

Full Length Research Paper

Natural parasitism of hymenoptera (insect) on bruquids associated with *Fabaceae* seeds in Northern Sinaloa, Mexico

Isiordia-Aquino N.¹, Lugo-García G. A.², Reyes-Olivas A.², Acuña-Soto J. A.³, Arvizu-Gómez J. L.⁴, López-Mora F.⁵ and Flores-Canales R. J.^{1*}

¹Universidad Autónoma de Nayarit, Unidad Académica de Agricultura. Km 9 Carretera Tepic-Puerto Vallarta, Colonia centro, C.P. 63780 Xalisco, Nayarit, México.

²Universidad Autónoma de Sinaloa, Colegio de Ciencias Agropecuarias, Facultad de Agricultura Del Valle Del Fuerte, Calle 16 y Avenida Japaraqui, C.P. 81110 Juan José Ríos, Ahome, Sinaloa, México.

³Instituto Tecnológico Superior de Tlatlaquitepec. Km 122 + 600, Carretera Federal Amozoc – Nautla, C. P. 73907 Almoloni, Tlatlaquitepec, Puebla, México.

⁴Universidad Autónoma de Nayarit, Secretaría de Investigación y Posgrado, Ciudad de la Cultura “Amado Nervo”, C. P. 63000 Tepic, Nayarit, México.

⁵Universidad Autónoma de Nayarit, Posgrado Ciencias Biológico Agropecuarias. Km 9 carretera Tepic-Puerto Vallarta, Colonia centro, C.P. 63780 Xalisco, Nayarit, México.

Received 29 January, 2020; Accepted 13 March, 2020

With the purpose of identifying the parasitic hymenoptera species associated with the diversity of bruchidae over *Fabaceae*, in 2017 seeds of 25 plant species were collected from the municipalities of Ahome, El Fuerte, Choix and Guasave (Sinaloa, Mexico). From 68,344 seeds, 19,396 adult bruquids were obtained, distributed in nine species: *Acanthoscelides desmanthi*, *Callosobruchus maculatus*, *Merobruchus insolitus*, *Mimosestes mimosae*, *Mimosestes nubigens*, *Microsternus ulkei*, *Stator limbatus*, *S. pruininus* and *Zabrotes subfaciatus*. Of the bruchids emerged 4,775 parasitoids, grouped in families Eulophidae (3,159), Braconidae (692), Pteromalidae (443), Eurytomidae (304), Bethyidae (134), Eupelmidae (40), and Trichogrammatidae (3), in 17 species; out of them, *Horismenus depressus*, *Triaspis* sp. and *Eurytoma* sp. had a presence in the four municipalities; 77.84% of the parasitoids was associated with *M. mimosae* (1,352), *A. desmanthi* (898), *M. ulkei* (753), and *M. insolitus* (714). The predominant species was *H. depressus*, with 60.63% of the population. In Ahome the highest parasitism was obtained (40.14%).

Key words: Bruchidae, *Fabaceae*, biological control, parasitism, *horismenus depressus*.

INTRODUCTION

The diversity of plant species included in the *Fabaceae* family are important as timber resources, coal production and human and animal feed; besides that species like

Prosopis juliflora (Sw.) DC. 1825, with drought resistance, prevents soil erosion (Aguado and Suarez, 2006).

In countries such as the United States of North America,

native legumes are a desirable component as plant cover, although seed predation by insects can substantially reduce the cultivation of these species (Boe and Johnson, 2017). Of little known biology, the insects known as brúquidos, weevils or seed beetles (Coleoptera: Bruchidae) represent one of the main regulatory factors of the fabaceae populations (Yus-Ramos et al., 2008). These insects feed mainly on seeds (Johnson, 1989; Luna-Cozar et al., 2002; Romero and Johnson, 2004), where they pass their pupa state; and once they emerge as adults, oviposit various plant seeds belonging to 33 botanical families, with preference over *Fabaceae* and *Convolvulaceae* (Luna-Cozar et al., 2002). Oviposition occurs in the remaining pods of the previous season, which have not fallen. This results in high levels of brúquidos during the following season (Saiz, 1993). These insects, considered as important pests in beans under field and storage conditions (Aebi et al., 2008), are distributed in most continents, for which case, most species are found in tropical regions of Asia, Africa, Central and South America (Ramírez et al., 2013). At present, there are about 1,700 species of turquidos reported. They are distributed in 66 genera, of which, of the 20 genera and 324 species present in Mexico, 90 species correspond to the state of Sinaloa (Lugo-García et al., 2015). Due to their sperm eating habits (Romero, 2002), these insects play an important role in the population regulation of wild plants, with damage to seeds that range between 50 and 100% (Romero and Johnson, 2000). In the particular case of beans, estimated damages have been attributed to 35% in Mexico and Central America, 13% in Brazil and 7.4% in Colombia (Van Schoonhoven and Cardona, 1986). The biological control of pests is related to the use of natural enemies, parasitoids and predators to combat pest insects, which, although not as effective and spectacular as chemical control, is very effective when used opportunely (Gómez and Vargas, 2014), with parasitoids and predators determining the regulation of their host populations in natural ecosystems (Hastings and Godfray, 1999). In the last decade, several successful biological control programs based on parasitoids on noctuid larvae, diamond back palomilla, among others (Godfray, 1994) have been documented. Although this information is relevant, this group of hymenoptera, as well as their biological and economic importance, has been little studied in Northern Sinaloa, with little information on the diversity of families in natural and agricultural ecosystems. Therefore, the objective is to identify the parasitic Hymenoptera species associated with the diversity of Bruchidae over fabaceae in four

municipalities in Northern Sinaloa, Mexico.

MATERIALS AND METHODS

For the study, the diversity of natural vegetation of fabáceas established in the north of Sinaloa was considered, with thorny scrub and coastal dunes over the municipalities of Ahome (located between the geographical coordinates of 26°02'00'' N and 109°01'00'' W) and Guasave (25° 45' 27'' N and 108° 49' 17'' W); as well as spiny forest in the municipalities of El Fuerte (26°27'00.5'' N and 108°35'20.1'' W) and Choix (26°53'10.5'' N and 108°23'13.8'' W) (Figure 1). The locations considered in the study have altitudes ranging from 0 to 115 m, with slopes that vary from slight to steep. The climate is very dry (BW) and dry (BS), with rainfall between 326-607 mm annually; the average temperatures range between 23.5 and 25.6°C, and has monthly extremes of 4.0 and 40.7°C.

In order to obtain bruquidos associated with *Fabaceae*, in accordance with the phenological stage of fruiting of the diversity of plant species, nuts (pods) from the diversity of established plant species were collected during the months of February to December 2017 in the four municipalities. The fruits were deposited in Kraft paper bags model S-13236, individually labeled with data such as location, date, species of fabaceous, etc. The collected material was transferred and conserved in the laboratory of the Entomological Collection of the Valle del Fuerte, of the Autonomous University of Sinaloa (CEVF-UAS). Here after the seeds were separated and deposited in plastic containers of 16.5 x 13 cm, covered with thin tulle cloth to allow air circulation and to prevent the escape of insects, maintained at temperatures of 23°C were checked every third day until adult emergencies were obtained. They were deposited in plastic bottles of 200 ml with 70% ethanol. For the morphological identification of the insects, the genitalia of the males were extracted, which were processed according to what was considered by authors such as Kingsolver (1970) and Kingsolver and Whitehead (1974). Also, the interpretation of genital structures was based on the nomenclature proposed by Romero and Johnson (1999). The material studied was deposited in the CEVF-UAS facilities.

To identify the emerging parasitoids, they were separated and placed in 5 ml polypropylene tubes with 70% ethanol; they were dehydrated with ethanol at different doses of purity (80, 90 and 100%, respectively) for a period 30 min. A subsequent treatment with amyl acetate was carried out to clean and accommodate its wings, antennae and legs for assembly. When the insects were quantified, representative samples of similar morphological characteristics were mounted on entomological pins and were morphologically identified with the help of a stereoscopic microscope, using identification keys of various authors, with corroboration of some species by specialists.

RESULTS

In the period 68,344 seeds were collected (Ahome 20,708, El Fuerte 24,346, Choix 9,860 and Guasave 13,430), from 25 species of *Fabaceae*. From these seeds

*Corresponding author. E-mail: ricardo_flores_uan@hotmail.com. Tel: +3111184365.

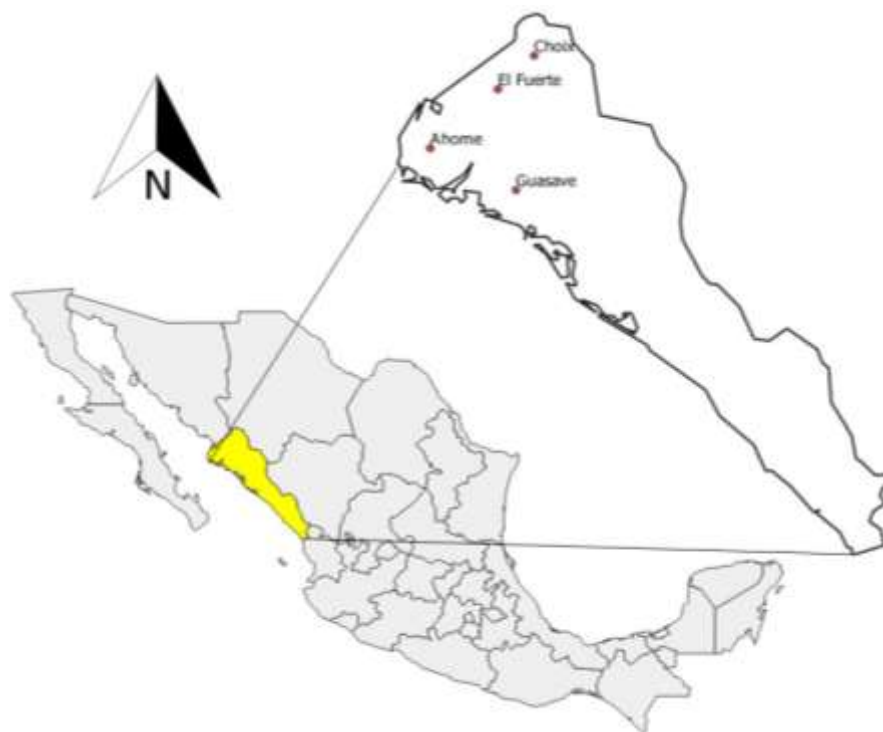


Figure 1. Mexico map showing the sampling area for bruchids in the state of Sinaloa.

Table 1. Monthly comparative of adult bruquids emerged from fabaceas seed in northern Sinaloa, Mexico.

Municipality/Month	E	F	M	A	M	J	J	A	S	O	N	D	Total
Ahome	24	23	53	138	42	394	325	472	693	236	182	48	2,630
El Fuerte	76	56	79	989	578	1,134	964	889	981	1,093	867	83	7,789
Choix	25	19	31	27	111	149	328	476	379	501	322	78	2,446
Guasave	43	36	58	61	248	204	1,188	2,134	967	693	476	423	6,531
Total	168	134	221	1,215	979	1,881	2,805	3,971	3,020	2,523	1,847	632	19,396

Table 2. Monthly emergency battle of adult parasitoids over immature bruquids in northern Sinaloa, Mexico.

Municipality/Month	E	F	M	A	M	J	J	A	S	O	N	D	Total
Ahome	13	58	57	133	190	245	212	223	324	87	136	86	1,764
El Fuerte	5	18	17	46	124	166	69	92	207	389	122	42	1,297
Choix	0	0	0	2	6	28	43	176	192	182	65	56	750
Guasave	0	2	8	4	47	123	127	181	96	168	162	46	964
Total	18	78	82	185	367	562	451	672	819	826	485	230	4,775

emerged 19,396 specimens of adult weevils (Table 1). The relative dominance of emergencies by municipality corresponded to Ahome (7,789), Guasave (6,531), Ahome (2,630) and Choix (2,446), equivalent to 40.16, 33.67, 13.55 and 12.51%, respectively. On a monthly level, the period between the months of July to October

represented 63.51% of emergencies.

In relation to the emergencies of parasitoids from the brúquidos present in the seeds collected in each of the municipalities (Table 2), the dominance in municipalities regarding the number of specimens corresponded to Ahome, El Fuerte, Guasave and Choix, with 36.94,

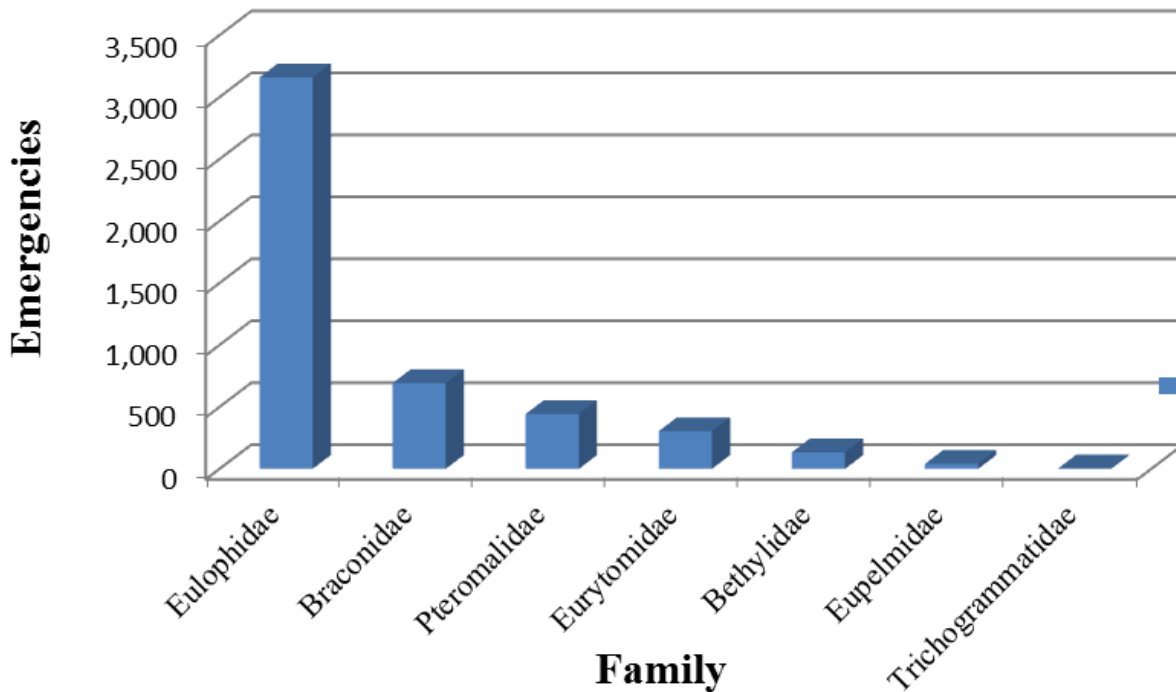


Figure 2. Distribution of parasitoid emergencies by family, associated with bruquids on fabaceae in northern Sinaloa, Mexico.

27.16, 20.19 and 15.71%, respectively. In turn, the highest amount of parasitoids obtained on a monthly level corresponded to the period from May to November, with 4,182 emergencies, equivalent to 87.58% of the population. All parasitic hymenoptera specimens were grouped into two superfamilies: 1. Ichneumonoidea, represented by the Braconidae family (692 specimens: 14.49%) and 2. Chalcidoidea, for the families Eulophidae, Pteromalidae, Eurytomidae, Bethylidae, Eupelmidae and Trichogrammatidae, with 3,159, 443, 304, 134, 40 and 3 emergencies, corresponding to 66.16, 9.27, 6.37, 2.81, 0.84 and 0.06%, respectively (Figure 2).

The emerged parasitoids were obtained from nine species of Bruchidae as prey: *Acanthoscelides desmanthi* Johnson, *Callosobruchus maculatus* (Fabricius), *Merobruchus insolitus* (Sharp), *Mimosestes mimosae* (Fabricius, 1781), *M. nubigens* (Motschulsky, 1874), *M. ulkei* (Horn, 1873), *Stator limbatus* (Horn, 1873), *S. pruininus* (Horn, 1873) and *Zabrotes subfaciatus* (Boheman, 1833) (Table 3). The greatest parasitoid emergencies were obtained from the *M. mimosae* (1,352), *A. desmanthi* (898), *M. ulkei* (753) and *M. insolitus* (714) bruquids, equivalent to 77.84% of the population. From the diversity of Hymenoptera, *Horismenus depressus* (Eulophidae) and *Bruchophagus mexicanus* (Eurytomidae) were identified at the species level, at the genus level at *Heterosphilus* sp. (two species)

(Braconidae), *Triaspis* sp. (Braconidae), *Eurytoma* sp. (Eurytomidae), and at the family level four species of Braconidae, three of Pteromalidae, two of Bethylidae, one of Eupelmidae and one of Trichogrammatidae, for a total of 17 species. The species *H. depressus*, *Triaspis* sp. and *Eurytoma* sp. were distributed in the four municipalities. Also, the species with the greatest diversity of Bruchidae species attacked were *H. depressus* (8) and *Eurytoma* sp. (5). Finally, the predominant species in the study was *H. depressus* with 2,895 specimens, equivalent to 60.63% of emergencies.

DISCUSSION

Boe and Johnson (2017) reported the presence *Acanthoscelides fraterculus* and *Bruchophagus mexicanus* living together in mature pods of *Astragalus plattensis* in northwestern Dakota, USA, with destruction of 44% of the seeds obtained in a sample of 10 pods, by these insects. Aebi et al. (2008) point to weevils of the genus *Zabrotes* as responsible for large economic losses on beans in the field and storage in Mexico and Central America.

Noyes (2013) indicates the presence of 62 *Horismenus* species parasitizing larvae belonging to the orders Lepidoptera, Coleoptera and Hymenoptera, considered

Table 3. Diversity of parasitoids emerged on fabaceas bruquids in northern Sinaloa, Mexico.

Bruchidae species	Parasitoid species	Specimens by municipality ¹			
		Ahome	El Fuerte	Choix	Guasave
<i>Acanthoscelides desmanthi</i> (Johnson, 1977)	<i>Horismenus depressus</i> (Gahan, 1930)	158	260	0	0
	<i>Heterospilus</i> sp. 1 (Haliday, 1833)	0	67	0	0
	<i>Heterospilus</i> sp. 2	0	34	0	0
	Braconidae specie 3 (striated) *	3	1	0	0
	Pteromalidae specie 2 *	0	154	177	0
<i>Callosobruchus maculatus</i> (Fabricius)	<i>Bruchophagus mexicanus</i> (Ashmead, 1894)	0	15	4	0
	<i>Eurytoma</i> sp. Illiger, 1807	8	9	0	0
	Eupelmidae Walker, 1833	1	7	0	0
	Pteromalidae specie 2*	0	27	0	0
<i>Merobruchus insolitus</i> (Sharp, 1885)	<i>H. depressus</i>	199	185	0	167
	<i>Triaspis</i> sp. Haliday	3	2	0	0
	Braconidae specie 4*	1	6	0	0
	<i>Eurytoma</i> sp.	5	12	0	0
	Bethylidae Haliday specie 1*	69	1	0	53
<i>Mimosestes mimosae</i> (Fabricius, 1781)	Bethylidae Haliday specie 2*	8	3	0	0
	<i>H. depressus</i>	20	183	212	12
	<i>Triaspis</i> sp.	165	1	140	3
	Braconidae specie 1*	48	0	89	0
	Pteromalidae specie 1*	16	0	12	0
	Pteromalidae specie 2*	35	8	20	1
	Pteromalidae specie 3*	82	17	38	72
<i>Eurytoma</i> sp.	44	6	119	2	
<i>Mimosestes nubigens</i> (Motschulsky, 1874)	Eupelmidae specie 1*	2	0	5	0
	<i>H. depressus</i>	10	0	0	8
	<i>Heterospilus</i> sp.1	2	0	0	5
	<i>Heterospilus</i> sp. 2	1	0	0	3
	Pteromalidae specie 2*	48	0	0	34
<i>Mimosestes ulkei</i> (Horn, 1873)	<i>Eurytoma</i> sp.	4	0	0	6
	<i>H. depressus</i>	303	46	0	305
<i>Stator limbatus</i> (Horn, 1873)	<i>Triaspis</i> sp.	43	0	0	56
	<i>H. depressus</i>	128	78	0	23
	<i>H. depressus</i>	88	139	127	0
	<i>Heterospilus</i> sp. 1	0	6	0	0
<i>Stator pruininus</i> (Horn, 1873)	Braconidae spp.	4	0	0	0
	Pteromalidae specie 1*	0	9	0	0
	Pteromalidae specie 2*	0	6	8	0
	<i>Eurytoma</i> sp.	22	0	0	0
	Eupelmidae specie 1*	0	12	13	0
<i>Zabrotes subfaciatus</i> (Boheman)	Trichogrammatidae specie 1*	0	3	0	0
	<i>H. depressus</i>	244	0	0	0
Total		1,764	1,297	964	750

1= number of specimens, * unidentified.

primary and secondary hosts. They are distributed in 14 countries of the neotropical region over 10 angiosperm families. Hansson et al. (2004) identified 131 specimens of four *Horismenus* species: *H. butcheri* Hansson Aebi & Benrey, *H. depressus* Gahan, *H. missouriensis* (Ashmead) and *H. productus*, attacking the bruquids *Acanthoscelides obtectus* and *A. obvelatus* Bridwell associated with *Phaseolus coccineus* subsp. *coccineus* and *P. vulgaris* var. *mexicanus* Delgado. Likewise, these authors indicate an emergency of 59.1% of parasitoids (*Horismenus* spp.) from *P. coccineus* seeds infested with *Acanthoscelides* sp. and *Zabrotes* sp. This situation is similar to that obtained in this study, with 57.97% of *H. depressus* emergencies on the *A. desmanthi* and *Z. subfaciatus* in Ahome, El Fuerte and Choix.

In this study, there was a low level of parasitism by braconids on *A. desmanthi* and *C. maculatus* (Ahome and El Fuerte); it was significant on *M. mimosae* (Ahome and Choix) and low on *S. pruininus* (Ahome). In this regard, Campan et al. (2005) studied the influence of three populations of the braconid *Stenocorse bruchivora* (Crawford) on *Z. subfaciatus* in wild and cultivated seeds of *P. vulgaris* of the states of Puebla, Estado de Mexico and Morelos. They did not find any differences between populations and there was a greater parasitism (60%) in wild seeds than in the cultivated ones. This is attributed to both the quality of the host plant as the genetic variation between populations is the crucial factor that determines the nature and evolution of the interaction between parasitoids and their prey.

In Burkina Faso (USA), Sanon et al. (1998) recorded efficient control of *C. maculatus*, responsible for large losses in *V. unguiculata*, through flood releases of *Dinarmus basalis* (Pteromalidae). This is similar to what happened to species of this family in this study, by virtue of having obtained a 100% parasitism on the bruquid in the municipality of El Fuerte, as well as 97.79% parasitism on *A. desmanthi* in Choix; in Ahome and Guasave it registered 73.84 and 62.96% parasitism on *M. nubigenis*.

Although in the study the presence of parasitoids belonging to Eupelmidae was only 40 specimens associated with the species of *A. desmanthi*, *M. mimosae* and *S. pruininus*, in the particular case of species of the genus *Eupelmus* in the Palearctic region, Noyes (2013) points to the orders Coleoptera, Diptera, Hemiptera, Hymenoptera Lepidoptera and Orthoptera. Brúquidos on which they develop like primary or secondary ectoparasitoides of larvae or pupae inside protect habitats like buds, seeds, fruits or gills (Gibson, 1995).

The highest total parasitism percentage was presented by the municipality of Ahome (40.14%), followed by Choix (23.46%), El Fuerte (14.27%) and Guasave (12.86%). The high percentage of parasitism in the first three municipalities may have been due to its great richness in *Fabaceae* species. This is in line with Molina-Ochoa et

al. (2004), who argue that the distribution and rates of natural parasitism may be related to the diversity of habitats with the proximity of forests. It is similar to that obtained in Guasave, by virtue of the fact that the sampled *Fabaceae* are located on the banks of agricultural plots. This could cause the parasitoid population to decrease due to the application of insecticides in agricultural crops. This also agrees with Hajek (2004), considering that insecticides significantly reduce the populations of existing natural enemies in crops.

Conclusion

From 68,344 seeds, 19,396 adult bruquids were obtained, and distributed in nine species: *Acanthoscelides desmanthi*, *Callosobruchus maculatus*, *Merobruchus insolitus*, *Mimosestes mimosae*, *M. nubigenis*, *M. ulkei*, *Stator limbatus*, *S. pruininus* and *Zabrotes subfaciatus*. The 4,775 adult parasitoids obtained were grouped into seven families: Eulophidae (3,159), Braconidae (692), Pteromalidae (443), Eurytomidae (304), Bethyilidae (134), Eupelmidae (40), and Trichogrammatidae (3), distributed in 17 species, of which, *Horismenus depressus*, *Triaspis* sp. and *Eurytoma* sp are present in the four municipalities. 77.84% of the population showed an association with bruquids *M. mimosae* (1,352), *A. desmanthi* (898), *M. ulkei* (753), and *M. insolitus* (714). The predominant species in the study was *H. depressus* (2,895 specimens: 60.63% of the population); also, with a general average parasitism of 19.75%, the greatest impacts corresponded to the municipalities of Ahome and Choix, with 40.14 and 23.46%, respectively.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors appreciate Dr. Beatriz Rodríguez Vélez, of the National Center for Biological Control Reference (CNRCB), under the National Service of Agrifood Health, Quality and Safety (SENASICA), for her contribution in the identification of some species of parasitoids.

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