INTERNATIONAL POLLINATORS INITIATIVE:

THE SÃO PAULO DECLARATION ON POLLINATORS

Report on the Recommendations of the Workshop on the Conservation and Sustainable Use of Pollinators in Agriculture with Emphasis on Bee

Brazilian Ministry of the Environment

Brasília 1999

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THE SÃO PAULO DECLARATION ON POLLINATORS

Report on the Recommendations of the Workshop on the Conservation and Sustainable Use of Pollinators in Agriculture with Emphasis on Bees

University of São Paulo, São Paulo, Brazil
7-9 October 1998

A framework of proposals for actions to implement an international initiative on the conservation and sustainable use of pollinators in agricultur

A contribution for the implementation of Decision III/11 of the Convention on Biological Diversity – CBD which established a work program on the conservation an sustainable use of agricultural biological diversity

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CONTENT

PREFACE

The vital importance of the sustainable use of biological diversity for society is evident and is clearly demonstrated in this report. The decline in the diversity and numbers of pollinators and the risks this involves for agriculture sustainability clearly demonstrate the importance of pollination i this sphere. This ecosystem service provided by biodiversity is on e of the simplest to demonstrate and for the public to comprehend. This is particularly opportune because the proposal described her could be the basis for a first global initiative to deal with the conservation and sustainable use of th components of biodiversity directly responsible for the maintenance of an ecosystem service.

At the second meeting of its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity (CBD) in Montreal, the Brazilia n Government proposed establishing a work program on Agricultural Biological Diversity which included a proposal for the establishment of an *"International Pollinator Conservation Initiative"*. Based largely on the Brazilian proposal, the third Conference of the Parties (COP3) in Buenos Aires, approved Decision III/11 on the "*Conservation and Sustainable Use of Agricultural Biological Diversity*", which identified pollinators as one of the initial priorities.

As a contribution to the development of this program the Brazilian Ministry of th Environment held an international workshop of experts to propose a framework for an International Initiative on Pollinators as a key element in this program. It was attende d by 61 scientists from 15 countries and four international organisations (CBD Secretariat, FAO, IBRA and ICPBR).

The workshop was very successful, with an intense programme that included individual presentations of case studies, poster presentations an workgroups on special topics. There was general agreement among the participants over identification of the problem and what, in general terms, needs to be done to begin to resolve it.

Therefore, it is my pleasure to submit this report, the *São Paulo Declaration on Pollinators*, to the attention of all delegates to the fifth meeting of the Subsidiary Body for Scientific, Technical an Technological Advic – SBSTTA of the Convention on Biological Diversity to be held 31 January to 4 February, 2000 in Montreal, Canada. I hope its proposals will be recommended for endorsement b the fifth meeting of the Conference of the Parties of the CBD - COP5 in Nairobi in May 2000. Th framework for action recommended by the Sao Paulo workshop could provide the needed guidelines for the Global Environment Facility – GEF and other financing agencies in supporting projects in different countries on this theme.

I would like to strongly support the recommendation that COP5 formally establish a *International Pollinators Initiativ* based on the framework for action contained in this report and th request that SBSTTA should co-ordinate, with support from the Executive Secretary, the preparation of a first *Global Biodiversity Outlook Report on Pollinators*. The Workshop participants also requeste that COP5 call for international co-operation to develop th *International Pollinators Initiative* and requested the financial support of the Global Environment Facility - GEF for this initiative and, finally, proposed the creation of a *Pollinators Specialist Group* within the Species Survival Commission of th IUCN.

In addition to this Report the Brazilian Ministry of the Environment and the International Bee Research Association plan to publish jointly a volume on the contents of 25 case studies that were presented during the workshop.

I would like to thank the following institutions for their support to this initiative: the University of Sao Paulo – USP, the Brazilian Corporation for Agricultural Researc – EMBRAPA, the Brazilian Council for Scientific and Technological Development – CNPq, the United Nations Development Progra – UNDP (Project BRA 95/012), the Food and Agriculture Organisation – FAO, the World Conservation Union – IUCN, the International Bee Research Association – IBRA, the International Commission for Plant-Bee Relationships – ICPBR, and the Secretariat of the Convention on Biological Diversity. Finally, I would like to thank and congratulate the participants of the São Paulo workshop for their significant contribut ion.

José Sarney Filho
State Minister of the Environment, Brazil

INTERNATIONAL POLLINATORS INITIATIVE:
THE SÃO PAULO DECLARATION ON POLLINATORS

Report on the Recommendations of the Workshop on the Conservation and Sustainable Use of Pollinators in Agriculture with Emphasis on Bees

EXECUTIVE SUMMARY

One-third of the world's crops demand pollination to set seeds and fruits and the great majority of them are pollinated by many of the estimated 25,000 species of bees. The annual value of this service in the U.S. is calculated at US $6-8 billion and the estimate worldwide is US $ 65-70 billion. The most widely used species in crop pollination is the honeybee (*Apis mellifera*). A major problem is emerging for the world's agricultural production reflecting the risk involved in relying on a singl pollinator species. Honeybees in many parts of the world have contracted a serious disease and th numbers of honeybee colonies have decreased dramatically. Fruit and vegetable growers in the U.S. and Europe are complaining about poor fruit sets despite good blooming. As the disease has spread throughout most of the world, specialists consider all countries will become seriously affected. Farmers and growers now wish to use native of bees. Many species of native bees are known to b efficient pollinators of crops and a few species have been managed for this purpose. However, the numbers of native bees are dwindling; some species seriously s . Declines in numbers have been reported in North and Central America and Europe. The losses are due mostly to the use of agrochemicals and monocultures, to deforestation, and possibly to the introduction of exotic pollinators

The emergence of a serious and widespread disease has made it clear that native pollinators need to be protected and sustainably managed for the pollination service they can provide and tha agricultural practices be designed to incorporate the protection and sustainable management of bee populations. The pollinator crisis exemplifies the intimate relationship existing between the welfar of natural environments and their biodiversity and the needs of sustainable agriculture.

As a contribution to the development of the CBD work program approved by Decision III/11 on the "Conservation and Sustainable Use of Agricultural Biological Diversity", which identified pollinators as one of the initial priorities, the Brazilian Government held an international workshop of experts to propose a framework for an *International Initiative on Pollinators* as a key element in this program. The workshop was attended by 61 scientists from 15 countries and four international organisations (CBD Secretariat, FAO, IBRA and ICPBR). Six groups of specialists discussed: 1 - Reducing the Taxonomic Impediment on Pollinators, 2- Monitoring the Decline of Pollinators, 3- Identifying the Causes of Pollinator Decline, 4- Quantifying the Economic Value of Pollinators t Agriculture, 5- Conservation of Pollinator Diversity, and 6- Sustainable Use of Pollinators

The recommendations of the Workshop include a proposal that COP5 formally establish an *International Pollinators Initiative* based on the framework for action contained in this report and request SBSTTA to co-ordinate, with support from the Executive Secretary, the preparation of a first Global Diversity Outlook Report on Pollinators. The Workshop participants also requested that COP5 call for international co-operation to develop the *International Pollinators Initiative* and request th financial support of GEF for this initiative and, furthermore, propose the creation of a *Pollinators Specialist Group* within the Species Survival Commission of the IUCN.

The recommendations produc d by this workshop should help foster support from agencies to enhance initiatives on all continents on pollinator conservation and sustainable use. This would help to mainstream the issue of biodiversity in our society and to direct the conservation mov ments to promote the maintenance of biodiversity as an essential component to ecosystem functioning.

The workshop participants concluded that there is insufficient reliable data on the reported declines in the numbers of pollinators and their effects o agriculture, but that the necessary expertis to collect such data is available. Furthermore, they agreed that such an effort is viable provided th institutional support is available. However, the difficulties in obtaining reliable identification of pollinators (especially of bees), which are vital for the success of both the monitoring programme and pollination research, was also stressed. They also emphasised that the pollination requirements of relatively few crops are known. The experts spoke of t he need to produce manuals and catalogues and agreed that the creation of websites with databases of specialists, publications and reports an information on the pollination requirements of crops and on their pollinators is vital and that success of the proposed actions will be greatly enhanced with public awareness of the problem. The spread of successful pollinators for some cultures should be regulated, in order to avoid their introduction in areas outside their natural distribution and avoid competition with local pollinators

The proposals for action of this Workshop are varied, and many are concerned with the collection of reliable information and its dissemination. The predominance of these two subjects demonstrates the participants' desire to have access to standardised extra data. Some of this information already exists but is not readily available, while much additional data need to b collected. An international training program was suggested, with standardised methodology an well-defined goals in order to create a worldwide network of experts capable to develop appropriate actions for the conservation and sustainable use of local pollinator diversity.

PROPOSALS FOR ACTION

TAXONOMIC IMPEDIMENT:

1. Assess the scale of the Taxonomic Impediment
2. Maintain continuity of existing taxonomic and reference collections of bees
3. Establish Centres of Excellence in Bee Taxonomy
4. Train bee taxonomists
5. Train parataxonomists
6. Repatriate data [Capacity building and benefit sharing]
7. Stimulate taxonomic output
8. Hold a Workshop on motivation and training of parataxonomists
9. Hold a Workshop on automated systems for bee identification

MONITORING THE DECLINE:

1. Establish a committee to co-ordinate a global monitoring plan and network
2. Refine plans and methods for implementation of a global monitoring plan
3. Assess methods, prepare manuals for monitoring pollinators and train participants
4. Implement a pilot global monitoring program in selected areas worldwid
5. Assess th potential impact of exotic pollinators on native pollinators
6. Establish a network of websites with databases for all pollinator monitoring data
7. Prepare a Global Biodiversity Outlook Report on the status and trends of pollinators
8. Promote follow up activities to ensure continuity and improve the proposed progra

CAUSES OF DECLINE:

1. Assess pollinator diversity and pollinator efficiency in representative agroecosystems an adjacent natural and seminatural environments
2. [This issue needs further attention, as workgroup report was not submitted

ECONOMIC IMPORTANCE:

1. Establish a network of experts and a network of database
2. Determine the pollination requirements of each crop species
3. Determine best pollinators for each crop species

4. Determine impact of pollinator presence/absence on fruit and seed yiel
5. Establish pollination models for selected crops
6. Develop a generalised economic method for evaluation of crop-pollinator-pollination systems
7. Conduct cost/benefit analyses for different crop and pollination systems, at the farm level
8. Conduct total crop production cost analyses for different crop-pollinator-pollination systems, at the national level, including externalities
9. Conduct cost analyses for changes from one crop-pollination system to another, at the international level, including infrastructure maintenanc
10. Disseminate information generated by various means

CONSERVATION AND RESTORATION:

1. Establish an international advisor group on pollinator conservation
2. Establish an international information network on pollinator conservation and a global directory of pollinator experts
3. Assess the state of scientific and indigenous knowledge on pollinator conservatio
4. Develop and update global and national lists of threatened pollinator species
5. Develop model-testing protocols for the introduction of non-native pollinators and to assess impacts of agrochemicals on pollinators
6. Develop an international communication outreach capacity
7. Produce multilingual manuals on pollinator conservation and restoration for farmers
8. Create "bee smart" certification labels for "pollination friendly" products

SUSTAINABLE USE:

1. Disseminate information on pollination in agricultural environments through data bases, websites, and networks
2. Establish a roster of existing pollination and pollinators experts to serve as a pool for consultations in technology transfer
3. Promote applied research on pollination in agricultural cosystems through training of post-graduates to work on gap issues
4. Protect natural habitats, within agricultural landscapes, as sources of wild pollinators for crop improvement
5. Evaluate positive and negative effects of alternative practices and technologies in agricultural production on pollinator conservation and effectiveness
6. Evaluate impacts on pollination of practices and technologies used in agricultural productio
7. Improve the knowledge on the real needs of pollination of tropical crops and forest trees
8. Gather and disseminate/exchange information of best practices
9. Conduct risk/impact assessments of main causes of pollination declin
10. Develop guideline for policy makers and for farmers

INTRODUCTION

*TOWARDS THE ESTABLISHMENT OF AN INTERNATIONAL INITIATIVE ON THE CONSERVATION AND SUSTAINABLE USE OF POLLINATORS **

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Biological diversity is a resource on which man is becoming increasingly dependent. This involves the direct use of biological resources, the indirect use of ecosystem services and the intrinsic uses associated with cultural, social, religious and moral values. Therefore, the world's biological diversity needs to be conserved and wisely utilised. A realistic way to ensure its conservation is to promote and enhance its value to society. Much of the conservation effort in recent decades has emphasised the intrinsic values of biodiversity by appealing to the public's emotional attachment to flagship animals, mostly furry mammals and colourful birds. Nonetheless, despite the increased awareness of the economic importance of the ecosystem services provided by biodiversity, not enough effort has targeted the components of biological diversity which are critical to the maintenance of key ecosystem services (see for example Costanza *et al* 1997, Daily 1997, Pimentel *et al* 1997).

The Brazilian Government presented to the Convention on Biological Diversity (CBD) at th second meeting of its Subsidiary Body on Scientific, Technical and Technological Advic (SBSTTA), held in Montreal, Canada, 2 to 6 Se tember 1996, a proposal to establish a work program on Agricultural Biological Diversity (later published as: Campanhola *et al* 1998) which, among other things, included a proposal for the establishment of an "*International Pollinator Conservation Initiative*". The third Conference of the Parties (COP3) of the CBD, held in Buenos Aires, Argentina, 4 to 15 November 1996, approved Decision III/11 on the "CONSERVATION AND SUSTAINABLE USE OF AGRICULTURAL BIOLOGICAL DIVERSITY" which was based to a large extent on the Brazilian proposal (MMA 1996).

Among the important elements of this decision, the COP3 decided to "*establish a multi-year program of activities on agricultural biological diversity aiming, firstly, to promote the positive effects and mitigate the negative impacts of agricultural practices on biological diversity in agro-ecosystems and their interface with other ecosystems; secondly, to promote the conservation and sustainable use of genetic resources of actual or potential value for food and agriculture; and thirdly, to promote the fair and equitable sharing of benefits arising out of the utilisation of genetic resources; and which, in support of the implementation of ongoing or the initiation of new policies programs and plans in the field of agrobiodiversity, will have the following components. (a) The identification and assessment of relevant ongoing activities and existing instruments at the international level. (b) The identification and assessment of relevant ongoing activities and existing instruments at the national level. (c) The identification of issues which need to be addressed and relevant knowledge. (d) The identification of priority issues for further developmen of the program. (e) The identification and implementation of case studies on issues identified. (f) The sharing of experiences and the transfer of knowledge and technologies"* (UNEP 1996a).

COP3 also decided to draw "*the attention of international funding agencies to the urgent need to support the conservation and sustainable use of biological diversity important to agriculture and invites these agencies to provide information and feedback in this respect to the Conference of the Parties and in this context, requests the interim financial mechanism [the Global Environment Facility - GEF] to give priority to supporting efforts for the conservation and sustainable use of biological diversity important to agriculture in accordance with this decision"* (UNEP 1996a).

Furthermore, COP3 decided to encourage "*interested Parties and international agencies to conduct case studies on the two initial issues identified by the Subsidiary Body on Scientific, Technical and Technological Advice in Recommendation II/7, described in Annex 3"* [of Decision III/11 - Pollinators and Soil Micr -organisms] and instructed "*the Subsidiary Body on Scientific Technical and Technological Advice to co-ordinate and assess the lessons learned from work on the*

topics described in Annex 3 and to report back thereon to the Conference of the Parties, as appropriate" (UNEP 1996a).

The terms of reference approved by COP3 for conducting case studies on the initial issue o pollinators were listed in Annex 3 of Decision III/11 as:

1. "*monitoring of the loss of pollinators worldwide*";
2. "*identification of the specific causes of pollinator decline*";
3. "*estimation of the economic cost associated with reduced pollination of crops*";
4. "*identification and promotion of best practices and technologies for more sustainable agriculture*";
5. "*identification and encouragement of the adoption of conservation practices to maintain pollinators or to promote their re-establishment*" (UNEP 1996a).

The fourth COP, held in Bratislava, Slovakia, 4 to 15 May 1998, approved Decision IV/6 which reiterated "*the invitation of Parties and Governments for further national submissions on ongoing activities, existing instruments and lessons learnt in the area of agricultural biological diversity*", requested Parties, Governments and international organisations " *to begin to provide inputs on the development and application of methodologies for assessments of agricultural biological diversity and tools for identification and monitoring*", requested SBSTTA *to develop and provide the COP in its fifth meeting advice and recommendations for the development of th first phase, and subsequent phases, of the multi-year work program on agricultural biological diversity*" (UNEP 1998a).

The COP also approved an important initial decision on Biodiversity Assessment, Monitori ng and Indicators (Decision III/10) (UNEP 1996b), which among other things approved the establishment of an "Indicator Initiative" for the development and implementation of biodiversity monitoring, materialised in Recommendation III/5 of SBSTTA which was ndorsed by Decision IV/1 at COP4 (UNEP 1998b). Also relevant was the approval at COP3 of a "Global Taxonomy Initiative" by Decision III/10 (UNEP 1996b), and further elaborated by Decision IV/1 (UNEP 1998b) which was based partially on the recommendations of the Darwin Workshop (Environment Australia 1998). Another important relevant development in the CBD was the approval by Decision II/8 that a "*ecosystem approach should be the primary framework of action to be taken under th Convention*", initially characterised in SBSTTA Recommendation I/3, a concept currently being developed within the CBD, as exemplified by the key principles recommended by the Malawi Workshop (UNEP 1998c).

The COP Decision III/5 (UNEP 1996c) further called on the Global Environment Facility - GEF, in accordance with Decision III/11, to provide financial resources to developing countries for country driven activities and programs, consistent with national priorities and objectives, for supporting, as a priority, efforts for the conservation and sustainable use of biological diversity important to agriculture.

The GEF Secretariat is working together with implementing agencies, STAP, the CBD Secretariat, and other stakeholders to address operational aspects of carrying out COP guida ce on agrobiodiversity. Recently the GEF released a draft framework document on how it can support activities concerning the conservation and sustainable use of biological diversity important to agriculture (GEF 1998), in response to COP Decision III/11. This statement aims to respond to COP Decision III/5 within the GEF mandate, which is to operate as a mechanism for the purpose of providing new and additional grant and concessional funding to meet the agreed incremental costs of measures to achieve agreed global environmental benefits. Recently the GEF decided to establish a new Operational Program on Agricultural Biodiversity.

An important initiative calling for the establishment of adequate policies for the conservation of pollinators has been documented by Stephen Buchmann and Gary Nabhan in their book "Th Forgotten Pollinators" (Buchmann and Nabhan 1996; see their Appendix 1 on the Call for a National Policy on Pollinators)

With a view to contributing to the development of the CBD's multi -year work program on agricultural biological diversity (approved by COP Decisions III/11 and IV/6) the Brazilian Government decided to hold an international workshop of experts to discuss a framework for an

International Initiative on the Conservation and Sustainable Use of Pollinators as one of the key elements in the first phase of this CBD work program and based on the Terms of Reference provided by Annex 3 of COP Decision III/11. We hope the recommendations produced by this workshop will help foster support from agencies worldwide to enhance initiatives on all continents on pollinator conservation and their sustainable use. This would provide critical data and experience, promot partnerships between agricultural, conservationist and academic institutions which would help to mainstream the issue of biodiversity in our society and direct the conservation movements to promot the maintenance of biodiversity as an essential component to ecosystem functioning.

The following broad questions were put before t e workshop participants:

1. Do we all agree we have a problem of pollinator decline (both in abundance and in species richness) and in pollination deficit which already affects agriculture [including managed forests and rangelands, as well as adjacent natural ecosystems] productivity and sustainability? How serious is this problem? Is it getting worst? Do we have adequate data to assess and quantify the current status and trend? Is the issue equally important/urgent in all continents and for all kinds of animal-pollinated crops? Could we provide a critical and comprehensive assessment of availabl data worldwide, continent by continent?
2. Do we have enough experts and adequate standardised methods to conduct a worldwide quantitativ assessment of the current status and trend of **pollinator decline** (both in abundance and in species richness)? How much time and resources would we need to do it? Could we obtain the necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
3. Do we have enough experts and adequate standardised methods to conduct a worldwide quantitativ assessment of the current status and trend of **pollination deficit** or flower resources harvested by wild pollinators? How much time and resources would we need to do it? Could we obtain th necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
4. Do we have adequate data to identify the relative importance of the different putativ **causes of pollinator decline** in the different regions of the world? Do we have enough experts and adequat standardised methods to conduct a worldwide quantitative assessment of the relative importance of current causes of pollinator decline? How much time and resources would we need to do it? Could we obtain the necessary data to produce a first worldwide "Glob al Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
5. Do we have adequate data to assess the current impact of **habitat fragmentation** on pollinator diversity in the different regions of the world? Do we have enough experts and adequat standardised methods to conduct a worldwide quantitative assessment of the contribution of habita fragmentation to pollinator decline? How much time and resources would we need to do it? Could we obtain the necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
6. Do we have adequate data to assess the current impact of **introduced exotic species** on pollinator diversity in the different regions of the world? Do we have enough experts and adequat standardised methods to conduct a worldwide quantitative assessment of the contribution of introduced exotic species to pollinator decline? How much time and resources would we need to d it? Could we obtain the necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
7. What kinds of criteria and assessments should be required before authorising th **introduction of exotic pollinators** to ensure the conservation of pollinator diversity to enhance agricultur sustainability? Could we provide national and international agriculture agencies with a set of concrete actions, criteria and targets to be implemented to promote and ensure the safe introduction of exotic pollinators that could have a positive impact on agriculture sustainability
8. Do we have adequate data to assess the current impact of **pesticides** on pollinator diversity in th different regions of the world? Do we have enough experts and adequate standardised methods to

conduct a worldwide quantitative assessment of the contribution of pesticides to polli ator decline? How much time and resources would we need to do it? Could we obtain the necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?

9. Do we all agree we have a problem of **taxonomic impediment** related to most pollinator groups, which limits our capability to assess and monitor pollinator decline and to sustainably manage an conserve pollinator diversity? How serious is this problem? Do we have adequate data to assess th current status and trend? Is the issue equally important/urgent in all continents? How much effor and time would it take to eliminate this impediment? What could be done internationally or at th regional and national level to significantly reduce this problem in a relatively short time?
10. Do we have adequate data to **identify the effective pollinators of all major crops** of the world, continent by continent? Do we have enough experts and adequate standardised methods to conduct a worldwide quantitative assessment of the effectiveness of key pollinators of all major crops of the world? How much time and resources would we need to do it? Could we obtain the necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for th Convention on Biological Diversity in, say, three years time?
11. Do we have adequate data to quantify the **economic value** of pollination to agriculture worldwide, in the different regions of the world? Do we have enough experts and adequate standardised methods to conduct a worldwide quantitative assessment of the economic value of pollination to agriculture and to assess the economic impacts of pollinator decline and pollination deficit? How much time and resources would we need to do it? Could we obtain the necessary data to produce a first worldwid "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
12. Are the current **conservation efforts** worldwide sufficient to halt the pollinator decline? Do th current conservation efforts aimed at biodiversity conservation have a significant impact on th conservation of native pollinators for agriculture? What kinds of conservation efforts/initiatives and criteria would be most appropriate to ensure the conservation of pollinator diversity to enhanc agriculture sustainability? Could we provide national and international conservation and agriculture agencies with a set of concrete actions, criteria and targets to be implemented to promot and ensure the conservation of pollinator diversity which could have a positive impact on agricultur sustainability?
13. Could we provide national and international agriculture organisations with a set o concrete actions, best practices and targets to be implemented to promote and ensure the **conservation of pollinato diversity**, which could have a positive impact on agriculture sustainability? Could we propose a set of concrete initiatives to **promote the co-operation** between agriculture and conservation agencies to enhance pollinator conservation and sustainable use?
14. Could we provide conservation and agriculture agencies worldwide as well national agencies and NGOs with an updated **redbook list of endangered pollinator species**, including information on their nesting and flower requirements, at the global, regional and national level? Do we have enough experts and adequate standardised methods to conduct a worldwide quantitative assessment of endangered pollinators? How much time and resources would we need to do it? Could we obtain th necessary data to produce a first worldwide "Global Biodiversity Outlook report on Pollinator Diversity" for the Convention on Biological Diversity in, say, three years time?
15. Are the current **restoration efforts** worldwide sufficient to revert or compensate the pollinator decline? Do the current restoration efforts aimed at biodiversity conservation have a significant impact on the conservation of native pollinators for agriculture? What kinds of restoration efforts/initiatives and criteria would be most appropriate to ensure the restoration of pollinator diversity to enhance agriculture sustainability? Could we provide national and international conservation and agriculture agencies with a set of concrete actions, criteria and targets to b implemented to promote and ensure th restoration of pollinator diversity which could have a positive impact on agriculture sustainability?
16. Are the current pollinator/pollination management practices sustainable? Do the current pollinator/pollination practices have a significant impact on the conservation of native pollinators?

Can we provide an assessment of such impact? What kinds of management efforts/initiatives an criteria would be most appropriate to ensure the conservation and **sustainable use of pollinator diversity** to enhance agriculture sustainability? Could we provide national and international agriculture agencies with a set of concrete actions, criteria and targets to be implemented to promote and ensure the sustainable use of pollinator diversity that could have a positive impact on agricultur sustainability?

17. As the 172 countries which have ratified their membership to the Convention on Biological Diversity are obliged to regularly present **National Reports** to the Conference of the Parties (COP) about the measures taken to implement the objectives of the Convention and to report on the effectiveness of such measures, could we provide the COP with suggested **guidelines** on how countries could prepar a first report on the issue of pollinator diversity conservation and sustainable use, based on the terms of reference already approved in Decision III/11 (paragraph 11 and annex 3)?

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DIVERSITY OF PLANT AND DIVERSITY OF POLLINATORS *
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There are some 240,000 species of flowering plants described. Why are they so diverse? Why ar their flowers so different in shape, colour and odour? The sexual organs of a plant are in its flowers. To set seed, flowers must be pollinated. This means, the male genes in a pollen grain must be brought from the male organ, the anthers, of a flower to the stigma, or female part, of another flower of the same species. In some cases this is done by wind or water. However, pollination in the majority of plants, specialised pollinators are needed to transfer the pollen between conspecific flowers.

Pollinators are found in diverse groups of the animal kingdom; among them b irds, bats, opossums (relatives of kangaroos), giraffes, reptiles, flies, beetles, moths, butterflies, wasps and - last but not least - bees (Faegri and van der Pijl 1979, Proctor *et al* 1996). Each pollinator species reacts to and is attracted by a specific set of signals given by the flowers. This variety of signals and th different modes of reaction by the receiver clearly show that most of the interrelations between plants and their pollinators ar finely tuned and can be easily disturbed or broken.

Diversity of pollination syndromes
Pollinators are animals that visit flowers to collect resources like nectar, oils, pollen, scents, etc. for their own use and for their young. It is not their ai to pollinate, but they are exploited by the flowers for this purpose. Plants produce pollen for their reproduction and, to breed successfully, they need specialised, reliable pollinators and, therefore, often hide their pollen from non-pollinating visitors. Each structure designed to hide the pollen or nectar results in the evolution of 'tools' to exploit it. Most of the forces which both shape flowers also mould the bodies and behaviour of pollinators and the surprisingly high diversity arises from these conflicting interests. According to their specific set of signals and reactions, flowers and their pollinators can be arranged in groups.

Melittophily
Melittophilous plants are attractive to bees. Their flowers are sweetly scented and most blue or yellow, rarely red. B -pollinated flowers show the highest diversity of all animal-pollinated plants. Much of the diversity in shape is due to the high variety of mechanisms by which the flowers hide or present their pollen and nectar. Plant and bee coevolution is based on the offer of resources that ar can only found in melittophilous flowers: droplets of resin, fatty oils and perfumes that are collected by numerous species of highly specialised bees. Furthermore, several melittophilous flowers imitate the shapes and the sex perfumes of female insects in order to attract the males that are the pollinators. There might be as many as 40,000 species of leafcutter bees, sweat bees, mason bees, sand bees, carpenter bees, minor bees, carder bees and stingl ss bees. The well-known honeybee is one of only seven species in the genus *Apis* worldwide. Bees pollinate the majority of the 240,000 species of flowering plants

Myiophily
The high diversity of fl -pollinated flowers is based on a variety of imitations with which they attract flies. They mimic the different substrates onto which flies lay their eggs. The display of thos mimicked substrates is often combined with traps which imprison the flies. Scent, colour and form of the flowers depend on the matter used in deceit: faeces, carcasses, rotten plants, fungi etc. Other flies, like hoverflies visit the open flowers which are attractive to bees.

Cantharophil
Some beetle-pollinated flowers are easily accessible but others form traps in which the pollinators are caught, dusted with pollen and released. The flowers emit strong odours which attract their pollinators and heating the flower often stimulates odour emission. Visual cues are less important for the beetles in detecting these flowers.

Sphingophily
Moth-pollinated flowers open only at night. Their strong sweet perfumes attract moths from afar. The moth remains on the wing while introducing its tongue into the deep nectar container, the entranc of which is star-shaped. These flowers include the longest nectar bearing tubes known in the plant kingdom. Much of the diversity originates from variations in the lengths of the floral tubes and th pollinators' mouthparts.

Psychophily
Butterfl -pollinated flowers emit an agreeable smell and have attractive colours. Their shape is usually a combination of a tube with a sta -shaped display on top. These tubes are considerably shorter than those of sphingophilous flowers. The flowers open and are visited during daytime. Nectar is availabl in small amounts, and has a low sugar content to enable it to pass through th narrow canal of the insects' tongue. Besides butterflies, certain long-tongued flies visit such flowers.

Ornithophily
Bird-pollinated plants are often lon -lived shrubs or trees. Their flowers are usually unscented but characterised by their bright, often contrasting colours, which often include scarlet. Usually th flowers are exposed outside the foliage so that they can be easily approached in flight. The larg amount of nectar has a low sugar content and is often located at the base of the tubular flower. Th high diversity of tubes coincides with the lengths and curvatures of the birds' beaks. The plants differ in whether they have landing platforms in front of the flowers. Some 2,000 (of 9,000) species of birds in some 50 families are pollinators. Birds have high energy demands and are relatively lon -lived, necessitating a sufficient supply of nectar year-round - either by long-lasting blooms or by a sequenc of different plants producing flowers.

Chiropterophily
Bat-pollinated flowers have sour or cabbagy odours. Generally they are located outside the foliage s they are readily approached by their nocturnal pollinators. The flower is large to accommodate th large head of a bat and, as the bat often holds on the flower or inflorescence, are robust. Thes pollinators have high energy needs and are long-lived, which requires a continuous sequence of flowers for an adequate supply of nutritious nectar in the for m of large quantities of dilute, often somewhat slimy, nectar.

The key role of pollination
Pollination is one of the most important mechanisms in the maintenance and promotion of biodiversity and, in general, life on earth. Only after pollination ca plants set seed and fruit, and plants depend on seeds for reproduction. Fruits (e.g. cucumbers, bananas, avocados, figs, cherries) and seeds (e.g. soy beans, peanuts, hazelnuts, sesame) are essential food for man and animals, as are their leaves (e.g. green salad), flowers (e.g. cauliflower and broccoli), stems (e.g. sugar cane) and roots (e.g. sweet potatoes). Maintaining the diversity of plants and pollinators also means maintaining the diversity of our food, even meat, as live stock fodder, such as clover and other forage legumes, require pollination for seed set.

* Dieter Wittman, University of Bonn, Germany

THE IMPORTANCE OF POLLINATION TO AGRICULTURE AND THE RISKS OF POLLINATOR DECLINE *
[* asterisk of previous line not to appear in Table of Contents]

One-third of the economic worth of the total agricultural production of the U.S. depends on insects visiting the crops' flowers so that the plants can produce seeds and fruits (McGregor 1972, [http://gears.tucson.ars.ag.gov/book/index.html]; Buchmann and Nabham 1996). As there is less wind pollination and more animal pollination in the tropics we can expect the proportion worldwide to be even higher. The annual value of this service in the U.S. alone is calculated at US$ 6-8 billion (G. Nabham per. obs.) and the estimate worldwide is US$ 65-70 billion (Pimentel *et al* 1997). In their presentation at this Workshop Kenmore and Krell estimated loss through lack of pollination for the 30 crops they cite to be US$ 54.6 billion representing a 46% loss of harvest.

Specialists estimate that two-thirds of the world's 3,000 species of agricultural crops requir animals for pollination. Thousands of species of animals are responsible for this servic comprising bees, birds, wasps, beetles, butterflies, moths and flies (Buchmann & Nabhan 1996; Kevan, 1999). By far the greatest part is provided by bees, which are responsible for the pollination of some 73 % of the world's crops (Roubik 1995a). The most widely used species in crop pollination is the honeybee (*Apis mellifera*) which is the only one that has been thoroughly domesticated.

Fundamentally agro-ecosystems are much the same as natural ecosystems in that some are more complex with greater numbers of species and some are simpler with fewer. This complexity is a result of the many links between the species present. Species depend on others for many services, the most obvious of which are in providing food and shelter and in the production and disseminatio of their seeds. Therefore, it seems inevitable that the increasing specialisation relying on fewer species, varieties and genetic strains of crops be reflected in losses of associated species of nativ organisms. However, in most instances we know little of the extent that agricultural success depends on these other species.

A major problem is emerging for the world's agricultural production reflecting the risk involved in relying on a single species (Buchmann & Nabhan 1996). Recently honeybees in many parts of th world have contracted the pandemic diseas – varroatosis caused by minute *Varroa* mites. Largely due to the presence of this disease in the U.S. (the only country for which reliable data exist) th number of honeyb colonies has decreased by one-third over the past six years. Fruit and vegetabl growers in the U.S. and in Europe are complaining of poor fruit sets despite good blooming. As varroatosis has already spread throughout most of the world specialists consi der it a matter of time before other countries also become seriously affected.

Farmers and growers have begun asking about the use of native bees. There are probably mor than 25,000 species of bees worldwide and many of them are known to be efficient pollinators of crops (Crane and Walker 1984, Roubik 1989, O'Toole and Raw 1991). Although most estimates o the economic value of crop pollinators give credit to the honeybee (*Apis mellifera*) (Southwick an Southwick 1989 & 1992), many other species of bees are involved (Richards 1993). For some years several species of wild bees have been managed for the pollination of crops (Bohart 1972, Torchi 1987, 1990, 1991, 1994) and the management of additional species for glasshouse crops has developed rapidly during the past few years.

However, the numbers of native bees are dwindling; some species seriously so. Declines in th numbers of native species have been reported in Central and North America (Janzen 1974, Torchi 1987, Kevan *et al* 1990, Kevan *et al* 1996, Frankie *et al* 1997, Allen-Wardell *et al* 1998) and six countries in Europe (Corbet *et al* 1991, Osborn *et al* 1991, O'Toole 1994, Banaszak 1995, 1996, Williams 1989 & 1996). Most of the reliable information is on species which visit crops. The losses are due mostly to the use of agrochemicals and monocultures and to deforestation. The chemicals kill bees and, with the removal of wild vegetation and crop specialisation, the bees find neither places to nest nor alternative flowers while they await the crop to bloom (Rathcke and Jules 1994).

The emergence of a serious and widespread honeybee disease has made it clear that native pollinators need be exploited for the pollination service they can provide and that agricultural practices be designed to incorporate the protection and the sustainable management of the bees' populations.

The rapid development of transgenic crops raises additional causes for concern amon specialists on bees. The employment of a herbicide or pesticide coupled with a variety of crop

resistant to it could eradicate all alternative forage for pollinators leading to a devastation of their numbers.

The emphasis in this Workshop was on suggesting means of reducing the effects of the losses of pollinators to agriculture, however, there is another positive side to the issue. We have little or n information on most of the world's crops to be able to say if they receive adequate visits of pollinators to effect maximum yields, yet detailed research on numerous crops has demonstrat d clearly that pollination can be a limiting factor to yields. Many farmers invest heavily in fertiliser and pest control, but do not heed the pollination requirements of their crops. The recommendations of the Workshop should enable us to improve the yi elds of many crops whose production depends on animal visitors.

* Anthony Raw, University of Brasília and State University of Santa Cruz, Ilhéus, Brazil

WORKSHOP RESULTS: THE SÃO PAULO DECLARATION ON POLLINATOR

EXPLANATORY REMARKS

The problem of the emerging pollinator crisis emphasises the need for a multi-faceted approach which unites the expertise of a wide variety of scientists. On the one hand are the bee taxon mists, those studying the biology of pollinators and managing their populations. On the other are botanists concentrating on pollination, crop management and economic botany. At a different level th pollinator crisis exemplifies the intimate relationship existing between the welfare of natural environments and their biodiversity and the needs of sustainable agriculture.

The six work groups produced a total of 31 proposals for action (Table 2). In practice the number is greater as two groups presented single composite actions. Through their deliberations a framework of proposals for action was compiled to enable the establishment of an international initiative for the conservation, restoration and sustainable use of pollinators worldwide. There follo the recommendations of the workshop o *The Conservation and Sustainable Use of Pollinators in Agriculture with Emphasis on Bees* (as a contribution for the implementation of Decision III/11 of th Convention on Biological Diversity).

SUMMARY OF MAJOR FINDINGS

1. All the participants remarked that we have insufficient reliable data on the reported declines in the numbers of pollinators and their effects on agriculture worldwide.

2. Some experts have clear evidence demonstra ting that numbers have declined, while most stated their data only suggest that pollinators are declining, but all considered the information to indicate emphatically that an impending crisis exists.

3. They stated that reliable methods are available to collect standardised data worldwide, on th status and trends of pollinators, provided that institutional support is given and more experts are trained.

4. All stressed the need to have access to reliable data on the reported declines to:
   a. explain why they are occurring,
   b. make confident evaluations of their expected effects on agricultural production,
   c. select the necessary action to resolve the question.

5. The experts agreed on the difficulties in obtaining reliable identificati n of pollinators (especially of bees) which are vital for the success of both the monitoring programme and pollination management.

6. They emphasised the need to expand the understanding of pollination requirements of crops worldwide.

7. All recognised the need to produce manuals on methods and catalogues of species and interactions.

8. The experts called for the creation of networks and websites with databases of specialists publications and information on pollination requirements of crops, pollinators decline an management.

9. The need for better public awareness of the problem was recognised, as well as the dissemination of best practices on native pollinators conservation and sustainable use.

10. The major tasks are to:
   a. monitor th numbers and diversity of pollinators of target crop systems and landscapes;
   b. determine the pollination requirements of crops and their effective pollinators
   c. refine the estimates of the economic worth of pollination and the cost of its decline;
   d. test and recommend pollinator management and restoration strategies;
   e. appraise methods to increase the sizes of pollinators' populations and diversity,
   f. stimulate public awareness of the role of pollinators in their lives.

LIST OF PROPOSALS FOR ACTION

TAXONOMIC IMPEDIMENT:

3. Assess the scale of the Taxonomic Impediment
4. Maintain continuity of existing taxonomic and reference collections of bees
5. Establish Centres of Excellence in Bee Taxonomy
6. Train bee taxonomists
5. Train parataxonomists
6. Repatriate data [Capacity building and benefit sharing]
7. Stimulate taxonomic output
8. Hold a Workshop on motivation and training of parataxonomists
9. Hold a Workshop on automated systems for bee ide tificatio

MONITORING THE DECLINE:

1. Establish a committee to co-ordinate a global monitoring plan and network
9. Refine plans and methods for implementation of a global monitoring plan
10. Assess methods, prepare manuals for monitoring pollinators a d train participants
11. Implement a pilot global monitoring program in selected areas worldwid
12. Assess the potential impact of exotic pollinators on native pollinators
13. Establish a network of websites with databases for all pollinator monitoring data
14. Prepare a Global Biodiversity Outlook Report on the status and trends of pollinators
15. Promote follow up activities to ensure continuity and improve the proposed progra

CAUSES OF DECLINE:

3. Assess pollinator diversity and pollinator efficiency in representative agroecosystems an adjacent natural and seminatural environments
4. [This issue needs further attention, as workgroup report was not submitted]

ECONOMIC IMPORTANCE:

11. Establish a network of experts and a network of database
12. Determine the pollination requirements of each crop species
13. Determine best pollinators for each crop species
14. Determine impact of pollinator presence/absence on fruit and seed yiel
15. Establish pollination models for selected crops
16. Develop a generalised economic method for evaluation of crop-pollinator-pollination systems
17. Conduct cost/benefit analyses for different crop and pollination systems, at the farm level
18. Conduct total crop production cost analyses for different crop-pollinator-pollination systems, at the national level, including externalities
19. Conduct cost analyses for changes from one crop-pollination system to another, at the international level, including infrastru cture maintenance
20. Disseminate information generated by various means

CONSERVATION AND RESTORATION:

9. Establish an international advisory group on pollinator conservatio
10. Establish an international information network on pollinator conservation and a global directory of pollinator experts
11. Assess the state of scientific and indigenous knowledge on pollinator conservatio
12. Develop and update global and national lists of threatened pollinator species
13. Develop model-testing protocols for the introduction of non-native pollinators and to assess impacts of agrochemicals on pollinators
14. Develop an international communication outreach capacity

15. Produce multilingual manuals on pollinator conservation and restoration for farmers
16. Create "bee smart" certification labels for "pollination friendly" products

SUSTAINABLE USE:

11. Disseminate information on pollination in agricultural environments through data bases, websites, and networks
12. Establish a roster of existing pollination and pollinators experts to serve as a pool for consultations in technology transfer
13. Promote applied research on pollination in a gricultural ecosystems through training of post-graduates to work on gap issues
14. Protect natural habitats, within agricultural landscapes, as sources of wild pollinators for crop improvement
15. Evaluate positive and negative effects of alternative practices and technologies in agricultural production on pollinator conservation and effectiveness
16. Evaluate impacts on pollination of practices and technologies used in agricultural productio
17. Improve the knowledge on the real needs of pollination of tropical crops and forest trees
18. Gather and disseminate/exchange information of best practices
19. Conduct risk/impact assessments of main causes of pollination declin
20. Develop guidelines for policy makers and for farmers

FOLLOW-UP RECOMMENDATIONS

The participants of the workshop proposed follow up activities to promote the initiative which needs to be developed:

1. Propose that COP5 formally establish an *International Pollinators Initiative* based on the framework for action contained in this report.

2. Request that COP5 call for international Co-operation to develop th *International Pollinators Initiative*. It is suggested that this initiative be supported by existing organisations, particularly the relevant organs of FAO, and IUCN, IBRA, ICPBR and Apimondia.

3. Recommend that COP 5 request the financial support of the Global Environment Facility - GEF for this initiative.

4. Recommend that COP 5 request SBSTTA to co-ordinate, with support from the Executive Secretary, the preparation of a first *Global Biodiversity Outlook Report on Pollinators – GBO-P*.

a) It is suggested that a first GBO-P be prepared for 2002 based on published and other existing data.

b) A second GBO-P could be prepared for 2005 based on standardised monitoring of pollinators and pollination worldwide. This will depend on establishing th monitoring programme with a functioning network of agreed selected sites and proven methods.

5. Propose the creation o f a Pollinators Specialist Group within the Species Survival Commission of the IUCN.

CONVERGENCE OF PROPOSALS

The proposals for action of this Workshop are varied, but many are concerned with the collection of reliable infor ation and its dissemination. The predominance of these two subjects demonstrates th participants' desire to have access to better data. Some of this information already exists but is not readily available, while much additional data need to be collected.

Need to collect reliable data:

1. Standardised monitoring of the numbers of pollinators (particularly bees) over a worldwide network of selected sites is essential for identifying patterns of change in their numbers.
2. The monitoring programme would entail substantial improvements in the services of the identification of pollinators and there is a serious limiting taxonomic deficit in this respect.
3. Assessment of the pollination requirements of agricultural crops and of the roles of pollinato rs will permit improvements in pollination and thus of crop production.
4. Assessment of the economic worth of crop pollinators should be feasible once the data from # 3 are available.
5. Identification of the means of conserving and increasing the numbers of pollinators is a subject for multidisciplinary approach.

Communication:

Suggested publications:
Manuals on monitoring techniques
Manuals for measuring pollinator decline
Manuals for promoting pollinator recovery
Global Biodiversity Outlook Reports on the Status of pollinators

Web site:
A co-ordinated network of web site is required with lists of researchers, crops, pollinators, pollination, publications, crop losses and all t e data from the monitoring programme. It should b organised at local and global levels and with Internet access. This might be organised and run b FAO and IBRA.

Education:
Educational programmes for the public, for schools and for post-graduate cour ses.
Training programmes for entomologists and parataxonomists.
Use of post-docs in long-term studies, to disseminate knowledge and in regional training programs, with the standardised methodologies established in this programme, emphasising regionally important pollinators.

Further specialist meetings:
Another international planning workshop like the Sao Paulo workshop should be organised an aimed at specialists from Asia, Australasia, Eastern Europe and Africa (regions under-represented at the Sao Paulo workshop) to complement the recommendations of the Sao Paulo workshop, from the perspectives of these regions. This event could provide an opportunity to further detail the proposals for actions recommended in São Paulo, as well as consolidate th support of international and national agencies to the proposed International Initiative on the Conservation and Sustainable Use of Pollinators.

Regional meetings should be organised in each continent, similar to the one that discussed th European perspectives held at the Linnean Society, London, 8 April 1995. Nevertheless international participation and guidelines are important for helping in the establishment of new and stronger joint projects, emphasising a general improvement of the pollinators' use on a global scale.

Follow-up discussions at international meetings:

International Congress of Entomology, Iguaçu, Brazil

In one follow up activity for the proposed framework for an International Initiative on th Conservation and Sustainable Use of Pollinators the Organising Committee of the XXI International Congress of Entomology, to be held in Foz do Iguaçu in Brazil in t he year 2000, has agreed o hold a symposium on the "International Initiative on the Conservation an Sustainable Use of Pollinators".

Seventh IBRA Conference on Tropical Bees, Chiang Mai, Thailand
It is planned to present an interim report on the São Paulo workshop and its consequences at the Seventh IBRA Conference on Tropical Bees: Management and Diversity, Chiang Mai Thailand, 19-25 March 2000.

Eighth International Symposium on Pollination, Hungary
It is planned to present further information on the São Paulo "International Initiative on th Conservation and Sustainable Use of Pollinators" at the Eighth International Symposium on Pollination in Hungary, 10-14 July 2000.

International Congress of Zoology, Athens, Greece
One of the Plenary Sessio s at the International Congress of Zoology to be held in Athens, 28 August - 2 September 2000 will be devoted to the Taxonomic Impediment, using bees as an example and drawing on the deliberations of the São Paulo Workshop.

ANNEXE

WORKSHOP PROGRAM

7-9 October 1998

DAY 1. STATE OF TH ART AND IMPORTANCE OF THE ISSUE

7 October: An open seminar with invited speakers

08:45 – 09:30 hr Opening ceremony

09:30 – 10:30 hr

Round table: The importance of pollinators to agriculture

Kenneth Richards and Peter Kevan. Aspects of bee biodiversity, crop pollination and conservation in Canada.

Ingrid Williams: Insect pollination and crop production: a European perspective.

John Donaldson. Do pollinators matter? Plant pollination and sustainable agriculture in th southwestern part of South Africa.

David Roubik. Coffee pollination in the Americas for the 21st Century?

10:50 – 11:50 hr

Round table: The causes of pollinator diversity decline

Marcelo Aizen. Forest fragmentation, bee decline and plant pollination in Argentina.

Luiza Ruz. Bee pollinators introduced into Chile.

Amots Dafni. Fire, *Bombus terrestris* and the threat to solitary bee diversity in a Mediterranean ecosystem.

Claudia Jacobi. Dispersal studies in pollinator-crop systems.

11:50 – 12:30 hr

Round table pollinator monitoring

Gordon Frankie, S. Bradleigh Vinson and Robbin Thorp. Monitoring; an essential tool for b ecology and conservation.

Afonso Orth and Sebastião Laroca. Melissocoenotics: historical perspective, method of sampling and an essay on the detection of diversity – Monitoring parameters at community level.

Poster section

14:00 – 15:15 hr

Round table: Impediments in pollinator taxonomy

Connal Eardley. Afrotropical bees now. What next?

Christopher O'Toole. Those other bees: how can we change the funding cultur

Ricardo Ayala. Bee diversity in Mexico.

Fernando A. Silveira. Knowing the local pollinator fauna as a condition for conservation and management: the Brazilian wild bee fauna.

Dieter Wittmann, S. Schröder, V. Roth and V. Steinhage. Automated identification system for bees (Hymenoptera, Apoidea).

15:15 – 16:25 hr

Round table: Conservation of pollinator diversity

Stephen Buchmann. Estimation, conservation and sustainable uses of native bees for pollination of agricultural and wildland plants in the United States, with implications for the tropics.

Michael Ruggiero. A federal agency's interest in saving pollinators.
Koos Biesmeijer. Partitioning of nectar resources, thermal melanis and biogeography of stingless bees.
Paulo Eugênio Oliveira. Pollinators of Cerrado trees: diversity and its consequences.
Paulo Nogueira-Neto. Management of plants to maintain and study pollinating bee species, and als to protect vertebrate frugivorous fauna.

16:45 – 17:45 hr

Round table: Sustainable use of pollinators

Aad de Ruijter. Sustainable beekeeping and pollination with honeybees, bumblebees and solitary bees.
Hayo Velthuis. The introduction of bumblebees into agriculture.
Haroldo Toro. Pollination of *Prosopis* in the Atacama Desert.
Rainer Krell. Global perspective of pollination on agriculture.
Gerhard Gottsberger and Christian Westerkamp. The costly crop-pollination crisis.

17:45 – 18:00 hr

Talk on organisation of the work

Braulio Dias. Results expected from the workshop and organisation of the work.

18:00 – 18:30 hr Discussion on expected results

18:30 – 19:30 hr Evening co-ordination meeting for organisers, co-ordinators, key participants and rapporteurs.

Issues: Review range of possible proposals for actio
Review possible follow up and c -ordination initiatives
Review ideas on the publication of book with submitted papers
Organisation of work for day 2

DAY 2. FRAMEWORK FOR AN INTERNATIONAL INITIATI E ON POLLINATOR

8 October: Work Group discussions

08:30 – 09:00 hr Short Plenary on the organisation of Work Groups

09:00 – 17:15 hr Work Group discussions

Six Work Groups, one each on the following program elements:

1. Reducing the Taxonomic Impediment on Pollinators
2. Monitoring the Decline of Pollinators
3. Identifying the Causes of Pollinator Declin
4. Quantifying the Economic Value of Pollinators to Agricultur
5. Conservation of Pollinator Diversity
6. Sustainable Use of Pollinators

13:30 – 14:00 hr Co-ordination meeting for organisers, co-ordinators and rapporteurs

Issue: Assess functioning of work groups

17:15 – 18:45 hr Short Plenary with presentation of Work Group reports

18:45 – 19.30 hr Co-ordination meeting and informal meetings for organisers, c -ordinators, key participants and rapporteurs

Issues: Assess functioning of work groups
Discuss preparation of work group reports

Organisation of ork for day 3
Review range of possible proposals for actio
Review possible follow up and c -ordination initiatives

DAY 3. CONSOLIDATION OF RECOMMENDATIONS

9 October An open plenary session with discussion of work group proposals

08:30 – 09:00 hr Short Plenary on the organisation of Work Groups

09:00 – 12:15 hr Work Group discussions (continuation)

13:30 – 14:00 hr Co-ordination meeting for organisers, co-ordinators and rapporteurs
Issues: Assess conclusion of discussions in work groups
Review preparations for presentation of work group reports
Organisation of work for the afternoon

14:00 – 17:30 hr Plenary Session
Presentation of Work Group reports
Discussions on Follow up activities

17:30 – 18:00 hr Closing ceremony

18:00 – 20:00 hr Co-ordination meeting for organisers, co-ordinators and rapporteurs
Issues: Assess results of work groups and plenary session
Review preparation of work group reports
Review preparation of workshop report
Selection of the editors for the book resultant from the meeting

FRAMEWORK OF ACTIONS TO IMPLEMENT INTERNATIONAL POLLINATORS INITIATIVE

Possible kinds of actions

At the start, possible topics, which might be discussed by the work groups, were suggested and th participants encouraged to add their own ideas. Some topics were discussed in more than one work group.

The list included the following:

- monitoring and indicators
- targeted research
- case studies
- conservation efforts
- restoration efforts
- best practices for management
- information dissemination
- training and capacity building
- economic incentives and measures
- partnerships and co-operation
- policy measures
- legislation

The specific suggestions provided for the separate groups are listed at the start of each group's program element report under "Topics suggested for discussion".

Presentation of the group reports

The reports of the six work groups for the program elements of day 2 are presented with their Proposals for Action. The structure of the reports of the work groups presented below is not standardised as it is considered important to maintain the original presentation of the c -ordinators of each work group.

However, each group was requested to present their **proposals for action** in a standardised format. The structure suggested for each proposal for action comprised:
a concise and clear title,
concise description of objectives,
rationale and urgency of the proposal,
indication of how the objectives can be achieved,
proposal of a feasible timeframe to implement the proposal,
identification of the needs and opportunities for partnerships and co-operation, an
identification of major constraints for the implementation of the proposed action.

PROGRAM ELEMENT 1: REDUCING THE TAXONOMIC IMPEDIMENT ON POLLINATORS:

Co-ordinator: Christopher O'Toole,

Members:

Ricardo Ayala	Isabel A. dos Santos
Connal Eardley	Fernando Silveira
Gabriel Melo	Robbin Thorp
Jesus S. Mour	Dieter Wittmann

Rapporteur: Professor Francis Dov Por

Topics suggested for discussion

1. Assess current state of knowledge
2. Identify constraints for pollinator taxonomy
3. Build on the recommendations of the "Darwin Declaration
4. Assess production of regional and world catalogues of major pollinator taxa
5. Assess production of taxonomic revisions of major pollinator taxa
6. Assess production of identification keys for major pollinator taxa
7. Assess consolidation of identification services for major pollinator taxa
8. Assess preparation of directories of pollinators, pollination syndromes and experts
9. Evaluate capacity building for pollinator identification and systematics

PREAMBLE

The animals responsible for crop pollination are bees, birds, butterflies, moth, beetles and flies (Buchmann & Nabhan 1996). The taxonomic expertise on these animals is varied; birds, butterflies and moths are well known, but bees, beetles and flies far less so. The great majority of crops needing pollination are pollinated by bees (Roubik 1995a) of which there are some 25,000 species (O'Tool and Raw 1991) so the work group discussed these insects.

Bees and their life-sustaining relationships with flowering plants occupy keystone positions in both natural and agricultural ecosystems (Buchmann & Nabhan 1996). Bee faunas are therefor important natural resources. As with all natural r esources, inventories of their diversity and distribution are needed if we are to manage them to our best advantage (O'Toole 1993)

Unfortunately, the current state of bee taxonomy imposes severe restraints on the realisation of these goals (O'Toole 1996) - as it does for other pollinator groups like flies, wasps and beetles. This, the Taxonomic Impediment (TI), derives from serious shortfalls in investment in training, researc and collections management. It seriously limits our capability to assess and monitor pollinator decline, to conserve pollinator diversity and to manage it sustainably. Moreover, there is a growing perception that access to sound bee taxonomy will be at a premium because:

- research projects in pollination biology, both of nati e floras and crop plants, are on the increase and require bee identifications
- biodiversity studies increasingly involve bees as bio-indicators via b -plant associations and require identifications
- the pandemic disease, varroatosis has resulted in a 40-50% decrease in beekeeping in many parts of the world, emphasising a greater understanding of no -*Apis* bees as alternative, managed pollinators in agriculture

A significant factor contributing to the TI is that the average age of active bee taxonomists is so high (Table 1), yet we are not training a new generation of bee taxonomists. In the Old World th average age is 60+ (O'Toole 1996) and only in Australia are new bee taxonomists being trained. This situation obtains not least because most modern university departments in the biological sciences hold taxonomy in low esteem. Therefore, we highlight the urgent need for universities to raise th academic status of taxonomic research by investing in new post-graduate programmes.

In seeking to improve this situation, we draw attention to the fact that in the Wester Hemisphere, the regard for taxonomy in university courses is like that of other branches of the biological sciences with a result that practising bee taxonomists in North America, Mexico and Brazil account for 61 % of the world total of those 28 scientists associated with major institutions. Nevertheless, there is a chilling fact embedded in these figures: 36 % of these specialists are beyond retirement age and only three of them, Charles D. Michener (age 81), Jesus S. Moure (age 87) and João M. F. de Camargo are involved in training a new generation of bee taxonomists (Table 1).

Table 1. Number of practising bee taxonomists associated with major institutions by country or region.

USA [a]	Mexico	Brazi [b]	Europe	S. Africa	China	Japan	Australia	Total
10 [1]	1	6 [2]	3 [3]	2	1	2	3	28

[1] includes 7 workers officially retired, but still activ
[2] includes 2 workers officially retired, but still activ
[3] includes 1 worker officially retired, but still activ

[a] figures supplied by Robbin Thorp
[b] figures provided by Fernando A. Silveira

The global Taxonomic Impediment is costly, especially when expressed in terms of thos research initiatives in pollination and conservation ecology which are wholly dependent on access to sound bee taxonomy and are rendered wholly non-viable in its absence. In three current British research projects with a combined budget of £ 2,072,000 (US$ 4,035,000), only £ 2,900 (US$ 4,640) or 0.14% was allocated for taxonomic support, even though the projects are inconceivable without it. These examples are typical of how taxonomy continues to be undervalued by the research community.

The funding culture needs to changed so to enable:

- Future, researchers to build adequate provision for taxonomic support into their grant proposals.
- Core funding to be made available for basic taxonomic research; for too long, taxonomy has subsisted on the coat tails of other research.

There is also a global Taxonomic Deficit; that is, the unacceptably high numbers of bee genera for which identification keys are not available.

Noting that the fourth Conference of the Parties (COP 4) in Bratislava, 1998, approved Decisions IV/1 (Indicator Initiative) and IV/6 (UNEP 1998a, b) which, among other things, requested Parties, Governments and international organisations "*to begin to provide inputs on the development and application of methodologies for assessments of agricultural biological diversity and tools for identification and monitoring*", we draw attention to the fact that:

- where these initiatives apply to bees as pollinators, they are entirely dependent on access to b taxonomy,
- yet the biological community is ill-served by the present state of bee taxonomy. In whole geographic regions such as the Mediterranean Basin, most of Africa and Asia there are no activ bee taxonomists. Even in Western Europe there are few specialists. Furthermore, there are very few modern taxonomic monographs. Many major genera have never been revised or the revisions are out of date so identification of the species is a major problem. This means that the identification of bees is a lengthy, arcane process, dependent on direct comparisons with original typ specimens.

Building upon the recommendations and resolutions of the Darwin Declaration (Environment Australia 1998) we agree that governments and multinational institutions, including funding agencies must recognise the cost benefits of working towards the complete elimination of the Taxonomic Impediment and Taxonomic Deficit as they apply to b s and other pollinators. This is best achieved by investment in taxonomic research and capacity building. Accordingly, we signal this opportunity to put the science of bee taxonomy on a sound and secure financial basis.

Our proposals for action there ore seek to eliminate the Taxonomic Impediment and Taxonomic Deficit as a matter of global urgency and as a necessary prerequisite for th implementation of any international initiatives on the conservation and sustainable use of pollinators. The proposals are under the following headings.

1. Assessing the scale of the Taxonomic Impediment
2. Maintaining continuity of taxonomic and reference collections of bees
3. Recognition of centres of excellence in bee taxonomy
4. Training bee taxonomists
5. Training a new cadre: parataxonomists
6. Capacity building and benefit sharin
7. Stimulating taxonomic outpu
8. Supporting the development of automated identification systems

PROPOSALS FOR ACTION: TAXONOMY

ACTION 1. Assessing the scale of the Taxonomic Impediment

Objectives.

- Identify as precisely as possible the various shortfalls which contribute to the Taxonomic Impediment.
- Provide all relevant information to governments, funding agencies and oth er decision and policy-makers.

Rationale and urgency These objectives are a prerequisite to sound decision and policy making an the means of achieving them should be instigated as a matter of global urgency.

Method of achievement. The objectives will be achieved by commissioning the appropriate bodies to:

1. Produce a global database of taxonomists active in bee taxonomy
2. Produce a global database of major collections of bees, with emphasis on their particular strengths in terms of geographic coverage and type specimens held
3. List those genera of bees by continent for which there are no modern publications for th identification to species
4. List those universities in whose active undergraduate teaching is sympathetic to taxonomy and suppor post-graduate studies in bee taxonomy

Timeframe. It should be possible to achieve these objectives within 12 months.

Opportunities for partnerships and co-operation. Establishing regional co-ordinating bodies briefed to oversee the implementation of the above objectives, for example, for the Western Palaearctic, re-vitalise Working Group on Pollination and Pollinator Diversity Management, originally set up at a meeting in London in April 1995.

Major constraints for implementation. No obvious constraints other than that of adequate funding.

ACTION 2. Maintaining continuity of existing taxonomic and reference collections of bees.
Objectives.

- Ensure the preservation of existing collections
- Stimulate collection enhancement and development
- Assure the availability of type specimens
- Assure the availability of data

Rationale and urgency. Reference collections are the main resource base for taxonomic research and identification services. Nevertheless, many are housed in poor conditions; some do not receiv appropriate levels of management while others have no suitable curatorial staff. Accordingly, we regard remedial action for the continued preservation of these collections to be of high urgency and a key factor in the elimination of the Taxonomic Impediment.

Method of achievement. By making funds available for the:

1. Renovation of existing buildings and construction of new ones
2. Training and employment of technical staff for the basic curation of collections
3. Acquisition of preservation equipment (storage cabinets, fire protection, humidity and temperature control systems)

Timeframe. Three to five years.

Opportunities for partnerships and co-operation. A very effective way to ensure the realisation of these objectives is to establish financial support for mentor relationships between institutions with well-established, well-curated collections and those where collection management is in need of improvement. Experienced staff from the mentor institution would enter into a support relationship with the recipient institution in terms of staff training, assessing immediate needs and report to th relevant funding agencies with detailed proposals for actio . Mentors would then be available for future advice and consultation.

Major constraints for implementation. Lack of funds.

ACTION 3. Establishment of Centres of Excellence in Bee Taxonomy.
Objectives. To establish world and regional centres for the co-ordination and support of taxonomi work and identification services for bees.

Rationale and urgency. To facilitate and optimise regional taxonomic output and identificatio services, resources should b concentrated in regional centres of excellence instead of being widel diffused among several small institutions. Such centres will place the enhancement of bee taxonomy on a cost-effective basis.

Achieving the objectives. Participating countries and multinational institutions should be invited to identify and propose centres of excellence according to the following suggested criteria:
A centre of excellence should be identified as having:

- An extensive, well identified and well-curated collection of bees
- Resident specialist(s) active in research in bee taxonomy
- A programme of post-graduate training and research in bee taxonomy or willingness to commit to the establishment of such training

Timeframe. Three to five years.

Opportunities for partnerships and co-operation. Supranational organisations can help in the recognition of centres of excellence and in the establishment of appropriate partnerships between countries and institutions.

Major constraints for implementation.

- Lack of funds
- Local bureaucracy
- Sensitivities based on nationalism and inter-institute rivalry

ACTION 4. Training of bee taxonomists
Objective. Create a critical mass of independent bee taxonomists for the next decade, that is doubling from the existing approximately 50 to about 100 scientists.

Bee taxonomists should be creative, high level scientists with their academic careers linked to collections with roughly one third of their time dedicated to routine identification services and th supervision of collection management, and two-thirds of their time divided between research and training.

Rationale and urgency. We are in the bizarre situation where our understanding of pollination biology of both crops and native floras is increasing faster than our ability to provide routin identifications of bees. Therefore, the Taxonomic Impediment subverts research in these fields an there is a global urgency to redress the balance. There are whole geographic areas such as th Mediterranean Basin, most of Africa and SE Asia where there are no active bee taxonomists. Moreover, there are many major genera which have never been revised or which have norecent revisions and their identification to species is a major problem.

Achieving the objectives. These would be achieved by:

- Up-grading the academic status of taxonomy-systematics
- Establishing post-graduate programmes in bee taxonomy at approp riate museums and universities
- Extending the time period for doctoral studies in taxonomy from the traditional three years to five or six years
- Ensuring ample travel funds for active bee taxonomists and doctoral students so that they may visit type depositories and key specialists

Timeframe. Ten years; it takes on average 5 or 6 years to train a postgraduate independent taxonomist and the final goal of 100 bee taxonomists would have to be phased and regionally based.

Opportunities for partnerships and co-operation. Knowledge transfer from senior bee scientists in major centres would be a key factor in establishing partnerships between centres of excellence an countries and appropriate institutions in the developing world. These institutions will be identified b their need for sound bee taxonomy, training and the development of local reference collections.

Major constraints for implementation
- Adequate academic training
- Opportunities to established posts associated with collections
- Adequate division of time between curation, identification services and creative research
- Availability of travel grants and research funds

ACTION 5. Training of parataxonomists
Parataxonomist are defined as an auxiliary to the taxonomist and his research.
Objectives. After suitable training, the parataxonomist would carry out the following functions:
- Collecting and sampling, especially in monitoring or faunistic studies, often in association with the taxonomist
- Preparation and processing of specimens
- Preliminary sorting to a convenient taxonomic level (subfamily, tribe, genus)

An ideal numerical relationship would be three parataxonomists per independent research taxo omist. Ideally, positions for parataxonomists should be permanent, with the opportunity for a tracked career structure.

Rationale and urgency. The appropriate proportion of parataxonomists to taxonomists shoul facilitate and enhance the service outpu of every collection facility and thus contribute to the elimination of the Taxonomic Impediment.

Method of achievement. Taxonomists and taxonomic services providing institutions should provid training for parataxonomists in accordance with a generally a reed curriculum (see follow-up report), on a national or regional basis, either as individual training or in training courses. Undergraduates in biology should be motivated to take an interest in this attractive new career opportunity, which is more than that of a simple technician, especially as it offers collection-related permanence. Parataxonomists should be eligible for academic up grading in their profession after a satisfactory period of activity.

Timeframe. Training of an undergraduate student for the position of a parataxonomist should normally take two years. In-house, workbench training by a senior colleague could take less time.

Opportunities for partnerships and co-operation. Partnerships between developed and developing countries and heir institutions would be necessary.

Major constraints for implementation.

- Adequate academic staff to provide trainin
- Opportunity to establish salaried posts associated with collections.
- Availability of travel and training grants

ACTION 6. Capacity building and benefit sharing

Objectives. Almost all the taxonomic resources needed by entomologists working in the developing world are located in museums and other institutions in the developed world. Because the total repatriation of specimens from collections in developed countries is not a serious option, the following mitigation measures should be put into action.

- A single web site with access to all databases of type material in the world's museums and other research institutes
- Repatriation of data associated with type specimens to appropriate institutions in countries of origin.
- A single web site to make data associated with specimens available to all *bona fide* researchers in taxonomy and pollination biology.
- Exchange and transfer of information, especially literature that is not widely available outside the museums and institutions of the developed world using photocopying and scanning facilities
- Provision of appropriate modern journals and monographic revisions to museums and institutions in developing countries
- Facilitate the development of reference collections including, where appropriate, the transfer of reliably named reference specimens of species represented by extensive series in museums in the developed world to those in developing countries
- Facilitate, where appropriate and with suitable conditions, lon -term loans of material
- Facilitate appropriate training at all levels of people from developing countries by experienced personnel in mus ums and universities in the developed world (See Actions 4 and 5 above)
- Facilitate travel scholarships for taxonomists from developing countries to enable them to visit experts and major collections in the developed world
- Development of partnerships between established Centres of Excellence and Imminent Centres

Rationale and urgency. The uneven geographic distribution of the above resources is a major contribution to the Taxonomic Impediment, and imposes severe limits on those people in developing countries who need access to bee taxonomy, literature and collection data. These problems need to b addressed with real urgency, especially if demands of those attempting to survey pollinator faunas and monitor changes therein are to be met. If realis d, the above objectives would:

- Accelerate access to type material, other material and associated data
- Facilitate research in bee taxonomy, identifications and plant-pollinator studies
- Facilitate communication between scientists, taxonomists and pollination biologists
- Help meet the growing demands placed on "pollinator systematists"

Method of achievement. This action will best achieved by ensuring that adequate funding is provided, so that financial considerations are no longer a powerful limiting factor in capacity buildin and benefit sharing are:

- Collections managers to make data and specimens availabl
- Central web-sites to be created as a result of the São Paulo Declaration, in conjunction wit BioNET-International and the International Bee Research Association (IBRA)
- Adequate numbers of data entry personnel to be employed in institutions with large, extensiv collections
- Appointment of a single co-ordinator for each web-based databas

Timeframe. Three to five years, with rate of progress in some area inevitably being user-driven.

Opportunities for partnerships and co-operation. Partnerships should be developed between museums and institutes in the developed world with major collections of bees and other pollinators and other countries and institutes wishing to participate and benefit from the above objectives. Institutes listed on the pollinator-based web-sites could be used to advertise and enhance the setting up of such partnerships.

Major constraints for implementation.

- Lack of funds
- Lack of trained specialists in bee taxonomy, database management and data input

ACTION 7. Stimulating taxonomic output

Objectives. (See also suggestions for web-based databases outlined in Action 6 above.) To eliminat the Taxonomic Impediment by:

- Assembling regional catalogues of bee species, indicating where appropriate, those genera which are in need of revision and making these available in electronic as well as printed form
- Production of illustrated keys to genera by regions, especially in forms suitable for use by parataxonomists, including electronic and printed versions
- Facilitating existing specialists to produce monographic revisions of bee genera, especially those identified as containing species which are either known pollinators of crops or have potential as managed pollinators and are major pollinators of native plants;
- Facilitating the publication of the abov
- Provision of travel scholarships to enable established taxonomists to visit major collections, colleagues and undertake field work
- Facilitating doctoral studentships under the supervision of established taxonomists

Rationale and urgency. The Taxonomic Impediment is expensive in terms of faunistic monitorin projects and pollination research, which cannot be completed without access to sound taxonomy. With the growing realisation that environmental change and degradation are accelerating, the urgency of the need to eliminate the Taxonomic Impediment is self-evident.

Method of achievement. It is suggested that:

- Governments, their funding agencies and supranational organisations should come to regard b faunas as natural resources that need to be inventoried (= monographed) and that the provision of adequate levels of funding for appropriate periods of time is an investment opportunity wit cost-effective, global benefit
- Government and supranational funding agencies collaborate to provide funds to support th publication of taxonomic monographs that would normally be considered too large for publication in standard journals

Timeframe. Three to ten years: these must be a set of lon - term objectives.

Opportunities for partnerships and co-operation. The establishing of partnerships and collaborative relationships between institutions in developed countries with those in the developin world to co-operate in the elimination of the Taxonomic Impediment. An example of a partnership that is likely to be productive: collaboration between museums in western and central Europe with countries of the Mediterranean Basin (including North Africa) and the Sahel. In making this suggestion three existing projects are documented as suitable models. These are: the Flora

Mesoamericana, Flora Neotropica and the Programa Coperativo sobre la Apifauna Mexicana (PCAM). The latter is a partnership between bee taxonomists from several institutes in the United States with Mexican colleagues. To date this programme has produced one major, highly illustrated work, which facilitates the identification of all bees from North and Central America to generic level (Michener *et al* 1994) and Ayala *et al* 1993. Several others are in press.

Major constraints for implementation.

- Lack of international levels of funding
- Lack of contact between experts in different countries
- Insufficient taxonomic expertise.

FOLLOW-UP ACTIVITIES

1. Workshop on motivation and training of parataxonomists

Objectives.

- To elaborate strategies to motivate students for studies in taxonomy
- To elaborate teaching material to prepare parataxonomists for field work, preparation and sorting of specimens and data banking and the application of automated identification systems (see Action 9).

Rationale and urgency. With a worldwide increase of monitoring of pollinators envisaged, large amounts of collection material will accumulate and will need to be identified. Therefore, there is a great demand for well-trained parataxono ists for the preliminary processing of this material.

Method of achievement. Simple textbooks and well-illustrated keys to bee genera should be developed for each region of the world, similar to Michener *et al* (1994).

Timeframe. It has been suggested that the workshop could be held soon at the National University of Mexico, Jalisco.

Opportunities for partnerships and co-operation.

- Funding for the organisation of the meeting, diaries and travel funding.
- No doubt appropriate partnerships and plans for collaborative enterprises will develop during th course of the meeting.

Major constraints for implementation. None.

2. Workshop on automated systems for bee identification.

Objectives. All available automated identification systems (O'Neill *et al* 1997, Weeks *et al* 1997, Wittmann 1999) would be presented to a meeting of taxonomists. Professional users would test and compare the systems and make suggestions for improvement where necessary.

Rationale and urgency. Routine identification services keep professional taxonomists fro important scientific work such as writing descriptions of species new to science, taxonomic revisions etc. The identification of bees can and should be automated.

Achieving the objectives. A network of c llections would be set up through which data on bee characters could be sent to regional institutions at which the automated system is installed.

Timeframe. The workshop could take place soon at the University of Bonn, Germany.

Opportunities for partnerships and co-operation. These would emerge at the workshop

Major constraints for implementation. Funds for the organisation of the meeting and travel.

PROGRAM ELEMENT 2: MONITORING GLOBAL CHANGES IN THE DIVERSITY AND FREQUENCY OF POLLINATORS

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Topics suggested for discussion

1. Identify constraints for pollinator monitoring *.
2. Identify benchmark experiences on pollinator monitoring.
3. Evaluate proposal for standardised methods and protocols for temporal and spatial comparisons.
4. Evaluate proposal for priority crops, management systems and pollinator taxa to be targeted.
5. Assess need for preparation of "Manuals for Measuring Pollinator Decline and Recovery".
6. Evaluate capacity building programme for pollinator monitorin .
7. Evaluate proposal for networks for monitoring pollinator decline and recovery.
8. Assess need for a "Global Biodiversity Outlook Report on the status of Pollinators".

PREAMBLE

Some scientific studies and various scattered records strongl suggest that the numbers of crop pollinators are declining in many parts of the world. The yields of some crops are diminishing as a result of insufficient pollinators and there is every reason to believe that the problem will worsen and become widespread as more nesting habitats and wild floral resources needed by pollinators ar adversely affected by human development and disturbances. More specifically, many specialists agronomists and fruit growers are concerned about the sharp declines in the numbers of bees in recent years.

A major limiting factor in presenting a strong case for the conservation of pollinator populations is the scarcity of sound data. Reliable data are available for some crops in the U.S.A. Canada, parts of Europe and for Costa Rica; however, researchers are attempting to compile data t explain the situation.

To implement the required policy changes, administrators, land stewards, lawmakers, politicians and other decision makers need access to convincing evidence to promote new directions in research and new land management practices especially when new costs are involved. Wit pollinators, there is a clear need to document patterns and trends, in whichever direction they may be. Some trends become apparent and significant only after several years of study and then only when supplemented with additional ecological information. Therefore, monitoring these trends is a critical need in the conservation and sustainability of any pollinator.

* Surveying entails collecting data on a single occasion; monitoring involves collecting comparativ data on several occasions in order to identify possible changes in the numbers.

The establishment of realistic goals is fundamental for sound monitoring activities. Monitorin pollinators by means of standardised systematic methods provides information on the presence and absence of organisms, on local abundance and frequency through time, while correlations with biotic and abiotic variables can reveal patterns which may be useful in predicting trends. When monitorin is conducted in a systematic manner it provides insights on:

- Importance of pollinators for both agricultural and natural systems
- Impact of native pollinators on agricultural systems
- Impact of specific agricultural management techniques on pollinators
- Impacts of introduced pollinators
- Presence of bioindicator organisms
- Periodic reports on pollinator status
- Guidelines for pollinator management and restoration.

Furthermore, co-ordinated monitoring programs worldwide should adhere to a clear and definite time frame.

GENERAL PROPOSAL

Objectives:

a. A network of c -operators should monitor changes in the diversity and frequency of pollinators through time in sel ted areas of the world.
b. Wherever possible, supplemental ecological information should be provided on possible causes for changes in the diversity and frequency of pollinators
c. A global network of co-operators should be established who would share fi dings annually and meet periodically to discuss local and global trends in pollinators.

Achieving the objectives

The success and efficiency of the dozen methods that have been used to sample flower visitors vary so much under different conditions that it is difficult to recommend any one specifically for widespread monitoring. Therefore, it is proposed to conduct a global monitorin program of pollinators in two stages.

Stage 1 Evaluation of the various collecting methods to assess which might be recommended for more widespread use. A second component of Stage 1 would be the compilation of descriptions of monitoring methods and appropriate statistical analyses which would be circulated for us and refined during the first two years. Results of this exercise would be published as a manual for use during Stage 2 (see below). These should be tested at a limited number of field sites. The selection of sites should be based on:

- representation of broad ecosystems
- comparable agro-ecosystems
- presence of co-operators who will conduct the wor
- locations known to possess substantial bee diversities
- preferably places for which plant and pollinator species lists exist

These suggestions are not exclusive and any researcher who wishes to participate in the initial stage of the programme should be encouraged to do so. Nonetheless, it must be borne in mind that participation in the programme is a long-term commitment.

Stage 2 would implement the findings of Stage 1 at a larger number of field sites throughout th world in order to collect the data needed to detect changes in diversity and frequency of pollinators, especially of bee species. Hopefully it should be possible to cover the greater part of the world's terrestrial habitats and agricultural crops in Stage 2.

Although it has been suggested that Stage 1 be conducted at a limited number of localities and Stage 2 at a larger number, it should be mentioned that Stage 1 sites would provide data from

the first day of the project and inclusion of a greater number of sites from the start would b advantageous.

Timeframe

It is planned to complete Stage 1 in two years. Data would be collected during the first year and the methods refined during the second.

Stage 2 is seen as a lon -term process. It is recommended that it be conducted for an initial period of five years and the programme renewed on a quinquennial basis thereafter

Opportunities for partnerships and co-operation:

The project cannot be contemplated without the active participation of many nations, institutions and co-operators. Program co-ordinators and specialists would need to develop a manual on monitoring techniques. Taxonomists would need to identify the material collected and help provide reference collections of determined species which should be made available to all co-operators (see below).

Major constraints for implementation

Five major limitations are expected:

- The availability of c -operators to conduct the monitoring may impose restrictions on th selection of suitable sites.
- Taxonomic impediments in the naming of the material collected. This would entail determination of known species, and it is expected that species new to science will b discovered.
- Possible problems in the standardising of monitoring methods among co-operators, especially in the lon -term.
- Limited ecological information collected by c -operators which may help explain pollinator trends which emerge from monitoring.
- Incentives needed to insure that monitoring would continue over a lon -term period. Important and significant trends are likely to emerge only after several years (5-10) o monitoring. Incentives (financial and other) would be necessary to maintain the progra momentum.

PROPOSALS FOR ACTION: MONITORING

ACTION 1. Establish a committee to co-ordinate global monitoring plan

Objectives. Organise a committee of three individuals to co-ordinate the global monitoring plan. Provide or develop specific goals and questions for monitoring. This committee would represent th starting point for contacting c -operators, selecting representa tive monitoring sites, establishing standard procedures for monitoring, setting up local and global data base centres, maintaining communication among co-operators, and distributing an annual report of the findings. These peopl would also lay the groundwork for developing a manual on pollinator monitoring.

Rationale and urgency. To implement a worldwide initiative a central co-ordination is fundamental to start the program and to assure the goals and objectives are achieved. The formation of the Central Committee is therefore the first essential step in the implementation of a pollinator monitorin program.

Method of achievement. Its members should be chosen from people with previous experience on monitoring and with leadership

Timeframe implementation. The Committee's initial period of two years, Stage 1, and thereafter a five year period.

ACTION 2. The global monitoring pla

Objective. To gather existing data and to obtain new comparative data from different habitats throughout the world in a c -ordinated fashion.

Method of achievement.

This comprises three phases

Phase I (1st and 2nd years)

- Gather information on exiting monitoring and inventorying methodologies
- Gather information on monitoring data analyses
- Local sites worldwide where monitoring activities and knowledge on local the fauna already exist
- Select sites in different parts of the world comprising major recognised pollinator fauna to test and standardise the monitoring methodology
- Establish a program of activities and reporting procedures to be conducted for selected sites. Some general guidelines should be given by the testing program
- Make the program guidelines (above) available to occasional volunteers who may wish to contribute data to the program

Phase II (1st and 2nd years)

- Test methodologies on monitoring at the selected sites
- Identify major environment types to be included in monitoring programs (wild-lands, agriculture, disturbed areas, etc.)
- Produce local identification keys to pollinators
- Build reference collections of pollinators
- Evaluate the progra
- Develop a manual with monitoring techniques and recommendations

Phase III (3rd year- 5th year)

- Select sites where monitoring program will be implemented
- Implement the monitoring program
- Collect data
- Analyse data
- Evaluate program.
- Reporting on global status and trends of pollinators
- Make recommendations for global pollinator management and restoratio

Expected products of monitoring activities

Monitoring should demonstrate patterns and trends of pollinators through time. Other products and findings are expected to emerge from lon -term monitoring. Examples of these are.

- Identification of important pollinator species and groups
- Development of new conservation measures aimed at these pollinators
- Restoration of populations of selected important pollinators
- Identification of bioindicator pollinator species
- Identification of exotic pollinators and assessments of their potential impacts on native pollinators
- Changes in pollinator frequencies will require that supplementary ecological information be collected to identify the cause and effects

Method of achievement. Analyses of data from monitoring programs conducted at monitoring sites and synthesised by the committee should enable the identification of important pollinator groups, indicate measures aimed to protect these pollinators, indicate the restoration of populations of selected pollinators when sufficient information is available; identify bioindicator pollinator species and highlight supplementary ecological information associated with changes in the fluctuation of pollinator numbers.

Rationale and urgency. Products from monitoring should be evaluated, synthesised and made available to institutions and interested people. Some of the products which emerge will suggest appropriate new courses of action which in turn should be monitored. A global monitoring plan requires a phased approach, with periodic evaluation, to ensure that comparative data is gathered. Pollinator diversity continues to decline so the implementation of Phase 1 must be considered to b urgent.

Note. Promote pollinator monitoring through national and international professional meetings an through other audiences. Once the monitoring has started, we expect some of the co -operators to undertake the responsibility of organising societal meetings, newsletters, etc. It is important to stress that the continual promotion of the program among c -operators is crucial to the success of long-term monitoring. Furthermore, co-operators must also be willing to extend their knowledge to other relevant audiences to raise their levels of understanding and awareness. These audiences woul include environmental journalists, land managers and administrators, politicians, large and small NGOs, local and state civic groups and committees, school boards, etc.

ACTION 3. Preparatory work for implementation of a global monitoring pla
Objectives. Preparatory work should consist of developing supporting material and qualified personnel for the global monitoring progra

Rationale and urgency It should be designed to minimise constraints to monitoring activities, which would affect the final products and should be started prior to or along ith the other global monitorin activities.

Method of achievement. Preparatory work entails:

- Compiling reference collections of pollinators
- Developing keys for pollinator identificatio
- Funding taxonomists and institutions for the identification of flowering plants and pollinators

Developing manuals on monitoring bees and other pollinators, and reporting, to maintain consistency in the data collection and final products, and in data retrieval.

Timeframe. Preparatory work would start in the first year of the program and major support materials and qualified personnel should be available by the end of the second year. This is a continuing process because it implies capacity building and biodiversity inventorying.

ACTION 4. Manuals for monitoring pollinators
Objectives. Development of manuals for monitoring pollinators, especially bees.

Rationale and urgency. Manuals are necessary to provide guidance and training for all co-operators, which in turn would help keep co-operators focused on the global objectives and also maintain consistency of data collections and final products which are expected to emerge. The

manuals would also provide directions on how to report findings and enter and retrieve data in a appropriate database.

Method of achievement. Specialists will be required to put together the information and write th manuals. This will be a continuing process because the methodologies will have to be tested in various ecosystems and additional pollinator species will be discovered as the monitoring programme compiles data.

Needs and opportunities for partnerships and co-operation. Co-operation would be useful between researchers to provide information over wide areas.

Timeframe. Preparatory work would start in the first year of the program and the first versions o some manuals should be available by the end of the second year.

ACTION 5. Assessment of the potential impact of exotic pollinators on native pollinators
Objectives. Identify the presence of exotic pollinators and assess their potential impact on populations of native pollinators.

Rationale and urgency. Exotic or introduced pollinators can affect native pollinator communities and populations potentially resulting in deterioration of the native flora.

Method of achievement. Comparisons of inventories of native species at locations with and without exotic species. Longer-term effects will entail monitoring.

Needs and opportunities for partnerships and co-operation. Co-operation would be useful between researchers to provide information over wide areas.

ACTION 6. Establishment of a? centralised web site of databases for all pollinator monitoring data
Objectives. The main objective of this action is to make available worldwide all the informatio obtained from monitoring pollinators in order to optimise the effort and avoid unnecessary data collection as well as contribute to any attempt of pollinator assessment and management.

Rationale and urgency. Through standardised data bases information should be made freely available to those who need it.

Method of achievement. A single web site with access to databases for all pollinator monitoring data at both local and global levels.

Opportunities for partnerships and co-operation. Local and global agencies and NGOs workin on databases. This could be organised in conjunction with the International Bee Research Association (IBRA) who have offered t store such data and with FAO and BioNET-International.

ACTION 7. Preparation of a Global Biodiversity Outlook Report on the status of pollinators
Objectives. A Global Biodiversity Outlook Report on the status of species of native bees and other pollinators emphasising those species threatened with local or total extinction. Similar documents ar

produced under the auspices of IUCN's Species Survival Commission, e.g., A global list of threatened vertebrate pollinators (Nabhan 1996).

Rationale and urgency. To provide a document for use by researchers, conservationists agriculturists and decision-makers. This report will only become available after the five-year monitoring period is complete.

Method of achievement. Preparatory work entails:

- Compiling data from monitoring programs on pollinator numbers
- Identification of important pollinator species
- Identification of bioindicator pollinator species

ACTION 8. Follow up activities

Objectives. Develop and encourage follow up activities to enable long -term monitoring of bioindicator species.

Rational and urgency The result of the initial research should be kept current for use by land -use decision-makers. This will only take place after Phase 1 and 2 of Action 2 have been completed.

Method of achievement. Promote pollinator monitoring debate through national and international professional meetings from now on.

Opportunities for partnerships and co-operation. Conferences, symposia and meeting o entomology, pollination, conservation, apiculture, and related issues should be addressed.

PROGRAM ELEMENT 3: IDENTIFYING THE CAUSES OF POLLINATOR DECLINE

Co-ordinator: David W. Roubik

Members:

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Rapporteur: Jorge Rodolfo Lima

Topics suggested for discussion

1. Identify the kinds of causes of pollinator decline: ecosystem fragmentation, extractivism, pesticides, herbicides, burning, atmospheric pollution, alien species, diseases, climat change, destruction of nesting sites, others.
2. Determine the relative importance of the different causes of pollinator decline in different crops and continents.
3. Determine the relationship between size and intensity of stress and pollinator richness and abundance.
4. Evaluate proposal of methods to determine caus -effect relationships.
5. Evaluate proposal of models and methods for risk assessments.

PREAMBLE

In recent years two major problems have appeared which are beginning to threaten the world's agricultural production. In many parts of the world honeyb s are suffering from the serious disease, Varroatosis. Although the most widely used species in crop pollination is the honeybee (*Apis mellifera*) (Southwick and Southwick 1989), many other species of bees are involved (Richards 1993). The second difficul ty is that reductions in the numbers of native bees and other pollinators have been reported in various parts of the world. These losses are due to the use of agrochemicals and monocultures and to deforestation. The chemicals kill bees and, with the remo val of wild vegetation and crop specialisation, the bees find neither places to nest nor alternative flowers while they await th crop to bloom (Rathcke and Jules 1994).

This issue needs further attention, as workgroup report was not submitted.

PROPOSALS FOR ACTION: POLLINATOR DECLINE

Global assessment of pollinator diversity and pollinator efficiency in agroecosystems and adjacent natural and seminatural environments

Objectives. A co-ordinated systematic examination of pollinator diversity to be conducted in carefully chosen representative agroecosystems to provide a database for extrapolating the state of the pollinator-agriculture interface and to identify “best practices” for alleviating the losses and maintaining diversity.

Rationale and urgency. There is an urgent need to determine the impact of human activities including agricultural practices and deforestation on pollinator decline to chart an effective course of action and to identify those agricultural practices which promote diversity and pollinator efficiency.

Methods of achievement.

- Develop a handbook describing approved but simple and easily accomplished methods of surveying pollinator diversity and pollination efficiency.
- Form a working group to select and prioritis agroecosystem locations for a survey based on considerations of type of agriculture, location, etc.

Timeframe.
- Development of the handbook: 3 to 6 months.
- Complete working group decision: 6 months to 1 year.
- Data collection and analysis: 2 or 3 years.
- Develop an Internet web site and other methods for disseminating information: 1 or 2 years.

Opportunities for partnerships and co-operation. This would be a necessary first step to implement a global monitoring system. The data would provide a basis for selecting lon -term monitoring sites.

PROGRAM ELEMENT 4: QUANTIFYING THE ECONOMIC VALUE OF POLLINATORS

Co-ordinator: Ken Richards

Members:

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Richard Jones
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Rainer Krell
Ramon Arigoni Ortiz
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Rapporteur: Dirk Koedam

Topics suggested for discussion

1. Identify important crops in different continents that need pollinators
2. Identify pollinator taxa important for key crop species (assessing the pollination efficiency)
3. Determine pollination efficiencies
4. Assess production of directories of pollinators for crops by regio
5. Identify methods for the economic valuation of crop pollination
6. Compare pollination versus production of honey, beeswax, propolis, etc.
7. Evaluate methods to identify and estimate the insufficiency of pollinators
8. Assess the economic impact of pollinator decline
9. Assess standardised methods to measure the social and economic impacts
10. Evaluate capacity building for the economic valuation of pollination
11. Identify the priorities for developing case studies
12. Compare migratory beekeeping versus the decline in native pollinators

PREAMBLE

A realistic evaluation of the economic value of animal-effected pollination is essential for the efficient planning of the world's agriculture. However, such estimates have been an internationall contentious issue for many decades. Attempts to assess the pollination activity of bees have ranged from "guesstimates" of no empirical substance, to estimates based on the practical experience of apiculturists and growers and a few concerted efforts by pollination scientists in collaboration with economists.

The justification for attempting to make these estimates is the wide acceptance that the accumulated economic value of the pollination service is huge. For example, recent calculations of the annual value of the service of pollination provided by animals is US$ 6 -8 billion in the U.S (G.Nabham per. obs.) and the global estimate is US$ 65-70 billion (Pimentel *et al* 1997). Moreover, in their presentation at this Workshop Kenmore and Krell estimated the loss through lack of pollination for the 30 crops they cite to be US$ 54.6 billion representing a 46 % loss of harvest

Restrictions to obtaining reliable estimates include:

- Insufficient information on the pollination needs of species and varieties of crops.
- Many crops are marketed locally and their economic worth is not documented.
- Animal visitors vary from effective pollinators and occasional pollinators to those which are simply visitors and offer no servic to the plant.

Target audienc (clients):

- Policy makers

- Advisors
- Farmers, growers, public
- Researchers

Proposal for action: Quantifying the economic value of pollinators

Objective. To evaluate, in economic terms, different crop-pollinator-pollination systems for optimal use of pollinators in sustainable agricultural systems. The goal is to collect, collate, interpret, elaborate and disseminate information on crop-pollinator-pollination systems.

Rationale and Urgency. World food security demands rational farming systems. To decide on best farming systems for efficient and sustainable world food production, a variety of economic analyses are essential. The description and evaluation, in economic terms, of pollinator contributi ns to agriculture and environmental diversity will improve informed decision making at farm, regional national and international levels. The importance of insect-pollinated plants to the world's food supply and the anticipated continuing increases in wo ld population, food consumption and erosion of pollinator populations, make it crucial that data collection in support of detailed economic analyses b started immediately.

Action Plan. We recommend the establishment of a large, relational, computer dat base, with Internet access, to handle the large data sets, existing or required, to perform the economic analyses. The database should be divided into four action sub-units, each with its own justification and rationale:

1. ***Plant-Crop Species.*** Worldwide, food is obtained from more than 3,000 plant species of which some 1,300 species are grown and harvested in semi-wild habitats in tropical countries. Little is known about the pollination requirements of many of these species and this information is required to support their sustained use.

Data required:

1. A list of crop species, classified by use, including medicinal and nutraceutical, value, and minor crops and plants which are no -cultivated but beneficial to mankind and pollinators;
2. Breeding system for each crop species, especially minor, often neglected but hig -value ones;
3. Production of nectar, pollen or oil per crop species, compared among cultivars;
4. Relative attractiveness of different crops to pollinators, with comparisons among cultivars;
5. Different requirements for pollinators by different cropping systems, e.g. hybrid vs. non-hybrid seed-production
6. Impact on pollination of transgenic crops in cropping systems, e.g. on apomixis, auto-pollination, crop quality.

To accomplish this action, a first task will be to identify active experts for the various crop species who can and are willing to lead the research. Although many of the crop species will require regional or national rather than worldwide initiatives, the information should be shared and collated in a co-ordinated manner through a central office and database and through workshops and Internet links. Various plant gene banks across the world might be able to assist with the determination of crop species of economi importance and their breeding systems; it is their raison d'être to enhance seed production, maintain genetic purity of accessions, and to assist plant development and conservatio efforts.

2. Pollinators. Optimum crop pollination is achieved only if the appropriate pollinator species is available to visit the flowers. The honeybee, *Apis mellifera*, as the most widely available and easil managed generalist pollinator, has in recent decades played a vital and dominant role in the pollination of insect-pollinated crops. However, research is demonstrating that bee species differ in their effectiveness and efficiency as pollinators of particular crops; some crops are better pollinated b other species of bee, e.g. alfalfa by the solitary bee, *Megachile rotundata* and tomatoes by the bumble

bee, *Bombus terrestris*, two species now commercially available. Honeybees have often been credited with pollination services which are actually performed by other bee species There are few economic estimates of the value of non-*Apis* pollination, and these insects are generally not appreciated

Data required:

1. Identify the optimum (most efficient and effective, but not necessarily the most abundant) pollinator species for each crop specie
2. Identify the secondary and tertiary pollinator species for each crop species and their relativ value
3. Distinguish between visitors to flowers and actual pollinators, i.e. those which collect transport and deposit compatible poll n
4. Develop a standard methodology for determining optimum pollinators

To accomplish this action, a first task will be to identify crop-pollination ecologists in different regions with expertise on the pollinators of particular crops to collect and collate the required data and devise standard methodologies in a c -ordinated fashion. As with crop species, this data needs to b shared and collated centrally.

3. Pollinator numbers. Realistic estimates are needed of the number of pollinators required per unit area of crop in flower to achieve optimum pollination. Estimates based on observations are difficul to obtain because pollinator effects on seed yields interact with other factors, e.g. flower fertility, soil weather and insect pests, and because the methods used to compare yields of crop areas caged with and without bees can affect plant performance. A modelling approach is needed to integrate b behaviour and plant and agronomic data. For many plant species, the population of bees required for optimum pollination can be assumed to be that population which would visit most of the flowers, to maximise seed setting through cross-pollination and to obtain a more uniform crop to harvest. However, even when all flowers on a plant are pollinated, not all produce seed, as genetic potential is seldom realised due to physiological constraints. This carrying capacity is largely unknown for mos crop and native plant species.

Data required:

1. Fruit and seed yields in the presence and absence of polli ators (a simple approach for most crop species)
2. Bee behaviour, plant yield and agronomy integrated in a pollination model to predict th probability of an individual flower being pollinated under various pollinator and flower densities (a more sophisticated approach for selected important world crop species).

To initiate this action, a workshop of selected world experts is needed to determine appropriat standardised methodology for estimating the number of pollinators needed to pollinate crops. Both the simple and more sophisticated approaches need to be discussed if appropriate information is to b generated for economic analyses.

***4. Pollination economic*s.** To promote the use of a diverse pollinator work force, a risk reductio approach may be necessary. Enhancing native pollinator populations by habitat management is a potentially cos -effective option that deserves attention and may become more essential as honeybees become less readily available. Habitat management might be most effective if p lanned on a scal larger than that of an individual farm and this would require co-ordination on a regional scale across government levels.

Data (economic) are needed on the following.

1. The farm scale, cost/ benefit analyses for different crop and pollination systems. Analyses will need input costs e.g. of fertiliser, pesticides, herbicides, integrated pest management, seed, machinery, irrigation, land, energy, labour, pollinators (rental costs of supplementary bees or habitat management costs for wild pollinators) and crop costs such as market value, quantity and quality are required.
2. The national scale, for total crop production costs for different systems and for marketing th crops, research and development costs, training, support and extension costs, environmental

costs and savings, integration of IPM into crop production systems here pollinators ar used.

3. The international scale, for changes from one crop-pollinator-pollination system to another and for infrastructure maintenance.
4. Specific aspects are:
   - **a)** evaluating the additional products from pollinators (e.g. honey, wax, pollen, propolis, royal jelly, health products)
   - **b)** quantifying the soci -economic benefits of introducing a new pollinator into a region an onto a crop against the detrimental environmental (for example competition with l ocal pollinator populations) and economic costs of non- introduction (e.g. inadequat pollination, food supply and global competitiveness)
   - **c)** quantifying the value of uncropped areas e.g. field margins, headlands, fence lines, hedgerows, roads, railways, utility rights of way, public lands, etc. (important refuges for a wide diversity of pollinators and associated plant species) to agricultural productivity;
   - **d)** evaluating different pollinator systems, for example, (1) the optimum and most availabl pollinator, (2) the secondary and tertiary pollinators, (3) mixing these two groups of pollinators, (4) the preservation and management of habitats for pollinators, (5) mixed managed pollinator and managed habitat systems.

To initiate this action, a worksh p of pollination ecologists and economists is needed to develop appropriate analytical methodologies and collaboration to accomplish the task.

Timeframe implementation

1. Identification of experts to complete the various crop, pollinator and systems tasks.
2. Creation of the database and its maintenance.
   - integrate and expand existing descriptive information relevant for pollination
   - connect and integrate with existing plant production databases.

   Possibly the database administration could reside with FAO with information input from IBRA. Funding should be sought from ETC, EU, private foundations and GEF.
3. Development of a generalised economic method for evaluation of crop-pollinator-pollinatio systems.
4. Comparison of pollinator efficiencies and effectiveness; target five crops per year.
5. Promotion of improved crop-pollinator-pollination systems with economic data and the use of case studies to explain environmental benefits. Different case studies would be used to depict different levels of management from high input and output to lower levels: greenhouse, field crop, intensive monoculture, mixed culture, organic small farm, traditional landscape.
6. Extension of information generated through training, newsletters, crop produ ction manuals, workshops, seminars, specific publications, inclusion of economic and biological information on pollination in agricultural courses at universities and colleges, development of on-farm research and extension, and potential partnership and co-operation with international organisations including FAO, IBRA, ICPBR, CGIAR, Apimondia and UNEP and with national grower organisations and the seed trade.
7. Research to increase the precision of economic analyses at national and international levels
8. Establishment of a network of experts for rapid interaction through discussion and for th creation and dissemination of data through workshops. This could be made available in a interactive format involving grower organisations or those like SREN.
9. Review the progress made in the various actions after 2 ½ and 5 years.

Action item	Year (x =start of activity, w = workshop) 1	2	3	4	5	6	7	...etc.	Priority (=emphasis)
1.	x	--------							1
2.	x	----------							1
3.	x	----------							3

4.	x	----------						2
5.	x	w	w	w	w			1
6.	x	w	w	w	w	w	w	1
7.	x	----------						3
8.	x	w	w	w	w			2
9.			x		x			

Major constraints for implementation of the proposed actions

1. Inadequate data on most of the different crop-pollinator-pollination systems.
2. Lack of any recognised structures for data collection and dissemination.
3. Lack of standardised methodology for the determination of plant, pollinator and interaction components and also for economic analysis.
4. An uneven geographic distribution of experts.
5. Lack of awareness by the public, farmers, policy makers and advisors about the benefits of pollinators for crop production and the needs of pollinators for human survival.
6. Lack of knowledge about economic and environmental costs and benefits for different crop pollination systems.

PROGRAM ELEMENT 5: CONSERVATION OF POLLINATOR DIVERSITY

Co-ordinator: Stephen Buchmann

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Rapporteur: Marcia de Fátima Ribeiro

Topics suggested for discussion

1. Determine nesting site requirements of pollinators
2. Assess improving nest site availabilit
3. Determine floral preferences and requirements
4. Evaluate enhancing availability of alternative flower resources as supplementary forag
5. Evaluate proposal of habitat management (traditional and modern)
6. Assess promotion of conservation of fragmented natural habitats within agriculture landscapes
7. Assess breeding techniques (traditional and modern)
8. Assess breeding of native pollinators (Meliponinae, Bombinae, etc.)
9. Assess promotion of conservation efforts on private properties
10. Evaluate proposal of incentives and labelling to promote sustainable pollinated crops
11. Assess promotion of certification and labelling of quality agricultural products
12. Assess identification and dissemination of best practices
13. Evaluate proposal of capacity building for conservation and sustainable us
14. Assess promotion of technology transfer
15. Assess balancing pollination with production of honey, etc
16. Evaluate proposal of public policies for pollinator conservatio

PREAMBLE

The aim is to achieve a situation where native pollinators are conserved in agricultural systems for the benefit of society.

At least one-third of the world's agricultural crops depends upon pollination provided by insects and other animals, and agricultural production throughout the world is threatened by declining populations of pollinators. The major contributors to this decline in pollinator populations are, inter alia, habitat fragmentation, agricultural and industrial chemicals, parasites and diseases, and th introduction of alien species. We need to take immediate international action to secure sustained pollinator services in agricultural ecosystems.

The following guiding principles provide a framework for international co-operation and action to conserve and restore pollinators.

- Pollinator plant relationships should be understood as an ecosystem service for sustainabl agriculture.
- Conservation and restoration of natural areas are necessary to optimise pollinator services in agricultural systems.
- Negative impacts by humans on pollinators should be minimised.
- Farming practices should promote the conservation and diversity of native pollinators
- Public awareness of the importance of pollinator conservation should be promoted.

Based on these principles we recommend an array of actions for international co-operation o pollinator conservation, which should be undertaken immediately and be completed within three t five years. The proposals for action fall within four general recommendations:

- Advisory
- Knowledge assessment
- Communication and outreach.

PROPOSALS FOR ACTION: CONSERVATION

ACTION 1. Establish an international advisory group on pollinator conservation

Objective. To provide expert advice to governments and society on pollinator conservation on which to base sound policy and decision making.

Rationale and urgency. The scope of the pollinator crisis is international both in the distribution of pollinators, the crops they service, and the threats to them. However, the distribution of expertise is unevenly distributed among nations and is declining largely through the retirement and lack of replacement of taxonomists and systematists. The co-ordination and effective use of the world's remaining experts is critical to formulating the important policies and making the correct decisions which will ensure the continued services of pollinators in agriculture.

Achieving the objectives

- Establish an experts group on pollinators within the CBD.
- Identify organisations and other instruments and utilise their international agreements and conventions to address pollinator conservation and work with them to incorporate principles and actions which benefit pollinators.
- Establish a specific working group on pollinators within IUCN's Species Survival Commission.

Timeframe. The first item above could begin immediately and be completed within a year under the auspices of CBD/ SBSTTA. The second should also begin i ediately. Identification of instruments can be competed within a year, but incorporation of principles and actions will entail a continuing effort during a few years. Initiation and completion of the third item is dependent on the IUCN process.

Opportunities for partnerships and co-operation. The relatively small number of experts in pollinator conservation will need to pool their resources on an international basis. Common problems and shared use of pollinators in both agricultural and natural ecosystems provide a unique opportunity for c -operation among experts in both sectors.

Major constraints for implementation. Logistics are the major constraint.

ACTION 2. Establish an international information network on pollinator conservation

Objective. To link information and databases on pollinator taxonomy, research, monitoring an conservation and make it widely available and accessible.

Rationale and urgency. Much existing data and information on pollinators exist in reports, collections, publications and other sources. However, it is not easily located, nor is it available in forms which are most useful to policy and decisio -makers. Existing data and information should b organised and made accessible for application to conservati n problems and to guide the efficient collection of new data.

Methods of achievement.

- Establish information networks on pollinator conservation. Develop a global thematic focus within the Clearing-House Mechanisms of CBD. Develop focus areas in regional networks such as the Inter-American Biodiversity Information Network.
- Create a global directory of pollinator experts (with locator information) on pollinator conservation, indexed by crops, plants and pollinator species.
- Create a directory of collections containing pollinator voucher specimens of the 20 to 30 major collections
- Create an electronic pollinator bibliographic database built on those that already exist (e.g. Gottsberger, Cane and Beltsville).

Timeframe. Begin immediately and complete within two years.

Opportunities for partnerships and co-operation. Developed countries possess much of the information about the pollinators in developing countries. Some developing countries have important collections and informatio as well. The information resides with governments, universities, museums and private sources. All sources should cooperage in the open exchange of information for maximum benefit and application.

Major constraints to implementation. The major constraints in information networking include the availability of software and hardware, Internet technology, data and metadata standards and data in electronic form.

ACTION 3. Assess the state of scientific and indigenous knowledge on pollinator conservation
Objective. To provide an evaluation of the knowledge base about pollinators and their conservation and to identify critical information gaps and priorities for future work.

Rationale and urgency. While there is much that needs to be learned about pollinators and pollination, a strategy is needed to determine the most important areas of work with respect to conservation. The strategy should be developed on the basis of what is already known from scientific and indigenous sources of information.

Method of achievement.

- Define and create a database as a "living document" on pollinators for world crops – (like that of Roubik 1995) and their conservation status.
- Assess the conservation status of wild pollinators of the world's major agri ultural crops. This should be on a country by country basis leading to a global economic assessment of the value of crop pollinators.
- Develop a compendium of pollinator conservation case histories.
- Synthesise and compile information on "pollinator-friendly" farming methods.
- Develop global and national lists of threatened pollinator relationship including "hot -spots" and migratory pollinators.
- Develop model-testing protocols for the introduction of non-native pollinators.
- Develop model-testing protocols for agrochemicals with reference to their effects on bees and other pollinators.

Timeframe. Begin immediately and complete within three years.

Opportunities for partnerships and co-operation. Pollinators and the plants they pollinate are international in scope. In addition, they occur in natural and managed ecosystems and landscapes. The conservation, environmental and agricultural sectors must cooperage as well as international and national organisations.

Major constraints to implementation. New funding will be required to conduct a systematic assessment. Institutional barriers among sectors will also need to be removed.

ACTION 4: Develop an international communication outreach capacity
Objective To disseminate high quality and understandable information about pollinators and their conservation to a wide variety of audiences and users.

Rationale and urgency. The impending crisis of the decline of pollinators is still relatively quiet. A major global campaign is needed to make people aware of pollinators and the potential loss of their services.

Method of achievement

- Define criteria and indicators to evaluate the status of and threats to agricultural production of a reduction in pollination
- Create multilingual manuals on pollinator conservation and restoration for farmers (in local idioms and adapted to the reality of each country);
- Approach International Standards Organisations to create "bee smart" labels on certification (like on tuna fish cans) for "pollination friendly" products. Promote pollinator awareness by putting charismatic bumblebees and other icons and logos on tomatoes and other fruits. Develop other business incentives (and remove disincentives) for pollinator conservati n.

Timeframe. Begin immediately and complete within three years.

Opportunities for partnerships and co-operation. The media should be enlisted to help publicis the need for pollinator conservation. The agricultural industry should work with cons rvation and environmental sectors.

Major constraints to implementation. Institutional barriers between sectors will need to b removed.

PROGRAM ELEMENT 6: SUSTAINABLE USE OF POLLINATORS

Co-ordinator: Hayo Velthuis

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Rapporteur: Astrid de Matos Peixoto Kleinert

Topics suggested for discussion

1. Review restoration experiences
2. Assess restoration experimentation
3. Assess restoration of nesting sites and floral diversity
4. Assess restoration efforts on private properties
5. Assess effectiveness of restoration efforts
6. Assess dissemination of best practices
7. Assess capacity building for restoration
8. Assess promotion of technology transfer

PREAMBLE

Few people are aware of the fact that there are over 25,000 different species of bees, which differ tremendously in size, and diverge accordingly in the plants they visit and pollinate. Both the diversity of wild plants and the variability of food crops depend on it. Though bees form the most important group of pollinators, other insects such as butterflies and moths, flies and beetles also contribute. In most cases we lack the knowledge about the exact relations between individual plant species and their pollinators, but studies in this field demonstrate that they are often quite specific. In order to maintain this aspect of biodiversity, ecosystems should be preserved so that the proper combinations of plants and their pollinators can continue to co-exist.

For agriculture to profit from the diversity of plant-pollinator relationships, the two extreme situations should be envisaged. On the one hand there is small-scale agriculture amidst undisturbed, natural areas from which pollinators may migrate onto the agricultural plots. On the other hand ar the extensive fi lds with hig -tech agriculture, where pollinators are usually locally extinct or present in very low numbers. In these, temporary importation of pollinators is necessary. Such a practic characterises the co-operation between agriculture and beekeeping. However, for a number of crops honeybees are not the only or the most suitable pollinators and, indeed, several other bee species ar being bred in managed systems, albeit on a limited scale. This has led to increases in quantity an quality of the crops concerned. Further diversification of pollinator species in agriculture can easily be imagined, if proper breeding systems can be developed. For maintaining the existing services of pollinators and for promoting new developments a number of measures n d to be taken.

GENERAL PROPOSAL

The group identified three areas as requiring particular attention.

1. Co-ordination between those working on pollination issues and other environmental and agricultural activities, programmes and networks emphasising the strengthening of the liaison between research, scientific bodies and policy development processes.

2. Co-ordination of methods, analyses and interpretation of biodiversity assessment.
3. Co-ordination among conventions, agreements and specific scientific working groups an networks related to biodiversity.

These areas should be equipped for three purposes:
A. Gathering and exchange of informatio
B. Research and assessment
C. Development and dissemination of techniques and guidelines

A. Gathering and exchange of information

1. Conduct an inventory of information and best practices in different agro-ecological systems. The following should be covered.
   - Pollinator diversity and decline
   - Identification of pollinator species and guilds of effective pollinators of the crops and wil plants which are important for food and agricultur
   - Identification of pollinator requirements of different crops and cultivars
   - Identification of threats and constrains to maintaining pollinator diversity
   - Effective techniques and best practices in different environments.

2. Development and dissemination of techniques and guidelines. Promote the exchange of information on pollination through databases and interactive scientific networks etc. Particular attention should be paid to the following.
   - Exchange of information between modern commercial agricultural systems and traditional (or small scale) agricultural systems, including low and high intensive systems in different agro-ecological areas, taking into account natural and managed pollinators.
   - Information exchange between countries on existing national regulations and guidelines, regarding the introduction of exotic pollinator species.

B. Research and assessment

1. Conduct risk/ impact assessments. These should be conducted in agro-ecosystems based on technical, ecological and socio-economic analyses with particular emp asis on the following.
   - Habitat fragmentation and degradation.
   - Disturbances to natural pollinators and their habitats.
   - Practices and technologies uses in agricultural production with emphasis on biological and behavioural changes in the pollinators resulting from pesticide use, plant nutrition, differences among cultivars, disruption of adjacent habitats, crop specialisation, etc.
   - Alternative and new practices and technologies, such as multi-cropping, non–tillage, crop rotation, organic farming, biotechnologies, etc.
   - Introduction of exotic species.
   - Use of transgenic plants.

2. Research on effective use and management of pollinators in agriculture. Research projects and activities should be pri ritised to develop appropriate breeding systems and techniques for target pollinator species in different regions and farming systems to promote the effective use an management of pollinators in agriculture (e.g. stingless bees, *Xylocopa*, *Megachil* , *Osmia*, *Centris, Bombus, Apis*).

3. Promote targeted applied research for farmers and rural communities. Targeted applied research, including participatory research should be developed with the co-operation of farmers and rural

communities and, where appropriate, be built on local knowledge systems. The following areas should be emphasised.

- Plant breeding systems and mechanisms.
- Pollination requirements.
- Threats to pollinator diversity.
- Effects of changing agricultural practices, technologies and crops.
- Relative effectiveness of pollinators worldwide with a view to developing the basis for sustainable agriculture through pollinator diversity
- Improved pollination management practices which complement plant breeding, techniques, fertilis r use, etc for enhancing productivity and sustainability of cropping systems

C. Development and dissemination of techniques and guidelines

1. Develop agricultural practices and techniques, for different agricultural production systems an disseminate information, and guidelines, through 'A' above. The documentation should include:
   - Range and pasture, cropping systems, managed forests and integrated systems
   - Incorporation of pollination into integrated pest management
   - Maintenance and manage of natural areas for pollinators in different farming systems and interfaces between ecosystems, such as forest crop margins, protected areas etc.
   - Promotion of pollination as an integral component of sustainable agricultural syst ms and cropping practices for enhance productivity.
   - Restore pollinators and pollinator habitats following degradation and natural calamities.

2. Encouragement of case studies on the impact of current biodiversity conservation and restoration efforts on the conservation and sustainable use of native pollinators for agriculture, with a view to developing recommendations and technical guidelines for enhancing the restoration and sustainable use of pollinator diversity.

3. Develop technical guidelines for best management practices in different agro-ecosystems. The following should be incorporated:
   - Local and regional experiences
   - Recommended pollinators and breeding techniques for specific crops
   - Techniques for maintaining pollinator diversity, including natural pollinator, and sustainabl beekeeping and required plant species and habitats
   - Pollinator management techniques
   - What to avoid and why i.e. introduction of exotic species
   - Assessment and monitoring mechanisms, including risk and impact assessment.

4. Develop technical guidance and recommendations for policy makers. These should be aimed a policy makers at national and international levels, including FAO, UNEP, CABI etc. They should include:
   - Guidelines and regulations on the introduction of exotic pollinator species
   - Other practices which might have negative impacts on pollinator diversity an effectiveness, such as changes in plant communities (species on which pollinators rely). Two case studies are Africanised honeybees in South America and oil palm in Malaysia
   - Promote public awareness.
   - Pollinators should be used as the entry point to promote public awareness through educational programs to highlight the importance of biological diversity and integrated natural resources management for sustainable agriculture

5. Include pollination in formal educational programs. Integrate pollination issues as a component of sustainable management into agricultural, biological and environmental science courses and

curricula and in primary and secondary schools by using local examples and relevant examples from other regions.

PROPOSALS FOR ACTION: **SUSTAINABLE USE OF OLLINATOR**

The actions presented below are linked to the three above topics:

A. Gathering and exchange of information.....Actions 1, 2
B. Research and assessment.....Action 3
C. Development and dissemination of techniques and guidelines.....Actions 4, 5, 6, 7, 8

ACTION 1: **Disseminate information on pollination in agricultural environments: Objective**

To establish a central, global focus for sharing information on pollination in agricultural environments through a web site, databases and interactive scientific networks.

Rationale and urgency. There is an urgent need for a web site, databases and interactive scientific networks.

Method of achievement. The web site should be established at a global focus location where existing library facilities are excellent, networking facilities well-established and professional expertis available and a global perspective exists. For efficacy in the dissemination of information ther should be a co-ordinated approach in the

- homogeneity in the quality of information
- co-ordination among the expertise in the field.

Timeframe. The development of a web site, data bases and interactive scientific networks should begin as soon as possible.

Needs and opportunities for partnerships and co-operation. Information dissemination is dependent on international partnerships and c -operation.

ACTION 2: **Inventory of pollination and pollinator experts.**

Objectives. List of existing experts on pollination and pollinators and their fields of interest.

- Development of interactive scientific networks
- Presentation of courses and practical demonstrations

Rationale and urgency. Although capacity is limited, existing expertise can be shared to initiate programmes and broaden experience. Interchange will indicate areas being investigated and avoid duplication. Information exchange is an essential first step for progress and should begin immediately.

Method of achievement.

- Compile lists of existing experts on pollination and pollinators, and their fields of interest preferably using e-mail
- Develop interactive scientific networks for exchange of information through e-mail

Opportunities for partnerships and co-operation. Opportunities are open. Furthermore, joint projects and technology transfer between countries and regions may attract increasing funding.

Timeframe. The inventory of experts to take place during the first year. Initial courses and technology transfer to be undertaken during the first two years, thereafter more advanced courses should be developed.

Major constraints for implementation. Funding for inventorying, project in administration and implement action.

ACTION 4: **Promotion of applied research on pollination in agricultural ecosystems throug training of post-graduates to work on specific points addressed in point 9**

- Present training cours s and practical demonstrations

No details were provided.

ACTION 5: **Natural habitats as sources of wild pollinators for crop improvement**
Objective. To provide a quantitative assessment in terms of crop yields of preserving tracts of natural landscapes in agricultural landscapes via pollination.

Rationale and urgency Despite the existence of some concerns on the pollinator decline issue, ther is an almost total lack of empirical data on the concrete benefits of "mosaic" landscapes for agriculture via pollination.

Achieving the objectives. Through the promotion of research on edge effects on pollinators, pollination and seed output levels into the matrix, and also comparing pollination and seed yield of crops across landscapes.

Timeframe. One year to implement; two more years for meaningful results.

Opportunities for partnerships and Co-operation. No special needs: research of the kind proposed is feasible and relatively inexpensive. Co-operation at the regional and international level coul be useful, however.

Major constraints for implementation. Lack of expertise in some regions. Possible kinds of action to be proposed are training and capacity building and targeted research.

ACTION 6: **Evaluation of positive and negative effects of alternative practices and technologies in agricultural production on pollinator conservation and effectiveness**
Objectives.

- Predict impacts of agricultural production practices/technologies on pollinators.
- Compare different production systems as regarding to pollination effectiveness.
- Identify production techniques and practices which are soft on pollinators and stimulat pollination.

Rationale and urgency. Some agricultural production techniques may have negative effects or may contribute to decreased pollination efficiency. There is a need to identify factors in the production systems which can interfere negatively with crop pollination as well as those which represent positiv effects. In this sense, alternative approaches have to be tested.

Achieving the objectives. Identify possible alternatives for production management, such as multi-cropping, crop rotation, non-tillage, organic agriculture, conservation of adjacent habitats, etc. Test them under different situations and conditions.

Timeframe. Five years to sort out the most appropriate alternatives for some particular conditions. Case studies in most representative conditions are recommended.

Opportunities for partnerships and Co-operation. Integration among research institutions and universities with NGOs which in most countries detain valuable knowledge on alternative agricultural production systems.

Major constraints for implementation.

- Need for incorporation of this priority in National Agricultural Research Systems.
- Low availability of specialised work teams.

ACTION 7: **Evaluation of impacts on pollination of practices and technologies used in agricultural productio**

Objective. Identify best methodologies to measure impact on pollinators by currently used technologies, such as pesticides, fertilisers, cultivars, monocultures, etc.

Rationale and urgency. Some agricultural production practices are disruptive on pollinators and can contribute to a low efficiency of pollination.

Achieving the objectives Use of general guidelines and practical approaches to rapidly differentiat among practices and technologies the ones which are softer on pollinators.

Timeframe. Three years for main ecosystems, conducting case studies in each one.

Opportunities for partnerships and Co-operation. Co-operation among research institutions universities and grower c -operatives.

Major constraints for implementation.

- Opposition by private sector (input industry, mostly)
- Organisation culture may counteract this initiative.
- Difficulty for identification of representative study areas.
- Lack of interest in identifying problems with agricultural production systems currently u sed.

ACTION 8: **Promote research to improve knowledge on the real needs of pollination o tropical crops and forest trees**

Objective. Knowledge on pollination biology of economically important tropical plants.

Rationale and urgency. There are many gaps about the reproductive biology and pollination of tropical crops. It is urgently necessary to know the real needs of the pollination requirement of thes crops.

APPENDICES

ACRONYM

Apimondia	International Federation of Beekeepers' Associations
BioNET	
CABI	
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CI	Conservation International
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnologico [Brazilian National Council for Research and Technology Development]
COP	Conference of the Parties
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária [Brazilian Corporation for Agricultural Research]
ETC	
EU	European Unio
FAO	Food and Agriculture Organisation
GDOR	Global Diversity Outlook Report
GEF	Global Environment Facility
GTI	Global Taxonomy Initiativ
IBRA	International Bee Research Associatio
ICPBR	International Commission for Plant-Bee Relationships
IUCN	the World Conservation Union – IUCN
MMA	Ministério do Meio Ambiente [Brazilian Ministry of the Environment]
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advic
SREN	Sustainable Rural Environmental Energy Network
STAP	
TI	Taxonomic Impediment
UND	United Nations Development Progra
UNEP	United Nations Environment Progra
USP	University of Sao Paulo

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