



Melipona fasciculata in Euterpe oleracea flower. Photo: Giorgio C. Venturini

# Pollinators Management in Brazil



Ministério do  
Meio Ambiente



*Pollinators  
Management  
in Brazil*

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Centro de Informação e Documentação Luís Eduardo Magalhães – CID Ambiental

Esplanada dos Ministérios – Bloco B – térreo - CEP - 70068-900

Tel.: 55-61-3317-1235 Fax: 55-61-3317-1980 - e-mail: cid@mma.gov.br

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**General Coordination**

CARLOS ALBERTO BENFICA ALVAREZ  
MARINA LANDEIRO

**Consolidation of information**

CARLOS ALBERTO BENFICA ALVAREZ  
MARINA LANDEIRO

**Technical Revision**

CARLOS ALBERTO BENFICA ALVAREZ  
MARINA LANDEIRO

**Graphic Design and Cover**

MAYKO DANIEL AMARAL DE MIRANDA

# Contents

## Introduction

### Summary for Probio Pollinators Subprojects:

FLORAL BIOLOGY AND MANAGEMENT OF STINGLESS BEES TO POLLINATE Assai Palm (*Euterpe oleracea* Mart., ARECACEAE) IN EASTERN AMAZON.....**10**  
Giorgio C. Venturieri

POLLINATION ECOLOGY AND POLLINATOR MANAGEMENT IN CUPUASSU (*Theobroma grandiflorum* Willd. Ex Spreng. Schum., STERCULIACEAE), AN AMAZONIAN FRUIT-TREE OF PROMISING ECONOMIC IMPORTANCE .....**14**  
Rogério Gribel

ASSESSMENT AND MANAGEMENT OF THE POLLINATORS OF MANGABA (*Hancornia speciosa* Gomez , APOCYNACEAE) AND WEST INDIAN CHERRY (*Malpighia emarginata* DC, MALPIGHIACEAE) IN NORTHEASTERN BRAZIL.....**18**  
Clemens Schindwein

POLLINATORS OF NANCE (*Byrsonima crassifolia* L. Rich, MALPIGHIACEAE): DIVERSITY OF SPECIES, NEST BUILDING AND THEIR SUSTAINABLE USE IN AGRICULTURE IN EASTERN AMAZON .....**22**  
Márcia Rêgo

LANDSCAPE MANAGEMENT AND POLLINATOR RICHNESS IN TOMATO (*Lycopersicon esculentum* Mill., SOLANACEAE) CROPS IN SOUTHEASTERN BRAZIL.....**26**  
Maria José Campos

SUSTAINABLE MANAGEMENT OF POLLINATORS FOR PASSION FRUIT (*Passiflora edulis* f. *Flavicarpa* DEG., PASSIFLORACEAE) PRODUCTION IN CENTRAL BRAZIL ..**30**  
Paulo Eugênio Oliveira

POLLINATORS OF YELLOW PASSION FRUIT (*Passiflora edulis* Sims, PASSIFLORACEAE) AND MANAGEMENT OF CARPENTER BEES IN SOUTHEASTERN BRAZIL.....**34**  
Maria Cristina Gaglianone

ASSESSMENT OF MANGO (*Mangifera indica* L., ANACARDIACEAE) AND PASSION FRUIT (*Passiflora edulis* f. *flavicarpa* DEG., PASSIFLORACEAE) POLLINATORS IN THE SAN FRANCISCO VALLEY, NORTHEASTERN BRAZIL.....**36**  
Lúcia Helena Piedade Kill

MANAGEMENT PLANS FOR FRUIT CROP POLLINATORS IN THE STATES OF BAHIA AND PERNAMBUCO, NORTHEASTERN BRAZIL.....**38**  
Blandina Felipe Viana



# INTRODUCTION

## THE BRAZILIAN POLLINATORS INITIATIVE (BPI)

The Brazilian Pollinators Initiative (BPI) is an initiative which has its roots in October 1998 at the “International Workshop on the Conservation and Sustainable Use of Pollinators in Agriculture, with emphasis on Bees” held at the University of São Paulo and promoted and organized by the Brazilian Ministry of the Environment (MMA) in partnership with the University of São Paulo, the Brazilian Agriculture Research Corporation – EMBRAPA and the Food and Agriculture Organization – FAO. Subsequent discussions on the BPI were held during the “4<sup>th</sup> and 5<sup>th</sup> Brazilian Meeting on Bees” organized by the University of São Paulo in September 2000 and in September 2002.

The BPI builds upon an extensive network of Brazilian experts on bee and pollination research (the “4<sup>th</sup> Brazilian Meeting on Bees”, for example, brought together almost 300 Brazilian experts who presented over 200 papers), an extensive network of beekeepers associations, a worldclass network of agricultural research centers maintained by the Brazilian Agriculture Research Corporation– EMBRAPA, a 50-year track-record of excellence in research and graduate education on bees at the University of São Paulo and a host of partnerships with governmental and non-governmental organizations, universities and institutions working towards agriculture sustainability.

An Interministerial Government directive established in 2005 a National Advisory Committee, under co-ordination of the Ministry of the Environment, with the goal of proposing actions to implement the Brazilian Pollinators Initiative, as part of the International Initiative for the Conservation and Sustainable Use of Pollinators –IPI, and to implement in Brazil the International Project EP/GLO/301/GEF “Conservation and Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach” under co-ordination of the Food and Agriculture Organization of the United Nations (FAO).

The following public organizations are members of the National Advisory Committee of the BPI: Science and Technology Ministry (MCT); Agriculture, Livestock and Supply Ministry (MAPA) and Rural Development Ministry (MDA). Other members are: the Brazilian Agriculture Research Corporation (Embrapa), the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), the National Confederation for Agriculture and Livestock (CNA), the Brazilian Bee Breeders Confederation (CBA), the Brazilian Forum of Non-Governmental Organizations and Social Movements and the Brazilian Service to Support Micro and Small Companies (SEBRAE).

Several academic expert are also members, covering the following issues: floral biology; gene flux; taxonomy; pollinators monitoring; stinglessbees breeding; apiculture; breeding of other social and solitary bees.

## THE BRAZILIAN BIOLOGICAL DIVERSITY CONSERVATION AND SUSTAINABLE USE PROJECT (PROBIO)

The Brazilian Biological Diversity Conservation and Sustainable Use Project (PROBIO/MMA) was a project co-ordinated by Ministry of the Environment - MMA in partnership with the National Council of Scientific and Technological Development – CNPq. PROBIO's goal has been to identify and support priority actions contracted as subprojects that promote partnerships between public and private institutions to produce and disseminate information for biodiversity conservation and sustainable use. All of its subprojects were approved by National Biodiversity Commission - CONABIO.

The Brazilian Government and the International Bank for Reconstruction and Development -World Bank signed on June 5, 1996 the Grant Agreement TF 28309 with US\$ 10 millions from the Global Environment Facility - GEF, and co-funding resource from National Treasure equivalent to US\$ 10 millions, to support the Brazilian Biological Diversity Conservation and Sustainable Use Project - PROBIO. This agreement has finished in December 31, 2005.

The PROBIO has made two Public Calls to support pilot projects on pollinators management, the first one was announced in September 2003, the second one in January 2004. The CONABIO selected the subprojects to elaborate management plans for one or more native pollinators species of plants of economic importance (either crops or plants subjected to intensive extractivism) that depend on animal pollination. The aim was to develop solutions for the sustainable use, conservation and restoration of pollinators diversity in crop systems and related ecosystems and to provide inputs for the elaboration of public policies that promote the conservation and sustainable use of biological diversity in agriculture landscape.

A total of 58 proposals were submitted to the two PROBIO Public Calls, 13 of which were approved by CONABIO and contracted by CNPq, with a total sum of R\$ 1,543,702.80 (equivalent to approximately US\$ 500,000.00) of financing from MMA plus counterpart funding from the implementing organizations. These projects were implemented from 2004 to 2006 in the following regions and states of Brazil (plants indicated in parenthesis):

Amazon Region: States of Amazonas (cupuassu) and Pará (assai palm);

Northeast Region: States of Maranhão (nance), Paraíba (cotton, soursop, West Indian cherry, mangaba), Pernambuco (mango and passion fruit), Bahia (guava, mango, umbu and passion fruit) ;

Central Region: State of Mato Grosso (marolo);

Southeast Region: State of Minas Gerais (passion fruit and tomato), Rio de Janeiro (passion fruit) and São Paulo (tomato);

Southern Region: State of Paraná (passion fruit)

All of the final report of Probio subprojets are available in the Ministry' website: [www.mma.gov.br/Probio](http://www.mma.gov.br/Probio). To access the subprojets go to “*subprojetos apoiados*”, choose the issue (*temas*), in this case “*Polinizadores*”, choose a subproject and access the results in the “*bibliografia*” key at the top of the page.

This booklet presents the abstracts of some of these pilot projects to demonstrate the potential and opportunities for promoting the conservation and sustainable use of pollinators in agriculture landscape.

Target plants and pollinators of the 13 pilot subprojects funded by PROBIO:

TARGET PLANTS	TARGET POLLINATORS	STATES
<i>Annona muricata</i> – soursop (Annonaceae)	<i>Cotalus</i> spp (Nitidulidae, Coleoptera)	Paraíba
<i>Annona crassifolia</i> – marolo (Annonaceae)	<i>Cyclocephala</i> spp (Scarabaeidae, Coleoptera)	Mato Grosso
<i>Hancornia speciosa</i> – “mangaba” (Apocynaceae)	Sphingidae & Hesperidae (Lepidoptera)	Paraíba
<i>Spondias tuberosa</i> – “umbu” (Anacardiaceae)	<i>Frieseomelitta</i> spp & <i>Trigona</i> spp (Meliponinae, Apidae, Hymenoptera)	Bahia
<i>Mangifera indica</i> – mango (Anacardiaceae)	Diptera & Hymenoptera	Pernambuco & Bahia
<i>Gossypium hirsutum</i> – cotton (Malvaceae)	<i>Bombus</i> spp & <i>Xylocopa</i> spp (Apidae, Hymenoptera)	Paraíba
<i>Byrsonima crassifolia</i> – nance (Malpighiaceae)	<i>Centris</i> spp (Apidae, Hymenoptera)	Maranhão
<i>Malpighia emarginata</i> – West Indian cherry (Malpighiaceae)	<i>Centris</i> spp & other Centridini (Apidae, Hymenoptera)	Paraíba
<i>Theobroma grandiflorum</i> – cupuassu (Sterculiaceae)	<i>Plebeia</i> spp, <i>Paratrigona</i> spp & <i>Frieseomelitta</i> spp (Meliponinae, Apidae, Hymenoptera)	Amazonas
<i>Psidium guajava</i> – guava (Myrtaceae)	<i>Frieseomelitta</i> spp (Meliponinae, Apidae, Hymenoptera)	Bahia
<i>Passiflora edulis</i> – passion fruit (Passifloraceae)	<i>Xylocopa</i> spp, <i>Centris</i> spp, <i>Epicharis</i> spp & <i>Eulaema</i> (Apidae, Hymenoptera)	Pernambuco, Bahia, Minas Gerais, Rio de Janeiro & Parana
<i>Passiflora alata</i> & <i>Passiflora</i> <i>cincinnata</i> – passion fruit (Passifloraceae)	<i>Xylocopa</i> spp (Apidae, Hymenoptera)	Pernambuco
<i>Lycopersicon esculentum</i> – tomato (Solanaceae)	<i>Melipona</i> spp (Meliponinae, Apidae, Hym.) & Halictidae (Hymenoptera)	Minas Gerais & São Paulo
<i>Euterpe oleraceae</i> – assai palm (Arecaceae)	<i>Melipona</i> spp (Meliponinae, Apidae, Hymenoptera)	Pará

# FLORAL BIOLOGY AND MANAGEMENT OF STINGLESS BEES TO POLLINATE Assai Palm (*Euterpe oleracea* Mart., ARECACEAE) IN EASTERN AMAZON

Giorgio C. Venturieri

Brazilian Agriculture Research Corporation– EMBRAPA, e-mail: [giorgio@cpatu.embrapa.br](mailto:giorgio@cpatu.embrapa.br)

The assai tree is a typical palm from the Amazon region, very important on the diet and economy of human populations of the Amazon estuary. According to the Brazilian Institute of Geography and Statistics (IBGE), in 2006 the assai was the non-timber forest product that generated the largest income in Brazil, totaling R\$ 103.2 million. The Amazon estuary region was described as the center of the origin and genetic diversity of this species. In the Amazon region, the assai tree blossoms and fructify almost the entire year. However, the blossom and fruiting peaks with larger frequencies during the periods of January-May and September-December, respectively. The most intense blossom period coincide with the time of larger pluviometric precipitation, and the fruiting period prevails in the dryer period. This research had as a goal to study the assai tree reproductive biology and its main pollinators. Due to the progressive increase of local assai consumption, and its exportation to other Brazilian States, there was a great increase on the cropped areas, in its majority, in the northeast of Pará State.

The increase of cropped areas, by its turn, has provoked a search for a greater understanding on its cropping system, its ecology and the management of its pollinators.

Field studies were conducted in the experimental area of Embrapa Amazônia Oriental, in the Combú Island, municipality of Belém, and in two farms in the cities of Benfica and Santo Antônio do Tauá, Pará State, Brazil. For observations, we used metallic scaffoldings and aluminum ladders. Flower morphology was analyzed with the help of portable and stereoscopic lens. Flower measurement was done with the help of a digital caliper. The period of masculine and feminine flower emission, anthesis, floral changes (color, odor, pollen and nectar secretion, and floral senescence) were observed. Stigma receptivity was tested through hydrogen peroxide 1% and pollination tests *in vivo*. For the analysis of sugar concentration and nectar volume, rachillae were previously bagged and investigated helped by microcapillary tubes and refractometer. Sugar concentration in masculine flowers was assessed

in intervals of half hour, from 9:30AM until 12:30PM. In each measurement, several flowers were used, randomly chosen, to complete the 2  $\mu$ l capacity of the microcapillary tubes. Regarding



feminine flowers, the measurement of sugar concentration and volume was followed using the same flowers, since the start of the first collect until the end of production (9:00AM until 4:00PM). In each interval of two hours between measurements, flowers were wiped with a paper handkerchief to verify the melliferous potential of these flowers. Microcapillary tubes of 1 and 2  $\mu$ l were used, respectively, to measure sugar concentration and nectar volume. The osmophores presence was determined through red neutral solution 0.1% and nose bioassay tests. Direct observations over the floral visitors were performed, flower morphology, compatibility with reproductive events, abundance and the insect food collection behavior. The collected insects were deposited in the Entomological Collection of Embrapa Amazônia Oriental. The pollen/ovule relation was evaluated, and the results were compared following the Cruden system. The treatments used for the pollination tests were the spontaneous self-pollination, induced self-pollination, xenogamy, and control. After the analysis of the results, the Self-Incompatibility Index – SII and the Reproductive Efficacy Index – REI, were calculated. These indexes allow estimate the indicative limit of self-incompatibility and the relative efficiency of natural

pollination (open), respectively. Based upon the observations about the ecology of pollinators, a management plan for *Melipona flavolineata* and *M. fasciculata*, genuine pollinators of *Euterpe oleracea*, and endemic of this region, was established. Fourteen colonies of *M. flavolineata* and 26 colonies of *M. fasciculata* were introduced in a 170 hectares crop of *E. oleraceae*. The performance of the colonies and the efficacy of the bees in the assai pollination were evaluated.

Flowers are placed in inflorescences of the intrafoliar spicate type that measure 57-81 cm long and 70-102 cm diameter, with 85-141 rachillae/inflorescences and 2088-8063 flowers/inflorescence. Flowers are masculine and feminine unisexual, normally disposed over the rachillae, with a proportion of two masculine flowers for each feminine. One of the individuals showed a proportion 1:1, and this may be an indicative of the existence of more productive varieties. The flower color varies from red to purple. The length and average diameter of the masculine flower was 5.24 and 4.93 mm and in the feminine 3.93 and 2.36 mm, respectively. The total anthesis period of inflorescences lasted in average 17 days, the first phase corresponding to the emission of masculine flowers, lasting about 13 days, and the second phase

of feminine flowers, lasting in average 3 days. The masculine flowers start to open at 9:00AM, and the senescence occurs in the same day, between 12:30 and 1:30PM. Feminine flowers start to open at 10:00PM, and when they are not fecundated, they remain in the flower until the fifth day after the anthesis. The receptivity tests of the stigma, using peroxide hydrogen, showed that flowers remain viable until the fifth day after anthesis. However, pollination tests *in vivo* showed that only feminine flowers pollinated in the first day fructify. The average sugar concentration in masculine flowers was 29.23%, and the volume per flower varied from zero up to 0.37 $\mu$ l. The average sugar concentration in feminine flowers was 53.64%, and the volume per flower varied from zero up to 0.25 $\mu$ l. The period of higher visitation coincided with the period of higher sugar availability, which occurs during the morning, from 10:30AM (43.5%) until 00:30PM (63%) for masculine flowers, and from 9:00AM (40.16%) until 04:00PM (73.87%) for feminine flowers. The flowers tested with red neutral for the osmophore detection did not show colored glands, corroborating the direct odor test. The most frequent and diverse group of visitors was stingless bees (11 spp.), being present, also, Halictidae bees, small Anthophorid bees and *Apis mellifera*. Beetles, wasps, flies and

ants were also found. The pollination tests, altogether with the estimate of the number of pollen grains and the inference of the reproductive system, shows that *E. oleracea* is a species with obligatory xenogamy. Each flower presents only one ovule and the pollen/ovule relation suggest an obligatory xenogamy reproductive system, with a P/O relation equals to 63,324.00. The rate of formation of fruits from natural pollination was 33.53%, smaller than the cross-pollination, which was 47.13%.

The estimate of the SII indicative was 0.11 (0.25 is considered as the maximum limit) and the estimate of relative efficacy of natural pollination through the REI index was 0.81. A management system, including boxes for rearing, supports and a number of colonies of *M. flavolineata* and *M. fasciculata* necessities for the pollination services, in commercial crops, is proposed.



Assai Palm plantation. Photo: Giorgio C. Venturiere

## POLLINATION ECOLOGY AND POLLINATOR MANAGEMENT IN CU-PUASSU (*Theobroma grandiflorum* Willd. Ex Spreng. Schum., STERCULIACEAE), AN AMAZONIAN FRUIT-TREE OF PROMISING ECONOMIC IMPORTANCE

Rogério Gribel

National Institute for Research in the Amazon (INPA) - e-mail: [rgribel@inpa.gov.br](mailto:rgribel@inpa.gov.br)

The cupuassu (*Theobroma grandiflorum*) is a pre-Colombian crop which is still found wild in the eastern Amazon. Nowadays cupuassu is widely cultivated in orchards throughout the Amazonian region. It is a species closely related to cacao and considered as one of the most promising fruits among the rich Amazonian flora. Cupuassu is an arboreal species which reaches 15 to 20m in height in the wild, but less than 8m when cultivated. The fruit occurs in the form of a drupe and the pulp has a strong and pleasant smell. It is smooth on the outside, ellipsoidal, 15-30 cm long by 8-12 cm wide and weighs up to 1.5 kg. The endocarp is a white, soft and sour-tasting pulp, surrounding 25-50 seeds in five rows. The highly-flavored pulp is used in the production of juices, ice creams, liquors, wine, and jellies. The seeds can be used to produce a



*Plebeia* sp in *Theobroma grandiflorum* flower. Photo: Rogério Gribel



*T. grandiflorum* Fruits. Photo: Rogério Górbel

high quality chocolate. The ripe fruit is harvested when it falls to the ground. The main goals of this project were: (a) to study the pollination ecology of *Theobroma grandiflorum* identifying the main pollinators, (b) to characterize the breeding and the mating system of this species through controlled pollinations and genetic analysis of the progenies using microsatellite markers; (c) to develop management techniques by rearing colonies of the main *T. grandiflorum* pollinators in order to increase the pollination rate and fruit yield.

*Flowering, Breeding System and Mating System* - In the Central Amazon,

*Theobroma grandiflorum* exhibited a flowering pattern characterized by two flowering peaks, the first during the dry season (August-September) and the second at the beginning of the rain season (November). Only the second flowering event resulted in significant fruit production. Pollination tests have confirmed that *T. grandiflorum* is self-incompatible. No fruit was yielded by hand self-pollination or by the apomixis control, whereas 12% of the cross-pollinated flowers set fruits. Natural fruit-set was very low, about 1.0%. Genetic analysis of 150 seedlings from eight open-pollinated families using microsatellites

confirm the predominantly allogamous mating system. However, we found a small proportion of seeds resulting from apomix and showing polyembryony.

*Pollination Ecology* - Our observations on floral visitors suggest that flowers of *T. grandiflorum* are visited and pollinated by small stingless bees such as *Plebeia minima* and *Aparatrigona impunctata*. Although both species have legitimate pollinator behavior, *A. impunctata* perforates the petals which conceal the anthers to collect pollen, acting also as pollen robber. Other species of native stingless bees (*Plebeia* sp, *Leurotrigona pusilla*, and *Trigona* sp) also visited the flowers eventually and were considered

as secondary pollinators. African honeybees do not play any relevant role in the pollination of *T. grandiflorum* flowers.

*Pollinator management* - We located natural nests of *Plebeia* and *Aparatrigona* in areas threaded by deforestation and burning nearby the Manaus region and transferred the colonies to different wood boxes in order to test the best artificial substrate for capture, transferability and division for these species. The colonies were maintained with artificial food (diluted honeybee honey) until adaptation to



the boxes. After the multiplication of the bee colonies in the wood boxes, 40 hives (20 of each species) were bunch together forming an “itinerant meliponary”. The meliponary was transferred to two plantations of cupuassu located at INPA’s Fruticulture Station, 45 km north of Manaus, during the flowering period of

2005. In both plantations we compared fruit-set in days with and without the itinerant meliponary. For both areas the fruit production of *T. grandiflorum* was higher in the days when hives were introduced into the plantations, but only in the area 2 the difference was statistically significant.



*Aparatrigona impunctata* in *T. grandiflorum* flower. Photo: Rogério Gribel

# ASSESSMENT AND MANAGEMENT OF THE POLLINATORS OF MANGABA (*Hancornia speciosa* Gomez , APOCYNACEAE) AND WEST INDIAN CHERRY (*Malpighia emarginata* DC, MALPIGHIACEAE) IN NORTHEASTERN BRAZIL

Clemens Schindwein

Federal University of Pernambuco - e-mail: [schindw@ufpe.br](mailto:schindw@ufpe.br)

Mangaba (*Hancornia speciosa*, Apocynaceae) and West Indian cherry (*Malpighia emarginata*, Malpighiaceae) are tropical fruit crops, which require specific insect pollinators to set fruit. Mangaba, native to Northeastern and Central Brazil, is still explored mainly in natural populations. The fruits are consumed mainly as juice and ice cream but supply does not satisfy the market. In agricultural research stations, there are currently several efforts of genetic improvement and cultivation of the small trees. West Indian cherry, also called Barbados Cherry, is a fruit crop already widely cultivated in Brazil, especially in the Northeast of the country. West Indian cherry is commercialized as pulp and shows an increasing national and international market. The goals of the study were to evaluate the pollination success in orchards of mangaba and West Indian cherry, to determine their effective pollinators, the environmental demands and conditions to maintain strong pollinator populations, as well as define pollinator species with potential to be reared for commercial use. The study was conducted in experimental orchards of the Paraíba State research

*Malpighia emarginata* fruit. Photo: Clemens Schindwein



station, in private plantations and in a native plant population. We first surveyed flower visitors and determined which species were effective pollinators. For these pollinators we evaluated their environmental demands, such as additional floral resources necessary to maintain adults and feed larvae, nesting sites (bees) and relationships to host

plants of caterpillars (hawkmoths). For both crops, their flower biology was described and their breeding systems determined. Trap nests were offered in the search of effective solitary bees with



potential to be reared for commercial use as pollinators in West Indian cherry orchards. The mangaba flowers were pollinated by insects of 33 species with long mouth-parts, especially hawkmoths (Sphingidae), but also butterflies (Hesperiidae and Heliconiinae) and some long-tongued bees of Euglossini

(Apidae). The flowers, like those of most other Apocynaceae, have a style head functionally divided into an apical sterile portion, where self-pollen is deposited, a middle and also sterile portion, which produces a sticky mucilage, and a basal receptive portion. Looking for nectar, long tongued insects insert their mouth parts through one of five apertures, into the flower tube. Withdrawing them, alien pollen is captured at the receptive portion of the style head. Then, sliding upwards, the mouth parts become covered with sticky mucilage, and finally pass through the pollen chamber removing pollen grains. Mangaba trees are self-incompatible and all groups of flower visitors with long mouth-parts were pointed out as effective pollinators. A simulation experiment of consecutive flower visits with a nylon thread showed that the probability to set fruit is only high in the first two flowers in a visiting sequence and from the fifth flower visit onward, there is no contribution to fruit set of that individual plant. Thus, mangaba plants, in general, benefit by a high pollinator abundance and diversity. The mangaba berries produced in the orchards showed a high variation in size and weight. Seed number was found to be directly correlated to fruit weight, in the manner that large fruits contained more seeds. An optimized

**WEST INDIAN CHERRY  
AND MANGABA**



Centridini). Females of these bees harvest these oils with specific brushes at fore and mid basitarsi. They use them in brood cell construction and/or to feed larvae, mixed with pollen. Controlled pollination showed that cross pollination increases fruit production in *Malpighia emarginata*. Females of 14 species of *Centris* and of two species of *Epicharis* were effective pollinators of West Indian cherry flowers. Analysis

pollinator mediated flow of cross pollen, thus, is responsible for large fruits. The maintenance of strong populations of mangaba pollinators requires sphingophilous plants in the surroundings of the plantation that provide nectar for adult hawkmoths when the mangaba plants do not flower. Moreover, their oligotrophic larvae need specific native species of host plants as food resources, like certain Apocynaceae, Rubiaceae, Euphorbiaceae and Convolvulaceae. Pollinator management, therefore, implies management of the surrounding vegetation of the mangaba orchards. The flowers of West Indian cherry (*Malpighia emarginata*) produce floral oils collected by specific oil collecting bees of the genera *Centris* and *Epicharis* (Apidae,

of scopa loads revealed that most of the Centridini females use pollen of *Solanum* species (Solanaceae), common weeds in orchards, as pollen resource mixed with pollen of West Indian cherry. Moreover, *Centris* and *Epicharis* bees depend on additional nectar flowers as energy supply for adult bees. Most of the species of Centridini recorded in West Indian cherry flowers nest in soil. Females of two species, however, *Centris analis* and *C. tarsata*, were attracted to trapnests offered in the West Indian cherry orchards. These are burrows drilled in solid blocks of wood. Females of both species accept this burrows and their daughters frequently re-used the same nests. Thus, both species are excellent

candidates to be used as manageable pollinators in West Indian cherry orchards. Pollen analyses of brood cells of *Centris analis* revealed that females of this species collect almost exclusively pollen from West Indian cherry flowers, when reared inside the plantations. To feed one larva, pollen of about 80 flowers of West Indian cherry is necessary. This pollen amount is collected during about 2900 flower visits. For both cultivated species we confirmed their need on the pollination service of specialized insect pollinators. Moreover, for both species a diminished fruit production was detected

in the studied orchards. Data suggest that fruit set could be substantially increased, about two to three times, if pollinator populations were stronger. Effective pollinators in both species require a diversified environment in the surroundings of the plantations. Large plantations of mangaba and West Indian cherry in monocultures as well as isolated plantations inside a hostile environmental matrix, impoverished in floral resources like that of sugar cane plantations, reduce their productivity and can sustain only small populations of specialized pollinators.



*Hancornia speciosa* fruits. Photo: Clemens Schindwein

## POLLINATORS OF NANCE (*Byrsonima crassifolia* L. Rich, MALPIGHIACEAE): DIVERSITY OF SPECIES, NEST BUILDING AND THEIR SUSTAINABLE USE IN AGRICULTURE IN EASTERN AMAZON

Márcia Rêgo

Federal University of Maranhão - e-mail: [regommc@uol.com.br](mailto:regommc@uol.com.br)

The nance (*Byrsonima crassifolia*, Malpighiaceae) is consumed in all the North and Northeast of Brazil. It is an extractive product with a high nutritional value, although its fruit production is still restricted to local markets, where it is sold *in natura* to be used as sweets, juices and ice creams. Many *Byrsonima* species known as nance in Maranhão and other Brazilian States are considered excellent species to keep biodiversity, for attracting many bee species, mainly oil bees: Centridini, Tetrapediini and

Tapinotaspidini. Among these bees, the Centridini are the most frequent visitors collected in their flowers and of 21 species in this tribes considered *B. crassifolia* pollinators, only 11 of them (52%) have their nest habits known: *Epicharis flava* (Friese), *Centris aethyctera* Snelling, *C. segregata* Crawford, *C. trigonoides* Lepeletier, *C. heithausi* Snelling, *C. flavofasciata* Friese, *C. aethiocesta* Snelling, *C. analis* (Fabricius), *C. aenea* Lepeletier, *C. tarsata* Smith and *C. flavifrons* (Fabricius). The objective of this work was to increase the knowledge about *B. crassifolia* pollinators - their diversity, phenology, nest building as well as verifying other plant species also used by these bees. From October/2004 to September/2005 a survey of visiting bees of *B. crassifolia* was done in an area of almost 1 ha with many native nance trees in a coastal woodland in the municipality of Barreirinhas, Maranhão, Brazil (2°43'22,5"S; 42°49'50"W) that is 345 km from the state capital, São Luís. The survey of bees was done using an entomological net (2 collectors) and nest traps. The nest building in the ground and foraging behaviours were



*Centris caxtensis* in *Byrsonima crassifolia* flower. Photo: Márcia Rêgo

also observed. Photographs and films were taken. The flowering plants were also collected and pollen grain analysis of them was made (pollen reference collection). Pollen grain cells of the nests and legs of the most frequent bees were analysed. The pattern of nance bloom is annual, extensive and irregular. The number of flowers by inflorescence varied by 6 to 23 (n=30), opening about

4.8 flowers/inflorescence/day. The incompatibility index (ISI) was high, 0.16. Twenty-five species of bees were collected, which based on data from previous works, raise to 40 the number of the floral visitors already collected in *B. crassifolia*. The most frequent species were *Centris byrsonimae*, *C. caxienseis* and *Centris* sp1 which nidifies in plain,



*Centris byrsonimae* in *Byrsonima crassifolia* flower. Photo: Márcia Régio

sunny and sanding soils. Thirty-nine nests of *Centris (Hemisiella) tarsata* were collected in trap-nests. 100% of the pollen grains found in *Centris* sp1 and *C. byrsonimae* were from the *Byrsonima* species. Other resources of oil and pollen

identified in the study area: *Mascagnia* sp, *Heteropteris* sp and *Byrsonima chrysophylla*. Nectar resources: *Anacardium microcarpum*, *Qualea parviflora*, *Cuphea* sp, *Stylosanthes gracilis*, *Securidaca bialata*, *Piriqueta*



*Centris byrsonimae* in *Byrsonima crassifolia* flower. Photo: Márcia Régio

cf. *cristoides*, *Humiria balsamifera*, and of pollen: *Comolia* sp, *Caesalpinia* sp, *Senna* sp, *Ouratea racemiformis*, *Myrcia obtusa*, *Myrcia sylvatica*, *Mouriri guianensis* among others. A total of 19 plant species could be used in a coastal woodland as alternative resources in a nance management plan

in this region. These plants would give the pollinators' population and their young, necessary niches to their survival and consequently help ecosystem maintenance allowing an adequate management and an increase of nance productivity.



*Centris (Melacentris)* in *B. crassifolia* flower. Photo: Márcia Rêgo



*Paratetrappedia punctifrons* in *B. crassifolia* flower. Photo: Márcia Rêgo

# LANDSCAPE MANAGEMENT AND POLLINATOR RICHNESS IN TOMATO (*Lycopersicon esculentum* Mill., SOLANACEAE) CROPS IN SOUTHEASTERN BRAZIL

Maria José Campos

State University of São Paulo - e-mail:[mjoc@rc.unesp.br](mailto:mjoc@rc.unesp.br)

In Brazil, tomato (*Lycopersicon esculentum* Mill.) is a very important crop both in terms of the extension of planted area and in terms of economic value. The total production varies around 3 million tons a year, which makes Brazil the eighth in the world ranking. Tomato flowers are hermaphrodites and are self compatible. Fruits can be formed by auto pollination. However, a more efficient pollination is promoted when bees vibrate the anthers and liberate the pollen (buzz pollination); the resulting crosspollination can increase fruit set and weight. In the same way, insufficient pollination is believed to cause low productivity. *Apis mellifera* is not able to vibrate tomato flowers and there is a search for wild bees with some potential as tomato pollinators. Some Meliponini have been tested for tomato cultivated in greenhouse, but there are only a few studies to evaluate the efficiency of wild bees in open field cultivation. This study aimed to characterize the wild bee fauna associated to tomato cultivated in open system comparing organic and conventional management and to evaluate the importance of landscape context to pollinator fauna composition

and richness. The work was carried out in three properties with organic and two with conventional cultivation management. We sampled 51 wild bee species belonging to Apidae, Halictidae e Andrenidae families. Among these species predominated those which are able to vibrate the anthers of tomato flowers and thus, can be considered pollinators in potential, such as *Augochloropsis* (9 species), *Augochlora* (2 species), *Pseudaugochlora* (1 species), among the Halictidae, *Melipona* (1 species), *Exomalopsis* (6 species), *Centris similis*, *C. nitens*, *C. tarsata*, *C. thygater*, *C. fuscata*, *Epicharis* sp, *Paratetrapedia* (2 species), *Tetrapedia* (1 species), *Bombus atratus*, *B. morio*, among the Apidae and *Oxaea flavescens* and *Anthrenoides* sp among



the Andrenidae. The distribution of these species among the areas with different management and landscape context pointed out some interesting aspects:

1 - Organic cultivations located in more diversified landscapes presented the more diversified bee fauna associated to tomato flowers. Species of the genus *Centris* and *Melipona* were collected only in these areas. 2 - Properties managed in a conventional system but

located in a more diversified landscape were richer in species if compared to those of organic cultivation located in a homogeneous landscape. It is important to consider that those conventional properties were small farms, with familiar based management, in which, despite the use of chemical control of pests, most of the area were not managed, resulting in foraging and nesting



*Lycopersicon esculentum* flowers. Photo: Maria José Campos

sites for wild bees. 3 – The similarity in the composition of wild bee fauna among the different properties was very low, around 33%. This brings the possibility that the number of species with some potential as tomato pollination could be very high and that many other factors, apart from soil management and landscape context, could be important in determine the occurrence of different species of bees in agricultural areas such as the disturbance context, the tolerance to weeds, the distance from natural areas / vegetation. 4 – The composition of weed species was very similar in all the studied areas, despite the management or the landscape context, but different management conditioned

a more diversified flora around the bed plants. In the organic properties the weeds were tolerated and in some conventional properties the presence of weeds was resulted from the difficulties in their control. Properties in a very homogenous landscape were poor in weed species even when their presence was encouraged. 5 - The analysis of the pollen collected by the bees reveled that only a few weed species growing around the cultivated fields were visited. It can suggest that bees were foraging in a very high distance, out of the 500 meters ray observed around the tomato cultivation and points out the importance of the landscape context. 6 – Other aspect to be considered is that most of



*Bombus morio* female collecting pollen from *L. esculentum* flowers. Photo: Maria José Campos



the weed species flowering in the study areas were annual species. Among the more abundant we can cite *Leonurus sibiricus*, *Solanum aculeatissimum*, *S. americanum*, *Bidens pilosa* and *Emilia sonchifolia*. All of these species have long period of flowering but only a few flower in each plant and very small flowers, with little amount of pollen or nectar. Most of them are considered pathogen reservoirs. The species of bees observed visiting tomato flowers in this study are solitary species that constitute small populations and low population growing potential. These factors make the pollination systems of low resiliency to community disturbance. In solitary species the female lays eggs as well

constructs and provision the nests, flying long distances to complete a pollen load. In this way, it is exposed to many risks such as chemical contamination, predation and resources shortage. So, apart from less resilient the pollination systems based on solitary bees have low resistance. Although some of these species have some potential to be managed, most of them will be always important in the pollination of tomato as non managed species. Considering these aspects, more effective than the proposition of management plans for species in particular, is the proposition of habitat management plans.

# SUSTAINABLE MANAGEMENT OF POLLINATORS FOR PASSION FRUIT (*Passiflora edulis* f. *flavicarpa* DEG., PASSIFLORACEAE) PRODUCTION IN CENTRAL BRAZIL

Paulo Eugenio de Oliveira  
Federal University of Uberlândia - e-mail: [poliveira@ufu.br](mailto:poliveira@ufu.br)

The project aimed to define and implement management actions to sustainable use of the pollination services of *Xylocopa* bees in commercial orchards of yellow passion fruit (*Passiflora edulis* f. *flavicarpa*) in the Triângulo Mineiro region, Minas Gerais, Brazil. Large bees of *Xylocopa*, specially three very common species in the region, *Xylocopa frontalis*, *X. suspecta* and *X. grisescens*, are the main natural pollinators of passion fruit but their populations are threatened by agricultural occupation of the region. Recent expansion of the agricultural frontier in central Brazil involved land clearing for soybean and other cash crops, besides open grasslands. Passion fruit has specialized strictly self-incompatible flowers which depend on large bee, as *Xylocopa* (*Neoxylocopa*) species, for pollination. Surveys on commercial orchards in the region resulted in 28 bee species visiting yellow passion fruit, 17 of them acting as pollinators but only seven, due to size and behaviour on the flowers were considered effective pollinators. Among effective pollinators the three cited species of *Xylocopa* are the most

regular ones but population estimates indicated that even in orchards with relatively pristine surroundings, carpenter bee populations did not exceeded fifty individuals. Experimental hand pollination versus natural pollination in the studied areas showed fruit sets from 1.7 to 6 times larger and pollen tube growth



analysis indicated fruits sets differences were due to less effective pollination of bee pollinated pistils. But in some of the studied areas, natural pollination, in spite of lower fruit set, is still active and economically viable when compared with no natural fruit set of yellow passion fruit orchards in São Paulo and other parts of Brazil. Reduced fruit production resulting from natural pollination, which may be already the result of agricultural occupation and land use, has obliged hand pollination of orchards in order to maintain profitable production levels.



*Xylocopa frontalis* in passion fruit flower. Photo: Paulo E. Oliveira

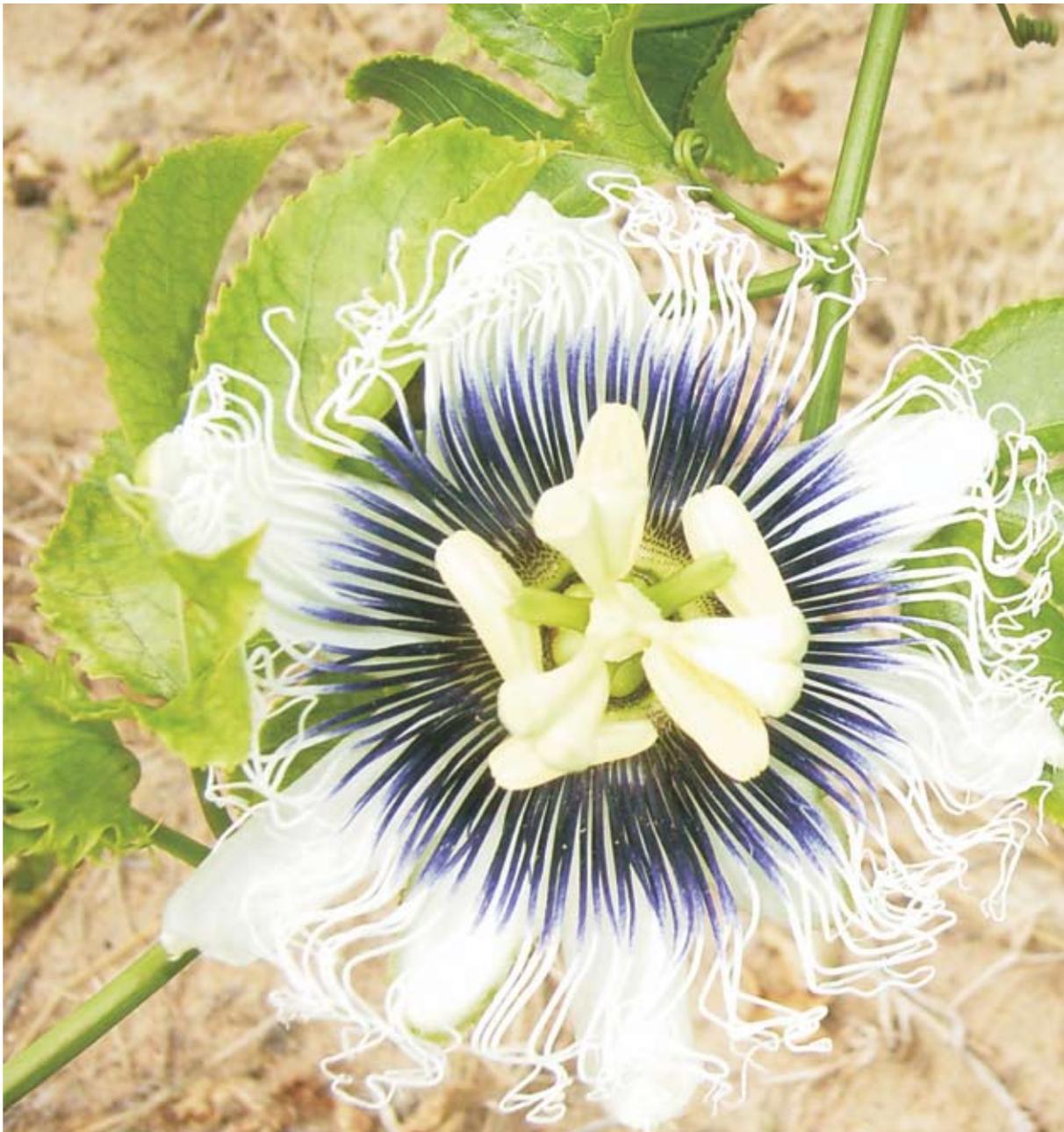


*Xylocopa suspecta* in passion fruit flower. Photo: Paulo Eugênio de Oliveira

But even in the Triângulo Mineiro, still a greatly rural region, urbanization has increased labour costs and makes hand pollination of orchards some 15% of the total production costs. Moreover, hand pollination and production has been increasingly affected by honey bee interference. *Apis mellifera* act as pollen thieves reducing availability and pollination efficiency to a point they are considered one of the main passion fruit plagues in some parts of Brazil. The control of honeybee with insecticides is further threatening native bee populations. Hand pollination of orchards using low fence conduction system, traditional in the region, increase 2.5 to 3 times the passion fruit production to some 45 ton/ha. But other conduction systems as vineyard-type or higher fences can lead to similar production without the hand pollination costs, given nowadays natural pollination levels. Based on this information we proposed management actions on a two years

base in order to test and disseminate techniques to optimize natural pollination of passion fruit orchards in the region. The proposed strategy is the installation of three demonstrative sites in production orchards in the region to introduce and multiply active nests of the main species of *Xylocopa* and also to

enrich the surrounding areas with plant species offering resources for foraging populations of these bees. The success of the management techniques would be monitored in a continuous base during the first two years using bee population size and diversity as compared with natural areas in the region. The impact on passion



Passion fruit flower. Photo: Blandina F. Viana

fruit production would also be compared using natural vs. hand pollination fruit set within the demonstrative sites and between these sites and traditional production orchards in the region. We believe that productivity yields by adopting management actions will be the main motivation for the dissemination of these actions among passion fruit

producers. Dependence of passion fruit production system on native pollinators and the possibilities of optimization and sustainable use of pollination services in this agroecosystem make it an ideal system to raise awareness among producers and the society as a whole about environmental conservation and use of ecological services.



# POLLINATORS OF YELLOW PASSION FRUIT (*Passiflora edulis* Sims, PASSIFLORACEAE) AND MANAGEMENT OF CARPENTER BEES IN SOUTHEASTERN BRAZIL

Maria Cristina Gaglianone

State University of North Rio de Janeiro - e-mail: [mcrisgag@uenf.br](mailto:mcrisgag@uenf.br)

The yellow passion fruit, *Passiflora edulis* f. *flavicarpa* Deg, is cultivated in tropical countries and Brasil is the most important producer of fruits destined to market in natura or derived products. The north of Rio de Janeiro state is an important plantation area; most of the production comes from 1-3 ha plantation areas in small rural proprieties. This project was developed in the years 2004-2005 in order to identify the main pollinators of passion fruit flowers in the north of Rio de Janeiro state and to propose a management plan to promote the sustainable use of the pollinators in the agriculture. Two peaks of flowering were identified: between September and February and in April-May. Nectar was produced during the anthesis and the greatest volume occurred between 12:30h e 14:30h reaching 40µl per flower and 38-42% of sugar concentration. Flowers of passion fruit need large pollinators able to contact stigmas and anthers during nectar collection. A roll of flower visitors was identified, including bees, butterflies and humming-birds. However, only large bees were able to pollinate the flowers.

only two species, *Xylocopa frontalis* and *Xylocopa ordinaria* (Xylocopini), were considered important pollinators because of their size, behavior and frequency on flowers. It was determined that at least three visits of these carpenter bees are necessary for fruit formation. Visits of stingless bees and honey bees were considered negative because they steal the pollen without pollinating the flowers. Fruiting rates varied in different situations of important factors such as pollinator abundance related to the flowering intensity, abundance of robbers, proximity of forest fragments and density of *Xylocopa* nests in the cultivated area. Maximum values of fruiting reach 50% but only 18,5% in average of five studied areas. The diversity of potential pollinators was higher in cultivated areas located near forest fragments. The abundance of carpenter bees was correlated to the number of opened passion fruit flowers; however the increasing of pollinators abundance was not proportional to that of flowers number. The data indicated low fruit set in situations of high numbers of flowers, indicating deficit of pollinators in these occasions. The carpenter bees were important also to

34 These species belong to Xylocopini, Centridini and Euglossini tribes, but

pollination of other plants in the studied areas and forest fragments nearby, such as poricide flowers (like *Solanum*), flag flowers (like many Leguminosae) and other native species of *Passiflora*. The high frequency of these carpenter bees in agricultural areas in the region and the nesting behavior in woody substrates are suitable factors to their inclusion in management programs of pollinators in agricultural systems. Nesting activities of *X. frontalis* e *X. ordinaria* were monitored and they occurred during the whole year, with higher intensity in the rainy season. Native substrates were identified and tests of artificial substrates were performed. The bees nested in bamboo holes installed in the cultivated area although this result was not observed for *Xylocopa ordinaria*. Woody poles used in the installation of the yellow passion fruit culture were excavated by the bees and high densities of nests (66 nests/ha) were observed in these areas. The choosing of nesting substrates is related to the characteristics of wood. In native vegetation of coastal woodland *Xylocopa ordinaria* was very abundant (98% of the carpenter bees) and nested preferentially in narrow branches (circumference of 7-25cm). The proposed strategies to the

management of carpenter bees is the establishment of nesting ranches nearby the passion fruit plantation introducing nests and suitable substrates for these bees. *Eucalyptus* and *Terminalia* were observed as good substrates for the bee nests as well as bamboo sections. The disposition of the nests in aggregation is also recommended. The proximity to forest fragments is desirable because the highest richness of pollinators in these areas and also the resources necessary to the biological cycle of these bees, like pollen. It is proposed also the use of native plant species sources of pollen belonging to six botanical families. In the same way nectar plants belonging to 15 families including native Passifloraceae are suggested as important sources for the bees and its use in the agricultural areas in periods without passion fruit flowers should be evaluated. The control of honey bee abundance in the agricultural areas is necessary and alternative plant resources for these bees were indicated. The conservation of native ecosystems in forest fragments is necessary to maintain populations of other important pollinators of passion fruit flowers like Centridini and Euglossini bees.

# ASSESSMENT OF MANGO (*Mangifera indica* L., ANARCADIACEAE) AND PASSION FRUIT (*Passiflora edulis* f. *flavicarpa* DEG., PASSIFLORACEAE) POLLINATORS IN THE SAN FRANCISCO VALLEY, NORTHEASTERN BRAZIL

Lúcia Helena Piedade Kiill

Brazilian Agriculture Research Corporation– EMBRAPA email: [kiill@cpatsa.embrapa.br](mailto:kiill@cpatsa.embrapa.br)

This study tried to understand aspects of the pollination ecology of fruit crop grown in the São Francisco Valley, in irrigated projects from Petrolina-PE/ Juazeiro-BA, NE of Brazil, during the years of 2005/2007. The works carried out in the crops of the *Mangifera indica* L.(Anacardiaceae), under conventional tillage for the varieties Tommy Atkins and Haden and *Passiflora edulis* f. *flavicarpa* Deg. (Passifloraceae). For the *M. indica* the panicles presented male and hermaphrodite flowers, in the proportion of 2:1, dicogamy was registered. The anthesis was diurnal, asynchronous, with the liberation of a strong sweet odour. The nectar production was continuous with an average value of 0.045µL/flower. The inflorescences showed visual differences between the varieties under study, interfering in the visitors' behaviour. The inflorescences of the variety Tommy Atkins displayed red colour rachis and higher number of flowers per panicle. In the Haden variety the rachis showed pink colour with less flowers, giving the panicle an open aspect. Twenty varieties of flower visitors were registered belonging to the orders Diptera, Hymenoptera and

Lepidoptera. *Apis mellifera* was the most frequent. Among the Diptera, *Belvosia bicincta* (17.7%) and *Musca domestica* (10.2%) were the most frequent visitors in conventional and organic crops respectively. The diversity and number of visits were bigger in the organic crop. The use of agrotoxics during the flowering period reduced the visit of bees (50%) and Diptera (20%). Because of its behaviour, frequency and active movement in the inflorescences, *Apis mellifera* was considered as the most efficient pollinator of the crop. In the pollination experiments the reproductive success was only registered for natural pollination, in both varieties, and in spontaneous pollination in Tommy Atkins variety. The relation fruit/panicle in the variety Tommy Atkins was (1.8) and (0.71) for Haden and the relation fruit/flower was considered low in both varieties. These differences can be due to the higher number of flowers per panicle registered in the variety Tommy Atkins. Throughout the fruit development, the abort rates registered in the first 15 days were 60.92% and 58.3% for Tommy Atkins and Haden, respectively.

The highest rates registered on the 28<sup>th</sup> day was 98.85% in Tommy Atkins and on the 50<sup>th</sup> day, 92.6% in Haden. The complete development of the fruits occurred in 120 days. After pollination the phases identified were “chumbinho” (7days), pea size (23 days), olive (33 days), nut (40 days), egg (50 days) and the fruit in the final stage. In *Passiflora edulis* f. *flavicarpa* the floral anthesis occurred between 12.00h and 13.00h. The time for style complete deflexion was  $71.4 \pm 12.4$  min (n=10). The pollen grains presented 94% viability and the stigmas were receptive during the entire anthesis. The nectar volume was in average 100 $\mu$ L, with 48% of sugar concentration. The number of pollen grains/flower was  $140.595 \pm 34.175$  (n=5) and  $426 \pm 77$  ovules/ovary (n=20). The highest frutification rates were obtained after cross pollination (74%), confirming the existence of a system of self-incompatibility. Were registered 10% of flowers with four stigmas, which when manually pollinated, produced bigger fruits with a higher number of seeds ( $477.77 \pm 76.83$ , n=9). Probably caused by a characteristic called secondary gymnogonese. A positive correlation was

found between the number of seeds and the weight of the fruits. The identified flower visitors were *Apis mellifera*, *Trigona spinipes*, *Xylocopa grisescens*, *X. frontalis* and *X. cearensis*. *Apis mellifera* and *T. spinipes* were considered pollen and nectar robbers, respectively. Bees of the genus *Xylocopa* were more frequent in the flowers during the dry season and *A. mellifera* during the wet season. The effective pollinators were *X. grisescens* and *X. frontalis*, and thus it was found that they were limited in number in the studied areas. However they were found to be more frequent in other plant species during the rain season which indicates competition with the passion fruit flowers. In general, it was observed a frutification increase for the crops studied when there was natural pollination, which indicates the importance of the flower visitors for the production. However, there is a pollinator restriction, especially for the native species that find in the scattered vegetation surrounding the crop's area, the place for nesting and feeding.

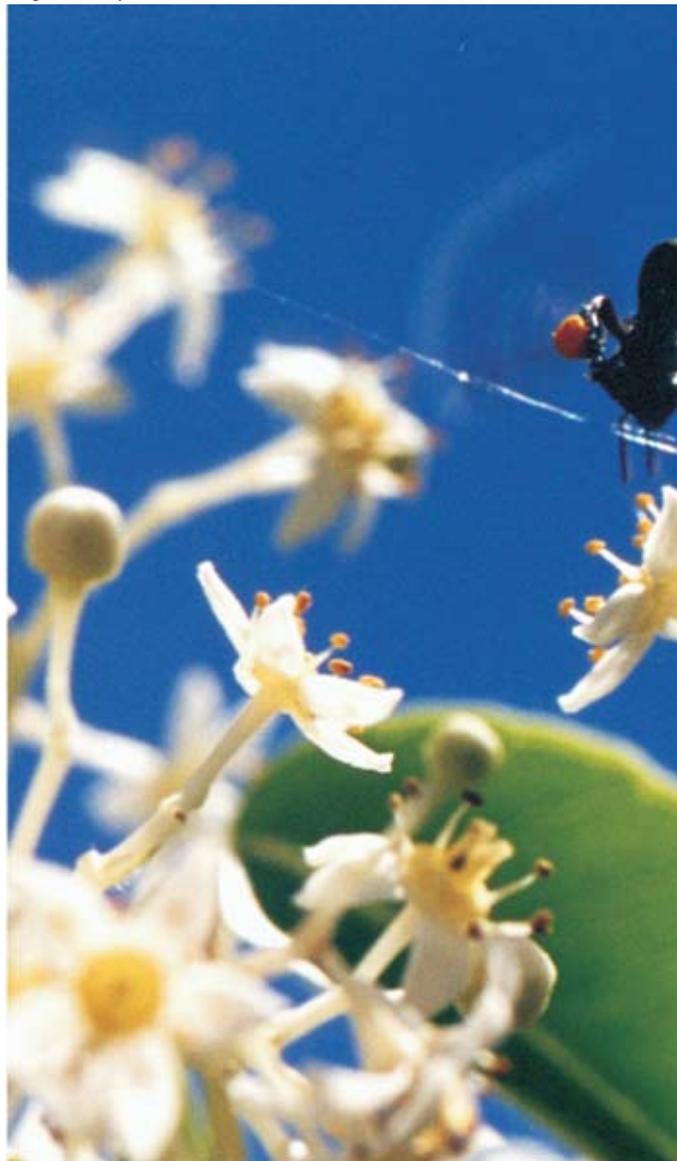
# MANAGEMENT PLANS FOR FRUIT CROP POLLINATORS IN THE STATES OF BAHIA AND PERNAMBUCO, NORTHEASTERN BRAZIL

Blandina Felipe Viana

Federal University of Bahia - e mail: [blande.viana@gmail.com](mailto:blande.viana@gmail.com)

The pollination needs of mango (*Mangifera indica*), cultivar Tommy Atkins, yellow passionfruit (*Passiflora edulis*), guava (*Psidium guajava*), cultivar Paluma, and “umbu” (*Spondias tuberosa*) was investigated in the states of Bahia and Pernambuco, Northeast of Brazil, and management plans for potential pollinators of those crops were proposed. Mango, guava and yellow passionfruit plantations have a great financial value to the economy of the São Francisco Valley, in Northeast of Brazil where are mainly produced for the export market. The expansion of those agriculture ecosystems in that area resulted in a mosaic landscape with significant loss of the natural vegetation of “Caatinga” (white dry forest), one of the most threatened biome in Brazil. The “umbu” on the other hand, is a native species that it grows on the natural vegetation of “Caatinga”. This fruit crop is locally important and if adequately managed can reach commercial importance for the farmers in that region. The researches on the “umbu” were accomplished in the area of the indigenous tribe of Pankararé, located in the “Raso da Catarina”, in the State of Bahia. For all crops we have

Stingless bee in *Spondias tuberosa* flower. Photo: Blandina F. Viana



done observations of visitors' foraging behavior, examined the floral morphology and biology, investigated the sexual and pollination systems, tested the efficiency of the potential pollinators and we also have proposed management plans for

pollinators of those crops. Our results showed that in the studies regions there were not evidences of pollination “service” limitation for mango, guava and “umbu”.

fruit (*Passiflora edulis* Sims), a native species, is an economically important crop in Brazil, but its establishment and expansion has been limiting by



its dependence on cross-pollination to increase fruit set. The principal pollinators of yellow passion fruit in São Francisco river valley are carpenter bees of the genus *Xylocopa*, which are strongly dependent on the presence of the *Commiphora leptophloeos* (Mart.) J. B. Gillett (Burseraceae) a plant species endemic of Caatinga, whose density is being reduced in the region by human activities as fire and selective cutting of forest. Several insects have been visited mango flowers during the study

However, the pollination experiments comparing natural and hand-cross pollination indicated that yellow passion fruit crops are suffering from pollinator population limitation. The yellow passion

fruit ( *Passiflora edulis* Sims), a native species, is an economically important crop in Brazil, but its establishment and expansion has been limiting by its dependence on cross-pollination to increase fruit set. The principal pollinators of yellow passion fruit in São Francisco river valley are carpenter bees of the genus *Xylocopa*, which are strongly dependent on the presence of the *Commiphora leptophloeos* (Mart.) J. B. Gillett (Burseraceae) a plant species endemic of Caatinga, whose density is being reduced in the region by human activities as fire and selective cutting of forest. Several insects have been visited mango flowers during the study period but the most important visitors were flies belong to the families: Calliphoridae, Chironomidae, Dolichopodidae, Milichidae, Muscidae, Otitidae, Sarcophagidae,

**MANGO, PASSION FRUIT, UMBU AND GUAVA**

Syrphidae, Tachinidae, Tephritidae and Tipulidae, and the small (body size: 4 and 10 mm) stingless bees *Plebeia* sp and *Tetragonisca angustula* that occur in the studied area. In flowers of guava we found 13 species of bees but *Apis mellifera*, *Melipona mandacaia*, *Xylocopa frontalis* and *X. grisescens* were considered the main vectors of pollen. Bees and the other insects also visited the flowers of “umbu” but among all visitors the potential pollinators were the eusocial bees, *Apis mellifera*, *Trigona spinipes* and *Frieseomelitta doederleini*.

Although our data showed that the need for cross-pollination it is not critical for mango, guava and “umbu” the results of pollination experiments conducted in the study area indicated that the lack of outside agents to transfer pollen from anther to stigma could affect the fruit set of those crops. Then investments in conservation and restoration of the population of pollinators and their ecological needs are a critical priority in order to improve higher yields of those crops in Northeast of Brazil.



*Mangifera indica* Fruits. Photo: Blandina C. Viana