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Survey for Hymenopteran and Dipteran Parasitoids of the Fall Armyworm (Lepidoptera: Noctuidae) in Chiapas, Mexico[1]

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ABSTRACT A survey of hymenopteran and dipteran parasitoids of the fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) larvae was conducted to determine their occurrence and parasitism rates in Western Chiapas, Mexico. 1247 FAW larvae were collected from whorl-stage corn cornfields in 21 locations in the region called "La Frailesca" in Chiapas, Mexico during the summer of 2002; 251 larvae produced parasitoids for an overall parasitism rate of 20.1%. Five braconids were recovered from FAW larvae, *Rogas vaughani* Muesebeck, *R. laphygmae* Viereck, *Chelonus insularis* Cresson, *C. cautus* Cresson, and *Glyptapanteles militaris* Walsh. Two ichneumonids, *Neotheronia* sp., and *Ophion flavidus* Brulle, and one eulophid, *Euplectrus plathypenae* Howard were recovered. Dipteran parasitoids were also recovered from last instars. These were the tachinids *Archytas marmoratus* Towsend, *Lespesia archippivora* Riley, *Archytas* sp., and *Winthemia* sp. *Megaselia scalaris* Low was a unique phorid recovered. Dipteran parasitoids produced a parasitism rate of 6.3%, and were mostly recovered from 5th and 6th FAW instars. Most of the parasitoid species were recovered from FAW larvae that were collected from corn plants in the V3 growth stage. In this survey, *O. flavidus*, *E. plathypenae*, *Chelonus* spp., and species of *Rogas* (Syn: *Aleiodes*) were the most frequently recovered species in "La Frailesca".

KEY WORDS Fall armyworm, survey of parasitoids, corn growth stages, parasitism rate, occurrence, Hymenoptera, Diptera, Chiapas, Mexico

The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is a highly polyphagous agricultural insect pest. Host plant species for FAW come from a broad diversity of families and include important agricultural

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crops (Andrews 1980). FAW is distributed throughout the Americas and has a tropical-subtropical origin in the western Hemisphere (Sparks 1979). Chemical control of FAW is a common practice using granular and spray insecticide applications; however, currently in agricultural pest control, the adverse effects of the use of insecticides are leading scientists to search for alternatives to chemical control of insect pests based on health, environmental, wild life, and economic concerns (Mattson *et al.* 2000). Biological control has been used for pest management for many years and it has gained renewed interest because of problems caused by the intensive use of pesticides. Most concentrated efforts for biological control appear to be directed towards the "rear and release" augmentation, followed by importation and thirdly by conservation; Lewis et al. (1997) suggested a reversed order of priorities. They maintained that there is a need to understand, promote and maximize the effectiveness of indigenous populations of natural enemies, then based on the knowledge and results of these actions, we should supplement any gaps by importation. In accordance with Lewis et al. (1997), and as a result of economic and environmental concerns, surveys for natural enemies of the FAW, particularly, pathogens, parasitoids and parasites, occurring in the Americas, and the Caribbean Basin have been conducted to develop a better understanding of this complex (Molina-Ochoa et al. 2001, 2003a, 2004).

The occurrence and parasitism rate of FAW larval parasitoids varies considerably between localities, regions, crop practices, plant stage, and years. This information is needed to assess the potential value of the existing larval parasitoid fauna in controlling FAW on corn. In Western Chiapas, Mexico, particularly in the region called "La Frailesca" documentation of the occurrence, diversity and parasitism rates of FAW parasitoids recovered from whorl-stage corn is incomplete or unknown. In this study, we surveyed whorl-stage corn in "La Frailesca" and recorded the occurrence, diversity and parasitism rates of hymenopteran and dipteran parasitoids of FAW larvae, as well as the corn growth stages from which FAW larvae were recovered.

Materials and Methods

This survey was conducted from June–August 2001 in Chiapas, Mexico in the region known as "La Frailesca" which includes the municipalities of Villacorzo, and Villaflores. This region has a tropical wet and dry climate (García 1987).

Twenty one localities were sampled in the municipalities of Villaflores and Villacorzo Chiapas, Mexico; twelve, and nine localities, respectively. The municipality of Villacorzo is located at the coordinates of 16°11′ Latitude North and 93°17′ Longitude West, has an elevation of 580 m, and has a annual mean temperature and mean rainfall of 48.0°C, and 1200 mm, respectively. Coordinates for Villaflores are 16°14′ Latitude North, 93°45 Longitude West. Villaflores has an elevation of 540 m, and has an annual mean temperature and rainfall of 22°C and 1200 mm, respectively. We used a Garmin eTrex (Olathe, KS) GPS to obtain the coordinates, and altitude.

For each locality, 43 larvae were sampled. Each sample consisted of different FAW instars, however the numbers of each instars were not classified. The larvae were collected from whorl-stage cornfields, and they were individually placed into glass flasks of 4.6 × 10.0 cm (diameter and height, respectively), covered on top

with fine screen from which the parasitoids did not go through the mesh. The larvae were fed with pieces of fresh corn leaves about 20 cm^2 which were replaced every 36 hours until pupation, and held at 25°C, 80% RH, and a photoperiod of 12:12 (L:D) h in the laboratory until parasitoid emergence. Coconut fiber was used as a substrate for pupation when the larvae reached the prepupal stage. For each larva collected, the corn growth stage was recorded according to Ritchie et al. (1992).

The parasitoids that emerged from the larvae and pupae were recorded every 24 h. For the dead larvae or pupae where nothing emerged, no dissections were made to examine for dead parasitoids. Percent of parasitism was calculated according Pair et al. (1986). Parasitoids were identified using the Manual for Identification of Parasitoids of Agricultural Pests in Central America (Cave 1995) and later submitted to the USDA-ARS Systematic Entomology Laboratory, Beltsville MD for confirmation of the identification.

Results and Discussion

In this study, out of the 1247 FAW larvae collected from whorl-stage corn, 251 larvae produced parasitoids, for a percent parasitism of 20.1%. One hundred fifty three larvae died from unknown causes, possibly unidentified pathogens or injury during handling.

Nine species of hymnopterous parasitoids were identified. Five species belonged to the family Braconidae: *Rogas vaughani* (Muesebeck), *R. laphymae* (Viereck), *Chelonus cautus* (Cresson), *Chelonus insularis* (Cresson), and *Glyptapanteles militaris* (Walsh.); three species belonged to the family Ichneumonidae: *Neotheronia* sp., *Pristomerus* sp., and *Ophion flavidus* (Brulle); and only one species belonged to the family Eulophidae: *Euplectrus plathypenae* (Howard) (Table 1).

Five species of dipteran parasitoids were recovered from FAW last instars and pupae; they belonged to the families Tachinidae and Phoridae. Tachinid parasitoids identified were *Archytas marmoratus* (Townsend), *Lespesia archippivora* (Riley), *Archytas* sp., and *Winthemia* sp. The unique phorid parasitoid recovered was *Megaselia scalaris* (Loew.) (Table 1).

According to the occurrence and percent of parasitism, the most prevalent parasitoids were *O. flavidus*, *E. plathypenae*, *R. vaughani*, and *A. marmoratus*. They occurred in 19, 18, 11, and 6 of the 21 localities sampled in this survey, and caused 5.77, 3.53, 1.36, and 1.60% of parasitism, respectively (Table 1). However, *L. archippivora* played an important role in the parasitism caused by tachinids (1.52%). The ichneumonid *Neotheronia* sp. occurred in four localities causing low mortality rates less than 0.32%. This is the first report of *Neotheronia* sp. as a larval parasitoid of *S. frugiperda*. A phorid parasitoid, *M. scalaris*, emerged from pupae of FAW from five localities, and caused a percent parasitism of 1.04% (Table 1). Something to highlight is that the complex of the genus *Archytas* totalized 3.04% of parasitism, almost comparable to the percent parasitism caused by *E. plathypenae* (3.53%) a eulophid parasitoid frequently reported in previous surveys conducted in Mexico (Molina-Ochoa et al. 2001, 2004). The braconids were more frequently recovered from young instars of FAW collected from corn plants in the V2–V3 stage of growth; most ichneumonids were recovered from third to fifth instars parasitizing corn plants in the growth stages

Table 1. Occurrence and percent parasitism of hymenopteran and dipteran parasitoids of Fall Armyworm larvae collected in cornfields in whorl-stage in "La Frailesca", Chiapas, Mexico.

Family and species	NLO*	Instar attacked	% parasitism	Corn growth stage
Braconidae				
Rogas vauganhi Muesebeck	11	1^{st}, 2^{nd}	1.36	V2, V3
Rogas laphygmae Viereck	5	1^{st}, 2^{nd}	0.56	V2, V3
Chelonus cautus Cresson	5	1^{st}	0.48	V3
Chelonus insularis Cresson	8	1^{st}	1.20	V2, V3
Glyptapanteles militaris Wash.	4	3^{rd}, 5^{th}	0.32	V2, V3
Ichneumonidae				
Neotheronia sp.	4	5^{th} **	0.32	V2, V3
Pristomerus sp.	3	3^{rd}, 4^{th}	0.24	V3, V4
Ophion flavidus Brulle	19	3^{rd}, 4^{th}, 5^{th}	5.77	V2, V3, V4
Eulophidae				
Euplectrus plathypenae Howard	18	1^{st}, 2^{nd}	3.53	V2, V3, V4
Tachinidae				
Archytas marmoratus Townsend	6	Pupae£	1.60	V3, V4
Archytas sp.	6	Pupae£	1.44	V3, V4, V5
Lespesia archippivora Riley	5	5^{th}, Pupae£	1.52	V4
Winthemia sp.	5	Pupae£	0.72	V3, V4
Phoridae				
Megaselia scalaris Low.	5	Pupae£	1.04	V4

*Number of localities of occurrence.
**Collected from FAW last instar, Pupae£ parasite recovered from FAW pupae.

from V2–V4, and the dipteran parasitoids were recovered from last instars and pupae obtained from corn plants in V3–V5 (Table 1).

The most important parasitoid in this survey was *O. flavidus* due to its widespread occurrence and high larval parasitism rates (≈5.8%) (Table 1). It has been reported from Argentina, Brazil, Honduras, Mexico, Nicaragua, and the US (Molina-Ochoa et al. 2003b). Previous reports of percent of parasitism of *O. flavidus* against FAW larvae ranged from 4.8% to 9.6% (Molina-Ochoa et al. 2001). Most of our results are between those ranges, with only three exceptions. *O. flavidus* has been reported attacking the fourth, fifth, and sixth instars of FAW with equal success (Gross & Pair 1991). We most frequently collected larvae parasitized by *O. flavidus* from corn plants in the V2, V3, and V4 growth stages in both municipalities.

The second most frequently recovered and important parasitoid in this survey was *E. plathypenae*. Its rate of parasitization was about 3.5%. Molina-Ochoa et al. (2001) found a similar percent parasitism in a survey conducted in the western coast of Mexico. It was more frequently recovered from FAW larvae collected from corn plants in the growth stages V2, V3, and V4. This parasitoid has been reported from Barbados, Brazil, Chile, Colombia, Cuba, Guyana, Lesser Antilles, Mexico, Nicaragua, Puerto Rico, Trinidad, and the US (Molina-Ochoa et al. 2003b).

Rogas vaughani caused 1.36% of parasitism most in first and second FAW instars. It has been reported to attack FAW larvae in Honduras, and Nicaragua (Maes 1989, Wheeler et al. 1989, Cave 1993) and other lepidopterous pests such as *Helicoverpa zea* (Boddie), *Peridroma saucia* (Hbn), *P. margaritosa* (Haworth), *Trichoplusia ni* (Hbn), *Spodoptera exigua* (Hbn), *Alabama argillacea* (Hbn), and *Prodenia ornithogalli* (Guenee) in North America, Tapachula Chiapas, Mexico, and Central America (DeCoss et al. 1977, Marsh 1978, Butler et al. 1982, King & Saunders, 1984).

Rogas laphygmae ≈ *Aleiodes laphygmae* (Viereck), has been reported to occur in Brazil, Chile, Honduras, Mexico, Nicaragua, Puerto Rico, and US (Molina-Ochoa et al. 2003b). It was reported to attack lepidopterous pests such as *Autographa* sp., *Feltia subterranean* (F.), *H. zea*, *P. saucia*, *Pseudaletia unipuncta* (Haw.), *Spodoptera eridania* (Cram.), *S. exigua*, *S. frugiperda*, *Agrotis subterranean* (Cram), and *Colias eurytheme* (Boisduval). It was well distributed in North, South, and Central America (Marsh 1978, King & Saunders 1984). This species was reported also to attack L1–L3 stages of *S. exigua* in Georgia, US (Ruberson et al. 1993, Ruberson et al. 1994), and it was found on first, and second instars collected from corn plants in the V1 stage; however, in this survey it occurred more in V2, and V3, causing 0.56% of parasitism.

The braconid, *C. insularis* caused low parasitism rate about 1.2%. Similar percent parasitism was reported by Molina-Ochoa et al. (2001). Luginbill (1928), and Vickery (1929) indicated that *C. insularis* was an important parasitoid controlling FAW populations in its overwintering habitats of Florida and Southern Texas. This parasitoid is reported to attack eggs and larvae of noctuids such as *F. subterranean*, *P. saucia*, *T. ni*, *H. zea*, *S. eridania*, *S. exigua*, *S. frugiperda*, *S. ornithogalli*, *S. praefica*, and the pyralids, *Loxostege stictidalis* (L.), *Ephestia eleutella* (Hbn), and it is distributed in the US (Ashley et al. 1980, 1982, 1983; Ashley 1986, Butler et al. 1982, Pair et al. 1986, Andrews 1988), Africa, and Hawaii (Marsh 1978), and Venezuela (Notz 1972). In this survey, *C. insularis* was found in FAW larvae collected from V2, and V3 corn. *C. cautus* also was found in V3 corn in five localities, but its distribution in this survey was less frequent than *C. insularis*, and its percent parasitism was never higher than 0.48% (Table 1). Molina-Ochoa et al. (2001) reported percents parasitism of *Chelonus* (probably *cautus*) of 11% and 10%, in one sample conducted in Colima and another in Jalisco, respectively. This braconid has been reported to occur in Honduras, and Mexico attacking FAW eggs and larvae (Cave 1993, Canas & O'Neil 1998, Molina-Ochoa et al. 2001). In this survey, the parasitoid was recovered from third instars collected from corn plants in the V3 growth stage (Table 1).

Glyptapanteles militaris and *Pristomerus* sp. were the braconid and ichneumonid parasitoids with the lowest occurrence with 0.4% and 0.24%, recovered from V2 and V3, and V3, and V4 corn growth stages, respectively (Table 1). *Neotheronia* sp. an ichneumonid occurred in four localities causing mortality rates less than 2.5%. This is the first report of *Neotheronia* sp as a parasitoid of FAW.

The results of this survey suggest that the parasitoid complex functioning in cornfields of Chiapas has the capacity to cause a significant reduction of the FAW larval populations. The results of this survey sustain that the parasitoid complex is a valuable component of the tropical agroecosystems, even though the rate of parasitism exhibited by each parasitoid species is variable among localities and

collections. In our survey parasitoid species diversity was greatest when FAW larvae were collected from cornfields in the growth stage V3.

In this survey, *O. flavidus*, *E. plathypenae*, *Chelonus* spp., and species of *Rogas* (Syn: *Aleiodes*) played a low suppressing role on the FAW larval populations in both municipalities of Chiapas. However, these parasitoids are well adapted to the environmental conditions of Western Chiapas and frequently occurred in most of the localities sampled. Something important to consider in this survey is that we did not dissect dead larvae and pupae to examine for dead parasitoids. Therefore, the actual percent parasitism could have been higher than what we report in this study. Because percent parasitism was usually less than 6%, there is potential to increase parasitism by mass releasing parasitoids. Additional studies of the behavior and ecology of these parasitoids are needed.

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