REFORESTATION WITH MAJOR BEE FOOD TREES IN EL SALVADOR

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Abstract
The preliminary results of a trial plantation with major bee food trees in El Salvador (Central America) will be shortly discussed. The 20 neotropical bee food trees will be presented and their characteristics for which they are selected in the reforestation will be highlighted. The trees are selected for the stingless bee Melipona beecheii*, and planted on the land of beekeepers by the project "PROMABOS". The aim of the reforestation is increasing the honey production of* M. beecheii*, thus enhancing its survival and augmenting the income of local beekeepers. PROMABOS has included the reforestation programm in the project activities because deforestation is the main hurdle in beekeeping with stingless bees in Central America. In El Salvador, only 2-5% of the land is covered with primary forest, around 30% with degraded woodland.*

Introduction

In this article, the selection of major bee forage trees for reforestation near beecolonies is discussed. The reforestation is aiming the development of stingless beekeeping in El Salvador, Central America, as part of the stingless beekeeping project PROMABOS. The selection criteria for these plant species and conditions for the reforestation are reviewed, and the major bee forage trees and shrubs are listed with a brief review of their properties.

Stingless Beekeeping in El Salvador: PROMABOS

The native bee species in the tropical Americas are stingless bees (Apidae, Meliponinae). These bees vary strongly in size, honey production and honey quality. One of the most appreciated species for its honey is *Melipona beecheii*, a stingless bee endemic to Central America with about the same size as the honeybee (*Apis mellifera*). It was already kept by the Mayas in pre-hispanic times for its highly appreciated honey, which is produced in lower quantities than in honeybee colonies but distinguishes in its taste and more medicinal properties are subscribed to it, and therefore it sells at a better price. Owing to their particular swarming behaviour and the requirements for nest-sites, *M. beecheii* is very vulnerable to habitat fragmentation.

Massive deforestation has taken place in the tropical Americas and El Salvador is left only with 5 to 10% of its original vegetation (FAO, 2000). *M beecheii* is in danger of extinction and in El Salvador it is kept only in certain regions in the North. Owing to its specific buzz-pollination in particular, this Melipona species seems important for the pollination and conservation of some of the indigenous trees and plants.

PROMABOS is a project aiming at the development of stingless beekeeping, specially the keeping of *M. beecheii*, in the region of La Palma, North-West of El Salvador. A major aspect of this project is a reforestation program with bee forage trees. These trees will be planted on the land of beekeepers with stingless bees in the region with the aim to increase the honey production of their *Melipona* colonies. For this reason, the project has inventoried the flora present in the region and is applying pollen studies to investigate what plant species are of greater importance in the diet of *M. beecheii*. On the plants listed in the inventory, information of different studies is gathered about their importance in the diet of *M. beecheii* and *A. mellifera* and major bee forage plants are selected for the reforestation program. In order to create a bee forage forest, 10 important nectiferous or polliferous trees forming the canopy are selected and for the understorey 10 important small trees or shrubs. These canopy and understorey trees are planted in trial plantations in May and June 2003. The mixing of species has the advantage of fast flowering of the fast growing shrubs and small trees while the larger trees develop and of creating a bee food understorey with the shade resistant shrubs; the disadvantage of mixed planting is that the faster growing species can take away light for the lower developing ones. The development of the mixed plantation under different ecological conditions will be monitored and accordingly a new selection will be made with the most promising species and recommendations on their planting and management will be provided.

The Region of La Palma

The region of La Palma is located in the North-West of El Salvador, close to the border with Honduras and Guatemala. The beekeepers with stingless bees are found approximately between 600 and

1300 meters above sealevel. The vegetation on the lower parts is a leafshedding tropical dry forest, and at the higher altitudes we find a tropical mountain cloud forest with pine (*Pinus oocarpa*), oak (*Quercus spp*) and *Liquidambar styraciflua* as characteristic species.

Importance Plants in the Diet of Melipona beecheii

Different information sources have been reviewed to learn whether the plant species in the inventory are of importance for nectar and/or pollen supply to *M beecheii*. Since there exist only few studies on this stingless bee, also information on utilization of the plant species by *A mellifera* is included. Having about the same size, it could be that they have a lot of overlap in their diets.

The studies reviewed are based on different methods: from interviews with beekeepers to palynological studies of pollen taken from the worker bees returning from the field. In many studies the methods or source of the information is not provided, so one does not know how reliable the information really is. E.g., when a bee is seen to visit a flower, this does not necessarily imply it is collecting nectar or pollen from it; one literature source can be stated in four different studies making the reader mistakenly believe that the species is recommended by four independent studies. To prevent these misunderstandings and provide more transparent information, a scheme is made with detailed information of the method used to identify the plant species collected by *Melipona beecheii*, *Melipona* sp or *Apis mellifera* when this was known or retraceable by the author.

Scheme 1

Summary table of the different studies on major bee food plants

The different existing methods of palynoligical research on pollen mosters are given in the first four columns. The mosters are taken from the pollen or honey storage pots in the nests (stored pollen and stored honey), from the curbiculae of the worker bee returning from the field collecting pollen (pollen loads) and from the body or the nectar in the honey stomach of the worker bee returning from the field collecting nectar (nectar loads). The other method is field observation on the flower. The final column contains studies claiming the importance of the plant species for bees but without the method or results on which this information is based.

	Bee species	Stored pollen	Stored honey	Pollen loads	Nectar loads	Observation on flower			Unknown method		
						Nectar	Pollen	?	Nectar	Pollen	?
Acacia angustissima	*Mb*							33*			
	Am								10, 29, 30, 31	30	
Anacardium occidentale	*Mb*								3		
	Msp				1						
	Am			16					9, 10, 13, 19, 27, 30, 31	9, 19, 27, 30, 31	
Andira inermis	*Mb*							34	3		
	Am							34	3, 9, 10, 18, 19, 30		6
Bixa orellana	*Mb*									3	
	Msp	2		20a	1	5				19	
	Am						10			3, 19, 29	6
Bursera simaruba	*Mb*								3	3	
	Msp								19	19	
	Am		28	23, 24		10			3, 7, 19, 29, 31	3, 7, 19, 29, 30	
Byrsonima crassifolia	*Msp*										3
	Am					10			3, 9, 19, 29, 31	9, 29	
Cassia grandis	*Mb*										3
	Am								3, 10, 19	3	
Cedrela odorata	*Mb*			12						3	
	Am								3, 10, 29, 30, 31	3, 19	6
Cochlospermum vitifolium	*Mb*									3	
	Am								9, 10, 19, 26, 30, 31	3, 7, 10, 19, 26, 29, 30, 31	6, 26d, g, i, j
Cordia alliodora	*Mb*			12							
	Am		11	11, 24, 26				34	3, 7, 10, 13, 14, 19, 26, 27, 29, 30, 31	3, 19, 26, 27	6, 26a, b, c, f, g

Croton reflexifolius	*Mb*							33*, 34			
Gliricidia sepium	*Am*			26		10		34	9, 19, 26, 27, 29, 30, 31, 32	26, 31	26a, c, e, h, j
Inga vera	*Am*			24					9, 10, 19		
Liquidambar styraciflua	*Mb*							33*			
Persea americana	*Mb*							33*			
	Am					10			9, 13, 18, 19, 27, 29, 31	9, 19, 27	6
Pithecelobium dulce	*Am*								3, 9, 10, 19, 28, 29, 30, 31	3, 9, 19, 29, 30	
Psidium guajava	*Mb*							17	3	3	
	Msp	20b	20b	4, 22, 25						19	
	Am		11, 15	8, 11, 22				17	3, 9, 10, 13, 19, 27, 31	3, 9, 10, 19, 27	
Spondias purpurea	*Am*								3, 10, 29, 30, 31		19
Tabebuia rosea	*Am*								3, 10, 19, 26 (a, d, g) 29, 30, 31	3	
Vernonia patens	*Mb*							17, 33*			
	Am			24				17, 34	10, 19, 30	19	

** Since it is difficult to distinguish* Apis mellifera *and* Melipona beecheii *in the field, this information provided by the beekeepers with stingless bees is not very "species reliable".*

References: Locality:

1 Absy et al (1980) Brazil (Manaus)
2 Absy et al (1984) Brazil (The Amazones)
3 Arce et al (2001) information from different countries
4 Bootsma MC (198?) Trinidad
5 Brantjes (1981) Brazil (Pará)
6 Chandrasekharan et al (1996) source locality information unknown
7 Chemas and Rico-Gray (1991) Mexico (Yucatán)
8 Cortopassi and Ramalho (1988) Brazil (São Paulo)
9 Crane et al (1984) information from different countries
10 Espina and Ordetx (1983) information from different countries
11 Girón-VanderHuck (1996) Colombia
12 Landaverde-Parada (2003) Costa Rica (Alajuela)
13 Laurence (1973) Trinidad
14 León and Poveda (1999) source locality information unknown
15 Lobreau-Callen et al (1986) West-Africa (Togo and Benin)
16 Magalhães-Freitas (1991) Brazil
17 Marroquín-Juarez (1994) Costa Rica
18 Niembro-Rocas (1990) source locality information unknown
19 Nieuwstadt van (1994) information from different countries
20 Ramalho et al (1990) Brazil (São Paulo)
20a Absy and Kerr (1977) in 20 ?
20b Kleinert and Imperatriz (1987) in 20 ?
21 Ramalho et al (1989) Brazil
22 Rooy de (1981) Trinidad

References: Locality:

23 Roubik et al (1986) Panama (Central)
24 Sánchez-Chaves (1999) Costa Rica (Guanacaste)
25 Sommeijer et al (1983) Trinidad
26 Stephen-Lobo (1999) Costa Rica
26a Bently and Elias (1983) in 26 ?
26b Crane (1990) in 26 ?
26c Espina (1984) in 26 ?
26d Frankie (1983) in 26 ?
26e Kerkvliet et al (1991) in 26 ?
26f Martinez (1993) in 26 ?
26g Palacios (1987) in 26 ?
26h Ramalho (1990) in 26 ?
26i Roubik and Moreno (1991) in 26 ?
26j Vinson (1987) in 26 ?
27 Svensson (1991) information from different countries
28 Villanueva (1994) Mexico (Yucatán)
29 Villegas-Durán et al (1998) Mexico (Yucatán)
30 Villegas-Durán et al (2002a) Mexico (Guerrero)
31 Villegas- Durán et al (2002b) Mexico (Chiapas)
32 Woyke (1983) El Salvador
33 Important according to stingless beekeepers El Salvador (La Palma region)
34 Personal observation El Salvador (La Palma region)

When interpreting this scheme, it is important to know that the same plant species will perform differently under different ecological and climatic conditions and therefore the same species can be a major forage tree in one region, while of no significant importance to the bees in another region (BRUYN, 1997). These facts underline the importance of local information from beekeepers and local information of the palynological research.

For this local importance, two plant species are included on which no information was found in the reviewed studies but which are mentioned as important by the beekeepers in the region, namely *Liquidambar styraciflua* and *Croton reflexifolius*. The reason they are not mentioned in the reviewed studies is probably that they do not occur in the region of study or very rarely.

Other Selection Criteria for Reforestation Plants

For the reforestation program to be successful, the situation in the field implies other selection criteria for the major bee forage plants as well besides their importance to bees.

When planting trees on the farmer's land, their development is only guaranteed when the farmers protect them from fire and cattle. They will do this only if the tree is sufficiently appreciated by them. So,

preferably the species has other uses besides being a major bee forage tree. The most appreciated characteristics gained by interviews with the beekeepers are trees producing timber (*A. occidentale, A. inermis*, *C. odorata*, *C. alliodora, I. vera*, *L. styraciflua* and *T. rosea*), producing fruit (*A. occidentale*, *Byrsonima crassifolia*, *C. grandis*, *I. vera*, *P. americana*, *P. guajava* and *S. purpurea*) or ornamentals (*A. angustissima*, *A. inermis*, *B. orellana*, *C. grandis*, *C. vitifolium*, *L. styraciflua*, *T. rosea* and *V. patens*).

The plants have to be applicable on different scales: if a farmer has no terrain available for reforestation, small trees or shrubs can be planted on the limited space near the bee hives where there are no possibilities for planting large growing trees. Furthermore, small trees and shrubs will give flowers shortly after planting, so in the bee forage forest they function as the "pioneers" in bee food provision. Large trees will be planted in the large-scale reforestation since their full-grown canopy gives a high quantity of flowers. The shrubs to small trees in the list are *A. angustissima*, *A. occidentale*, *B. orellana*, *B. crassifolia*, *C. reflexifolius*, *G. sepium*, *P. guajava*, *S. purpurea* and *V. patens*. The medium sized to large trees in the list are: *A. inermis*, *B. simaruba*, *C. grandis*, *C. odorata*, *C. vitifolium*, *C. alliodora, I. vera*, *L. styraciflua*, *P. americana*, *P. dulce* and *T. rosea*.

The tree has to develop well and have a high nectar flow under the local conditions. For this reason, trees are selected which already naturally occur in the region and in the trial plantations their development on different altitudes, different soils and different light conditions will be monitored. Furthermore, their nectar flow and pollen provision for *M. beecheii* will be investigated. Depending on their performance under the local conditions, a new selection will be made and for the following years the trees will be planted where they perform best.

Ultimately, the PROMABOS project aims at managing the natural forest and therefore only native species will be planted (species native to the tropical Americas) as not to disturb the natural composition of the forest.

The last criteria for the reforestation programm to have an effect on the stingless bees is that the trees will be planted within the flight range of *M. beecheii* and preferably as close as possible. The degradation of importance with the distance to the beehive is not known so this should be investigated.

Summary of Criteria

Criterion 1: the trees must be primary source of pollen and / or nectar for *Melipona beecheii*.

Criterion 2: the trees must be appreciated by the landowners.

Criterion 3: in the selection we need large and small trees or shrubs to plant on different sized terrains.

Criterion 4: the tree must develop well and perform well as a bee forage source under the local conditions.

Criterion 5: the tree must be native to the tropical Americas.

Criterion 6: the trees must be planted near the beehives, at least within the flight range but preferable as close as possible.

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