REPORT OF ACTIVITIES AND DISCUSSIONS RESULTS OF SUBGROUP 3.1.

Bee Management for Pollination Purposes - Bumblebees and Solitary bees

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SUMMARY

Solitary bees can potentially be used as pollinators to various crops cultivated in Brazil, but no solitary bees are yet commercially available to growers and rearing techniques are available only for a few species such as *Xylocopa* spp. Ground-nesting bees of *Exomalopsis, Epicharis* and *Centris* genera are good pollinators of crops such as tomato (*Lycopersicum esculentum*) and acerola or West Indian cherry (*Malpighia emarginata*), but they are difficult to manage, in that for most cases there is no practical way to colonize areas with new nests, and merely providing suitable nesting sites (e.g. sand) rarely yields productive nesting for many years. For ground-nesting bees that are effective and abundant pollinators of a crop (or desired tree species) or its close relatives, the farmer must manage the crop (care with spraying, for instance) and the surrounding land (size of monoculture acreage, proximity to fallow nesting sites), as these bees' nests cannot be moved and artificial or "created" nesting sites are unlikely to be reliably and quickly colonized. Promising taxa of cavity-nesting species of solitary bees are *Xylocopa, Centris, Megachile, Anthidiini* and *Tetrapedia*, but there is lack of knowledge on the species' natural histories, floral hosts, parasites, diseases, etc. Cost-effective technological improvements are needed to reliably provide large numbers of manageable bees for commercial pollination. However, methods/techniques will need to be tailored to each bee species. The use of solitary bees as pollinators can be launched with small growers that probably will own their own bees, and stimulating them to show the results the growers can have when they use the pollinators (in numbers, value, amount of profit). Other growers will be very rapidly convinced once they see the profits of their neighbours. As it is not common in Brazil to value the pollination services, bees in general, especially solitary bees, it is important to spread information (about simple concepts as pollination, pollinators, their services, etc), distributed by extension programmes (for example in agriculture of small areas of *Passiflora*, since techniques to rear and use *Xylocopa* as pollinators are already available in the country). Regarding *Bombus* species, it is necessary to investigate the economic value of greenhouses crops in Brazil to assess the need or not of using *Bombus* as pollinators. If necessary, native species such as *B. atratus* and *B. brevivillus* (not so aggressive when in small colonies) and meliponini bees such as

Melipona quadrifasciata (at least for tomatoes) should be considered. There should be a national regulation forbidding importation of exotic *Bombus* species and a monitoring program of invasive *B. terrestris* from Uruguay, where it was introduced since 1995 and now is free in nature. Finally, researches on *Bombus* and solitary bees' natural histories, floral hosts, parasites, diseases, foraging behavior, rearing techniques, management and pollination effectiveness in various crop species are necessary for these bees to be used as large-scale reliable pollinators in Brazilian agriculture.

SOLITARY BEE SPECIES

Considering nesting habits, solitary bees can be split into two distinct groups:

1. Grounding nesting bees
2. Cavity nesting bees

Currently promising taxa to be worked on are:

Exomalopsis (there are reports on tomato pollination);
Epicharis (There are reports on West Indian cherry or acerola pollination);
Centris (There are reports on West Indian cherry or acerola pollination).

Grounding nesting bees are difficult to manage, in that for most cases there is no practical way to colonize areas with new nests, and merely providing suitable nesting sites (e.g. sand) rarely yields productive nesting for many years.

There is little knowledge about grounding nesting bees as pollinators and their management for this purpose. Three main approaches are suggested to help identifying potential pollinating bee species:

- Search for areas with less intensive agriculture for visitation to crop species (e.g. home plantings of *Cucurbita*) where insecticide use is unlikely, so that populations can increase without extermination by pesticides;
- Search for promising species of non-social pollinators (or social Halictidae) in wild crops and their wild relatives (co generics). ex. *Rhambutan* is visited and pollinated by *Euglossa*;
- Investigate pollen use by any large aggregations where solitary bee species are found and discovered (e.g *Oxaea*) to judge if they might be using flowering species of agricultural interest (e.g. aggregations of *Peponapis*).

RECOMMENDATION:

For ground-nesting bees that are effective and abundant pollinators of a crop (or desired tree species) or its close relative, the farmer must manage the crop

(care with spraying, for instance) and the surrounding land (size of monoculture acreage, proximity to fallow nesting sites), as these bees' nests cannot be moved and artificial or "created" nesting sites are unlikely to be reliably and quickly colonized.

There are considerably more information and well-succeeded examples of cavity nesting species of solitary bees. Species such as *Osmia lignaria pronpiqua* and *Megachile rotundata* are largely used and managed for apple (*Malus domestica*) and alfalfa (*Medicago sativa*) pollination, respectively, and their commerce is responsible for millions American dollars every year.

Other promising taxa such as *Xylocopa, Centris, Megachile, Anthidiini, Tetrapedia* already nest in artificial nesting-sites and can potentially be managed for large populations and use for pollination. Among these taxa, *Xylocopa* can be considered special in Brazil because there is a demand for these bees and some knowledge on its biology and rearing technique for use especially in *Passiflora*.
Serious constrains were identified and must be overcome for large production and economic viability of exploiting these bees as crop pollinators:

- Ants are serious predators of nests and must be controlled;
- Need to eliminate parasites and diseases (clean management) before establishing populations for increase;
- Need of insecticide management by coordination of sprays to avoid the crop's bloom;
- Lack of knowledge of techniques and species' potential to produce bees in large numbers;
- Lack of knowledge of what crops benefit most from pollination by solitary bees;
- Lack of margins/fallow/hedgerows areas for grounding nesting bees;
- Field assessment of pollination value;
- Affordable nesting materials/trap nests after knowing which bees are going to be used;
- Lack of taxonomic pollen analysis or floral visitation analysis to establish floral use.

RECOMMENDATION:

Main recommendations are to compile Brazilian studies of past trap-nesting experience in Brazil to have a starting point from those species that are present in the country and can be reared in trap-nests; and to develop an insecticide management programme, in which practices should minimize mortality (label requirements on insecticides, for instance, emphasize scouting + economic thresholds). This programme could be developed by the honeybee management group due to their larger experience on using bees for pollination purpose.

Some cultivated plants that probably benefit from pollination by solitary bees.

		Common name	
Botanic Family	Scientific name	English	Portuguese
Apocynaceae	*Hancornia speciosa*		Mangaba
Anacardiaceae	*Anacardium occidentale*	cashew	Caju
	Spondias tuberosa		Umbu
	Spondias spp		caja, cajarana, umbu-caja
Bixaceae	*Bixa orellana*		urucum, coloral, açafrão
Cucurbitaceae	*Cucurbita pepo*	pumpkin	Moranga
	Cucurbita moschata	squash	Abóbora
	Cucumis melo	melon	Melão
	Cucumis sativus	cucumber	Pepino
Fabaceae	*Glycine max*	soyabean	Soja
	Vicia faba	field bean	
	Phaseolus vulgaris	kidney bean	Feijão
	Lens esculenta	lentils	Lentilha
	Pisum sativum	pea	Ervilha
	Vigna sinensis	cowpea	feijão de corda
Lecythidaceae	*Bertholletia excelsa*	Brazil nut	castanha do Pará
Malpighiaceae	*Malpighia emarginata*	West Indian cherry	Acerola
	Byrsonima crassifolia	wild cherry	Murici
Malvaceae	*Hibiscus esculentus*		
	Gossypium hirsutum	cotton	Algodão
Passifloraceae	*Passiflora edulis*	passionfruit	Maracujá
	Passiflora quadrangularis	giant granadilla	maracujá-açu
	Passiflora mucronata		Maracujá
	Passiflora alata		maracujá-doce
Solanaceae	*Lycopersicum esculentum*	tomato	Tomate
	Solanum melongena	egg-plant	Berigela
	Capsicum annuum	sweet pepper	Pimentão
	Capsicum spp.	peperoni	Pepperony

Study Cases

Recommendations to some individual crops

Passion Fruit (*Passiflora edulis*)

Bees: *Xylocopa frontalis, X. grisescens, X.augusti, X. ordinaria, X. suspecta,* and other large X. spp;
Nests: dead tree trunks, trap nests, *Xylocopa* nests;
Bee density: 25 females/ha in the case of *X. frontalis*
Crop management: need of complementary floral resources: buzz pollinated species (Melastomataceae, *Cassia, Sena, Solanum*, etc)

Cashew (*Anacardium occidentale*)

Bees: *Centris* species. *Centris tarsata* tested, but other species can also be important. Take in account behaviour of bee, pollen distribution in bee body, and viability of pollen is important: only for 4 hours;

Nests: trap nests

Bee density: unknown

Crop management: will need supply pollen and oil producing plants (*Byrsonima crassifolia* for wild cashew), possibly mixed culture with West Indian cherry (acerola) in commercial plantation.

Cotton (*Gossypium* spp.)

Bees: Emphorini spp; Augochlorini; *Bombus; Xylocopa*
Nests: depends on species used;
Bee density: very large crops will need hundreds of bees (to be estimated):
Crop management: depending on variety, there is a possibility of gain in frutification period (?)

Cucurbitaceae

Bees: several taxa of ground-nesters (*Peponapis*, augochlorines);

Nests: natural, in the ground (see discussion above);

Bee densitiy: unknown

Crop management: local conservation should be promoted through education of growers. Free pollinators when available, but impossible to re-colonize once exterminated.

West Indian cherry (*Malpighia emarginata*)

Bees: *Centris* (both ground and cavity nesters), *Epicharis* (ground-nester). Nests: both natural, in the ground, and trap-nests depending on the species;

Bee density: unknown

Crop management: Not visited by bees that do not use oil (ex. honey bee). Will need to understand behaviour of bee, pollen distribution on bee body, optimize trap nesting techniques; Could be beneficial to grow with cashew bloom.

Vegetable or oil seed crops

Production of high-value specialty seed, such as onion and carrot, or hybrid seed crops (sunflower) on small acreages.

Regional or specialty fruits

Some solitary bee species can be important pollinators of regional or specialty fruits like mangaba (Apocynaceae: *Hancornia speciosa*) and umbu (Anacardiaceae:

Spondias tuberosa).

Suggestion:

Bee biologists should participate in crop symposia sponsored by the International Society for Horticulture Science (ISHS), in order to exchange expertise with the world's most knowledgeable producers, breeders and processors of specific crops.

PROTOCOL WITH GENERAL RECOMMENDATIONS TO USE SOLITARY BEES AS CROP POLLINATORS

- complementary floral resources should be provided;
- plants for nidification (trunks) initially, later provided nesting substrates (although these two may be made from natural materials, such as stick nests, rather than drilled nesting blocks);
- conservation of natural areas (in order to keep natural populations); need not be proximate to crop of interest (sustainably extractive reserves for initiation of trap-nesting programs);
- spray management- toxic spray must be avoided during bloom;
- different *Xylocopa* nests must be compared (Freitas & Oliveira Filho vs. Camillo models);
- cultivation of other crops simultaneously for year-round forage (no extensive monocultures at scale greater than flight range);
- adequacy of local/regional conditions;
- management of ruderal plants where necessary.

Cost-effective technological improvements needed to reliably provide large numbers of manageable bees for commercial pollination

1) Paper nesting straw inserts

Reason: Need these in large numbers for selection of precise sizes for both a trap-nesting program and for handling large numbers of managed species (ex. for *Centris*, anthidiines).

Advantages: easy re-use of drilled nesting blocks, better control of disease and parasites (esp. mites) from generation to generation, opportunity to X-ray nest contents to eliminate diseased or parasitized cells prior to establishing

new populations. Plastic straws unsuitable, as many bees do not like the slick surface, plus lack of air permeability leads to serious mold problems.

Options: purchase paper straws from manufacturers in North America (list of suppliers at: www.loganbeelab.usu.edu or Europe (sources?) or perhaps still manufactured in Brazil. Should consider technique of thin-walled paper straw inserted in paper tube inserted in hole in nesting block. The benefits are analogous to the moveable-frame hive for honey bees.

2) Use of X-ray units:

Reason: needed for evaluating nest contents, progress of development and metamorphosis, location of diseased or parasitized cells (for surgical removal from nest) and other applications.

Advantages: quick and reliable.

Options: Could be a central unit at one laboratory to which samples can be sent by researchers around Brazil. Consider purchase of a used unit from hospital, possibly from overseas if not available within country. Applications detailed in published studies with *Osmia lignaria* and *Megachile rotundata*. Alternatively, can use stick nests of soft, easily split wood or possibly reeds (Japanese *Osmia* system). Choice will be guided by practicality, cost, use by bees, and local availability

3) Mass-production for drilled nesting blocks.

For Brazil's economy and labor market, what is the cost-effective method for mass production of acceptable nesting materials for cavity-nesting bees? Are manufacturers of hive equipment interested in producing interchangeable, easily assembled components of *Xylocopa* nest boxes? Are there manufacturers interested in producing drilled wooden nesting blocks in large numbers, or clever methods for using paper straws inserted within cardboard tubes within boxes (holes must be straight and approx. 15 cm deep for larger species, although research with individual species will demonstrate the hole diameters and depths that yield the greatest number of daughters per nest). Can begin by mimicking techniques already in use with *Megachile* and *Osmia* in the US, Japan and Europe. Aspects of these programs will clearly need adaptation to Brazil's tropical environments, although aspects may be more applicable in the south, such as for apple pollination in Santa Catarina (for instance, how to handle multivoltine species, irrelevance of refrigerated overwintering).

4) Control of enemies

Simple techniques needed for excluding ants from nesting blocks, especially blocks managed for crop pollination (would be nice for trap-nesting too, but perhaps not practical).

Options: Physical barrier over which ants cannot walk. Must persist and not catch bees.

FINAL CONSIDERATIONS REGARDING SOLITARY BEES

1. Measuring effectiveness of methods for population increase:

   a. The only practical species to manage are those whose populations can be increased (more daughters than mothers);

   b. Methods that produce populations with limited parasites and disease;

   c. Affordable nesting materials that are practical to make and endure for *Xylocopa* and *Megachile*, there is the possibility for adaptation of existing methods).

2. Greenhouse pollination

The main difficult in using solitary bee as pollinators in greenhouse is that glass and plastic absorb UV, which interferes with bee orientation during flight. How to measure their pollination efficiency in greenhouse is not relevant; at this stage it is known which species can be used for that.

3. Stimulating people to get involved in rearing and making business with solitary bees.

Stimulate small growers that probably will own their own bees; to show the results the growers can have when they use the pollinators (in numbers, value, amount of profit). We just have to convince about 1% of them, the rest will be very rapidly convinced once they see the profits of the neighbours. As it is not common in Brazil to value the pollination services, bees in general, specially solitary bees, it is important to spread information (about simple concepts as pollination, pollinators, their services, etc), distributed by extension programmes (for example in agriculture of small areas of *Passiflora*).

Considerations regarding Bombus

1) No importation of non-native species.

There should be regulation on importation of bees:

- Brazilian laws must be made prohibiting and punishing *Bombus* importation;

- Seek an agreement among South American countries or in the Mercosul to regulate and punish the country that import *Bombus*, or at least to make it responsible for consequences;

- Establish a monitoring programme of invasive *Bombus terrestris* from Uruguay. This species was introduced in Uruguay in 1995 and now is free in nature, colonizing new areas and spreading towards the Brazilian border.

2) Need of importation of non-native *Bombus* species

There is no need of importation, because:

- These bee species are used only for pollination of greenhouse crops. What is the economic value of greenhouses crops in Brazil?

- They are used mainly for tomato pollination, but recent studies have shown that the native stingless bee *Melipona quadrifasciata* is an excellent tomato pollinator in greenhouses;

- Exotic *Bombus* species may bring parasites and diseases to native species.

3) Using native *Bombus* species for crop pollination

Do not currently have knowledge to handle native *Bombus* to agriculture at the moment. If it is going to be used, research is needed to study biology and rearing methods. Some species are promising:

B. atratus - not so aggressive when in small colonies;

B. brevivillus - in Northeast Brazil, not aggressive; potential as pollinator of crops of glasshouses or in open areas.

Research is needed.

CONCLUSION:

Bombus are used commercially only to pollinate greenhouse crops. This agricultural segment is still small in the country, comparing to the size of the Brazilian agricultural system, and does not justify the risk and unknown consequences of importing or allowing the entry of exotic *Bombus* species. Also, most greenhouse cultivation is done with tomatoes and the stingless bee *Melipona quadrifasciata* has shown a good alternative to pollinate this crop in enclosures, and there are promising native *Bombus* species that could also be studied for this purpose. Finally, Brazil should create laws prohibiting and punishing *Bombus* importation, follow the spread of *B. terrestris* in Uruguay and monitor its arrival in the South of the country.