Caring for Pollinators

Safeguarding agro-biodiversity and wild plant diversity

- Current progress and need for action presented in a side event at COP 09 in Bonn (22.05.2008) -

Federal Agency for Nature Conservation

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Caring for Pollinators

Safeguarding agro-biodiversity and wild plant diversity

Results of a workshop and research project commissioned by the German Federal Agency for Nature Conservation

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Mareike Vischer-Leopold

Federal Agency for Nature Conservation

universitätbonn
Ecology of Culture Landscape

Cover picture: Fruit basket with its pollinators (Photos: A. Hamm, M. Schindler, K.L. Schuchmann, A. Ssymank, M. Tschapka)

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Preface

Pollinators posses a key function in ecosystems and secure a substantial portion of world sustenance. The biological diversity of pollinators is deemed to be an important foundation for the conservation of species diversity in the international context (CBD-target stopp the loss 2010), the European context and also in Germany. The decline in numbers of the natural pollinators has led to the composition of the "Sao Paulo Declaration on Pollinators" for the protection and sustainable use of pollinators 1998 in Sao Paulo within the scope of the International Pollinators Initiative and to its signing at the COP 5. Since then the International Pollinators Initiative, under the direction of the FAO and regional pollinators initiatives, works on safeguarding this important ecosystem service.

Besides the honeybee it is mainly numerous feral bee- and fly species that significantly secure the pollination of our crops and of feral plants. However, many of the pollination relevant animal species are threatened through numerous dangers, of witch habitat loss, change of land use and application of pesticides are just a few examples. Global changes such as e.g. the warming of the climate and its repercussions additionally accrue.

As small as they may be, pollinating insects are indispensable for the pollination of many horticultural crops and therefore are of high economic value. About 35% of the world production of food depend on flower visiting insects (Food and Agriculture Organization of the United Nations 2008). In addition pollinators are important for the maintenance of the biodiversity of a majority of feral plants and for the thereon depending animals. Last not least the aesthetic and recreational value of a blooming meadow that contains various species should be mentioned.

It is undisputable that the efforts made for the conservation of pollinators have to be continued to counter the dangers faced and to maintain biological diversity. The side event of the Federal Nature Conservation Agency and the University of Bonn at the ninth Conference of the Parties of the Convention on Biological Diversity has given new proposals here and has contributed to the networking of the Pollinators Initiatives at international level. The present volume documents the current state of the work of the Pollinators Initiatives, gives recommendations and points out the need for action and research. We hope to therewith give assistance and suggestions for the long term preservation of pollinators and their ecosystem services.

Our special thanks go to the Pollinators Initiatives, the University of Bonn and to all those who have contributed to the success of this project.

Prof. Dr. Beate Jessel
President of the Federal Agency for Nature Conservation, Germany

Vorwort

Blütenbestäuber nehmen eine Schlüsselfunktion in Ökosystemen ein und sichern wesentliche Anteile unserer Welternährung. Die Biodiversität der Bestäuber gilt als wichtiger Grundstein zum Erhalt der Artenvielfalt in Deutschland, im europäischen und im internationalen Kontext (CBD-target stopp the loss 2010). Der Rückgang natürlicher Bestäuber hat dazu geführt, dass 1998 in Sao Paulo im Rahmen der Internationalen Pollinator Initiative die "Sao Paulo Declaration on Pollinators" zum Schutz und zur nachhaltigen Nutzung von Bestäubern ausgearbeitet und während der COP5 unterzeichnet wurde. Seither arbeiten die Internationale Bestäuber-Initiative unter der Leitung der FAO und regionale Bestäuber-Initiativen an einer Absicherung dieser wichtigen Ökosystem-Dienstleitung. Neben der Honigbiene sind es vor allem zahlreiche wildlebende Bienen- und Fliegenarten, die maßgeblich die Bestäubung unserer Kultur- und Wildpflanzen sichern.
Viele für die Bestäubung wichtige Tierarten sind jedoch von zahlreichen Gefährdungen wie z. B. Habitatverluste, Landnutzungswandel oder Pestizideinsatz bedroht. Hinzu kommen außerdem globale Veränderungen wie z. B. der Klimawandel und seine Folgen.
So klein sie auch sein mögen, blütenbesuchende Insekten sind unabdingbar für die Bestäubung vieler Kulturpflanzen und haben daher einen hohen wirtschaftlichen Wert. Rund 35 % der Welt-Nahrungsproduktion hängen von blütenbesuchenden Insekten ab (Food and Agriculture Organization of the United Nations 2008). Daneben sind sie für den Erhalt der biologischen Vielfalt eines Großteils der wildlebenden Pflanzen und der davon abhängigen Tierarten wichtig. Nicht zu vergessen sind auch der ästhetische und der Erholungswert, den z. B. blüten- und artenreiche Wildwiesen bieten.

Es ist unumstritten, dass die Anstrengungen zum Erhalt der Blütenbestäuber fortgeführt werden müssen, um den Gefährdungen entgegenzuwirken und die biologische Vielfalt zu erhalten. Das Side-event des Bundesamtes für Naturschutz und der Universität Bonn auf der 9. Vertragsstaatenkonferenz zum Erhalt der Biologischen Vielfalt (COP 9) im Mai 2008 hat hier neue Impulse gesetzt und einen Beitrag zur Vernetzung der Bestäuberinitiative gerade auch auf internationaler Ebene geleistet. Der vorliegende Band dokumentiert den derzeitigen Stand der Arbeiten der Bestäuberinitiativen, gibt Empfehlungen und zeigt den Handlungs- und Forschungsbedarf auf. Wir hoffen damit Anregungen und Handreichungen für den langfristigen Erhalt der Blütenbestäuber und ihren Ökosystemleistungen geben zu können. Unser Dank gilt den Bestäuberinitiativen, der Universität Bonn und allen Beteiligten, die zum Gelingen dieses Projektes beigetragen haben.

Prof. Dr. Beate Jessel
Präsidentin des Bundesamtes für Naturschutz

Contents

1 Introduction

by A. Ssymank, A. Hamm, M. Vischer-Leopold & D. Wittmann

Pollination is a key function in all terrestrial ecosystems, interlinking the fate of plants and animals. Pollinating animals are themselves a major part of the biodiversity worldwide, they are safeguarding plant biodiversity and indirectly all the animals depending on fruits or leaves of animal pollinated plants for their food. A world without pollination is beyond imagination and would have lost all its richness and most of its vegetation. Pollination services cannot just be replaced by humans, are extremely valuable and are a precondition for or affecting an estimated 35% of the world's crop production, increasing outputs of 87 of the leading food crops (FAO 2008). The total economic value of pollination services worldwide is estimated to €153 billion, with vegetables, fruits (see fruit buffet, p. 121 as the leading crop categories in value of insect pollination (Gallai et al. 2008).

There is direct and indirect evidence of pollinators decline worldwide in different regions, which is likely to impact production of fruits and vegetables and to accelerate the loss of species diversity. This is particularly important in highly modified agricultural landscapes, where pollinators are most needed for food production and crop security.

Animal pollination is wide-spread among plant species (estimated 85 % of all plants) with probably close to 300,000 flower visiting animal species worldwide (Nabham & Buchmann 1997). Pollen limited fecundity in wild plants is frequent and pollen transfer by animal is vital for the biodiversity of all terrestrial ecosystems. For example many of the beautiful tropical cacti (for example *Pachycereus pringlei*) are bat-pollinated, many ornamental plants with large red or orange flowers are bird pollinated. However the large majority of plants are insect-pollinated: wasps, beetles and butterflies visit flowers. Especially the bees and the true flies are the main pollinator groups worldwide (see fact sheets of pollinator groups, p. 148). They transfer the pollen between different flowers while using plant resources and ensure or enlarge the reproduction success of cultivated and wild plants.

Bees were called "testimonies of the golden days" by Virgil, the Roman writer Publius Vergilius, 70-19 BC. In his book "Georgica" (about Agriculture), Virgil displayed no knowledge on where nectar comes from. He thought that honey 'drops from the sky as tears of Narcissus'. He also had no notion of pollination by wind or by animals. Only as late as the 18th century did such facts emerge, recorded by a school teacher and naturalist living in the small German town of Jena. Christian Konrad Sprengel observed that in the fields and woods around his home several insects, especially bees, transport pollen grains and deposit them on the stigma of a flower. In a series of careful experiments he discovered that those pollen grains are essential for the production of fruits and seeds. He published his results in the book "The Discovered Secret of Nature in the Morphology and Fertilisation of Flowers", in 1793. This should have been a breakthrough for science. Instead, Wolfgang von Goethe, celebrated writer of "Metamorphis of Plants" and well known nature scientist condemned Sprengel's findings. The non-scientific argument he gave was that such a wonderful creation as a flower could not possibly depend for its reproduction on such an ugly creature as an insect.

Today we understand that bees and other pollinators have an outstanding function in ecosystems because they literally maintain terrestrial plants. In other words, pollination ranks with photosynthesis as the most important processes in plant life. Today we indeed have to be somewhat afraid that the golden days of bees on earth are about to end. Although there are more than 25,000 bee species, we are losing pollinators in agricultural areas, where we need them most. And losing pollinators means losing fruits, seeds, and money - about € 153 billion per year .

Flies represent one of the largest insect groups of the world with approx. 160.000 species in 162 families. They play a major role in pollination of wild plants and crops with over 70 families known to visit regularly flowers.

No chocolate without flies! Who knows that the cocoa-tree is pollinated by small midges and that only fly-pollination will yield the cocoa-fruit, refined into chocolate, a product that had an overwhelming triumphant success shortly after its introduction in Europe.....

This is just one example of many crops and flies are second in their importance as pollinators compared to the better-known bees. They have been largely neglected and have special importance for example in sub(arctic) or high altitude ecosystems, in the understory of tropical forests and many wild plants worldwide are almost exclusively pollinated by flies. While a few groups of flies are known as vectors of diseases, the major part of the flies are beneficial and essential in their pollination services, in decomposing organic material or as biological control agents.

More than 200 years after Sprengel's insight, some 40 scientists initiated the International Pollinators Initiative (IPI) in Sao Paulo, Brazil. The decline in numbers of the natural pollinators has lead to the composition of the "Sao Paulo Declaration on Pollinators" for the protection and sustainable use of pollinators 1998 in Sao Paulo within the scope of the International Pollinators Initiative and to its signing at the 5th Conference of Parties (COP 5) of the Convention on Biological Diversity.

In April 2002 the Convention on Biological Diversity (COP 6) adopted the Decision VI/5, a "Plan of Action for the International Initiative for the Conservation and Sustainable Use of Pollinators" prepared by the Food and Agriculture Organization of the United Nations (FAO) together with leading pollination scientists (http://www.beesfordevelopment.org/info/info/pollination/international-pollinator-.shtml). This plan under the leadership of the FAO aims to promote co-ordinated action worldwide to:

- Monitor pollinator decline, its causes and its impact on pollination services,
- Address the lack of taxonomic information on pollinators,
- Assess the economic value of pollination and the economic impact of decline of pollination services, and
- Promote the conservation and the restoration and sustainable use of pollinator diversity in agriculture and related ecosystems.

The plan has four elements: assessment, adaptive management, capacity building and mainstreaming, each with a detailed operational objective, rationale, activities, ways and means and a timing of the expected outputs.

A series of international and national activities has been organized to conserve and sustain the use of pollinators, and to maintain or restore their habitats (African Pollinators Initiative, Brazilian Pollinators Initiative, European Pollinators Initiative, North American Pollinators Protection Campaign and Oceania Pollinators Initiative). Each initiative has the aim to integrate and co-ordinate local, national and international activities relating to pollination into a cohesive network.

Furthermore there is a UNEP/GEF project "Conservation & Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach" witch will contribute to the conservation, sustainable use and management of pollinators for example by developing and implementing tools, methodologies, building local, national, regional and global capacities to enable the design or promoting the coordination and integration of activities related to the conservation and sustainable use of pollinators at the international level to enhance global synergies.

As the following pages will show, there is a growing number of research and activities to maintain pollination services. However there is still a long way to go with research, networking and information transfer, political awareness and pollinator management as core activities to maintain biological diversity worldwide.

We may hope that pollinators will be kept in our minds. We need them and we need to care for them!

Citations:

FAO (2008): A contribution to the International Initiative for the Conservation and sustainable Use of Pollinators. – Rapid Assessment of Pollinator's Status. January 2008, 52 pp., FAO, Rome.

GALLAI, N., SALLES, J.M., SETTELE, J. & VAISSIÈRE, B. (in press): Economic valuation of the vulnerability of world agriculture confronted to pollinator decline. Ecological Economics (in press; doi:10.1016/j.ecolecon.2008.06.014).

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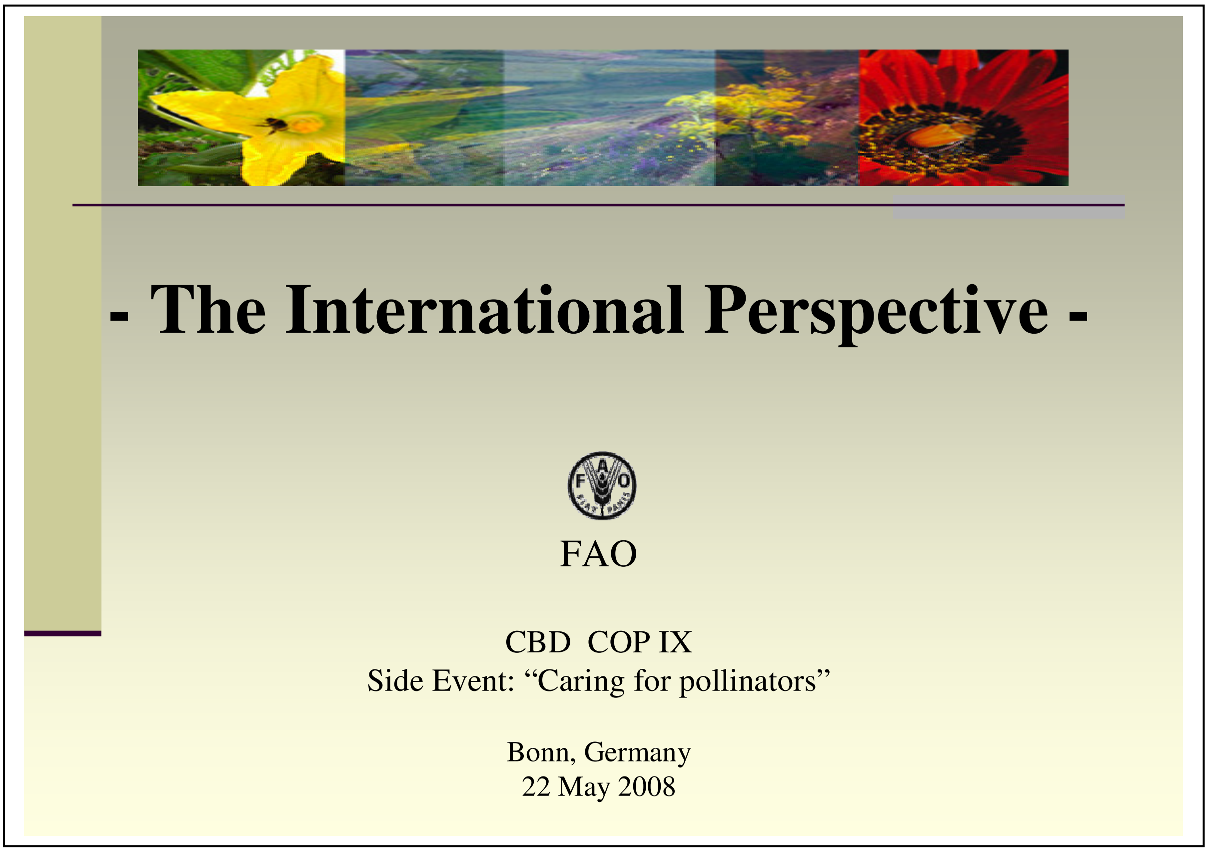
2.1 International Perspektive

by Linda Collette, FAO



- Global Challenges -

- Pollinators provide an essential ecosystem service, contributing to crop production and hence food security
- Approximately two-thirds major world crops and 80% of all flowering plant species rely on animal pollinators (Klein)
- Agricultural production, agro-ecosystem diversity and biodiversity are being threatened by declining pollinator populations
- Some contributing factors to declining pollinator populations include habitat loss/fragmentation, land management practices, agricultural and industrial chemicals, parasites/diseases, alien species

- Convention on Biological Diversity -

- CBD COP Decision III/11
- The São Paulo Declaration on Pollinators
- CBD COP Decision V/5 (2000): established the International Initiative for the Conservation and Sustainable Use of Pollinators (International Pollinators Initiative - IPI) and called for the development of a Plan of Action
- At CBD COP V (Decision V/5), the CBD Executive Secretary was requested to *"invite the Food and Agriculture Organization of the United Nations to facilitate and coordinate the Initiative in close cooperation with other relevant organizations..."*
- CBD COP Decision VI/5 (2002):
  - Adopted the Plan of Action for the International Initiative for the Conservation and Sustainable Use of Pollinators (IPI)

- International Pollinators Initiative (IPI) -

- Objectives of the IPI:
  - Monitor pollinator decline, its causes and its impact on pollination services;
  - Address the lack of taxonomic information on pollinators;
  - Assess the economic value of pollination and the economic impact of the decline of pollination services; and
  - Promote the conservation and the restoration and sustainable use of pollinator diversity in agriculture and related ecosystems.

-International Pollinators Initiative –

-Elements of the Plan of Action -

Element 1: Assessment

Element 2: Adaptive Management

Element 3: Capacity Building

Element 4: Mainstreaming

- FAO's Global Action on Pollination Services for Sustainable Agriculture -

- Knowledge management of pollination services (Pollination Management Information System (PIMS))
- Best practice profiles for management of pollination services
- Pollinator diversity and abundance on farms
- Climate change and pollination services
- Awareness-raising
- FAO/UNEP/GEF Global Pollinators Project

- FAO/UNEP/GEF Project on Conservation and Management of Pollinators for Sustainable Agriculture, Through an Ecosystem Approach -

Objectives

- The development objective of the project is improved food security, nutrition and livelihoods through enhanced conservation and sustainable use of pollinators.
- The immediate objective is enhanced understanding, conservation and sustainable use of pollinators through the ecosystem approach in selected countries for sustainable agriculture.

- (...cont'd) -

Four main components of the Project

- Expansion of the Knowledge Base
- Promotion of Pollinator-friendly Practices
- Capacity-building
- Public Awareness, Mainstreaming and Information-sharing

- 5 year project (Brazil, Ghana, Kenya, India, Nepal, Pakistan, South Africa)

- Looking ahead -

- Global collaboration
- Cover all pollinators
- Contribute to PIMS and other global databases
- Regional international initiatives
- Raising awareness
- Building capacity
- Mainstreaming

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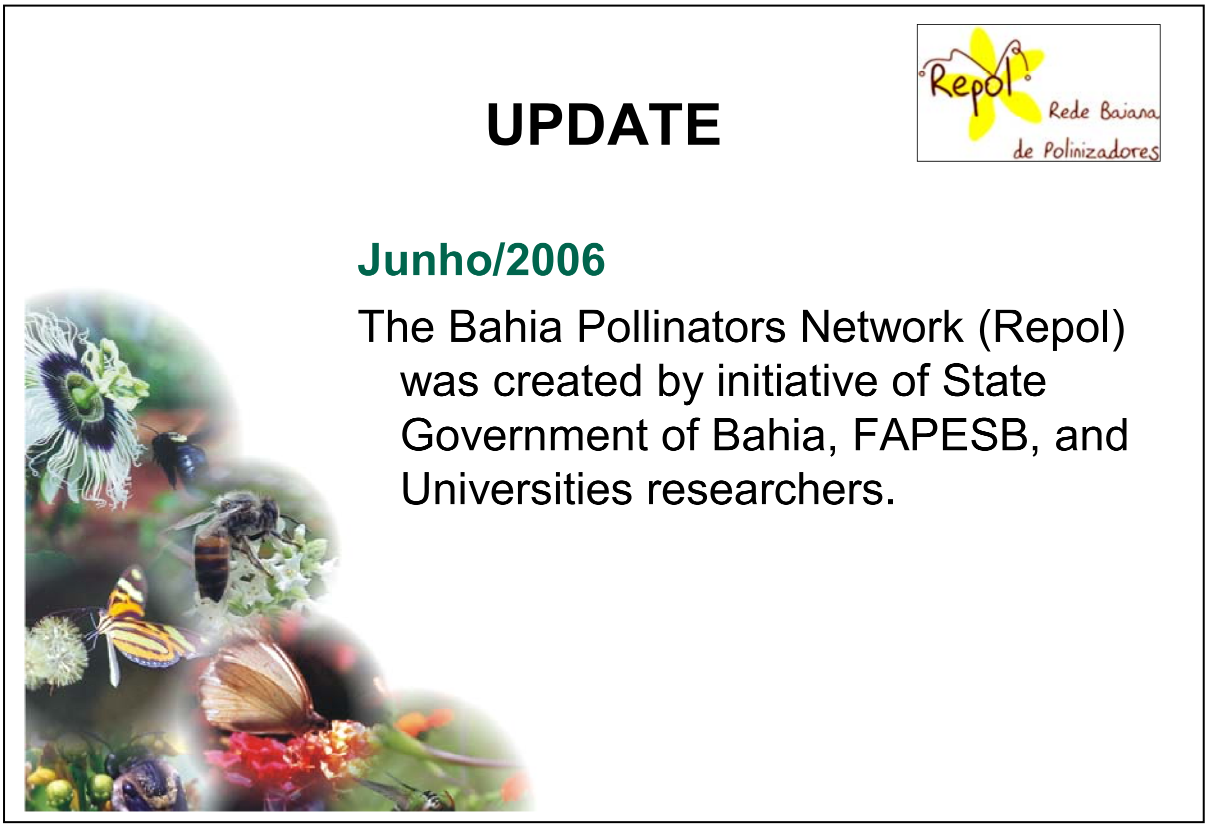
2.2 The Brazilian Pollinators Initiative (BPI)

by Braulio F. de Souza Dias, Brazil



GOALS

- Researcher groups integration;
- Dissemination of the information about Pollinators diversity;
- Researcher partnership and projects elaboration incentives;
- Technological transfer facility.

UPDATE

Junho/2007

The FAO/MMA Project: “Conservation and Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach has approved in GEF Work Program”

Conservation and Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach

Components

1) Development of a Base Knowledge
2) Extension and Promotion of Pollinator-friendly Best Management Practices
3) Capacity Building
4) Sharing of Experiences, Dissemination of Results and Awareness Raising

UPDATE

Agosto/2007

Meeting of the Integrated Fruit Production – EMBRAPA/MAPA- Project partner- With lectures of Dr. Breno Freitas and Dr. Braulio Dias.

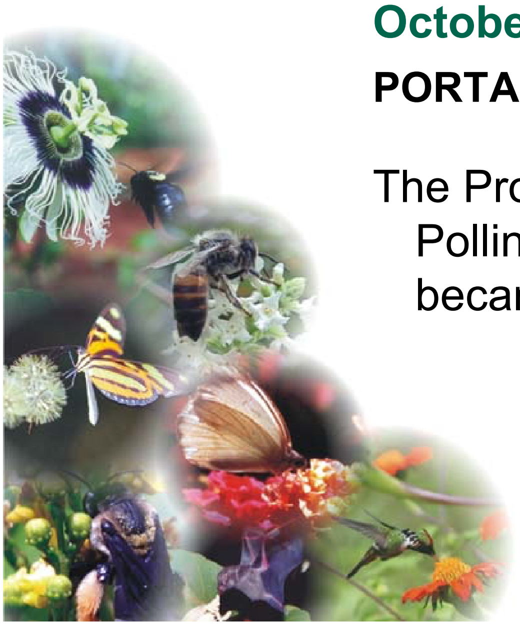
UPDATE

Setembro/2007

Brazilian Congress of Ecology Caxambú/MG

Pollination Ecology Table Participants: Ludmila Aguiar (Embrapa Cerrado), Blandina Viana (UFBA), Rogério Gribel (INPA), Marcia Maués (Embrapa Cpatu) and Marina Landeiro (MMA)

UPDATE



October/2007

PORTALBio

www.mma.gov.br/portalbio

The Probio subprojects results – Pollinating Management Plans - became available in PortalBio .

UPDATE

February/2008

SIDE EVENT SBSTTA/CDB

Rome, Italy

Dra Maria José Campos participation (UFSCar) in the side event about Agriculture biodiversity organized by FAO

UPDATE

April/2008

Workshop about pollinating deficit mechanism

Avignon, França

Dr. Breno Freitas, as BPI member, and Dr. Paulo Oliveira, as a subproject Probio coordinator.

UPDATE

July/2008

Symposium SP+10 Table

Braulio Dias (MMA)

GEF Pollinators Project – Update and Events about Pollinating in COP9;

Marina Landeiro (MMA)

Report BPI 2006/2007 e 2008 and Presentation of the analysis of the questionaires sent to the researchers

UPDATE

July/2008

Symposium SP+10 Table

Breno Freitas (UFC)

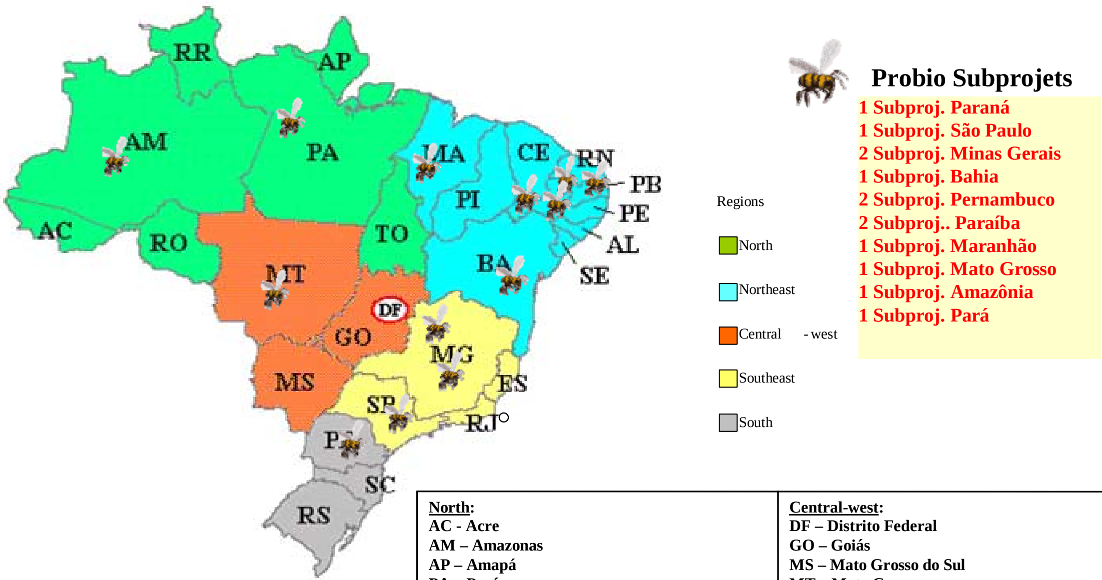
Pollitating Deficit

Maria José Campos

Agriculture biodiversity

PROBIO (Brazilian Biological Diversity Conservation and Sustainable Use Project)

- Two Public Calls to support projects on pollinators management (September 2003 and January 2004).
- 58 proposals were submitted, 13 of which were approved by CONABIO and contracted by CNPq, with a total sum of approximately US$ 500,000.00 of financing from MMA plus counterpart funding from the executing organizations.



North: AC - Acre AM – Amazonas AP – Amapá PA – Pará RO – Rondônia RR – Roraima TO – Tocantins Northeast: AL – Alagoas BA – Bahia CE – Ceará MA – Maranhão RN – Rio Grande do Norte SE – Sergipe PB – Paraíba PE – Pernambuco PI - Piauí	Central-west: DF – Distrito Federal GO – Goiás MS – Mato Grosso do Sul MT – Mato Grosso Southeast: ES – Espírito Santo MG – Minas Gerais RJ – Rio de Janeiro SP – São Paulo South: PR – Paraná RS – Rio Grande do Sul SC – Santa Catarina

Subproject 1: **Assessment and Management of Pollinators of Mangaba (Hancornia speciosa, Apocynaceae) and West Indian Cherry (Malpighia emarginata, Malpighiaceae) in the State of Paraíba**

Objective: to elaborate an assessment and management of the mangabeira (*Hancornia speciosa*, Apocynaceae) and aceroleira or West Indian cherry (*Malpighia emarginata*, Malpighiaceae) pollinators.

Administration: Federal University of Pernambuco Development Support Foundation - FADE, in partnership with the Federal University of Pernabuco - UFPE, the Federal University of Paraíba - UFPB, The Campina Grande Federal University and the Paraíba State Corporation for Agriculture Research.

Agreement value: US$ 26,359.46 funded by PROBIO, with a co-funding of US$ 116,344.82.

(This subproject has received an initial disbursement from PROBIO of US$ 55.539,25).

Subproject 2: **Pollinators Assessment and Management in Mango (*Mangifera indica*, Anacardiaceae) and Passion Fruit (*Passiflora* spp, Passifloraceae) of the São Francisco valley in the State of Pernambuco**

Objective: to conduct a pollinators assessment in the São Francisco Valley traditional and organic crops mainly Mango (Mangifera indica) and Passion Fruit (Passiflora edulis) crops.

Administration: The Embrapa Center for the Semi-Arid.

Agreement value: US$ 37,5155.51 funded by PROBIO, with a co-funding of US$ 79,665.86.

Subproject 3: Management Plans for Pollinators of Mango (*Mangifera indica*, Anacardiaceae), Passion Fruit (*Passiflora edulis*, Passifloraceae), Guava (*Psidium guajava*, Myrtaceae) and Umbu (*Spondias tuberosa*, Anacardiaceae) in the State of Bahia

Objective: to undertake a pollinators assessment of the following crops: Mango (Mangifera indica), Passion Fruit (Passiflora edulis), Guava (Psidium guajava) and Umbu (Spondias tuberosa), and to propose a management plan for the pollination of these crops.

Administration: Bahia Polithecnic School Foundation

Agreement value: US$ 51,501.37 funded by PROBIO, with a co-funding of US$ 63,488.27

(This subproject has received an initial disbursement from PROBIO of US$ 45.884,44).

Subproject 4: Management of Pollinators of Passion Fruit (*Passiflora* spp, Passifloraceae) in the State of Paraná

Objective: development of a management plan and a practical manual for the pollinators sustainable use in Passion Fruit cops in Paraná State.

Administration: Federal University of Paraná Foundation for Science, Technology and Culture Development - FUNPAR administrates and implements this project in partnership with the Federal University of Paraná, the Tuiuti University of Paraná and the Londrina State University.

Agreement value: US$ 51,113.59 funded by PROBIO, with a co-funding of US$ 31,358.52.

(This subproject has received an initial disbursement from PROBIO of US$ 37,961.85).

Subproject 5: *Melipona quadrifasciata* Management as Pollinator of greenhouse tomato (*Lycopersicon esculentum*, Solanaceae) crops in the State of Minas Gerais: a conservationist alternative

Objective: to increase the productivity of greenhouse tomato crops using the pollination of wild stinglessbees of the species *Melipona quadrifasciata*. This project also aims to disseminate this technique due the smaller impacts compared to use of pesticides in wild bees populations.

Administration: Rain Forest Research Institute — IPEMA and the Viçosa Federal University - UFV researchers implement it in the State of Minas Gerais.

Agreement value: US$ 55,539.25 funded by PROBIO, with a co-funding of US$ 53,620.68.

(This subproject has received an initial disbursement from PROBIO of US$ 55,539.25).

Subproject 6: Pollinators Assessment and Management in Cotton (*Gossypium hirsutum*, Malvaceae) and Soursop (*Annona muricata*, Annonaceae) crops in the State of Paraíba

Objective: to elaborate a wild pollinators assessment and management plan for Cotton (*Gossypium hirsutum*, Malvaceae) and Soursop (*Annona muricata*, Annonaceae) crops.

Administration: Federal University of Pernambuco Development Support Foundation – FADE

Implemented: researches of the Federal University of Paraíba - UFPB -, the Federal University of Pernambuco – UFPE, the Campina Grande Federal University – UFCG, the Embrapa Center for Cotton and the Agriculture Research Institute from Pernambuco.

Agreement value: US$ 51,659.9 funded by PROBIO, with a co-funding of US$ 28,893.00.

(This subproject has received an initial disbursement from PROBIO of US$ 24,066.66)

Subproject 7: Crop Management and Pollinators Diversity in tomato (*Lycopersicon esculentum*, Solanaceae) crops in the State of São Paulo

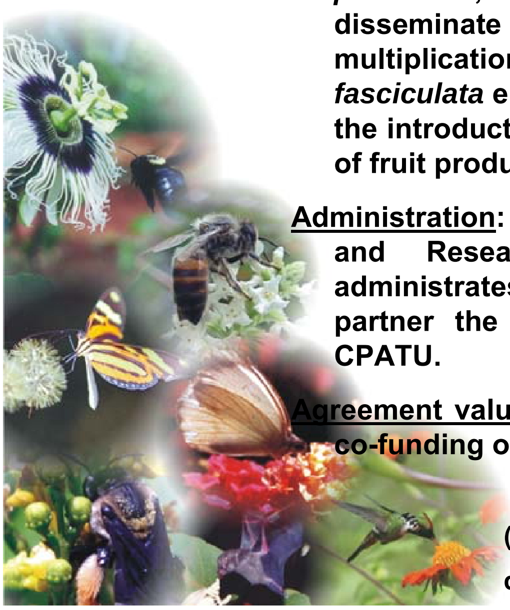
Objective: to evaluate in tomato crops how opposite techniques (organic and traditional) and the landscape frame have influenced on pollinators diversity in agriculture systems. The preliminary results will be the base for a management plan proposal to identify bees as a potential pollinators and so to guarantee the arrival, establishment and maintenance of the pollinators in the crop areas. The subproject also has a goal to disseminate the research results and to give permission to the local farmers to access information about the importance of pollinators to increase the crop output and about the importance of pollinators conservation.

Administration: State University of São Paulo– UNESP administrates and implements the project.

Agreement value: US$ 51,712.75 funded by PROBIO, with a co-funding of US$ 31,189.65.

(This subproject has received an initial disbursement from PROBIO of US$ 24.771.11)

Subproject 8: Wild Pollinators Management of the assai palm (*Euterpe oleracea*, Palmae) in Eastern Amazonia



Objective: to make a review of the Assai Palm (*Euterpe precatoria*, Palmae) reproductive biology, to study and disseminate the breeding methods and colony multiplication of two species of Stingless bees (*Melipona fasciculata* e *M. flavolineata*) and to evaluate the impact of the introduction of stingless bee colonies on the increase of fruit production.

Administration: Agriculture and Amazon Forest Development and Research Support Foundation – FUNAGRI administrates this subproject and has as its implementing partner the Embrapa Center for Eastern Amazonia – CPATU.

Agreement value: US$ 43,333.44 funded by PROBIO, with a co-funding of US$ 31,144.82.

(This subproject has received an initial disbursement from PROBIO of US$ 40,152.96).

Subproject 9: Cupuassu (*Theobroma grandiflorum,* Sterculiaceae) Pollination in Central Amazonia: technics development for crops and pollinators management

Objective: to understand the genetic factors related to auto-incompatibility mechanisms as well as ecological mechanisms related to pollination that affect de productivity of the Cupuassu (*Theobroma grandiflorum*, Sterculiaceae). Bee colonies breeding techniques of main pollinators will be developed, to quantify the effects of the introduction of these colonies on the pollination rate and on fruit production in Cupuassu crops.

Administration: Djalma Batista Foundation and the Amazon National Research Institute – INPA's researchers implements it.

Agreement value: US$ 19,965.51 funded by PROBIO, with a co-funding of US$ 18,068.96.

(This subproject has received an initial disbursement from PROBIO of US$ 15,256.75).

Subproject 10: Management of Araticum or Marolo (*Annona crassifolia*, Annonaceae) Pollinators in savannahs of the State of Mato Grosso

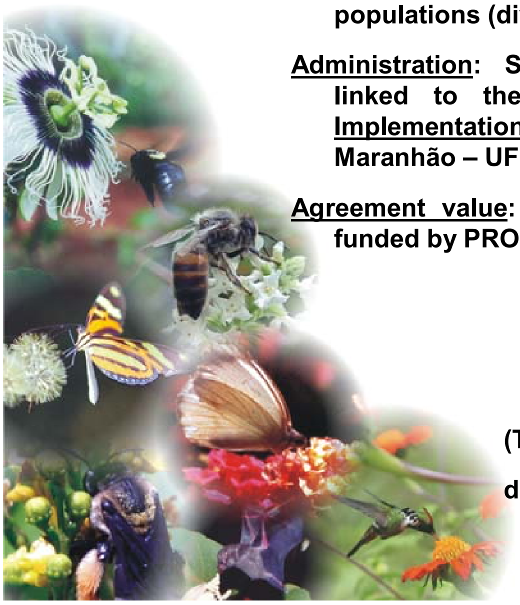
Objective: to understand the relation ships of the pollinators of Araticum or Marolo (*Annona crassifolia*, Annonaceae) relationship in the savannahs ("cerrado") of the State of Mato Grosso. The results will contribute to the conservation of pollinators through reproductive biology studies of Araticum and the ecology of the beetle pollinators.

Administration: The Mato Grosso State University – UNEMAT administrates this subprojects and implements partnership with the Viçosa Federal University – UFV.

Agreement value: The value of the agreement is US$ 45,816.92 funded by PROBIO, with a co-funding of US$ 16,091.03. (This subproject has received an initial disbursement from PROBIO of US$ 29,725.92).

(This subproject has received an initial disbursement from PROBIO of US$ 15,256.75).

Subproject 11: Management of Murici or Nance (*Byrsonima crassifolia*, Malpighiaceae) Pollinators in natural areas of the State of Maranhão: species diversity, nesting and the their use



Objective: to increase the knowledge about the guild of pollinators in native Murici or Nance (*Byrsonima crassifolia*, Malpighiaceae) populations (diversity, frequency, abundance and seasonally).

Administration: Souzandrade Development Support Foundation linked to the Federal University of Maranhão – FSADU **Implementation**: researchers of the Federal University of Maranhão – UFMA.

Agreement value: The value of the agreement is US$ 44,680.68 funded by PROBIO, with a co-funding of US$ 14,724.13.

(This subproject has received an initial disbursement from PROBIO of US$ 39,601.85).

Subproject 12: Sustainable Management of Carpenter bees (*Xylocopa* spp, Apidae) for Pollination and Production of Passion Fruit (*Passiflora edulis*, Passifloraceae) in the State of Minas Gerais

Objective: to assess the populations of the genus *Xylocopa* in yellow Passion Fruit crop areas and in surrounding natural vegetation in Araguari and Uberlandia counties in the State of Minas Gerais to subsidise the development of a management plan that optimises the fruit production and the conservation of the natural pollinators.

Administration: University Support Foundation and is implemented by the researchers from the Uberlândia Federal University.

Agreement value: US$ 50,347.58 funded by PROBIO, with a co-funding of US$ 17,425.51.

(This subproject has received an initial disbursement from PROBIO of US$ 37,225.55).

Subproject 13: Management of Passion Fruit (*Passiflora edulis*, Passifloraceae) Pollinators in the north of the State of Rio de Janeiro

Objective: to assess the pollination of Passion Fruit (*Passiflora edulis*, Passifloraceae) in the North of the State of Rio de Janeiro and to assess the effect of natural pollinators and their bionomic characteristics in native vegetation areas, to subsidise the elaboration of a management plan of these pollinator species in the Passion Fruit crop areas

Administration: Foundation for Regional Development of the North of Rio de Janeiro State - FUNDENOR, and is developed by researchers from the Northern Rio de Janeiro State University.

Agreement value: US$ 20,076.20 funded by PROBIO, with a co-funding of US$ 20,620.68.

(This subproject has received an initial disbursement from PROBIO of US$ 19,416.29).

PROBIO – Expected Products

- Management Plans for pollinators of 19 crop species;
- Manuals for capacity building of farmers in small and large properties, local communities and their organizations for the sustainable management of the diversity of pollinators and the increase of the pollination service they provide

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2.3 Small bees have a big job - holding up biome biodiversity

by David W. Roubik, Panama

Open habitats are tree graveyards. Their shade, wood, fruit, flowers and seeds have been replaced by a different set of species, obviously including humans, with their domesticated and associate organisms. While '*Homo consumatus*' appropriates landscapes and subsequently thrives, the benefits of growing many kinds of plants and having natural reservoirs of pollinators to service them has become a subject of considerable concern. Which pollinators are important, and how does what we require complement or conflict with their biology? One resounding successs has been the mobilization of plants and certain pollinators, those we have learned to keep in mobile pollination units, throughout the globe. The flaws in this technique are the gaps in our practical knowledge of biology—both of crops and pollinators—and our inadequate understanding of their limits and susceptibilities. Many of the fruits of our collective labors are tropical, and much of their continued existence is a mystery, or attributable to blind luck. A science of pollination ecology and the awareness of what pollinates these crops and how these animals live, particularly in the tropics of the world, is the theme of this presentation. Our efforts to insure pollination through the use of exotic species, like the honey bee *Apis mellifera*, which has become invasive in much of the world, may result in either failure or success. The many other organisms that either were the original pollinators, or that continue to perform their services, unappreciated, are themes that should be foremost in future efforts to understand and guarantee continued pollination services. The alternative, largely to continue the *status quo*, is untenable.

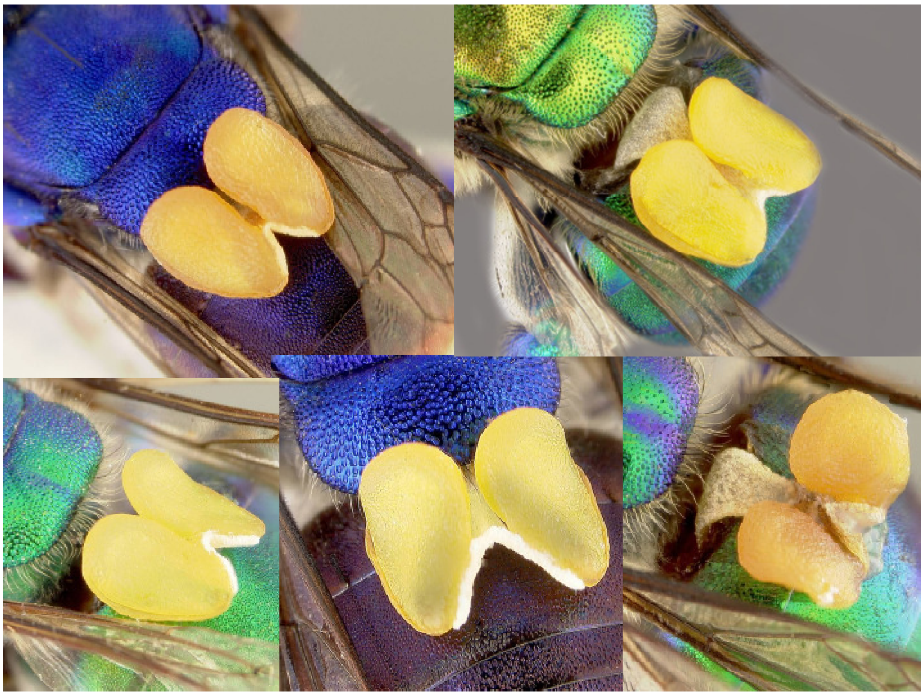
A tree graveyard, "woodhenge"?

Workers of *Apis florea* visit the flowers of aquatic 'lilies' even in the dense urban settlement of Bangkok, Thailand. They have survived human landscapes.

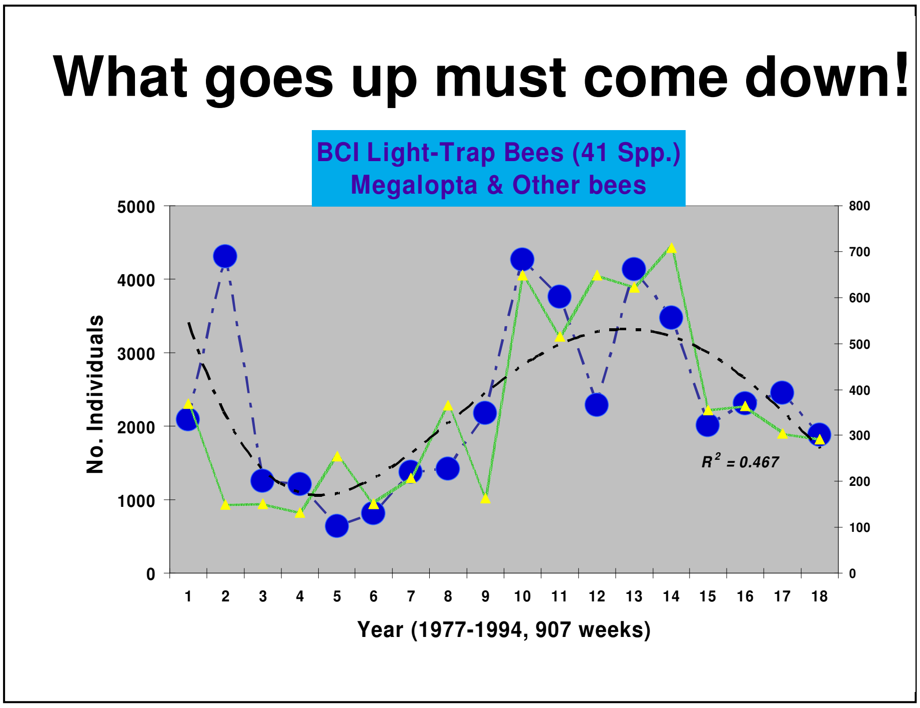
Female *Xylocopa latipes* on the wing, one of the most common and powerful pollinators in Asia, prepares to 'stop and shop' for pollen at a flower of the melastome, *Melastoma affinis* in S. China.

A pair of male *Euglossa igniventris* (Neotropical orchid bees) engaged in brushing odors from the flowering bucket orchid, *Coryanthes* in central Panama.

A natural forest is a reserve for pollinators. A view of the disappearing rain forest from Central Panama, seen from atop Cerro Bruja at 700 m elevation. The Atlantic Ocean, and the remaining 'biological corridor' between Central and South America, lies between the observer and the ocean, at 13 km distance.



Pollinators are backpackers! These photographs are of several *Euglossa* (*mixta, analis, tridentata, deceptrix, ignita*) with a pollinarium load from a flower of *Coryanthes.* The dual pollen packets, called pollinia, contain thousands of individual pollen grains.



Bee population dynamics require time to study and understand. The data shown here were gathered using two ultraviolet light traps on Barro Colorado Island, Panama. Shown are population trajectories of two noctural Megalopta (blue dots), 39 other, diurnal solitary and social bees (green line) and a curve fitted to their dynamics over time. See D. W. Roubik and H. Wolda. Do competing honey bees matter? Dynamics and abundance of native bees before and after honey bee invasion. Population Ecology 43:53-62 (2001).

Despite the richness and abundance of wildlife, bees and flower held by wildlands worldwide, much of this ‘space’ is needed for agriculture, which nonetheless continues to rely on a certain diversity and abundance of native, and increasingly, exotic, pollinators. Shown are some crops that depend on bees: beans and coffee in Central America, and honey (from exotic *A. mellifera*) in China.

China is one example of a mosaic landscape that contains patches with agriculture and natural vegetation. The rubber, tea, coffee and vegetable plots are interspersed with some forest trees and other woody vegetation.

A coffee shrub in flower, *Coffea arabica*, a plant native to eastern equatorial Africa.

Wet-processing of *Coffea arabica* in Panama. 'Beans' taken after fermentation has removed their mucilage are slowly dried for a few months until 'green' and ready for export, and eventual roasting.

Asian *Apis cerana* pollinating the flower of African *Coffea liberica* in S. China.

Giant Asian *Apis dorsata* nesting on the branches of tall trees in S. China.

Rubber trees from tropical America, *Hevea brasiliensis*, are widely cultivated in Asia. A cup with raw rubber is taken from a ‘tapped’

Rubber tree plantation in S. China.

Native flowers rely on diverse native bees as pollinators. Workers of *Trigona corvina* take nectar and extrafloral nectar from Poinsettia = *Euphorbia pulcherrima* in Panama.

Workers of both *Apis cerana* and *A. mellifera* forage on flowering *Coffea arabica* in S. China.

How ‘safe’ and ‘stable’ is a protected forest? In the Americas, all protected forests, like this one in the Chagres National Park of Panama, have been invaded by exotic honey bees from Africa or Europe. The ‘big’ question is whether invasive bees are more likely to enrich or threaten such natural ecosystems.

Are honey bees worth the ‘risk’?

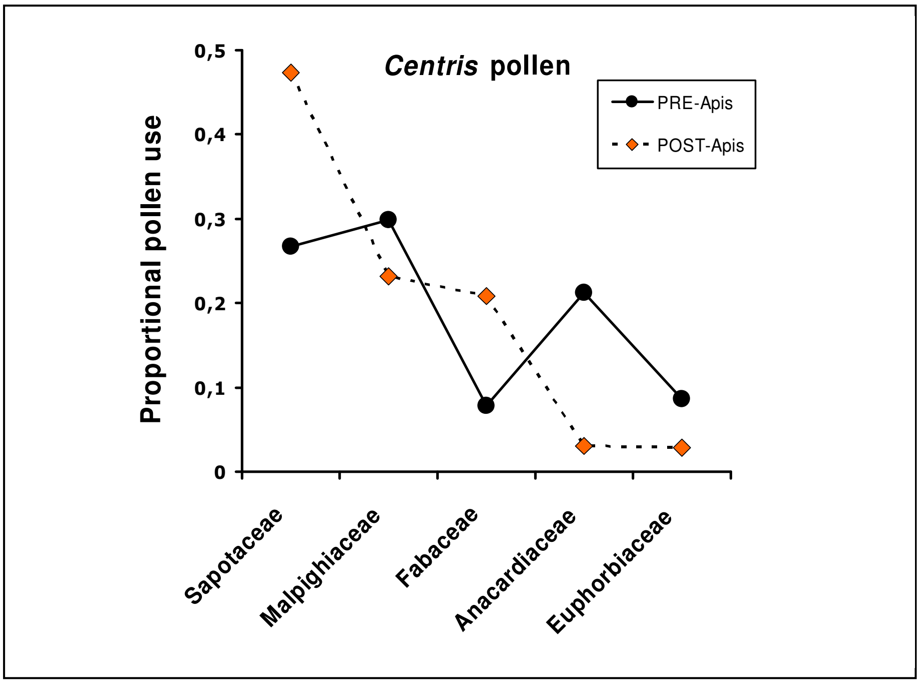
What do they normally visit?

5 extensive Neotropical pollen studies—

Show AHBs use 20-55 local plant families, 38-250 species

Mostly rosids (not mostly asterids), many monocots, roughly 25% local flora

What do we need to consider before purposefully introducing exotic *Apis*, which are invasive? Their flower visitation habits are one long-neglected aspect of their biology. In natural habitats, at least in the American tropics, they visit a full range of flowering plants, including many grasses, sedges, and trees, but not very many of the pretty ‘daisies’ upon which they are frequently depicted.



How do invasive honey bees impact native bees? One long-term study utilized a natural experiment that occurred in a large biosphere reserve in Yucatan, Mexico. An abundant native bee, *Centris analis*, substantially shifted its floral resources to avoid competition with the honey bees, and it survived (R. Villanueva and D. W. Roubik, Why are African honey bees and not European bees invasive? Pollen diet diversity in community experiments. Apidologie 35:481-491; D. W. Roubik and R. Villanueva, Pollinators adjust to invasive honey bees, Biology Letters (in review).

Unknown to many merchants, much of their produce comes from the work of pollinators- like the chile, mangoes, fruit and even chicle from the tree *Manilkara*, sold here in S. Mexico.

Unknown to most people, bees and other pollinators literally make the world go around- their work insures that vegetation, fruit, and seeds continue to be provided to many different herbivores. The one shown here, the three-toed sloth *Bradypus variegates*, eats a lot of leaves from *Cecropia* trees, and those trees are pollinated by bees, including many derived from African *Apis mellifera* (ibid. Villanueva and Roubik, 2004).

A little patch of *Impatiens* growing near coffee farms. *Impatiens* provides pollen loaded with the crystals of calcium oxalate- probably a deterrent to unwanted flower visitors- but nonetheless has orchid bees visiting its flowers for nectar. There are still countless such interactions and systems awaiting discovery and explanation, which may eventually lead to wise management.

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2.4 Flies –Pollinators on two wings

by Axel Ssymank, Bonn & Carol Kearns, Santa Clara

1. Diptera as pollinators

Diptera, the true flies, are an important, but neglected group of pollinators. Diptera can be distinguished from other insects by their two membranous front wings and the highly reduced halteres that represent the remnants of the second pair of wings. They are an ancient group, and were probably among the first pollinators of early flowering plants.

Fig. 1: *Neoascia podacrica*, a small flower fly looking for nectar on a *Euphorbia*-flower near a pond margin.

Fig. 2: The drone-fly, *Eristalis tenax*, a harmless flower fly pollinating a garden Aster.

Fig. 3: *Rhingia campestris*, a flower fly with a long snout concealing a proboscis as long as its body sitting on a *Geranium*-flower.

Many people think of flies as pests, and certainly there are many pest species. Fewer people realize the beneficial activities provided by flies, including pest control, as food for valued species such as birds and fish, as decomposers and soil conditioners, as water quality indicators, and as pollinators of many plants.

Fig. 4: *Anopheles mosquito*, known as vector for malaria-disease.

Fig. 5: Chironomidae – midge larvae

Fig. 6: Aphid-eating flower fly larvae (*Syrphus* spec., Syrphidae)

At least seventy-one of the 150 (Evenhuis et al. 2008) Diptera families include flies that feed at flowers as adults. More than 550 species of flowering plants are regularly visited by Diptera (Larson et al. 2001) that are potential pollinations. Diptera have been documented to be primary pollinators for many plant species, both wild and cultivated.

Fig. 7: Tachinidae

Fig. 8: Bombyllidae-fly (*Systoechus*) on *Echinaceus* (Asteraceae)

Fig. 9: metallic fly on *Euphorbia esula*

Flies live almost everywhere in terrestrial ecosystems and they are abundant in most habitats. With over 160,000 species, flies form an extremely large and diverse group, varying in mouth parts, tongue length, size and degree of pilosity. The diversity of flower-visiting flies is reflected in their effectiveness as pollinators. Some flies, such as long-tongued tabanids of South Africa, have specialized relationships with flowers, while other flies are generalists, feeding from a wide variety of flowers. In some habitats, such as the forest under-story where shrubs may produce small, inconspicuous, dioecious flowers, flies seem to be particularly important pollinators. In arctic and alpine environments, under conditions of reduced bee activity, flies are often the main pollinators of open, bowl-shaped flowers, with readily accessible pollen and nectar.

Fig. 10: Muscoid fly on *Thymus vulgaris.*

Fig. 11: Flower fly (*Sphaerophoria* spec., female) on *Thymus vulgaris*.

2. Why do flies visit flowers?

Flies visit flowers for a number of reasons. The most important is for food in the form of nectar and sometimes pollen. Nectar, a sugary solution, provides energy. Pollen is rich in proteins, which is required by some adult flies before they can reproduce.

Other flies visit flowers to lay eggs, and the larvae feed on the flower heads or the developing fruits and seeds. Plants with carrion flowers deceive flies into visiting and effecting pollination by providing a scent and appearance that mimics the carcasses where these types of flies normally lay their eggs.

In cold, arctic and alpine habitats, some flowers attract flies by providing a warm shelter. Flies bask in the warmth, which can be more than 5 degrees C warmer than the ambient temperature (Luzar and Gottsberger 2001). This keeps their flight muscles warm, and allows them to fly at temperatures that would thwart most bees. Their movement between flowers results in pollination.

Flowers can also serve as rendezvous sites for mating. Large numbers of flies will congregate at a particular type of flower, and the byproduct of their behavior can be pollination.

Fig. 12: *Stapelia hirsuta*, carrion flower

Fig. 13: *Plecia nearctica*, Bibionidae – “love bug” flies on *Solidago*-flowers.

Fig. 14: Muscoid fly on *Linum lewisii*

3. Cultivated plants pollinated by flies

More than 100 cultivated crops are regularly visited by flies and depend largely on fly pollination for abundant fruit set and seed production (Ssymank et al. 2008). In addition a large number of wild relatives of food plants, numerous medicinal plants and cultivated garden plants benefit from fly pollination. Klein et al. (2007) reviewed the literature for crop pollination and concluded that 87 out of 115 leading global food crops are dependent on animal pollination. They present a table of pollinators for those crops where this information is known. For thirty crop species flies are listed as pollinators and visitors (with 14 cases referring to flower flies, Syrphidae).

This result certainly underestimates the importance of fly pollination for two major reasons: first pollination studies focus mainly on bee pollination, second the literature and data on fly pollination are much more dispersed and often published in smaller journals with less complete indexing. From just my own non-systematic field data (Ssymank) we could add at least 12 crop species which are visited or partly pollinated by flower flies, such as *Fagopyron esculentum* (18), *Mangifera indica* (6), *Prunus spinosa* (35), and *Sambucus nigra (*24; number of fly species known to visit in brackets*).*

Fig. 15b: cocoa-blossom

Fig. 15c: cocoa-fruit

Fig. 15a: A cocoa-plantation (*Theobroma cacao*) in Togo, Africa with the ripening fruit on the stem.

Fig. 16: *Ornidia obesa*, a large metallic green neotropic flower fly, now spreading in cocoa-plantations over the whole african continent.

No chocolate without flies: For the cocoa tree (*Theobroma cacao,* Fig. 16a) fly pollination is essential for fruit production, with various levels of self-incompatibility present in different cocoa varieties. Here very small midges of the families Ceratopogonidae and Cecidiomyidae pollinate the small white flowers emerging from the stems.

In addition to these midges, *Ornidia obesa* (a flower fly, Fig. 17) may visit the cocoa flowers, since it is widespread in tropical cocoa plantations and larvae live in organic waste in the moist environment.

Larger flies such as carrion and dung flies visit and pollinate pawpaw (*Asimina triloba*). Many Rosaceous flowers in the northern hemisphere are visited and at least partly pollinated by flower flies (Syrphidae): Apple (*Malus domestica*) and Pear (*Pyrus communis*) trees, strawberries (*Fragaria vesca*, *F*. x *ananassa)*, *Prunus* species (cherries, plums, apricot and peach), *Sorbus* species (e.g. Rowanberry) and most of the *Rubus*-species (Raspberry, Blackberry, Cloudberry etc.) as well as the wild rose *Rosa canina*.

Fig. 17 (◄): Mango trees (*Mangifera indica*) represent an important tropical crop on local markets with a complex pollinator system involving many flower flies.

Fig. 18: The flower fly *Asarkina madecassa* is an endemic flower fly visiting Mango-flowers in Madagascar.

Flower flies are among the most important pollinating insect groups other than bees (Apidae), pollinating and visiting a number of tropical fruits such as Mango (*Mangifera indica*, Fig. 18, 19), *Capsicum annuum* and *Piper nigrum*. They also visit a number of spices and vegetable plants of the family Apiaceae like fennel (*Foeniculum vulgare)*, coriander (*Coriandrum sativum*), caraway (*Carum carvi*), kitchen onions (*Allium cepa*), parsley (*Petroselinum crispum)* and carrots (*Daucus carota*).

Most people are aware that bees are vital for the pollination of flowers. Fewer people realize that flies are second in importance to bees as pollinating insects. Compared to bees, which must provision a nest with floral food, adult flies have low energy requirements. Although this makes flies less devoted to the task of moving quickly between flowers, it also frees them to bask in flowers and remain active at low temperatures.

Conditions affecting bee populations can be quite different from those affecting fly populations due to the great difference in larval requirements. Most entomophilous flowers are visited by multiple types of insects. Since insect populations fluctuate temporally, the relative importance of a particular pollinator to a flower is likely to vary with time. Many types of flies have few hairs when compared to bees, and pollen is less likely to adhere to the body surface. But under conditions when bees are scarce, an inefficient pollinator is better than none. Higher flight activities of flies may well compensate lower pollen carrying capacity. Even in cases where honeybees are abundant on flowers and specialised bees like *Megachile lapponica* on *Epilobium angustifolium* are foraging, flower flies (Syrphidae) can be the most effective pollinators producing the highest seed set (Kühn et al. 2006).

Fig. 19: *Prosoeca peringueyi*, a fly of the family Nemestrinidae with extremely long proboscis foraging on *Lapeirousia pyramidalis* subsp. *regalis* on flowers in Iris family, South Africa.

Fig. 20: Some harmless flower flies like this *Temnostoma meridionale* display a remarkable wasp mimicry in coloration and behaviour.

4. Flower flies (Syrphidae) as pollinators and in biocontrol

Flower flies (Syrphidae) represent a large family of flies with a double role in ecosystems: adults are mostly flower visitors and of high importance for pollination services, while about 40 % of the world's species have zoophagous larvae contributing to biocontrol in agriculture and forestry.

The family of flower flies has approximately 6000 named species in 200 genera worldwide. They occur in almost every terrestrial habitat, from dunes, salt marsh, heath lands, bogs, all grassland ecosystems, scrub and forest-ecosystems, from low altitudes up to glacial moraine fields. They are represented in all zoogeographic regions of the world. Flower flies as pollinators have a wide range of adaptations for visiting different flower types, including proboscis lengths from 1mm to almost body length (with 11 mm for example in *Rhingia*, Ssymank 1991), enabling them to exploit deep corollas of zygomorphic flowers.

Flower flies visit large numbers of different plant species. For example in Germany more than 600 plant species are visited (Ssymank unpubl. data) and in Belgium more than 700 plant species (De Buck 1990, 1993). Regional studies in Europe (Ssymank 2001) showed that up to 80% of the regional flora may be visited by flower flies. Preferences for certain colours, flower types, flight height and phenology of simultaneously flowering plants usually ensure a high flower constancy of flower flies. With their high flight and flower-visiting activity they can be quite effective pollinators. Even long distance pollen transport is possible by migrating species like *Eristalis tenax* or *Helophilus* species.

Fig. 21: On forest margins *Dasysyrphus tricinctus* is pollinating Euphorbia-species

Fig. 22: In continental dunes on the dry sparse sandy grasslands the purple flowers of *Armeria elongata* are visited by the flower fly *Chrysotoxum festivum*.

Many flower fly larvae play an important role in biocontrol. About 40% of the species have zoophagous larvae, mainly eating crop-damaging aphids. Some species, such as *Episyrphus balteatus* in Europe can reproduce rapidly, producing large numbers of eggs and up to five generations per year. Females can smell aphid colonies and and use olfactory cues to oviposit directly in or in the vicinity of the colonies. Provided semi-natural structures are present in a habitat, rapid population growth and effective biocontrol preventing aphid outbreaks is possible.

Fig. 23: The flower fly *Rhingia campestris* comfortably leans back and probes the pollen of a *Nepeta* garden mint with its long proboscis.

The life cycle of an aphidophagous flower fly like e.g. *Episyrphus balteatus* can be completed within only 15 – 20 days under optimal conditions. Eggs are laid in aphid colonies, larvae hatch immediately, fist larvae mould after 1 day, the second larvae mould after 2-3 days and larval stage 3 is devouring up to 300 aphids per night until it pupates. The newly emerged adult is after a short time ready for mating and giving rise to a new generation.

Fig. 24 b: Flower fly pupae before hatching (*Syrphus*).

Fig. 24 a: Third stage larvae of Syrphus eating aphids.

Fig. 24 c: Newly emerged *Episyrphus balteatus*, male.

5. Plant-pollinator interactions

Pollinators have a keystone function in ecosystems. Without pollination many wild plants could not reproduce and survive. Animals, too, are indirectly dependent on pollination services, as they feed on fruit or plants that would not exist without pollinators. Pollination is an ecosystem service that maintains wild plant and crop diversity, guarantees food safety and is a cornerstone of animal diversity. Flies and bees are the most important pollinator groups. Over 71 families of Diptera are known to visit and pollinate flowers, linking the fate of plants and animals. Depending on the region, the time of the day, the flowering phenology and weather conditions, flies may be the main or exclusive pollinators, or share pollination services with bees and other pollinator groups.

Fig. 25: The flower fly *Chrysotoxum bicinctum* visiting the small flowers of *Polygonum aviculare* on a field margin in western Germany.

While some flower – pollinator relationships are highly specialised, many pollinator interactions are complex systems usually involving several pollinators. Daily and seasonal changes in pollinator communities are frequent, especially in plants with long flowering periods. Plant species with large ranges or cultivated in large areas may have a significant regional or geographical variation in pollinator communities, and the surrounding landscape with its features and habitat requisites can play an important role. Many pollinator assemblages are not well understood or even known, a fact not only true for wild plants but also for many crops and cultivated plant species.

Fig. 26: The flower fly *Chrysotoxum "intermedium"* (aggregate) pollinating the flowers of the tree spurge (*Euphorbia dendroides*) on the Maltese islands.

Fig. 27: A small and black flower fly (*Melanogaster nuda*) with a preference for yellow buttercup flowers eating pollen on *Ranunculus repens*.

6. Pollinator decline and research needs

Our understanding of pollination services is considerably hampered by a lack of some very basic knowledge. Although some types of fly pollinators have been well studied, as a group, fly pollination deserves far more research. It is striking how large the gaps in species knowledge are: probably less than 10% of all Diptera species are named worldwide; considerable gaps exist even in Europe, where the fauna is generally well documented. For many groups, even the existing knowledge is not easy to use, as identification keys are missing.

Fig. 28: Monoceromyia is a flower fly genus with many afrotropical species, mimicking wasps, and visiting tropical trees.

Pollination services of flies are underestimated and functional relations poorly understood. In the past, much pollination research has focused on bees, leaving a wide opportunity open for the study of other pollinator assemblages. A systematic look at ecosystems without bees (e.g. on some islands, in high mountains, nordic or arctic environments) could provide insight into functional replacements, and into the evolution of plant and fly adaptations. The review by Klein et al. (2007) makes it apparent that even crop plant - pollinator systems are incompletely studied. Many cases of "unknown" pollinators or order-level indications of "Diptera" indicate the need for more research.

Today, ecologists are concerned that climate change may decouple the synchrony of inter-dependent organisms. For the majority of flies, we do not have baseline phenology information. For flower flies (Syrphidae) the data are better than for many other small Diptera groups. Examples of changes in range and phenology of flower flies exist – however possible desynchronisation of flowering plants and their pollinators have not yet been studied. There is evidence of parallel pollinator and insect-pollinated plant decline for flower flies and bees in UK and NL (Biesmeijer et al. 2006). The factors threatening the species are mostly unknown. Data from other countries is largely absent. Many pollinating Diptera groups are not even assessed in Red-data-Books as no data or no fly specialists exist.

Fig. 29: One of the biggest European flower flies *Volucella zonaria*, mimicing hornets, exploiting nectar from *Knautia arvensis* with its long proboscis in a dry calcareous grassland in western Germany.

Fig. 30: The flower fly *Ischiodon aegypticus* visiting the spurge *Euphorbia millii,* a wide-spread cultivated plant, in its natural environment in Madagascar.

Fig. 31: The flower fly *Parhelophilus* frutetorum walking over the umbels of *Heracleum sphondylium*, freely offering nectar and pollen.

What consequences can we expect from the loss of pollinators? To what extent can any one pollinator be replaced by another? The answers to these questions are unknown and urgently need investigation. The loss of honeybees to Colony Collapse Disorder has led to severe declines of bee colonies in the U.S. Unwise application of pesticides has caused honeybee losses again and again. The loss of honeybees has not only beekeepers and ecologists, but the general public alarmed. And yet loss of natural pollinator communities may cause dramatic changes in ecosystems and biodiversity. Our current knowledge is too limited to extend to natural systems. There is an urgent need for networking among researchers, and for more fundamental and applied research toward improving our knowledge of pollination services. A new and better understanding will allow for active, effective management of pollinators for crop production and for the conservation and maintenance of biodiversity of terrestrial ecosystems worldwide.

Fig. 32 (top left): *Tropidia quadrata*, Syrphidae.

Fig. 33 (top right): Bombyliidae (*Systoechus*) on *Potentilla*.

Fig. 34 (bottom left): *Sphaerophoria*, Syrphidae.

Fig. 35 (bottom right): Male flower-fly (*Erstalis interrupta)* on *Aster* carrying pollen on the whole hairy body.

Fig. 36 - 38: Examples for habitats rich in flower flies: lakes with their margins, old deciduous oak-hornbeam forests in northeastern Germany, richly flowering dry calcareous meadows with *Primula veris*.

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Ken Keefover-Ring, Ph.D., University of Colorado, USA. Fig. No. 7, 8, 9, 10, 11.

Thomas Murray, Copyright 2008, with permission; Massachusetts, USA. tmurray74@yahoo.com. Fig. No. 5, 32, 34.

Axel Ssymank, Federal Agency for Nature Conservation, BfN, Bonn. Fig. No. 1, 2, 3, 15 a-c, 16, 17, 18, 20, 21, 22, 23, 24 a-c, 25, 26, 27, 28, 29, 30, 31, 35, 36, 37, 38.

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3.1 North and Inter-American Pollinator Initiatives

by Michael Ruggiero, USA; Laurie Adams, USA; Antonio Saraiva, Brazil

Two important regional pollinator initiatives have developed as a result of the concern for declining pollinator populations in the Americas: the North American Pollinator Protection Campaign (NAPPC) and the Inter-American Biodiversity Information Network's (IABIN) Pollinators Thematic Network (PTN). The former is a partnership of more than 120 organizations in the United States, Canada, and Mexico, while the latter is a pollinator-specific information network relevant to the countries of the western hemisphere. This presentation highlights several activities that can be classified among the major elements of the International Pollinators Initiative (IPI) implementation plan as elaborated by the UN Convention on Biological Diversity. These elements include assessment, adaptive management, capacity building, and mainstreaming.

Assessment stresses the need to determine the status and trends of pollinator populations, prepare checklists and catalogs of pollinators, and associate pollinators with their sources of pollen. NAPPC partners have supported a study by the U.S. National Academy of Sciences on the status of pollinators in North America. The 2007 report found direct evidence for the decline of some pollinator species. NAPPC partners (the Integrated Taxonomic Information System (ITIS) and the Smithsonian Institution) have contributed to the development of a world checklist of bees (available at www.itis.gov, www.discoverlife.org, and the *Species 2000 and ITIS Catalogue of Life Annual Checklist*) and to digitizing and providing an on-line version of the seminal work, *Catalog of Hymenoptera in America North of Mexico* (Krombein et al., 1979 at http://www.archive.org/search.php?query=krombein). The IABIN PTN has collaborated with the FAO Global Pollination Project to develop a schema and tool for entering data on pollinators and their associated plants and making it available on the web.

Adaptive management includes conservation measures such as preventing the importation of exotic pollinators, restoring native vegetation to support pollinators, and supporting targeted research on the causes of pollinator population declines. NAPPC partners have responded by publishing a "white paper" on the *Importation of Non-native Bumble Bees into North America: Potential Consequences of Using Bombus terrestris and Other Non-Native Bumble Bees for Greenhouse Crop Pollination in Canada, Mexico, and the United States (Winter et. al., 2006)* and a series of regional planting guides for farmers, resource managers, and gardeners. In addition, NAPPC has worked with private industry (Burt's Bees and Häagen-Dazs Ice Cream) to fund research on Colony Collapse Disorder in honeybees.

Capacity building involves promoting awareness of pollinators and pollination as well as developing information networks. NAPPC has developed a wide variety of information materials to educate the public about pollinators. A particularly significant activity was working with the United States Postal Service to create a special set of stamps about pollinators. NAPPC and partners have also developed several websites for pollinator information including www.pollinator.org, www.nappc.org, and http://pollinators.nbii.gov. The IABIN Pollinators Thematic Network is building a distributed data and information network that will provide content in the following areas: pollinator checklists, experts, specimens and observations, pollinator-plant-relationships, and literature. This information can be accessed at http://pollinators.iabin.net and http://pollinators.incubadora.fapesp.br.

Mainstreaming requires the incorporation of pollinator conservation practices into broader societal programs. NAPPC has supported the inclusion of pollinator conservation measures into national agricultural legislation (the Farm Bill) in the United States and has prepared a report on laws affecting pollinators in Canada. The U.S. Secretary of Agriculture issued a proclamation establishing National Pollinators Week and federal land management agencies have signed agreements with NAPPC to protect pollinators on more than 1.5 billion acres of federal and public lands in the United States.

The North American Pollinator Protection Campaign and the IABIN Pollinators Thematic Network have provided rallying points for carrying out activities relevant to the International Pollinators Initiative. NAPPC is largely a human network and IABIN PTN is largely a digital network. Both types are necessary for supporting and communicating the broad regional programs needed to conserve pollinators and their habitats and to prevent their further decline.

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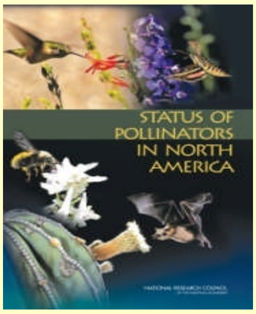
Laurie Adams, Pollinator Partnership, USA

Antonio Saraiva, University of Sao Paulo, Brazil

North and Inter-American Pollinator Initiatives

Michael Ruggiero, Smithsonian Institution, USA
Laurie Adams, Pollinator Partnership, USA
Antonio Saraiva, University of São Paulo, Brazil

Assessment

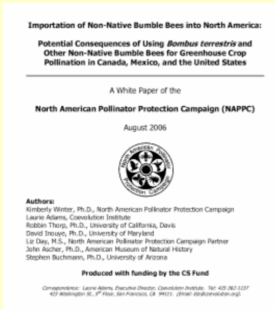


Status and Trends

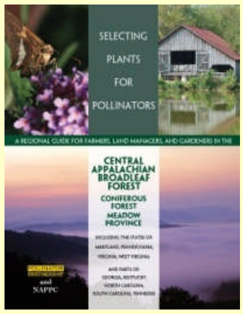
Electronic Catalogs

Identification Tools

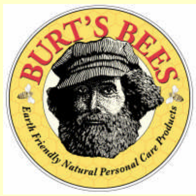
Adaptive Management



Prevention



Conservation



Private Research Funding

Capacity Building

Awareness

Networking

Mainstreaming

Legislation

Proclamation

Protection

3.2 An overview of pollinator studies in Kenya

Mary Gikungu, Kenya; Melanie Hagen & Manfred Kraemer, Germany

Introduction

Pollinator communities are currently endangered more than ever globally following the continuous degradation of natural habitats. Rapid increase in human population in Kenya has not only led to biodiversity loss but also increased poverty levels and the consequent degradation of habitats. While a lot of knowledge exists in the country on various functional groups and their roles in ecosystem functioning, very little is known about pollination interactions, and its conservation. Lack of data in this field is attributed to the fact that pollinationservice has been for granted over the years until recently.

Moreover, lack of local expertise and well curated reference collections, especially of insects, have been major barriers in pollinator studies in East Africa. However there has been a rapid increase in pollinator studies in the recent past triggered by the global outcry to conserve and manage pollinators following Sao Paulo declaration. Currently there are efforts to develop strategies for conserving Kenyan pollinators in order to enhance food security and biodiversity conservation.

Trends in pollinator studies

Pollinator studies in Kenya are at their infancy and only a few studies have been published (e.g. Bogdan 1962, Onim 1979, Morimoto *et al* 2004, Njoroge *et al* 2004, Gikungu 2007). The first pollinator study in Kenya was conducted by Bogdan (1962) on grass pollination but this was followed by a lag phase in pollinator research (Fig. 1). Because agricultural production and agroecosystem diversity are threatened by declining populations of pollinators, the current pollinator studies in Kenya endeavor to adhere to the key priority topics as identified by Food and Agriculture Organization of the United Nations (FAO) and International Pollinators Initiative (IPI). These include

- Monitoring pollinator decline, its causes and its impact on pollination services
- Addressing the lack of taxonomic information and expertise on pollinators

- Assessing the economic value of pollination and the economic impact of the decline of pollination services
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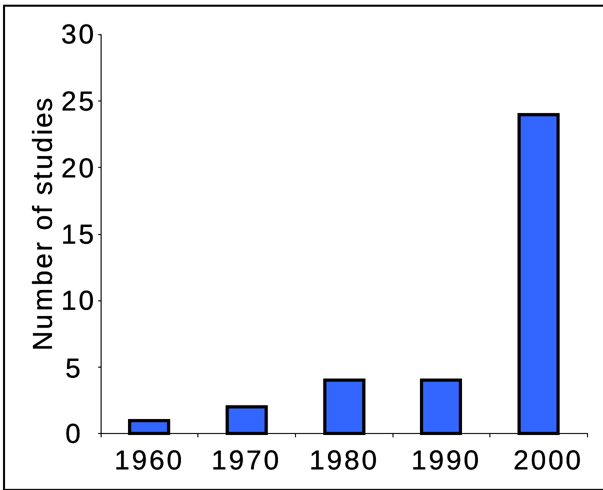


Fig. 1: Current trends in pollination studies in Kenya

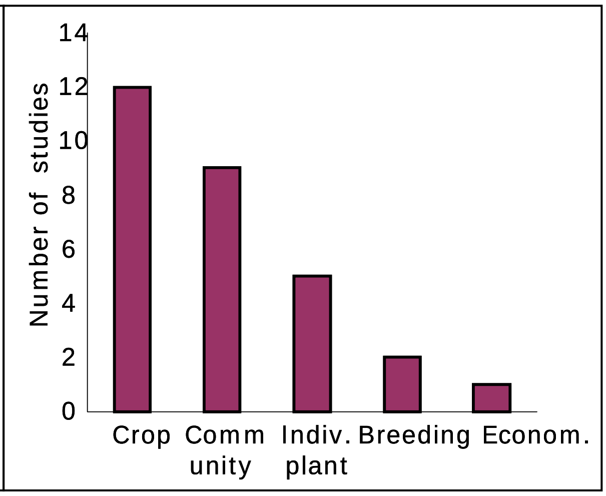
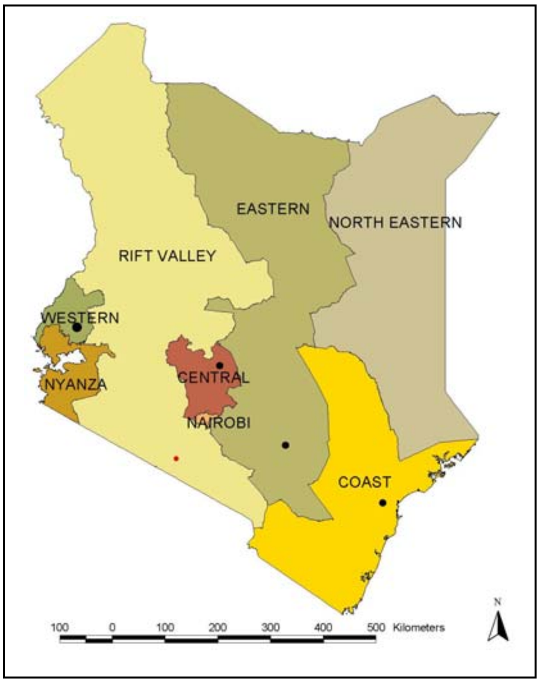


Fig. 2: Types of pollinator studies in Kenya

Diversity of pollinator studies in Kenya

Most pollination ecology studies in Kenya have been on crop pollination (e.g. Onim et al 1979, Khaemba 1985, Njoroge 2004) followed by community studies (Gikungu 2002, 2006, Gikungu & Njoroge 2007)(Fig 2). Crop pollination studies have been mainly on important cash crops such as coffee, fruits and vegetables. There is need to conduct more community studies especially in natural and proteced areas in Kenya, where a lot has been documented on big mammals but virtually nothing on pollinator diversity and their interactions with plants. However, the existing pollinator studies in Kenya have not been equally distributed and they are skewed towards western Kenya (Fig 3). In the recent past two major projects that is, BIOTA East (Biodiversity Monitoring Transect Analysis in Africa) and RPSUD (Research Programme in Sustainable management and Utilization of Dry land biodiversity) have contributed greatly to pollinator studies in Kenya.

Apis mellifera visiting cowpea flower



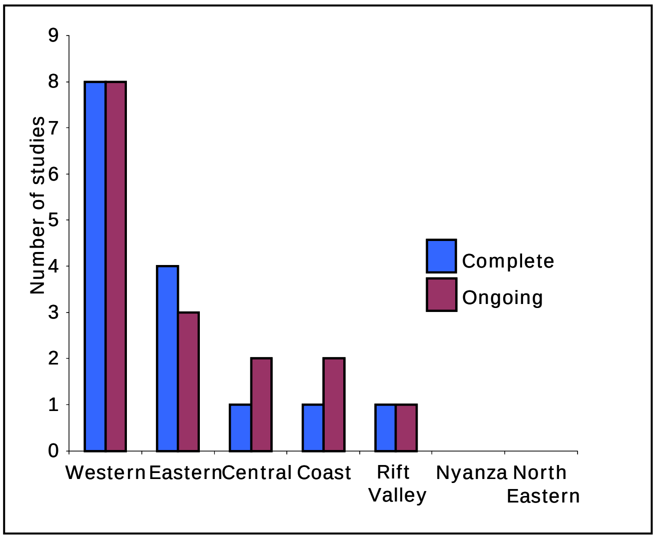


Fig. 3: Current distribution of pollinator studies in Kenya

Western Kenya:

Recent studies in Kakamega Forest, the only remnant of the Guineo-Congolian rainforest in Kenya, revealed that agricultural ecosystems are richer in bees than the forest itself (Fig.4). Over 240 species of bees including several new species have been recorded in this forest (Gikungu 2006). Interestingly, contrasting observations were documented around Mt. Kenya (Gikungu 2002). Furthermore, forest fragmentation has been found to influence pollinator diversity and abundance as well as reproduction of important forest plant species. Bergsdorf (2006) tested the effects on five plant species (Fig. 5) and observed a general tendency of higher visitation frequencies as well as seed set in forest fragment study sites compared to the main forest. However, he did not find a general pattern in fruit set. The encountered tendencies were attributed to edge effects and a high diversity of pollinators in the agroecosystems.

In order to appreciate the role of pollinators in agricultural economics, some studies have been conducted on selected crops in western Kenya. The net economic benefit gained by farmers due to bee pollination (on eight different crops) in the Kakamega region was about 40% of their annual market value, amounting in total to 3.19 Million US$.

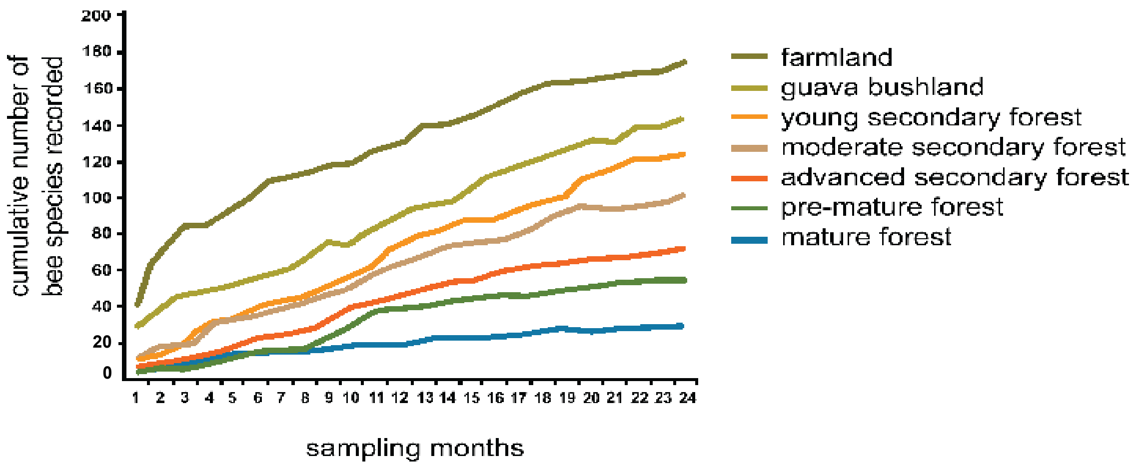


Fig. 4: Cumulative number of bee species collected at seven study sites over 24 months, Kakamega Forest, Kenya

Eastern Kenya:

In the Eastern part of Kenya a few community and individual plants studies including crops such as water melon (Njoroge 2004, 2006) and Pigeon Pea have been conducted and some are still ongoing. Because the Eastern province is mostly a dry area, most pollinator conservation projects have been on apiculture and meliponiculture with the aim of alleviating poverty and enhancing biodiversity in general. In addition, the traditional knowledge and diversity of stingless bees have been conducted where a lower diversity of stingless bees was observed as compared to Western Kenya (Gikungu & Njoroge 2007).

Coastal Areas:

Pollinator studies in coastal areas are still scarce but some work has been published on studies on bee diversity, foraging behaviour (e.g. DIno 2004, Gikungu & Schwarz in press). Further studies on pollinator diversity and nesting ecology are still ongoing especially in the coastal forests. According to the current data, the coastal forests are fairly rich in bee diversity but they cannot be compared with Kakamega Forest (Gikungu in press).

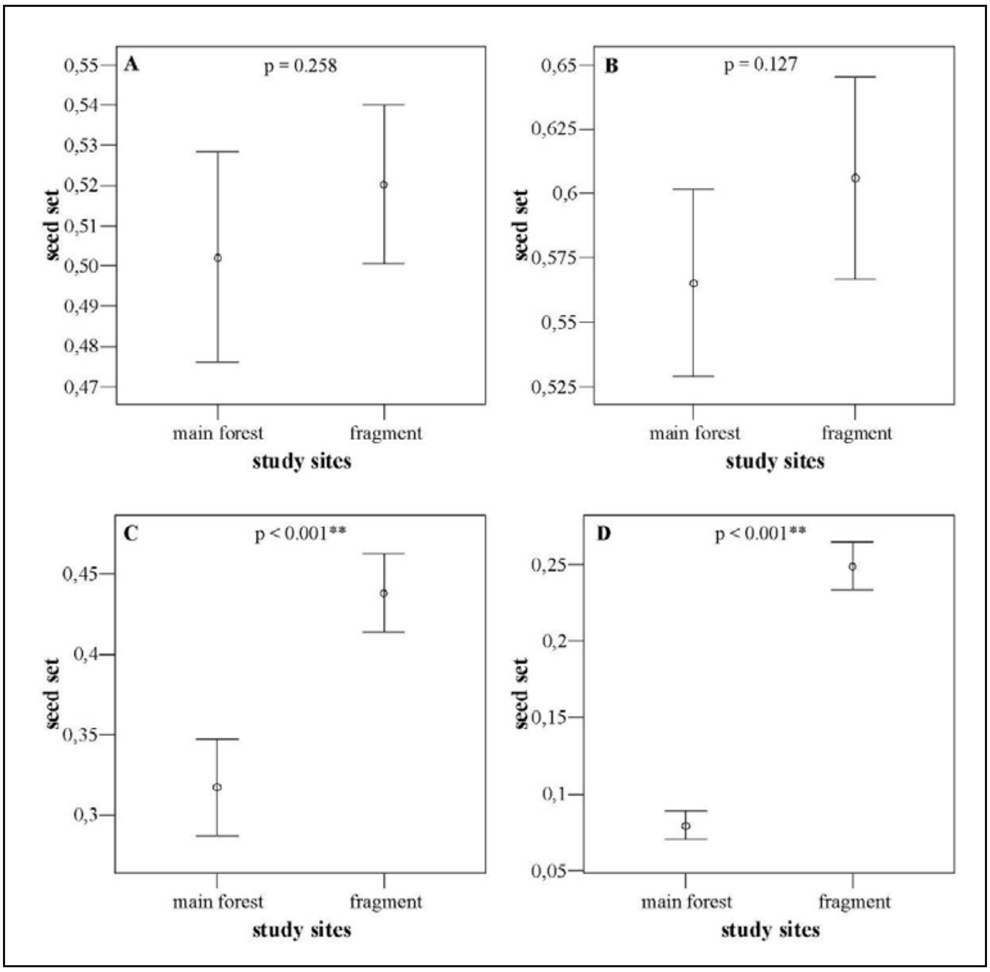


Fig. 5: Seed set in study sites:
(A) *Acanthopale pubescens*; (B) *Acanthus eminens*;
(C) *Heinsenia dervilloides*; (D) *Dracaena fragans*

Capacity building in pollinator studies

Pollination ecology has been the most poorly studied link in biodiversity ecology and conservation in Kenya. However, with the increased awareness of declining pollinators and their role in enhancing food security, there has been a sudden rise in Msc, PhD and parataxonomist training through international collaborations (Fig 6). The greatest contributor to increased capacity building in Kenya has been BIOTA-East followed by UNESCO and local expertise, especially in bee taxonomy. Thus, in the recent past there has been a tremendous increase and enthusiasm in pollination ecology studies. With the formation of API (African Pollination Initiative) and the implementation of BIOTA-East in 2001, two parataxonomist courses have been held in the country since 2003 and the third one will be held in August 2008 for one month funded by the BIOTA-East. Further, a pollination centre is under construction at National Museums of Kenya (Fig. 7).

Fig. 5: Construction of the Pollination Centre at Nairobi Museums

Fig. 7: Training in Pollination Ecology and Bee Taxonomy at National Museums of Kenya

Way forward and recommendations:

Conservation of pollinators in Kenya is urgent, given the prevailing anthropogenic disturbances and threat from climate change. It is unfortunate that a lot has not been documented in pollinator relationships and requirements. There is need for increased pollinator studies at landscape level, pollinator management and restoration in every part of the country. Further understanding of pollinator networks in different eco-regions and more research collaborations remain very crucial.

But who is willing to participate in saving Kenyan pollinators but not in zoos...?

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Biological Collection

University of Bielefeld

AN OVERVIEW OF POLLINATOR STUDIES IN KENYA

Mary Gikungu[1], Melanie Hagen[2] & Manfred Kraemer[2]

1. National Museums of Kenya, Zoology Department, Nairobi, Kenya. mgikungu@yahoo.com;
2. Bielefeld University, Biological Collection, Bielefeld, Germany. melanie.hagen@uni-bielefeld.de

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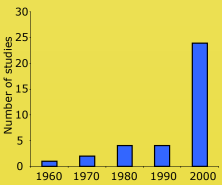

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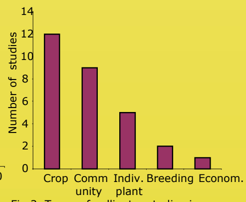

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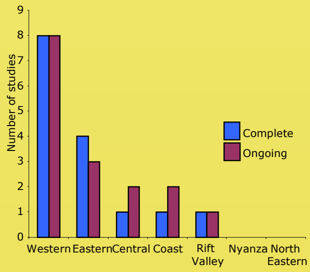
Apis mellifera visiting cowpea flower

Apis mellifera visiting flower of *Justicia flava*



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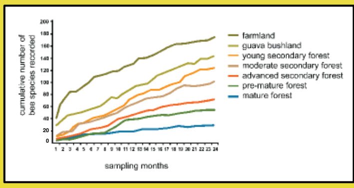

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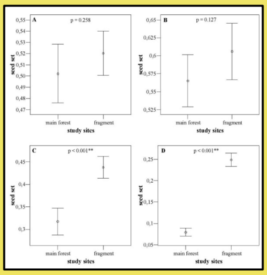

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Fig 6. Construction of the Pollination Centre at Nairobi Museums

Way forward and recommendations:

Conservation of pollinators in Kenya is urgent, given the prevailing anthropogenic disturbances and threat from climate change. It is unfortunate that a lot has not been documented in pollinator relationships and requirements. There is need for increased pollinator studies at landscape level, pollinator management and restoration in every part of the country. Further understanding of pollinator networks in different eco-regions and more research collaborations remain very crucial.

But who is willing to participate in saving Kenyan pollinators but not in zoos...?

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3.3 Brazilian Pollinators Initiative: Biodiversity and Sustainable Use of Pollinators

by Vera Lucia Imperatriz Fonseca, Antônio Mauro Saraiva, Lionel S. Gonçalves, David De Jong, Denise de Araujo Alves, Cristiano Menezes and Tiago M. Francoy, Brazil

Pollinators Initiatives are characterized by actions of different stakeholders who activate and develop parts of the framework defined by the International Pollinators Initiative. People are generally encouraged to carry out these activities through the program focal point and leaderships as well as a result of increased awareness concerning the role of pollinators as ecosystem services providers. The “Brazilian Pollinators Initiative” is developed by several actors from civilian society who define the bases of activities to promote the sustainable use and conservation of Pollinators and Pollination (Imperatriz-Fonseca et al., 2008).

Brazilian activities related to pollinators since 1998 included mainly assessment and management.

Assessment

In assessment we consider information on pollinators as the first step. A survey of the Brazilian literature on pollinators and pollination was published in 2006 as a book. The biodiversity and the sustainable use of pollinators were also discussed in important meetings, held in Brazil with participants from several countries. The first survey was prepared after the International Workshop on the *Conservation and Sustainable Use of Pollinators in Agriculture, with an Emphasis on Bees*, by Kevan & Imperatriz-Fonseca eds. (2002; reprinted in 2006). Freitas & Pereira organized the first meeting considering solitary bees as pollinators in Brazil and the book from this meeting. Imperatriz-Fonseca et al. reviewed the results of the meeting S. Paulo Declaration on Pollinators plus 5, assessing the status and suggesting best practices for the use of bees as pollinators in Brazil.

The Catalog of Bees (Hymenoptera, Apoidea) in the Neotropical Region is a very important source of information on stingless bees, by João M. F. de Camargo and Silvia R. M. Pedro; literature until 2005 was included. An electronic version of this catalog will be on line in August 2008.

Pollinators Network and other Information Technology Tools

Many activities related to the use of information technologies for research, education and awareness on pollinators in Brazil deserve attention. They include instrumentation systems, information systems and networks on pollinators.

Data acquisition systems for research on pollinators have been developed mainly by L.S. Gonçalves and collaborators (for *Apis*) and by A.M Saraiva, V.L. Imperatriz-Fonseca and collaborators (for stingless bees). Examples are instruments for studying flight activity and thermo-regulation inside the colonies. Networked sensors that can be accessed by the Internet are also the focus of the Virtual Network Center of Ecosystem Services. Weblabs on pollinators are being developed, e.g. laboratories whose data and/or experiments can be accessed via Internet. The availability of an Internet 2 connection between the project partners at the Universidade de Sao Paulo, (Agricultural Automation Lab and BeeLab) will allow sharing contents such as high definition images and real-time high-definition video. Video and audio data can be recorded and analyzed for behavioral studies. This project is financed by FAPESP (TIDIA – KyaTera project). Other novel approaches such as wireless sensor networks are currently being studied for use on pollinator research.

Handheld computers have been used to run computer programs that help collect data in the field. Ethologer (for behavioral studies, developed with J.C. Nieh, from U.C. San Diego) and Trap nest scouter (for trap nest experiments) are two examples of specific software developed for use in pocket PC computers.

Information about Brazilian native pollinators have been on-line at the BeeLab's web pages since the mid 90's and led to the development of WebBee, which is an on-line information system (developed originally with support from CNPq-Brazil), with a database of stingless bees species data: text, images and videos and also hosting most of the activities of the Brazilian Pollinator Initiatives (www.webbee.org.br). The experience gained in the development of this system has been important to help develop the IABIN Pollinators Thematic Network (http://pollinators.iabin.net). This is a distributed data and information network that will provide content in the following areas: pollinator checklists, experts, specimens and observations, pollinator-plant-relationships, and literature. This project of the InterAmerican Biodiversity Information Network (IABIN) aims at providing access to information on pollinators from the integrating data providers from all American countries, linking to other global data networks, such as GBIF, the Global Biodiversity Information Facility.

The digitization of biological collections data is a crucial and basic point. Many Brazilian pollinators collections have now been digitized by CRIA (Centro de Referência em Informação Ambiental), with support from agencies such as Fapesp in Brazil, and GBIF which helped develop the speciesLink project (splink.cria.org.br). Biological collections on pollinators are included, 12 collections are part of the network, with around 213,000 records online, of which 169,000 are georeferenced (20% of total estimated records in Brazilian collections).

Automatic bee identification

Automatic identification of bees is also a subject of interest to Brazilian researchers. As the Meliponini are one of the most important bee groups in the tropical region, the development of identification techniques other than traditional taxonomy is of extreme importance. Among the new morphometric techniques used to identify bee species, one that is presenting very good results is geometric morphometry of forewings. It consists in photographing the forewings of the specimens and in plotting vein junction landmarks. After software rotation of the images for an optimal fit, the relative positions of the landmarks are used to describe the wings and to calculate the differences among the groups. All the softwares needed to make these analyses are available via internet at http://life.bio.sunysb.edu/morph/. As preliminary results, we present the discrimination of 17 stingless bee species that are found on the campus of the University of Sao Paulo in Ribeirao Preto. When we analyzed the identification of individuals, we obtained a rate of 91% of correct identifications and the major problems we found were in the *Scaptotrigona* group, a group not very well resolved in taxonomic terms. When working with colony identifications, using five workers per colony, we achieved 96% correct identifications. The problem was found again in the *Scaptotrigona* group. The results obtained till now are very important and are encouraging us to keep working on this line, a very promising one. Other algorithms are being studied to help improve the rate of correct identifications and will be integrated in a software tool.

Management

Stingless bees

Beekeeping and inbreeding

The wide scale production of stingless bee nests is an important aspect to be investigated, because these bees are potential pollinators of several crops. We studied queen and male production in *Melipona scutellaris*, a species found in Northeast Brazil that has a high value for regional meliponiculture, in an isolated population, located in São Simão, São Paulo State, and we compared the results with data obtained from colonies belonging to a beekeeper near Recife, Pernambuco state, a natural population. Alves et al. evaluated 53 brood combs (18,929 bees) from different colonies of the inbred population, and 44 combs (16,812 bees) from colonies of the exogamic population. The inbred population began with two nests 12 years ago, and 30 nests were reached due to successive splitting by Dr. Paulo Nogueira-Neto. The results until now indicate that colonies in the isolated population invest significantly more in reproductives (queens and males) than colonies in the natural population. This could be due to an inbreeding effect, which we are investigating with molecular tools (microsatellite markers) to look for diploid males in these populations and the responses to their presence in the colonies.

How to obtain stingless bees nests in nature

Trapnests are widely used for solitary bees in several regions of the world. Beekeepers in Brazil have been using plastic bottles to attract stingless bee swarms, with successful results for some species, mainly *Tetragonisca angustula* and *Plebeia* spp. Using a standardized methodology, we have been testing the practicability of the method and the influence of cavity size to attract Meliponini swarms. The trapnests are well accepted in disturbed areas and attracted 5 Meliponini species in one of the experiments. Out of 200 groups of trapnests, each group containing four plastic bottles of different volumes, we collected 38 nests of stingless bees during one year. A special tool for field data acquisition (trap nest scouter software on a pocket PC) was developed to facilitate the field work. Experiments are in progress to test different materials for the trapnests and their efficiency in various environments.

Queen production in stingless bees *in vitro*

For Meliponini bees we highlight the importance of developing in vitro techniques for rearing queens, fertilization under controlled conditions and development of small colonies into normal colonies. In most stingless bee species any female larva can become a queen if a large quantity of larval food is provided. The technique for rearing in vitro queens has been improved in the last few years and we have already obtained 93% of success with *Scaptotrigona depilis*. We have successfully tested the technique for two other species until now (*Nannotrigona testaceicornis* and *Plebeia droryana*), and other researchers have had success with *Tetragonisca angustula* and *Frieseomelitta varia*. Hypothetically, it would be possible to use this technique for any stingless bee species, except for *Melipona* genera. Although we have already demonstrated the viability of these queens for *Nannotrigona testaceicornis* (publication in preparation), other experiments are in progress to compare in vitro queens with natural queens. Fertilization under controlled conditions and development of small colonies into normal colonies are the next steps for this project. The success of this project would make many important improvements in Meliponiculture possible, such as colonies multiplication on a large scale and selection for more productive colonies.

Africanized honey bees

Bees to be used in Pollination

Beekeeping in Brazil has grown considerably since the introduction of the African honey bee, *Apis mellifera scutellata*, in 1956, as beekeepers learned to work with the polyhybrid Africanized honey bee (AHB), a product of crosses between the African bee and the previously introduced European honey bees (*Apis mellifera ligustica*, *Apis mellifera mellifera*, etc.). The introduction of the African bee to Brazil is the event responsible for the expressive change and development of beekeeping since its beginnings in this country in 1839; today the AHB is the only honey bee found in nature and used in commercial beekeeping. At the beginning of this new era of beekeeping, especially in the 1960s, the Africanized bees caused serious concern due to stinging incidents; numerous social and economic problems were caused by its aggressiveness and high tendency to swarm. At that time, the chaotic period of our beekeeping history, researchers had no information available about the biology of these new bees, and beekeepers did not know how to handle them; consequently many of them abandoned their apiaries. However, fortunately thanks to the continuous scientific and technical support of researchers and technicians, today the biology and behavior of the AHB is better understood. The number of scientific and technical publications about bees increased more than 30 times after the arrival of the African bees. Beekeeping technology in Brazil improved considerably, so that today there is now no need to import beekeeping equipment and working with these bees became possible. Brazilian honey production before 1956 was about 5,000 tons/year; today it is more than 50,000 tons/year. These bees thrive in climates where European bees did not survive, making beekeeping viable throughout the country. An important feature of the AHB is that they have been little affected by the mite *Varroa destructor,* one of the world's most important enemies of honey bees, which appeared in the 1970s in Brazil. Honey bees in other countries must be treated with acaricides in order to survive this mite. However, fortunately, the AHB rapidly became tolerant to *Varroa*. As a result, no chemical products are imported or needed to treat for this mite; indeed, Brazilian beekeepers do not treat their colonies for any disease or parasite. This makes Brazilian honey 'naturally' organic. Brazil has not traditionally been an important honey exporter. However, since 2000 the international honey market changed after problems with contaminated Chinese honey; consequently, Brazil became a large-scale honey exporter. Since 2004, Brazil annually exports around 20,000 tons of honey, especially organic honey; the Northeast region of Brazil (with considerable native vegetation: Caatinga, Cerrado etc.) is responsible for about 30% of the exported honey, produced mainly by Piauí and Ceará states. However, beekeeping in that region still needs developing; beekeepers lose about 50% of their colonies every year due to swarming and absconding. Brazil has today about 2,500,000 colonies available for bee products production (propolis, pollen, wax, royal jelly, bee venom and honey, including organic honey) and for pollination purposes. There are already many beekeepers who rent colonies for pollination in Brazil, especially for apples and melons. In order to obtain export quality fruit, bee pollination is absolutely necessary. The aggressiveness and swarming behavior of the AHB are still a serious problem for beekeepers and for the public. In order to understand and control swarming behavior of AHB, we set up a project on swarming behavior induced by temperature using a climatic chamber both in Ribeirão Preto-São Paulo state and Mossoró-Rio Grande do Norte state. We observed that many factors can influence the colony and provoke colony abandonment, such as: lack of water, high temperature, lack of food and other types of stress. A key factor, according to our findings, is temperature. We observed in our experiments that when the temperature reaches about 41°C inside the hive, there is an exit in mass of all colony individuals (absconding), leaving behind brood and food. This helps explain the great loss of colonies due to absconding in the northeast every year. In other research we have shown that the AHB is superior to European honey bees for pollination purposes; however, before we can fully explore their potential the difficulties with managing AHB for pollination in the field must be resolved. The main difficulties are:

1. There are no established techniques for using AHB under Brazilian conditions on most crops. There is also very little mechanization of beekeeping.

2. Often the hives are not made with standard measures, or with inferior materials, making transport and management difficult.

3. The bees are quite defensive and growers are often reluctant to place them in or near the crops that need pollinating.

4. There is not sufficient care in the transportation of colonies, so that accidents are common and this discourages their use for pollination.

5. Beekeepers are unaware of disease problems, and sometimes incorrectly try to treat their colonies; some have introduced contaminated bee products and equipment from abroad, threatening beekeeping throughout the country.

6. There is a lack of central laboratories that can provide timely and accurate diagnoses of bee diseases, and also there are no field personnel to advise beekeepers about this kind of problem.

7. Growers are frequently unaware of the importance of bees and pollination, and in fact they often prohibit the introduction of bees into their properties; they use insecticides indiscriminately and incorrectly without any concern for the effects on commercial and native bees.

8. There is no tradition for making pollination contracts that include a provision for compensation for the beekeeper in the case of losses due to pesticides or the stealing of hives on the grower's property. There should also be a provision for responsibilities in the case of an accident with the bees.

9. The availability of honey bee colonies for pollination would be increased considerably if the beekeepers could avoid the serious problems caused by swarming and absconding observed each year.

10. Organic honey and pollination fees are important sources of income for beekeepers, especially in the Northeast region of Brazil; however, beekeepers need technical support so that they can more efficiently attend these markets.

Undoubtedly, increased investment in beekeeping technology in Brazil would improve its status as one of the most important food producing regions of the world.

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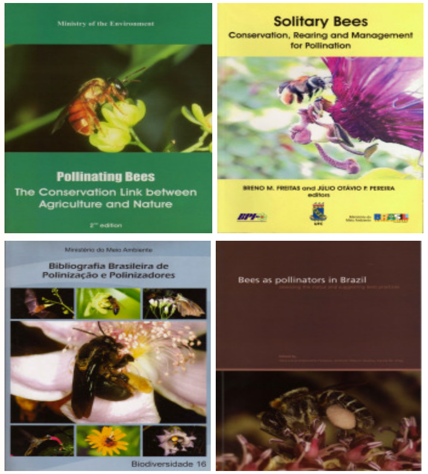
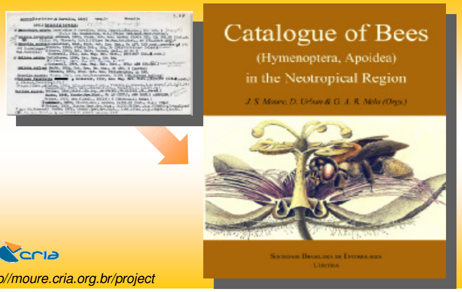
Brazilian Pollinators Initiative: Biodiversity and Sustainable Use of Pollinators

Vera Lucia Imperatriz Fonseca; Antonio Mauro Saraiva; Lionel Segui Gonçalves

Assessment





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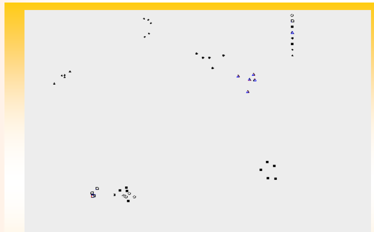
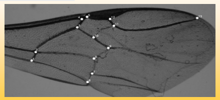


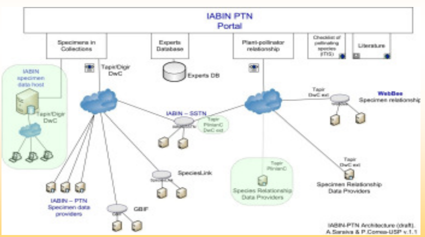


New tool for automatic identification under development: morphometric geometry of Meliponini wings (T.M. Francoy, USP)

Nesting of stingless bees in trapnests.

Tools for field data acquisition: trap nest scouter software on a pocket PC

(E.M.M. Jorge & A.M. Saraiva, USP)

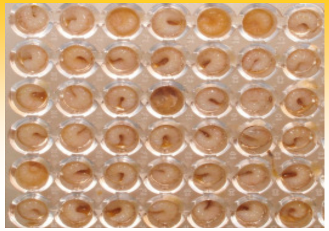


Portals for pollinators data: IABIN – Pollinators Thematic Network (pollinators.iabin.net) with CoEvolution Institute, ITIS, NBII. (L.D. Adams coordinator, M. Ruggiero and A.M. Saraiva)

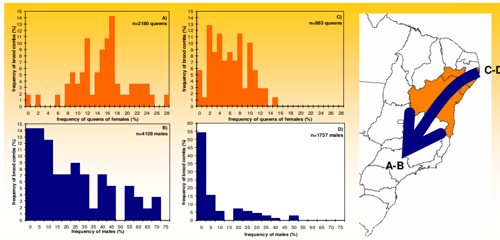
Pollinators Collections Network

Pollinators collections and their records: The pollinators collections network has 12 collections with about 213 thousand records of which 169 thousand are georeferenced (20% of total estimated records)

Stingless Bees Management



Queen rearing *in vitro* in *Nannotrigona* and *Scaptotrigona* (Meliponini)
(C. Menezes, USP)



Distribution of the frequency of queens (of females) (A, C) and males (B, D) in *M. scutellaris* brood combs. A-B: isolated population; C-D: natural population. (D.A. Alves, USP)

Stingless bees conservation and management in Rio Grande do Sul, Brazil

S.W. Freitas (FEPAGRO); B. Blochtein (PUC-RS) & V.L. Imperatriz-Fonseca (USP)

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3.4 Brazilian Pollinators Initiative - Time line

Vera L. Imperatriz Fonseca, Denise de A. Alves, Antonio M. Saraiva, Marina C. P. P. Landeiro & Braulio F. S. Dias, Brazil

Pollinators Initiatives are characterized by actions of different stakeholders who activate and develop parts of the framework defined by the International Pollinator Initiative. People are generally encouraged to carry out these activities through the program focal point and leaderships as well as a result of increased awareness concerning the role of pollinators as ecosystem services providers. The “Brazilian Pollinators Initiative” is developed by several actors from civilian society who define the bases of activities to allow the sustainable use and conservation of Pollinators and Pollination.

The Brazilian activities time line is presented here, 10 years after the meeting held in S. Paulo in October 1998 that encouraged the proposal for an International Pollinators Initiative in CBD-agricultural biodiversity program.

Time line

1998. International Workshop on the **Conservation and Sustainable Use of Pollinators in Agriculture, with an Emphasis on Bees**, was held in Sao Paulo, Brazil, from 7 to 9 October 1998. Result: S. Paulo Declaration on Pollinators.

1999. **S. Paulo Declaration on Pollinators** (http://www.cbd.int/doc/case-studies/agr/cs-agr-pollinator-rpt.pdf) was presented by the Brazilian Government at the Fifth Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice.

2000. Brazilians are encouraged to work on Bees as Pollinators and Pollination, and the programme was presented by Dr. B. F. S. Dias at the meeting **IV Encontro sobre Abelhas de Ribeirão Preto.**

2000. COP 5, decision V/5, establishes an **International Initiative for the Conservation and Sustainable Use of Pollinators** as a cross-cutting initiative within the work program on agricultural biodiversity.

2001. The first project aimed at using Information Technology for building a pollinator information network in Brazil is approved (executive agency CNPq): **WebBee – a Brazilian information network on bee biodiversity.** www.webbee.org.br (coordination: A. M. Saraiva and V.L. Imperatriz-Fonseca).

2002. COP 6 (http://www.biodiv.org/doc/meetings/cop/cop-06/official/cop-06-04en.pdf), **Decision VI/5 - adoption and decision to periodically review, as appropriate, the plan of action for the International Initiative for the Conservation and Sustainable Use of Pollinators.**

2002. The workshop **World Bee Checklist** was held within the meeting Trends and Developments in Biodiversity Informatics, (http://www.cria.org.br/eventos/tdbi/wbcw), in Indaiatuba, SP, Brazil, coordinated by CRIA (V. P. Canhos), ITIS (M. Ruggiero) and BPI (V.L. Imperatriz-Fonseca).

2002. The **Brazilian Pollinators Initiative and the role of bees in pollination** was presented at National Meetings (XIV Brazilian Beekeeping Congress; V Encontro Sobre Abelhas de Ribeirão Preto). Dr B. F. S. Dias presented the plans for a global project, under FAO facilitation and GEF support.

2003. **First Brazilian Field Course on Biology and Ecology of Pollination**, by B. F. Viana (Bahia Federal University) and P. G. Kevan (Guelph University).

2003. Brazilian participation in the workshop in South Africa (**Building a Policy and Pollinator Conservation Strategy**). Delegates: V. L. Imperatriz-Fonseca, B. M. Magalhães Freitas and M. S. de Castro.

2003. The Brazilian Government included the Pollinators and Pollination in the **Pluriannual Government Program (2004-2007).**

2003. The Brazilian Government (MMA) improved financing aids for a National Project on crop pollination in Brazil **(PROBIO).** 13 proposals approved.

2003. B. M. Freitas represented BPI at the CGIAR meeting **Managing Agricultural Biodiversity for Sustainable Development,** in Kenya, Africa.

2003. **S. Paulo Declaration on Pollinators plus 5** Forum, with 2 workshops: **"Standard Methodologies"** and **"Pollinator Initiatives and the role of IT: building synergism and cooperation"**. Participation: 12 countries, 77 participants. Financial support: FAO, MMA and MCT (Brazil), USP.

2004. **International Workshop on *Solitary bees and their role in pollination***, held in Beberibe, Ceará, organized by B. M. Freitas, from Ceará Federal University. Published book: FREITAS, B.M. & PEREIRA, JOP. (eds.) **Solitary bees - conservation, rearing and management for pollination**.

2004. XV Brazilian Beekeeping Congress and First Brazilian Meliponiculture Congress- **BPI for beekeepers.**

2004. **Beginning of Pollinators Collections Network** at CRIA, with digitalization of two bee collections In S. Paulo State, around 107.000 records. Support from FAPESP.

2004. **First National Stakeholders Meeting of the Brazilian Pollinators Initiative** as part of the FAO Project EP/GLO/301/GEF .

2004/2005**.** Development of PDF-B of the project financed by GEF and coordinated by FAO, **Conservation and management of pollinators for sustainable Agriculture through an ecosystem approach.**

2005. The project ViNCES – Weblabs on ecosystem services, aimed at developing on line experiments and data on pollinators (and photosynthesis) was approved by FAPESP. www.ib/usp/br/vinces. Coordination: A. M. Saraiva, V. L. Imperatriz-Fonseca and M. S. Buckeridge.

2005. Brazilian Ministry of Environment makes the Brazilian Pollinators Initiative official, through an inter-ministry designation, representative for civil society.

2005. **Second National Stakeholders Meeting of the Brazilian Pollinators Initiative** as part of the FAO Project EP/GLO/301/GEF.

2005. **Second Brazilian Field Course on Biology and Ecology of Pollination,** by B. F. Viana (Bahia Federal University) and P. G. Kevan (Guelph University), in Bahia State, Brazil.

2006. **VII Encontro sobre abelhas de Ribeirão Preto**, with two symposia on Pollinators and the Brazilian Program coordinated by MMA.

2006. Activities of BPI in the **XVI Brazilian Beekeeping Congress and II Brazilian Congress of Meliponiculture**, held in Sergipe, Brazil.

2006. Settlement of **Repol, Network of Pollinators from Bahia State**, Brazil, supported by Bahia State Scientific Agency.

2006. **IABIN Pollinator Thematic Network** project approved by the Organization of the American States. The consortium led by CoEvolution Institute (L. D. Adams) has Brazilian partners (University of São Paulo – A. M. Saraiva and V. L. Imperatriz-Fonseca), besides ITIS (M. Ruggiero) and NBII (L. Sellers). The Brazilian group is responsible for the IT infrastructure.

2006. **Meeting in COP8, side event Pollinators**, Curitiba, Brazil.

Publications supported by the Ministry of the Environment: **Brazilian References on Pollination and pollinators**; **Pollinating bees: the conservation link between nature and agriculture** (revised edition) and **Solitary bees and their role in pollination** (reprinted).

Publication supported by FAO and Conservation International-Brazil: **Bees as pollinators in Brazil: assessing the status and suggesting the best practices** (Imperatriz-Fonseca et al., eds.).

2006. **Workshop Pollinator Information in the Americas** was held in Indaiatuba, SP, Brazil, as a joint workshop of IABIN and GBIF. Organized by A. M. Saraiva, P. Correa and the Pollinators Network Thematic (PTN) project colleagues (www.iabin.net).

2006. The Thematic project **Biodiversity and sustainable use of pollinators, with emphasis on bees**, supported by FAPESP was approved and started. Coordination: V.L. Imperatriz-Fonseca.

2007. **Approval of the project GEF Conservation & Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach.** Executive agency: FAO.

2007. **Third Brazilian Field Course Biology and Ecology of Pollination**, by B. F. Viana (Bahia Federal University) and P. G. Kevan (Guelph University), in Bahia State, Brazil.

2007. **Pollinators Collections network:** CRIA digitizes additional nine pollinators' collection in Brazil with 213,345 records until May 2008.

2007. **Round table on Pollinators Ecology**. VIII Brazilian Congress of Ecology, held in Caxambu, 24th-28th September, organized by I. Alves-dos-Santos.

2007. Publication of the **Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region** (Moure, J.S.; Urban, D. & Melo, G.A.R.).

2008. Dra. M. J. O. Campos participated (UNESP Rio Claro) in the side event about Pollination of Crops organized by FAO Rome, Italy.

2008. Participation of Dr. B. M. Freitas (UFC), as a BPI member, and Dr. Paulo Oliveira (UFU) as a Probio project coordinator in the INRA /FAO Workshop about pollinating deficit. Avignon, France.

2008. **First International Field Course on Biology and Ecology of Pollination, with emphasis on Agriculture,** by Breno M. Freitas (Ceará Federal University), Peter Kevan (Guelph University) and Blandina Viana (Bahia Federal University).

2008. **Brazilian Pollinators Initiative** was presented in COP9 side event on Pollinators, **Caring for pollinators: safeguarding agrobiodiversity and wild plant diversity,** held in Bonn, April 22.

Acronyms

BPI Brazilian Pollinators Initiative

CGIAR Consultative Group on international Agricultural Research

CNPq Brazilian National Research Council

COP Conference of the Parties

CRIA Reference Center on Environmental Information

FAO Food and Agriculture Organization of the United Nations

FAPESP The São Paulo State Research Support Foundation

GEF Global Environmental Facility

IABIN Inter American Biodiversity Information Network

IPI International Pollinator Initiative

ITIS International Taxonomy Information Service

MMA Ministry of the Environment

MCT Ministry of Science and Technology

PDF-B Project Development Facility phase B

PROBIO National Biodiversity Project

UFC Ceara Federal University

UNESP São Paulo State University

USP University of São Paulo

VINCES Virtual Network Center of Ecosystem Services

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3.5 Integrated Information System for the Oceania Pollinator Initiative based on a federation of distributed databases

by LE Newstrom-Lloyd, J Cooper, NJ Spencer, AD Wilton, New Zealand

Introduction

Most of the island ecosystems of Oceania evolved in isolation from continental landmasses and have unique and fragile plant-pollinator partnerships that are particularly vulnerable to climate change, land use intensification, habitat losses and invasion by alien species. The Oceania Pollinator Initiative (OPI) is a network of pollination ecologists and other researchers, policy makers, farmers, agronomists, beekeepers, conservationists and interested public to promote the conservation and sustainability of pollinators in natural and agricultural ecosystems in the region. OPI is aligned with four other continental size pollinator initiatives under the umbrella of the CBD International Pollinator Initiative (IPI), facilitated and coordinated by FAO. Our website is at www.oceaniapollinator.org

The Oceania Pollinator Network Challenge

A first assessment of the status of pollination services in Oceania will require sharing information across a broad geographic region with small remote islands in the Pacific Ocean. Information needed for conserving and sustaining pollination systems for the nations of Oceania is scarce, scattered or non-existent and many key pollinator collections are in overseas museums. We are initiating and seeking funding for an information network of linked integrated databases to aggregate existing information from diverse local, national, regional and global resources. This will allow us to target information gaps in our future monitoring efforts and case studies. Our vision is to build on existing databases to provide dynamic updatable information primarily via the internet with tools for querying the databases and downloading current summaries based on reliable, traceable, evidence-based data.

We will integrate four major types of information (names, occurrences, descriptors, and summaries) and develop "end to end" reporting tools that will support decision making and promote awareness of pollinator sustainability issues. The information for names (taxonomy), specimens, observations, distributions, and images are relatively straightforward to manage, while the information for interactions, traits data and summaries are more complex and specialised to the field of pollination biology. For example, our interaction and traits databases that we have initiated for New Zealand draw information from specimens, distributions, literature reviews and field data from monitoring studies that we have conducted. The dynamics of native and exotic naturalised pollinators visiting both native and exotic plants has resulted in complex patterns of floral resource visitation overlaying the original native-to-native interactions. The remoteness of oceanic island geography means that the evolution of the flora and fauna progressed in isolation from other regions and therefore the vulnerability of the native pollination networks on these islands needs to be assessed and understood.

Proposed OPI Integrated Information Network

Figure 1 shows a diagram of the proposed content and hierarchical structure of the OPI Integrated Information system with inputs and outputs, data resources, services, technologies and related networks. The organization from local, national, regional to international data sources in a "federated distributed network" will allow information flow up and down the hierarchy. The OPI national level is exemplified in Figure 1 primarily by existing New Zealand and Australian databases but other Oceania nations will be added as they are developed. Our future plans are to utilise existing and developing technologies and databases at each level shown in Figure 1 from national (e.g, 22 member nations of Oceans) to regional (e.g., Oceania, Africa, Brazil, Europe and North America) to international (e.g., the global Plant Information Management System (PIMS) of FAO (Gemmill-Herren et al., 2008). We propose to adopt and leverage current and emerging international protocols for transferring biodiversity data (Figure 2). Some of these technologies and databases are still in development and so are marked in red * on Figure 1 and 2. We also are engaged in following data exchange standards for inter-compatibility to the wider community of international initiatives in particular PIMS-FAO (Gemmill-Herren et al., 2008) and the Inter-American Biodiveristy Information Network (IABIN) Pollinators Thematic Network (PTN) (Ruggiero et al., 2008). We are hoping to be able to link to existing regional networks such as PBIF and others as OPI develops further.

Proposed Outputs and Outcomes for OPI

The proposed future outputs from the OPI Integrated Information system will be widely and freely available via the internet and as published booklets and reports on request. The OPI portal will provide search tools for queries by plant or pollinator species as well as habitats at various spatial and temporal scales. Web-based information pages will contain summary reports with analyses, images, and information on species interactions or pollination systems or communities with references to the literature and data sources. Tools for endusers will include "snapshots" of the raw data traceable to the source (at any level) as well as updatable summaries integrating the current state of information available for Oceania. The portal will deliver new research on best practice management with summaries from the literature. The information will support and enhance decision making by policy makers, best practice management by farmers and agronomists, research by pollination ecologists, and conservation and restoration planning by conservationists. We are planning to develop educational pages that will increase awareness and understanding of the nature and vulnerability of pollination systems in Oceania and feedback up to the global levels to promote International Pollinator Initiative goals.

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Ruggiero M, Sellers E, Saraiva AM, Correa PLP, Adams L. 2008. A Network for Pollinator Information and Extertise in the Western Hemisphere. Poster abstract from FAO at the SBSTTA – 13 meetings of the United Nations Convention on Biological Diversity, Rome, Italy Feb 18-22, 2008.

Figure 1 (next page): Schematic diagram for structure of the proposed Oceania Pollinator Integrated Information System with three levels of a hierarchy from local/national to regional to global and information flow in both directions.

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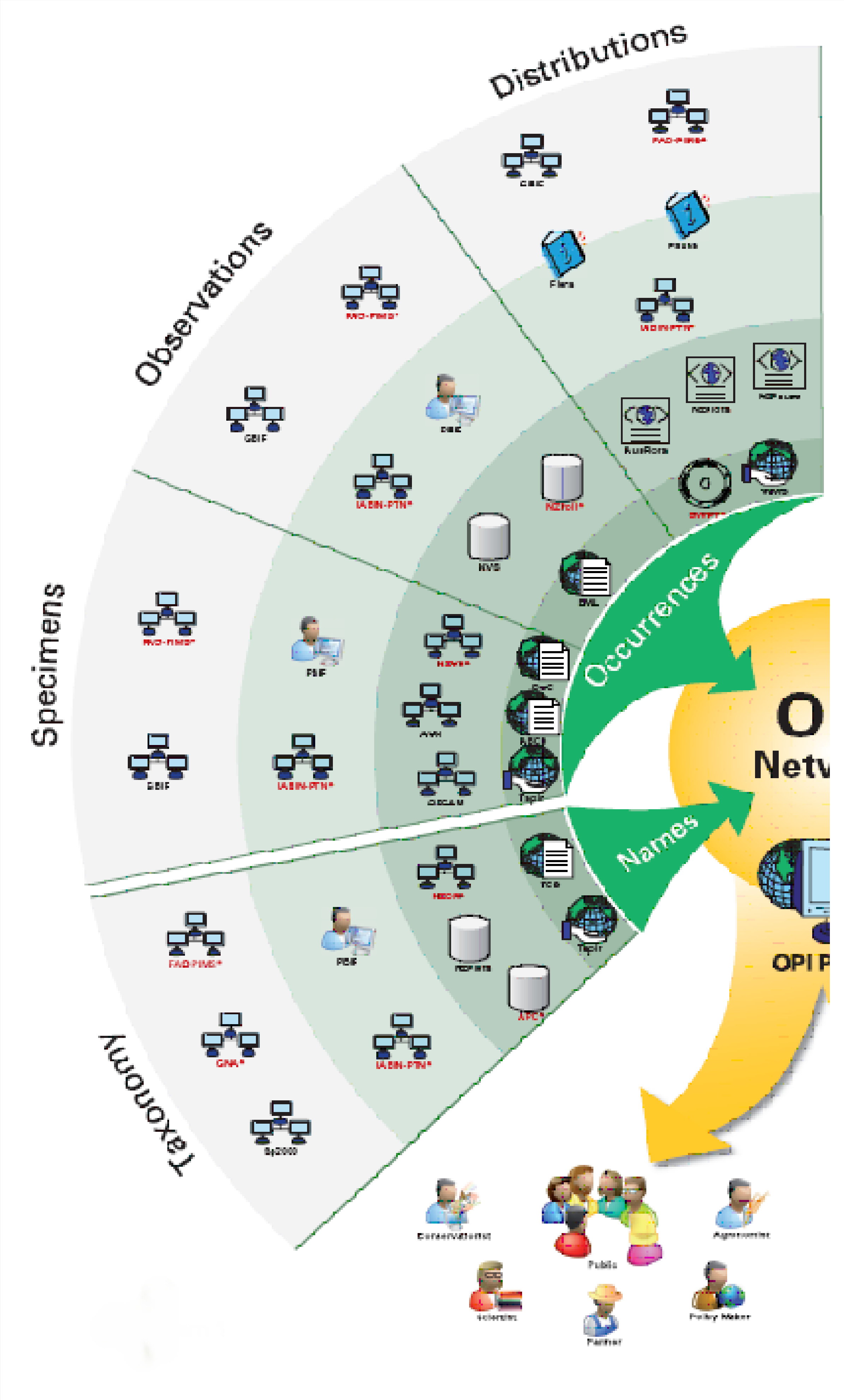
Distributions
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Tapir
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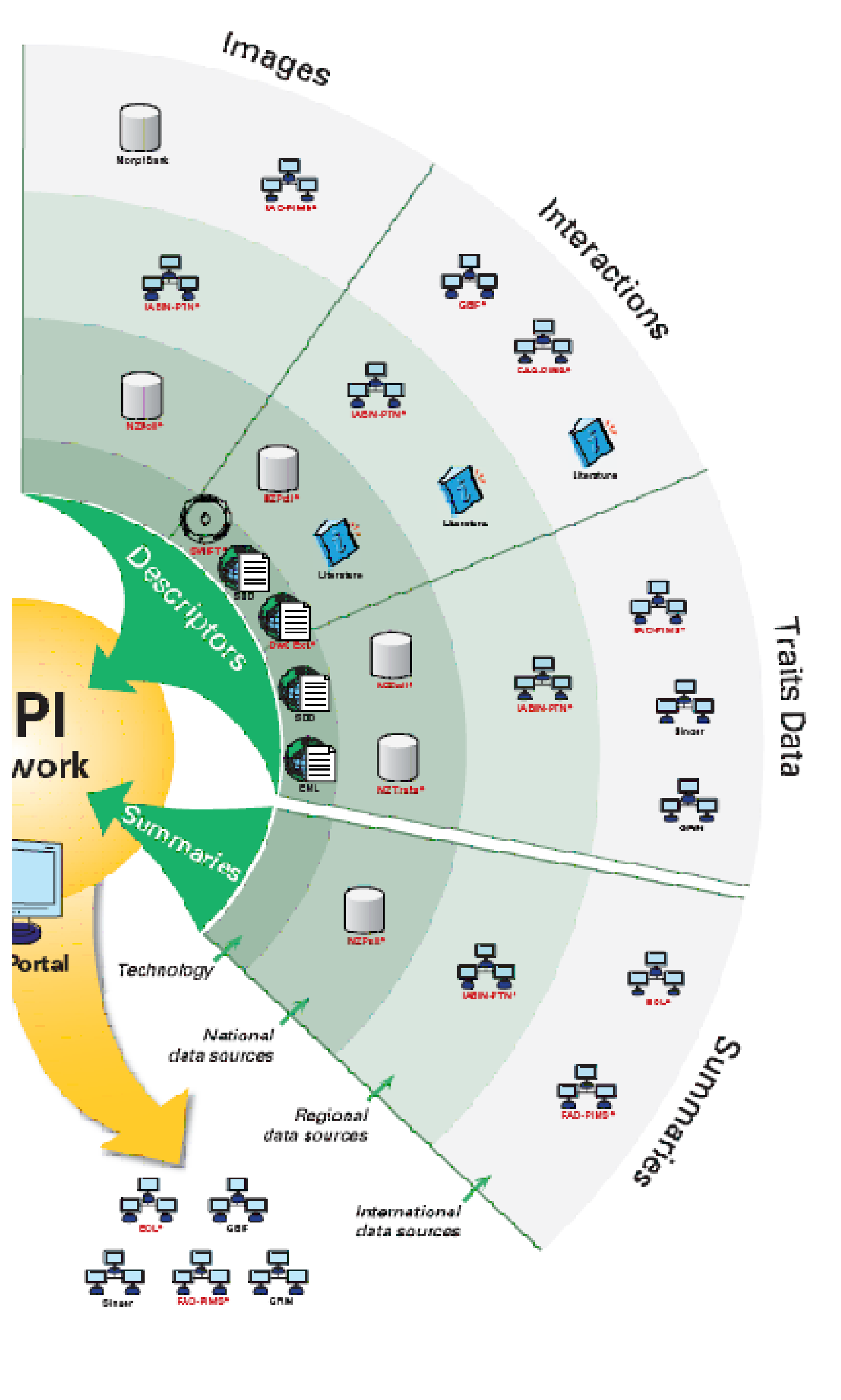
Farmer
Policy Maker


Images
Interactions
Traits Data
Summaries
Descriptors
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PI
work
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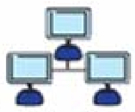
Technology
National
data sources
Regional
data sources
International
data sources
IABIN-PTN*
Literature
SDD
EML
NZTraits*
FAO-PIMS*

Figure 2: List of existing and developing technologies and databases that are proposed for use in developing the Oceania Pollinator Integrated Information System.



AVH – Australia's Virtual Herbarium
www.anbg.gov.au/avh/

EOL – developing Encyclopedia Of Life
www.eol.org

FAO-PIMS – developing Pollinator Information Management System

GBIF – Global Biodiversity Information Facility (network)
www.gbif.org

GNA – developing Global Names Architecture
http://eolinformatics.mbl.edu/meetings/nomina1 final_report.html

GRIN – Germplasm Resources Information Network of USDA
www.ars-grin.gov

IABIN-PTN – developing Interamerican Biodiversity Information Network – Pollinators Thematic Network
www.iabin.net/

NZOR – developing New Zealand Organisms Register

NZVH – developing New Zealand Virtual Herbarium

OZCAM – Online Zoological Collections of Australian Museums
www.ozcam.gov.au/

SINGER – System-wide Information Network for Genetic Resources
www.singer.cgiar.org

Sp2000 – Species 2000 /Integrated Taxonomic Information System – The Catalogue of Life Consortium
www.sp2000.org

TDWG Standards:

TDWG – Taxonomic Database Working Group Biodiversity Information Standards Body
www.tdwg.org/standards/

ABCD – data exchange standard used for collection data (especially in Europe) endorsed by TDWG

DwC – Darwin Core data exchange standard for collection data endorsed by TDWG

DwCExt. – developing Darwin Core Extension data exchange standard

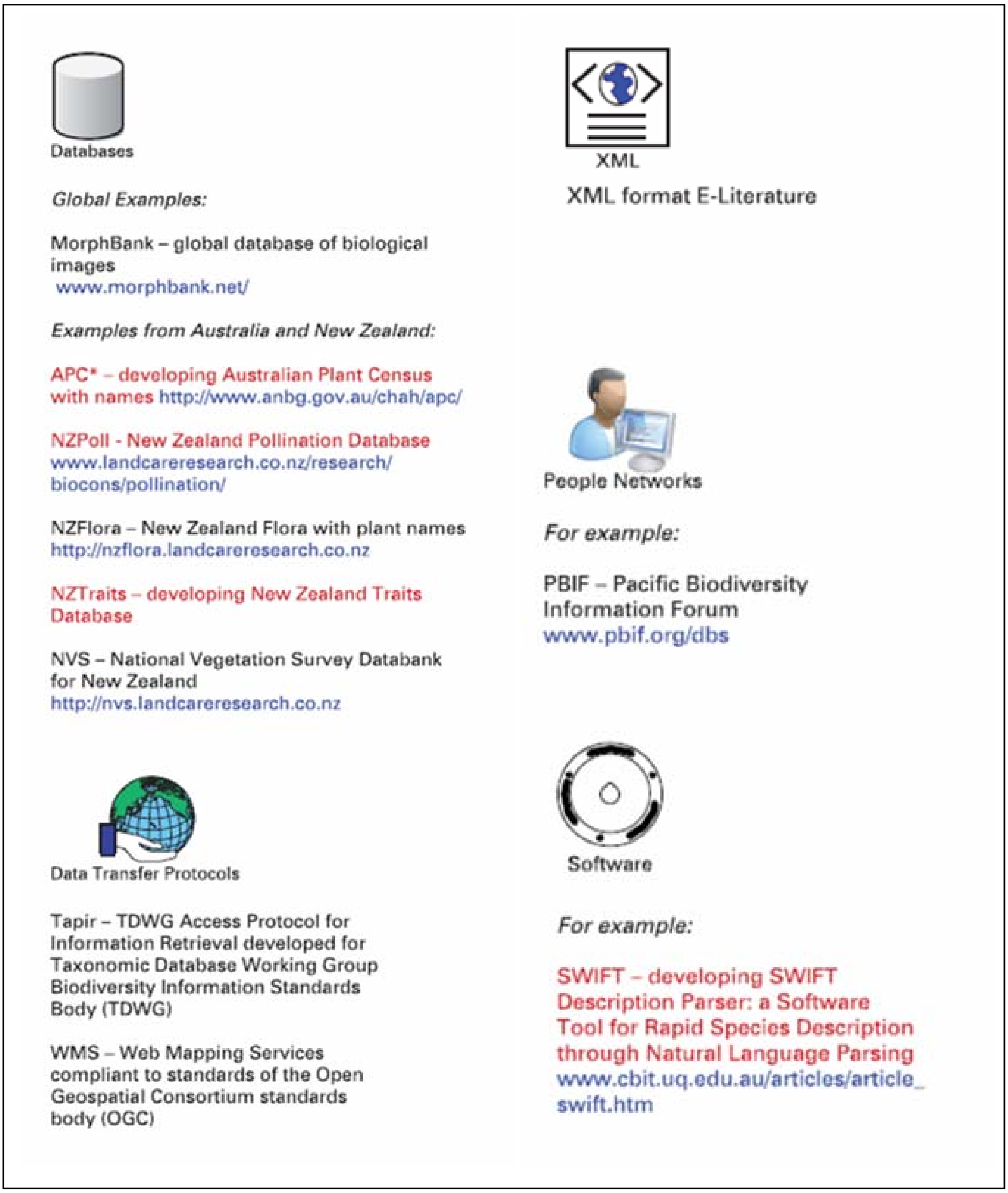
TCS – Taxon Concept Scheme data exchange standard endorsed by TDWG

SDD – Structured Descriptive Data exchange standard endorsed by TDWG

Other Standards:

EML – Ecological Metadata Language from The Knowledge Network for Biocomplexity (KNB)
http://knb.ecoinformatics.org/software/eml

Published literature


Databases
Global Examples:
MorphBank – global database of biological images
www.morphbank.net/
Examples from Australia and New Zealand:
APC* – developing Australian Plant Census with names http://www.anbg.gov.au/chah/apc/
NZPoll - New Zealand Pollination Database
www.landcareresearch.co.nz/research/biocons/pollination/
NZFlora – New Zealand Flora with plant names
http://nzflora.landcareresearch.co.nz
NZTraits – developing New Zealand Traits Database
NVS – National Vegetation Survey Databank for New Zealand
http://nvs.landcareresearch.co.nz
Data Transfer Protocols
Tapir – TDWG Access Protocol for Information Retrieval developed for Taxonomic Database Working Group Biodiversity Information Standards Body (TDWG)
WMS – Web Mapping Services compliant to standards of the Open Geospatial Consortium standards body (OGC)
XML
XML format E-Literature
People Networks
For example:
PBIF – Pacific Biodiversity Information Forum
www.pbif.org/dbs
Software
For example:
SWIFT – developing SWIFT Description Parser: a Software Tool for Rapid Species Description through Natural Language Parsing
www.cbit.uq.edu.au/articles/article_swift.htm

3.6 Monitoring Pollinators: Case studies from Australia and New Zealand

by CL Gross, New England; LE Newstrom-Lloyd, B Howlett, New Zealand; G Plunkett, New England and BJ Donovan, New Zealand

Pollination is an essential ecosystem service — yet in Australia, New Guinea, New Zealand and on the Oceanic Islands- we know very little about our pollinators. Monitoring is a key step here as it provides data on longer term trends and the information we lack on the distribution and ecology of pollinators and their ecosystem service-role. In addition the relative contributions of introduced and native pollinators in natural and agro-ecosystems is poorly understood from an economic perspective.

To establish baselines for monitoring trends in pollinator services in Oceania, we have adopted diverse methods depending on the type of plant-pollinator interaction and the purpose of the investigation. Monitoring is undertaken for a variety of reasons, e.g. to detect change in pollinator communities in fragmented landscapes, to gauge the impact of exotic pollinators on native and exotic plant species, or to determine the contribution of alternative native pollinators in crops. Pollination systems in Oceania depend on the pollinating fauna available which is of very low diversity on most of the small remote islands (e.g., New Zealand) but higher in diversity in large continental sized islands (e.g., Australia).

In island systems, exotic naturalized insects and plants are significant components of many habitats. Exotics may have positive or negative effects on native pollination systems (Newstrom and Robertson 2005). In some cases, it is clear that only exotic pollinators (e.g., bumblebees or honeybees) are capable of pollinating exotic plants. This type of interaction is called an “invasive mutualism” because without the exotic pollinator the exotic plant would not set seed and spread (e.g., broom, Simpson et al. 2005). In other cases, exotic pollinators may benefit native flora because they replace lost pollinators (e.g. birds on the mainland of New Zealand). Similarly, exotic plants rich in floral resources may benefit native pollinator populations but this could lead to abandonment of native plants leaving them bereft of pollinators.

Monitoring for Conservation in Australia

10 year monitoring of a native legume

Monitoring for pollinator decline is a time consuming operation that involves replication of sites over the landscape and over many years. The legume shrub *Pultenaea campbellii* (Fabaceae) (Fig. 1) is a rare species that exists in a fragmented landscape in northern New South Wales, Australia.

Fig. 1: Lycaenid butterfly on the flowers of *Pultenaea campbelli*

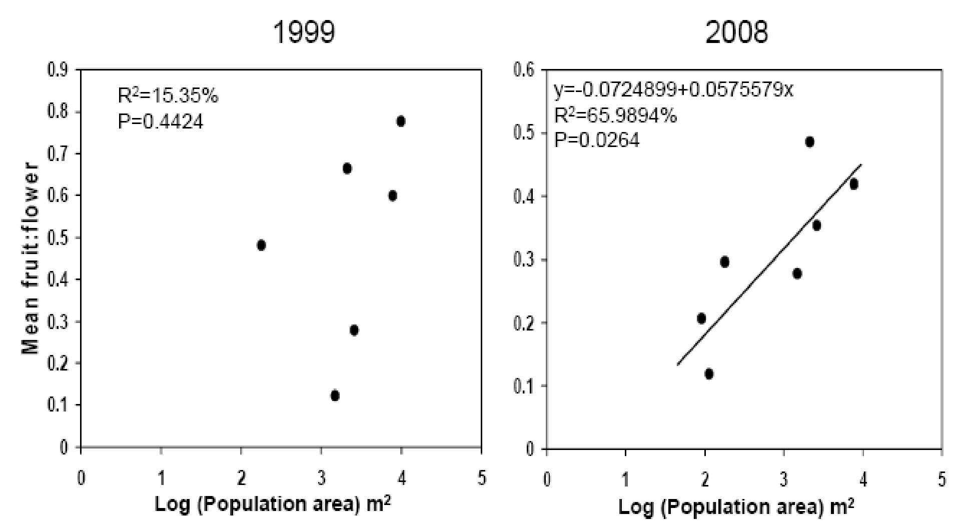


Fig. 2: Fruit to flowers ratios in plants of *P. campbelli* in a ten year interval 1999 (N = 6 populations) and 2008 (N= 7 populations) showing that in 2008 plant population size is correlated with fruiting success and that overtime there has been a decrease in reproductive performance in this insect-dependant species.

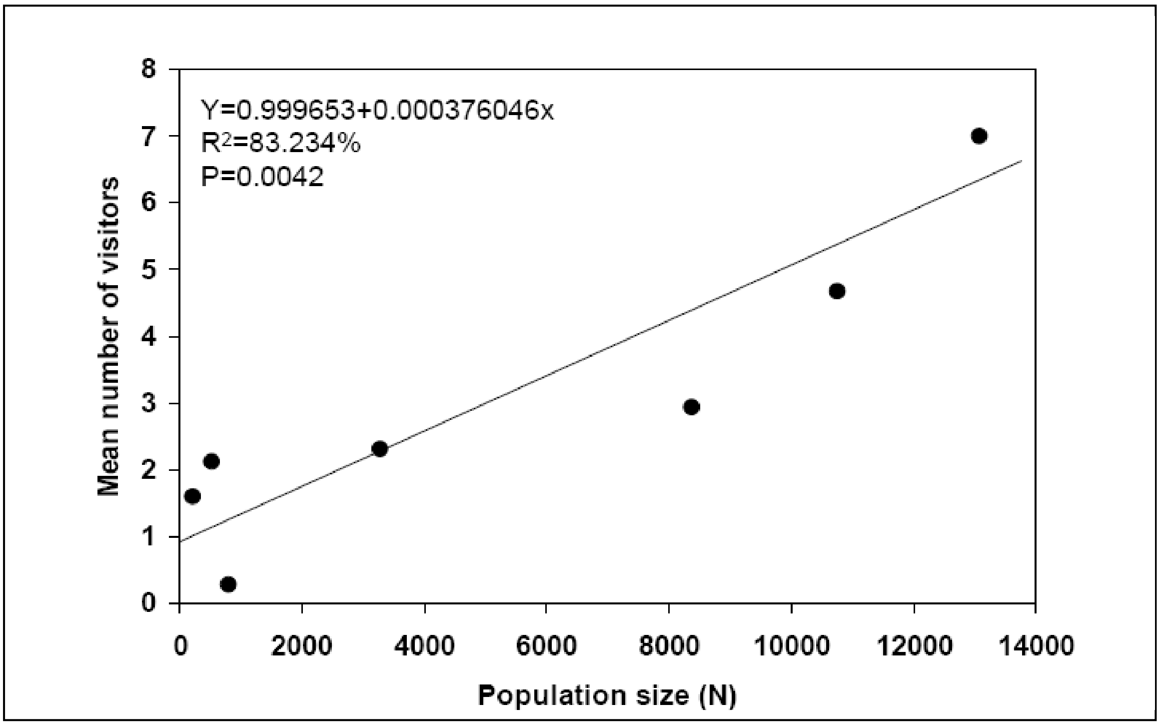


Fig. 3: Mean number of insect visitors to flowers of *P. campbelli* in 2007 (N = 7 populations) showing that floral visitation is positively correlated with plant population size.

In our monitoring study we have value added to our temporal data set (ten year monitoring period) by using plant populations of different sizes. In this way we have detected a relationship between fruit to flower ratios against population area over time (Fig. 2) which is correlated with floral visitor patterns against population size (Fig. 3).

This study is an example of using indirect or remote methods such as fruit to flower ratios in a pollinator dependant species to obtain efficient results when visitation data are difficult to collect.

Fig. 4: The honeybee *Apis mellifera* is an introduced species in Australia and here a feral worker is visiting an inflorescence of the introduced and invasive weed Lippia (*Phyla canescens*). Lippia is not capable of automatic self-pollination (Gorrell & Gross 2007, unpub. data).

An Australian Invasive Mutualism

The invasive species *Phyla canescens* (Lippia) (Fig. 4) relies on pollinators for seed set. We have determined using video monitoring at virgin flowers (Fig. 5), followed by bagging, that the introduced honeybee, *Apis mellifera*, is facilitating the spread of this weed by being the only pollinator in introduced landscapes in Australia.

Fig. 5: The monitoring set-up at patches of Lippia. Video footage is gathered for 10-20 minutes at 'virgin' flowers of *Phyla canescens.* The plant patch is then re-bagged to capture fruits and to extrapolate the efficacy of floral visitors. The video footage was scored for the number of visitors per minute and compared with fruit to flower ratios for the same flowers which showed that feral honeybees are the obligate pollinators for this invasive species (Gross & Gorrell 2008, unpub. data).

New Zealand flowers evolved with no large social bees (Lloyd 1985). The native bee fauna is comprised of 32 species of solitary bees in Leioproctus, Hylaeus and Lasioglossum (Donovan 2007). Exotic social bees, honeybees (Apis mellifera) and bumblebees (Bombus spp.), introduced for agriculture in the 19th century, are fully naturalized throughout New Zealand. Evolutionarily we would expect exotic pollinators to prefer exotic plant species and native pollinators to prefer native plant species. However, many exotic bees are supergeneralists and may displace native bees. Many exotic plant species are rich in nectar and pollen and may draw native pollinators away from native plants (Newstrom and Robertson 2005).

Rapid assessments of pollinator abundance

To investigate crossover among native and exotic plants and pollinators, we made rapid assessments of day active floral visitors along transects in regenerating scrub habitats. For methods see www.landcareresearch.co.nz/research/biocons/pollination/

We observed a total of 370 plants in 58 exotic and 34 native plant species at 4 times a day for at least 12 days at each of 7 sites (Fig. 7). We made a total of 15,000 observations and counted 32,000 floral visitors.

Extensive crossover in both directions

The pattern of crossover is shown in the graphical summary (Fig. 6). Many native plant species are dominated by exotic bees while some exotic plant species are dominated by native bees. These baseline data can be used in the future to detect trends in crossover patterns or declines in floral visitor abundance. Further research is needed to determine the impact of crossovers, the pollinator performance of floral visitors, and the floral resource base needed to maintain native pollinator populations.

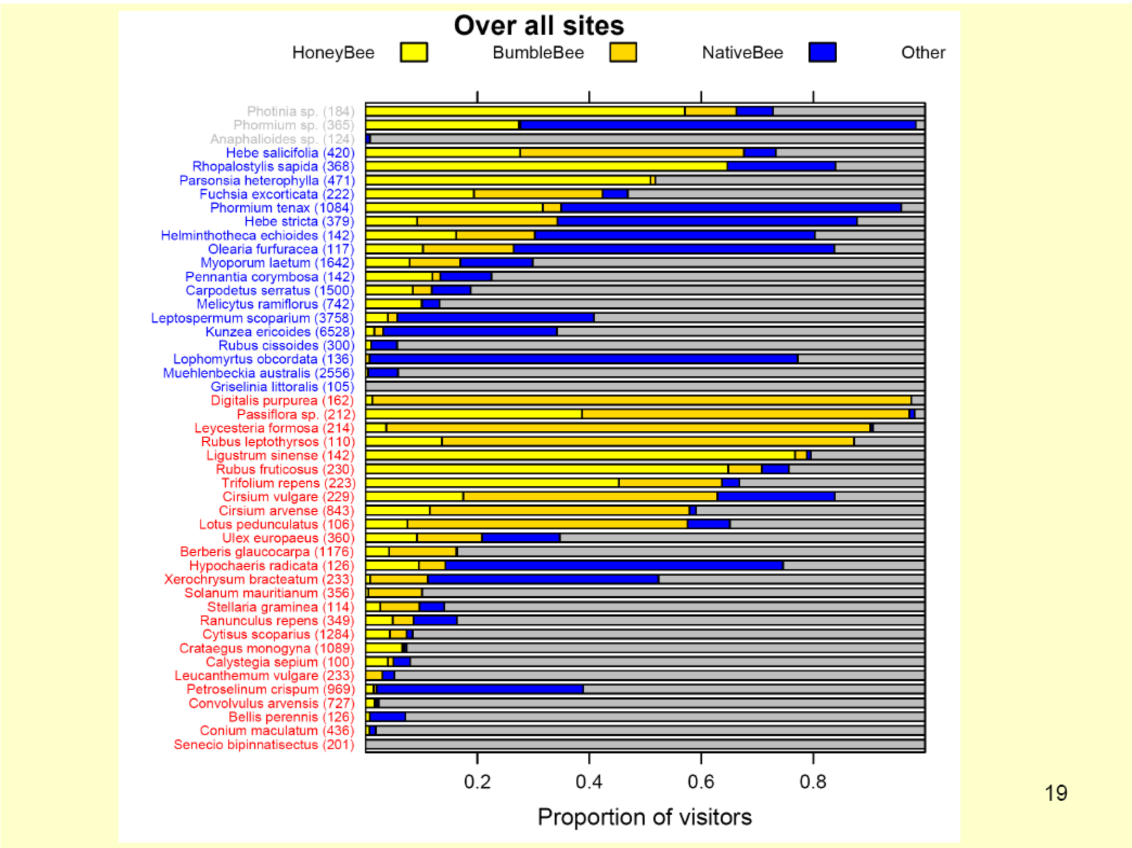


Fig. 6: The relative proportion of exotic bee, native bee and other floral visitors to native and exotic naturalized plant species summed over 7 sites in New Zealand. Red letters indicate exotic and blue letters native plant species. Numbers in brackets indicate total number of visitors observed for each species.

Native pollinators in crops in New Zealand

Native insects as alternative pollinators

Native pollinators in crops may become more important as honey bee populations decline from pests and diseases such as Varroa and Colony Collapse Disorder (Winfree et al. 2007). To assess the potential role of native insects in crops, we monitored commercial onion and pak choi over 5 years in 5 regions of New Zealand. We observed floral visitors and used window pan traps to intercept flying insects in the crop during peak flowering.

Diversity and Abundance of Natives

We found 9 species of native bees and at least 16 species of native flies visiting onion flowers. Figure 7 shows the relative abundance of native bees (Leioproctus and Lasioglossum) versus exotic bees (*Apis mellifera* and *Bombus* spp.) in traps in onion fields during 2004 and 2005 across all regions.

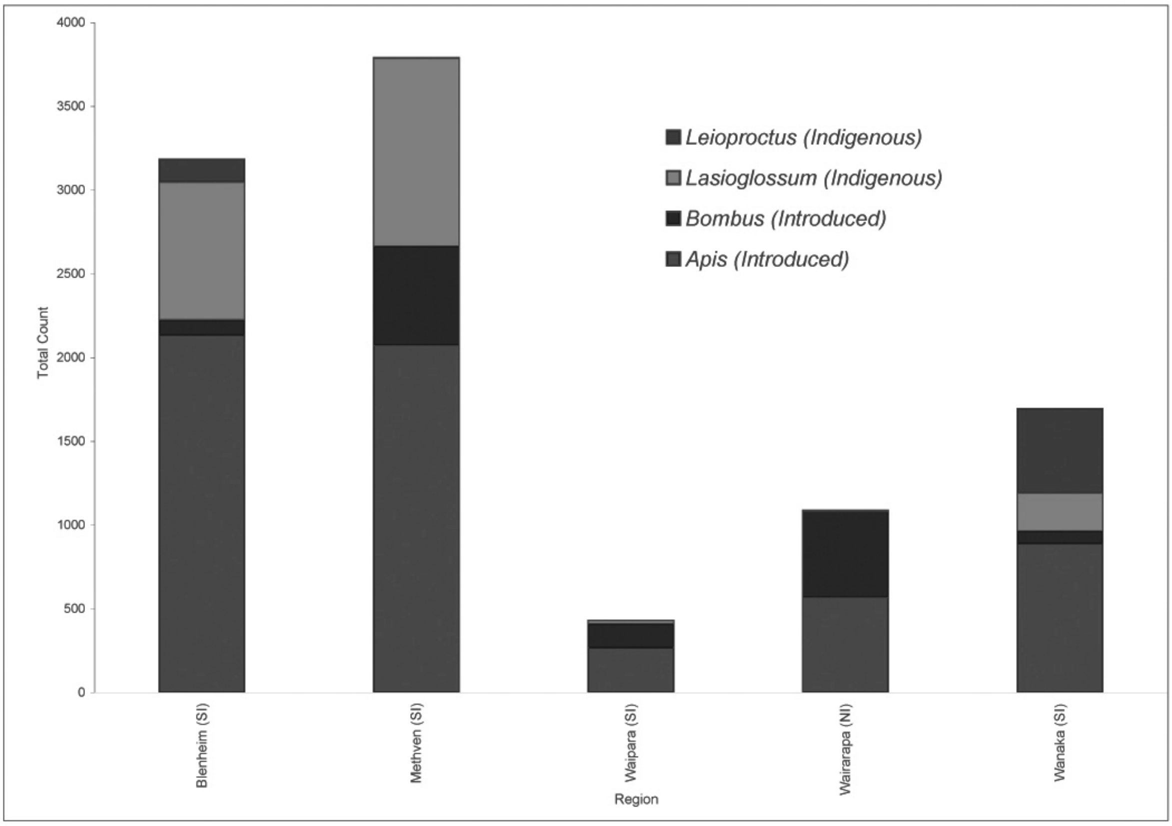


Fig. 7: The relative proportion of native and exotic bees from traps in onion fields during peak flowering in regions of New Zealand. SI = South Island; NI = North Island

Pollinator Performance of Natives

We compared pollen loads and pollen deposition on onion stigmas for 15 flower visiting species. Pollen deposition on virgin stigmas correlated strongly with pollen loads (loose pollen) and insect body length. The larger native bees in Leioproctus and flies (Calliphoridae and Tachinidae) carried and deposited a number of pollen grains comparable to honey bees. Smaller native bees in Lasioglossum transferred much less pollen but their high abundance in the crop counterbalanced this. Future research aims to understand the lifecycle and landscape factors that influence native pollinator population dynamics. Management strategies can then be formulated to increase the reliability of native pollinators in crops.

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4.1 The status of European pollinators

by Simon G. Potts, Stuart Roberts; William E. Kunin & Jacobus C. Biesmeijer, UK

Importance of European pollinators

It is estimated that more than 150 (84%) of European crops are directly dependent upon insects for their pollination (Williams 1994). Crop pollination is estimated to be worth €14.2 billion per year in European Union (Gallai et al. 2008). European crops for which the number of fruits and seeds and their quality are dependent upon, or enhanced by, insect pollination (Corbet et al. 1991; Williams 1996) include:

Fruits – apple, orange, tomato, pear, peach, melons, lemon, strawberry, raspberry, plum, apricot, cherry, kiwifruit, mango, currants, olives and grapevine; Vegetables – carrot, potato, onion, pepper, pumpkin, field bean, French bean, eggplant, squash, cucumber, and soy bean; Seeds and nuts – sunflower, almond, walnut and chestnut; Herbs – basil, sage, rosemary, thyme, coriander, cumin and dill; Industrial crops – cotton, oilseed rape, white mustard, and buckwheat; Fodder crops for animals – alfalfa, clover and sweetclover; Essential oils – chamomile, lavender, and evening primrose.

To date there is a growing body of case studies and anecdotal evidence for declines in pollinators in Europe and elsewhere, however the information is very fragmented and often reported outside the mainstream literature. Since many European crops depend on pollinators, and loss of pollination services may have huge negative impacts it is essential to understand the status and trends of Europe's pollinators. The ALARM project (Assessing Large-scale threats for biodiversity with tested methods. www.alarmproject.net) undertook large scale studies of the trends in honeybees, solitary bees and hoverflies at the national and continental scales.

Are European honeybees (*Apis mellifera*) in decline?

There is increasing concern that managed honeybees are under increasing threat in Europe. Severe losses of colonies have been reported by many individual beekeepers and beekeeping organisations but no overall continental scale picture could be drawn. In the US, Colony Collapse Disorder (CCD) and other factors have been linked to the massive decrease in honeybee colonies from 1989-1996 and a recent drop in 2005 (National Research Council, 2006). As many European crops depend upon pollination and honeybees are the most important managed species of bee it was therefore necessary to quantify the current status of honeybees in Europe and assess recent trends in their numbers.

We collated data, where available, on colony numbers collected from national beekeeping journals, national beekeeping organisations and government reports on the numbers of honeybee colonies in 1985 and 2005 in 17 European countries: Austria, Belgium, Czech republic, England, Finland, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Scotland, Slovakia, Sweden and Wales. We considered Austria, Belgium, Czech republic, England, Germany, Luxemburg, Netherlands, Portugal, Scotland, Slovakia, and Wales to be central European with the remainder as geographically peripheral European. We calculated the percentage change in colony numbers between 1985 and 2005 (see Fig 1).

Trends were mixed across countries: some showed clear declines while other showed increases in colony numbers, but the overall trend was an 11% decline since 1985. There were distinct regional differences with central European countries exhibiting an overall 23% decline and peripheral regions countries a 6% increase. There were also declines in colonies from 1965 and declines in the number of beekeepers (see Potts et al.).

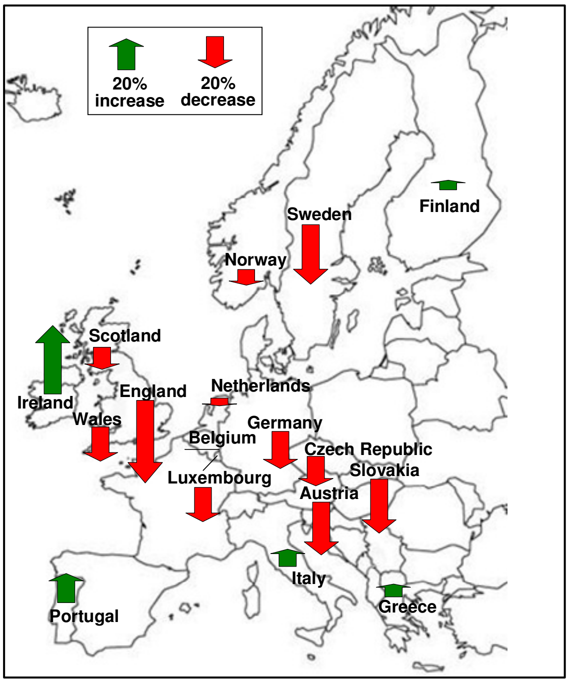

Figure 1: Proportional change in honeybee colony numbers between 1985 and 2005. Size of arrows indicate relative extent of change.

Several causes of the declines in European honeybees have been recorded and include the increased incidence of diseases (e.g. *Varroa* and tracheal mites, chalk brood), unusually cold winters and summer droughts, overuse of pesticides and loss of good bee forage habitats. Combinations of different drivers in each country and region are likely to be the causes of the observed patterns but further research is needed to quantify this. Though CCD has been suggested to be in Europe, actual evidence has not been provided to date. However, given that CCD, small hive beetle and other diseases are potential threats to European honeybees, future risks for further losses are high. As honeybees and wild bees have such a high economic value in Europe and many of our food crops and wild plants rely on their services, it is essential that we invest in research to fully understand the nature of the problem and in activities which will help safeguard pollinators and pollination services for the future.

Are European wild bees and hoverflies in decline?

While there has been substantial discussion about loss of wild pollinator and some striking case studies, until recently there was little solid evidence of geographically widespread declines. This is largely due to the lack of any coordinated monitoring programmes for bees or other pollinators – or indeed for any but the most charismatic (butterflies) or destructive (agricultural pest) invertebrates. In the absence of such monitoring data, scientists have had to rely on less direct methods to test for changes in the pollinator community.

Biesmeijer and colleagues (2006) devised a novel approach based on the accumulation of records in national entomological databases. Many countries have societies of largely amateur naturalists, who record sightings of insect species in shared databases. While these databases are not systematic sampling programmes, they nonetheless include hundreds of thousands of carefully collected records. Biesmeijer and his colleagues used a technique called rarefaction, in which random samples of records of different sizes are repeatedly sub-sampled from the pool of all records, providing a fairly robust measure of species diversity despite uneven sampling effort. They examined bees and hoverflies, the two biggest groups of insect pollinators, in two countries with excellent entomological data: the UK and the Netherlands.

The results were striking (see Figure 2). In both countries, the diversity of bees has fallen significantly in the majority of landscapes (80% in the Netherlands, 70% in the UK), while very few landscapes showed significant diversity increases. The results for hoverflies were quite different, with increased diversity in the Netherlands, and a mixed response in the UK. Reduced biodiversity in itself might have only a limited impact on pollination services, if the species remaining had traits similar to those being lost. However, further analyses of the traits of the pollinators involved suggested that this was not the case. In both bees and hoverflies, there tended to be declines in specialist and sedentary species, while mobile generalists tended to thrive.

In addition, the research found evidence of shifts in the plant communities of the two countries that echo the shifts in the pollinator communities. In the UK there has been a recent decline in animal-pollinated plants that depend on pollinators for reproduction, whereas self pollinating and wind-pollinated species have held constant or increased. In the Netherlands, however, where bee diversity declines have been accompanied by increased hoverfly richness, only bee-pollinated plants have declined, while plants pollinated by hoverflies and other pollinators have continued to thrive. The parallel dynamics between plants and their pollinators suggest some sort of link between the two, but its nature is unclear. It could be that plant declines are caused in part by lack of pollination services, or bees could be declining due to lack of floral resources, or indeed both could be declining due to shared sensitivity to environmental changes. Only by additional research into pollinator populations and the pollination services they provide can the answers become known.

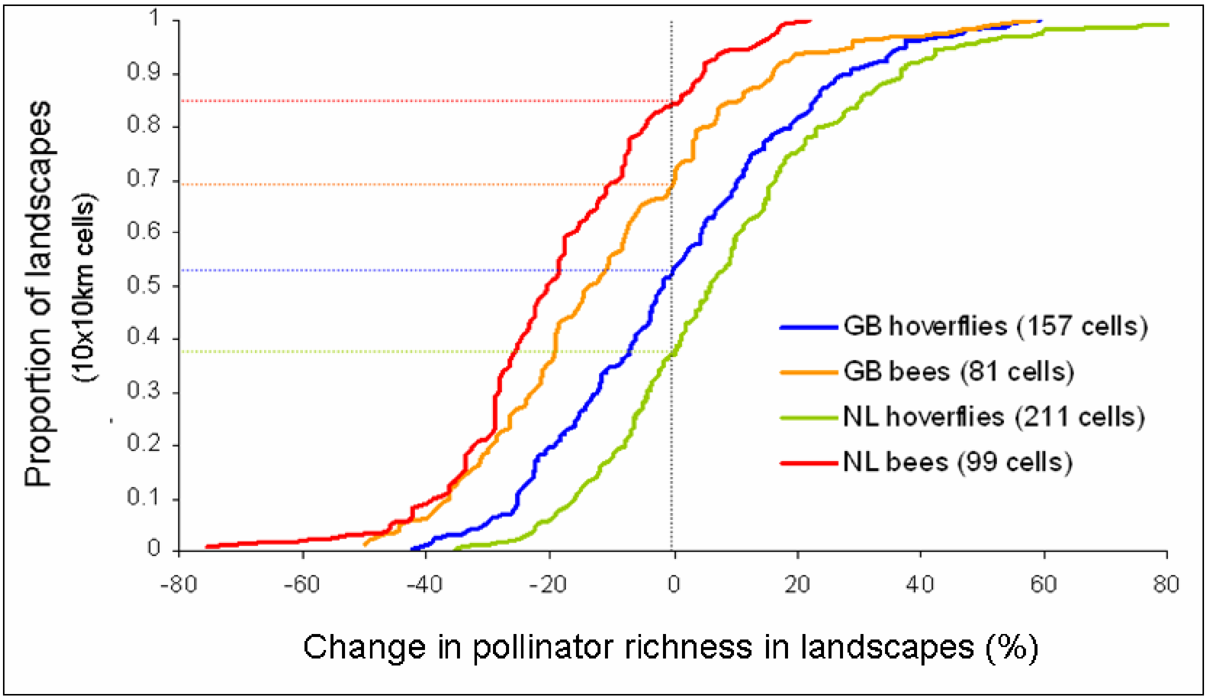

Figure 2: Change in pollinator richness in British (GB) and Dutch (NL) landscapes since 1980. Bee richness decreased in 80% of Dutch and 70% of British landscapes, whereas hoverfly show no change (UK) or tend to increase (NL)

A Europe-wide assessment is currently in process and the first results indicate that on average about half of the wild bee species are threatened in European countries (average of 12 countries, ranging from ~30-65%) and that again the specialists tend to be declining more than the generalists. A survey among bee specialists in 12 countries indicates an overall opinion that land use change and habitat loss, particularly agricultural intensification and change in management, are the major causes for wild bee declines (Biesmeijer et al. in prep.).

European Pollinator Initiative

Across Europe there are large numbers of activities addressing pollinators and pollination services. These include scientific research, conservation activities, and the commercial use of pollinators and pollination products. These are well established and diverse activities but in many ways quite fragmented due to geographical, linguistic and disciplinary fragmentation. Therefore there has been a clear opportunity to bring together interested parties for the exchange of knowledge and a tool was needed to facilitate the integration of different stakeholders.

The European Pollinator Initiative (EPI) was established in 2000 and shares the same core objectives as the IPI but with a European focus. The EPI aims to bring together interested parties to focus on a range of activities which will help conserve and manage pollinators to enhance the services they provide. The overarching mission of EPI is to protect and enhance the biodiversity and economic value of pollinators throughout Europe. The EPI aims to integrate and co-ordinate local, national and international activities relating to pollination into a cohesive network in order to safeguard the services provided by pollinators across the continent. EPI works as an informal network with a bottom-up approach with a network of national contact points which aims to facilitate collaborations across borders and sectors. A list of national contacts can be found at www.europeanpollinatorinitiative.org.

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4.2 Pollinator declines and loss of pollination services: research in the framework of the EU-project ALARM

by Ingolf Steffan-Dewenter, University of Bayreuth

Introduction

The International Convention on Biological Diversity specifically cites pollination as a key ecosystem function that is threatened globally. This ecosystem service is not only essential for the pollination of approximately 80% of wild plant species but also ensures the production value of crops. Pollinator diversity and consequently pollination services are at risk due to the destruction and fragmentation of natural or semi-natural habitats, increasing land use intensification, pesticide use, environmental pollution, invasive species and climate change. However, the relative importance of these risk factors and in particular there combined effects on plant-pollinator interactions are mainly unknown. Furthermore, risk factors may vary between different habitat types, landscapes and biogeographical regions. In the following I will briefly describe the structure, aims and key results of research performed in this context in the framework of the EU-project ALARM (www. alarmproject.net).

Structure and aims of the “Pollinator loss” module in the EU-project ALARM

The EU-Project ALARM (Assessing large-scale risks for biodiversity with tested methods) is an Integrated Project (IP) under the 6th EU Framework programme (subpriority 6.3 sustainable development, global change and ecosystems). ALARM started on 1st February 2004 and has a duration of five years. Currently it is the largest EU-funded research program dealing with environmental risks for biodiversity. The general objectives are to assess and forecast large-scale shifts in biodiversity and ecosystem functioning. The focus is on risks arising from climate change, environmental chemicals, rates and extent of loss of pollinators and biological invasions including pathogens and the development of ecological and socio-economic risk indicators. Accordingly, the project is subdivided into 5 closely cooperating modules. The module on loss of pollinators plays an important integrative role in the project as pollinators are on one side threatened by several environmental drivers while on the other side pollinator loss itself might trigger future loss of biodiversity and ecosystem services (Figure 1). The “Pollinator loss” module has the following general objectives in order to mitigate risks for pollinator diversity and ensure sustainable pollination services in the future: (1) Quantify distribution shifts of key pollinator groups across Europe, (2) determine the relative importance of drivers of pollinator loss (land use, climate chance, environmental chemicals, invasive species), (3) measure the economic and biodiversity risks associated with the loss of pollination services in agricultural and natural ecosystems, (4) promote the conservation and sustainable use of pollinators in natural and agricultural ecosystems, and (5) develop predictive models for pollinator loss and subsequent risks.

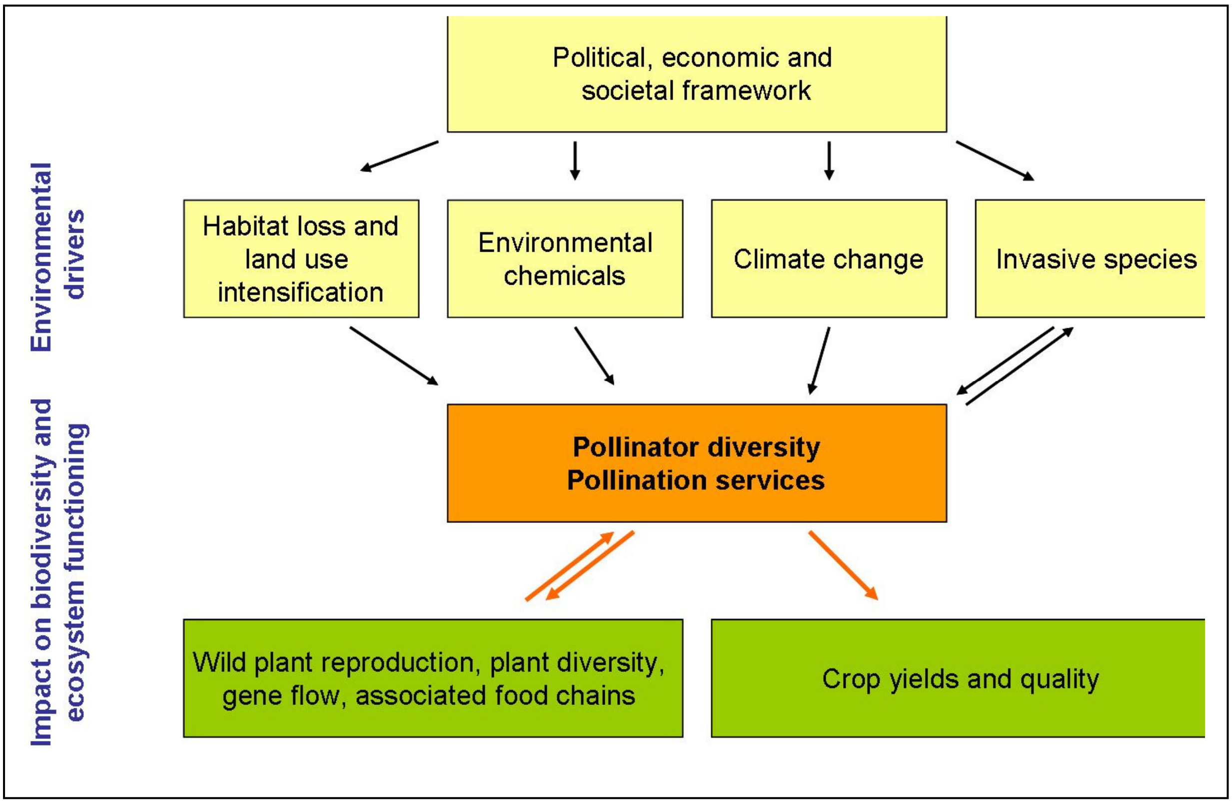

Fig. 1: Integration of the "Pollinator loss" module in EU-project ALARM

Key achievements of the project

The project is now in its final phase and several interesting and highly relevant results have been obtained. In the following I will give a brief overview of some key results with respect to four leading questions:

1) Is there a pollinator decline?

2) Which methods are most effective for monitoring pollinators?

3) What are the major drivers of pollinator loss?

4) What are the consequences of pollinator declines for rare plant and crop pollination services?

Documenting pollinator declines

Simon Potts and colleagues from the University of Reading compiled data for managed honeybee colonies across Europe. They can show that overall numbers of managed honeybee colonies declined by 11.2 % with largest declines in Central Europe with 23.3% decline between 1985 and 2005. However, in some Mediterranean countries they found slight increases of colony numbers during this time (Potts et al., submitted). In a second study Koos Biesmeijer and coworkers from the University of Leeds performed a large-scale analysis of pollinator diversity in the UK and the Netherlands based on grid data for the occurrence of bee and syrphid species before and after 1980. Their data provide evidence for significant declines of bee species richness in both countries in almost 80% of the cells, whereas syrphid flies showed no direction or even increased (Biesmeijer et al. 2006).

Monitoring pollinator diversity

A critical aspect of long-term monitoring of pollinator declines is the lack of well evaluated and standardised methods. In this project we systematically evaluated the performance of six commonly used sampling methods across a wide range of biogeographical regions in Europe in different agricultural and seminatural habitat types (Figure 2). The results allow the comparison of different methods with respect to their efficiency and the calculation of the required sampling effort to reach sufficient sample coverage. The most efficient method in all geographical regions and habitat types was the pan trap method. It had the highest sampling coverage, collected the highest number of species and showed no collector bias. The transect method was also relatively efficient, but had a significant collector bias. The tested methods will provide the basis for the development of standardised long-term and large scale monitoring and risk assessment schemes of pollinator declines (Westphal et al. 2008).

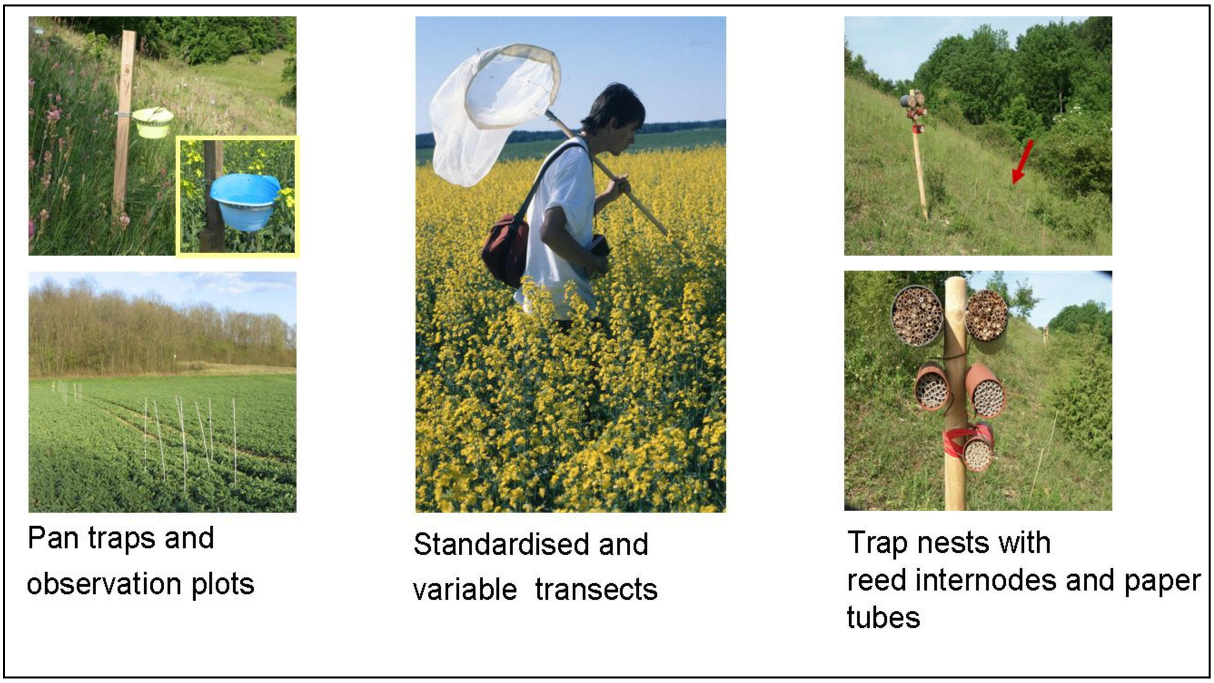

Fig. 2: Different methods to assess pollinator diversity evaluated in five European countries

Drivers of pollinator loss

Several case studies identify habitat fragmentation and land use intensification as important drivers of pollinator declines (Figure 3). The reduction of habitat area and the increase of habitat isolation lead to lower species richness and abundance and shifts in community composition. Particularly food plant specialists, cuckoo bees and small, solitary bee species are affected by habitat fragmentation (Steffan-Dewenter & Westphal 2008). Interestingly, not only local habitat characteristics but also the management of the wider landscape play a vital role for pollinator diversity. Thus the implementation of adequate agri-environmental schemes could contribute to the conservation of pollinators in agricultural landscapes (Steffan-Dewenter & Westphal 2008, Meyer et al. 2008). The functional consequences of pollinator declines for pollination of rare plants and crops are a controversially discussed and still unsolved research question.

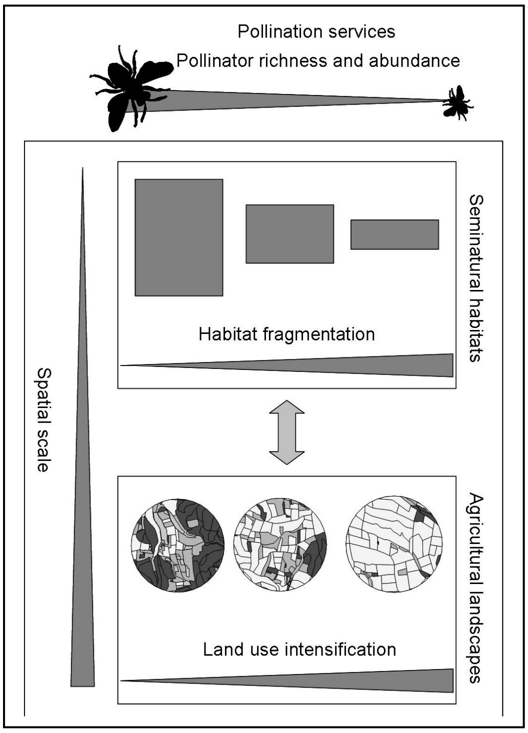

Fig. 3: The interplay of pollination services, pollinators, habitat fragmentation and land use intensification (from Steffan-Dewenter & Westphal 2008)

Consequences of pollinator declines for rare plant pollination

In the framework of the EU-project ALARM we developed a common study design and protocols to evaluate the importance of population size, patch size and plant density on flower visitation, pollinator diversity, and fruit or seed set. The research was performed in 5 European countries with altogether 10 focal rare plant species. The results show no effect of overall population size but significant effects of patch area and patch density on flower visitation rates and seed set. For five out of 10 plant species the data provide evidence for significant pollination limitation (Dauber et al., submitted).

Consequences of pollinator declines for crop pollination

In a recently published review on the "Importance of pollinators in changing landscapes for world crops" by Alexandra Klein from the University of Göttingen and coauthors we evaluate the reliance of world crop production on animal pollination based on primary data from 200 countries (Klein et al. 2007). We found that fruit, vegetable or seed production from 87 of the leading global food crops is dependent upon animal pollination, while 28 crops do not rely upon animal pollination. Pollinators turned out to be essential for 13 crops, while production is highly pollinator dependent for 30, moderately for 27, slightly for 21, unimportant for 7, and is of unknown significance for the remaining 9 crop species.

In the context of the EU-project ALARM we performed collaborative crop studies in five different countries with a focus on annual field crops (Figure 4). Crop fields were studied along gradients of increasing land use intensification to evaluate the possible loss of pollination services in monotonous agricultural landscapes without source habitats for pollinators (Figure 3). The data indicate that lower visitation rates in such landscapes result not only in lower yields but also negatively affect yield quality (Bommarco et al., submitted). Further, Bernard Vaissère and coworkers from INRA Avignon assessed the monetary value of insect pollinators in Europe. The total economic production value of 80 crops used directly for human food was 127.7 billion € in 2005. 41 of these crops depend or benefit from insect pollination for their production resulting in an estimated annual economic value of pollinators in Europe of 12.3 billion € (Gallai et al. 2008).

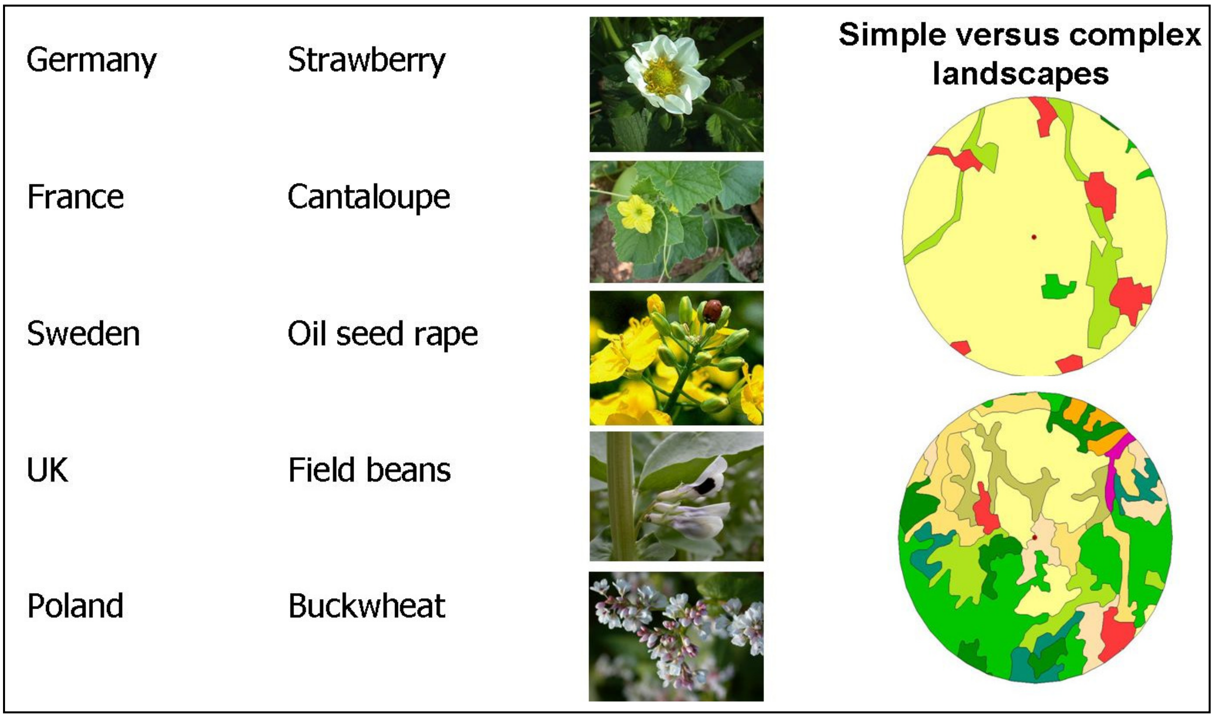

Fig. 4: Collaborative crop studies in 5 countries performed in the framework of the EU-project ALARM

Conclusions

The presented examples and results provide only an incomplete overview of the research activities performed in the EU-project ALARM. A major strength of the presented project is the rather unique implementation of collaborative studies with standardised study designs across Europe. Further major achievements concern the development of a European bee data base and multiple cross-cutting studies that aim to identify effects of combined drivers of pollinator loss including habitat fragmentation, land use and climate change, invasive species and environmental pollution.

In conclusion the ongoing research in the EU-project ALARM significantly adds to the progress made in landscape-based research on pollinators and plant-pollinator interactions over the last decade. However, to understand and counteract the ongoing declines of pollinators and insect-pollinated plant species more comprehensively, future studies should build up on the knowledge achieved to reach a more general understanding of the combined effects of different drivers at different spatial and temporal scales on pollinator diversity.

Acknowledgements

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5. Highlights

by Axel Ssymank

1. Objectives

Pollinators provide an essential ecosystem service ensuring crop production and food security world wide as well as maintaining the biodiversity of plants. A decline in pollinators is thus a serious threat to biodiversity as a whole. With COP V/5 decision in 2000, an International Pollinators Initiative (IPI) was established under the coordination of FAO - and in 2002, with COP Decision VI/5, an action plan was endorsed. Since that time, a number of regional pollinators initiatives has been established, and become operational.
At COP 9, a side-event was held on "Caring for pollinators". The main objectives of the side-event were to: (i) support the various pollinator initiatives, by raising awareness on the importance of pollinators and possible consequences of their decline (FAO report 2008); (ii) broaden the work in order to investigate all main pollinator groups; (iii) identify the actual state of action being taken to conserve and manage pollinators and actions needed in future.
The side-event was organized by the Federal Agency for Nature Conservation (BfN), Bonn in cooperation with the University of Bonn (Prof. Wittmann). It consisted of two components: a workshop and a pollinator's buffet. The workshop started with oral presentations to illustrate and introduce the key ecosystem service of pollinators with bees and flies as main pollinator groups and presented the tasks of the International Pollinators Initiative and the practical example of a regional initiative with the successful Brazilian Pollinators Initiative. A series of posters with the work of the other regional pollinator initiatives complemented the presentations.
The pollinator's buffet was a fruit buffet to demonstrate that fruits worldwide are dependent on pollination: fruit diversity and our food is directly linked to pollinator diversity and offered the occasion to discuss different issues of pollination with delegates at COP9.

2. Presentations and posters
The following oral presentations were given:

2.1. "The Brazilian Pollinators Initiative: Update of recent progress" by Braulio Dias, Ministry of Environment, Brazil
Braulio Dias introduced the Brazilian Pollinators Initiative (BPI), being one of the most active regional pollinator initiatives. The BPI was established in 2000, and has initiated a number of activities, in addition to participating in the development of the FAO coordinated project "Conservation and Management of pollinators for Sustainable Agriculture, Through an Ecosystem Approach". Amongst the activities initiated, the Probio (Brazilian Biological Diversity Conservation and Sustainable Use Project) Project issued two public calls to support projects on pollinators management were launched in 2003 and 2004. Nineteen subprojects have developed management plans for pollinators of nineteen different crop species and

manuals for capacity building of farmers have been elaborated, including for example west indian cherry, mango, passion fruit, tomatoes, cotton and assai palm.

2.2 “Little bees with a big job: holding up biome diversity” by David Roubik, Panama
David Roubik gave some wonderful insights into bee pollination and functional aspects of pollination. Effective pollinators need to transfer the pollen from one plant to another, reach the pollen and stigmas and not only to visit a flower. Interactions between tropical bees and orchids are fascinating and can be very complex. Fluctuations, vertical and spatial distribution of plants and their pollinators in tropical forests make studies difficult and challenging. Solitary bees may adjust in different ways and react to introduced African honey bees and other impacts. Saving the bees as major pollinators does not only save many plants, but also larger animals depending on pollinators for their food (fruits or plants). Bees sustain biome diversity and need our attention and sustainable management.

2. 3 “Flies – Pollinators on two wings” by Axel Ssymank, BfN & Carol Kearns, University of Colorado
Flies (Diptera) form an extremely species rich group with over 160,000 known species inhabiting almost all terrestrial habitats. Over 71 families of flies regularly visit flowers and contribute to pollination services with more than 100 cultivated plants depending largely on fly pollination for abundant fruit set and seed production. The reality of “No chocolate without flies” was presented, as cocoa is a typical example for fly pollination of small midges. Flower flies (Syrphidae) were presented as a case study being both important pollinators and many species playing an important role as larvae in bio control. Pollinator decline, large gaps in species knowledge and even in food plant -pollinator systems and largely underestimated pollination services, were addressed. Flies and bees are the main pollinator groups worldwide.

2. 4 “The International Perspective - Pollinators Initiatives” by Linda Collette -FAO
Linda Collette began FAO’s presentation by giving an overview of the global challenges in the context of pollination services. She then provided the international context for the International Initiative for the Conservation and Sustainable Use of Pollinators (IPI), describing the chronology and decisions taken at the Conference of Parties of the Convention on Biological Diversity. She described the four main elements of the Plan of Action of the IPI, which are assessment, adaptive management, capacity building and mainstreaming. Finally, FAO’s Global Action on Pollination Services for Sustainable Agriculture was presented, highlighting, and describing the major components and activities of, the global-sized FAO/UNEP/GEF-project on the “Conservation and management of pollinators for sustainable agriculture through an ecosystem approach“.

The work of other regional Pollinator Initiatives was presented as Posters:

2. 5 “North and Inter-American Pollinator Initiatives” by Michael Ruggiero, Smithsonian Institution, USA; Laurie Adams, Pollinator Partners-hip, USA; Antonio Saraiva, University of São Paulo, Brazil
In America two important pollinator initiatives have developed: the North American Pollinator Protection Campaign (NAPPC) and the Inter-American Biodiversity Information Network’s

(IABIN) Pollinators Thematic Network (PTN). Following the main elements of the IPI action plan, the work and achievements of NAPPC are presented: Assessment - NAPPC partners supported a study by the U.S. National Academy of Sciences on the status of pollinators in North America and contributed to a world checklist of bees and a Catalogue of Hymenoptera in America North of Mexico. Activities on adaptive management included research on pollinator decline, restoration of native pollinator communities and contributing to research on Colony Collapse Disorder in honeybees. Capacity building, awareness raising and public education is a major part of the work of North and inter-American pollinator initiatives, as well as mainstreaming (for example the inclusion of pollinator conservation measures into national agricultural legislation).

2.6 "An overview of pollinator studies in Kenya" by Mary Gikungu, Melanie Hagen & Manfred Kraemer
Pollinator interactions are not well studied in Kenya, despite pollinator declines and continuous degradation of natural habitats. Monitoring pollinator decline, the lack of taxonomic information and expertise, the assessment of economic value of pollination services and the conservation and sustainable use of pollinator diversity in agricultural and forestry ecosystems are essential fields of work, which need urgent action. The poster gives an overview of trends in pollinator studies, highlighting the lack of community studies and at landscape level, gaps in research especially in natural and protected areas and in capacity building. In Western Kenya the number of ongoing studies is higher than in any other region of Kenya. Despite recent efforts in Biota east Africa and RPSUD (Research programme in sustainable management and utilization of dry land biodiversity) further understanding of pollinator networks and capacity building remain crucial and pollinator studies in Kenya are at their "infancy".

2.7 "Brazilian Pollinators Initiative: Timeline & Biodiversity and sustainable use of pollinators" by Vera L. Imperatriz Fonseca, Denise A. Alves, Antonio M. Saraiva & Lionel S. Gonçalves
In addition to the presentation held by Braulio Dias two posters highlighted the work of the Brazilian Pollinators Initiative (BPI). The development and timeline of the BPI from 1998 until 2008 with its activities and main projects is presented, such as Brazilian field courses on biology and ecology of pollination, pollinators in the government program, the pollinators collections network, the catalogue of bees and scientific congresses and events. The second part of the poster illustrates some of the achievements of the BPI in detail, such as the catalogue of bees, bee identification tools and stingless bees management with rearing and conservation in the Rio Grande do Sul area.

2.8 "The Oceania Pollinators Initiative (OPI): Integrated Information System for OPI based on a federation of distributed databases" by L.E. Newstrom-Lloyd, J. Cooper, N.J. Spencer & A.D. Wilton, Landcare Research New Zealand
Island ecosystems of Oceania host fragile plant-pollinator partnerships which may be particularly vulnerable to climate and land use change and to invasive species. As data on pollinators in this region are scarce and widely scattered, OPI will create an integrated information system with components on taxonomy, specimen, observations, distributions, image data, interactions, traits data and summary analyses. This will build primarily on existing New

Zealand and Australian databases and integrate distributed data, as they become available, and seeks to have a close link to existing pollination information systems.

2.9 OPI: Monitoring Pollinators: Case studies form Australia and New Zealand by C.L.Gross, L.E. Newstrom-Lloyd, B. Howlett, G. Piunkett & B.J. Donovan
The poster focuses on monitoring of pollinator communities. Major reasons for monitoring are to detect changes in pollinator communities and to assess the impact of exotic pollinators and their relationships with both native and introduced plants, because these play a major role in many of the oceanian islands. Examples are given from Australia with a legume shrub *Pultenia campbelli*, the invasive mutualism of the introduced plant *Phyla canescens* pollinated solely by introduced honeybees. New Zealand studies investigated the use of native flowers by exotic bees in relation to native bee species, as well as the role of native bees in crop pollination of onion and pak choi.

3. The Pollinators Buffet

The pollinators buffet was a practical demonstration of the benefits of pollination services: 55 different fruits worldwide - from tropical to temperate regions - were presented on a large buffet to taste the delicious results of pollination. Each fruit was labelled with name of the plants, its pollinators and its country or region of origin. The selection of fruits was well balanced to demonstrate all different pollinator groups, such as flies, bees, butterflies, bats, mammals etc. with the fruit they are responsible for pollinating. Fruits could be eaten directly from the buffet and were at the same time offered cut, for tasting by a professional cook; information on the producers was also available, and a fruit cocktail bar served freshly squeezed juices. The buffet was a full success and attracted approximately 1200 visitors and delegates within 3 hours, resulting in vivid discussions, talks on cooperation and on the importance of pollination services. A result of this “pollinators buffet” was the demonstration that pollination services are “palatable“ and deserve a lot more attention, and highlighted the need to encourage raising public awareness on the vital ecosystem services of pollination.

4. Additional information

In addition to the presentations and poster of the workshop, the book includes a more complete overview of the various Pollinators Initiatives, as well as a contribution of the work of the EPI (European Pollinator Initiative) by Potts et al. Projects from the European Union on pollinators are also presented, through the EU-ALARM project (Steffan-Dewenter et al.): an overview is given on current research, and first results of the pollinator module are summarized.
The book includes annexes with detailed information on the pollinators buffet, an overview on the main pollinator groups in short fact sheets and a collection of web-links with useful information and some of the most important institutions involved.

5. Highlights

Considering the functional importance of pollinators in ecosystems worldwide, the pollinator decline due to climate change and other causes with the risk of a major reduction in pollination capacity, the FAO 2008 first *Rapid Assessment of Pollinators' Status Report* (http://www.cbd.int/doc/meetings/sbstta/sbstta-13/other/sbstta-13-fao-pollinators-en.pdf) the functional and economic importance of pollinators in all ecosystems worldwide, the presentations and discussion reiterated and stressed the following:

1. a reinforcement of studies on pollination ecology
    - Reinforcement of fundamental taxonomic research, in order to reduce the large number of pollinators that remain undescribed or virtually unknown, even in the most "well-studied" regions:
    - The recognition of Hymenoptera and Diptera as the most important pollinator groups and flower visiting insects among a number of other pollinator groups;
    - Build determination tools/ keys for all key pollinator groups
    - Reinforcement of studies on pollination ecology (both in fundamental & applied research)
    - Enhancement and completion of information on pollinator species, their ecology and functional interactions as a necessary basis for assessing pollination services and to maintain biodiversity
    - to systematically expand applied pollinator research to all crops (including regional crops)

2. greater capacity-building
    - Greater capacity-building in institutions and higher levels of human resource development and training;
    - Maintenance and reinforcement of the activities of the existing pollinator initiatives, based on a review of the ongoing projects around the world;
    - Expansion of the activities of pollination initiatives to cover all major ecosystems & all major pollinator groups;
    - Creating a Non-Bee Pollinator Initiative/ Action Group and to put more emphasis on so far neglected groups like the Diptera.

3. improved awareness and networking on pollinator issues;
    - The global economic importance of pollinators to sustainable crop production (food, biofuels, animal-feed-stuffs);
    - Awareness of pollination services to the maintenance of the diversity of medical plants and to plant diversity as a whole;
    - Improved communication, education and public awareness and networking on pollinator issues
    - Greater financial support and more political awareness for taxonomic initiatives relating to pollinator biodiversity, in cooperation with the Global Taxonomy Initiative (GTI)
    - systematic assessment of the value of pollination services for all major pollinator groups

4. establishment of monitoring systems and sustainable management of pollinators

- Establishment of a system for monitoring and assessing pollinator declines and their causes
- Systematic monitoring for pollinators and pollinator shifts resulting from climate change
- Taking into account all major pollinator groups in landscape assessments, impact assessment and management planning in nature conservation;
- Further develop integrated functional systems in order to maintain or promote pollinations services for sustainable crop production;
- Assess and monitor risks for pollinators and pollination services of landscape change due to biofuel production and GMO's in modern agriculture

While political decisions and declarations exist within the frame of the CBD and the 2010 targets, research, capacity building, awareness, monitoring and management of pollinators as functional key organisms for ecosystem services and maintaining biodiversity will need more attention and action worldwide.

Acknowlegdement
Many thanks to Linda Collette for providing valuable comments and corrections to the summary.

5. Zusammenfassung

von Axel Ssymank

1. Hintergrund und Ziele

Die Blütenbestäuber leisten unverzichtbare Dienste in unseren Ökosystemen. Sie stellen durch ihre Blütenbesuche sowohl die weltweite Produktion vieler Nahrungsmittel als auch den Erhalt der biologischen Vielfalt der Wildpflanzen sicher. Damit ist ein Rückgang der Bestäuber eine ernsthafte Bedrohung für die Biodiversität insgesamt. Im Rahmen der COP V/5 wurde im Jahr 2000 die Internationale Bestäuber Initiative gegründet, die von der FAO koordiniert wird. Bereits 2002 (COP-Entscheidung VI/5) wurde ein Aktionsplan beschlossen. Seitdem sind zahlreiche regionale Bestäuber Initiativen gegründet worden und haben ihre Arbeit aufgenommen.
Während der COP 9 fand das Side-Event „Caring for Pollinators“ statt. Die Hauptziele des Events waren: (i) die Unterstützung der verschiedenen Bestäuber Initiativen bei der Öffentlichkeitsarbeit hinsichtlich der Wichtigkeit der Bestäuber und den möglichen Folgen ihres Rückgangs (ii) die Ausweitung der aktuellen Arbeiten auf die Erforschung aller Hauptbestäubergruppen, (iii) einen Überblick über den aktuellen Stand der Arbeiten zum Schutz und zum Management der Bestäuber sowie über zukünftige Forschungsschwerpunkte zu geben.
Das Side-Event wurde vom Bundesamt für Naturschutz (BfN, Bonn) in Zusammenarbeit mit der Universität Bonn (Prof. Wittmann) organisiert. Wesentliche Teile des Events waren ein Workshop und ein Früchte-Buffet. Im Workshop wurde in Powerpoint-Präsentationen die Schlüsselfunktion der Bestäuber in Ökosystemen am Beispiel der beiden Hauptbestäubergruppen, den Bienen und Fliegen, dargestellt. Außerdem wurde in die Aufgaben der Internationalen Bestäuber Initiative eingeführt und als erfolgreiches Beispiel die Arbeit der brasilianischen Bestäuber Initiative dargestellt. In einer Posterausstellung nutzten die anderen regionalen Bestäuber Initiativen die Gelegenheit, ihre Arbeit zu präsentieren.
Das Früchtebuffet demonstrierte eindrucksvoll die Abhängigkeit der Früchteproduktion von den Bestäubern: die Vielfalt der präsentierten Früchte spiegelte die Vielfalt der Bestäuber wider und war damit Grundlage und Auslöser zahlreicher Diskussionen unter Delegierten und Besuchern der COP 9.

2. Präsentationen und Poster

Folgende Powerpoint-Präsentationen wurden vorgetragen:

2.1 “Die Brasilianische Bestäuber Initiative: Aktuelle Entwicklungen“ von Braulio Dias, Ministry of Environment, Brasilien
Braulio Dias gab eine Einführung in die Arbeit der Brasilianischen Bestäuber Initiative (BPI), als eine der aktivsten regionalen Bestäuber Initiativen. Die BPI wurde 2002 gegründet und hat seitdem bereits eine Vielfalt an Aktivitäten initiiert, darüber hinaus hat sie bei der Erarbei-

tung des von der FAO koordinierten Projektes „Conservation and Management of pollinators for Sustainable Agriculture, Through an Ecosystem Approach“ mitgewirkt. Im Rahmen des Probio Projektes (Brazilian Biological Diversity Conservation and Sustainable Use Project) fanden in den Jahren 2003 und 2004 zwei öffentliche Ausschreibungen statt, um Projekte zum Management der Bestäuber zu fördern. Das Projekt ist in 19 Unterprojekte gegliedert, in denen Managementpläne für Bestäuber von 19 verschiedenen Kulturpflanzen (darunter z. B. Mango, Passionsfrucht, Tomate und Baumwolle) erstellt und Praxisleitfäden zur Weiterbildung von Landwirten erarbeitet werden.

2.2 „Kleine Bienen haben einen großen Job: sie erhalten die Diversität der Biome“ von David Roubik, Panama

David Roubik gab einen wunderbaren Einblick in die Bestäubergruppe der Bienen und stellte die funktionalen Zusammenhänge der Bestäubung dar. Für eine effektive Bestäubung muss der Pollen von einer Pflanze zur anderen transportiert werden und dabei in Kontakt mit den Narben kommen; ein einfacher Besuch der Blüte ist nicht ausreichend. David Roubik erläuterte die faszinierenden Interaktionen zwischen tropischen Bienen und Orchideen, die ausgesprochen komplex sein können. Durch Populationsschwankungen sowie die vertikale und räumliche Verteilung von Pflanzen und deren Bestäubern in den tropischen Wäldern werden Forschungen schwierig und anspruchsvoll. Solitär lebende Wildbienen passen sich in vielerlei Hinsicht an und reagieren so auf die Einführung der afrikanischen Honigbiene und andere negative Umwelteinflüsse. Der Schutz der Bienen als Hauptbestäubergruppe sichert nicht nur das Fortbestehen vieler Pflanzenarten, sondern auch größere Tiere hängen über ihren Nahrungsbedarf (Früchte, Pflanzen) von den Diensten der Bestäuber ab. Bienen erhalten die Diversität der Biome und verdienen daher unsere Aufmerksamkeit und ein nachhaltiges Management.

2.3 “Fliegen – Bestäubung auf zwei Schwingen” von Axel Ssymank, BfN & Carol Kerans, Universität Colorado

Die Ordnung der Fliegen (Diptera) stellt mit mehr als 160.000 bekannten Arten eine extrem artenreiche Insektengruppe dar, die in nahezu allen terrestrischen Habitaten anzutreffen ist. Fliegen aus über 71 Familien besuchen regelmäßig Blüten und tragen zur Bestäubung und damit zur Frucht- und Samenproduktion von mehr als 100 Kulturpflanzen bei, die in hohem Maße von Fliegenbestäubung abhängig sind. Unter dem Slogan „Ohne Fliegen keine Schokolade“ wurde verdeutlicht, dass die Kakaopflanze ein typisches Beispiel für die Bestäubung durch kleine Fliegen darstellt. Die Gruppe der Schwebfliegen (Syrphidae) wurde beispielhaft als wichtige Bestäubergruppe präsentiert. Bei dieser Gruppe spielen die Larven vieler Arten außerdem eine wichtige Rolle in der biologischen Schädlingsbekämpfung. Auf die möglichen Folgen eines Bestäuberrückganges wurde ebenso hingewiesen, wie auf große Wissensdefizite im Bereich der Artenkenntnis und der Interaktion zwischen Nutzpflanzen und Bestäubern. Oft werden die Dienste der Bestäuber deutlich unterschätzt: Fliegen und Bienen sind weltweit die beiden wichtigsten Bestäubergruppen.

2.4 “Die internationale Sichtweise – die Bestäuber Initiativen” von Linda Collette, FAO

Linda Collette von der FAO gab zunächst einen Überblick über die weltweiten Herausforderungen zum Schutz der Bestäuberleistungen. Im Anschluss daran stellte sie die Internationale Bestäuber Initiative (IPI) für den Schutz und die nachhaltige Nutzung der Bestäuber vor und erläuterte dabei die bis heute auf den Vertragsstaatenkonferenzen zur Biodiversitätskonvention getroffenen Entscheidungen und Beschlüsse. Sie stellte die vier Hauptelemente („assessment", „adaptive management", „capacity building" und „mainstreaming") des Aktionsplanes der IPI vor. Schließlich wurden der weltweite Handlungsrahmen der FAO für Bestäuberleistungen und die nachhaltige Landwirtschaft präsentiert mit besonderem Hinweis auf das weltweit ausgelegte Projekt „Conservation and management of pollinators for sustainable agriculture through an ecosystem approach", das von FAO, UNEP und GEF gemeinsam durchgeführt wird.

Posterpräsentationen der anderen Bestäuber Initiativen

2.5 "Nord und Zentral-Amerikanische Bestäuber Initiative" von Michael Ruggiero, Smithsonian Institution, USA; Laurie Adams, Pollinator Partnership, USA; Antonio Saraiva, University of São Paulo, Brazil
In Amerika haben sich zwei wichtige Bestäuber Initiativen gegründet: die „North American Pollinator Protection Campaign" (NAPPC) und die „Inter-American Biodiversity Information Network's" (IABIN)/ „Pollinators Thematic Network" (PTN). Den vier Hauptelementen des Aktionsplanes der IPI folgend, werden die Arbeit und die Erfolge der NAPPC präsentiert: „Assessment": Die Partner der NAPPC unterstützten eine Studie der Amerikanischen Akademie der Wissenschaften (U.S. National Academy of Sciences), die den Status der Bestäuber in Nord-Amerika untersuchte. Daneben trugen sie zu einer weltweiten Bienen-Checkliste und einem Hymenopteren-Katalog für Nordamerika bei. „Adaptive management": Es wurden Untersuchungen zum Bestäuberrückgang durchgeführt, natürliche Bestäubergemeinschaften wiederhergestellt und Beiträge zur Untersuchung des Absterbens der Völker der Honigbiene geleistet (CCD, Colony Collapse Disorder). „Capacity building" und „Mainstreaming": Die Sensibilisierung der Öffentlichkeit nimmt einen großen Teil der Arbeit der Nord- und Zentral-Amerikanischen Bestäuber Initiative ein. Beispielweise wurden Maßnahmen zum Schutz der Bestäuber in der nationalen Gesetzgebung zur Landwirtschaft verankert.

2.6 "Ein Überblick über Bestäuber-Studien in Kenia" von Mary Gikungu, Melanie Hagen & Manfred Kraemer
Trotz des Bestäuberrückgangs und der anhaltenden Zerstörung natürlicher Habitate sind die Interaktionen zwischen Bestäubern in Kenia nur ansatzweise untersucht. Dringenden Handlungsbedarf gibt es beispielweise in den entscheidenden Arbeitsfeldern wie Monitoring des Bestäuberrückganges, dem Schließen von taxonomischen Wissenslücken, der Herausarbeitung des ökonomischen Wertes der Bestäuberdienste sowie beim Schutz und der nachhaltigen Nutzung von Bestäubern in land- und forstwirtschaftlich genutzten Bereichen. Das Poster gibt einen Überblick über Trends, die in den verschiedenen Bestäuber-Studien herausgefunden wurden, es weist auf das Fehlen von Studien auf der Ebene von Bestäubergilden sowie auf landschaftsökologischer Ebene hin. Außerdem werden Forschungsdefizite speziell in für die Natur geschützten Gebieten und Defizite in der Ausbildung und Information von Landnutzern angesprochen. Im Westen Kenias ist die Anzahl der laufenden Studien deutlich größer als in den anderen Regionen Kenias. Trotz der derzeitigen Bemühungen von BIOTA Ost-Afrika und RPSUD („Research programme in sustainable management and utilization of dry land biodiversity") sind die Weiterbildung von Landnutzern und Erforschungen der Zu-

sammenhänge im Bestäubersystemen weiterhin entscheidend. Außerdem stecken viele dieser Studien in Kenia noch immer in den Kinderschuhen.

2.7 “Brasilianische Bestäuber Initiative: Zeitachse & Biodiversität und nachhaltige Nutzung von Bestäubern“ von Vera L. Imperatriz Fonseca, Denise A. Alves, Antonio M. Saraiva & Lionel S. Gonçalves
In Ergänzung zu der von Braulio Dias vorgetragenen Präsentation wurden zwei Poster ausgestellt, die die Arbeit der Brasilianischen Bestäuber Initiative (BPI) veranschaulichten. Der Aufbau und die Zeitachse der BPI von 1998 bis 2008 inklusive ihrer Hauptprojekte und Aktivitäten wird vorgestellt. Dazu gehören zum Beispiel brasilianische Untersuchungen zur Biologie und Ökologie der Bestäubung, zur Einbindung von Bestäubern in Programme der Regierung, ein Netzwerk der Museumssammlungen von Bestäubern, ein Bienenartenkatalog sowie wissenschaftliche Kolloquien und Veranstaltungen. Der zweite Teil des Posters stellt einige Erfolge der BPI im Detail dar, wie z.B. den Bienenkatalog, automatisierte Bestimmungshilfen für Bienenarten und das Management stachelloser Bienen, die in der Region Rio Grande do Sul gezüchtet und geschützt werden.

2.8 “Die Ozeanische Bestäuber Initiative (OPI): Das integrierte Informationssystem der OPI basiert auf dem Verbund dezentraler Datenbanken.“ von L.E. Newstrom-Lloyd, J. Cooper, N.J. Spencer & A.D. Wilton, Landcare Research New Zealand
Die Insel-Ökosysteme Ozeaniens beherbergen sensible Pflanzen-Bestäuber-Partnerschaften die teilweise durch Klimaveränderung, Änderungen in der Landnutzung und die Einwanderung invasiver Arten besonders gefährdet sind. Da die Daten zu Bestäubern in dieser Region rar und zudem weit zerstreut sind, entwickelt die OPI ein integriertes Informationssystem mit Komponenten z.B. zur Taxonomie, Probennahme, Beobachtung, Verbreitung, Bildern, ökologischen Daten, Interaktionen und mit zusammenfassenden Analysen. Es baut in erster Linie auf in Neuseeland und Australien bereits vorhandenen Datenbanken auf, die vernetzt werden und integriert dezentrale Daten, soweit sie verfügbar sind. Außerdem wird eine enge Verbindung zu bestehenden Bestäuber-Informationssystemen hergestellt.

2.9 “OPI: Monitoring von Bestäubern: Fallstudie aus Australien und Neuseeland” von C.L.Gross, L.E. Newstrom-Lloyd, B. Howlett, G. Piunkett & B.J. Donovan
Das Poster stellt das Monitoring von Bestäubergemeinschaften in den Mittelpunkt. Einer der wichtigsten Gründe für ein Monitoring sind Veränderungen in den Bestäubergemeinschaften zu erkennen und den Einfluss exotischer Bestäuber und deren Beziehung sowohl zu einheimischen als auch zu eingeführten Pflanzen zu bewerten, weil diese eine wichtige Rolle auf vielen ozeanischen Inseln spielen. Beispielhaft werden der als Gemüse genutzte australische Strauch *Pultenia campbelli* (Fabaceae) vorgestellt und der Mutualismus der eingeführten Pflanzenart *Phyla canescens,* die ausschließlich von eingeführten Honigbienen bestäubt wird. Neuseeländische Studien erforschen das Aufsuchen einheimischer Blüten durch exotische Bienenarten im Vergleich zu einheimischen Bienenarten, sowie die Rolle einheimischer Bienen bei der Bestäubung von Zwiebeln und Pak Choi.

3. Das Bestäuber Buffet

Mit dem Früchtebuffet wurden die Dienstleistungen der Bestäuber in beeindruckender Weise veranschaulicht: 55 verschiedene Früchte aus der ganzen Welt – von tropischen bis zu den gemäßigten Regionen – wurden zur Verkostung angeboten. Ein kleines Schild gab zu jeder Frucht Auskunft über deren Namen, seine Bestäuber und die Herkunftsregion. Die Früchte wurden so ausgewählt, dass die verschiedenen Bestäubergruppen (wie Fliegen, Bienen, Schmetterlinge, Fledermäuse, Säugetiere) ausgewogen präsentiert werden konnten. Ein professioneller Koch bereitete die Früchte am Buffet zu, wo sie direkt verzehrt werden konnten, Informationen zum Erzeuger waren verfügbar. An einer Cocktailbar wurden frisch gepresste Säfte gereicht. Das Buffet war mit dem Besuch von 1200 Delegierten ein großer Erfolg. Es entstanden lebhafte Diskussionen und Gespräche über Kooperationen und über die enorme Bedeutung der Dienste der Blütenbestäuber. Ein wichtiges Fazit des Früchtebuffets war, dass die Leistungen der Bestäuber ausgesprochen schmackhaft und nahrhaft sein können und deutlich mehr Aufmerksamkeit verdienen. Herausgestellt wurde, dass das öffentliche Bewusstsein für die Bedeutung der Blütenbestäuber erhöht werden muss.

4. Weiterführende Informationen

In Ergänzung zu den Präsentationen und Postern des Workshops enthält das Buch ausführlichere Informationen zu den verschiedenen Bestäuber Initiativen sowie einen zusätzlichen Beitrag über die Europäische Bestäuber Initiative (EPI) von Potts et al. Projekte der Europäischen Union im Zusammenhang mit Blütenbestäubern werden mit dem EU-ALARM Projekt (Steffan-Dewenter et al.) ebenfalls vorgestellt. Dabei wird ein Überblick über den aktuellen Forschungsstand und die ersten Ergebnisse gegeben.

Das Buch enthält im Anhang detaillierte Informationen über das Bestäuberbuffet, einen Überblick über die verschiedenen Tiergruppen, die als Hauptbestäubergruppen von Bedeutung sind in Form kurzer Datenblätter und eine Sammlung von Internetlinks für nützliche Informationen und Kontakte zu Organisationen, die sich mit der Bestäuberthematik beschäftigen.

5. Highlights

In Anbetracht der weltweit hohen Bedeutung der Bestäuber in den Ökosystemen, des Bestäuberrückgangs z.B. aufgrund der Klimaveränderung und des damit einhergehenden Risikos bezüglich des Fortbestandes der Bestäuber-Leistungen, verfasste die FAO 2008 einen ersten Status-Bericht über die Situation der Blütenbestäuber (http://www.cbd.int/doc/meetings/sbstta/sbstta-13/other/sbstta-13-fao-pollinators-en.pdf). Vor diesem Hintergrund und der funktionalen und ökonomische Bedeutung der Bestäuber in allen Ökosystemen weltweit kristallisieren sich folgende Erfordernisse heraus:

1. Eine Intensivierung der Studien zur Bestäuberökologie
   - Verstärkung grundlegender taxonomischer Forschung um die Anzahl unbeschriebener bzw. unbekannter Bestäuber auch in den vermeintlich gut untersuchten Regionen zu minimieren,

- die Anerkennung von Hymenopteren und Dipteren als Hauptbestäubergruppen und wichtigste blütenbesuchende Insekten unter einer Vielzahl anderer Bestäubergruppen,
- Erstellung von Bestimmungshilfsmitteln/ -schlüsseln für alle wichtigen Bestäubergruppen,
- Vorantreiben von Studien zur Bestäuberökologie (sowohl grundlegende als auch angewandte Forschung),
- Erweiterung und Vervollständigung von artbezogenen Informationen zu Bestäubern, deren Ökologie und Interaktionen als nötige Grundlage zur Einschätzung der Bestäuberleistung und deren Beitrag zur Erhaltung der Biodiversität,
- Systematische Erweiterung der Bestäuberstudien auf alle Nutzpflanzen (inklusive regionaler Nutzpflanzen).

2. Verbesserung der Handlungskompetenzen und der Wissensvermittlung (capacity buil ding)
   - Erhöhung der institutionellen (personellen und finanziellen) Kapazitäten und Fachkompetenzen einschließlich der hierfür erforderlichen Fachausbildung,
   - Erhaltung und Verstärkung der Aktivitäten in den bestehenden Bestäuber-Initiativen, auf der Grundlage einer Analayse aller laufenden Projekte weltweit,
   - Ausweitung der Aktivitäten der Bestäuber-Initiativen auf alle wesentlichen terrestrischen Ökosysteme und alle Hauptbestäubergruppen,
   - Gründung einer „Nicht-Bienen"-Bestäuber Initiative/Aktionsgruppe, wie z.B. Fliegen (Diptera), um eine verstärkte Erforschung und Beachtung der bisher wenig berücksichtigten Bestäubergruppen zu erreichen.

3. Verbesserung des öffentlichen Bewusstseins und der Zusammenarbeit in Bestäuberfra gen (awareness & networking)
   - Anerkennung der weltweiten ökonomischen Bedeutung der Bestäuber zur Nutzpflanzenproduktion (Nahrungsmittel, Biokraftstoff, Tierfutter),
   - Herausstellen der Leistungen von Bestäubern für die Erhaltung der Vielfalt von Arznei- und Heilpflanzen und der Vielfalt wildlebender Pflanzen insgesamt,
   - Verbesserung der Kommunikation und Wissensvermittlung, Sensibilisierung der Öffentlichkeit und der Vernetzung der verschiedenen Bestäuber-Aktivitäten (Expertennetzwerke)
   - Erhöhung der finanziellen Unterstützung und größere politische Unterstützung für taxonomische Initiativen zur Bestäubervielfalt in Zusammenarbeit mit der Global Taxonomy Initiative (GTI),
   - Systematische Herausstellung des Wertes der Bestäuberdienstleistungen für alle Hauptbestäubergruppen.

4. Einrichtung eines Monitorings und nachhaltiges Management von Bestäubern
   - Einrichtung eines Monitoringsystems zur Beobachtung und Abschätzung des Bestäuberrückganges und dessen Ursachen,
   - Systematische Beobachtung der Bestäuber und Beobachtung der Verschiebung in den Bestäubergemeinschaften aufgrund der Klimaveränderung,

- Berücksichtigung aller Hauptbestäubergruppen bei der Bewertung von Landschaften und Eingriffen sowie bei der Managementplanung im Naturschutzbereich,
- Weiterentwicklung integrierter Systeme um die Bestäuberdienste im Sinne einer nachhaltigen Nutzpflanzenproduktion zu erhalten bzw. zu fördern,
- Abschätzung und Beobachtung der Gefährdungen für Bestäuber, insbesondere im Zusammenhang mit den Landschaftsveränderungen durch den Anbau von Biokraftstoffen und den Anbau genetisch veränderter Organismen (GVO).

Zwar bestehen die politischen Entscheidungen und Erklärungen im Rahmen der CBD und bezüglich des 2010 Zieles. Es wird weltweit allerdings deutlich mehr Aufmerksamkeit und Handlungsbereitschaft in den oben genannten Punkten für Bestäuber als Schlüsselorganismen für Ökosystemdienste benötigt, um den Erhalt der biologischen Vielfalt zu sichern. Dazugehören z.B. Forschung, Weiterbildung, Sensibilisierung, Berücksichtigung von Bestäubern in der Land- und Forstwirtschaft und ein Monitoring um Folgen der Klima- und Landnutzungsänderungen abpuffern zu können.

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Impressions from the side event and the „Pollinators Buffet"

ONE NATURE · ONE WORLD · OUR FUTURE
COP 9 MOP 4 Bonn Germany 2008

Federal Agency for Nature Conservation

universitätbonn
Ecology of Culture Landscape

22 May 2008

Caring for Pollinators

BfN – Uni Bonn, Side Event – 118 Salon Haydn

Programme:

18:15 h	Opening by AXEL SSYMANK - BfN
18:20 h	Intro by LINDA COLLETTE - FAO
18:30 h	„The Brasilian Pollinators Initiative: Update of recent progress" – BRAULIO DIAS, Ministry of Environment, Brazil
18:45 h	„Little bees with a big job: holding up biome diversity" – DAVID ROUBIK, STRI-Panama
19:00 h	„Flies - Pollinators on two wings" – AXEL SSYMANK, BfN & CAROL KEARNS, University of Colorado

During the whole SIDE EVENT:

- **Postersession:** Projects and work of pollinator initiatives
- **Pollinatorbuffet:** Juices and fruits from animal pollinated plants

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Institute of Crop Science and Ressource Conservation - Ecology of Culture Landscape, Animal Ecology, Melbweg 42, 53127 Bonn (E-Mail: tieroekologie@uni-bonn.de, phone +49 228 910 1913)

6.1 Impressions of the side-event and the pollinators buffet – demonstrating the benefits of pollination

by Hamm, A. & Ssymank, A., Bonn

At the 9th Conference of Parties of the Convention on Biological Diversity, a side-event was held on "Caring pollinators" in the conference rooms of the Hotel "Maritim" in Bonn. The event opened with a workshop of four presentations, introducing the Brazilian Pollinators Initiative, presenting bees and flies as main pollinator groups and the work of the International Pollinator Initiative.

Linda Collette (FAO, Italy) introducing „The International Perspective" (Photo: A. Ssymank)

Braulio Dias (Ministry of Environment, Brazil) during his presentation "The Brasilian Pollinators Initiative (BPI): Update of recent progress"; In the backround: David Roubik (Smithonian Tropical Research Institute, USA). (Photo: A. Ssymank)

A lot of delegates and participants of the COP 9 listened to the presentations. (Photo: A. Ssymank)

During the following poster session after the presentations the possibility was given to discuss actual problems concerning “Caring for pollinators” with a presentation of the work of the regional Pollinator Initiatives.

Dieter Wittmann (Institute of Crop Science and Ressource Conservation, University Bonn); David Roubik (Smithonian Tropical Research Institute, USA); Axel Ssymank (Federal Agency for Nature Conservation, Germany). (Photo: A. Hamm)

Pollinator´s talk: Axel Ssymank (Federal Agency for Nature Conservation, Germany) and Linda Newstrom – Lloyd (Landscare Research, New Zealand). (Photo: M. Vischer-Leopold)

Poster discussion: Mary Gikungu (National Museums of Kenya, Zoology Departement, Nairobi, Kenya; Denise de A. Alves, and Vera L. Impertrize Fonseca (Instituto de Biociencias, Universidade de S. Paulo, Brazil); Axel Ssymank (Federal Agency for Nature Conservation, Germany); Dieter Wittmann (Institute of Crop Science and Ressource Conservation, University Bonn). (Photo: A. Hamm)

To demonstrate practically the benefits of the “work” done by the pollinators for humans worldwide, the “Pollinators Buffet” opened during the poster session. The idea of the “Pollinator Buffet” was to present fruits from many countries of origin and regions of all continents and to offer them to consumption. Each fruit was labelled with its name, its pollinators and its origin. We selected fruits consumed either directly or maybe as juices worldwide every day. Therefore a lot of different fruit juices were also offered at a “Juicebar” next to the buffet. In that way and in addition to the presentations and the posters we wanted to make obvious the significance of animal pollination. Overall more then 55 different fruits and juices were presented. The “Pollinator Buffet”, organised together with an event agency (CMP-EVENT GmbH, Troisdorf/Germany), was a great success. The fruits were provided from a local fruiterer (Abels Früchte Welt GmbH, Bonn/Germany).

Photo: A. Hamm

Diversity made by Pollinators !

Photo: A. Hamm

Photo: A. Hamm

Diversitity for everyone !!

More than 1200 visitors tasted the healthy “Pollinators Buffet”.

Photo: A. Hamm

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6.2 Fruit crops presented on the pollinators buffet

by Hamm, A. & Ssymank, A., Bonn

The following chapter contains most of the fruits provided during the "Pollinator Buffet". The specific informations on the different fruit species are taken from KLEIN et al. (2006), ROUBIK et al. (1995), FAO 2007 and complemented by observations of the authors. The list is not listing all known visitors and pollinators, but giving a selection of species within each pollinator group. Beside the indicated kind of animal pollination, wind pollination often is possible as well. Because of the context of this volume, we did not include additional information for mixed pollination systems. However the positive impact by animal pollination for fruit set and yield is given. By reading this list, please keep in mind that there are many useful, cultivated plants that depend on animals as pollinators. So-called insect pollinated "cash crops" like coffee, cotton, vanilla or alfalfa, have an enormous economic importance worldwide.

***Actinidia deliciosa* (Actinidiaceae)**	
Crop name:	**Kiwifruit**
Positive impact by animal pollination:	**great/essential**

Origin:	SW China
Main producers:	New Zealand, Italy, S Europe
Main pollinators and visitors:	Bees (Hymenoptera) Honey Bees (*Apis mellifera*); Bumble bees (e.g. *Bombus terrestris*); Solitary bees

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

Anacardium occidentale **(Anacardiaceae)**
Crop name: **Cashew, Maranon**
Positive impact by animal pollination: **great/essential**

Origin: Brazil
Main producers: Brazil
Main pollinators and visitors: Bees, Wasps (Hymenoptera)
Honey bees (*Apis dorsata*, *A. mellifera*); Stingless bees (Meliponini); Bumble bees; Solitary bees (*Centris tarsata)*; Megachilidae; Halictidae; Xylocopa
Flies (Diptera)
Flowerflies (Syrphidae); Calliphoridae
Butterflies (Lepidoptera)
Birds (Aves)
Hummingbirds (Trochilidae)

Photo: W. Barthlott/W. Rauh

Photo: A. Hamm

Annona muricata **(Anonaceae)**
Crop name: **Soursop, Guanabana**
Positive impact by animal pollination: **great/essential**

Origin: C America, W India
Main producers: Florida, Hawaii, Egypt, India, S China, SO Asia
Main pollinators and visitors: Beetles (Coleoptera)
Nitidulid beetles (*Carpophilus hemipterus*, *C. mutilatus*)

Photo: W. Barthlott

Annona squamosa (Anonaceae)	
Crop name:	**Shugar apple**
Positive impact by animal pollination:	**great/essential**

Origin: C America, W India

Main producers: Florida, Hawaii, Egypt, India, S China, SO Asia

Main pollinators and visitors: Beetles (Coleoptera)

Nitidulid beetles (*Carpophilus hemipterus*, *C. mutilatus*)

Photo: W. Barthlott

Artocarpus heterophyllus (Moraceae)	
Crop name:	**Jackfruit**
Positive impact by animal pollination:	**unknown**

Origin: W India

Main producers: Thailand, Malaysia, Brazil, Kenya.

Main pollinators and visitors: Bees (Hymenoptera)

Stingless bees (Meliponini)

Flies (Diptera)

Moths (Lepidoptera)

Photo: A. Hamm

Photo: A. Hamm

***Averrhoa carambola* (Oxalidaceae)**
Crop name: **Starfruit, Carambola**
Positive impact by animal pollination: **great/essential**

Origin: India, Malaysia
Main producers: Malaysia
Main pollinator and visitors: Bees (Hymenoptera)
- Honey bees (*Apis cerana*); Stingless bees (*Trigona thoracia*)

Flies (Diptera)

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

***Carica papaya* (Caricaceae)**
Crop name: **Papaya**
Positive impact by animal pollination: **little**

Origin: C America, S Mexico
Main producers: Brazil, Pantropics
Main pollinators and visitors: Bees (Hymenoptera)
- Honey bees (*Apis* sp.)

Flies (Diptera)
- Flowerflies (Syrphidae); Calliphoridae; Tephritidae

Moths (Lepidoptera)
Butterflies (Lepidoptera)
- Sphingidae (*Macroglossum trochilius, Herse sp.);* Noctuidae; Hesperiidae

Birds (Aves)
- Hummingbirds (Trochilidae)

Photo: W. Barthlott/W. Rauh

Citrullus lanatus (Cucurbitaceae)	
Crop name:	**Watermelon**
Positive impact by animal pollination:	**great/essential**

Origin: SC Africa
Main producers: China, Turkey, Iran
Main pollinators and visitors: Bees (Hymnoptera)
Honey bees (*Apis cerana*); Bumble bees (*Bombus californicus*, *B. impatiens*, *B. vosnesenskii*); Solitary bees (*Halictus tripartitus*, *Peponapis pruinoisa; Lasioglossum* sp.)
Flies (Diptera)
Flowerflies (Syrphidae: *Allobaccha* sp., *Allograpta nasuta*, *Betasyrphus adligatus*); Calliphoridae

Photo: A. Hamm

Photo: A. Hamm

Citrus aurantifolia (Rutaceae)	
Crop name:	**Lime**
Positive impact by animal pollination:	**little**

Origin: N India
Main producers: USA, Italy, Spain, Argentina, Iran, Egypt, Turkey.
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis cerana*, *A. mellifera*); Bumble bees (*Bombus* sp.)

Photo: W. Barthlott/W. Rauh

***Citrus limetta* (Rutaceae)**
Crop name: Kumquat
Positive impact by animal pollination: little

Origin: N India
Main producers: USA, Italy, Spain, Argentina, Iran, Egypt, Turkey, S Europe
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis cerana*, *A. mellifera*); Bumble bees (*Bombus* sp.)

Photo: W. Barthlott/W. Rauh

***Citrus limon* (Rutaceae)**
Crop name: Lemon
Positive impact by animal pollination: little

Origin: N India
Main producers: USA, Italy, Spain, Argentina, Iran, Egypt, Turkey
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis cerana*, *A. mellifera*); Bumble bees (*Bombus* sp.)

Photo: W. Barthlott

Citrus paradisi **(Rutaceae)**
Crop name: **Grapefruit**
Positive impact by animal pollination: **little**

Origin: Barbados
Main producers: USA
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis cerana*, *A. mellifera*);
Bumble bees (*Bombus* sp.)

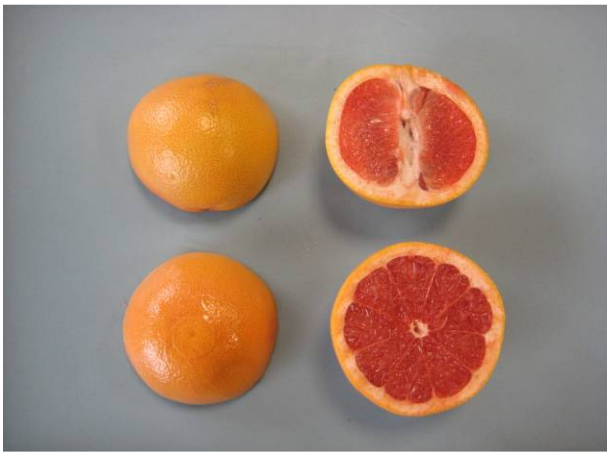

Photo: A. Hamm

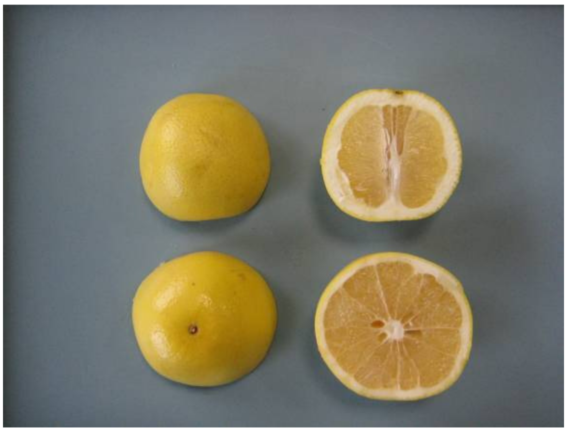

Photo: A. Hamm

Citrus sinensis **(Rutaceae)**
Crop name: **Sweet Orange**
Positive impact by animal pollination: **little**

Origin: SE Asia, China
Main producers: Brazil
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis cerana*, *A. mellifera*);
Bumble bees (*Bombus* sp.)

Photo: W. Barthlott/W. Rauh

Cucumis melo (Cucurbitaceae)	
Crop name:	**Cantaloupe**
Positive impact by animal pollination:	**great/essential**

Origin: Africa
Main producers: China, USA, Spain
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Bumble bees (*Bombus* sp.); Solitary bees (*Ceratina* sp.)

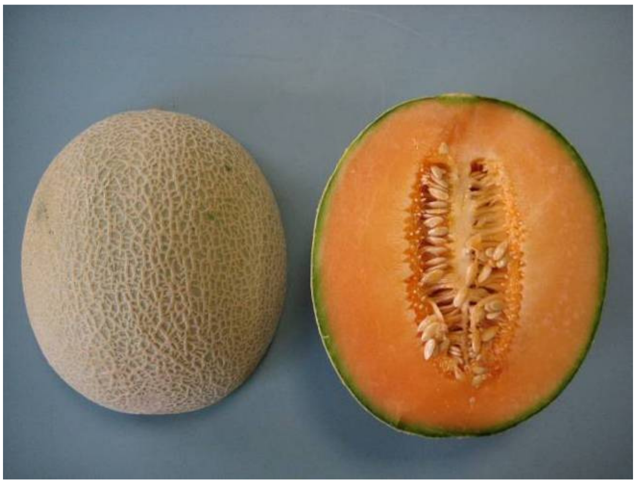

Photo: A. Hamm

Diospyrus kaki (Ebenaceae)	
Crop name:	**Chinese Persimmon**
Positive impact by animal pollination:	**little**

Origin: China, Japan
Main producers: Italy, Israel, Japan, New Zealand, Florida, California
Main pollinators and visitors: Bees, Wasps (Hymenoptera)
Honey bees (*Apis cerana*, *A. mellifera*); Bumble bees; Solitary bees
Flies (Diptera)

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

Eriobotrya japonica **(Rosaceae)**
Crop name: **Loquat**
Positive impact by animal pollination: **great/essential**

Origin:	China, Japan
Main producers:	China, Japan, India, S Europe
Main pollinators and visitors:	Bees (Hymenoptera) Honey bees (*Apis cerana*); Bumble bees Bats (Megachiroptera) *Roussetus* spp.

Photo: W. Barthlott/W. Rauh

Fortunella spp. **(Rutaceae)**
Crop name: **Kumquat**
Positive impact by animal pollination: **unknown**

Origin:	S Asia
Main producers:	America, Africa, S Europe
Main pollinators and visitors:	Bees (Hymenoptera)

Photo: A. Hamm

***Fragaria vesca* and x ananassa (Rosaceae)**
Crop name: **European strawberry**
Positive impact by animal pollination: **modest**

Origin: America, Chile
Main producers: Worldwide
Main pollinators and visitors: Bees (Hymenoptera)

Honey bees (*Apis mellifera*); Stingless bees (Meliponini: *Trigona angusula*, *T. minangkabau*, *Nannotrigona testaceicornis*) Bumble bess (*Bombus terrestris*); Solitary bees (*Osmia cornuta*)

Flies (Diptera)

Flowerflies (Syrphidae: *Syritta pipiens*, *Episyrphus balteatus*, *Eristalis* spp., *Sphaerophoria* spp.)

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

***Luffa cylindrica* (Cucurbitaceae)**
Crop name: **Smooth Loofah**
Positive impact by animal pollination: **unknown**

Origin: Tropics
Main producers: Tropics, Asia, Africa, America
Main pollinators and visitors: Bees (Hymenoptera)

Honey bees (*Apis* sp.); Stingless bees (Meliponini. *Trigona* sp.); Solitary bees (*Xylocopa* sp.)

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

***Lycospersicon esculentum* (Solanaceae)**
Crop name: **Tomato**
Positive impact by animal pollination: **little**

Origin: SC America
Main producers: Worldwide
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Bumble bees (*Bombus hypnorum*, *B. pascuorum*, *B. sonorous*, *B. Terrestris*, *B. vonesenskii*) ; Stingless bees (Meliponini: *Melipona quadrifasciata*, *Nannotrigona perliampoides*); Solitary bees (*Amegilla chlorocyanea*, *A. holmesi, Xylocopa* spp.)

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

***Malus domestica* (Rosaceae)**
Crop name: **Apple**
Positive impact by animal pollination: **great/essential**

Origin: SW China
Main producers: China, USA, France, Italy
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*, *A. cerana*); Bum ble bees (*Bombus* sp.); Solitary bees (*Andrena* sp., *Anthophora* sp., *Osmia cornifrons*, *O. lignaria propinqua*, *O. rufa*)
Flies (Diptera)
Flowerflies (Syrphidae: *Eristalis cerealis*, *E. tenax, Episyrphus balteatus, Eupeodes corollae*)

Photo: A. Hamm

Photo: A. Hamm

Mangifera indica **(Anacardiaceae)**
Crop name: **Mango**
Positive impact by animal pollination: **great/essential**

Origin: S Asia, Himalaya
Main producers: India
Main pollinators and visitors: Bees, Wasps, Ants (Hymenoptera)
Honey bees (Apis sp.); Stingless bees (Meliponini: Trigona sp.); Halictidae
Flies (Diptera)
Flowerflies (Syrphidae: *Senaspis* sp., *Asarkina* sp., *Syritta* sp., *Eristalis* sp.)
Bats (Megachiroptera)
Pteropus sp.

Photo: W. Barthlott/W. Rauh

Photo: A. Hamm

Manilkara zapota **(Sapotaceae)**
Crop name: **Chicle**
Positive impact by animal pollination: **modest**

Origin: Mexico, Costa Rica
Main producers: India, Sri Lanka, Malaysia, Mexico, Venezuela
Main pollinators and visitors: Bees (Hymenoptera)

Photo: A. Hamm

Musa balbisiana **(Musaceae)**	
Crop name:	**Banana**
Positive impact by animal pollination:	**great/essential**

Origin: SE Asia
Main producers: Brasilien, Ecuador, Honduras, Costa Rica, Panama
Main pollinators and visitors: Bats (Chiroptera, Megachiroptera)
Birds (Aves)

Photo: A. Hamm

Nephelium litchi **(Sapindaceae)**	
Crop name:	**Litchi**
Positive impact by animal pollination:	**little**

Origin: S China
Main producers: India, China
Main pollinators and visitors: Bees, Wasps (Hymenoptera)
Honey bees (*Apis* sp.); Stingless bees (Meliponini: *Trigona* sp.)
Flies (Diptera)
Flowerflies (Syrphidae)

Photo: A. Hamm

***Nephelium lappoceum* (Sapindaceae)**	
Crop name:	**Rambutan**
Positive impact by animal pollination:	**little**

Origin: S China
Main producers: India, China
Main pollinators and visitors: Bees, Waps (Hymenoptera)
Honey bees (*Apis cerana*); Stingless bees (Meliponini. *Trigona* sp.)
Flies (Diptera)

Photo: A. Hamm

***Opuntia ficus-indica* (Cactaceae)**	
Crop name:	**Prickly Pear**
Positive impact by animal pollination:	**modest**

Origin: Mexico
Main producers: Mexico
Main pollinators and visitors: Bees (Hymenoptera)
Bumble bees (*Bombus* sp.)

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

Passiflora edulis **(Passifloraceae)**
Crop name: **Maracuja**
Positive impact by animal pollination: **great/essential**

Origin: Neot.
Main producers: S America, New Zealand, Australia
Main pollinators and visitors: Bees, Wasps (Hymenoptera)
Solitary bees (*Xylocopa frontalis*, *X. suspecta*); Bumble bees
Birds (Aves)
Hummingbirds (Trochilidae)

Photo: A. Hamm

Photo: A. Hamm

Persea americana **(Lauraceae)**
Crop name: **Avocado**
Positive impact by animal pollination: **great/essential**

Origin: Neot.
Main producers: Mexico, Spain
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees; Stingless bees (Meliponini); Solitary bees
Bats (Megachiroptera)
Pteropus sp.
Flies (Diptera)
Flowerflies (Syrphidae: *Allobaccha* sp., *Paragus* sp.); Calliphoridae; Sarcophagidae; Muscidae

Photo: W. Barthlott/W. Rauh

Photo: A. Hamm

Prunus armeniaca **(Rosaceae)**	
Crop name:	**Apricot**
Positive impact by animal pollination:	**great/essential**

Origin: N China
Main producers: Turkey
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Bumble bess; Solitary bees; (*Osmia cornifrons*, *O. lignaria propinqua*)
Flies (Diptera)

Photo: A. Hamm

Prunus avium **(Rosaceae)**	
Crop name:	**Sweet cherry**
Positive impact by animal pollination:	**great/essential**

Origin: Europe, Asia
Main producers: Turkey, USA, Italy
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Bumble bees; Solitary bees (*Osmia lignaria*)
Flies (Diptera)
Flowerflies (Syrphidae: *Cheilosia lenis*; *Ch. vernalis)*

Photo: W. Barthlott/W. Rauh

Photo: W. Barthlott/W. Rauh

Photo: A. Hamm

Prunus pesica **(Rosaceae)**
Crop name: Peach
Positive impact by animal pollination: great/essential

Origin:	China
Main producers:	China, USA, S Europe, S Afrika, S Amerika
Main pollinators and visitors:	Bees (Hymenoptera) Honey bees (*Apis mellifera*); Bumble bees; Solitary bees (*Osmia cornifrons, O.lignaria propinqua*) Flies (Diptera)

Photo: A. Hamm

Prunus domestica **(Rosaceae)**
Crop name: Plum
Positive impact by animal pollination: great/essential

Origin:	S Asia
Main producers:	China, USA, Germany
Main pollinators and visitors:	Bees (Hymenoptera) Honey bees (*Apis mellifera*); Bumble bees; Solitary bees (*Osmia lignaria propinqua*) Flies (Diptera) Flowerflies (Syrphidae: *Eristalis* sp., *Cheilosa pagana)*

Photo: A. Hamm

Psidium guajava **(Myrtaceae)**
Crop name: **Common Guava**
Positive impact by animal pollination: **modest**

Origin: C America
Main producers: Mexico, Brazil, Florida, S Africa, S Asia
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Stingless bees (Meliponini: *Trigona cupira*, *Melipona* sp., *Xylocopa* sp.) Bumble bees (*Bombus mexicanus*); Solitary bees (*Lasioglossum* sp.)
Bats (Megachiroptera)
Rousettus sp.

Photo: W. Barthlott/W. Rauh

Pyrus communis **(Rosaceae)**
Crop name: **Pear**
Positive impact by animal pollination: **great/essential**

Origin: China
Main producers: China, S Europe, USA, S America, S Africa, Australia
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Bumble bees; Solitary bees (*Osmia* sp.)
Flies (Diptera)
Flowerflies (Syrphidae: *Eristalis* sp.)

Photo: A. Hamm

Photo: A. Hamm

Rubus fruticosus **(Rosaceae)**	
Crop name:	**Blackberry**
Positive impact by animal pollination:	**great/essential**

Origin: Europe, Asia, N America
Main producers: USA, Europe, Chile
Main pollinators and visitors: Bees (Hymenoptera)
Honey bees (*Apis mellifera*); Bumble bees (*Bombus* spp.); Solitary bees (*Osmia aglaia*, *O. cornuta*)
Flies (Diptera)
Flower flies (Syrphidae: *Eristalis* sp.)

Photo: A. Hamm

Solanum muricatum **(Solanaceae)**	
Crop name:	**Pepino dulce**
Positive impact by animal pollination:	**great/essential**

Origin: The Andes
Main producers: S America, Switzerland, Spain
Main pollinators and visitors: Bees (Hymenoptera)

Photo: A. Hamm

Solanum quitoense **(Solanaceae)**	
Crop name:	**Naranjilla, Lupo**
Positive impact by animal pollination:	**great/essential**

Origin:	Columbia, Ecuador
Main producers:	Columbia, Ecuador
Main pollinators and visitors:	Bees (Hymenoptera) Bumble bees (*Bombus* sp.); Solitary bees (*Eulaema* sp.)

Photo: W. Barthlott/W. Rauh

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POLLINATOR GROUP:

HYMENOPTERA

Author: ANDRÉE HAMM

Species number
Worldwide: nearly 100.000

Distribution
Virtually in all terrestrial habitats worldwide. Across from arid deserts to swamps and from sub arctic tundra to tropical rain forests.

Celonites abbreviatus eating pollen from *Satyreya thymbra* out of her front tarsus after wiping over her cortex. (Photo: V. Mauss)

Hymenopterans and pollination

The order Hymenoptera (bees, wasps and ants) is characterized by a large number of species and high diversity regarding biological organisation and behaviour. Hymenopterans diversified to occupy many terrestrial and semi-terrestrial habitats and also display both diurnal and nocturnal activity. They use a seemingly endless variety of resources as food. Hymenopterans can be phytophagous or carnivorous and perhaps most are parasitic and live within their host during part of the life cycle. Multiple specializations also exist, for example by adults that visit flowers and also are parasites of other insects.

Many phytophagous species have a narrowly defined relationship to specific plants. They feed on nectar and pollen or lay their eggs in specific plant parts. During their “residence” in or on the flowers Hymenopterans often act as pollinators. That partly resulted in complex adaptations involving not only morphological and behavioural features, but precise responses to host odors or chemicals. A long history of coevolution between plants, arising during the Cretaceous, typifies many Hymenoptera. Some examples are the fig trees of the genus Ficus which depend on one or two figs-wasps (Agaonidae) for pollination. Other examples are the pollen-wasps (Masarinae) which use pollen for feeding their larvae.

Ants, because of their small body size and smooth integument, lacking hairs that might transport pollen, only rarely achieve plant pollination. Therefore ants usually are nectar thieves. Anyway some ants do form a mutualistic relationship with plants and provide for pollination in an indirect way: they guard flowers and discourage nectar and pollen consumers that are not pollinators, and also keep the plant free from herbivores.

Bees – with 20.000 or 30.000 species worldwide – contrast greatly with ants: Many are hairy and have other adaptations for acquiring the pollen they use as food. They are the most important pollinator group. To a large degree bees are responsible for the preservation of biodiversity in terrestrial ecosystems (see fact sheet bees).

Major flower preferences

Because of their remarkable diversity it is difficult to characterize the typical flower preferences for the Hymenoptera as a whole. Wasps for example prefer flowers that present nectar of easy access. These flowers are often brown coloured and lack complete morphological or anatomical features or specific fragrances or have long tubular corollas in which the anthers, stamens and nectar are presented. The sugar type or concentration and even the presence of ultraviolet colors (seen by bees but not by humans), and even reflectance of nectar are among floral traits that aid and entice bees to visit flowers. Moreover, the floral structure often determines which Hymenoptera can extract their food, often requiring a certain tongue length, body size or behaviour.

Pollinated crops

Primarily the honey bees (*Apis mellifera*), bumblebees and wild bees are usefull crop pollinators. At least 30% of human food comes from bee pollinated plants world wide. The most important cash crops are among these plants.

Anacardium occidentale (Anacardiaceae); Cashew	*Macadamia integrifolia* (Proteaceae); Macadamia
Artocarpus heterophyllus (Moraceae); Jackfruit	*Malus sylvestris* (Rosaceae); Apple
Brassica alba (Brassicaceae); Mustard	*Mangifera indica* and *M. foetida* (Anacardiaceae); Mango and Gray Mango
Brassica napus (Brassicaceae); Rape	*Medicago sativa* (Fabaceae); Alfalfa
Carica papaya (Caricaceae); Papaya	*Nephelium litchi* (Sapindaceae); Litchi
Citrullus lanatus (Cucurbitaceae); Watermelon	*Opuntia ficus-indica* (Cactaceae); Prickly Pear
Citrus paradise (Rutaceae); Grapefruit	*Passiflora edulis* (Passifloraceae); Maracuja
Citrus limon (Rutaceae); Lemon	*Prunus avium* (Rosaceae); Sweet cherry
Cocos nucifera (Arecaceae); Coconut	*Prunus domestica* (Rosaceae); Plum
Coffea arabica (Rubiaceae); Arabian Coffee	*Pyrus communis* (Rosaceae); Pear
Coriandrum sativum (Apiaceae); Coriander	*Rubus fruticosus* (Rosaceae); Blackberry
Diospyrus kaki (Ebenaceae); Chinese Persimmon	*Rubus idaeus* (Rosaceae); Raspberry
Fragaria x *ananassa* (Rosacaea); Strawberry	*Vanilla planifolia* (Orchidaceae); Vanilla
Helianthus annuus (Asteraceae); Sunflower	*Vicia faba* (Fabaceae); Bean
Lycospersicon esculentum (Solanaceae); Tomato	

Hymenopterans and biodiversity of wild plants

The impact of hymenopterans on maintenance of wild plant diversity is the highest among insects.

Aceraceae	Cornaceae	Linaceae	Ranunculacae
Apiaceae	Cucurbitaceae	Malvaceae	Salicaceae
Araliaceae	Dipsacaceae	Oleaceae	Scrophulariaceae
Arecaceae	Ebenaceae	Onagraceae	Solanaceae
Asteraceae	Ericaceae	Orchidaceae	Tiliaceae
Betulaceae	Fabaceae	Papaveraceae	Violaceae
Boraginaceae	Fagaceae	Plantaginaceae	Vitaceae
Brassicaceae	Gentianaceae	Polygonaceae	
Cactaceae	Geraniaceae	Rosaceae	
Campanulaceae	Liliaceae	Rubiaceae	

See also fact sheet Flower Bees.

Specific remarks

The earliest fossil records of Hymenoptera are from the Middle Triassic of Central Asia and the Upper Triassic of Austria. By the time of the Jurassic (200 mya) the group had radiated considerably (approximately 21 families were represented). The first groups were phyto-phagous exclusively on non-flowering vascular plants. Most of the modern families began to appear towards the end of the Cretaceous. The hymenopteran families of today probably arose with the radiation of the angiosperms in the late Cretaceous. The most recent hymen-opteran families have existed for at least 50 million years and the oldest bee specimen is from Bumese Amber of nearly 100 mya in age.

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POLLINATOR GROUP:

BEES

Super family Apoidea
Order Hymenoptera

Author: ANDREE´HAMM

Species number
Worldwide: over 17.000,
estimated > 30.000
Number of genera: 425

Andrena haemorrhoa on a flower of *Prunus avium,* Photo: M. Schindler

Distribution

Bees live in almost all terrestrial habitats. The places where they establish nesting populations are most often warm and their microsites are open or not densely vegetated. That is the reason why the number of species increases from the poles towards the equator, while in equatorial forests, where species that live in perennial colonies predominate, species numbers are not the highest.

Bees biology and pollination

Most bees collect pollen and nectar for rearing their larvae. Some species also collect plant oils and even certain floral scents. The bees often have a close relationship to particular plants as a result of co-evolution. Bumble bees (*Bombus*) and orchirds (*Orchidaceae*) in Europe, some sand-bees (*Andrenidae*) and petunias (*Solanaceae*), or euglossinae bees (*Euglossini*) with the orchids of neotropical forests are examples of such close relationships.

A great number of bee species are apparently specialized on particular flowers. As so-called oligolectic bees they exclusively use pollen from plants which are members of one family or order. The reproductive success of these specialized bees depends on the availability of their flowers.

Major flower preferences

Melittophilous plants (“Beeplants”) are attractive for bees. Frequently their flowers are blue or yellow, but rarely red. They have a sweet odour. Bee-pollinated flowers show the highest diversity of all animal-pollinated plants. Much of their diversity in shape is due to a high variety of mechanisms by which they conceal or present their pollen and nectar. A further explosion of diversity in plants and bees is based on the offering of resources which can only be found in melittophilous flowers: droplets of resin, fatty oils and perfumes, which are collected by highly specialised bees. Furthermore several melittophilous flowers imitate the shape and the sex perfumes of female insects in order to attract the males as pollinators. Many flowers visited by bees have the following characteristics:

Major flower preferences	
favored floral shapes	flowers formed like a bell, brush, jaw, flag or tube
morphological characteristics	zygomorphous flowers with landing platforms, often a bottom lip, deep flowers, opportunity to enter
microscopic characteristics	Non-slip surface, sometimes with silky gloss
favored colours	blue, yellow, white
scent	mild, often like honey
nectar	concealed, from 15 to 60 % sugar

Composed and modified after HEß, D. (1983)

Bees as crop pollinators

More than 30 % of human foods belong to bee pollinated plants. A great number of herbs or medicinal plants or animal-fodder or ornamental plants are also pollinated by bees. Bees and their pollination service are responsible for an enormous yield increase in cultivated plants and crops. Wild bees pollinate crops like red clover, alfalfa, beans and tomatoes better than honey bees. Therefore the “pollination-service” of the bees, which cannot be replaced by technology, has not only an enormous ecological, but also an economic importance. Honey bee pollinate more crops than any other bees, but their services are artificial and variable. At present the most important insect pollinated crops in Europe have an annual market value of 65 million €.

Because of the continuous decline of pollinator abundance in croplands, particularly in wild bees, a “pollination-deficit“ is a reality. Biodiversity as well as yields in agriculture are reduced. Therefore appropriate pollinator management is needed both for natural ecosystems and agricultural ecosystems.

Fruits and nuts	
Actinidia deliciosa (Actinidiaceae); Kiwifruit	*Malus sylvestris* (Rosaceae); Apple
Anacardium occidentale (Anacardiaceae); Cashew	*Mangifera indica* (Anacardiaceae); Mango
Averrhoa carambola (Oxalidaceae); Starfruit	*Myrciaria cauliflora* (Myrtaceae); Jaboticaba
Carica papaya (Caricaceae); Papaya	*Nephelium litchi* (Sapindaceae); Litchi
Citrullus lanatus (Cucurbitaceae); Watermelon	*Opuntia ficus-indica* (Cactaceae); Prickly Pear
Citrus limon (Rutaceae); Lemon	*Passiflora caerulata* (Passifloraceae); Maracuja
Citrus paradise (Rutaceae); Grapefruit	*Persea americana* (Lauraceae); Avocado

Citrus sinensis (Rutaceae); Sweet Orange	*Prunus armeniaca* (Rosaceae); Apricot
Cucumis melo (Cucurbiaceae); Cantaloupe	*Prunus avium* (Rosaceae); Sweet cherry
Diospyros kaki (Ebenaceae); Chinese Persimmon	*Prunus communis* (Rosaceae); Almond
Eriobotrya japonica (Rosaceae); Loquat	*Prunus domestica* (Rosaceae); Plum
Eugenia uniflora (Myrtaceae); Surinam cherry	*Psidium guajava* (Myrtaceae); Common Guava
Fortunella spp. (Rutaceae); Kumquat	*Pyrus communis* (Rosaceae); Pear
Fragaria vesca (Rosaceae); European strawberry	*Rubus idaeus* (Rosaceae); Raspberry
Lycospersicon esculentum (Solanaceae); Tomato	*Solanum muricatum* (Solanaceae); Pepino Dulce
Macadamia integrifolia (Proteaceae); Macadamia	*Solanum quitoense* (Solanaceae); Naranjilla
Malpighia punicifolia (Malpighiaceae); Acerola	*Syzygium jambos* (Myrtaceae); Rose Apple
Seed crops	
Brassica napus (Brassicaceae); Oilseed Rape	*Sinapis alba* (Brassicaceae); White Mustard
*Cocos nucifera (*Arecaceae); Coconut	*Gossypium hirsutum* (Malvaceae); Seedcotton
Helianthus annuus (Asteraceae); Sunflower seeds	*Linum usitatissimum* (Linaceae); Flaxseed
Spieces and vegetables	
Allium cepa (Alliaceae); Onion	*Pastinaca sativa* (Apiaceae); Parsnip
Elettaria cardamomum (Zingiberaceae); Cardamon	*Sinapis alba* (Brassicaceae); Mustard
Foeniculum vulgare (Apiaceae); Fennel	*Vanilla planifolia* (Orchidaceae); Vanilla
Others	
Coffea arabica (Rubiaceae); Coffee	

Bees and biodiversity of wild plants

Bees are pollinators of most of the 300.000 species of vascular plants. For 80% of flowering plants they are the most important pollinators. Because of their very high influence on the reproduction of flowering plants and biodiversity as a whole, bees are called “keystone species“. A selective list of their host species that they sustain includes:

Acanthus longifolius (Acanthaceae)	*Helianthemum nummularium* (Cistaceae)
Acer campestre (Aceraceae)	*Impatiens glandulifera* (Balsaminaceae)
Aconitum napellus (Ranunculaceae)	*Iris pseudacorus* (Iridaceae)
Adonis vernalis (Ranunculaceae)	*Knautia arvensis* (Dipsacaceae)
Aegopodium podagraria (Apiaceae)	*Lathyrus pratensis* (Fabaceae)
Antirrhinum majus (Scrophulariaceae)	*Leucanthemum vulgare* (Asteraceae)
Atropa belladonna (Solanaceae)	*Leucojum vernum* (Amaryllidaceae)
Aquilegia vulgaris (Ranunculaceae)	*Linaria vulgaris* (Scrophulariaceae)
Berberis vulgaris (Berberidaceae)	*Lotus corniculatus* (Fabaceae)
Borago officinalis (Boraginaceae)	*Medicago sativa* (Fabaceae)
Calceolaria integrifolia (Calceoariaceae)	*Melampyrum pratense* (Scrophulariaceae)
Campanula rapunculoides (Campanulaceae)	*Muscari botryoides* (Hyacinthaceae)
Campanula scheuchzeri (Campanulaceae)	*Nigella damascena* (Ranunculaceae)
Centaurea jacea (Asteraceae)	*Origanum vulgare* (Lamiaceae)
Cornus sanguinea (Cornaceae)	*Pedicularis sylvatica* (Scrophulariaceae)

Corydalis cava (Papaveraceae)	*Polygala chamaebuxus* (Polygalaceae)
Cytisus scoparius (Fabaceae)	*Pulmonaria officinalis* (Boraginaceae)
Daucus carota (Apiaceae)	*Reseda lutea* (Resedaceae)
Delphinium consolida (Ranunculaceae)	*Rhinanthus alectorolophus* (Scrophulariaceae)
Digitalis purpurea (Scrophulariaceae)	Salix sp. (Salicaceae)
Echium vulgare (Boraginaceae)	*Salvia pratensis* (Lamiaceae)
Epilobium angustifolium (Onagraceae)	*Stachys sylvatica* (Lamiaceae)
Epipogium aphyllum (Orchidaceae)	*Symphytum officinale* (Boraginaceae)
Euphrasia rostkoviana (Scrophulariaceae)	*Trifolium pratense* (Fabaceae)
Galanthus nivalis (Amaryllidaceae)	*Vinca minor* (Apocynaceae)
Gentiana acaulis (Gentianaceae)	Tropical orchids (Orchidaceae)
Hedera helix (Araliaceae)	

Specific remarks

During an international workshop in Sao Paulo in 1998 it became clear that a sustainable pollinator management is only possible if between specialised bees and their plants are well known. For example, little is known about the pollen use by the bees and the development of their larvae. As research progresses, more important information will become available.

Acknowlegdement

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POLLINATOR GROUP:

TRUE FLIES

Order Diptera

Authors: A. SSYMANK, C. KEARNS, T. PAPE & F.C. THOMPSON

Species number
Worldwide: 154.322 named species [estimated total: 1.5 million]
Number of families: 162

Bombylius, probably *facialis* Cresson (Bombyliidae),.western Colorado , photo by David W. Inouye, Rocky Mountain Biological Laboratory, USA.

Distribution

Worldwide true flies occur in virtually all habitat types except the open oceans. The true flies are represented with 45,443 extant valid species in the Palaearctic, 21,505 in the Nearctic, 31,430 in the Neotropical, 20,268 in the Afrotropical, 22,917 in the Oriental and 19,053 species in the Australasian/Oceanian Region (species counts provided by the BioSystematic Database of World Diptera on 14 Nov. 2008). The knowledge on true flies in the different regions is heterogenous, but the relative rank of the regions probably reflects the true biodiversity.

True Flies, biology and pollination

Diptera, together with Hymenoptera, form the two most important pollinator groups worldwide. Diptera from at least 71 families are known to be regular flower visitors capable of acting as pollinators, and they represent a complex and wide-ranging spectrum of pollination strategies. The large majority of anthophilous dipterans are nectar consumers and only a modest number of species are regular and obligate pollen consumers. Flower flies (family Syrphidae) are among the most prominent flower visiting flies (see separate fact sheet for flower flies). Strong fliers like many Bombyliidae, Muscidae, Nemestrinidae, Tabanidae, and Tachinidae as well as small, delicate gnats like many Ceratopogonidae, Sciaridae and Mycetophilidae visit and pollinate flowers.

Flies are well-adapted for visiting flowers by having trichromatic colour vision and morphologically complex, sucking mouthparts forming a proboscis, which in some species may be greatly elongated. The world record is found in the South African tangle-veined fly *Moegis-*

torhynchus longirostris (Wiedemann), which has a proboscis of 90-100 mm, which is about three times its body length.

Nectar and pollen are usually ingested while the fly is sitting on or in flowers, but some flies are able to hover in front of the flowers while sucking nectar (e.g., some Bombyliidae, Nemestrinidae, Tabanidae). Some flies show learning behaviour for flower colour and nectar reward. Flies can fly at low temperatures, and they often outnumber bees in damp or shady places such as the understory of rainforests. Flies show an increasing dominance at higher altitudes and higher latitudes.

Main flower preferences

Diptera form a major part of the pollinator guild for plants that are pollinated by multiple insect groups. Even generalist flower visitors have been shown to contribute significantly to fruit set. An increasing number of flowering plants are being discovered that are entirely dependent on dipteran pollinators. Examples include the 'seed-for-seed' mutualism where species of the anthomyiid genus *Chiastocheta* pollinate the closed flowers of *Trollius europaeus*, and the gall midge pollination of *Artocarpus integer*, which is a mutualism involving also a parasitic fungus. A significant number of flowers have specialized in being pollinated by carrion flies, including the world's largest flower *Rafflesia arnoldii* and its relatives, and several commercially important flowers like *Stapelia* spp., *Amorphophallus* spp. Many flies prefer white, yellow or inconspicuous small or greenish flowers. Flat or bowl-shaped actinomorphic flowers and umbels of the Apiaceae are commonly visited by flies. Flowers are visited not only for food (pollen and nectar), but for several other reasons as well. For example, some flies warm up by sitting in flower cups that face the sun; others rendezvous with mates at certain types of flowers; some flies are are fooled or trapped by flowers (carrion flowers, mate-deceiving flowers, funnel-traps like in the plant family Araceae or Asclepiadaceae) that they unwittingly pollinate. Even pollinia (pollen packages) of some orchids may be distributed by flies (the flower fly genera *Microdon*, *Eristalis*).

Flies and pollinated crops

More than 100 cultivated plants are known to be pollinated by Diptera. Among them plants like Cocoa, where small Diptera are a guarantee for good harvests and later on chocolate-production. Also, flies are increasingly being used for the pollination of various greenhouse crops.

Examples for pollinated plants are:

Fruits	**Spice-plants and vegetables:**
Acacia tortilis (Fabaceae); Umbrella Thorn	*Allium ampeloprasum* var. *porrum* (Alliaceae); Leek
Anacardium occidentale (Anacardiaceae); Cashew	*Allium cepa* (Alliaceae); Onion
Camellia sinensis (Theacaceae);Tea Plant	*Carum carvi* (Apiaceae); Caraway
Coffea arabica (Rubiaceae); Arabian Coffee	*Daucus carota* (Apiaceae); Carot
Fragaria x *ananassa* (Rosacaea); Strawberry	*Foeniculum vulgare* (Apiaceae); Fennel
Malus domestica (Rosaceae); Apple	*Lycopersicon* (Solanaceae); Tomato
Mangifera indica and *M. foetida* (Anacardi-aceae); Mango and Gray Mango	*Manihot dulcis* and *M. esculenta* (Euphor-biaceae); Sweat Cassava and Bitter Cassava
Persea americana (Lauraceae); Avocado	*Petroselinum crispum* (Apiaceae); Parsley
Pyrus communis (Rosaceae); Pear	*Sinapis alba* (Brassicaceae); Mustard
Theobroma cacao ssp. *cacao* (Sterculiaceae); Cacao	

In addition a number of medical plants and many ornamental plants are pollinated by flower flies.

See also fact sheet for Flower flies.

Flies and biodiversity of wild plants

The contribution of flies to maintaining wild plant diversity is very high. They are often present in large numbers in a wide variety of different habitats where they visit or pollinate many different flowers. A study in Belgium showed that flower flies alone visited more than 700 plant species in 94 different families. Flies may be the most effective pollinators in some ecosystems, e.g., small flies may be the most important pollinators in the forest understory, particularly for shrubs with numerous small, inconspicuous and dioecious flowers

Examples of plant families with many fly-visited or -pollinated species are:

Alliaceae	Caprifoliaceae	Euphorbiaceae	Polygonaceae
Anacaridaceae	Caryophyllaceae	Geraniaceae	Polygonaceae
Apiaceae	Celastraceae	Hypericaceae	Ranunculacae
Araceae	Chenopodiaceae	Lauraceae	Rosaceae
Araliaceae	Cistaceae	Liliaceae	Rubiaceae
Asteraceae	Convolvulaceae	Malvaceae	Salicaceae
Berberidaceae	Crassulaceae	Mimosaceae	Saxifragaceae
Boraginaceae	Cucurbitaceae	Onagraceae	Scophulariaceae
Brassicaceae	Cyperaceae	Plantaginaceae	
Caesalpiniaceae	Dipsacaceae	Poaceae	

Specific remarks

- Probably as little as 10% of fly species are named and described. Considerable research is needed to fill large gaps in current taxonomic knowledge. In addition, applied research into Diptera as pollinators in agriculture and of wild plants is needed.
- Diptera probably were among the first angiosperm pollinators and may have been instrumental in early angiosperm radiation.
- Mobility of species varies a lot, ranging from local territorial behaviour around a single bush to long distance migration.
- Diptera visit many species of wild plants, but they are also important for pollination in greenhouses (Calliphoridae, Syrphidae) and for commercial seed production.

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POLLINATOR GROUP:

FLOWER FLIES

Family Syrphidae
Order Diptera

Author: AXEL SSYMANK

Species number
Worldwide: 5926
Number of genera: 198

Sericimyia silentis visiting *Calluna vulgaris* (Scots Heather) flowers in a sandy heathland. (Photo: A. Ssymank)

Distribution:

Worldwide in almost all habitat types, except marine, being more abundant in temperate areas. The family is represented with 2,048 extant valid species in the Palaearctic, 818 in the Nearctic, 1,518 in the Neotropical, 591 in the Afrotropical, 879 in the Oriental and 416 species in the Australasian / Oceanian Region (species counts provided by the BioSystematic Database of World Diptera on 14 Nov. 2008).

Flower Flies biology and pollination

Adults: Both male and female flower flies visit flowers for nectar or pollen. Egg-production in females is at least partly dependant on pollen ingestion as a source of protein. Proboscis length is varies from 1 mm up to more than 11 mm. Species with long probosces, and those with a narrow head and slender thorax may use flowers with deep corollas. Flower flies have trichromatic vision (yellow, blue and ultra-violet). They show indications of learning behaviour related to flower colour. Buzz pollination is known for some larger species. Syrphidae usually show a marked diurnal activity pattern in flower visiting.

Larvae: Flower fly larvae exploit a wide range of different food sources with zoophagous larvae (mainly aphids; important in bio-control), phytophagous larvae (in leafs, roots, and bulbs), saprophagous larvae (in plant material, and dead wood) aquatic detritophagous larvae (e.g. rat-tailed maggots in ponds and lakes), and larvae living in ant or other hymenopteran nests; Thus flower flies live in a wide range of different habitats all over the world.

Main flower preferences

The number of flowering plants in a community that are visited by syrphids is usually high, reaching up to 80% of the regional flora. Flower constancy is usually high due to individual species' preferences for flower colour, height and floral type combined with the requirement for synchrony of fly and flower phenology. Many species prefer white and yellow flowers with easily accessible nectar, however a number of species are highly specialised. Anemophilous plants, including some grasses, shrubs and trees may be partly pollinated by flower-flies.

In Europe, the plant families known to be regularly visited by flower flies include Apiaceae, Asteraceae, Brassicaceae, Chenopodiaceae, Dipsacaceae, Hypericaceae, Polygonaceae, Ranunculaceae and Rosaceae. Some grasses and sedges (Poaceaea, Cyperaceae and Juncaceae) are regularly visited by flower flies of the genera *Melanostoma* and *Platycheirus*. In sheltered situations, these flies are likely to be important for the pollination of otherwise wind-pollinated plants like in *Plantago* (e.g. Stellemann 1978). Some typical "Diptera-flowers" like *Sanicula europaea*, *Galium* sp. and *Saxifraga* species may be more or less exclusively pollinated by flower flies.

Flower flies as crop pollinators

In Europe
Brassica napus (Brassicaceae); Oilseed Rape
Fragaria x *ananassa* (Rosacaea); Strawberry
Malus domestica (Rosaceae); Apple
Pyrus communis (Rosaceae); Pear
Rubus-species like *Rubus idaeus, Rubus chamaemorus* (Rosaceae); Raspberry and Cloudberry
Sorbus aucuparia (Rosaceae); Mountain Ash
In tropical regions
Mangifera indica and *M. foetida* (Anacardiaceae); Mango and Gray Mango
Camellia sinensis (Theacaceae);Tea Plant
Coffea arabica (Rubiaceae); Arabian Coffee
Anacardium occidentale (Anacardiaceae); Cashew
Persea americana (Lauraceae); Avocado
Acacia tortilis (Fabaceae); Umbrella Thorn
Spice-plants and vegetables
Petroselinum crispum (Apiaceae); Parsley
Allium cepa (Alliaceae); Onion
Carum carvi (Apiaceae); Caraway
Daucus carota (Apiaceae); Carot
Foeniculum vulgare (Apiaceae); Fennel

A number of medical plants and many ornamental plants are pollinated by flower flies.

Flower flies and biodiversity of wild plants

The importance of Flower flies for the pollination and fruit set of wild plants is very high: They are often present in high numbers and the pollen-carrying capacity is medium, to high in species with dense fur or curled hairs. High local flower constancy due to flower preferences and local phenology combined with medium to high visitation rates and flight activity may ensure pollination. Long distance migration in some species makes long distance pollen transport and fertilization possible. Flower flies visit a large range of different flower families.

Plants visited by flower flies, examples:

Aegopodium podagraria (Apiaceae); Bishop´s Weed	*Heracleum sphondylium* (Apiaceae); Hogweed
Alliaria petiolata (Brassicaceae); Hedge Garlic	*Hypericum perforatum* (Clusiaceae); St John´s Wort
Armeria elongata (Plumbaginaceae); Common Thrift	*Knautia arvensis* (Dipsacaceae); Blue Buttons
Chenopodium album (Chenopodiaceae); Fat Hen	*Knautia dipsacifolia* (Dipsacaceae);
Cornus sanguinea (Cornaceae); Common Dogwood	*Origanum vulgare* (Lamiaceae); Oregano
Crataegus monogyna (Rosaceae); English Hawthorn	*Sanicula europaea* (Apiaceae); Butterwort
Filipendula ulmaria (Rosaceae); Meadow Sweet	

Specific remarks

- Mobility of species varies greatly, ranging from local territorial behaviour around a single bush up to regular migration, with some flies capable of crossing the Alps and covering distances of over 200 km in a few days.
- Many species mimic stinging hymenoptera such as wasps, and bees. Sometimes mimicry is only in coloration, but other times includes flight sounds and behavioural mimicry (examples include *Volucella bombylans*, *Temnostoma, Criorhina*, and *Spilomyia* species).
- The larvae of some phytophagous species feed from the same plants where the adults collect nectar and pollen (e.g. *Cheilosia fasciata* and *Portevinia maculata* on ramson, *Allium ursinum*) and show a double relation to these plant species.

See also: contribution Ssymank & Kearns: “Flies –Pollinators on two wings” in this volume.

Web links:

World names: http://www.diptera.org/biosys.htm
General information, distribution Europe, Africa: www.syrphidae.com
German Diptera Group: www.ak-diptera.de
Nearctic checklist: http://www.nearctica.com/nomina/diptera/dipsyrph.htm
Australasian/Oceanian catalogue: http://hbs.bishopmuseum.org/aocat/syrphidae.html

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POLLINATOR GROUP:

BUTTERFLIES, MOTH

Order: Lepidoptera

Authors: ANDREE´ HAMM,
DIETER WITTMANN

Species number
World wide: 180.000
Number of families: 130

Polygonia c-album (Nymphalidae) inbibing nectar on a flower, Photo: A. Hamm

Distribution

After the beetles the lepidopterans are the largest insect order. They occur almost all kinds of terrestrial biotopes on all continents except the Antarctica. Temperate and tropical biotops with high diversity of flowering plants are characterized by a high diversity of butterflies and moths.

Butterflies/Moths alimentation and pollination

Because of their food requirements, instars and adult butterflies depend on specific feeding plants. Adult butterflies normally imbibe nectar from different plants while larvae mainly depend on specific food plants, where they feed on leaves. Their plant preferences range from poly- to monophagie. Due to their specific food requirements populations of some monophagous species of lepidopterans can easily get endangered. As adults have to visit many flowers for taking up nectar as fuel for their flight activities they do a good job as pollinators.

Main flower preferences

Butterfly-pollinated flowers are red, blue and yellow and emit agreeable scents. Many of these flowers are star shaped with elonged nectar tubes which are considerably shorter than the tubes of sphingophilous flowers. They are open all-day and usually will be visited during daytime. Nectar is offered in small amounts. Its concentration is low so that it can pass through the narrow canal formed by the mouthparts of the lepidopterans.

Moth-pollinated flowers open at night. In order to be detectable they have white and ultraviolet star like corollae and emit strong sweet odors. When moths take up nectar from the deep nectar tubes, they remain on wings. As the moth gets just a small amount of nectar, they have to change the flowers frequently. This is of great advantage for the flowers as they get multiple visits which assure good pollination. Furthermore, migration of lepidopterans, like Monarch butterflies which move between Canada and Central Mexico, leads to pollen transfer over long distances.

Main flower preferences	
Butterflies	
favored floral shapes	flowers formed like a tube
morphologic characteristics	flowers often with landing platforms, marginally feathered
anatomic characteristics	fine structures
favored colours	red, blue, yellow
colour marks	yes
scent	milder than moth-plants
nectar	concealed, up to 40mm deep
periodic phenomenons	flourish during the day, seldom close by night
Moth	
favored floral shapes	flowers formed like a tube
morphologic characteristics	strongly feathered
microscopic characteristics	fine structures, often with a waxy surface
favored colours	white, dirty-yellow, greenish, reddish
colour marks	no
scent	strong and sweet
nectar	concealed, up to 200mm deep
periodic phenomenons	flourish during the night, scent during the night

Composed and modified after HEß, D. (1983)

Butterflies/Moths and pollinated crops

The following list presents a selection of crops visited and pollinated by lepidopterans:

Butterflies	
Anacardium occidentale (Anacardiaceae); Cashew	*Cephaelis ipecacuanha* (Rubiaceae);
Arachis hypogaea (Fabaceae); Peanut	*Cinchona calisaya* (Rubiaceae); Quinine
Macadamia ternifolia (Proteaceae); Macadamia	*Grewia asiatica* (Malvaceae); Phalsa
Moth	
Arthocarpus heterophyllus (Moraceae); Jackfruit	*Luffa acutangula* (Cucurbitaceae); Angled Luffa
Bombax malabaricum (Malvaceae); Indian Silk Cotton	*Myristica argentea* (Myristicaceae); Papuan Nutmeg

Cananga odorata (Annonaceae); Ylang-Ylang	*Pachira aquatica* (Malvaceae); Chestnut of America
Carica papaya (Caricaceae); Papaya	*Trichosanthes cucumerina* (Cucurbitaceae); Snakegourd
Carissa edulis (Apocynaceae); Egyptian Carissa	*Yucca filamentosa* (Agavaceae); Yucca
Lagenaria siceraria (Cucurbitaceae); Bottle Gourd	

Butterflies/Moths and biodiversity:

Much of the diversity of moth pollinated plants originates from variations of the length of the floral tubes. Tube length and length of the mouthparts of butterflies and moths are shaped by co-evolution. This happened in many different angiosperm families. Between lepidopteras and plants some highly specific mutualistic relationships evolved.

For example moth of the genus Tegeticula (Perdoxidae) have a special impact on the reproduction of some yucca – plants, due to their behaviour inside the flowers. During their visits they actively pollinate the flowers with their front legs and their mouthparts.

Several hawk moth (Sphingidae) have a extremely long proboscis. Therefore, while hovering and taking up nectar the insect will not get into contact with the flower. The advantage of the long proboscis is that it keeps the insect in a secure distance from hunting spiders which await their pray at flowers.

Butterflies	**Moth**
Anacamptis pyramidalis (Orchidaceae)	*Angraecum sesquipedale* (Orchidaceae)
Bougainvillea spectabilis (Nyctanigaceae)	*Calystegia sepium* (Convolvulaceae)
Cardamine pratensis (Brassicaeae)	*Capparis spinosa* (Capparaceae)
Centranthus ruber (Valerianaceae)	*Lilium martagon* (Liliaceae)
Dianthus deltoides (Caryophyllaceae)	*Lonicera caprifolium* (Caprifoliaceae)
Gentiana verna (Gentianaceae)	*Oenothera biennis* (Onagraceae)
Gymnadenia conopsea (Orchidaceae)	*Phlox* spp. (Polemoniaceae)
Lilium bulbiferum (Liliaceae)	*Platathera bifolia* (Orchidaceae)
Narcissus poeticus (Amaryllidaceae)	*Platanthera chlorantha* (Orchidaceae)
Phlox spp. (Polemoniaceae)	*Silene nutans* (Caryophyllaceae)
Silene dioica (Caryophyllaceae)	*Yucca filamentosa* (Agavaceae)
Viola calcarata (Violaceae)	

Specific remarks:

As butterflies use their habitats in different ways we can discriminate three types of habitat inhabitants:

„One - habitate - inhabitants“: In these species the development from the egg to the imago takes place within a single habitat in which the adult butterflies also remain (e. g. *Parnassius apollo*).

“Biotope – complex – inhabitants”: The adults of these species move for feeding to different biotopes (e. g. *Papillio machon*, *Iphiclides podalirius*).

„Different – biotope- inhabitants“: These species are able to settle in different biotopes. However, once settled in a biotope they behave like „one - habitat – inhabitants“ (e.g *Eumedonia eumedon*, *Euphydryas aurinia*, *Brenthis ino*).

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POLLINATOR GROUP:

BEETLES

Order: Coleoptera

Author: ANDREE´ HAMM

Species number
Worldwide: 380.000
Number of families: 187

Trichodes apiarius (Cleridae) pollinating *Leucanthemum vulgare* (Asteraceae), Photo: M. Schindler

Distribution

Beetles live on all continents except Antarctica. They are the insect order which is represented with the most species worldwide. Because of their enormous diversity, they occupy all biotops except ice and pure salt water.

Beetles biology and pollination

The order Coleoptera comprises the largest number of pollinating species and individuals. A lot of beetle species live only on the flower products nectar and pollen (e.g. Nitidulidae, Cerambycidae, Buprestidae*).* Many predatory species additionally eat pollen of different flowers. While feeding in a flower beetles frequently get in contact with both anthers and stigmas. Some beetles are good pollinators as larvae (e.g. *Meloe spec.).* After hatching the larvae climb into specific flowers, where they feed on pollen. When an adequate host bee visits the flower the beetle larva mounts the bee (e.g. *Andrena spec.)* and is carried to its nest. There it feeds on the bee´s larva provisions.

Major flower preferences

Flowers pollinated by beetles emit strong odours to attract their pollinators. Odour emission often is enforced by the warming of the flowers through the sun light. Visual cues are not so important for the detection of the flowers by the beetles. Beetle pollinated flowers normally white, yellow or brown coloured and easy to access. Therefore they are formed like a disk or a bowl. Some flowers form traps that catch visiting beetles and shed them with pollen before releasing (*Calycanthus floridus*).

Major flower preferences	
favoured floral shapes	flowers formed like a disk or bowl
morphological characteristics	no
microscopic characteristics	no
favoured colours	white, yellow, brown
scent	strong, fruity
nectar	open, accessible

Composed and modified after HEß, D. (1983)

Beetles as crop pollinators

Because of their unspecific behaviour beetles are normally not important for crop pollination like for example flies or bees. Anyway their flower visits often have an “additive“ pollination of certain crops as a result. A famous example for beetle pollination is the oil palm tree *Elaeis guineensis* (Aricaceae). The african beetle *Elaidobius kamerunicus* (Cucurlionidae) is the main important pollinator of *Elaeis guineensis*. Because of his affectivity it has been introduced in SO Asia. The annual benefit of the oil crop increased about 100 Mio. US Dollar.

Acacia tortilis (Fabaceae);	*Momordica balsamica* (Cucurbitaceae); Balsam-Apple
Annona muricata (Anonaceae); Soursop	*Momordica charantia* (Cucurbitaceae); Balsam-Pear
Annona squamosa (Anonaceae); Shugar apple	*Parkia biglobosa* (Fabaceae); African Locust Bean
Bactris grasipaes (Arecaceae); Peach Palm	*Sambucus nigra* (Caprifoliaceae); Elderberry
Elaeis guineensis (Arecaceae); African Oil Palm	*Ziziphus jujuba* (Rhamnaceae); Jujube

Beetles and biodiversity of wild plants

A large range of plant species of various families are visited and pollinated by a high number of beetle species. These beetles are responsible for the conservation of plant biodiversity in the ecosystems world wide. The biggest flowers on earth, *Amorphophallus titanium*, are pollinated by beetles.

Specific remarks:

Beetles belong to the oldest group of flower visiting and pollinating animals. In the earth-history Hymenoptera, Diptera or Lepidoptera appeared later. Some authors believe that beetles are essentially responsible for the radiation of angiosperms. Today beetles still remain important pollinators especially for ancient plants like magnolias or spicebushes.

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POLLINATOR GROUP:

BIRDS

Author: Karl-L. Schuchmann

Blue-throated Hummingbird (*Lampornis clemenciae*), Arizona, USA, visiting flowers of Penstemon sp. (Scrophulariaceae), Photo: Karl-L. Schuchmann

I. Hummingbirds

Family Trochilidae
Order Apodiformes

Non-Passeres

Species number
New world: c. 330
Number of genera: 115

Distribution

New World only (Nearctic and Neotropical Region). Extremely wide range of habitats from sea-level to Andean snowfields and glaciers above 4000 m, absent only in extreme hot South American deserts (Peru and Chile). Highest species diversity in the equator-near mountains (Andes, Atlantic Rain Forest Mts. of Brazil) between 1000-2000 m a.s.l. (Schuchmann 1999). 70% of all species occur in South America, species number declines strongly with increasing latitudes.

Hummingbird biology and pollination

Hummingbirds are the smallest of all nectarivorous birds. Their body mass ranges from 1.9 to 22 g.

Thousands of New World plant species rely exclusively upon hummingbirds for pollination. As a consequence of the year-round high energy requirements of trochilids, plants that are pollinated by hummingbirds provide nectar at all times of the year, creating the opportunity of a phenological displacement of flowering times as a means of reducing interspecific pollen flow.

The evolutionary relationship between hummingbirds and their food plants is a good example of close mutualism, resulting in the many adaptations between flower and pollen vector that together is called ornithophily. Plants that have converged upon the “hummingbird” syndrome bear relatively large flowers, solitary or loosely clustered, often placed in a horizontal or pendent position. Typical hummingbird plants open their blossoms during the day: the flowers are generally brightly coloured, often red, orange or yellow, sometimes in combination with contrasting white corolla parts. Exceptions can be found in the Gesneriaceae, where some epiphytic species exhibit solitary inconspicuous whitisch flowers. However, hummingbirds are attracted to these well-camouflaged flowers by their ornamental red-edged or red-centered leaves, a little studied advertisement strategy in hummingbird-pollinated plants known as phyto-flagging.

The corolla of a typical hummingbird flower is often long, thickened, tubular in shape, and scentless. It contains sucrose-rich nectar which is taken by trochilids in hovering or hover-clasping flight. Many characterisitics of hummingbird-pollinated flowers, such as red colour, lack of odour, or the floral tubes with their thick walls, are adaptations either to avoid attracting insect competitiors or to prevent nectar robbing. Ornithophily seems to be energetically expensive for plants. Although the energetic expenditures of plant reproductive strategies are still poorly understood, it is most likely that this process is energy-demanding. The evolution of ornithophily must therefore be viewed from from the perspective of costs and benefits, obviously well balanced between hummingbirds and their plants.

Due to their relatively high body mass hummingbirds have a much higher potential mobility than most insects. Foraging distances of more than 1 km have been reported for trochilids visiting widely distributed flowering shrubs in a single feeding bout. For most insects the travelling distance between successive flower visits tends to be much smaller and foraging strategies are much more stereotypic. A long-lived pollinator such as a hummingbird experiencing several flowering seasons during its lifespan, combined with the capacity of its excellent spatial memory, can easily remember localy or patchily flower stands. Thus, the floral environment for trochilids is much more differentiated in time and space than for insects.

Main flower preferences

Hummingbirds pollinate about 30% of all Neotropical angiosperms. In cloud forests (c. 1000-2500 m), where trochilids are the major pollinators, up to 60% of the local angiosperm population may depend on hummingbirds as pollen vectors.

Common and well-studied hummingbird-pollinated species belong to the genus *Zauschneria* (Onagraceae), *Delphinium* and *Aquilegia* (Ranunculaceae), *Mimulus* (Scrophulariaceae), *Aphelaria* (Acanthaceae), *Centropogon* (Lobeliaceae), Psamisia and *Cavendishia* (Ericaceae), *Psittacanthus* (Loranthaceae), *Heliconia* (Heliconiaceae).

Most ornithophilous plants are dicotyledonous perennial herbs and shrubs, and only a few trees are pollinated by hummingbirds. Flowering trees with a very large nectar source, like many *Erythrina* (Leguminosae) species, are quickly occupied by territorial hummingbirds which remain in the tree tops for the whole flowering period until the nectar declines. By doing so, pollen flow is greatly reduced. The most efficient pollinators of ornithophilous trees in America are songbirds, such as orioles (Icterus), which move in groups between widely scattered flowering trees. The pollen loads from different conspecific trees, deposited on their feathers, support the obligate reproductive system of these trees: cross-pollination (Grant and Grant 1968, Proctor *et al.*1996, Schuchmann 1999, Thery *et al.*).

Hummingbirds and pollinated crops

Hummingbirds have been observed to visit various crops during flowering (e.g., plantations of coffee, banana, pea etc.). However, no proof exists that trochilids play an obligate role during the reproductive process of crops in general.

II. Sunbirds (incl. sugarbirds, flowerpeckers, and spiderhunters)

Family Nectariniidae
Order Passeriformes

Species number: Old world: c. 170; Number of genera: 40

Distribution

Old World radiation. Afrotropical region, Madagascar and near-by islands, Oriental region, Palaearctic region (Levant), New Guinea, Solomons, eastern Australia. About 50% of all species occur in the Afrotropical, 40% in the Oriental region (Cheke et al. 2001, Wolters 1983).

Sunbirds biology and pollination

Sunbirds are small to medium sized birds of 6 – 30 g.

They occur in almost all tropical and subtropical habitats, reaching high mountain altitudes in the Himalayas above 3000 m. They mainly forage near water and rarely invade arid areas or swamps.

The diet of sunbirds consists to a much smaller fraction of nectar than in hummingbirds (sunbirds less than 40%, hummingbirds over 90%). Their main food constituent are arthropods (c. 60%; in hummingbirds c. 10 %) (Schuchmann 1984). Besides nectar, fruits, and pollen are known to be consumed by all sunbirds. Arthropods are frequently collected at or around flowers. Sunbirds mainly consume nectar while perching. During feeding at flowers pollen is dusted onto the bill, tonuge, and the feathers. Any that is not consumed will be carried to other conspecific flowering angiosperms inducing pollination. Many sunbirds are nectar robbers piercing the bases of corollas thus reducing the chances of pollination.

In sunbirds pollen is deposited mainly on the crown feathers and on the bill. However in the case of *Strelitzia nicolai* (Strelitziaceae) pollen seems to be transferred to the reproductive organs via the feet (Frost & Frost 1981). Sunbirds are generally much less associated with certain angiosperms. So far the only known exception is the Cape Sugarbirds (*Promerops cafer*) which seems to pollinate only South African Protea species (Proteaceae).

Main flower preferences

Common and widely distributed angiosperms, e.g. *Leonotis leonurus* (Labiatae) and *Strelitzia* sp. (Strelitziaceae) are known to be pollinated by sunbirds. Flowering exotic ornamental plants are frequently visited by sunbirds in search for insects and nectar. However, these angiosperms rarely depend on sunbirds for pollination. The pollination syndrome of sunbirds and their flowers is much less known to science than in hummingbirds.

Sunbirds and pollinated crops

No information is available on that topic.

Sunbirds and biodiversity of wild plants

Sunbirds have a wide range of food items (esp. arthropods, fruits) and depend much less on nectar, which frequently is compensated by sugar-rich fruits. Hence their impact on the reproductive system and speciation mode of plants seems to be less effective.

III. Honeyeaters

Family Meliphagidae
Order Passeriformes

Species number: Old world: c. 173; Number of genera: 52

Distribution

Old World. Australasian region, including New Zealand and New Guinea, Lesser Sunda and Bonin Islands, Micronesia, Melanesia, Polynesia, and Hawaii. Australia is the most species-diverse region (68 species) (Pizzey 1980). Honeyeaters occupy every vegetational zone including mangroves and subalpine habitats as far as 4500 m asl.

Honeyeaters biology and pollination

Honeyeaters are fairly slim birds with elongated often slightly decurved bills. They vary in size and body mass (size 10 – 40 cm, 8 – 80 g). Although many species are basically sedentary they still show local movement, especially in those taxa occuring in arid habitats. A few species are regular migrants, e.g., Yellow-faced (*Lichenostomus chrysops*) and White-naped Honeyeaters (*Melithreptus lunatus*), which migrate from south to central-east Australia. Much movement is associated with flowering patterns of major food plants, such as eucalyptus, coastal banksias or the arid-zone emu-bush (Eremophila).

Probably all honeyeaters consume some nectar and some of them depend on it as their main food source of energy, others take it when it becomes locally abundant. Likewise, all honeyeaters feed on arthropods (c. 60% of all food items), fruits and mistletoe berries (e.g., Painted Honeyeater, *Grantiella picta*). Unusual food items include crustaceans (Mangrove Honeyeater, *Lichenostomus fasciogularis*) and lizards (Wattled Honeyeater, *Foulehaio carunculata*).

Main flower preferences

Honeyeaters are important pollinators of native plants of the families Myrtaceae, Proteaceae, and Epacridaceae in Australia, New Zealand, and elsewhere (Armstrong 1979, Ford & Paton 1986). Bird flowers are usually red, yellow or white, though some are cryptically coloured. Corollas are open and cup-like, tubular or gullet-shaped. Many inflorescences of native plants in Australia and New Zealand are brush-like. Some honeyeaters are seed dispersers, others are both pollinators and seed dispersers of mistletoes (Loranthaceae).

Honeyeaters and pollinated crops

No information available.

Honeyeaters and biodiversity of wild plants

The importance of honeyeaters for the pollination of native plants is not well documented. However, for some species of the families Myrtaceae, Proteaceae, and Loranthaceae, honeyeaters are obligate pollinators.

IV. (Hawaiian) Honeycreepers

Family Carduelidae
Order Passeriformes

Species number: Hawaiian islands only: 22; Number of genera: 17

Distribution

Endemic to the Hawaiian Islands. All island habitats above 600 m asl (Pratt et al. 1987).

Honeycreepers biology and pollination

The ancestors of Hawaiian honeycreepers stem from Eurasian cardueline finches, most of them seedeaters. Hence it is not surprising that during their radiation on the oceanic islands of Hawaii distinct feeding habits gave raise to fairly defined groups. One group includes finches not very different from the thick billed seedeaters of other taxonmic groups. The second group includes an array of thin-billed mainly “green” birds of superficial similarity that feed on both nectar and insects. The third group comprises some of the most brightly coloured (red) long-billed nectar-feeders, that are strongly associated with the red-flowering ohia-lehua tree (*Metrosideros collina*). Nectar-feeding honeycreepers are extremely territorial. They aggressively defend their food sources against conspecifics and other nectarivores. When nectar is scarce many species feed on fruits and on foliage insects. The body mass of Hawaiian honey ranges from 8 – 40 g (Berger 1981).

Main flower preferences

Besides the ohia tree (*M. collina*), lobeliads, such as the endemic *Clermontia arborescens*, as well as various introduced passiflora and banana species are the basic nectar source for most members of the nectarivorous guild (Scott et al. 1986). However, *M. collina* seems to be the dominant species pollinated by various Honeycreepers (e.g. *Vestaria coccinea*, *Himatione sanguinea, Drepanis pacifica*).

Honeycreepers and pollinated crops

Not known, but unlikely.

Honeycreepers and biodiversity of wild plants

Presuming for less than a dozen angiosperms Hawaiian honeycreepers are obligatory pollinators (Scott et al. 1986), a quite frequently observed phenomenon for plant populations occurring on subtropical or tropical oceanic islands.

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POLLINATOR GROUP:

BATS

Order: Chiroptera

Author: MARCO TSCHAPKA

Species number

Worldwide: ca. 100 species.
Number of families: 2 (Phyllostomidae, Pteropodidae, additionally very few opportunistic flower visitors in other bat families, e.g. Mystacinidae)

A Neotropical *Lichonycteris obscura* (Phyllostomidae: Glossophaginae) approaching an inflorescence of *Marcgravia nervosa* (Marcgraviaceae), a canopy liana. Photo by Marco Tschapka, University of Ulm.

Distribution

Subtropical and tropical regions. Main specialized flower visitors in the Neotropics are the Glossophaginae (Phyllostomidae). Among the Old World Pteropodidae (Flying Foxes) are only a few specialized flower visitors, while a larger number of species opportunistically visit flowers and supplement their fruit diet with nectar.

Bat biology and pollination

Bat pollination (Chiropterophily) is an entirely subtropical and tropical phenomenon, due to the necessity of year-round availability of the floral resources for the long-lived animals. Corresponding to size and food requirements of their comparably large pollinators, bat pollinated flowers are usually rather big and offer considerable amounts of nectar and pollen.

Main bat flower visitors in the **Old World** are flying foxes (Pteropodidae), bats that evidently have lost their echolocation capability and rely instead on an excellent night vision for nocturnal orientation (Teeling *et al.* 2005). Most of the pteropodid bats are rather unspecialized flower visitors that opportunistically consume nectar in addition to a diet mainly based on fruits. Only a number of taxa, e.g. the genera *Macroglossus, Megaloglossus* and *Syconycteris* specialize on nectar and show distinct adaptations to this diet, such as elongated rostra and tongues. Nectar is mainly consumed while clinging to a flower; hovering visits are rare. Another Old World flower visitor is the extraordinary *Mystacina tuberculata* (Mystacinidae) from New Zealand. This bat, one of the two species of native terrestrial mammals in New Zealand, feeds mainly on arthropods but visits also a number of flowers that appear to be specialized on bat pollination (Lord, 1991, Arkins *et al.* 1999).

In the **New World** bat pollination systems appear to be more specialized. Especially the Glossophaginae, a subfamily within the ecologically extremely adaptable New World Leaf-Nosed bats (Phyllostomidae) evolved into using nectar as their main dietary item. Fruits and insects form for several species also part of the diet; however, the main morphological and behavioural adaptations of Glossophagines are only related to nectarivory: An extremely long tongue and an associated long rostrum allow the access to nectar produced deep within blossoms; teeth are frequently reduced and flowers are visited in short hovering flights. New World glossophagine bats are distributed from the Southern United States to Argentina and live in deserts, rain forests and tropical mountain ranges up to 3000 m. A few species migrate seasonally in response to the phenology of important food plants, such as *Agave* spp. and columnar cactus species. Besides the specialized Glossophagines and the small Antillean subfamily Phyllonycterinae, there are also a number of opportunistic phyllostomid flower visitors such as *Phyllostomus discolor* (Phyllostomidae: Phyllostominae) or *Artibeus jamaicensis* (Phyllostomidae: Stenoderminae) that feed mainly on other resources, such as insects or fruit but may include also nectar from large flowers into their diet.

Main flower preferences

The main motivation for flower-visitation by bats is nectar; only in a few plant species serve fleshy floral parts as a reward for the visitors (Lord 1991, Tschapka 2003). Pollen is for specialized nectar-feeding bats an important source of protein that is ingested both directly from the flower and also indirectly while grooming the fur during nocturnal resting periods. Night-blooming flowers pollinated by bats both in the New and the Old World are characterized by – to humans – not very pleasant odours, that have been compared to e.g., the smell of garlic, mouse urine or human excrements (Dobat & Peikert-Holle 1985). To facilitate the flower access for the relatively large bats, inflorescences are often raised well above the leaves or hang on long stalks into the open air space below branches (flagelliflory). At some trees flowers emerge also directly from the trunk or from larger branches (cauliflory). During the night bright colours are of less importance for finding flowers, and consequently many bat-pollinated flowers are dull brown, green, or purple. Nevertheless, white flowers, such as those of some columnar cacti in the Mexican deserts (e.g. *Stenocereus* spp., *Pachycereus* spp.), may also provide optical guidance for the bats in these more open habitats. Some flowers in the Neotropics may even address the bats´ echolocation system by providing particularly good sound reflecting properties, such as the vine *Mucuna holtonii* (Fabaceae) (Helversen & Helversen 1999). Flower visitation by pteropodid bats in the Old World occurs mainly by landing on the flowers, and the specifically adapted flowers, such as *Musa* (Musaceae) or *Kigelia* (Bignoniaceae) have to be robust enough to support the weight of their large visitors. The hovering capabilities of the New World Glossophagines, however, allowed also some of the more fragile plant families to develop mutualisms with pollinating bats. Consequently Neotropical bats visit robust flowers, such as *Agave* spp. and *Ochroma pyramidale*, but also smaller and more delicate flowers, even from herbs, such as *Irlbachia alata* (Gentianaceae), *Capanea grandiflora* (Gesneriaceae) or *Burmeistera* spp. (Lobeliaceae). The latter are exclusively used by the hovering glossophagines, while opportunistic nectar-feeding phyllostomid bats generally perch on some of the more robust flowers.

Bats and pollinated crops

Bat-pollinated plants are utilized by humans in many ways, ranging from fruits like durian and bananas, to fibres and trees cultivated for their wood. Occasionally, generalist bats of the genus *Glossophaga* carry in their fur also pollen from some cultivated plants where they probably do not contribute much to pollination, but just opportunistically exploit insect – pollinated flowers, e.g. coconut (*Cocos nucifera*) or papaya (*Carica papaya*).

Examples are:

Fruits	**Other:**
Durio zibethinus (Bombacaceae), Durian, O	*Agave tequilana* (Agavaceae), Tequila, N
Musa spp. (Musaceae), Banana, O	*Agave sisalana* (Agavaceae), Sisal, N
Stenocereus spp. (Cactaceae), Pitaya, N	*Ceiba pentandra*, (Bombacaceae), Kapok, O & N
Anacardium occidentale (Anacardiaceae), Cashew N	*Crescentia cujete* (Bignoniaceae), Calabash tree, N
Matisia cordata (Bombacaceae), Zapote, N	*Bombacopsis quinata* (Bombacaceae), wood, N
Syzygium jambos (Myrtaceae), Malay apple, O	*Ochroma pyramidale* (Bombacaceae), wood, N

The letters N (New World) and O (Old World) in the table indicate the natural occurrence of the mentioned species in the respective regions. However, bat-pollinated plants transferred from one region to the other will frequently get visits from non-coevolved flower-visiting bats, e.g. the Old World species *Musa* spp. and *Kigelia aethiopica* are in the New World readily visited by glossophagine bats.

Bats and biodiversity of wild plants

While bats pollinate certainly fewer plants than most insect groups, they may play especially in dry habitats an important role as valuable long-distance pollinators that may cover up to 100 km during just a single night (Horner *et al.* 1998). Some examples of families with bat pollinated species are:

Family	**Selected genera and species:**
Bignoniaceae	*Crescentia alata, C. cujete, Kigelia* spp., *Parmentiera* spp.
Bombacaceae	*Bombacopsis quinata, Pseudobombax ellipticum, Ceiba* spp., *Matisia* spp., *Adansonia digitata*
Bromeliaceae	*Werauhia* (*Vriesea*) spp.
Cactaceae	*Stenocereus* spp., *Pachycereus* spp., *Carnegia gigantea*, *Weberocereus* spp.
Capparaceae	*Cleome* spp., *Crataeva* spp., *Capparis* spp.
Caesalpiniaceae	*Bauhinia* spp., *Hymenaea courbaril*
Fabaceae	*Mucuna* spp., *Erythrina* spp.

Malvaceae	*Abutilon* spp., *Wercklea* spp.
Mimosaceae	*Inga* spp., *Parkia* spp., *Calliandra* spp.
Musaceae	*Musa* spp., incl. many cultivated varieties
Solanaceae	*Merinthopodium* spp., *Solandra* spp., *Trianaea* spp.

General summaries on chiropterophily and bat pollinated plants are found in Dobat & Peikert-Holle (1985), Helversen (1993) and Tschapka & Dressler (2002). A review by Fujita & Tuttle (1991) focuses particularly on Old World pteropodid bats' interactions with plants. A valuable online resource is the regularly updated database on Neotropical bat / plant interactions (Geiselman et al. 2002).

Specific remarks

Bats are in many regions of the earth threatened indirectly by habitat conversion but also directly by destruction of their roosting places. The New World frugivorous and nectarivorous species are frequently confused with vampire bats (*Desmodus rotundus,* Phyllostomidae: Desmodontinae) that regularly drink blood from livestock and may even transmit dangerous diseases, such as rabies. In consequence, many people project the characteristics of these potentially harmful species on *all* bat species, kill them whenever they find them and destroy encountered bat roosts. Environmental education initiatives are essential to overcome these misbelieves and to secure the bats´ pollination services for the future.

Web links

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Links

International Pollinators Initiatives

Convention on Biological Diversity: International Pollinator Initiative
http://www.cbd.int/agro/pollinator.shtml

The Sao Paulo Declaration on Pollinators
http://www.biodiv.org/doc/ref/agr-pollinator-rpt.pdf

COP 6 (Decision VI/5). Plan of Action of IPI.
http://www.biodiv.org/decisions/default.aspx?lg==&dec=VI/5.

Convention of biological diversity (COP9, 9th Conference of Parties, Bonn, 2008)
http://www.cbd.int/cop9/

Food and Agriculture Organization (FAO)
http://www.fao.org/biodiversity/ecosystems/bio-pollinators/en/

Rapid Assessment of Pollinators´ status (FAO 2008)
http://www.cbd.int/doc/meetings/sbstta/sbstta-13/other/sbstta-13-fao-pollinators-en.pdf

Regional Pollinators Initiatives

African Pollinator Initiative
http://www.up.ac.za/academic/entomological-society/rostrum/apr01/page5.html
http://www.scienceinafrica.co.za/pollinator.htm

Asia: International Centre for Integrated Mountain Development (ICIMOD)
http://www.icimod.org/?page=86

Brasilian Pollinator Initiative
http://eco.ib.usp.br/beelab/

European Pollinator Initiative
http://www.europeanpollinatorinitiative.org/

North American Pollinator Protection Campaign
http://www.nappc.org/

Oceania Pollinator Initiative
http://www.oceaniapollinator.org/

Other interesting links

Brazilian information network on bee biodiversity
http://www.webbee.org.br/

Centre for Agri-Environmental Research
http://www.apd.rdg.ac.uk/Agriculture/CAER/

EU Project: Assessing large-scale risks for biodiversity with tested methods
http://www.alarmproject.net/alarm/

Global Biodiversity Information Facility
http://www.gbif.org/

Global Taxonomy Initiative
http://www.cbd.int/gti/

List of national focal points
http://www.cbd.int/doc/lists/nfp-gti.pdf

German contact
http://www.gti-kontaktstelle.de/kontakt_nat.html

International Bee Research Association (IBRA)
http://www.ibra.org.uk/

International Federation of Beekeepers' Associations
http://www.beekeeping.com/apimondia/

International Network of Expertise for Sustainable Pollination (INESP)
http://www.uoguelph.ca/~inesp/

National Biological Information Infrastructure
http://pollinators.nbii.gov

Pollinator Partnership
http://www.pollinator.org/

Smithsonian Tropical Research Institute
http://www.stri.org/

Task Force on Declining Pollination of the Species Survival Commission World Conservation Union (IUCN)
http://www.uoguelph.ca/~iucn/

The BioSystematic Database of World Diptera: http://www.diptera.org/biosys.htm.

World Bees Checklist workshop. Assess
http://www.cria.org.br/eventos/tdbi/wbcw

World Fly Names (BioSystematic Database of World Diptera)
http://www.diptera.org/biosys.htm

Editors homepages

Federal Agency for Nature Conservation
http://www.bfn.de

University of Bonn
http://www.tieroekologie.uni-bonn.de