



## **Evaluation of oligolecty in the Brazilian bee *Ptilothrix plumata* (Hymenoptera, Apidae, Emphorini)**

Clemens Schlindwein, Raquel Andréa Pick, Celso Feitosa Martins

### **► To cite this version:**

Clemens Schlindwein, Raquel Andréa Pick, Celso Feitosa Martins. Evaluation of oligolecty in the Brazilian bee *Ptilothrix plumata* (Hymenoptera, Apidae, Emphorini). *Apidologie*, 2009, 40 (2), pp.106-116. <hal-00891983>

**HAL Id: hal-00891983**

**<https://hal.science/hal-00891983v1>**

Submitted on 11 May 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

## Evaluation of oligolecty in the Brazilian bee *Ptilothrix plumata* (Hymenoptera, Apidae, Emphorini)\*

Clemens SCHLINDWEIN<sup>1</sup>, Raquel Andréa PICK<sup>2</sup>, Celso Feitosa MARTINS<sup>3</sup>

<sup>1</sup> Universidade Federal de Pernambuco, Departamento de Botânica - UFPE, Av. Prof. Moraes Rego, s/n, Cidade Universitária, 50670-901 Recife, PE, Brazil

<sup>2</sup> Programa de Pós-Graduação em Ciências Biológicas (Zoologia), Universidade Federal da Paraíba - UFPB, 58059-900 João Pessoa, PB, Brazil

<sup>3</sup> Universidade Federal da Paraíba - UFPB, Departamento de Sistemática e Ecologia, 58059-900 João Pessoa, PB, Brazil

Received 9 May 2008 – Revised 27 August 2008 and 13 October 2008 – Accepted 14 October 2008

**Abstract** – *Ptilothrix plumata* is a solitary bee, oligolectic on Malvaceae. In this study we evaluate its oligolectic behavior through quantitative and qualitative analyses of larval provisioning in the National Park of Catimbau, Brazil. Quantitative pollen analysis showed that, to feed one larva, females collect pollen from an average of 17.2 flowers of *Pavonia cancellata*, 8.5 flowers of *P. varians*, 4.8 flowers of *P. humifusa* and 12.4 flowers of *Sida galheirensis*. Preference for pollen of *Pavonia* seems to be characteristic for the species and is even more accentuated when considering the volumes of the very large *Pavonia* pollen grains in the pollen mass: more than 90% of total pollen volume of larval food was from *Pavonia* species. Comparison to food preferences of *P. plumata* at other sites shows that the degree of specialization also depends on the composition of plant species at a given locality and a local seemingly monolectic relationship may result from missing opportunities for choice.

*Ptilothrix plumata* / pollen analysis / Malvaceae / oligolecty / larval diet / bee

### 1. INTRODUCTION

Records of bees on their pollen and nectar flowers give first information about the association of bee species to plants in their environments, indicating, for example, which are oligolectic bees – taxonomic pollen specialists according to Robertson (1925). Such information is provided, for example, in standardized yearlong bee – plant community studies. Recently, Cane and Sipes (2006) revised the terminology of pollen specialization in bees and defined several degrees of relationships of bee species to pollen hosts, from monolecty to

broad polylecty. They recommend the application of pollen analysis of scopal loads and cell provisions because this permits a numeric evaluation of the bee-plant relationship. However, they point out that pollen contents can get contaminated by wind pollen and pollen from nectar sources, and allow up to 10% contamination to consider pure loads of one genus or family.

Pollen analyses of provisions of brood cells provide the most comprehensive information on the plant hosts of a bee species. As a summation of the daily pollen foraging effort of a female bee, cell contents contain all pollen grains of numerous pollen collection trips of this female and contain what larvae actually eat. Qualitative pollen analysis of the brood cells facilitates the identification of

Corresponding author: C. Schlindwein,  
[schlindw@ufpe.br](mailto:schlindw@ufpe.br)

\* Manuscript editor: Jean-Noël Tasei

which plant species contributed with pollen resources and in what proportion. Knowing the amounts of pollen presented by a flower of this plant species, quantitative pollen analysis permits a calculation of the number of flower equivalents in pollen required to feed one bee larva (Schlindwein and Martins, 2000; Schlindwein et al., 2005; Müller et al., 2006; Larsson and Franzén, 2007). For those cases where a forager removes only a portion of the available pollen from a flower, this represents a minimum number of floral equivalents of pollen to feed one offspring. However, only in a few cases have pollen contents of brood cells been identified and quantified for ground-nesting solitary bees.

*Ptilothrix plumata*, one of the three Brazilian *Ptilothrix* species (Silveira et al., 2002), belongs to Emphorini, a New World bee tribe that is composed of species which are all thought to be oligolectic (Schlindwein, 2004; Schlindwein and Martins, 2004; Minckley and Roulston, 2006; Cane and Sipes, 2006; Michener, 2007). Preliminary information showed that *P. plumata* is oligolectic on Malvaceae (Schlindwein and Martins, 2000; Schlindwein, 2004), as has been previously demonstrated for some species of several genera in Emphorini (Neff et al., 1982; Neff and Simpson 1992; Schlindwein, 1998; Sipes and Tepedino, 2005).

On the coastal plain of João Pessoa (Paraíba state, northeastern Brazil), females of *Ptilothrix plumata* exclusively visit flowers of *Pavonia cancellata* (Malvaceae), and nest provisions contained only pollen of this species, pointing to monolecty (Schlindwein and Martins, 2000). However, in the area surrounding the Paraíba site, *Pavonia cancellata* was the only abundant Malvaceae plant species.

At the National Park of Catimbau, Pernambuco, NE Brazil, where three species of *Pavonia* are abundant and grow among several other melittophilous species of Malvaceae in a diverse tropical dry forest, we re-evaluated the relationships of *P. plumata* to plants paying special attention to the amount of pollen grains stored in the brood cells. We investigated the degree of specialization of *Ptilothrix plumata* on Malvaceae in an environment where several

species of Malvaceae occur; and the contribution of the different species of Malvaceae, to the cell contents of *P. plumata*.

## 2. MATERIALS AND METHODS

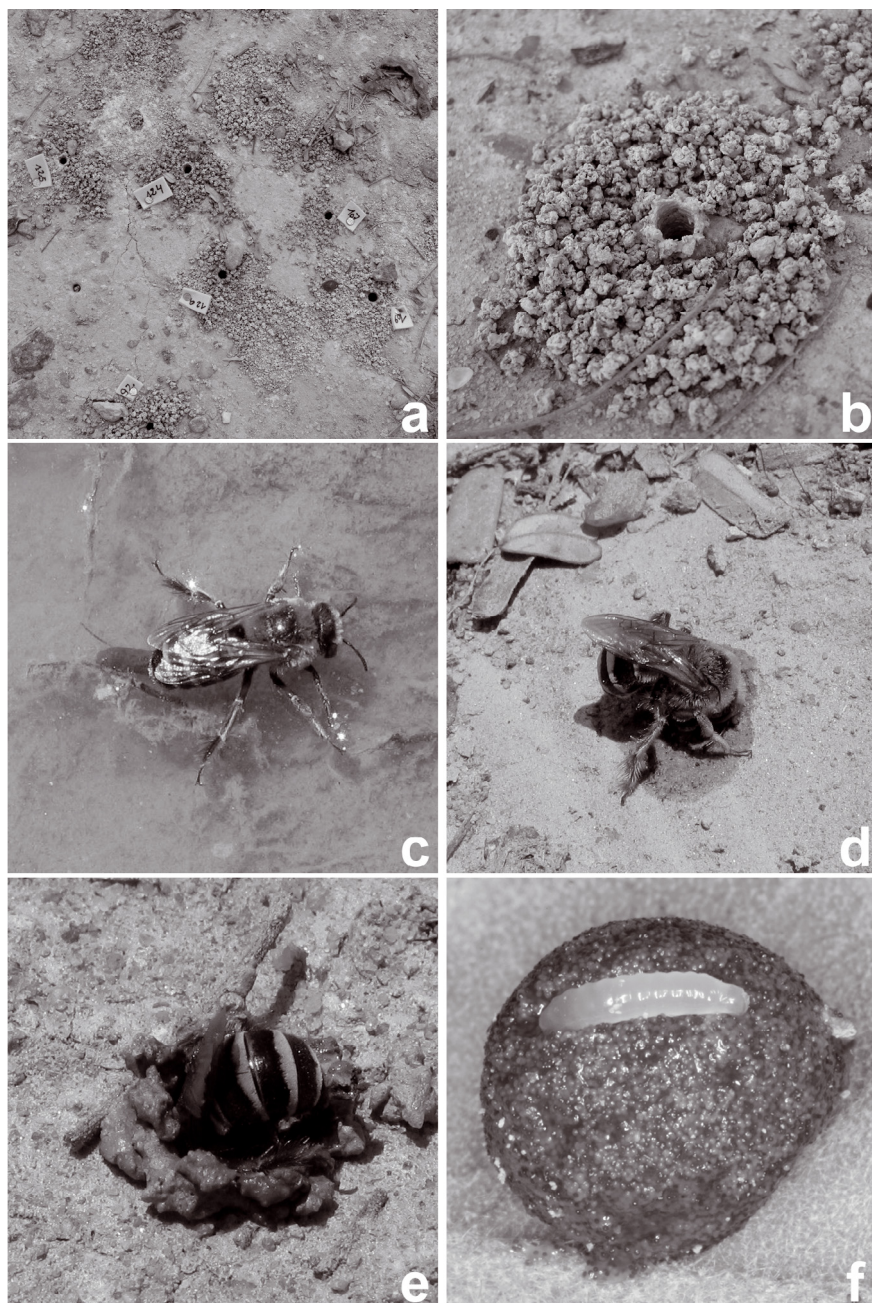
### 2.1. Study site

The study was carried out from August to November of 2005 and 2006, at *Parque Nacional do Catimbau*, Buíque, Pernambuco, in semiarid northeastern Brazil (08°35'91"S and 037°14'28"W). The climate is tropical seasonal with a rainy season from March to July and annual precipitation between 650 and 1100 mm. Medium annual temperature is 23 °C (Parna, 2002).

Flora and fauna of the Catimbau National Park are characterized by a mixture of elements from Caatinga, Cerrado, Campo Rupestre, Atlantic Rain Forest and endemic species. The vegetation at the study site is open shrubby and arboreal with a well developed, diversified herbaceous layer. During the study period numerous woody and herbaceous species were blooming and among Malvaceae, *Pavonia cancellata* Cav., *P. humifusa* A. Juss., *Pavonia varians* Moric., *Sida galheirensis* Ulbr., *S. cordifolia* L., *Sidastrum multiflorum* (Jaq.) Fryxell, *Herissantia crispa* (L.) Brizicky and *H. tiubae* (K. Schum.) Brizicky were flowering.

### 2.2. Nesting biology

The aggregation of *Ptilothrix plumata* occupied 48 m<sup>2</sup> with 328 nests with a density of 6.8 nests/m<sup>2</sup> (Fig. 1a) on an unpaved road, in places with bare, hard, clayey soil. Nests in construction were identified individually with labels and recorded. The nesting period started at the end of the rainy season, beginning in August, and ended by the end of October. The nests showed a small entrance turret about 2 mm long with soil pellets removed during nest construction around the nest entrance (Fig. 1b), as is common in *Ptilothrix* species (Linsley et al., 1956; Butler, 1967; Rust 1980; Martins et al., 1996; Schlindwein and Martins, 2004). Nests were composed of a short vertical straight tube, 2.9 cm ( $\pm$  1.2 cm; n = 20) long, ending in an urn-shaped brood cell, which was easily isolated from the substrate. Most nests (18) contained only one brood cell and two nests contained two cells in a row. Brood cells were on average  $1.6 \pm 0.14$  cm long and



**Figure 1.** Nests and females of *Ptilothrix plumata* during nest construction at *Parque Nacional do Catim-bau*, Pernambuco, Brazil; (a) nesting site and general aspect of the nesting aggregation; (b) nest entrance with turret surrounded by soil pellets removed during nest construction; (c) Female on the water surface collecting water, note that tarsi (including basitarsi) of the three pairs of legs are submerged; (d) first regurgitating of water by a female at the nesting site to moisten the clayey soil during nest construction; (e) removal of the softened soil substrate with mandibles and legs; (f) pollen mass with first instar larva; note the mixture of light and dark (red) pollen grains of different *Pavonia* species.



$1.1 \pm 0.06$  cm broad. The spheroid pollen mass was compact, covering a long egg underneath. Completed nests were closed with a plug of mud, 0.7 cm long, and showed a slight depression in the soil. Loose soil material occupied the rest of the nesting tube up to the brood cell.

Nest construction started between 12:00 h and 13:00 h with the females flying close to the soil surface alighting repeatedly at the future nesting site. To soften and work the hard substrate, they took up water with their mouth parts at a puddle nearby the aggregation, floating on the water surface for 5 s ( $\pm 1.0$ ;  $n = 10$ ). Tarsi and basitarsi of the three pairs of legs were submerged (Fig. 1c). At the nesting site, the bees regurgitated the collected water (Fig. 1d) and worked the soil with mandibles and legs (Fig. 1e). They first constructed the entrance turret and then placed the removed soil pellets around the entrance. Water collection trips were very rapid (17 s;  $n = 26$ ). Nest construction, in general, finished at about 16:00 h and females stayed in the nesting tube until the next morning with head downwards, closing it with the metasoma.

Nest provisioning started at about 0815 h on the following day. Females made 22 to 24 pollen collection trips, which lasted on average 182 s ( $\pm 62.8$ ;  $n = 24$ ), to provision one brood cell. Pollen foraging finished between 10:00 h and 11:00 h. Then, they laid an egg and positioned it under the pollen mass. Females again collected water to close the brood cell and nest entrance with soil material, using first the material of the turret.

### 2.3. Pollen analysis

We made pollen reference slides from all species of Malvaceae and the most common other plant species in the surroundings of the nest aggregation. The quantity of pollen produced per flower of each *Pavonia* species was estimated by counting the total number of pollen grains in 10 randomly sampled anthers from 10 flowers. Pollen size of 300 grains was measured under the microscope at 400X magnification.

The pollen types in the brood cells were identified by comparison with the reference collection. In 13 brood cells from different nests, the relative frequency of the different pollen types was determined. The pollen content of a brood cell was transferred to an Eppendorf tube with alcohol (70%) and homogenized in an agitator (Vortex) for 5 minutes. Six small subsamples were removed to prepare

pollen microscope slides according to the method of Louveaux et al. (1978). At least 300 pollen grains were counted per sample.

In five brood cells with complete pollen masses where larvae had not started to consume any food, the total number of pollen grains per cell and pollen types were determined. The pollen mass of one brood cell was transferred to an Eppendorf tube with 1.5 mL volume of glycerined lactic acid. The sample was homogenized in an agitator for 5 minutes, and six sub-samples of  $0.9 \mu\text{L}$  were transferred to a microscope slide for counting the total number of pollen grains of each type.

The volume of the pollen grains was determined using the formula of a sphere ( $V = 4\pi r^3/3$ ) (all Malvaceae grains were spherical). To calculate the volume of the non-identified pollen types, the medium diameter of these types were used. The number of pollen grains per plant species and per cell were related to the quantity of pollen produced by the flowers of each species to determine the number of flowers necessary to feed one larva.

## 3. RESULTS

### 3.1. Nest provisioning and larval diet

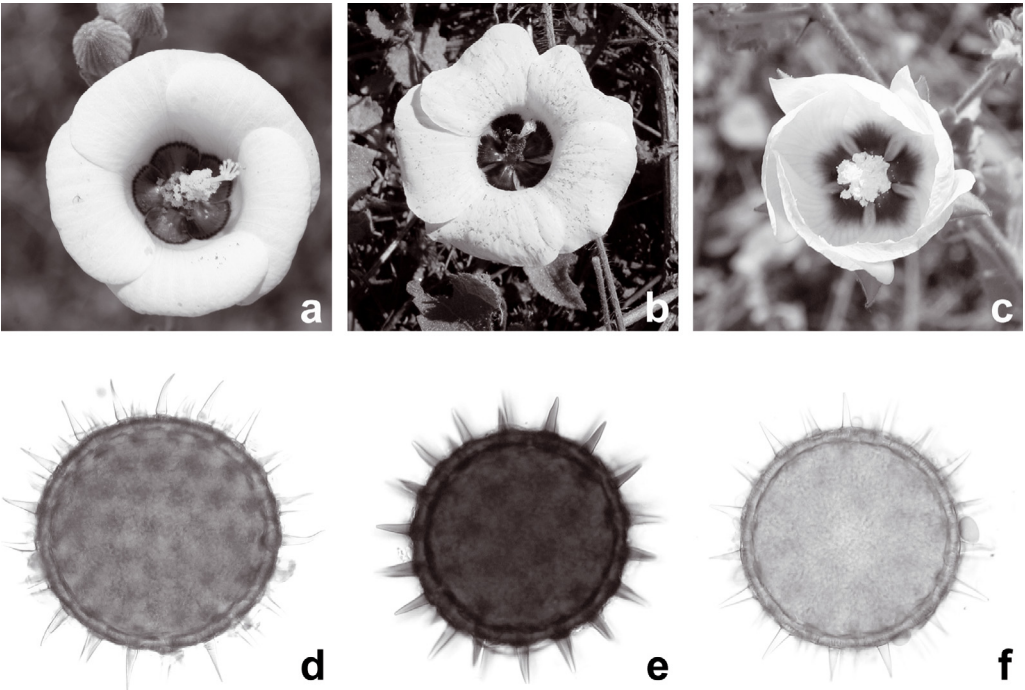
*Ptilothrix plumata* females were recorded visiting the flowers of the three species of *Pavonia* (as predominant flower visitors) and *Sida galheirensis*, but not those of *Sida angustissima*, *Herissantia crista* and *H. tiubae*. The flowers of the *Pavonia* species opened between 07:00 h and 07:30 h and closed between 12:00 h and 13:00 h.

Among the species of Malvaceae, the pollen grains of *Pavonia* with a diameter of 140 to 180  $\mu\text{m}$  were larger than those of the genera *Sida* and *Herissantia* (65.5–88.8  $\mu\text{m}$ ). Each *Pavonia* flower produced 2400–2700 pollen grains (Tab. I, Fig. 2).

Pollen analysis of 13 brood cells, each provisioned by a different individual, showed that females collected pollen from the following Malvaceae: *Pavonia cancellata*, *P. humifusa*, *P. varians*, *Sida galheirensis*, *Sida* sp., *Herissantia crista*, and an unidentified species of Malvaceae. All nest provisions contained two to three species of *Pavonia* (Tab. II). In eight brood cells, *Pavonia* pollen accounted for 72 to 100% of the total grains (Tab. II, Fig. 1f).

**Table I.** Size of pollen grains, numbers of anthers and pollen grains per flower in *Pavonia cancellata*, *P. varians* and *P. humifusa* (N = 10).

	<i>P. cancellata</i>	<i>P. varians</i>	<i>P. humifusa</i>
Ø of pollen grains (µm) (mean ± sd)	143.7 ± 5.5	178.8 ± 8.4	159.9 ± 9.3
Number of anthers	44.5 ± 9.0	35.5 ± 4.5	50 ± 4.9
Number of pollen grains per anther	57.8 ± 12.6	67.5 ± 11.2	54.2 ± 14.5
Number of pollen grains per flower	2.572	2.396	2.710



**Figure 2.** Flowers and pollen grains of *Pavonia* (Malvaceae); a-c flowers; (a) *Pavonia humifusa* (pollen grains of lower stamens are red, those of upper stamens yellow); (b) *Pavonia cancellata* (red pollen grains); (c) *Pavonia varians* (yellow pollen grains); d-f pollen grains, optical section, (d) *P. humifusa*; (e) *P. cancellata*; (f) *P. varians*.

Seven brood cells, however, contained pollen of *Sida galheirensis*, *Sida* sp. or *Herissantia crispa*, besides grains of *Pavonia* (Tab. II). Six pollen types were non-Malvaceae pollen grains (Asteraceae, Rubiaceae and unidentified tri-zono-colporate pollen).

The brood cells of *Ptilothrix plumata* contained, on average, about 61% pollen of *Pavonia* (*P. cancellata* 19%, *P. varians* 21.54%, *P. humifusa* 21%), 19% of *Sida galheirensis*, 4% of *Herissantia crispa* and 2.5% of *Sida* sp.

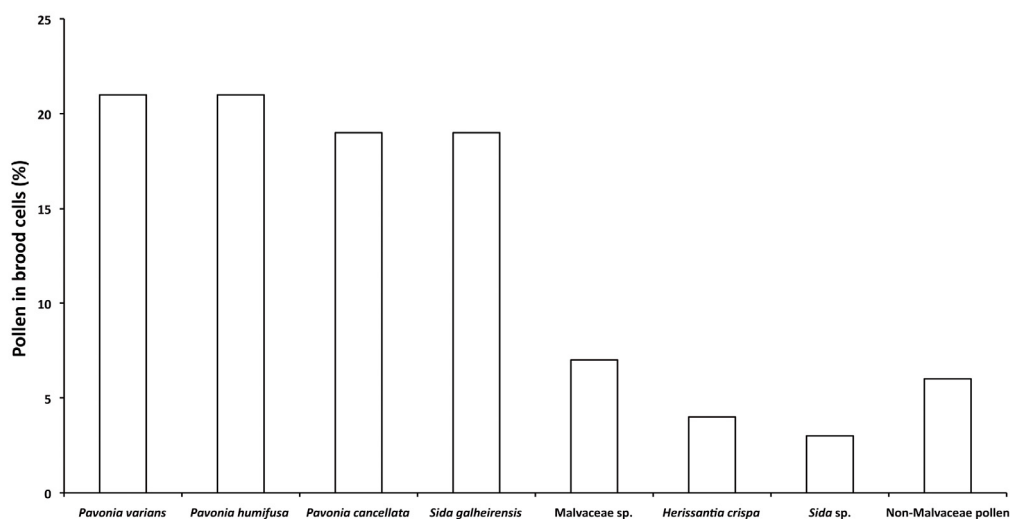
(Tab. II; Fig. 3). Pollen grains of other families accounted for, on average, about 6%.

Five brood cells were excavated soon after nest provisioning and still contained all pollen grains (brood cells 1 to 5 in Tab. II). Quantification of the pollen grains revealed that a female of *P. plumata* collected on average 178 667 +/- 99 140 grains to feed one larva (Tab. III). Considering the number of pollen grains of a flower of *Pavonia* (Tab. I) and *Sida galheirensis* (5307 ± 620.5 grains per flower, Andrade & Schlindwein, unpubl. data),

**Table II.** Relative frequency of pollen grains in 13 brood cells of different individuals of *Ptilothrix plumata* at the *Parque Nacional do Catimbau*.

Brood cell Number	<i>Pavonia cancellata</i>	<i>Pavonia varians</i>	<i>Pavonia humifusa</i>	<i>Sida galheirensis</i>	<i>Sida</i> sp.	<i>Herissantia crispa</i>	Malvaceae sp.	Non-Malvaceae
1	17.67	15.67	7.33	57.33	-	-	0.27	1.73
2	16.67	1.00	2.67	40.00	-	-	36.67	3.00
3	9.67	18.33	9.00	61.00	-	-	-	2.00
4	41.19	32.33	19.33	0.14	-	-	5.67	1.33
5	67.33	5.00	6.33	-	-	-	20.33	1.00
6*	1.00	99.00	-	-	-	-	-	-
7*	1.00	-	4.33	92.33	-	-	-	2.33
8*	7.00	-	65.67	-	-	-	-	27.33
9*	37.33	-	36.00	-	-	6.00	-	20.67
10*	18.33	70.00	11.67	-	-	-	-	-
11*	31.33	37.00	16.33	-	-	-	-	15.33
12*	-	1.67	72.67	-	-	-	25.33	0.33
13*	3.00	-	18.00	-	33.33	45.67	-	-
Mean	19.35	21.54	20.72	19.29	2.56	3.97	6.79	5.77

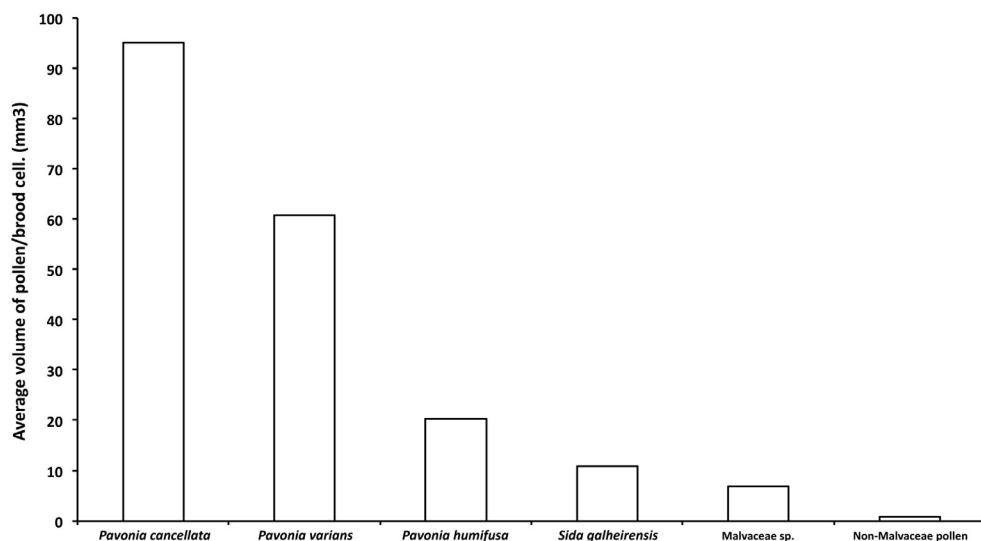
\* Pollen partially consumed by the larva.

**Figure 3.** Larval diet of *Ptilothrix plumata*. Percentage of pollen of the different plant species in 13 brood cells of different females at *Parque Nacional do Catimbau*.

the brood cells of *P. plumata* contained, on average, the floral equivalents of 17.2 non-visited flowers of *Pavonia cancellata*, 8.5 of *P. varians*, 4.8 of *P. humifusa* and 12.4 of *Sida galheirensis* (Tab. III).

Considering the contribution of the pollen grains of the different species to the amount

of food in these five brood cells, pollen of *Pavonia cancellata* accounted for the largest volume (49%; 95 mm<sup>3</sup>). The three species of *Pavonia* together accounted for 91% of the total volume of the pollen mass, but only 43% of the total number of pollen grains (Fig. 4, Tab. III). The volume of non-Malvaceae pollen



**Figure 4.** Larval diet of five brood cells of different females of *Ptilothrix plumata*; average volume of pollen of the different plant species per brood cell.

grains in these five brood cells was minute ( $0.2\%$ ;  $0.34 \text{ mm}^3$ ).

## 4. DISCUSSION

### 4.1. Pollen analysis of larval diet

Quantitative and qualitative pollen analysis of larval diet in *Ptilothrix plumata* showed that females feed their larvae almost exclusively with pollen of Malvaceae. The small number of pollen grains of other plant families is probably due to contamination, such as grains from nectar hosts, wind-pollinated flowers and laboratory manipulation, and fall within the acceptable levels of contamination suggested by Cane and Sipes (2006). Quantitative analysis of five complete food provisions showed that the total pollen amount of about 40 to 50 flowers of Malvaceae with complete pollen content is necessary to feed one bee larva. More than half of the pollen grains come from three species of *Pavonia*. This corresponds to the results of Müller et al. (2006), who showed that most solitary bees require the pollen equivalent of more than 30 flowers for one larva.

Many more flowers, however, are visited to gather this amount, because females, in general, collect only a part of the total pollen mass of a flower during a visit and often arrive at flowers that have been previously visited by other pollen collecting bees. When females of *P. plumata* collect pollen in flowers of *Pavonia cancellata*, this number has to be multiplied 5–20 times (Schlindwein and Martins, 2000).

Our results show that generalization of food preferences of a bee species resulting from the larval diet at a single site has to be made with care. In particular, the options for alternative forage at a single site must be considered to avoid a false conclusion of oligolecty or monolecty. In a previous study on the pollination of and competition for floral resources of *Pavonia cancellata* at the coastal plain of Paraíba, all pollen provisions of *P. plumata* were homogeneously composed of pollen of this species (Schlindwein, 2000; Schlindwein and Martins, 2000) and this bee species appeared to be monolectic. At this study site with cerrado-like *Tabuleiro* vegetation, however, *Pavonia cancellata* was the only species of Malvaceae present.



**Table III.** Total number of pollen grains of 5 brood cells of different females of *Ptilothrix plumata* at the Parque Nacional do Catimbau. N flowers correspond to the numbers of flowers of the respective species that contain the mean number of pollen grains found in the brood cells.

Brood cells	<i>Pavonia cancellata</i>	<i>Pavonia varians</i>	<i>Pavonia humifusa</i>	<i>Sida galheirensis</i>	Malvaceae sp.	Non-Malvaceae pollen	Total
1	23 261	20 628	9 656	75 489	351	2 282	131 667
2	58 000	3 480	9 280	139 200	127 600	10 440	348 000
3	17 948	34 039	16 710	113 257	-	3 713	185 667
4	48 461	37 884	22 652	167	6 639	1 562	117 167
5	74 628	5 542	7 019	-	22 536	1 108	110 833
Mean pollen	44 459	20 314	13 063	65 623	31 425	3 821	178 667
number $\pm$ SD	20 680–68 238	4512–36 116	6588–19 538	1648–129 596			
N. Flowers	17.2	8.5	4.8	12.4			
(95% CI)	5.8–28.7	0.3–16.7	1.8–7.8	2.6–27.3			

In contrast, in the diversified environment of the *Parque Nacional do Catimbau*, where numerous species of Malvaceae are abundant, females of *Ptilothrix plumata* also diversify larval diet. Nevertheless, pollen of *Pavonia* spp. dominated in the food provisions. When considering the volume of the pollen grains, the very large *Pavonia* pollen contributed more than 90% of the pollen mass in completed brood cells. Also in the eight brood cells whose pollen amount was partially consumed by larvae, the proportions of pollen of *Pavonia* to pollen of other species of Malvaceae and to non-Malvaceae pollen grains were similar to that of the five complete brood cells. Considering the mean total amount of pollen of these five brood cells (178 000 pollen grains) and that for the eight brood cells with partial pollen amounts, the average amount of pollen in a brood cell would correspond to about 46 flowers of the three species of *Pavonia* (8.6 flowers of *P. cancellata*, 19.3 of *P. varians* and 18.4 of *P. humifusa*). In three brood cells, the contribution of non-Malvaceae pollen was above 10%. The small tri-zono-colporate grains, however, contributed to less than 3% of the volume of the respective pollen mass.

The composition of the pollen diet of all brood cells demonstrated that females of *Ptilothrix plumata* discriminate flowers of Malvaceae from all other families. Among Malvaceae, pollen of *Herissantia crispa* and *Sida galheirensis*, very common in the National Park, were less frequent in brood cells (present in 2 and 5 cells respectively) than *P. cancellata* and *P. humifusa* (both present in 12 cells), which were much less abundant than *H. crispa* and *S. galheirensis*. These pronounced differences might be the result of (a) individual foraging variation among females, (b) morphological adaptation to very large pollen size or (c) competition. All analyzed brood cells were from different females, and within the population, different individual preferences for pollen may exist. Therefore, it would be interesting to compare larval diets of females throughout their lifetime to check if these differences are manifested individually or within the general range of food preferences in the population.

## 4.2. Morphological adaptation

Very large pollen grains like those of the *Pavonia* species with a diameter of 150  $\mu\text{m}$  and more are rare in angiosperms (Erdtman, 1952; Roubik and Moreno, 1991). Females of *Ptilothrix plumata* have a scopa adapted to transport these large grains: pollen is transported on the inner (posterior) surface of the hind tibia between very long sparse scopal setae that insert along the tibial borders and leave a broad space between each other. Pollen in this species, thus, is transported at the opposite side of hind tibiae when compared to other Apidae where pollen adheres to the anterior surface. Females of most species are not able to collect or transport such large pollen grains, and also larvae might have difficulties in eating and digesting these grains. Polylectic honey bees, for instance, actively remove and discard very large pollen grains that adhere to their body surface like those of *Opuntia* (Cactaceae) (Schlindwein and Wittmann, 1997) and cotton (*Gossypium*, Malvaceae) (Martins et al., in press). Curiously, in both cases flower visits of bees of oligolectic species of *Ptilothrix* are cited: *P. fructifera* in *Opuntia* (Schlindwein and Wittmann, 1997), *P. plumata* in cotton (Martins et al., op. cit.) and an unnamed species of *Ptilothrix* in cotton (Michener, 2007). Oligolectic bees with morphologically adapted scopae to collect pollen grains of similar size are also known for visitors of flowers of *Ludwigia* (Onagraceae) (Gimenes, 1991).

## 4.3. Competition

In flowers of *Pavonia cancellata*, *P. humifusa* and *P. varians*, bees of *Ptilothrix plumata* were frequent visitors and only sporadic visits of a few other species were recorded. In the flowers of most other species of melittophilous Malvaceae growing in the *Parque Nacional do Catimbau*, bees of several species were common, including three other oligolectic species, *Sarocolletes fulva* (Colletidae, Paracolletinae), an undescribed *Perditomorpha* and an undescribed *Diadasina* (Emphorini). Females of these three species do not visit flowers of *Pavonia*. These bees might be strong competitors of *P. plumata* in flowers of *Sida* and

*Herissantia*, whose pollen grains are relatively large when compared to other plant species, but have only about half the diameter of pollen of *Pavonia*.

In flowers of *Pavonia cancellata*, females of *Ptilothrix plumata* fill their scopae extraordinarily fast, and foraging trips last less than 3 min, which was interpreted as a result of harsh competition with the tiny flower closing beetle *Pristimerus calcaratus* (Curculionidae) at the Paraíba site (Schlindwein and Martins, 2000). It is interesting that these beetles were also very common in flowers of all three species of *Pavonia* at the Catimbau site. However, they did not visit flowers of other melittophilous Malvaceae. This extends the tight association of both insect species also to the yellow flowered *P. humifusa* and *P. varians*.

Following Cane and Sipes (2006), *Ptilothrix plumata* can be classified as a narrowly oligolectic species. Pollen analysis of brood cells proved to be an excellent tool to reveal larval diet and the trophic niche of an oligolectic species. The bees seem to include minor amounts of pollen of non-*Pavonia* Malvaceae into larval diet if these are common in the surroundings. Pollen analysis of brood cells is also a useful approach to evaluate the supporting capacity of the environment for a population of an oligolectic species by knowing the number of flowers necessary to rear one bee.

Unfortunately, there are no experimental studies with inexperienced females of oligolectic species that confirm innate preferences on specific pollen hosts. The repetitive selective of certain specific food plants by females of an oligolectic species, however, points to a genetically influenced characteristic of the bee species. Recently it was shown that specific substances in the floral odor of host plants seem to be chemical markers for oligolectic bees (Dötterl et al., 2005; Füssel et al., 2007). This could be true also for the *Pavonia* – *Ptilothrix* – *Pristimerus* association.

## ACKNOWLEDGEMENTS

We thank the reviewers for their comments which improved the manuscript, Fernando Zanella

(UFCG) for help in the identification of bee species and constructive criticism, IBAMA for the permission to work in the Catimbau National Park, Francisco Araujo (IBAMA) and the Catimbau association of field guides for logistic support, and the members of working group "PLEBEIA – Bee and Pollination Ecology" for help in the field and discussion. The study was financially supported by the Brazilian Research Council (CNPq), the "O Boticario" foundation and the "Research Program of Biodiversity in semi-arid Brazil" (PPBio) and by grants of CAPES and CNPq.

### Évaluation de l'oligolectie chez l'abeille brésilienne *Ptilothrix plumata* (Hymenoptera, Apidae, Emphorini).

*Ptilothrix plumata* / oligolectie / comportement alimentaire / régime alimentaire / larve / analyse pollinique / Malvaceae

**Zusammenfassung – Untersuchung zur Oligolectie der brasilianischen Biene *Ptilothrix plumata* (Hymenoptera, Apidae, Emphorini).** *Ptilothrix plumata* (Apidae, Emphorini) ist eine für Malvaceen oligolectische solitäre Biene, die im Boden in dichten Nestaggregationen nistet (Abb. 1a, b). In dieser Studie beschreiben wir das Nistverhalten von *P. plumata* und untersuchten ihre Beziehung zu Malvaceen-Blüten im Nationalpark von Catimbau im semiariden Nordosten Brasiliens, wo mehrere Arten dieser Familie vorkommen. Im allgemeinen enthielt jedes Nest eine einzelne Brutzelle, die 3 cm unter der Bodenoberfläche angelegt war. Die Weibchen sammelten Wasser, um den Boden aufzuweichen und das Nest zu bauen. Sie führten bis zu 24 Pollensammelflüge durch, um eine Brutzelle zu verproviantieren. (Abb. 1c–e). Im Proviant der Larven fanden wir Pollen von insgesamt sieben Malvaceen-Arten, wobei durchschnittlich 61% von 3 *Pavonia*-Arten stammten, während der Rest zwei *Sida*- und einer *Herissantia*-Art, sowie einer nichtidentifizierten Malvaceen-Art zugeordnet werden konnte (Abb. 1f). Der Pollenanteil von Nicht-Malvaceen belief sich auf weniger als 6% (Tab. II). Quantitative Pollenanalysen zeigten, dass die Weibchen durchschnittlich an 17,2 Blüten von *Pavonia cancellata*, an 8,5 Blüten von *P. varians*, an 4,8 Blüten von *P. humifusa* und an 12,4 Blüten von *Sida galheirensis* Pollen sammelten, um eine Larve zu versorgen (Tab. I und III). Die von den 13 Weibchen am Untersuchungsort angelegten Pollenvorräte zeigten jedoch eine erhebliche Variation in den relativen Anteilen der Pollenkörner der mellitophilen Malvaceen-Arten (Tab. II). Dies könnte auf individuelle Unterschiede innerhalb der Weibchen

dieser lokalen Bienenpopulation zurückzuführen sein. Eine generelle Präferenz für *Pavonia*-Pollen scheint jedoch für die Art charakteristisch zu sein und ist umso deutlicher, wenn das Volumen der sehr grossen *Pavonia*-Pollenkörner in dem Pollenball in Betracht gezogen wird: mehr als 90% des gesamten Pollenvolumens im Larvenfutter war von *Pavonia*-Arten und weniger als 1% des Pollenvolumens war von Nicht-Malvaceen (Abb. 4). Wir diskutieren die offensichtlich enge Oligolectie von *Ptilothrix plumata* für *Pavonia*-Blüten. Der Vergleich der Sammelpräferenzen einer Population an einem Standort mit nur einer *Pavonia*-Art zeigt, dass der Grad der Pollenspezialisierung auch von der Zusammensetzung der Pflanzenarten an einer gegebenen Lokalität abhängt, und dass eine lokal monolektische Beziehung auf fehlenden Auswahlmöglichkeiten beruhen kann.

*Ptilothrix plumata* / Pollenanalyse / Malvaceae / Oligolectie / Larvenfutter / Biene

### REFERENCES

- Butler G.D. (1967) Biological observations on *Ptilothrix sumichrasti* (Cresson) in southern Arizona, Pan-Pac. Entomol. 43, 8–14.
- Cane J.H., Sipes S. (2006) Characterizing floral specialization by bees: analytical methods and a revised lexicon for oligolecty, in: Waser N.M., Ollerton J. (Eds.), Plant-pollinator interactions: from specialization to generalization, The University of Chicago Press, Chicago, pp. 99–122.
- Dötterl S., Füssel U., Jürgens A., Aas G. (2005) 1,4-Dimethoxybenzene, a floral scent compound in willows that attracts an oligolectic bee, J. Chem. Ecol. 31, 2993–2998.
- Erdtman G. (1952) Pollen morphology and plant taxonomy. Angiosperms, Chronica Botanica Co., Waltham, Mass, New York.
- Füssel U., Dötterl S., Jürgens A., Aas G. (2007) Inter and intraspecific variation in floral scent in the genus *Salix* and its implication for pollination, J. Chem. Ecol. 33, 749–765.
- Gimenes M. (1991) Some morphological adaptations in bees (Hymenoptera, Apoidea) for collecting pollen from *Ludwigia elegans* (Onagraceae), Rev. Bras. Entomol. 35, 413–422.
- Larsson M., Franzén M. (2007) Critical resource levels of pollen for the declining bee *Andrena hattorfiana* (Hymenoptera, Andrenidae), Biol. Conserv. 134, 405–414.
- Linsley E.G., MacSwain J.W., Smith R.F. (1956) Biological observations on *Ptilothrix sumichrasti* (Cresson) and some related groups of emporine bees, Bull. Southern Cal. Acad. Sci. 55, 83–101.

- Louveaux J., Maurizio A., Vorwohl G. (1978) Methods of melissopalynology, *Bee World* 59, 139–157.
- Martins R.P., Guimarães F.G., Dias C.M. (1996) Nesting biology of *Ptilothrix plumata* Smith, with a comparison to other species in the genus (Hymenoptera: Anthophoridae), *J. Kansas Entomol. Soc.* 69, 9–16.
- Martins C.F., Zanella F.C.V., Schlindwein C., Camarotti M.F., Melo R.R. (in press) Diagnóstico dos polinizadores do algodoeiro, in: Oliveira P.E., Gaglianone M.C., Gribel R. (Eds.), *Uso sustentável e restauração da diversidade de polinizadores autóctones na agricultura e nos ecossistemas relacionados*, Ministério do Meio Ambiente/GEF, MMA, Brazil.
- Michener C.D. (2007) *The bees of the world*, second edition, The John Hopkins University Press, Baltimore.
- Minckley R.L., Roulston T.H. (2006) Incidental mutualisms and pollen specialization among bees, in: Waser N.M., Ollerton J. (Eds.), *Plant-pollinator interactions: from specialization to generalization*. The University of Chicago Press, Chicago, pp. 69–98.
- Müller A., Diener S., Schnyder S., Stutz K., Sedivy C., Dorn S. (2006) Quantitative pollen requirements of solitary bees: implications for bee conservation and the evolution of bee-flower relationships, *Biol. Conserv.* 130, 604–615.
- Neff J.L., Simpson B.B. (1992) Partial bivoltinism in a ground-nesting bee: the biology of *Diadasia rinconis* in Texas (Hymenoptera, Anthophoridae) *J. Kansas Entomol. Soc.* 65, 377–392.
- Neff J.L., Simpson B.B., Dorr L.J. (1982) The nesting biology of *Diadasia afflicta* Cress. (Hymenoptera: Anthophoridae), *J. Kansas Entomol. Soc.* 55, 499–518.
- PARNA (2002) Projeto técnico para a criação do Parque Nacional do Catimbau/PE. Sociedade Nordestina de Ecologia. Contrato n° 086-00/02, Proposta para criação do Parque Nacional do Catimbau/PE.
- Robertson C. (1925) Heterotropic bees, *Ecology* 6, 412–436.
- Roubik D.W., Moreno J.E. (1991) Pollen and Spores of Barro Colorado Island, Missouri Botanical Garden, 268 p.
- Rust R.W. (1980) The biology of *Ptilothrix bombyformis* (Hymenoptera: Anthophoridae), *J. Kansas Entomol. Soc.* 53, 427–436.
- Schlindwein C. (1998) Frequent oligolecty characterizing a diverse bee-plant community in a xerophytic bushland of subtropical Brazil, *Stud. Neotrop. Fauna E.* 33, 46–59.
- Schlindwein C. (2000) Verhaltensanpassungen oligolektischer Bienen an synchrone und an kontinuierliche Pollenpräsentation, in: Breckle S.W., Schweizer B., Arndt U. (Eds.), *Results of worldwide ecological studies*, Verlag Günter Heimbach, Stuttgart, pp. 235–250.
- Schlindwein C. (2004) Are oligolectic bees always the most effective pollinators?, in: Freitas B.M., Pereira J.O.P. (Eds.), *Solitary bees. Conservation, rearing and management for pollination*, Imprensa Universitária, Fortaleza, pp. 231–240.
- Schlindwein C., Wittmann D. (1997) Stamen movements in flowers of *Opuntia* (Cactaceae) favour oligolectic bee pollinators, *Plant Syst. Evol.* 204, 179–193.
- Schlindwein C., Martins C.F. (2000) Competition between the oligolectic bee *Ptilothrix plumata* (Anthophoridae) and the flower closing beetle *Pristimerus calcaratus* (Curculionidae) for floral resources of *Pavonia cancellata* (Malvaceae), *Plant Syst. Evol.* 224, 183–194.
- Schlindwein C., Martins C.F. (2004) Nest construction and brood cell provisioning in the ground nesting bee *Ptilothrix plumata* (Apidae, Emphorini), *Proceeding of the 8th IBRA International Conference on Tropical Bees and VI Encontro sobre abelhas*, USP, Ribeirão Preto, pp. 86–92.
- Schlindwein C., Wittmann D., Martins C.F., Hamm A., Siqueira J.A., Schiffler D., Machado I.C. (2005) Pollination of *Campanula rapunculus* L. (Campanulaceae): How much pollen flows into pollination and into reproduction of oligolectic pollinators? *Plant. Syst. Evol.* 250, 147–156.
- Silveira F.A., Melo G.A.R., Almeida E.A.B. (2002) *Abelhas brasileiras: sistemática e identificação*, Ed. IDMAR, Belo Horizonte.
- Sipes S.D., Tepedino V.J. (2005) Pollen-host specificity and evolutionary patterns of host switching in a clade of specialist bees (Apoidea: *Diadasia*), *Biol. J. Linn. Soc.* 86, 487–505.