to the style promoting bee-mediated cross-pollination between flowers of opposite 'handedness' by 'buzz-pollinating' bees. *Cyanella* is a genus of nine species mostly endemic to the Western Cape; six are straight-styled and two possess enantiostyly. In *C. alba* three kinds of plants occur with either L or R flowers, or both (M). We investigated multiple populations of *C. alba* in the Biedouw valley and Bokkeveld plateau. Surveys of plant handedness revealed average frequencies of L=0.47, R=0.43, M=0.10 among 26 populations with an average daily display size of 1.58 flowers. Censuses of marked plants throughout the season revealed an increase in M frequency concomitant with decreases in L or R plants. Controlled crosses demonstrated moderate self-incompatibility, with plants incapable of autonomous self-pollination and comparisons of open- versus controlled cross-pollinations confirmed chronic pollen limitation of seed set in three populations. Despite 20+ hours of observation, we observed no buzz pollination in any population and only very limited generalist bee visitation in a few populations on the Bokkeveld Plateau. Observations of stamen dimorphism in this region suggest that heteranthery may be breaking down in some populations enabling generalist pollination, perhaps in response to the absence of bees capable of buzz pollination.

A GROWING NEED FOR TAXONOMY

Connal Eardley

ABSTRACT

Four decades ago there was a vibrant community of taxonomists around the world. In spite of Bionet-International the Global Taxonomy Initiative and many regional and national initiatives today taxonomists are few and far between. However, the need for taxonomists is increasing. Biodiversity is apparently disappearing around the world, but we cannot measure this in South Africa, and probably in most of the world. This is because we cannot monitor at species level - we cannot identify the species; we do not know their distributions and we do not know their associated organisms. However, there is a growing citizen scientist interest ready to come to the rescue. But they need appropriate tools. They are, understandably, not inclined to use identification keys in scientific journals. I am, therefore, planning illustrated guides to the bees of South Africa. Like many plant guides that do not follow taxonomic groups, like guides to trees, I'm starting with the big bees – large xylocopids, megachilids, fidelids and diggerbees. The tool of choice used by citizen scientists today is the cell phone, and these bees can be adequately photographed for identification purposes. We already have a tool, in iNaturalist, for the publication of their data, and to identify their associated plants, in Candide, to add floral associations. Enthusiasm should grow if we can pick the big fruits first, and then move onto the smaller bees.

CHARACTERIZATION OF THE DIVERSITY OF POLLINATING INSECTS AND THEIR INTERACTIONS WITH THE FLORA OF THE "AGRO FORÊTS POUR LE DÉVELOPPEMENT DE KIPUSHI" (AFODEK) PERIMETER

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ABSTRACT

Forest ecosystems are facing worldwide disturbances that make them fragile due to their anthropization. This progressive degradation leads to a progressive drop in biodiversity, while they provide nature and man with indispensable ecosystem services such as plant pollination. The present work had the objective of characterizing the diversity of wild bees and other pollinating insects, as well as the interactions maintained with the flora of the Agroforests for the Development of Kipushi (AFODEK). Rigorous sampling led to statistical analyses of community biodiversity for insects and hosts.

The results of this study showed that the AFODEK perimeter has a high abundance of insect pollinators with inseparable interactions and a specific richness distributed according to the location of the agroforestry plots. A total of 30 species of pollinators are observed, including 3 families of bees (Halictidae, Megachilidae, Apidae); one family of wasps (Crabonidae) and another family of Hymenoptera not yet determined. Extrapolation of the observed species richness could potentially bring it up to 52 species (41.99 ± 9.64 according to Chao). The abundance rank is dominated by the carpenter bee "*Xylocopa albiceps*". Diversity is found to be higher at sites Y and H, where there is a high probability of encountering a new species at each observation. Contrary to the sites with low probability of new species, there is a low regularity of Piélou in these sites. It is noted that the majority of pollinators in the area are generalists attributable to the "polylectic" category, with the exception of a few mono- and oligolectics. There is every reason to believe that the agroforestry developed in this perimeter has a probable impact on the general biodiversity.

A KNOWLEDGE COLLATION PROCESS TOWARDS SANPARKS'S FIRST STATE OF THE KNOWLEDGE REPORT ON INVERTEBRATES AND POLLINATORS

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ABSTRACT

The South African National Parks (SANParks) began a process of modernising biodiversity data management systems and mobilising data for management and policy use in 2020. As part of the JRS Biodiversity Foundation (second funding phase), four (4) projects have been implemented to support the four Scientific Services nodes. One of the key deliverables will be the collation of knowledge and data from multiple parks across nodes. The invertebrates and pollinators were identified as one critical component across the parks and nodes, triggering the need to produce a State of Knowledge Report. The following focus areas were identified: 1) the need to establish what invertebrates and pollinators are present across the different parks; 2) explore any links that the invertebrates and pollinators have towards ecosystem functions and roles within the landscapes; 3) threats associated with the various groups/taxa; 4) determine the conservation/protection status for the different groups/taxa; and 5) identify knowledge and identify priority areas for future work and research. Here, I provide a brief overview on the progress of the project to date, highlighting some of the key preliminary findings. I further indicate how your contribution and participation can be of great assistance to the project, especially on providing any valuable information of the work and/or research your might have conducted in the different parks.

CITIZEN SCIENCE AS A "HANDS-ON" TOOL TO LINK SCIENCE LEARNING TO CONSERVATION ON POLLINATORS AND POLLINATION SERVICE

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ABSTRACT

The approximation between the scientific knowledge generated in academia and its application is gaining relevance to address conservation problems such as pollinator and pollination service loss. In this perspective citizen science is a valuable approach to promote engagement and building science literacy.

This on-going research applies the Citizen Science project Guardiões dos Sertões as a teaching tool in the curricular component Science of Life, of the agrarian science courses at Federal University of Sergipe (UFS), in semiarid Sergipe, Northeast, Brazil. From September 2022 to April 2023, students performed observations in private gardens, due to their importance for pollinator´s conservation in urban context.

The 125 engaged students provided 159 records on interactions between flower visitors and plants. Mostly bees and butterflies were recorded, and pollination was the main recognized interaction. So, the "Guardiões" project was successfully integrated into the pedagogic practice, as a hands-on teaching method of didactic transpositions, providing field experience and training in observations using scientific protocols. The data generated by the students are used to discuss ecological concepts, while providing field data for the monitoring of the interactions between animals and flowering plants from semiarid Caatinga.

CLOSE-FOCUSING CAMERA TRAPS: A VALUABLE NEW TOOL FOR POLLINATION STUDIES

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ABSTRACT

Camera traps allow for remote recordings of animal behaviour in places and at times that are not suitable for direct human observations. I discuss applications of close-focusing camera traps in pollination studies, with special reference to issues of cost, sensitivity, reliability, battery life and resolution of cameras. The most sensitive camera traps use video motion detection (VMD), but addition of close-focusing lenses to cameras with passive-infrared (PIR) detection can bring sensors close enough to the subject to allow cameras to be triggered by some insect pollinators. Close-focussing enables recordings of sufficient resolution to allow identification of some insects to species level. Camera traps with capability for night-time video recordings using infra-red illumination have provided important recent breakthroughs in our understanding of the behaviour of nocturnal pollinators such as bats, rodents and moths. Close-focusing camera traps therefore have tremendous potential to improve our understanding of plant-pollinator interactions which are not easy to study using traditional methods.

USING NECTAR LANDSCAPES TO ASSESS COMPETITION BETWEEN DOMESTICATED HONEYBEES AND WILD INSECTS IN SOUTH AFRICA AND SCOTLAND

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ABSTRACT

Domesticated honeybees can compete with wild insect populations for resources such as nectar and pollen. Within the Fynbos biome and in Scottish heathlands, beekeepers are often prevented from placing hives within National Parks due to concern over such competition. Comprehensive research on whether honeybee-insect competition occurs in both contexts remains lacking however. In 2016, a landmark paper by Baude *et al.* 2016 quantified landscape nectar sugar production for the UK from the 1940s-2000s. By quantifying nectar sugar production through time at the landscape level in this way, it is possible to determine the carrying capacity of a habitat for groups of nectar-feeding insects, as well as periods which present potential 'hunger-gaps', and which plant taxa are most important to different insects groups through time.

Using a similar community-wide approach, we quantified the landscape nectar sugar production in Scottish Heathlands and three South African Fynbos types across the flowering season. Plant-pollinator network analysis and a predictive modelling approach will be used to describe the insect nectar sugar demands through time, to determine what stocking density of honeybee hives is required to avoid competition with wild pollinators in these habitats. Given the economic and ecological value of both managed honeybees and wild pollinators, it is important to determine the carrying capacity for nectar-feeding insects to ensure that these habitats are not over-stocked.

STANDARDIZING BEE SAMPLING: A SYSTEMATIC REVIEW OF PAN TRAPPING AND ASSOCIATED FLORAL SURVEYS

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ABSTRACT

A number of methodological studies and conceptual frameworks offer guidance on bee sampling with pan traps (aka bee bowls, Moericke traps). Nevertheless, a large methodological variety persists in bee studies using pan traps. This lack of standardization complicates the comparison of sampling results among studies, and so it remains in question how floral abundance around pan traps affects the number of bees sampled.

We systematically reviewed all peer-reviewed studies, which used pan traps for bee collection, were published in English until spring 2022 and were listed in the Web of Science core collection. We extracted details of pan-trap characteristics and the methodology used to sample flower abundance and diversity around pan traps. We also obtained information on correlations between floral and bee abundance/diversity found in these studies.

Our systematic search yielded 369 references in total, yielding relevant 290 studies. Some methodological aspects such as trap color were often similar in the majority of studies; other aspects such as sampling duration, filling level or trap solution composition varied considerably. Few studies used floral abundance and/or diversity as an explanatory variable in their analyses. In comparison to botanical surveys, these studies often simplified floral sampling methods, probably due to time constraints and the need for synchronization with bee sampling. Correlations between floral abundance/diversity and bee abundance/diversity did not indicate an unambiguous relationship between pan trap results and surrounding floral context. The small pool of studies using floral context in their bee analyses indicates a great need for more research on this topic in the future, which should incorporate standardized methods.

PERCEPTION OF FARMERS ON THE RELATIONSHIP BETWEEN WILD VEGETATION AND INSECT POLLINATORS ON A HIGHLY HETEROGENOUS AGRICULTURAL HIGHLANDS LANDSCAPE OF GUATEMALA

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ABSTRACT

Structurally complex landscapes, agroforestry and non-intensive, tradition-based practices may play an important role in preserving biodiversity in agroecosystems. Agricultural practices in Guatemalan highlands show a highly heterogeneous combination of traditional and technified methods. Despite the intense land use practiced in the area, insect pollinator populations are still relatively abundant and diverse. We surveyed 37 farmers from agricultural lands in the department of Chimaltenango about different crop-management practices that may affect pollinator populations, such as pesticide use and weed management. Also, we asked about their perception of the relationship between natural vegetation and insect pollinators.

We found that local agriculture is characterized by a combination of intensive and non-intensive practices (rotation, fallowing). Almost 80% of the surveyed farmers reportedly implement integrated pest control. Close to 50% answered that they have at times sprayed pesticides over flowering crops, and 30% of farmers abstain from using pesticides altogether. Most farmers (62%) answered that sometimes they allow weeds and wild vegetation surrounding their crops, while 24% report that they always let wild plants grow. Only 13.5% of farmers kept any bee species, although none of them consider any kind of bee to be harmful to their crops. Our results support the role of traditional and varied agricultural practices in the maintenance of insect pollinator populations and highlight the importance of traditional farming knowledge on pollinator conservation in agricultural lands.

TRADITIONAL SLASH AND BURN MILPA AGRICULTURE IN MESOAMERICA AND IT EFFECT ON POLLINATORS AND THEIR POLLINATION SERVICES

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ABSTRACT

The Yucatán Peninsula of Mexico has a >4000-year history of traditional slash-and-burn agriculture, termed ‘milpa’ that may adversely affect ecosystem services such as pollination, which are required for successful crop yields. Yet, this traditional tropical agriculture milpa is also practiced in other areas of Central America as in Guatemala. In the present study I review different studies and analyse the effect that this traditional practice has on pollinators in the region and how the pollination service is affected. In México I analyse pollinator visiting Habanero chilli (*Capsicum chinense*). In Guatemala pollinator visiting pumpkins (*Cucurbita pepo*) crops and turnip (*Brasica rapa*). I observed that low-intensity traditional slash-and-burn (milpa) agriculture provides small generalist species as *Lasioglossum* spp., *Partamona bilineata* and other stingless bees for successful fruit production of habanero chilli, pumpkins and Turnip; fallow land, Mayan gardens and pasture derived from milpa practices therefore need to be valued as important habitats for these and related ground-nesting bee species. Additionally, floral resource availability provided by heterogeneous areas within these traditional practices are positive related with the abundance and richness of these pollinator and indirectly related to the production of fruits. Suggesting that the existence of traditional practices can benefit the richness of bees and the provision of pollination services in the Mesoamerican region.

SEAMS IN THE FOREST FABRIC: THE ROLE OF POLLINATORS IN SUPPORTING FOREST-DEPENDENT LIVELIHOODS

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ABSTRACT

Animal pollination supports the production of most of the world's leading crops and wild plants and plays an integral role in the pollination of crops and products that supply essential nutrients to rural subsistence farming communities. Pollination services are, however, increasingly imperilled by habitat destruction, and while there is growing awareness of the importance and plight of pollinators in the West, there is still little evidence to show whether these concepts are recognised in developing regions. Information is required, firstly to assess the degree to which rural livelihoods are pollinator-reliant, and secondly to understand current perceptions and attitudes toward pollinators to inform appropriate awareness programs which can promote pollinator-friendly land-use. Pollinator exclusion experiments were conducted on two forest tree species that supply forest products to rural communities (*Julbernardia paniculata* and *Syzigium guineense*) in North-Western Zambia and findings reveal differing dependence on outcrossing facilitated by insect pollinators, and differences in the degree to which they were affected by pollen limitation. We assessed the impacts of forest loss on insect pollinators and investigated pollinator dependence of rural communities by conducting 574 household interviews, collecting information on crops and forest products being utilized. Attitudes towards insects and perceptions of insect pollinators and pollination were also recorded. Trends show that hymenopteran abundance was affected by forest cover. 79% of crops and forest products used were pollinator-dependent but understanding of pollination was limited and insects were generally disliked. This may have implications for land-use practices affecting pollinators and could be addressed by appropriate outreach initiatives.

INSECTS, GM MAIZE AND CHANGING AGRICULTURAL KNOWLEDGE LANDSCAPES IN SOUTH AFRICA

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ABSTRACT

Like farmers, agricultural scientists and researchers are makers, keepers and transmitters of agricultural knowledge. This knowledge and the ways in which it is generated is always shifting in relation to economic, political, technological, ideological and biophysical factors. Technologies bring change to the systems they enter. Through a focus on insects, this presentation focuses specifically on how the addition of GM maize seed has affected ecological-based knowledge within maize research and development (R&D) in South Africa.

POLLEN TUBE GROWTH IN *Calotropis procera* IS CONTROLLED BY ENVIRONMENTAL CHANGES: DOES IT HAVE AN IMPACT ON DELAYED FERTILIZATION?

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ABSTRACT

In C. procera, as in many other Apocynaceae, the nectar from these flowers is secreted from the nectaries located inside the stigmatic chamber, with the excess flowing via the capillary system into special reservoirs (cucculi). The nectar has two functions: it is used as a reward to attract pollinating insects; and it serves as the germination medium for pollen grains. Under natural conditions the nectar concentration is subjected to a large variability, ranging from 22-68% sucrose.

In the present study we followed the process of pollen germination under various experimental sucrose concentrations simulating the nectar. We found that the optimal concentration of a sucrose medium for pollen germination is 20%. However, if the already-germinated pollen grains are subjected to high sucrose concentration for different periods of time (between one and three hours), elongation of the pollen tubes is inhibited. In all the experimental groups, the pollen tubes renewed their elongation following a reduction of the sucrose concentration to 20%.

This phenomenon of increased sucrose levels causes delayed fertilization, as already well known in animals (Blandau and Young 1939); and in the plant it enables it to postpone fertilization until conditions improve and thus to thrive under the extremely high temperatures and fluctuations in relative humidity that characterize its habitat.

CONSERVATION OF POLLINATOR HABITAT IN A VITICULTURAL LANDSCAPE THROUGH FALLOW MANAGENT AND RECULTIVATION

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ABSTRACT

In the Moselle Valley (SW Germany), a region appreciated for high-quality wine production, bush encroachment on abandoned vineyard fallows deteriorates habitat quality for the charactersitic xerothermophilic insect fauna. Two options for counteracting succession exist: fallow management and recultivation with grapevines. Therefore, we compared different treatments for managing open and flower-rich vineyard fallows (annual mulching and sowing of wildflowers) from 2012 to 2020, sampling bee, butterfly and Auchenorrhyncha populations. Moreover, we compared a novel vineyard design with greened embankments to conventional vineyards without embankments.

While fallow treatments had no effect on butterfly and Auchenorrhyncha taxa richness and abundance, sowing was associated with significantly higher numbers of sampled bee individuals compared to plots without sowing, but only when plots were also mulched. Significantly more butterfly individuals and species were sampled in all fallow treatments compared to adjacent vineyards.

The number of species and individuals of wild bees and butterflies was significantly higher in vineyards with greened embankments compared to conventional vineyards without embankments. This also held true for the number of specialised and endangered species. The communities of wild bees and butterflies differed remarkably between both vineyard structures.

We conlude that vineyard fallow management can promote bee and butterfly communities in viticultural landscapes. Since Auchenorrhyncha were indifferent to fallow management, these measures are not likely to compromise plant protection in terms of increased disease vector populations. Moreover, we assume a great synergistic potential of vineyards with greened embankments to reconcile agricultural use and biodiversity conservation, because vine production in these vineyards is less cost-intensive than in conventional vineyards.

SIZE MATTERS: NUMBERS OF COLLECTED BEE INDIVIDUALS AND SPECIES INCREASE WITH PAN TRAP DIAMETER

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ABSTRACT

Pan traps are an established method for sampling bees and have been used across a wide range of habitats and geographical regions. Despite the long tradition of this method, uncertainty persists as to how pan-trap design influences sampling results.

We investigated the effect of pan-trap diameter on sampled bee communities at agricultural sites around Braunschweig, Germany. We installed 108 pan traps at six sites, with equal proportions of color-diameter combinations per site (yellow, blue and white; 22 cm versus 12 cm in diameter). We sampled bee individuals in three rounds of 24 hours (March/April, June, August/September) in 2021.

We collected 1154 bee individuals, which to a large extend have been identified to species level. We observed interacting effects of pan trap size and color on the number of sampled bee individuals and species. For all pan trap colors, larger pan traps collected significantly more bee individuals and species than smaller pan traps (Abundance: Negative Bionomial GLMM; Species: Poisson GLMM). At all sampling sites, the estimated number of sampled species, based on the same number of sampled individuals (individual-based rarefaction), was higher for large pan traps than for small pan traps. Based on our findings, we advocate for the use of larger pan traps for sampling bees in order to increase trap efficacy and efficiency.

HOW DOES FLOWER COVER AROUND PAN TRAPS IMPACT ON BEE SAMPLING RESULTS?

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ABSTRACT

Pan traps have been used for sampling bees across a wide range of habitats and geographical regions for decades. Varying floral resources around pan traps may bias sampling results, possibly affecting standardization of sampling effort, a fundamental reason for choosing this sampling method. This raises questions about the suitability of pan traps for bee monitoring programs that sample sites with varying flower cover.

We investigated the effect of floral context around pan traps on sampled bee communities at agricultural sites around Braunschweig in a two-year field experiment. We installed 72 pan traps at 13 sites in 2021 and 2022, respectively, with equal proportions of color-context combinations per site (yellow, blue and white; center of flower strip versus adjacent to flower strip, i.e. at 1 m distance from the edge of the flower strip). We sampled bees for 24 hours three times (March/April, June, August/September) each year. Simultaneously, we assessed the percent flower cover in 2.5 m radii around each trap.

Collected bees totalled more than 3600 individuals. Statistical analyses of the two-year dataset revealed effects of flower cover interacting with bee taxon on detection probability per trap (Logit GLMM) as well as on the number of sampled bee individuals per trap (Negative Binomial GLMM). Based on our findings, we encourage bee researchers to assess flower cover around traps to account for differences in trap attraction, especially when sampling bees in habitats with contrasting floral resource availability

THE ROLE OF BOTANICAL GARDENS AS A POLLINATOR REPOSITORY IN URBAN LANDSCAPES

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ABSTRACT

Botanical gardens are the unique and distinctive kind of scientific and cultural institutions. They have made major botanical and horticultural contributions to our societies. Jaywant Botanical Garden at Krishna Mahavidyalaya, Rethare (Bk.), M.S., India focuses largely on the *ex-situ* conservation of RET plants species from Western Ghats, India. The Garden is with 3 acres area and has established conservatory for RET plants of Western Ghats. Exotic and specific nectar and pollen producing plants are also introduced for attracting pollinators. We investigated survey of the botanical garden by point count method for detecting and assessing pollinator diversity. Faculty experts in taxonomy from Botany and Zoology departments take initiative in the survey. The collected samples are identified with available literature and documented in the form of photographs and herbarium. About 59 plants frequently visited by honeybees, butterflies, birds and other insect pollinators in the garden are documented. *Crotalaria juncea, Heliotropium indicum, Lantana camara* are the most promising plants frequently visited by butterflies**.** *Magnolia grandiflora, Nymphaea varities, Wodyetia bifurcata, Leucophyllum frutescens, Jacquemontia violacea, Portulaca oleracea, Cuphea hyssopifolia, Echinodorus cordifolius, Arachis pintoi, Solidago canadensis* are the plants specifically visited by honey bees. *Erythrina suberosa, Cassia fistula, Helicteres isora, Stachytarpheta indica, Stachytarpheta mutabilis* are the plants that attracts more number of bird species. About 31 species of butterflies, 26 species of birds and 3 species of honey bees were observed during the survey. We conclude that botanical gardens with relatively small-scale landscape features having diverse plant diversity in urban settings can provide important pollinator habitat in this era of biodiversity loss.

HEAVY METAL CONCENTRATIONS IN SOUTH AFRICAN POLLINATORS: *Apis Mellifera Capensis* AS A CASE STUDY

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ABSTRACT

Pollinators are important for the functioning of almost all terrestrial ecosystems globally through plant reproduction and productivity. Generalist pollinators like honeybees have been used as an indicator to assess pollution, mostly in the global north. Honeybees in South Africa are interchangeable between managed and natural colonies and the effects of heavy metals on native honeybee populations in South Africa are largely unknown. Bees are potentially good biological indicators as they have considerable, systematized colonies with diverse feeding habits and ephemeral lifespans that are sensitive to environmental change. Unlike other pollutants, metals do not degrade, but can accumulate. This is discussed in relation to positive and negative influences. Bees are thus of environmental and economic importance, as pollutants could have negative impacts ecologically as well as economically. The objective of this study is to firstly determine heavy metal contamination of pollen, honeybees, beehives, and honey of the Cape honeybee, Apis mellifera capensis, and secondly, evaluate the potential of Apis mellifera capensis to act as biological indicators of environmental pollution. The methods include comparing apiaries placed at sites (within the fynbos biome) representing, agricultural, urban, and natural areas. Heavy metals will be detected from foraging bees via atomic absorption spectroscopy. Representative plant species will be gathered on site and pollen viability tested using the TTC method. Fresh honey samples from the same hives will be assessed through mineralization methods.

COMPOSITION OF THE FLORAL NECTAR IN THE LITHOSPERMEAE TRIBE - CLADE C (BORAGINACEAE) AND THEIR POLLINATOR GUILDS

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ABSTRACT

It is recognized that phylogenetically-distinct nectariferous species visited by the same pollinator guild may display a convergent chemistry of their floral nectar revealing a pollinator-driven selection of nectar. Cases of convergence in nectar chemistry within a restricted phylogenetic context are of particular interest. At this regard, the available scattered data about the nectar chemistry of species of Clade C of the Lithospermeae tribe (Boraginaceae), reveal an heterogeneous sugar and amino acid profile. This clade comprises 95 species distributed along Europe, temperate and tropical Asia, Africa, Northern and Southern America. They are characterized by a wide range of flower visitors from short-tongued and large-tongued Apoidea to hummingbirds in the New World. The aim of this study is to assess if and how the nectar chemistry varies as a function of specific pollinator guilds. Wide field nectar sampling and pollinators observations will be coupled with chemical analysis of floral nectar including both primary (sugars and amino acids) and secondary compounds (non protein amino acids and biogenic amines).

VISUAL AND CHEMICAL ADVERTISEMENTS IN A BEE-POLLINATED NEOTROPICAL LIANA

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ABSTRACT

Animal-pollinated plant species depend on pollinator attraction to ensure sexual reproduction. The Bignonieae tribe is a charismatic clade of Neotropical lianas, with conspicuous flowers that attract diverse pollinators such as bats, hummingbirds, butterflies, hawkmoths, and mainly medium- and large-sized bees. Among the bee-pollinated species is *Amphilophium mansoanum* (DC.) L.G.Lohmann (Bignoniaceae), a liana that shows large conspicuous white flowers with internally yellow throat. The sweet-scented flowers are visited and pollinated by medium and large-sized bees that search for floral nectar, accumulated at the bottom of the floral tube. The aim of this study was to characterize visual and chemical floral traits and to associate them with the information available about bee sensorial abilities.

Although these flowers are visually conspicuous to humans, the two colours of the corolla are indistinguishable in bumblebee vision. Moreover, the flowers are indistinguishable from the background. Floral scent is dominated by terpenoids together with few aromatic and aliphatic compounds. Compounds such as β-pinene, (*E*)-β-ocimene, linalool, β-myrcene, 2-phenylethanol and eugenol are associated with bee pollination.

Thus, in this pollination system floral scent seems to have a crucial role in pollinator attraction, especially considering that bees present a highly sensitive olfactory system. However, our interpretation of flower color perception by bees was based on the sensory capability of *Bombus terrestris*. The shortage of information regarding the sensorial capabilities of tropical pollinators limits our interpretation, as it is possible that the *Centris* and *Epicharis* bees that pollinate this Neotropical liana have a lower threshold of visual sensibility.

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REBIPP: THE BRAZILIAN NETWORK OF PLANT-POLLINATOR INTERACTIONS

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ABSTRACT

The Brazilian Network of Plant-Pollinator Interactions (REBIPP) is a collaborative network of specialists in Pollination Biology that investigate plant-pollinator interactions in its multiple dimensions. REBIPP was founded to encourage scientific, educational and outreach activities related to pollination. Among the actions are: 1) encourage collaborative studies among its participants; 2) elaborate an assessment of plant-pollinator interactions in natural, agricultural, urban and restored areas in Brazil and identify knowledge gaps; 3) propose guidelines to contribute for public policies related to conservation of biodiversity and ecosystem services. REBBIP has been developing actions highlighting: 1) development and maintenance of the Plant-Pollinator Interactions Database (http://db.rebipp.org.br/); 2) publication of the Brazilian Assessment on Pollination, Pollinators and Food Production (2019); 3) organization of the XII, XIII and XIV International Pollination Course (2017, 2019 and 2023); 4) development of the Brazilian Proposal for Conservation of Pollinators that was sent to CBD in 2021 to be considered for COP 15; 5) development of Surpass Project - Safeguarding Pollination Services in a Changing World: theory into practice; 6) development of synthesis about knowledge on use of pollination intensification practices to promote sustainable agriculture (SPIN project); 7) proposal for Long and Medium Term Objectives, Action Goals for 2030 and Indicators for Pollination and Pollinators within the Post-2020 Global Biodiversity Framework Scope; 8) act as an “Observer” in Promote Pollinators since 2021. Overall, the REBIPP network has been successful in carrying out its activities and integrating several Brazilian stakeholders to achieve challenging goals in the area of Pollination Biology.

DROUGHT AFFECTS NECTAR AVAILABILITY TO POLLINATORS IN *Cucurbita Pepo* L.

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ABSTRACT

Floral nectar is a highly energetic secretion, widely found in angiosperms and consumed by several groups of pollinators, being the trophic resource that most frequently mediates plant-animal interactions. Changes in abiotic factors can affect nectar characteristics, influencing pollinator attraction and behaviour and, consequently, the maintenance of plant-pollinator interactions.

We investigated whether changes in rainfall, as predicted by the IPCC (AR-6), affect the floral nectar production and the abundance of this trophic resource to pollinating bees of *Cucurbita pepo* L. in an agricultural scenario.

We submitted 60 plants to one of two treatments: [Control] average natural rainfall in Botucatu-Brazil during the period in which this crop is cultivated and [Drought] simulating periods of extreme drought. We investigated the effects of the treatments on nectar production including its volume, concentration, and the amount of sugar per flower and per plant. Additionally, we estimated the resource abundance in an agricultural scenario, using data on the caloric supply per hectare.

We verified a decrease in nectar production per flower and per plant, as the number of flowers per plant was also reduced in drought treatment. The drought treatment reduced the caloric offer available to floral visitors from 1.32 t to 71 kg per hectare. Changes in trophic resource supply can alter pollinator attraction and decrease visitation in cultivated areas, negatively affecting the *C. pepo* fruit production. Furthermore, lower food availability can change pollinator feeding patterns impairing the maintenance of their local populations. Thus, potentializing the decline in zucchini production.

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