Plants used by *Megachile* (*Moureapis*) sp. (Hymenoptera: Megachilidae) in the provisioning of their nests

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(With 3 figures)

Abstract

This study was carried out in the Parque Municipal das Araucárias, located in the municipality of Guarapuava (PR) from May (06) to April (07). Its aim was to investigate which plants are used by *Megachile (Moureapis)* sp in provisioning of larvae, and to verify if this bee is oligolectic or polilectic. The collection of the plants was carried out during the bees activity period and in an area covering a 500 m radius from where the nests had been built. A sample of pollens from founded nests and from flowers was used to make permanent slides using the acetolysis method and with the aid of a light microscope, all pollen grains were examined in order to identify the plants used by this bee. A total of 80 pollen grain slides, from 16 nests were analysed. Although 99 plants were collected close to the bee's nesting site, in nest slides, the pollen of *Ludwigia peruviana* (36%) and *Ludwigia sericea* (63.6%) (Onagraceae) accounted for 99.6% of the total amount of pollen collected. With these results we are able to conclude that *Megachile (Moureapis)* sp is an oligolectic species and that these plants species are their important pollen source.

Keywords: *Ludwigia peruviana*, *Ludwigia sericea, Megachile* (*Moureapis*) sp., provisioning.

Plantas usadas por *Megachile* (*Moureapis*) sp (Hymenoptera: Megachilidae) no aprovisionamento de seus ninhos

Resumo

Esse estudo foi realizado no Parque Municipal das Araucárias, Guarapuava, PR, no período de maio (06) a abril (07). Seu objetivo foi investigar as plantas utilizadas por *Megachile (Moureapis)* sp. no aprovisionamento larval, e se essa é uma espécie oligolética ou polilética. No período de atividade destas abelhas foram realizadas coletas das plantas floridas num raio de 500 m dos locais onde elas estavam nidificando. Foram preparadas amostras do material polínico dos ninhos e das plantas pelo método de acetólise e com a ajuda de microscopia de luz, identificados os tipos de pólen. Foi analisado o pólen de 16 ninhos, totalizando 80 lâminas. Embora 99 plantas tenham sido coletadas próximo aos locais de nidificação desta abelha, nas lâminas provenientes dos ninhos os pólens de *Ludwigia peruviana* (36%) e *Ludwigia sericea* (63,6%) (Onagraceae) corresponderaram a 99,6% dos daqueles coletados. Através desses resultados nos concluímos que *Megachile (Moureapis)* sp. é uma espécie oligolética e que essas plantas são suas importantes fontes de pólen.

Palavras-chave: aprovisionamento, *Ludwigia peruviana*, *Ludwigia sericea, Megachile (Moureapis)* sp.

1. Introduction

It is estimated that there are today, approximately four thousand amply distributed bee genera (Michener, 2000), with over twenty thousand described species (Alves-dos-Santos, 2002). Of these, more than 80% are solitary, 15% infest other species' nests and 5% exhibit some degree of sociality (Campos et al., 1987).

The factors that explain or alter the distribution of Apoidea are probably related to the local flora abundance and diversity (Silveira et al., 2002), as well as to the occurrence of appropriate nesting sites (Linsley, 1958). As opposed to that which has been observed for social bees, the diversity and abundance of solitary bees increases from the Equator towards the north and south poles. In South America, bee diversity is richer from the "cerrado" (Brazilian savannah) towards the southern native fields of Brazil (Michener, 1979).

Bees of the family Megachilidae are well represented in low altitude areas in southern Brazil and poorly abundant in the northeast (Viana and Alves-dos-Santos, 2002). The genus *Megachile* Latrulle, 1802 is very rich in number of species worldwide, with 524 of these recorded from the Americas (Raw, 2004). The subgenus *Moureapis* Raw, 2002 is most diverse in Argentina and southern Brazil, even though its distribution range reaches Mexico (Silveira et al., 2002).

Among pollinating agents, bees are the most important (Raven et al., 2001), since many flowering plants depend exclusively on them for crossed pollination to occur. In order to promote pollination, these plants have attractive features such as color, fragrances, nectar, oils and pollen which are the main resources used by bees (Raven et al., 2001; Morgado et al., 2002; Santana et al., 2002).

According to their feeding habits, bees are classified into polylectic, when they collect pollen from several species of plants, and oligolectic, when they exhibit floral fidelity, collecting pollen from few species of plants, usually belonging to a same genus or family. The oligolectic habit is usually associated to plants that occur in open areas (Schlindwein, 2000). This is due to the fact that many plants that occur in these areas have significantly large pollen grains, such as those of the genera *Ludwigia* L. 1753*, Pavonia* Cav. 1786, *Sida* L. 1753, *Opuntia* Mill. 1754 and *Ipomoea* L. 1753. This requires a specialised scopa with long and unbranched hairs, enabling an adequate handling of the pollen (Gimenes, 1991). Oligolectic relationships between plants and bees were demonstrated in Brazil for 19 families of plants of which Onagraceae was the one that presented the highest number of associated oligolectic bees (Schlindwein, 2004).

Generally, bees of the family Megachilidae are oligolectic (Villanueva-Gutiérrez and Roubik, 2004) playing an important role in the maintenance of plant species and being irreplaceable by generalist bees (Schlindwein, 2004). Within Megachilini, *Megachile apicipennis* Schrottky, 1902 shows an exclusive floral preference for plants of the genera *Senecio* L. 1753 and *Vernonia* Schreb. 1791 (Asteraceae), *Megachile brasiliensis* Dalla Torre, 1896 for *Ludwigia* (Onagraceae) and *Megachile nigropilosa* Schrottky, 1902 for Asteraceae such as *Elephantopus* L. 1753 and *Vernonia* (Schlindwein, 2004). Other Megachilidae bees that also show floral specificity are *Liturge huberi* Ducke, an *Ipomoea asarifolia* (Dres.) Roem. and Schult. 1819 (Convolvulaceae) pollinator (Kiill and Ranga, 2003), and *Pseudocentron* sp., a *Sophora tomentosa* L. 1753 (Fabaceae) pollinator (Nogueira and Vaz-de-Arruda, 2006).

The aim of this study was to investigate which plants are used by *Megachile (Moureapis)* sp. in provisioning of larvae, and to verify if this bee is oligolectic or polilectic.

2. Material and Methods

This study was carried out in the Parque Municipal das Araucárias, located in the municipality of Guarapuava, Paraná (25° 21' 06" S and 51° 28' 08" W). The park comprises an area of approximately 104 ha. The vegetation is composed of Mixed Ombrophilous Forest (42.75%), gallery forest (10.09%), fields (6.8%), swamps (7.13%) and altered areas (33.23%). According to Köoper's classification the climate is humid mesothermic with no dry season and mild summers due to the altitude. The winter is moderate with frequent occurrence of frost. Annual mean temperature stays around 16 to 17.5 °C. Average monthly rainfall is above 100 mm and annual 1,961 mm, being uniform throughout the year.

For this study, data of nests collected in previous years was used (Buschini, 2006). A sample of the founded nests was used to remove pollinic material and make permanent slides, using the acetolysis method (Miranda and Andrade, 1990). For each nest five pollen grain slides were made. According to the data collected between 2001 and 2003, *Megachile (Moureapis)* sp. founded their nests only in swamp and field habitats. Thus, the collection of the plants was carried out only in these areas between May/06 and April/07, covering a 500 m radius from where the nests had been built. Pollen was removed from flowers and/or buttons of each plant in order to mount two slides per plant. With the aid of a light microscope all pollen grain slides from both nests and plants were examined in order to identify the plants used by this bee. For pollen quantification, consecutive counting of 200 pollen grains per slide was carried out, totaling 1,000 pollen grain per nest.

3. Results

A total of 80 pollen grain slides, from 16 nests of *Megachile (Moureapis)* sp. were analysed, corresponding to 53% of the number of founded nests. Of these, 13 were collected in the swamp and 3 in the field. Although 99 flowering plants were collected close to the bee's nesting site (Table 1), in nest slides, the pollen of *Ludwigia peruviana* (L.) H. Hara, 1953 (36%) and *Ludwigia*

Table 1. Plants collected in an area covering a 500 m radius from where the *Megachile* (*Moureapis*) sp nests had been built.

Family	Species
ACANTHACEAE	
	Ruellia brevicaulis (Ness) Lindau
AMARANTHACEAE	
	Gomphrena elegans Mart.
	Pfaffia tuberosa (Sprengel) Hicken
ANACARDIACEAE	
	Schinus johnstonii F. A. Barkley
APIACEAE	
	Eryngium horridum Malme
APOCYNACEAE	
	Oxypetalum parnasum Decne.
ASTERACEAE	
	Achyrocline satureioides (Lam.) DC.

Table 1. Continued...

Family	Species
	Austrupatorim laetevirens (Hook. and Arn.) R.M King and H. Rob.
	Austroeupatorium picturatum (Malme). R. M. King and H. Rob.
	Baccharis anomala DC.
	Baccharis articulata (Lam.) Pers.
	Baccharis dracunculifolia DC.
	Baccharis helichrysoides DC.
	Baccharis microdonta DC.
	Baccharis sp.
	Baccharis uncinella DC.
	Calea cymosa Less.
	Calea hispida (DC) Baker.
	Campovassouria cruciata (Vell.) R. M. King and H. Rob.
	Campuloclinium macrocephalum (Less.) DC.
	Campuloclinium purpurascens (Sch. Bip. ex Baker) R. M. King and H. Rob
	Chromolaena congesta (Hook. and Arn.) R. M. King and H. Rob.
	Chromolaena laevigata (Lam.) R. M. King. and H. Rob.
	Chromolaena stachyophylla
	Chrysolaena platensis (Spreng.) H. Rob
	Chrysolaena propinqua (Hieron.) H. Rob.
	Erechtites valerianifolius (Link ex Spreng.) DC.
	Erigeron maximus (D. Don.) Otto ex DC.
	Eupatorium macrocephalum Less.
	Gochnatia polymorpha (Less.) Cabrera
	Grazielia serrata (Spreng.) R. M. King and H. Rob.
	Lessingianthus glabratus (Less.) H. Rob.
	Lessigianthus plantaginodes (Kuntze) H. Rob.
	Mikania micrantha Kunth
	Mikania pinnatiloba DC.
	Polymnia connata (Spreng.) S. F. Blake
	Senecio brasiliensis (Spreng.) Less.
	Solidago chilensis Meyen
	Stevia tenuis Hook. and Arn.
	Symphyotrichum squamatum (Spreng.) G. L. Nesom
	Trixis sp.
	Venonanthura tweedieana (Baker) H. Rob.
	Vernonanthura westiniana (Less.) H. Rob.
	Vittetia orbiculata (DC.) R. M. King and H. Rob.

Table 1. Continued...

Family	Species
BALSAMINACEAE	
	Impatiens sp.
BEGONIACEAE	
	Begonia fischeri Schrank
	Begonia cucullata Willd.
BORAGINACEAE	
	Moritzia dusenii I. M. Jonst.
CAMPANULACEAE	
	Lobelia camporum Pohl
	Siphocampylus verticillatus (Chamisso)} G. Don
CAPRIFOLIACEAE	
	Lonicera japonica Thunb.
COMMELINACEAE	
	Commelina erecta L.
CONVOLVULACEAE	
	Ipomoea grandifolia (Dammer) O' Donell.
	Ipomoea indivisa (Vell.) Hallier f.
	Ipomoea purpurea (L.) Roth.
	Ipomoea sp.
CURCUBITACEAE	
	Sycios polyacanthus
ESCALONIACEAE	
	Escallonia bifida Link and Otto
EUPHORBIACEAE	
	Croton heterodoxus Baill.
FABACEAE	
	Desmodium incanum DC.
	Eriosema crinitum (Kunth) G. Don.
	Mimosa flocculosa Burkart
	Mimosa lanata Benth.
	Senna multijuga (Rich.) H. S. Trwin and Barneby
	Sesbania punicea (Cav.) Benth.
	Trifolium riograndense Burkart
GESNERIACEAE	
	Sinningia allagophylla (Mart.) Wiehler
HYPERICACEAE	
	Hypericum connatum Lam.
	Hypericum brasiliense Choisy
LAMIACEAE	
	Leorunus sibiricus L.
	Hoehnea scutellarioides (Benth.)
	Hyptis lappulacea Mart. ex Benth.
LYTHRACEAE	
	Cuphea glutinosa Cham. and Schltdl.
	Cuphea sp.

Table 1. Continued...

Family	Species
	Heimia myrtifolia Cham. and Schltdl.
MALPIGHIACEAE	
	Janusia guaranitica (A. St.-Hil.) A. Juss.
MALVACEAE	
	Pavonia guerkeana R. E. Fr.
	Sida rhombifolia L.
	Sida sp.
MELASTOMATACEAE	
	Tibouchina cerastifolia Cong.
MYRTACEAE	
	Campomanesia adamantium (Cambess) O. Berg
	Eugenia speciosa Cambess.
ONAGRACEAE	
	Ludwigia peruviana (L.) H. Hara
	Ludwigia sericea (Cambess.) H. Hara
OROBANCHACEAE	
	Castilleja arvensis Schltdl. and Cham.
POLYGONACEAE	
	Polygonum acuminatum Kunth
	Polygonum punctatum Elliott
RUBIACEAE	
	Diodia brasiliensis Spreng.
	Galianthe dichasia (Sucre and Costa) E. L. Cabral
	Galianthe sp.
SOLANACEAE	
	Cestrum corymbosum Schldl.
	Solanum americanum Mill.
	Solanum sp.
	Solanum variabile Mart.
	Vassobia breviflora (Sendtn.) Hunz.
VERBENACEAE	
	Verbena hirta Spreng.
	Verbena rigida Spreng.
	Verbena sp.
STERCULIACEAE	
	Waltheria douradinha Saint-Hilaire

sericea (Cambess.) H. Hara, 1953 (63.6%) (Onagraceae) (Figure 1) accounted for 99.6 % of the total amount of pollen collected (Figure 2a and b and Figure 3). In these slides, the sporadic occurrence of pollen of *Tibouchina cerastifolia* Cogn, 1885 (Melastomataceae), *Solanum* L. 1753 (Solanaceae) (Figure 2d) and Asteraceae were also observed (Table 2).

Pollen morphology of *Ludwigia peruviana* and *Ludwigia sericea* is quite similar. Thus, to better distinguish the species, measurements were taken of 25 randomly picked pollen grains. Description followed Punt et al. (1999) and Miranda and Andrade (1990). The pollen of these plants are multiplanar grains with medium sized tetrahedral tetrads, triangular amb and oblate spheroidal shape. The mean values obtained for the pollen of *Ludwigia peruviana* were 46 µm for the diameter (DM = 2.7) and 2.6 µm for the width of the exine, the latter with rugulate ornamentation. For *Ludwigia sericea,* the mean values were 34 µm for the diameter (DM = 2.3) and 1.4 µm for the width of the exine, with only slightly rugulate ornamentation (Figure 1c and d). Thus, species were separated mainly by the size of their pollen grains and by the width and ornamentation of the exine.

Both species of *Ludwigia* are herb-subshrub and occurred only in swamp areas. *Ludwigia sericea* flowered most intensively during the month of February while *Ludwigia peruviana* flowered most intensively in March, although their flowering periods occur during other months as well.

4. Discussion

Our results show that the two species of *Ludwigia* are basically the only source of pollen used by this bee in the provisioning of the nests. The fact that the pollen of *Ludwigia sericea* appeared on the slides in considerably higher quantities does not mean that there is a preference for *Ludwigia sericea* by *Megachile (Moureapis)* sp. because the analysis of each individual nest showed that *Ludwigia peruviana* was present in higher quantities.

The occurrence of pollen of *Tibouchina cerastifolia, Solanum* and Asteraceae, in small quantities, might be due to contamination by wind or by the presence of other pollinating sources in the flowers of *Ludwigia* due to the flux of visitors and not due to the fact that these plants are important food sources for *Megachile (Moureapis)* sp.

Since the flowering period of *Ludwigia peruviana* and *Ludwigia sericea* corresponded to the period of highest nesting activity of *Megachile (Moureapis)* sp., there seems to be a synchrony between these plants and the bees. This had already been observed by Laroca (1972), who stated that a perfect synchrony between the bee's reproductive cycle and the plant's flowering period is necessary for the bee to be considered a specialist. This situation becomes very delicate if the plant's flowering period is short and unpredictable. Robertson (1914) cited by Antonini (1995) states that, in addition to the synchrony between the plant's flowering period and the bee's reproductive activity, the effort to avoid competition, short flights and nesting in areas close to the plants used in nest provisioning are factors that lead to the evolution of oligolecty. Vieira (2002) stated that in southeastern Brazil, all *Ludwigia* species have flowers that are open for only one day and that the flowering period is concentrated in the beginning of the dry period, when their pollinators, oligolectic bees, are active.

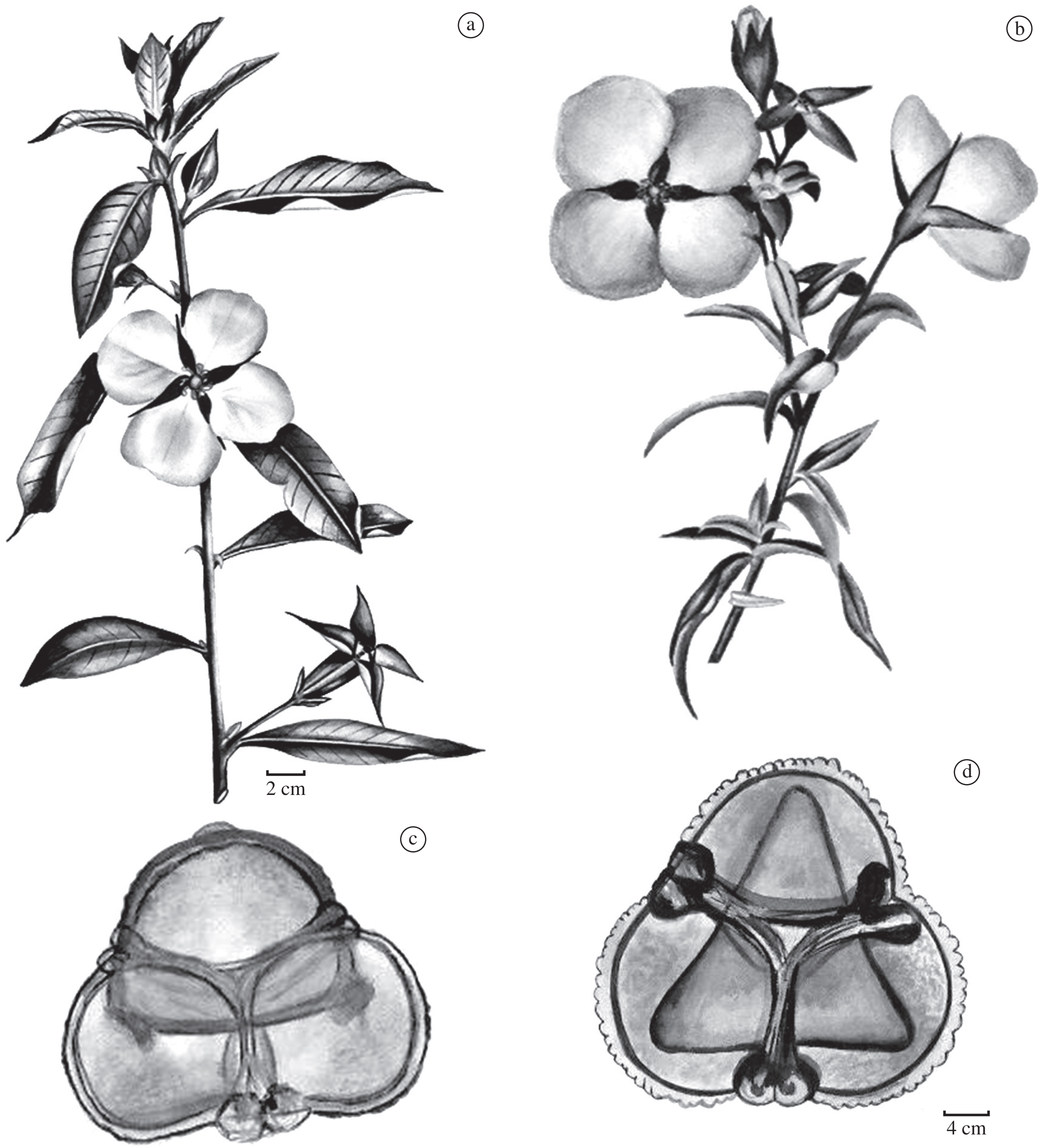

Figure 1. Species of *Ludwigia* in fertile stage and their pollen. a) *Ludwigia peruviana*, b) *Ludwigia sericea*, c) pollen of *L. sericea* e d) pollen of *L. peruviana.* (Illustration: Rigon, J.).

Although many species of bees can visit *Ludwigia*, it is probable that their pollination is carried out mostly by oligolectic bees. A study that shows this was carried out by Borges (1997) in *Ludwigia laruotteana* (Cambess.) H. Hara, 1953. The floral visitors of this species were *Apis mellifera* Linnaeus, 1758 (generalist) and *Diadasina distincta* (Holmberg, 1903) (specialist). According to this author, despite the aggressiveness of *Apis mellifera* towards *Diadasina distincta,* the species normally foraged at different times. Gimenes (2003) observed a high frequency of *Tetraglossula anthracina* (Michener, 1989), *Rhophitulus* sp. and *Pseudagapostemon* spp. in *Ludwigia elegans* (Cambess) Hara, 1953 flowers. These species were considered specialists in relation to the collection of pollen and nectar in these flowers, being temporally adjusted to the flower opening schedule and with synchronised seasonality with the flowering period of this plant.

Studies have shown that the genus *Ludwigia* is pollinated by oligolectic bees. To date, 10 species specialised in the collection of *Ludwigia* pollen have been recorded, namely: *Panurgillus flavitarsis* Schilindwein and Moure, 1998 (Andrenidae), *Diadasina distincta, Diadasina riparia* (Ducke, 1913), *Ptilothrix relata*

Table 2. Occurrence of pollen types in 16 nest slides of *Megachile* (*Moureapis*) sp.

Pollen	I	II	III	IV	V	VI	VII	VIII
Ludwigia sericea	864	677	690	508	986	446	943	690
Ludwigia peruviana	136	323	308	492	12	544	57	310
Solanum	-	-	2	-	-	10	-	-
Tibouchina cerastifolia	-	-	-	-	-	-	-	-
Asteraceae	-	-	-	-	2	-	-	-
Total	1000	1000	1000	1000	1000	1000	1000	1000
Pollen	**IX**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XV**	**XVI**
Ludwigia sericea	948	476	871	506	363	17	992	213
Ludwigia peruviana	50	522	119	486	635	983	8	772
Solanum	1	-	9	4	1	-	-	3
Tibouchina cerastifolia	-	-	-	-	-	-	-	10
Asteraceae	1	2	1	4	1	-	-	2
Total	1000	1000	1000	1000	1000	1000	1000	1000

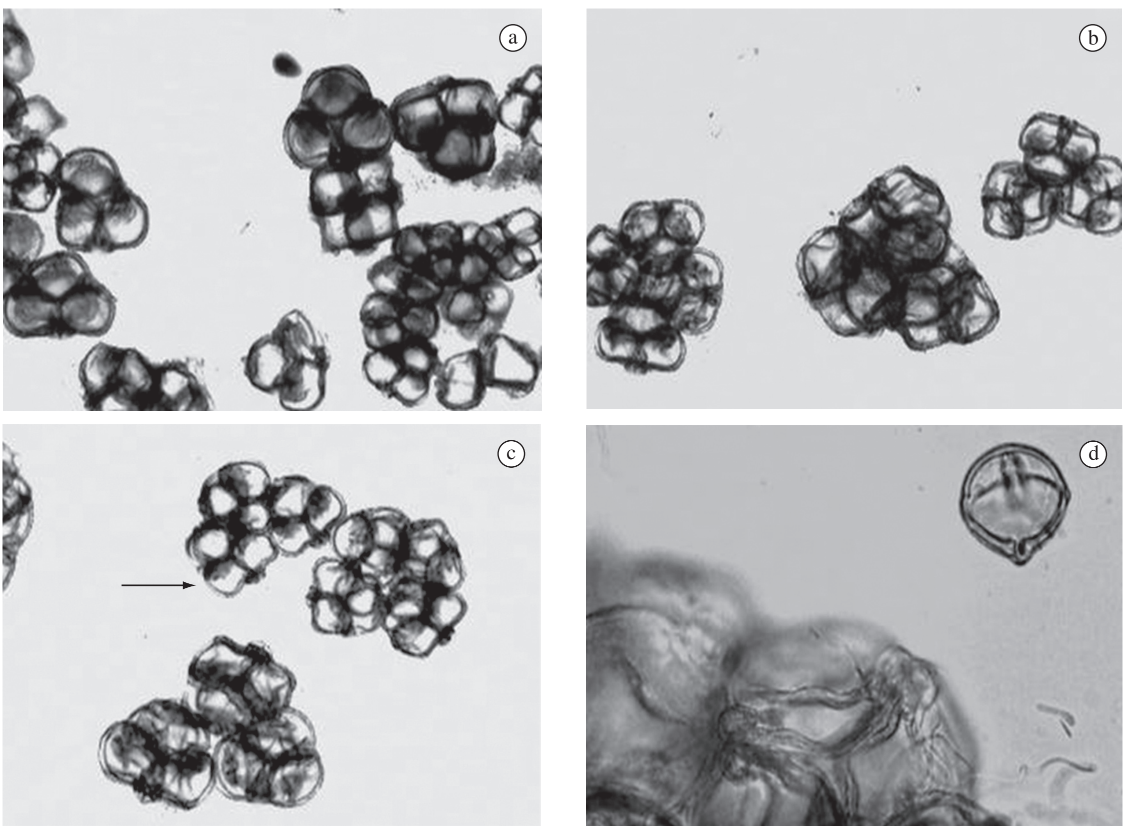

Figure 2. Pollen grains of *Megachile (Moureapis)* sp. a, b and c) nests, pollen of *Ludwigia sericea* (smaller grains, arrow) and of *Ludwigia peruviana* (larger grains) magnification 100×. d) Pollen of *Solanum* (upper right side), this type showed sporadic occurrence, magnification 400×.

(Holmberg, 1903), *Melissoptila paraguayensis* (Brèthes, 1909) (Apidae), *Tetraglossula anthracina*, *Tetraglossula bigamica* (Strand, 1910) (Colletidae) *Pseudagapostemon brasiliensis* Cure, 1989, *Pseudagapostemon pruinosus* Moure and Sakagami, 1984 (Halictidae) and *Megachile brasiliensis* (Megachilidae) (Schlindwein, 2004). Thus, *Megachile* (*Moureapis)* sp. is one more oligolectic species to be included in this list.

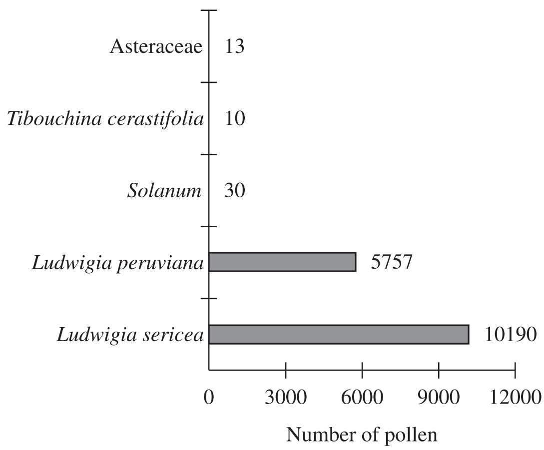

Figure 3. Number of types of pollen per botanical species found in nests of *Megachile (Moureapis)* sp.

According to Odum (1988), specialisation arises if this characteristic holds some kind of competitive advantage for the species. In general, oligolectic bees show morphological and/or behavioural adaptations that make them better collectors than generalist species (Schlindwein and Martins, 2000; Schlindwein, 2004; Pinheiro and Schlindwein, 1998). In *Megachile (Moureapis)* sp. the ventral scopa used as a pollen collecting structure, is a morphological trait that probably enables these bees to collect pollen from *Ludwigia* flowers very efficiently. Raven (1979) points out that bees with rigid and sparse ventral bristles are successful in the collection of Onagraceae pollen. Also, according to Borges (1997) the structural aspect of the pollen of *Ludwigia* facilitates collection by specialised pollinators. With these results we are able to conclude that *Megachile (Moureapis)* sp. is an oligolectic species and that both *Ludwigia peruviana* and *Ludwigia sericea* are their pollen source. We can also conclude that there is a synchrony between the phenology of *Megachile (Moureapis)* sp. and *L. peruviana* and *L. sericea*, indicating that *Megachile (Moureapis)* sp. is one of their main pollinators.

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