Analysis of digestive tract content of the larvae of *Polybia scutellaris* (White) (Hymenoptera, Vespidae)

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ABSTRACT. Analysis of digestive tract content of the larvae of *Polybia scutellaris* (White) (Hymenoptera, Vespidae). *Polybia scutellaris* (White, 1841) is a social wasp of biological interest for its role as pollinator and maybe as biological control agent of sanitary and agricultural pests. This study examines the digestive tract contents of the larvae of *P. scutellaris* from four nests in Magdalena (Buenos Aires province, Argentina). Contents included both animal (arthropod parts) and plant (pollen, leaf and fruit epidermis) parts. The pollen content analysis showed that the wasps visited 19 different taxa of plants during the last active period of the colony before the nests had been collected. The range of sources used by *P. scutellaris* allows us characterizing the species as a generalist flower visitor. Wasps visited both native and exotic plants located nearby the nest. Most of the epidermal plant remains found in the larval digestive tract belonged to Malvaceae, a family not exploited by the studied colonies as pollen source.

KEYWORDS. Epidermal tissues; generalist visitor; pollen; social wasp.

RESUMO. Análise do conteúdo do trato digestivo das larvas de *Polybia scutellaris* (White) (Hymenoptera, Vespidae). *Polybia scutellaris* (White, 1841) é uma vespa social de interesse biológico devido ao seu papel como polinizador e possível agente de controle biológico de pragas sanitárias e agrícolas. O presente estudo analisou o conteúdo do trato digestivo de larvas de *P. scutellaris* de quatros ninhos em Magdalena (província de Buenos Aires, Argentina). O conteúdo inclui restos animais (partes de artrópodos) e vegetais (pólen, epiderme de folhas e frutos). A análise do conteúdo polínico mostrou que as vespas visitaram 19 táxons durante o último período ativo da colônia antes dos ninhos serem coletados. A diversidade de recursos utilizados por *P. scutellaris* permite caracterizá-la como um visitante generalista de flores. As vespas visitaram plantas nativas e exóticas localizados nas proximidades do ninho. A maioria dos restos de epiderme encontradas no trato digestivo das larvas pertence às Malvaceae, uma família não explorada pelas colônias estudadas como fonte de pólen.

PALAVRAS CHAVE. Pólen; tecido epidérmico; vespa social; visitante generalista.

Polybia Lepeletier, 1836 is a genus of social wasp belonging to Vespidae, Polistinae, Epiponine, recorded in Argentina by nine species: *P. scutellaris* (White, 1841), *P. ruficeps* Schrott, 1902, *P. occidentalis* (Olivier, 1892), *P. sericea* (Olivier, 1982), *P. ignobilis* (Haliday, 1836), *P. paulista* von Ihering, 1896, *P. fastidiosuscula* de Saussure, 1854, *P. hecuba* Richards, 1951 and *P. minarum* Ducke, 1906. The wasp studied in this work, *Polybia scutellaris* (White, 1841), is widespread in Paraguay, Brazil, Uruguay and Argentina (mainly in eight provinces: Misiones, Corrientes, Santa Fe, Buenos Aires, Córdoba, Entre Ríos, San Juan and Mendoza) (Willink 1998).

The Neotropical swarm-founding wasps, Epiponini, are characterized by the complexity of nest construction and slight differentiation between queens and workers (Richards & Richards 1951; Richards 1978). Different developmental stages, i.e. eggs, larvae and pupae, can be found simultaneously in the cells of a single comb (Bruch 1936). Brood care is cooperative and the larvae are fed by means of progressive provisioning (Hunt *et al.* 1987).

The larvae of a species morphologically similar to that one studied here, *Polybia occidentalis*, are fed by nectar, tissues of foraged arthropod and probably also receive most of the hemolymph of the arthropod provisions. Once assimilated, in late stages of development, these nutrients produce a glandular secretion known as saliva. The saliva is rich in aminoacids and represents the major food source for adults, besides the hemolymph and nectar that they collect (Hunt *et al.* 1987).

Species of *Polybia* prey on different arthropod orders (Bruch 1936; Richards 1978; Willink 1998; Silva & Jaffe 2002) and may be potential biological control agents for pests that affect both, human health (Bertoni 1911) and crops (Willink 1998; De Moura *et al.* 2000; Reis *et al.* 2000). They forage on flowers searching for nectar, and produce low amount of honey (Bertoni 1911; Bruch 1936; Tellería 1996; Willink 1998). There are records of active collection of pollen by *Polybia scutellaris* as has been mentioned as a pollinator agent by Medan *et al.* (2006), Basilio *et al.* (2006) and Quirino & Machado (2001).

Costa de Bringas (1986), Tellería (1996) and Daners Chao (2003) analyzed the pollen content of honey produced by *Polybia* wasps from Córdoba, the Pampean region (Argentina) and Montevideo (Uruguay), respectively.

The goal of this work was to determine the composition of the stomach tract contents of *Polybia scutellaris* larvae, as

a contribution to the knowledge of the biology and pollination ecology of this wasp and its potential role as biological pest control agent.

MATERIAL AND METHODS

Sampling location and nest collecting method. The nests of *P. scutellaris* which the larvae came from, were collected in Magdalena, Buenos Aires province, Argentina (35º04'S, 57º31'W) along National Route 11, in March 2001 and January 2002. The sampling area is within humid grassland in Salado River basin. Plant community composition is influenced by flooding in the lower areas and intense cattle grazing, favored by the presence of native grasslands. Many species introduced are cultivated in the area; being the most abundant *Salix babylonica* L.*, Populus alba* L.*, Eucalyptus* sp. and *Acacia* sp. These exotic trees grow alongside native trees and shrubs such as *Celtis ehrenbergiana* (Klotzsch) Liebm., *Scutia buxifolia* Reissek, *Schinus longifolius* (Lindl.) Speg., *Jodina rhombifolia* (Hook. & Arn.) Reissek*, Sambucus australis* Cham. and Schltdl. and *Phytolaca dioica* L. (Vervoorst 1967).

A total of 4 nests were sampled. Adults were identified using the key of Willink (1950) in the laboratory. Specimens were deposited in the Entomology Section of Museo Argentino de Ciencias Naturales "Bernardino Rivadavia".

Material processing and data analysis. Wasp larvae from each nest were placed in boiling water for 15 minutes and then transferred to 80% ethyl alcohol for preservation.

Stomach content composition from 26 larvae (6–7 larvae of each nest, selected as representative sample of the different development instars) was analyzed. The digestive tract was removed from each larva and its contents were mounted in gelatin-safranin. Plant epidermal remains were identified under a Wild M20 light microscope, using polarization to assist in the recognition of plant cells through the birefringence of cell wall cellulose. The taxa corresponding to each remain were determined by comparison with available bibliographical sources (Freire *et al.* 2005; Metcalfe & Chalk 1950) and reference material prepared for this purpose. The reference collection comprised 63 herbarium specimens (leaves and fruits) of local flora species. Herborized leaves were hydrated and then cleared following the procedure outlined by Dizeo de Strittmater (D'Ambrogio 1986). The materials were stained with 1% aqueous safranin and mounted on gelatin-glycerin; subsequently, drawings of them were made under light microscope using *camera lucida* and photographs were taken using a Zeiss photo microscope.

One nest was randomly chosen to analyze the composition of the disk-shaped comb cell walls. Two preparations were made, one using the basal and lateral walls of a cell and other from the cap that covers individual cells. A few drops of water were added to each sample and its components were teased apart using dissecting needles. Subsequently, they were mounted in gelatin-safranin on a microscope slide with a coverglass. Identification of components was made under light microscope using available bibliography (Esau 1972). Identification of pollen types (mean: 350 grains per larva) was made under light microscope using the reference collection of the Paleobotany and Palynology Laboratory of the Facultad de Ciencias Exactas y Naturales (Universidad de Buenos Aires) and available bibliography (Markgraf & D'Antoni 1978; Roubik & Moreno 1991).

Richness of pollen types and percentage of each morphological type were calculated considering the total pollen values from all the larvae in each nest (on average, 1172 pollen grains per nest). Four categories were established to facilitate the interpretation of percentual data: dominant D (>45%), secondary S (16–45%), minor importance M (3–15%) and trace T (< 3%), following Louveaux *et al.* (1978) *apud* Tellería (1996). In order to establish which plant species were used by wasps from different nests during the last active season of each colony, constancy of each pollen type (C) was calculated using the following formula (Matteucci & Colma 2002): C = (Number of nests in which pollen type *i* occurs within the digestive tract of larvae/Total number of nests)*100

RESULTS

The material from both, the nest cells and the cell caps was composed of fiber and metaxylem elements (Fig. 1A). The plant remains identified from the digestive tract content of *P. scutellaris* larvae belonged to the families Malvaceae and Platanaceae. Among the representatives of Malvaceae, foliar trichomes of three species were recognized: *Sida rhombifolia* L., with stellate (Fig. 2A) and simple (Fig. 2B) trichomes, *Malva sylvestris* Mill., with fascicular (Fig. 2C) and simple (Fig. 2D) trichomes, and *Sphaeralcea bonariensis* (Cav.) Griseb., with stellate trichomes (Fig. 2E, F).

The Platanaceae trichomes corresponded to the genus *Platanus*, for which pluricellular and branched trichomes from leaves (Fig. 1B) and fruit (Fig. 2G) were identified.

The samples also contained starch granules, which were in some cases highly abundant in the larval digestive contents. In addition, diverse arthropod remains, including insect mandibles from a chewing bucal apparatus and characteristic Lepidoptera scales (Fig. 1C, D), were found in this analysis but most of them could not be identified.

A total of 19 pollen types were identified, being 2 determined to species level, 12 to genus level, 3 to tribe level and 1 to family (Table I). The pollen grains of *Conium* and *Ammi* were grouped together for the counts on the basis of their morphological similarity. For the same reason, for the Astereae, *Aster* sp.*, Solidago* sp.*, Conyza* sp. and *Baccharis* sp. were considered together, and in the Lactuceae the pollen of *Lactuca* sp.*, Sonchus* sp.*, Hypochoeris* sp., and *Taraxacum officinale* G. Weber ex F. H. Wigg.were also grouped.

During the last active period, the *Polybia* population studied here foraged on a total of 19 floral resources, with a mean of 12.5 (SD 4.51, n = 4) different taxa per nest.

The most abundant pollen grains found in the digestive tract of the larvae corresponded to Myrtaceae, Apiaceae and Salicaceae. In three out of the four nests analyzed, the dominant pollen type in the larval digestive tract was *Eucalyptus* spp. (Fig. 1E); this taxon was a minor component only in the remaining nest. In one of the nests, pollen of the *Conium-Ammi* complex (Fig. 1F) was dominant or secondary, and *Salix* spp., was secondary. Various pollen types, such as *Hydrocotyle* spp., *Celtis ehrenbergiana*, *Verbena* spp., *Carduus* spp., *Ambrosia* spp., *Polygonum* spp., *Sagittaria montevidensis* Cham and Schltdl., Lactuceae and Inuleae were found as trace components only.

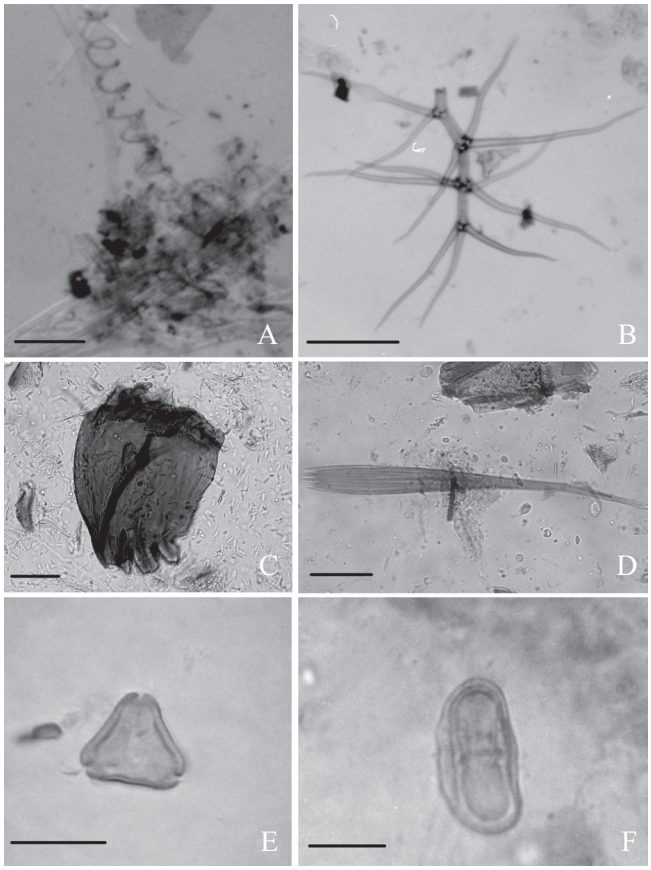

Fig. 1. (A) Material from the *P. scutellaris* nest, fibers and metaxylem elements; (B) pluricellular and branched foliar trichomes of *Platanus* sp. from larvae content. (C-D) Arthropod remains: (C) Mandible; (D) Lepidopteran scale. (E-F) Pollen grains types: (E) *Eucalyptus* spp.; (F) *Conium-Ammi* complex. Scale bars: A 50μm; B100 μm; C-D 20μ; E-F 10μm.

The pollen types that occurred commonly in the digestive tract of larvae from all the nests were: *Sagittaria montevidensis*, *Conium- Ammi* spp., *Carduus* spp., *Eucalyptus* spp., *Salix* spp., and Poaceae. In at least half of the nests, the digestive content of larvae included pollen grains of *Eryngium* spp., *Ambrosia* spp., *Ligustrum* spp., Astereae and Lactuceae, with *Mentha* spp. and *Lotus* spp. having secondary importance (Fig. 3).

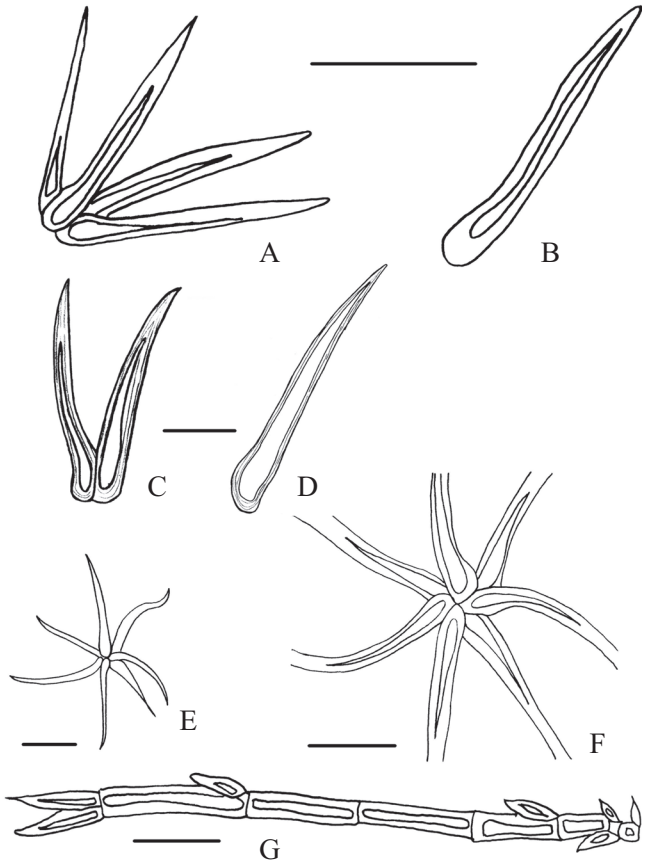

Fig. 2. (A-C) Malvaceae, foliar trichomes: (A-B) *Sida rhombifolia*: (A) stellate trichome, (B) simple trichome. (C-D) *Malva sylvestris*: (C) fascicular trichome, (D) simple trichome. (E-F) *Sphaeralcea bonariensis*, stellate trichomes: (E) general aspect, (F) detail. (G) Platanaceae: *Platanus*, pluricellular and branched trichome from the fruit. Scale bars: A-F 50 μm, G 100 μm.

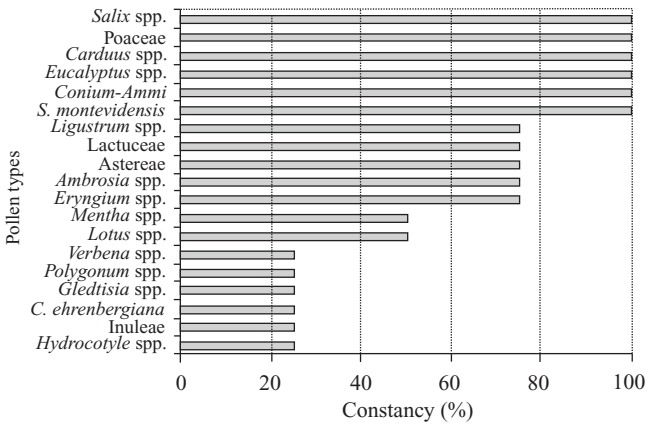

Fig. 3. Constancy of each pollen type in the digestive tract content of *P. scutellaris* larvae from different nests. The graphic shows only the taxa with constancy values higher than 25%.

DISCUSSION

The components found in the digestive content of *P. scutellaris* larvae are diverse, comprising pollen grains, arthropod parts and plant epidermal remains.

Table I. Pollen types found in the digestive tract content of *Polybia scutellaris* larvae from each nest. T: trace, M: minor component, S: secondary, D: dominant.

Family	Taxa	Nest 1	Nest 2	Nest 3	Nest 4
Alismataceae	*Sagittaria montevidensis* Cham & Schltdl.	T	M	T	T
Apiaceae	*Conium-Ammi* complex	S	S	T	D
Apiaceae	*Eryngium* spp.	T	M	T	
Apiaceae	*Hydrocotyle* spp.		T		
Asteraceae	*Ambrosia* spp.	T	T	T	
Asteraceae	Astereae		M	T	T
Asteraceae	*Carduus* spp.	T	M	T	T
Asteraceae	Inuleae		T		
Asteraceae	Lactuceae	T	T	T	
Celtidaceae	*Celtis ehrenbergiana* Klotzsch		T		
Fabaceae	*Gleditsia* spp.		T		
Fabaceae	*Lotus* spp.		M		T
Lamiaceae	*Mentha* spp.		M	T	
Myrtaceae	*Eucalyptus* spp.	D	M	D	D
Oleaceae	*Ligustrum* spp.	T		T	T
Poaceae		M	T	M	T
Polygonaceae	*Polygonum* spp.		T		
Salicaceae	*Salix* spp.	T	S	T	T
Verbenaceae	*Verbena* spp.		T		
Number total of pollen identified		1110	1318	1090	1075
Richnes in pollen types		10	19	12	9

Table II. Association between host plants and lepidopteran phytophagous larvae.

Host plant	Lepidopteran families and species	Reference
Sida rhombifolia	Pterophoridae; *Crocidosema plebejana* Zeller	Cordo *et al.* 2004
	Psychidae; *Oiketicus kirbyi* Guilding.	
	Noctuidae; *Anomis erosa* Hübner	
	Hesperiidae; *Gesta gesta gesta* (Herrich-Schaeffer), *Heliopyrgus americanus bellatrix* (Plötz), *Pyrgus communis orcynoides* (Giacomelli), *Pyrgus oileus orcus* (Stoll).	
Sphaeralcea bonariensis	Nymphalidae; *Vanessa carye* (Hübner)	Cordo *et al.* 2004
Malva sylvestris	Hesperiidae; *Heliopyrgus americanus bellatrix* (Plötz)	Cordo *et al.* 2004
Platanus spp.	Psychidae; *Oiketicus geyeri* Berg., *Oiketicus platensis* Berg.	Pastrana 2004; Cordo *et al.* 2004
	Saturniidae; *Automeris* spp., *Hylesia nigricans* Berg	
	Arctiidae; *Halysidota* spp.	

A small amount of honey was found deposited in the nest cells, in agreement with previous observations by Bruch (1936) and Tellería (1996). The abundance of pollen from melliferous flowers in the larval digestive content confirmed Tellería's (1996) statement that honey is not exclusively used for consumption by the colony during winter, as pointed out by Bruch (1936).

A previous study about of the pollen content accumulated in nests of *Polybia scutellaris* characterized this species as a generalist flower visitor (Fernández Corujo *et al.* 2010). The results of the larvae analysis of different nests allowed establishing that within the studied community, the *P. scutellaris* population exploited 19 different taxa of plants (both native and exotic) during its last active period. This broad range of exploited resources confirms that this species is a generalist flower visitor. The relatively most important resource were *Eucalyptus* spp., *Conium-Ammi* spp. and *Salix* spp. Comparing the pollen content from the digestive tract of larvae collected in January with the composition of honey produced by *P. scutellaris* from the Pampean region during the same period of the year, as studied by Tellería (1996), showed that in both cases *Eucalyptus* spp. was the dominant item. In contrast, in the honeys analyzed by Costa de Bringas (1986), and Daners Chao (2003), *Eucalyptus* spp. was only recorded as a trace element. Although it is a native wasp, *P. scutellaris* intensely exploited *Eucalyptus* spp., a dominant tree among the exotic

timber tree species cultivated in the area (Vervoorst 1967). This nectariferous plant plays a role as source of monofloral honeys made by *Apis mellifera* in different parts of Argentina (Naab & Torroba 1993; Forcone 2003).

The selection of a given floral resource by the wasps could depend on several factors, such as: a- abundance of the resource, b- proximity to the nest, allowing for more frequent visits, c- attraction exerted by the flowering plant (Gómez 2002).

The most frequent pollen types in the larval digestive tract of *P. scutellaris* corresponded to plant species with dense inflorescences (*Conium-Ammi* spp., Asteraceae, *Eryngium* spp. and *Eucalyptus* spp.). Pollen grains from aquatic plants (*Sagittaria montevidensis*, *Hydrocotyle* spp., and *Polygonum* spp.), which are abundant in the lentic habitats of the area, appeared as trace or low importance pollen components.

The presence of arthropod remains, including some items identified as scales and mandibles, indicates that *Polybia* is a predator, as mentioned in previous works (Bruch 1936; Hunt *et al.* 1987; Willink 1998; De Moura *et al.* 2000; Reis *et al.* 2000; Silva & Jaffe 2002). The adult wasps feed their larvae with chewed-up prey, since the larvae lack chewing mouth parts (Bruch 1936).

According to Willink (1998), *P. scutellaris* preys on the larvae of diverse lepidopterans and can be an efficient control agent for the bagworm *Oiketicus* spp. All the plant epidermal remains found in the digestive system of *P. scutellaris* larvae corresponded to plants that act as hosts for the phytophagous larvae of diverse Lepidoptera families (Table II), which are common in the study site (Canals 2000; Nuñez Bustos 2006). Therefore, the presence of abundant plant epidermal remains could be evidence that the larvae of *P. scutellaris* were fed lepidopteran larvae captured by the adult wasps, as part of their diet. Thus, *P. scutellaris* could act as a biological control agent for Lepidopteran pest species, such as *Crocidosema plebejana*, whose larvae are considered as cotton pests (Hamilton & Zalucki 1993).

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