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IDENTIFICATION OF MEGACHILID SPECIES (HYMENOPTERA: MEGACHILIDAE) AND OTHER POLLINATORS IN APPLE ORCHARDS IN CHIHUAHUA, MÉXICO

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Animal pollination is a mutually beneficial to both plants and pollinators. Plants benefit by being pollinated, which assures seed formation and sexual reproduction; and in return, the plant provides the pollinator with nectar, pollen and sweet fruits. Pollination has contributed to the evolution of floral diversity, mainly of angiosperms (Cane 2008; Sheffield et al. 2012). Thirty five percent of the world's food production (vegetables, fruits, edible oil crops, stimulants, nuts and spices) depends on crop pollination by honey bees, bumblebees and solitary bees (Kraemer & Favi 2005; Klein et al. 2007; Gallai et al. 2009; Das et al. 2011). Recently an appreciation of the fragility of many plant-pollinator relationships has emerged, along with the realization that it is necessary to understand the complex relationships and factors that influence the richness and abundance of species in the ecosystem in order to prevent its decline in a wide range of habitats (Biesmeijer et al. 2006; Winfree 2010; Williams et al. 2010). Pollination management in apple orchards is a critically important activity to assure fruit set and quality (Kraemer & Favi 2005; Das et al. 2011). Solitary bees of the genus *Osmia* (Hymenoptera: Megachilidae), known as effective pollinators, have excellent anatomical and behavioral adaptations and lifestyles dependent entirely of floral phenology (Drummond & Stubbs 1997; Kraemer & Favi 2005; Felicioli & Pinzauti 2008). Pollinators bees including *Osmia* species are favored by warm climates; however, they are still active in cool and cloudy days, which are frequent during the flowering period in apple orchards of Cuauhtémoc and Guerrero, Chihuahua, México. *Osmia* species are non-aggressive to humans and can easily be induced to nest in artificial nests, which are the basis for increasing the use of *Osmia* species in the management of apple orchards (Felicioli & Pinzauti 2008). Given the importance of organisms locally adapted to pollinate apple trees (*Malus* × *domestica* Borkh.) (Rosaceae), and since knowledge of the natural pollinators in México is poor, the main objective of this study was to observe and document the native pollinators in unmanaged apple orchards using artificial nests in Cuauhtémoc and Guerrero Chihuahua, México.

The experiment was established in 2 apple orchards 1) "La Concepción" (28° 23.9' N, 107° 01.58' W, 2194 m asl), and 2) "San Martín" (28° 24.51' N, 107° 03.88' W, 2256 m asl) located in Cuauhtémoc and Guerrero, Chihuahua, México respectively. Habitats surrounding apple orchards were a forest-complex species predominated by hardwood/coniferous woodland species such as pine tree *Pinus* spp. (Pinaceae), juniper *Juniperus* spp. (Cupressaceae), oak *Quercus* spp. (Fagaceae) and a mix of noncrop vegetation. Undergrowth in both orchards was composed primarily of sage brush (*Artemisia* sp. L.; Asteraceae) and grasses (Poaceae), typical plants in the Midwest plains of Chihuahua. Both apple orchards had been without chemical pesticide application for at least 10 years, and sited near water-bodies, a requirement for the establishment of Megachilid pollinators. Distance between orchards was approximately 4 km, and each had an area of 3 to 5 ha with mature 30-35-year-old 'Red Delicious' and 'Golden Delicious' trees.

Nesting wood traps designed to capture *Osmia* spp. were used. These were fabricated by beekeeper Eng. Ruben Rivera-Landeros based on a model developed by U.S. researchers (Bosch & Kemp 2001). Traps were installed 2 m high in the canopy around orchards, and were sampled periodically from 2010 to 2012 in both orchards (Tonietto et al. 2011). Traps were installed in mid-Mar and removed in Oct or Nov each year, and carried to CIAD laboratory for processing. The pupae were extracted, disinfected with sodium hypochlorite 2% and stored at 7 °C. Also bees and wasps were collected weekly with entomological nets from Apr to Jun 2010 and from May to Sep

2011. Specimens collected were stored in 70% ethanol; some were pinned with entomological needles and identified to genus with taxonomic keys (Laverty & Harder 1988; Michener et al. 1994; Michener 2000; Michener 2007).

A great diversity in species was observed in 3 years, mainly due to an extensive variety of weeds and woody plants surrounding the sited where the pollinators obtained their provisions from many flowering plants including dandelion (*Taraxacum officinale* F. H. Wigg.), clover (*Trifolium repens* L.), Mexican prickly-poppy (*Argemone mexicana* L.), and jagged-edge sunflower (*Helianthus laciniatus* A. Gray.). Various native plant species preferred by these bees and some exotic plants, such as Prickly sow thistle (*Sochus asper* (L.) Hill) and weld (*Reseda luteola* L.), among other forbs bloomed from May to Oct (Cane 2001). According to other studies, where there is great plant diversity, there is great bee diversity (Potts et al. 2003; Hendrix et al. 2010; Wojcik 2011).

We found that the pollinator communities inhabiting the canopies of apple trees orchards of Cuauhtémoc and Guerrero, Chihuahua, were highly diverse, with over 12 bee species found both in nests and trapped in weeds in the orchards. The most taxonomically diverse group in this study was the family Megachilidae. Also during 3 years of sampling we found more than 11 wasp species (Tables 1 and 2). In 2010 with entomological nets, we collected 32 hymenopteran species on weeds, and 22 (68.75%) of these were collected from "La Concepción" orchard, where *Anthidium* sp. (Megachilidae), was the main representative, and 10 (31.25%) species were collected from the "San Martin" orchard (Table 1). In 2011, 45 hymenopteran species were collected in "La Concepción", which consisted of 21 genera, distributed in 8 families; and the main representative s belonged to the Megachilidae family, with 35.56% of the specimens belonging to the genus *Anthidium*. In the "San Martin" orchard only 15 hymenopteran species were found, which were distributed in 7 genera, 4 genera (9 species) belonging to the Megachilidae and 3 genera belong to Halictidae and Vespidae families (Table 1).

In the 20 traps installed in both orchards in 2011, 245 hymenopterans specimens were collected of which 219 (89.34%) were found in "La Concepción" and 26 (10.61%) in "San Martín" (Table 2). Thus, we was found *Osmia lignaria*, *O. integra* and *Osmia* sp.1 pollinators in "La Concepción", but in "San Martín" we found only *O. lignaria* specimens (Table 2).

Megachile pugnata Say, was the greatest contributor to the differences between the 2 orchards, and it was the only species collected from a green canopy in "La Concepción" in both years (Matteson et al. 2008; Frankie et al. 2009). *Trachusa* sp., *T. ridingsii* Cresson and *Augochlorella aurata* Smith are widely found in northern México (Tonietto et al. 2011). Also *Heriades carinatus* Cresson, *Crabro* sp., *Halictus* sp., *Augochlora* sp. and *Anthidium* sp., *Xylocopa* sp. and *Bombus* spp. were each represented by one specimen (Table 1) (Greenleaf et al. 2007; Tonietto et al. 2011). In this study, an increase in abundance of species that nest in cavities was observed, over those that nest in other nesting types during the 3 years, and similar results were obtained by Matteson et al. (2008) and Dalmazzo (2010).

Other specimens collected from weed flowers with entomological nets were: *Pepsis aciculata* Taschenberg, *Sphex lucae* Saussure, *Dipogon subintermedius* Magretti (recorded in México for first time), *Triscolia ardens* Smith, *Ammophila* spp., *Vespula* sp., *Bicyrtes* sp., and *Lasioglossum* sp. The latter 5 species commonly occur in habitats in apple orchards. Over 29% of the species were represented by a single specimen, which was a similar proportion to those found in other studies (Cane 2001; Tonietto et al. 2011).

Our results are in agreement with earlier surveys in apple orchards of North America, which documented great diversity of bees (Sheffield et al. 2003; Sheffield et al. 2008; Sheffield et al. 2012) and of wasps (Sheffield et al. 2008; Mates et al. 2012). Abundance and diversity of native bees in agricultural systems are positively correlated with proximity and extent of the surrounding habitat (Steffan-Dewenter 2003; Kremen et al. 2004; Taki et al. 2007; Sobek et al. 2009; Hagen & Kraemer 2010). However anthropogenic habitats can be of high value to native bees as evidenced Winfree et al. (2007) and Tonietto et al. (2011) and that the proximity to more natural habitats, as field margins plentiful in floral resources, generally increases bee and wasp diversity (Sheffield et al. 2008; Hagen & Kraemer 2010; Roulston & Goodell 2011; Watson et al. 2011). The pollinator bees associated with crops grown over wide geographic ranges can show remarkable differences from region to region, and each region may have a particular profile of diversity and abundance of species (Michener 2007). In this respect, Neumann & Carreck (2010); Murray et al. (2009); Winfree et al. (2009); Tonietto et al. (2011) mentioned that the abundance of pollinators in the ecosystem is strongly affected by various biotic factors including resource availability (fragmentation and loss) and abiotic factors including loss of natural habitats, human-dominated green spaces and other land-use changes. Restoration of the natural populations of pollinators requires reversal of these changes (Dixon 2009; Winfree 2010; Tonietto et al. 2011), since remnant natural habitats are often insufficient to conserve biodiversity (Rosenzweig 2003). Nevertheless, native bee communities can persist in some anthropogenic

TABLE 1. HYMENOPTERA COLLECTED WITH ENTOMOLOGICAL NETS IN TWO APPLE ORCHARDS IN CUAUHTÉMOC, CHIHUAHUA IN 2010-2011.

Orchard	Year	Family	Genera	Species	Number of Specimens
"La Concepción"	2010	Megachilidae	*Trachusa*	sp.1	6
				ridingsii	3
			Megachile	*pugnata*	3
			Anthidium	sp.	8
		Halictidae	*Augochlorella*	*aurata*	2
	2011	Megachilidae	*Trachusa*	sp.1	5
			Heriades	*carinatus*	3
			Megachile	*pugnata*	4
			Anthidium	sp.	1
			Osmia	*integra*	3
		Halictidae	*Augochlorella*	*aurata*	1
			Halictus	sp.	1
			Augochlora	sp.	1
		Crabronidae	*Crabro*	sp.	2
		Apidae	*Xylocopa*	sp.	1
			Bombus	sp.	1
		Vespidae	*Parancistrocerus*	*pedestris*	3
			Ancistrocerus	*tuberculocephalus*	2
			Vespula	sp.	
		Sphecidae	*Chlorion*	sp.	2
			Sphex	lucae	2
			Ammophila	sp.	1
			Bicyrtes	sp.	2
		Pompilidae	*Pepsis*	*aciculata*	1
			Dipogon	*subintermedius*	3
		Scoliidae	*Triscolia*	*ardens*	2
"San Martín"	2010	Halictidae	*Augochlora*	sp.[P]	2
			Lasioglossum	sp.	1
		Megachilidae	*Trachusa*	sp.1	2
			Anthidium	sp.	3
		Crabronidae	*Crabro*	sp.	2
	2011	Megachilidae	*Trachusa*	sp.1	4
			Heriades	*carinatus*	2
			Megachile	sp.	1
			Anthidium	sp.	2
		Halictidae	*Augochlora*	sp.	1
		Vespidae	*Ancistrocerus*	*tuberculocephalus*	3
			Vespula	sp.	2

habitats (Cane 2001; Marlin & LaBerge 2001). Rosenzweig (2003) and Tonietto et al. (2011) noted that the return to organic management provides suitable habitats for native species and thus supports native biodiversity

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SUMMARY

Research on the diversity and abundance of taxa pollinators at the community level are essential to know aspects of their biology, ethology, ecology and the impacts on reproduction and plant diversity. Bees have an important role in providing pollination, which is essential to plant reproduc-

TABLE 2. HYMENOPTERA FOUND IN NESTS OF OSMIA SPP. IN TWO APPLE ORCHARDS IN 2011-2012.

Orchard	Year	Family	Genera	Species	Type of Nest	Number of Specimens
"La concepción"	2011	Megachilidae	*Osmia*	*lignaria*	C	6
				integra	C	3
			Osmia	sp.1	C	180
			Megachile	*pugnata*	C	8
		Vespidae	*Parancistrocerus*	*pedestris*	C-SW	6
			Ancistrocerus	*tuberculocephalus*	C-SW	12
		Sphecidae	*Chlorion*	sp.	S	4
	2012	Megachilidae	*Osmia*	sp.1	C	143
			Osmia	sp.2	C	20
			Megachile	sp.	C	4
		Vespidae	*Ancistrocerus*	*tuberculocephalus*	C-SW	84
		Sphecidae	*Chlorion*	sp.	S	2
"San Martín"	2011	Megachilidae	*Osmia*	*lignaria*	C	5
			Megachile	*pugnata*	C	12
		Vespidae	*Ancistrocerus*	*tuberculocephalus*	C-SW	9
	2012	Megachilidae	*Osmia*	sp.2	C	64
			Megachile	*pugnata*	C	69
			Megachile	sp.	C	20
		Vespidae	*Ancistrocerus*	*tuberculocephalus*	C-SW	47

Nesting type (nest location): S, soil; C, cavity; SW, soft wood; according to Tonietto et al. (2011).

tion. The objective of the study was to document the diversity and abundance of bee pollinators, with emphasis in Megachilid species, in 2 unmanaged apple orchards, located in Cuauhtémoc and Guerrero, Chihuahua, México. Both orchards had similar conditions, with intermediate levels of adjacent natural/semi-natural habitat. In 2010, 2011 and 2012, special wood nesting traps for capturing *Osmia* spp. were installed. Four species of solitary pollinator bees of *Osmia* genus were captured, of which the most represented was *Osmia* sp.1, with 323 specimens, followed by *Osmia* sp.2 with 84 specimens, *O. lignaria* Say with 11 specimens and 3 specimens of *O. integra* Cresson. Also, other species of bees and wasps visitors of plants with flowers were found such as *Trachusa* sp., *Anthidium* spp., *Megachile pugnata* Say, *Heriades carinatus* Cresson, *Xylocopa* sp., *Bombus* sp., *Ancistrocerus tuberculocephalus* (Saussure) and *Vespula* sp.

Key Words: pollination, insect pollinators, blue orchard mason bee, Megachilid, *Osmia lignaria*, *Osmia integra*

RESUMEN

Las investigaciones sobre la diversidad y abundancia de taxas polinizadoras a nivel comunidad son esenciales para conocer aspectos relacionados con su biología, ecología, etología y los impactos sobre la reproducción y diversidad de plantas. Por lo que, mantener la relación entre plantas y polinizadores es vital para la estabilidad de los ecosistemas y agroecosistemas donde las abejas juegan un rol muy importante para la polinización, la cual es esencial para la reproducción de las plantas. El objetivo del estudio fue estimar la diversidad y abundancia de abejas polinizadoras, con énfasis en especies de Megaquílidos, en dos huertos de manzano, sin manejo, localizados en Cuauhtémoc y Guerrero, Chihuahua, México. Ambos huertos muestran condiciones similares, con niveles intermedios de hábitats adyacentes naturales y semi-naturales. En 2010, 2011 y 2012, se colocaron trampas especiales de madera para la anidación de polinizadores para la captura de *Osmia* spp. Se encontraron cuatro especies de abejas solitarias polinizadoras pertenecientes al género *Osmia,* donde *Osmia* sp.1 fue la más representada, con 323 especímenes, 84 especímenes de *Osmia* sp.2, 11 especímenes de *O. lignaria* Say y tres de *O. integra* Cresson. Se encontraron otras especies de abejas y avispas visitadoras de plantas con flores tales como *Trachusa* sp., *Anthidium* spp., *Megachile pugnata* Say, *Heriades carinatus* Cresson, *Xylocopa* sp., *Bombus* sp., *Ancistrocerus tuberculocephalus* (Saussure) and *Vespula* sp.

Palabras Clave: Polinización, insectos polinizadores, abeja albañil, Megaquílidos, *Osmia lignaria*, *Osmia integra*

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