Review of Occurrence of Vespoidea (Hymenoptera) in the State of Campeche, Mexico[1]

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Abstract The superfamily Vespoidea of the order Hymenoptera is reportedly comprised of 27,389 species worldwide within 10 taxonomic families and represents a diversity of composition, behavioral habits, and ecological roles. Studies of Vespoidea in the state of Campeche, Mexico, are scarce, and most reports are focused on the family Formicidae. This study presents an analysis based on a literature review of the occurrence of Vespoidea in Campeche. Results indicate that 91 species in 3 taxonomic families (Formicidae, Pompilidae, and Vespidae) are found in Campeche. Tropical ecosystems of Campeche serve as habitats for 6.3% of the total species of Vespoidea in Mexico. Further research on the diversity and ecology of Vespoidea is suggested to increase our knowledge of Vespoidea as natural enemies and pollinators in agroecosystems and natural environments in the state of Campeche, Mexico.

Key Words Campeche, Hymenoptera, Vespoidea, wasps

Campeche is a Mexican state located on the Yucatan Peninsula and is characterized by tropical ecosystems, such as high evergreen forest and medium semievergreen forest (Rzedowski 1978, Miranda and Hernández 1963). Anthropic influences (e.g., agriculture and livestock) contribute substantially to the fragmentation of tropical ecosystems in the state. According to Ceballos et al. (2002), the original distribution of evergreen tropical forests has decreased by about 40%, which results in decreases in species diversity in the region.

The superfamily Vespoidea includes species that contribute substantially to ecological processes in different agroecosystems and natural environments as either natural enemies or pollinators. Moreover, the knowledge of Vespoidea may be a useful tool for evaluating the impact of the anthropic influence on natural ecosystems and agroecosystems. Therefore, the goal of this work was to review the species occurrence of the superfamily Vespoidae in the state of Campeche, Mexico.

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Methods

We performed an exhaustive review of studies focused on occurrence records and reports of the superfamily Vespoidea in Campeche, Mexico. We consulted scientifically based books, papers, and publications included in the Journal Citation Reports, Latindex, Scielo, and others. Also, the review included other sources, such as local study reports in Mexico and databases available on the worldwide web. This work is only comprised of records identified at the species level from the state of Campeche. Any omissions of pertinent available literature were unintentional.

The Superfamily Vespoidea

Members of the order Hymenoptera include the bees, wasps, and ants, which are of economic and ecological importance in their roles as pollinators, predators, parasitoids, and nutrient recyclers (Guzmán 2014, Myartseva et al. 2014, 2015). The number of reported Hymenopteran species may vary by study. For example, Zhang (2013) and Peters et al. (2017) recently noted approximately 155,000 species worldwide, whereas older publications report 115,000 species (Triplehorn and Johnson 2005) and 199,000 species (Nieves-Aldrey and Fontal-Cazalla 1999). Several others estimate that the order likely exceeds 250,000 species and could reach 500,000 (Gauld and La Salle 1993, Fernández 2000, González 2006).

The suborder Apocrita includes two divisions, namely Parasitica and Aculeata. The latter comprises three superfamilies—Chrysidoidea, Vespoidea, and Apoidea (Finnamore and Brothers 1993). Vespoidea is composed of 10 families—Bradynobaenidae, Formicidae, Mutillidae, Pompilidae, Rhopalosomatidae, Saypigidae, Scoliidae, Sierolomorphidae, Tiphiidae, and Vespidae (Brothers 1999, 2006). Except for Formicidae, all of these families are commonly known as wasps.

Anatomically, Vespoidea species possess antennae with 10 flagellomeres in females and 11 flagellomeres in males, a pronotum with the posterolateral apex reaching or exceeding the tegula, an anterior wing with well-developed venation usually with 9 to 10 closed cells, posterior wings with 2 closed cells and usually with a jugal lobe, the metasoma I and II sternites frequently separated by a constriction, and females without an articulation within gonocoxito II (Brothers and Finnamore 1993). Fernández and Sharkey (2006) observed that Vespoidea appears in the middle of the Cretaceous period and exhibits an evolutionary history characterized by exploiting a great diversity of niches in different habitats. Indeed, vespoids present a variety of behavioral habits and complexity, ranging from solitary to eusocial species. Their ecological importance resides in their trophic interactions in terrestrial ecosystems in which they serve as natural enemies of other insects and as pollinators of a vast number of plant species, many of which are economically important (La Salle and Gauld 1993, Chiappa 2017).

Relative Occurrence Globally and in Mexico

Studies of the Vespoidea superfamily have been conducted in different parts of the world with different scientific approaches, including, but not restricted to, taxonomic (Persson 2015, Krauth 2018, Andrade et al. 2018, Barthélémy et al.

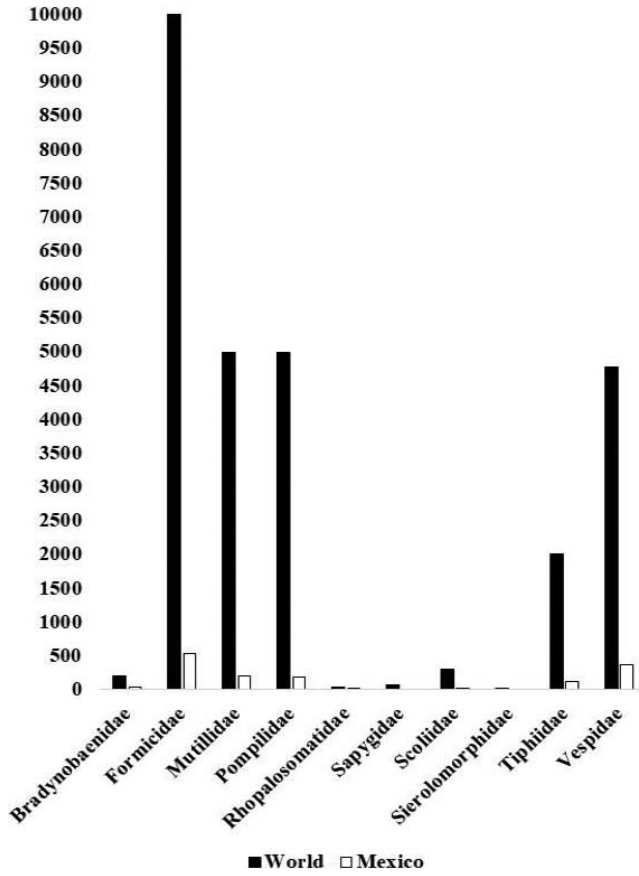

Fig. 1. Number of reported species of the Vespoidea superfamily in Mexico and worldwide.

2018), ecological (Rodrigues 2018), and molecular techniques (Khan et al. 2018, Seok et al. 2017). Guamán and Alexandra (2017) reported that 27,389 species of Vespoidea are known worldwide, with the family Formicidae possessing the greatest diversity (37%), followed by Mutillidae and Pompilidae with 18% each, and Vespidae with 17%. Five families (e.g., Bradynobaenidae, Rhopalosomatidae, Sapygidae, Scoliidae and Sierolomorphidae) each compose barely 1% of the total number of species (Fig. 1). Approximately 24,000 Vespoidea species have been recorded from the neotropics.

In Mexico, the superfamily Vespoidea is represented by 1,439 species, which accounted for 5% of the total species worldwide. Formicidae and Vespidae are the families involving the highest number of species, with 37% and 25% of the total, respectively. Formicids and vespids are the most studied gorup of Vespoidae worldwide (Persson 2015). Two of the 10 vespoid families—Sapygidae and Sierolomorphidae—have not been not reported from Mexico.

Occurrence in Campeche

We recovered records of 91 species of Vespoidea represented by three families—Formicidae, Pompilidae, and Vespidae—in the state of Campeche. The highest proportion of species (88%) were members of Formicidae (Table 1). We provide notes of Vespoidea families, and when appropriate, their occurrence in Campeche is highlighted.

Family Bradynobaenidae. This group of wasps is similar to Mutillidae, and the species are often found in arid regions. Recent taxonomic reorganizations eliminated two of the five constituent genera, with both genera from the New World, placing them in the separate family Chyphotidae, which restricts the true bradynobaenids to the Old World. The family comprises four genera, namely, *Apterogyna* Latreille, *Gynecaptera* Skorikov, *Bradynobaenus* Spinola, and *Macrocula* Panfilov, none of which are reported from Campeche (Pilgrim et al. 2008).

Family Formicidae. Vásquez-Bolaños (2015) reported 65 formicid species from Campeche. AntWeb (https://www.antweb.org; last accessed 9 September 2019) lists 18 species for the state, whereas Chanatásig-Vaca et al. (2011) documented 37 morphospecies, of which only 13 were identified to the species level. The 13 identified species in the latter study are included herein. Based on the previous reports by Vásquez-Bolaños (2015), AntWeb, and Chanatásig-Vaca et al. (2011), a total of 80 species of Formicidae are recognized from the state of Campeche. We did not include the 78 species of Formicidae reported by Chan (2002), as it was an unpublished thesis. *Cardiocondyla reina* reported by Chanatásig-Vaca et al. (2011) is also not included herein because its report is based on one single record with no additional reports of that species found in our review of the literature. This species was collected in the town of Tikinmul, belonging to the municipality of Campeche, Mexico, in a cedar monoculture with apparent high soil density.

Family Mutillidae. Nine species of mutillids are reported from Campeche, but none were identified to the species level (Mendoza 2017). Delfin and Chay (2018) mentioned the presence of mutillids on the Yucatan Peninsula, including the state of Campeche.

Family Pompilidae. Members of this family are also reported from the state of Campeche and include individuals that hunt spiders, depositing them in their nests to feed their young (Wesbauer 1995). In Campeche, five pompilid species are recorded, which represents 3% of the total species recorded in Mexico (Vanoye-Eligio et al. 2014).

Family Rhopalosomatidae. This family comprises wasps that parasitize members of Gryllidae (Orthoptera). Few individuals can be found in entomological collections due to their biology. In Mexico, only five species are reported: *Liosphex varius* Townes (Veracruz), *Olixon banksii* Brues (Mexico), *O. testaceum* Cameron (Tabasco), *Rhopalosoma obliquum* Townes (Oaxaca), and *R. simile* Brues (Veracruz, Chiapas, Sinaloa, Yucatan, and Tamaulipas) (Coronado and Ruíz 2002). No reports of members of this family in Campeche exist.

Family Sapygidae. These insects are solitary Aculeates wasps, commonly known as "horns of maso." Individual wasps are black with yellow or white markings, similar to the species of Tiphiidae. They are kleptoparasites or parasitoids of bees. The females deposit their eggs in the nests of solitary bees,

Table 1. List of Vespoidea species reported from the state of Campeche, Mexico.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
Formicidae	*Forelius pruinosus* (Roger, 1863)	22	Vásquez-Bolaños 2015
	Camponotus atriceps (Smith, 1858)	20	Vásquez-Bolaños 2015
	Labidus coecus (Latreille, 1802)	20	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011, Vásquez-Bolaños 2015
	Neivamyrmex swainsonii (Shuckard, 1840)	18	Watkins 1982, Vásquez-Bolaños 2011
	Pseudomyrmex gracilis (Fabricius, 1804)	18	Vásquez-Bolaños 2015, AntWeb 2019
	Camponotus sericeiventris (Guérin-Méneville, 1838)	15	Vásquez-Bolaños 2015
	Paratrechina longicornis (Latreille, 1802)	15	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011, Vásquez-Bolaños 2015
	Tetramorium spinosum (Pergande, 1896)	15	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011; Vásquez-Bolaños 2015
	Crematogaster torosa Mayr, 1870	14	Vásquez-Bolaños 2015
	Pseudomyrmex ferrugineus (Smith, 1877)	14	Ward 1989, Vásquez-Bolaños 2011, AntWeb 2019
	Pseudomyrmex elongatus (Mayr, 1870)	14	Vásquez-Bolaños 2015, AntWeb 2019
	Solenopsis geminata (Fabricius, 1804)	14	Chanatásig-Vaca et al. 2011
	Neoponera villosa (Fabricius, 1804)	13	Vásquez-Bolaños 2015

Table 1. Continued.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
	Cephalotes minutus (Fabricius, 1804)	11	De Andrade and Baroni Urbani 1999, Vásquez-Bolaños, 2011
	Pachycondyla harpax (Fabricius, 1804)	11	Vásquez-Bolaños 2015, AntWeb 2019
	Ectatomma tuberculatum (Olivier, 1792)	10	Vásquez-Bolaños 2015
	Monomorium ebeninum Forel, 1891	10	DuBois 1986, Vásquez-Bolaños 2011
	Monomorium pharaonis (Linnaeus, 1758)	10	Vásquez-Bolaños 2015
	Neivamyrmex pilosus mexicanus (Smith, 1859)	10	Watkins 1982, Vásquez-Bolaños 2011
	Octostruma balzani (Emery, 1894)	10	Vásquez-Bolaños 2015
	Pseudomyrmex cubaensis (Forel, 1901)	10	Ward 1989, Vásquez-Bolaños 2011
	Atta cephalotes (Linnaeus, 1758)	9	Márquez-Luna 1996, Vásquez-Bolaños 2011
	Labidus praedador (Smith, 1858)	9	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011, Vásquez-Bolaños 2015, AntWeb 2019
	Neivamyrmex melshaemeri (Haldeman, 1852)	9	Watkins 1982, Vásquez-Bolaños 2011
	Pseudomyrmex peperi (Forel, 1913)	8	Ward 1993, Vásquez-Bolaños 2011, AntWeb 2019
	Belonopelta deletrix Mann, 1922	8	Macías et al. 2013, Vásquez-Bolaños 2015, AntWeb 2019
	Pseudomyrmex perboscii (Guérin-Méneville, 1844)	8	Ward 1989, Ward 1993, Vásquez-Bolaños 2011

Table 1. Continued.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
	Cephalotes cristatus (Emery, 1890)	7	Vásquez-Bolaños 2015
	Cheliomyrmex morosus (Smith, 1859)	7	Brandão 1991, Watkins 1982, Vásquez-Bolaños 2011
	Eciton hamatum (Fabricuis, 1781)	7	Watkins 1982, Vásquez-Bolaños 2011
	Pheidole punctatissima Mayr, 1870	7	Vásquez-Bolaños 2015
	Pseudomyrmex kuenckeli (Emery, 1890)	7	Vásquez-Bolaños 2015
	Acromyrmex octospinosus (Reich, 1793)	6	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011, Vásquez-Bolaños2015
	Camponotus planatus Roger, 1863	6	Vásquez-Bolaños 2015
	Dolichoderus bispinosus (Olivier, 1792)	6	MacKay 1993, Suárez 2005, Del Toro et al. 2009, Rodríguez-Garza 2008, AntWeb 2019
	Neivamyrmex crassiscapus Watkins, 1990	6	Brandão 1991, Watkins 1990, Vásquez-Bolaños 2011
	Neoponera apicalis (Latreille, 1802)	6	Vásquez-Bolaños 2015, AntWeb 2019
	Neoponera unidentata (Mayr, 1862)	6	Vásquez-Bolaños 2015
	*Odontomachus yucatecus (*Brown, 1976)	6	Brandão 1991, Vásquez-Bolaños 2011
	Proceratium micrommatum (Roger, 1863)	6	Rodríguez-Garza 2009, Vásquez-Bolaños 2011
	Pseudomyrmex boopis (Roger, 1862)	6	Kempf 1960, Vásquez-Bolaños 2011, AntWeb 2019

Table 1. Continued.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
	Pseudomyrmex oculatus (Smith, 1855)	6	Vásquez-Bolaños 2015, AntWeb 2019
	Temnothorax subditivus (Wheeler, 1903)	6	Baroni Urbani 1978, Vásquez-Bolaños 2011
	Tetramorium simillimum (Smith, 1851)	6	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011; Vásquez-Bolaños 2015
	Azteca instabilis (Smith, 1862)	5	Vásquez-Bolaños 2015
	Basiceros stannardi (Brown y Kempf, 1960)	5	Rodríguez-Garza 2005b, Vásquez-Bolaños 2011
	Camponotus conspicuus zonatus Emery, 1894	5	Vásquez-Bolaños 2015
	Camponotus coruscus coruscus (Smith, 1862)	5	Vásquez-Bolaños 2011
	Camponotus novogranadensis Mayr, 1870	5	Vásquez-Bolaños 2015
	Camponotus rectangularis Emery, 1890	5	Vásquez-Bolaños 2015
	Cephalotes multispinosus (Norton, 1868)	5	De Andrade and Baroni Urbani 1999, Vásquez-Bolaños, 2011
	Hypoponera nitidula (Emery, 1890)	5	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011, Vásquez-Bolaños 2015, AntWeb 2019
	Neivamyrmex fumosus (Forel, 1913)	5	Watkins 1982, Vásquez-Bolaños 2011
	Neivamyrmex guerinii (Shuckard, 1840)	5	Watkins 1982, Vásquez-Bolaños 2011
	Nylanderia guatemalensis (Forel, 1885)	5	Vásquez-Bolaños 2015

Table 1. Continued.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
	Octostruma rugiferoides Brown & Kempf, 1960	5	Vásquez-Bolaños 2015
	Pheidole subarmata Mayr, 1884	5	Vásquez-Bolaños 2015
	Pseudomyrmex caeciliae (Forel, 1913)	5	Ward 1989, Vásquez-Bolaños 2011, AntWeb 2019
	Dolichoderus lutosus (Smith, 1858)	5	Vásquez-Bolaños 2015, AntWeb 2019
	Solenopsis corticalis Forel, 1881	5	Vásquez-Bolaños 2015
	Basiceros wheeleri (Mann, 1922)	4	Rodríguez-Garza 2005b, Vásquez-Bolaños 2011
	*Cardiocondyla nuda (*Mayr, 1866)	4	Chanatásig-Vaca et al. 2011, Vásquez-Bolaños 2011, Vásquez-Bolaños 2015
	Nomamyrmex hartigii (Westwood, 1842)	4	Vásquez-Bolaños 2015
	Pheidole megacephala (Fabricius, 1793)	4	Vásquez-Bolaños 2015
	Anochetus micans Brown, 1978	3	Vásquez-Bolaños 2015
	Cyphomyrmex minutus Mayr, 1862	3	Vásquez-Bolaños 2015
	Discothyrea testacea Roger, 1863	3	Rodríguez-Garza 2009, Vásquez-Bolaños 2011;
	Neivamyrmex diabolus (Forel, 1912)	3	Kempf 1972, Watkins 1982, Vásquez-Bolaños 2011
	Neivamyrmex inflatus Borgmeier, 1958	3	Watkins 1982, Vásquez-Bolaños 2011
	Pheidole radoszkowskii Mayr, 1884	3	Vásquez-Bolaños 2015

Table 1. Continued.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
	Pseudomyrmex godmani (Forel, 1899)	3	Vásquez-Bolaños 2015
	Rasopone ferruginea (Smith, 1858)	3	Vásquez-Bolaños 2015, AntWeb 2019
	Rogeria cornuta Kugler, 1994	3	Vásquez-Bolaños 2015, AntWeb 2019
	Temnothorax goniops (Baroni Urbani, 1978)	3	Baroni Urbani 1978, Vásquez-Bolaños 2011
	Acromyrmex coronatus (Fabricius, 1804)	2	Vásquez-Bolaños 2015
	Crematogaster limata Smith, 1858	2	Vásquez-Bolaños 2015
	Cephalotes kukulcan Snelling, 1999	2	Vásquez-Bolaños 2015, AntWeb 2019
	*Amblyopone degenerata (*Borgmeier, 1957)	1	Rodríguez-Garza and Suárez 2004, Vásquez-Bolaños 2011
	Pheidole dumicola (Wilson, 2003)	1	Wilson 2003, Vásquez-Bolaños 2011, AntWeb 2019
	Rasopone arhuaca (Forel, 1901)	1	Vásquez-Bolaños 2015
Pompilidae	*Episyron conterminus posterus* Fox, 1893	15	Vanoye-Eligio et al. 2014
	Anoplius apiculatus apiculatus Smith, 1855	11	Vanoye-Eligio et al. 2014
	Allaporus pulchellus Banks, 1910	8	Vanoye-Eligio et al. 2014, Discoverylife 2018
	Pepsis thisbe Lucas, 1894	6	Vanoye-Eligio et al. 2014
	Priochilus sericeifrons (Fox, 1897)	2	Vanoye-Eligio et al. 2014

Table 1. Continued.

Family	Species	No. of States from Which Species Are Reported	Reference(s)
Vespidae	*Brachygastra mellifica* (Say, 1837)	21	Vanoye-Eligio et al. 2014
	Polybia (Myrapetra) occidentalis nigratella (Olivier, 1791)	18	Vanoye-Eligio et al. 2014
	Polistes (Aphanilopterus) instabilis Saussure, 1853	15	Vanoye-Eligio et al. 2014
	Zethus (Zethus) fuscus (Perty, 1833)	6	Vanoye-Eligio et al. 2014
	Zethus spinosus Saussure, 1857	4	Ruiz et al. 2010
	Polybia (Formicola) rejecta (Fabricius, 1798)	3	Vanoye-Eligio et al. 2014

and the emerged larvae feed on both the bee larvae and the food stored for them. About 80 species are described worldwide, although there are no records for Mexico. However, in the United States, the family Sapygidae is widely reported (Peterson et al. 1992, Naturalistas 2018).

Family Scoliidae. This group of wasps comprises approximately 560 species with a worldwide distribution. In the Yucatan Peninsula, this family is reported from the state of Yucatán (Lambdin and McKeown 2003). Also, species of this family are documented from Baja California. Moreover, three species are also reported from Tamaulipas (Ruiz et al. 2010, Monroy-Alcantara et al. 2017). No species are reported in Campeche.

Family Scoliidae. González-Hernández et al. (2008) listed three genera, including eight species, in their review of Scoliidae in Mexico. No species are reported from Campeche.

Family Sierolomorphidae. There are no records on the occurrence of members of this family in Mexico. Species of this family are reported in Central America. The biology of Sierolomorphidae is still unknown (Fernández 2002). According to Guaman and Alexandra (2017) and Resh and Cardé (2009), only 10 species are known worldwide.

Family Tiphiidae. Species of this family are solitary ectoparasites, mainly of melolonthid larvae, and in some cases, they attack Apidae and Vespidae members. Females of the subfamilies Brachycistidinae, Diamminae, Methochinae, and Thynninae lack wings, whereas females of the subfamilies Tiphiinae, Anthoboscinae, and Myzininae are winged (Arnett 2000). There are 124 species reported in Mexico (González-Hernández and Carpenter 2011), but no species are reported from Campeche. However, reports of six individuals of this family are registered from Yucatan, a neighboring state of Campeche (Lambdin and McKeown 2003).

Family Vespidae. These insects are solitary wasps that store pollen, store nectar, or paralyze insect larvae as food for their larvae. In Mexico, there are 361 species known (Morrone and Márquez 2008, González-Hernández and Carpenter 2011). In Campeche, six species are reported (Ruiz et al. 2010, Vanoye-Eligio et al. 2014).

Summary

According to this review, a total of 91 species representing 47 genera in the superfamily Vespoidea occur in the state of Campeche. These species represent three families—Formicidae (80 species), Pompilidae (5 species), and Vespidae (6 species). Therefore, the number of species of Vespoidea occurring in Campeche represents 6.3% of the total species recorded from Mexico.

Some species reported from Campeche are also widely reported from other states in the country. For example, *Forelius pruinosus* (Roger) (Formicidae) occurs in 22 states, *Episyron conterminus posterus* Fox (Pompilidae) is reported from 15 states, and the vespid *Brachygastra mellifica* (Say) is reported in 21 Mexican states. In contrast, three species of formicids are only reported from Campeche: *Fulakora degenerata* (Borgmeier), *Rasopone arhuaca* (Forel), and *Pheidole dumicola* (Wilson).

Based on this review, further research is required to identify species richness and ecological roles of Vespoidea wasps in Campeche. It appears that only two

previous studies of Vespoidea were conducted in Campeche, which were mainly focused on Formicidae (Chanatásig-Vaca et al. 2011, Lachaud and Lachaud 2013). The state of Campeche is part of the most important tropical areas and conservation sites in Mexico. So, studies of diversity and ecology of Vespoidea contribute to the knowledge of these insects and their role in agroecosystems in the regulation of pest populations and pollinators of plants of economic importance, as well as in the ecological dynamics of undisturbed environments.

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