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Original article

Pollen residues in nests of *Centris tarsata* Smith (Hymenoptera, Apidae, Centridini) in a tropical semiarid area in NE Brazil*

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Abstract – Pollen sources used by *Centris tarsata* bees were identified in an area of "caatinga" vegetation (Canudos Biological Station) in NE Bahia, NE Brazil, by analyzing the pollen residues encountered in the nests. The analysis of the pollen residues was performed by pulverizing the sediments used to construct the cells, followed by the application of the acetolysis method. Thirty-one pollen types were identified belonging to 13 botanical families (in associations of from 4 to 15 distinct pollen types per nest), indicating which plants were used by the bees to feed their offspring. The plant families most represented were Leguminosae and Malpighiaceae, while the pollen types most frequently found were *Chamaecrista ramosa* (46.5%), *Senna rizzinii* (19.7%), and *Solanum paniculatum* (19.6%). The identification of the pollen types and information about the resources offered by the plants indicated that many species were visited as nectar sources rather than as pollen or oil sources by *C. tarsata.*

entomopalynology / pollen / solitary bees / *Centris* / caatinga

1. INTRODUCTION

With the implementation of the Brazilian Pollinators Initiative Program, there has been a growing interest in species of *Centris* bees as potential native pollinators of cultivated plants (e.g. Oliveira and Schlindwein, 2009). *Centris tarsata* Smith seems to be fit for the role as pollinator in agricultural areas because it readily accepts nesting in artificial cavities and their nests are easily obtained and manipulated (Aguiar and Garófalo, 2004). Several studies have pointed out the role of *C. tarsata* as pollinator of several plant families, including commercial fruits such as acerola (*Malpighia glabra* L.) (Freitas et al., 1999) and cashew (*Anacadium occidentale* L.) (Freitas et al., 2002).

The nesting biology of *C. tarsata* is well known (e.g. Aguiar and Garófalo, 2004; Mendes and Rêgo, 2007), although little information on the floral resources needed to maintain its populations is available. Most of our present knowledge concerning the floral resources used by *Centris* species is derived from standardized studies of bee communities whose methodology consists mainly of collecting specimens during floral visits. In spite of the fact that numerous similar studies have been undertaken in Brazil, most of the information on the plants visited by *C. tarsata* has not been published. Some data on plants visited by the species are available for different Brazilian vegetations, such as the "Cerrado"

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(e.g. Gaglianone, 2003) and the "Caatinga" (e.g. Aguiar et al., 2003).

Although capturing bees on target flowers furnishes valuable data on bee use of floral resources, it is not always possible to infer which plants are the most important as sources of pollen. On the other hand, analyses of the provisions stocked in nests will provide a wider spectrum of qualitative data and allow for a better quantitative evaluation of the importance of the different pollen sources used. There have been relatively few studies analyzing the provisions stocked in nests of *Centris* species in Brazil (Rêgo et al., 2006; Mendes and Rêgo, 2007; Ramos et al., 2007; Dórea et al., 2009). The recent standard method for pollen analysis from sediments used to construct cells (Dórea et al., 2009) allowed for the study of pollen stored in *Centris* nests based on the pollen residues left after emergence of the adults.

Studies on bee abundance and on the diversity of melittophilous flora in protected areas (such as the law-protected preservation units) are particularly relevant because they allow for comparison between preserved and degraded areas, in addition to long-term comparisons in restricted areas. Such protected areas can become control areas for the urgently needed, long-term monitoring studies to be conducted primarily in biomes strongly affected by human-caused actions. Such is the case of the Brazilian seasonal dry forests ("caatinga"), where some bee species populations are declining (Martins, 2002; Lima-Verde and Freitas, 2002; Freitas et al., 2009).

The impact of the Africanized bee *Apis mellifera* on native bee fauna has been studied by combining the techniques to sample bees in trap-nests with the analysis of the pollen stocked in bee nests (see Villanueva-Gutiérrez and Roubik, 2004). These techniques are likely to help in the assessment of conservation of the flora supporting bee populations because they allow for the identification of changes in native flora composition and their effects on pollinator population, which is done by identifying: (1) changes in abundance of some bee species in time; (2) changes in importance of different plant species as food for selected bee species.

The focus of the present work was the identification of the pollen, oil and nectar sources used by *C. tarsata* in a law-protected preservation area of "caatinga" vegetation in the semi-arid region of Bahia State, Brazil. The study consisted of the analysis of the pollen residues found in the sandy substrate used to construct nest cells and the quantification of the pollen grains, to assess the importance of different plant species.

2. MATERIALS AND METHODS

The present work was undertaken in the Canudos Biological Station (CBS) (09°56′40.9″S × 39°00′55.7″W), situated in the municipality of Canudos, Bahia State, Brazil, during the period between January, 2004, and December, 2006. The CBS is located in the Raso da Catarina eco-region, and is dominated by shrubby hyperxerophilous "caatinga" vegetation. The regional climate is semi-arid tropical, with an average annual temperature of 24.15 °C and an average annual rainfall rate of 454 mm (SEI, 1998).

Our study of the pollen sources used by *C. tarsata* was performed by analyzing pollen residues found in cells after adult emergence. A total of 224 trap-nests were available to nesting-cavity bees. The trap-nests were 0.8 × 10.5 cm tubes made from black cardboard, that were inserted into wooden boards with holes drilled through them (4 boards, with 56 drilled holes each); bamboo internodes (1.5 × 17 cm) were also employed as trap-nests, as described by Aguiar and Garófalo (2004).

The trap-nests used by the bees were removed monthly and the nests were taken to the Plant Micromorphology Laboratory (LAMIV/UEFS) for analysis. The adult bees that emerged from each nest were pinned and subsequently deposited in the Entomology Collection Johann Becker of the Zoology Museum of the Universidade Estadual de Feira de Santana (MZUEFS) to identification. After the emergence of the adults, the nests were treated chemically to remove any pollen residues according to the methodology described by Dórea et al. (2009).

After acid treatment of the nests, seven slides were prepared for each sample, and glycerine jelly stained with safranin was applied to five of them. The slides were covered with cover slips and sealed with paraffin. Qualitative analyses involved the identification of the pollen types, and the quantitative analyses were based on 1000 pollen grains, at least, counted per sample following Vergeron (1964).

Data from the quantitative analyses was used to calculate the frequencies of occurrence of the pollen types in each nest studied, and the average frequency of each pollen type among the samples (see Villanueva-Gutiérrez and Roubik, 2004). The identification of the pollen types was subsidized by pollen previously collected from the CBS and stored in the palynotheca at LAMIV/UEFS.

3. RESULTS

Nesting activity of *C. tarsata* was restricted to the months of March (2005), July and August (2004), September and December (2006) (Tab. I). Thirteen nests were analyzed. We were able to identify 100% of all of the pollen grains recovered from residues left in the nests of *C. tarsata* – representing 31 pollen types (Fig. 1) derived from 13 plant families. Leguminosae was the best represented plant family, with 14 pollen types (Tab. I).

The representation of the pollen types among sampled nests were variable, the main pollen types represented in them were *Byrsonima vacciniifolia* (12 nests), *Chamaecrista ramosa* (10), *Krameria tomentosa* (7), *Solanum paniculatum* (7), *Banisteriopsis muricata* (6), *Caesalpinia microphylla* (6), *Rhaphiodon echinus* (6), *Senna rizzinii* (6), and *Capparis yco* (5). No pollen type was present in all 13 nests, however *B. vacciniifolia* was present in 12 of the 13 nests analyzed, and in all months of nesting activity of *C. tarsata* in CBS. The number of pollen types per nest varied from four (in samples II, V, and VI) to 15 (sample IX) (Tab. I).

Considering the total sampling period, the pollen types *Chamaecrista ramosa*, *Senna rizzinii*, *Solanum paniculatum* and *B. vacciniifolia* stood out due to their high average frequency in the 13 nests of *C. tarsata* (46.5%, 19.3%, 19.6% and 8.7%, respectively) (Tab. I). Eleven pollen types were present with low average frequencies (<0.01%), and sixteen pollen types had average frequency between 0.01% and 10%, including *Byrsonima vacciniifolia* (8.7%). Almost 50% of the pollen types (n = 14) were observed in just a single sample. Among them, *Aeschynomene brevipes* present a high average frequency (10.7%) in sample IX.

We observed a substitution of the most important pollen resources used by *C. tarsata* during the course of the study period. *Chamaecrista ramosa* type was frequently found in nests (9 of the 13 examined), and had high representation in the six nests in July and August/2004 (87% to 97%). In March/2005, however, the representation of this pollen type fell down to 36%, although it continued to be important in stocking *C. tarsata* nests, appearing as the second most representative pollen type. In the September/2006, no grains of this pollen type were observed, and in December/2006 it was only marginally represented in the two nests (1.0% and 3.7%). *Solanum paniculatum* pollen type was identified in samples from March/2005, September/2006, and December/2006, with frequency per nest that varied from 0.3% to 71.4%. *Senna rizzinii* pollen type was important for *C. tarsata* during the months of September and December/2006, with frequency per nest that varied between 9.1% and 90.8% (Tab. I).

In Dec./2006, three different pollen types were the most important to the nests sampled: *S. paniculatum* (0.3% to 71.4%), *S. rizzinii* (9.1% to 90.8%), and *B. vacciniifolia* (1.7% to 69.6%). On the other hand, in July/2004 females of *C. tarsata* hardly foraged on *C. ramosa*, the pollen type most representative in all of the five nests examined (87% to 97%).

4. DISCUSSION

According to the pollen types surveyed and the CBS flora (Silva, 2007), plants used by *C. tarsata* belong to taxa whose floral available resources are pollen, nectar and oil (Tab. II). This information, combined with each pollen type frequency (Tab. I) was used to distinguish pollen plants from the nectar or oil sources. The high frequency observed in some pollen types in the samples indicates that these plants are important pollen sources used by *C. tarsata*.

Table I. Frequency of occurrence (FO, %) of the different types of pollen encountered in nests of *C. tarsata* in the EBC, Canudos, Bahia State, Brazil. Averages FO < 0.05 are represented by -.

Samples	Average FO	JUL (2004)					AUG (2004)	MAR (2005)	SEPT (2006)	DEC (2006)				
pollen types		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
AMARANTHACEAE														
Alternanthera ramosissima	-										0.1			
ASTERACEAE														
Conocliniopsis prasiifolia	-												0.2	
BIGNONIACEAE														
Anemopaegma laeve	-				0.1									
Tabebuia heptaphylla	-									0.1				
CAPPARACEAE														
Capparis yco	0.2							0.4	0.1	0.1	1.6		0.1	
KRAMERIACEAE														
Krameria tomentosa	0.5		0.1	0.7				0.4		3.1		1.0	0.4	0.3
LAMIACEAE														
Rhaphiodon echinus	1.4	2.6	3.0	1.8	3.8	2.2	4.7							
LEG.-CAESALPINIOIDEAE														
Apuleia leiocarpa	-									0.1				
Caesalpinia microphylla	0.6								1.2	0.1	0.5	0.6	5.1	0.7
Caesalpinia pyramidalis	-							0.4						
Chamaecrista ramosa	46.5	96.6	96.4	97.2	93.0	87.0	92.4	36.6		1.0				3.7
Chamaecrista swainsonii	-										0.1			
Senna rizzinii	19.3								29.6	9.1	66.1	40.4	90.8	14.4
LEG.-MIMOSOIDEAE														
Anadenanthera colubrina	-										0.1			0.3
Mimosa filipes	-	0.1		0.1										0.2
Mimosa misera	0.1										1.2			0.4
LEG.-PAPILIONOIDEAE														
Aeschynomene brevipes	0.8									10.7				

Table I. Continued.

Samples	Average FO			JUL (2004)			AUG (2004)	MAR (2005)	SEPT (2006)			DEC (2006)		
pollen types		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Aeschynomene martii	-													0.1
Lonchocarpus araripensis	0.1								0.1	0.6				
Zornia brasiliensis	0.6							5.6	1.9	0.3				
Zornia echinocarpa	0.1								0.1	0.5		0.2		
MALPIGHIACEAE														
Banisteriopsis muricata	0.5	0.6		0.1	1.9	1.6	2.3	0.9						
Banisteriopsis pubipetala	0.2										2.6			
Barnebya harleyi	0.1									1.1	0.3	0.1		
Byrsonima vacciniifolia	8.7		0.5	0.1	1.1	9.1	0.6	2.8	13.7	1.7	7.7	2.9	3.1	69.6
MALVACEAE														
Herissantia tiubae	-										0.1			
MYRTACEAE														
Campomanesia sp.	-									0.1				
OXALIDACEAE														
Oxalis psoraleoides	-										0.2			
RUBIACEAE														
Spermacoce sp.	-	0.1												
SOLANACEAE														
Solanum megalonyx	0.7							8.6					0.1	
Solanum paniculatum	19.6							44.4	53.4	71.4	19.7	54.7	0.3	10.4

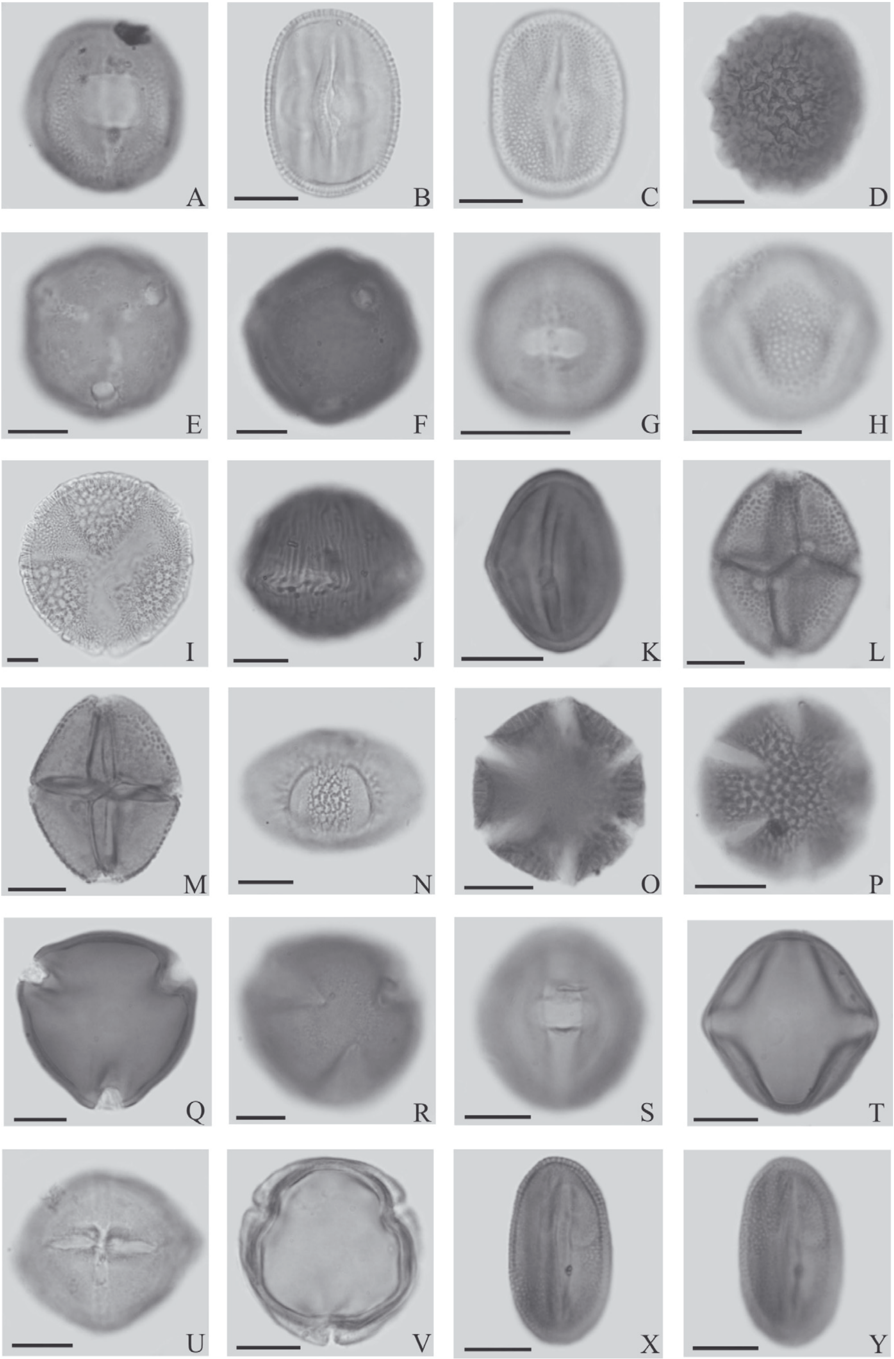

Figure 1. Pollen types present in nests of solitary bee *Centris tarsata*. A. *Aeschynomene brevipes*. B–C. *Aeschynomene martii*. D. *Anemopaegma laeve*. E. *Banisteriopsis muricata*. F. *Barnebya harleyi*. G–H. *Byrsonima vacciniifolia*. I. *Caesalpinia microphylla*. J. *Krameria tomentosa*. K. *Lonchocarpus araripensis*. L–M. *Mimosa filipes*. N–P. *Raphiodon echinus*. Q–T. *Senna rizzinii*. U–V. *Solanum paniculatum*. X–Y. *Zornia echinocarpa* (bar = 10 μm).

Table II. Plant groups and their floral rewards according to their respective authors.

Plants	Resource offered	References
Alternanthera	Nectar	Freitas and Silva, 2006; Santos et al., 2006
Conocliniopsis	Nectar	King and Robinson, 1987
Anemopaegma	Nectar	Correia et al., 2006
Tabebuia	Nectar	Aguiar et al., 2003; Machado and Lopes, 2006
Capparis	Nectar	Dafni et al., 1987
Krameria	Oil	Machado and Lopes, 2006
Rhaphiodon	Nectar	Santos et al., 2006
Caesalpinia	Pollen/ Nectar	Aguiar et al., 2003; Freitas and Silva, 2006
Chamaecrista	Pollen	Aguiar et al., 2003
Senna	Pollen	Aguiar et al., 2003; Machado and Lopes, 2006
Anadenanthera	Pollen/Nectar	Freitas and Silva, 2006
Mimosa	Pollen/Nectar	Aguiar et al., 2003; Freitas and Silva, 2006
Aeschynomene	Nectar	Santos et al., 2006
Lonchocarpus	Nectar	Aguiar et al., 2003; Machado and Lopes, 2006
Zornia	Nectar	Aguiar et al., 2003
Banisteriopsis	Oils	Gaglianone, 2003; Machado and Lopes, 2006
Barnebya	Oils	Buchmann, 1987
Byrsonima	Oil/Pollen	Machado and Lopes, 2006
Herissantia	Pollen	Machado and Lopes, 2006
Campomanesia	Pollen	Gressler et al., 2006
Oxalis	Nectar	Aguiar et al., 2003
Spermacoce	Nectar	Santos et al., 2006
Solanum	Pollen	Aguiar et al., 2003; Machado and Lopes, 2006

Pollen types *Chamaecrista ramosa*, *Solanum paniculatum*, *Senna rizzinii*, and *Byrsonima vacciniifolia* had the greatest average frequencies of occurrence considering all nests (Tab. I), and seem to represent the most important pollen sources for *C. tarsata* in the "caatinga" region.

Nine legume species from the local flora of CBS had representation in the pollen spectrum surveyed in pollen residues of *C. tarsata* nests: *Anadenanthera colubrina* (Vell.) Brenan, *Caesalpinia microphylla* Mart. ex. G. Don, *C. pyramidalis* Tul., *Chamaecrista ramosa* (Vogel) H.S. Irwin & Barneby, *C. swainsonii* (Benth.) H.S. Irwin & Barneby, *S. rizzinii* H.S. Irwin & Barneby, *Lonchocarpus araripensis* Benth., *Mimosa filipes* Mart., and *M. misera* Benth. Probably these plants represent the main sources of pollen for *C. tarsata* in "caatinga" environment, mainly *C. ramosa* and *S. rizzinii*, which pollen grains were the most heavily represented in samples. Other legume species (*Aeschynomene brevipes* Benth., *A. martii* Benth., *Zornia braziliensis* Vogel, and *Z. echinocarpa* Benth.) may be important nectar sources due to the frequencies of their pollen types in the samples and also according to available information on nectar resources offered by these plants (Tab. II).

Aguiar et al. (2003) noted that *Chamaecrista* spp. and *Senna* spp. (in addition to the species of genus *Solanum*) are important sources of pollen for *Centris* bees in several areas of the "caatinga". These data are corroborated by Machado and Lopes (2005), who likewise indicated species of *Chamaecrista*, *Senna*, and *Solanum* as main sources of pollen in "caatinga" vegetation. Another interesting aspect of CBS sampling was that the pollen types related to these genera appear to be often associated in the same nest. This suggests a possible complementarity of pollen types along with the nesting season of *C. tarsata*. These pollen types are produced by plants with poricidal anthers whose pollen grains are liberated through buzz-pollination. According to Buchmann (1983), pollen is the floral reward of plants with poricidal anthers, which are pollinated by bees that vibrate their bodies during floral visits, as *Centris* bees do. As such, the significant presence of these pollen grains in nests of *C. tarsata* can reflect the ability of these bees to gather pollen through vibration.

The nectar sources used by *C. tarsata* can not be clearly established by examining the pollen grains stored in nests because some pollen may represent "contamination" during the search for floral rewards. It is possible, however, to indicate plants used as sources of nectar by cross-checking pollen frequency data with types of floral rewards of each plant species found in the study area. *Aeschynomene brevipes*, *A. martii*, *Z. brasiliensis*, and *Z. echinocarpa* appear to be probable nectar sources due to the low frequencies of their respective pollen per nest, and according to available information concerning nectar resources of these plants (Tab. II). *C. microphylla*, *Rhaphiodon echinus* Schauer and *Capparis yco* Mart. are also most likely nectar sources.

Three species of Malpighiaceae and one Krameriaceae were identified as oil sources to *C. tarsata* in the CBS, based on available information about floral resources (Tab. II). Pollen from three species was only poorly represented in the nests, suggesting that oil is the principal resource used by *C. tarsata*, but *Byrsonima vacciniifolia* pollen type had a higher frequency in some samples, indicating the species importance for oil and pollen. The families Krameriaceae, Malpighiaceae, and Scrophulariaceae are known producers of oils and their species supply resources for a guild of specialized oil-collecting bee species, such as *Centris* spp. in the "caatinga" ecosystems (Machado et al., 2002). According to Buchmann (1983), *Krameria* species have poricidal anthers but pollen is liberated in a sticky mass, making the liberation of large quantities of grains much more difficult. The author observed that species of this genus are visited in order to collect oils instead of pollen and included them within the group of plants that have poricidal anthers but are not buzz-pollinated. This may help to explain the low frequency of occurrence (< 1.5%) of pollen grains of *Krameria tomentosa* in the CBS samples.

The majority of the pollen types were found at least in three nests and did not represent even 1% of the overall pollen quantified per nest. According to other authors (Tab. II), a majority of these pollen grains come from plants that are probably nectariferous.

The identification of the pollen found in *C. tarsata* nests in the "caatinga" region of Canudos, in addition to the available information concerning the floral resources of local plants, indicated that these bees visited more plant species to gather nectar than to gather pollen or oils. This conclusion supports Aguiar et al. (2003), who studied floral resources used by species of *Centris* in the "caatinga" region and observed the predominant tendency for these bees to collect pollen or oil from a relatively small number of plants in each locality, while they are more generalist in using sources of nectar.

The blending of methodologies to collect bees on individual flowers and to analyze the pollen present in nests of *C. tarsata* will enlarge our understanding of their use of floral resources and provide useful data to help the development of adequate strategies for *Centris* species management and conservation. Our study shows that *C. tarsata* uses several different sources of floral resources in preserved environments with diversified flora. The findings should guide comparisons among usages of the melittophilous flora by this bee species in areas with different levels of preservation. Solitary bee conservation is still scarcely emphasized (see Vinson et al., 1993) in spite of the recent growing interest in native bee conservation. Recently, some authors have identified several threats to these pollinator populations (see Batley and Hogendoorn, 2009; Freitas et al., 2009). Few monitoring studies to identify the decline of bee populations have included species of *Centris* (e.g. Frankie et al., 1997, 1998, 2005). In the Brazilian seasonal dry forests ("caatinga"), bee populations are highly affected by human-caused actions, particularly are wood gathering, deforestation, and the intensification of agriculture (Martins, 2002; Lima-Verde and Freitas, 2002; Freitas et al., 2009). *Centris* bee populations demand special requirements as far as sources of floral oils and cavities for nesting for instance, and are highly susceptible to floral depletion. Our study suggests that legume plant species such as *Senna rizzini*, a frequently found and widely distributed species, are promising for monitoring the abundance of *Centris* bees in target plants.

The effects of invasive alien bees (such as the Africanized *Apis mellifera*) on native bees, particularly the negative interactions of *A. mellifera* with solitary bees have seldom been studied (Freitas et al., 2009; Stout and Morales, 2009; Murray et al., 2009). Stout and Morales (2009) suggest that priority should be given to examine the impacts of invasive alien bees on solitary native bees, particularly rare and specialist bee species because most of such interactions are still unknown. Analyses of the pollen stocked in bee nests have been used to assess Africanized *Apis mellifera* (AHB) impact on native bee fauna when data on the use of floral resources by native bees could be collected before the establishment of AHB (Villanueva-Gutiérrez and Roubik, 2004). In Brazil, the introduction and establishment of AHB preceded studies on the use of floral resources by native bees. Efforts to analyse AHB use of floral resources at the Canudos Biological Station have been done recently by our research team (Novais et al., 2009), which shall allow for comparison of the overlapping levels of AHB trophic niches with native bee species such as *Centris tarsata*.

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Résidus de pollen dans les nids de *Centris tarsata* Smith (Hymenoptera, Apidae, Centridini) dans une région tropicale semi-aride du nord-est du Brésil.

entomopalynologie / pollen / abeilles solitaires / *Centris* / caatinga

Zusammenfassung – Pollenreste in Nestern von *Centris tarsata* Smith (Hymenoptera, Apidae, Centridini) in einer tropischen Halbtrockenregion im Nordosten Brasiliens. Bienen der Gattung *Centris* sind potentielle Bestäuber von Kulturpflanzen in Brasilien und verschiedene Untersuchungen weisen bereits auf die Bedeutung dieser Bienen als Bestäuber verschiedener Pflanzenfamilien, einschließlich kommerzieller Früchte hin. Wenig ist allerdings darüber bekannt, welche floralen Ressourcen für den Erhalt der Populationen notwendig sind. Anhand der Analyse von Pollenresten im sandigen Substrat der Nistzellen dieser solitären Bienen untersuchten wir die von *C. tarsata* genutzten Pollen-, Öl- und Nektarquellen in einer Region mit nativer Vegetation in einer Halbtrockenregion im Nordosten Brasiliens, der Caatinga. Pollenkörner wurden quantifiziert, um die Bedeutung der verschiedenen Pflanzenarten für die Bienen abschätzen zu können. Hierzu wurden monatlich Nistfallen eingesammelt, so dass aus den Nestern (n = 13) nach dem Schlupf der Imagines die Pollenreste chemisch herausgelöst werden konnten. Pro Probe wurden sieben Mikrospopiepräparate erstellt. Die quantitative Analyse basierte auf jeweils 1000 Pollenkörnern. Wir identifizierten 31 verschiedene Pollentypen, wobei die von *Chamaecrista ramosa*, *Senna rizzinii*, *Solanum paniculatum* und *Byrsonima vacciniifolia* die größten Häufigkeiten aufwiesen (Tab. I) und damit vermutlich die wichtigsten Pollenquellen für *C. tarsata* in dieser Region darstellen. In geringen mittleren Häufigkeiten (<0,01 %) waren 11 Pollentypen vertreten, und 16 Pollentypen wiesen Häufigkeiten von 0,01 % bis 10 % auf, darunter *Byrsonima vacciniifolia.* Neun Arten der lokalen Flora im Pollenspektrum des Materials aus *C. tarsata* Nestern stellen vermutlich die Hauptpollenquellen dieser Bienen in der Caatinga dar. Die Mehrzahl der Pollentypen stellte weniger als 1 % des aus den Nestern gewonnen Pollenmaterials dar (Tab. II). Drei Malpighiaceen-Arten und eine Krameriacee konnten wir als Ölquellen von *C. tarsata* identifizieren. Wir konnten zeigen, dass Pollenanalysen in Nestmaterial interessante Ergebnisse liefern können. Eine Verbindung dieser Methode mit einer Sammelstrategie von Bienen an einzelnen Pflanzenarten sollte es dementsprechend ermöglichen, dass wir unser Wissen über die Nutzung floraler Ressourcen erweitern und daraus angemessene Strategien zum Erhalt und Nutzung von *Centris*-Arten als Bestäuber entwickeln können.

Entomopalynologie / Pollen / solitäre Bienen / *Centris* / Caatinga

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