Natural parasitism of *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) in four departments in Paraguay

Parasitismo natural de *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae), en cuatro departamentos de Paraguay

Claudia C. Cabral-Antúnez¹*, Bolívar Garcete², Rocío I. Montiel-Cáceres³, Alexis B. Gonzalez-Vega³, Sergio R. Cárdenas⁴, Nancy Armoa⁴ and María Bernarda Ramírez de López⁴

*Corresponding author: claudia_c_cabral@hotmail.com

Received: 25 October 2018 - Accepted: 23 November de 2018

1 Universidad Nacional de Asunción, Facultad de Ciencias Agrarias, Asunción, Paraguay
2 Universidad Nacional de Asunción, Facultad de Ciencias Exactas y Naturales, Asunción, Paraguay

**Abstract**

The impact produced by natural enemies on culture pests is a very important factor to consider at the moment of evaluating control methods. In this context, the characteristic fauna of a region and its influence on a particular pest are relevant data. This paper records the occurrence of parasitoids naturally associated with the fall army worm *Spodoptera frugiperda* (Smith, 1797) and their percentual impact calculated from rearing larvae of the host collected during the period 2015 – 2016 in Paraguay in the departments of Caaguazú, Alto Paraná, Canindeyú and Itapúa. The parasitoids recorded were: *Dissomphalus* spp. (Hymenoptera: Bethylidae), *Exasticolus fuscicornis* Cameron (Hymenoptera: Braconidae), *Ophion* spp. (Hymenoptera: Ichneumonidae), *Archytas* spp. (Diptera: Tachinidae) and *Winthenia* spp. (Diptera: Tachinidae).

**Resumen**

El impacto que los enemigos naturales producen sobre las plagas de cultivos es un factor importante a tener en cuenta en el momento de evaluar los métodos de control a aplicar. En este contexto, la fauna propia de una región y su influencia sobre una plaga en particular son datos relevantes. Este artículo reporta la ocurrencia de parasitoides asociados de manera natural al gusano cogollero *Spodoptera frugiperda* (Smith, 1797) y su impacto porcentual calculado en la base de cría de larvas del hospedero recolectados durante el periodo 2015 - 2016 en Paraguay en los departamentos de Caaguazú, Alto Paraná, Canindeyú e Itapúa. Los parasitoides registrados fueron: *Dissomphalus* spp. (Hymenoptera: Bethylidae), *Exasticolus fuscicornis* Cameron (Hymenoptera: Braconidae), *Ophion* spp. (Hymenoptera: Ichneumonidae), *Archytas* spp. (Diptera: Tachinidae) y * Winthenia* spp. (Diptera: Tachinidae).
Introduction

The cultivation of maize (*Zea mays* L.) in Paraguay is second in importance after soybeans, both in surface area (950,000 ha) and in grain production (4,985,881 Mg). The departments of Alto Paraná, Canindeyú, Itapúa, and Caaguazú are the leading producers of maize, accounting for 74.8% of the area sown (DCEA, 2015). One of the main phytosanitary problems of this crop is the armyworm (*S. frugiperda*). The most widely used control method is the application of chemical products, which is often inefficient, in addition to increasing production costs and generating problems such as pest resistance and environmental contamination. In the search for alternatives to control this pest, the use of parasitoids arises as a strategy and an opportunity to protect the crop.

There are registers of the presence of *Chelonus* sp., *Chelonus cautas* Cresson, 1872; *Chelonus insularis* Cresson, 1865; *Cotesia* sp.; *Cotesia marginiventris* Cresson, 1865; *Meteorus laphygmae* Viereck, 1913 and *Exasticolus* sp. (Hym., Braconidae), *Pristomerus spinator* Fabricius, 1804; *Campoletis flavicincta* Ashmead, 1890 and *Ophion* sp. (Hym., Ichneumonidae) and *Archytas incertus* Giglio-Tos, 1893; *Archytas marmoratus* Townsend, 1915 and *Lespesia archippivora* Riley, 1871 (Dip., Tachinidae) (Dequech et al., 2004; Figueiredo et al., 2006 a, b; Cruz et al., 2009; Gutiérrez et al., 2013; Estrada et al., 2013). Because of the lack of information on parasitoid species associated with the armyworm in Paraguay, the objective of this study was to verify the occurrence of parasitoids that act as natural biological control agents of *S. frugiperda* larvae in the main maize producing departments.

Material and methods

Sampling points

Larvae of *S. frugiperda* from different instars were collected in corn crops in the 2014/2015 and 2015/2016 agricultural years, the number of larvae collected was variable. The collections were made in four departments: Caaguazú, Alto Paraná, Canindeyú and Itapúa, which are the central corn producing departments in Paraguay. The data of temperature, precipitation, altitude, localities sampled by department and number of samples collected are presented in table 1.

Table 1. Department, Temperature, precipitation, altitude, sampled localities and number of samples made in the agricultural years 2014/2015 and 2015/2016. Paraguay, 2018.

| Department  | Average temperature (°C) | Average precipitation (mm) | Average altitude (msnm) | Number of locations sampled and (number of samples) |
|-------------|--------------------------|----------------------------|-------------------------|----------------------------------------------------|
| Canindeyú   | 21.92                    | 1587.95                    | 268.37                  | 10 (1009)                                          |
| Caaguazú    | 22.06                    | 1592.71                    | 236.06                  | 6 (1015)                                           |
| Alto Paraná | 21.22                    | 1630.01                    | 260.02                  | 8 (905)                                            |
| Itapúa      | 21.41                    | 1720.16                    | 180.65                  | 10 (1115)                                          |

Larvae collection

The number of points sampled (table 1) was variable according to the presence of the pest. The gathering was carried out in each batch in a random manner, and an average of 100 *S. frugiperda* larvae was collected. The larvae collected in the field were identified in situ by morphological characteristics, then placed in 50 mL falcon tubes and placed in containers to be transferred to the Entomology laboratory of the Plant Protection Area of the Faculty of Agricultural Sciences of the Universidad Nacional de Asunción. Once in the laboratory, the larvae of *S. frugiperda* were reared in plastic tubes (4.5 cm diameter x 7.5 cm long), with a temperature of 25 ± 5°C, HR 70 ± 10% and a photoperiod of 12 hours. The larvae were fed with corn leaves, which were replaced daily until the larvae completed their cycle or until the emergence of the parasitoids, the observations were made daily. The adult parasitoids were located in alcohol 70% labeled and identified.
Identification of parasitoids

The parasitoids were separated in order and family using the taxonomic keys of Evans (1964), Achtenberg (1979), Wharton et al. (1997), Brown et al. (2010), López-Martínez et al. (2011) and Rafael et al. (2012). Then the identification of gender and species was made in the laboratory of the Facultad de Ciencias Exactas y Naturales (FACEN, by its acronym in Spanish). The evaluations were based on the diversity and frequency of the parasitoid species emerged by location. The percentage of parasitism was calculated according to the formula proposed by García et al. (2013).

\[
\text{\% Parasitism} = \frac{\text{Number of Parasitized Larvae}}{\text{Number of useful Larvae (Total)}} \times 100
\]

Where:
Number of Useful Larvae: difference between larvae recollected and killed by handling, leak or disease.
Number of Parasitized Larvae: only from useful larvae, whether the parasitoid emerged or not.

Results and Discussion

In the surveys carried out in the different departments, seven species of parasitoids were identified (table 2), the species collected and the percentage of parasitism obtained varied, depending on the locality and department. The rates of parasitism varied between 1.85 and 38.46%, occurring parasitism in all the areas sampled. The highest number of species collected was obtained in the departments of Canindeyú and Caaguazú, and the lowest diversity was observed in Itapúa.

The average percentage of parasitism in the department of Canindeyú was 14.80 % (table 3), with similar percentages found by Murúa et al. (2006) with 15% parasitism in the Argentine Northwest and 13.22 % in Yucatan-Mexico by Delfín et al. (2007).

Table 2. Parasitoids of S. frugiperda in the agricultural years 2014/2015 and 2015/2016, in the departments of Alto Paraná, Canindeyú, Itapúa, and Caaguazú. 1. Alto Parana 2. Caaguazu 3. Canindeyu 4. Itapúa.

| Orden       | Family   | Sub family | Species                | Locality |
|-------------|----------|------------|------------------------|----------|
| Hymenoptera | Braconidae| Cheloniinae| Chelonus sp.           | 1 2 3 4   |
|             |          | Homolobinae| Exasticolus fuscicornis| x x x     |
|              |          |            | Glyptapanteles militaris| x        |
|              |          | Ichneumonidae| Ophion sp.       | x x x     |
|              |          | Bethylidae | Dissomphalus spp.     | x         |
| Diptera     | Tachinidae| Tachininae| Archytas sp.          | x x x x   |
|              |          | Goniinae   | Winthenia sp.         | x x x x   |

The highest percentage of natural parasitism was 41.38 % in a harvest carried out by a small producer in the Curuguaty district. This higher percentage could be due to the fact that this producer had a polyculture in its premises and this regard, Figueiredo et al. (2006a) and Souza (2015), mention that a greater diversity of species of parasitoids is observed in polycultures, production system characteristic of small producers, however in large areas of monocultures an adverse influence is observed in relation to the presence of parasitoids. The species of parasitoids in the department of Canindeyú were: Dissomphalus spp. (Hymenoptera: Bethylidae), Exasticolus fuscicornis Cameron (Hymenoptera: Braconidae), Ophion spp. (Hymenoptera: Ichneumonidae), Archytas spp. (Diptera: Tachinidae) and Winthenia spp. (Diptera: Tachinidae) (table 2). Dissomphalus spp., Has not been reported as a parasitoid of S. frugiperda, this specimen constitutes the first record of this species associated with the armyworm in Paraguay. According to Redighieri and Azevedo (2006), Dissomphalus is the most abundant genus of the Bethylidae family in tropical forests and has a wide distribution in the Brazilian Atlantic Forest.
Table 3. Municipality, coordinates, number of larvae collected, number of useful larvae, parasitized and percentage of natural parasitism of *S. frugiperda* in the Department of Canindeyu, Paraguay. NLC = number of larva collected; ULN = useful larva number; % p = parasitism percentage.

| Collection | Municipality | Coordinates                  | NLC | ULN | NLP | % P  |
|------------|--------------|-------------------------------|-----|-----|-----|------|
| 1          | Curuguaty    | S -24°28'56.4" W -055°37'16.4" | 79  | 53  | 8   | 15.09|
| 2          | Yvyrarovana  | S -24°24'00.7" W -055°07'35.6" | 111 | 48  | 17  | 35.42|
| 3          | Yvyrarovana  | S -24°20'21.1" W -055°07'13.2" | 105 | 47  | 4   | 8.51 |
| 4          | Yvyrarovana  | S -24°22'16.6" W -054°58'59.9" | 125 | 78  | 12  | 15.38|
| 5          | Yvyrarovana  | S -24°22'11.4" W -055°07'16.7" | 75  | 59  | 2   | 3.39 |
| 6          | Yvyrarovana  | S -24°18'12.4" W -054°58'34.5" | 95  | 36  | 5   | 13.89|
| 7          | Curuguaty    | S -24°15'44.3" W -055°43'53.5" | 90  | 54  | 1   | 1.85 |
| 8          | Curuguaty    | S -24°15'38.0" W -055°43'50.7" | 115 | 70  | 9   | 12.86|
| 9          | Curuguaty    | S -24°15'27.6" W -055°43'53.7" | 114 | 29  | 12  | 41.38|
| 10         | Curuguaty    | S -24°15'35.0" W -055°44'08.2" | 100 | 80  | 12  | 15.00|
| Total      |              |                               | 1009| 554 | 82  | 14.80|

In the Department of Caaguazú (table 4), the average percentage of parasitism was 20.25 %, similar to those found by Dequech *et al.* (2004), Murúa *et al.* (2006), Murúa *et al.* (2009), Silva *et al.* (2011), Ordóñez *et al.* (2015a) and Ordóñez *et al.* (2015b) who obtained parasitism of 22.01; 19.94; 18.93; 2.3; 18.20 and 22.08 % respectively, in countries of America. Meanwhile, it is considered low when compared to the works of García *et al.* (2013), who mention parasitism of 62.40 % and 48.46 % respectively in Mexico. The percentage varied between 15.32 % in the municipality from February 3 to 36.45 % in the town of Dr. J. M. Frutos, which could be considered as acceptable since a large amount of non-selective chemical products is used in the area. Of the total of 152 emerged parasitoids, with five identified species (table 2), the species *Glyptapanteles militaris* was the most common in the repatriation and February 3, *Archytas sp.* was the most abundant in Yroura and Campo 9, while in Dr. J. M. Frutos the species with the highest number of emerged parasitoids was *Winthenia* sp. and in Caaguazú the most abundant was *Opion* sp.

In the department of Alto Paraná, there was natural parasitism of 16.73 % (table 5), varying from 2.56 % (Itakyry) to 38.46 %. The average value could be considered low when comparing the results presented by Dequech *et al.* (2004), Pérez (2008) and Ordóñez *et al.* (2015a). For the Alto Paraná localities, the most abundant species was *Exasticolus fuscicornis*, while the least abundant was *Chelonus* sp. (table 1).

The average percentage in the department of Itapúa was 19.3% (table 6), the value similar to those presented by Molina *et al.* (2004), Silva *et al.* (2011) and García *et al.* (2013). The lowest percentage of parasitism was obtained in the municipality of Pirapó (5.50 %) and Natalio (5.90 %), while the highest value was obtained in the municipality of Edelira (37.50 %). The Low values levels may be related to the use of non-selective chemicals applied continuously in the area. In the monitored localities, the most abundant species was *Winthenia* sp. followed by *Archytas* sp., while the least abundant species was *Opion* sp. These results agree with the works of Murúa *et al.* (2006), which mention the Tachinidae family as the most abundant in Argentina. The species *Chelonus* sp., *Exasticolus fuscicornis*, *Glyptapanteles militaris; Opion* sp.; *Archytas* sp. and *Winthenia* sp. found in this research, have already been reported as parasitoids of *S. frugiperda* and other noctuids (Cave, 1993; Dequech *et al.*, 2004; Estrada *et al.*, 2013; Gutierrez *et al.*, 2013), in countries such as Brazil, Mexico, Honduras, Cuba. The exception is the species *Dissomphalus* spp., This being the first record of parasitoids in larvae of *S. frugiperda*.

It should be noted that these species have been reported as natural parasitoids. However, they are not produced on a large scale, and basic studies are needed to determine their potential as biological controllers as a basis for mass production.
Table 4. Municipality, coordinates, number of larvae collected, useful larvae, parasitized and percentage of natural parasitism of *S. frugiperda* in the Department of Caaguazú, Paraguay. NLC = number of larva collected; ULN = useful larva number; % p = parasitism percentage.

| Collection | Municipality | Coordinates       | NLC  | NLU  | ULN  | % P  |
|------------|--------------|-------------------|------|------|------|------|
| 1          | Caaguazú     | S -25°27'20.60'' W -055°59’00.83'' | 190  | 138  | 24   | 17.39|
| 2          | Dr. Frutos   | S -25°19'52.02'' W -055°51’12.48'' | 225  | 96   | 35   | 36.45|
| 3          | Yhú          | S -25°17'08.60'' W -055°58’32.13'' | 215  | 96   | 17   | 17.70|
| 4          | Campo 9      | S -25°22'53.14'' W -055°40’10.91'' | 120  | 56   | 9    | 16.07|
| 5          | Repatriación | S -25°32’07.51” W -055°40’10.91” | 55   | 30   | 6    | 20   |
| 6          | 3 de Febrero | S -55°13’40.47” W -055°46’56.56” | 210  | 137  | 21   | 15.32|
| Total      |              |                   | 1015 | 553  | 112  | 20.25|

Table 5. Municipality, coordinates, number of larvae collected, useful larvae, parasitized and percentage of natural parasitism of *S. frugiperda* in the Department of Alto Paraná, Paraguay. NLC = number of larva collected; ULN = useful larva number; % p = parasitism percentage.

| Collection | Municipality | Coordinates       | NLC  | ULN  | NLP  | % P  |
|------------|--------------|-------------------|------|------|------|------|
| 1          | Dr. Mallorquin | S-25° 27’ 19” W-55° 13’ 05” | 38   | 26   | 6    | 7.69 |
| 2          | Yguazú       | S-25° 22’ 40” W-54° 55’ 29” | 15   | 6    | 5    | 6.41 |
| 3          | Hernandarias | S-25° 16’ 03” W-54° 51’ 13” | 102  | 45   | 11   | 14.1 |
| 4          | Itakyry      | S-25° 01’ 24” W-55° 00’ 09” | 55   | 38   | 2    | 2.56 |
| 5          | Mbarakayú    | S-25° 05’ 32” W-54° 57’ 26” | 164  | 86   | 10   | 12.82|
| 6          | Minga Porã   | S-24° 53’ 42” W-54° 56’ 35” | 285  | 130  | 30   | 38.46|
| 7          | San Alberto  | S-24° 56’ 15” W-54° 56’ 47” | 84   | 41   | 5    | 6.41 |
| 8          | Santa Fé     | S-25° 16’ 53” W-54° 43’ 23” | 162  | 100  | 9    | 11.53|
| Total      |              |                   | 905  | 472  | 78   | 16.73|

Table 6. Municipality, number of larvae collected, useful larvae, parasitized and percentage of natural parasitoidism of *S. frugiperda* in the Department of Itapúa, Paraguay. NLC = number of larva collected; ULN = useful larva number; % p = parasitism percentage.

| Collection | Municipality | Coordinates       | NLC  | ULN  | NLP  | % P  |
|------------|--------------|-------------------|------|------|------|------|
| 1          | Pirapó       | S-26°30’03 Ð “ W-055°41’29” | 73   | 55   | 3    | 5.45 |
| 2          | Capitán Miranda | S-27°02’97” W-055°57’19” | 29   | 18   | 4    | 22.22|
| 3          | Fram         | S-27°09’00” W-055°49’23” | 60   | 40   | 10   | 25   |
| 4          | La Paz       | S-27°04’89” W-055°30’74” | 46   | 23   | 3    | 13.04|
| 5          | Obligado     | S-27°04’27” W-055°38’18” | 29   | 17   | 4    | 23.53|
| 6          | Hohenau      | S-27°07’22” W-055° 51’20” | 77   | 39   | 5    | 12.82|
| 7          | Capitán Meza | S-26°50’06” W-055°30’50” | 37   | 27   | 5    | 18.52|
| 8          | María Auxiliadora | S-26° 46’20” W-055°16’34” | 318  | 231  | 27   | 14.33|
| 9          | Edelira      | S-26°37’15.0” W-055°19’50” | 39   | 24   | 9    | 37.50|
| 10         | Natalio      | S-26°45’35” W-055°10’20” | 407  | 272  | 16   | 5.88 |
| **Total**  |              |                   | 1115 | 746  | 86   | 11.53|
Conclusions

Based on the results in the different departments where the gathering was made, it can be concluded that the natural occurrence of parasitoids in the cultivation of corn constitutes essential components of the regulation of the pest population, and the conservation of the same, through ecological management.

Seven species of *S. frugiperda* parasitoids were found, represented by the following four families and their respective species, Braconidae: *Chelonus* sp., *Exasticolus fuscicornis*, *Glyptapanteles militaris*; Ichneumonidae: *Ophion* sp.; Bethylidae: *Dissomphalus* spp and Tachinidae: *Archytas* sp. and *Winthenia* sp.

Natural parasitism varied between departments, being 14.8 %; 20.25 %; 16.73 % and 11.53 % for the departments of Canindeyú, Caaguazú, Alto Paraná and Itapúa, respectively.

References

Achterneng, C. 1979. A revision of the subfamily Zelinae auct. (Hymenoptera, Braconidae). *Tijdschrift voor Entomologie* 122 (7): 241-479.

Brown, B., Borkent, A., Cumming, J., Wood, N., Woodley, N. and Zumbado, A. 2010. *Manual of Central American Diptera*. Resench Press, Otawa.

Cave, R. 1993. Parasitoides larvales y rurales dé *Spodoptera frugiperda* (Smith) (Lepidoptera:Noctuidae) en Centro América con una clave para las especies encontradas en Honduras. *Revista CEIBA*. 34(1): 33 – 56.

Cruz, I., Figueiredo, M., Silva, R., Del Sarto, M. and Penteado-Dias, A. 2009. Monitoramento de parasitoides de lagartas de *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera:Noctuidae) em Municípios de Minas Gerais, Brasil. Siete Lagunas. EMBRAPA Maiz y Sorgo, Siete Lagunas.

DCEA (Dirección de Censos y Estadísticas Agropecuarias, Py). 2015. Estimación de superficie, producción y rendimiento de cultivos agrícolas del Paraguay. Ministerio de Agricultura y Ganadería.

Dequech, S., da Silva, R. and Fiuza, L. 2004. Ocorrência de parasitóides de *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae) en lavouras de milho em Cachoeirinha, RS. Ciência Rural. 34 (4): 1235 – 1237. Disponible en: http://www.scielo.br/pdf/cr/v34n4/a42v34n4.pdf. Accesed July 20, 2014.

Delfín-González, H., Bojorquez-Acevedo, M. and Manrique-Saide, P. 2007. Parasitoids of fall armyworm (Lepidoptera: Noctuidae) from a traditional maize crop in the mexican state of Yucatan. *Florida Entomologist* 90(4): 759-761.

Estrada-Virgen, O., Cambero-Campos, J., Robles-Bermudez, A., Rios-Velasco, C., Carbajal-Casola, C., Isiordia-Aquino, N. and Ruiz-Cancino, E. 2013. Parasitoides y entomopatógenos nativos asociados al gusano cogollero *Spodoptera frugiperda* (Lepidoptera: Noctuidae) en Nayarit, México. *Southwestern Entomologist* 38 (2): 339-344.

Evans, H. 1964. A sinapsis de the American Bethylidae (Hymenoptera, Aculeata). *Bulletin of the Museum of Comparative Zoology* 132 (1):1 – 222.

Figueiredo, M., Martins- Dias, A. and Cruz, I. 2006 a. Associação entre inimigos naturais e *Spodoptera frugiperda* (J. E. Smith 1797) (Lepidoptera: Noctuidae) na cultura do milho. *Revista Brasileira de milho e sorgo*. 5 (3): 340 -350.

Figueiredo, M., Martins- Dias, A. and Cruz, I. 2006 b. Relação entre a lagarta-do-cartucho e seus agentes de controle biológico natural na produção de milho. Pesquisa agropecuaria brasileira. 41(12):1693-1698.

García, C. González, M. and González, A. 2013. Parasitismo natural de Braconidae e Ichneumonidae (Hymenoptera) sobre *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Revista Colombiana de Entomología. 39 (2): 211-215.

Gutiérrez, A., Robles, A., Cambero, J., Santillan, C., Ortiz, M., Coronado, J. and Campos, M. 2013. Parasitoide de *Spodoptera frugiperda* (Lepidóptera: Noctuidae) encontrados en Nayarit, México. *Southwestern Entomologist*. 40 (3): 555-564. 2013.

López, V., Saavedra, M., Delfin, H., Figueroa, J. and García, M. 2011. A new species of the genus *Exasticolus* van Achterbeng (Hymenoptera: Braconidae: Homolobinae) from Mexico. *Studies on Neotropical Fauna and Environment*. 46(1):59-62.

Molina, J., Carpenter, J., Lezama, R., Foster, J. and González, M. 2004. Natural distribution of Hymenopteran parasitoids of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae in Mexico. *Florida Entomologist*. 87 (4): 461-472.

Murúa, G., Molina, J. and Fidalgo, P. 2009. Natural distribution of parasitoids of larvae of the fall armyworm, *Spodoptera frugiperda*, in Argentina. *Journal of Insect Science*. 9(20):1-17. 2009.
Ordoñez, M., Rios, C., Berlanga, D., Acosta, C., Salas, M. and Cambero, J. 2005 a. Occurrence of natural enemies of Spodoptera frugiperda (Lepidoptera: Noctuidae) in Chihuahua, México (en línea). Florida Entomologist. 98 (3): 843 – 847.

Ordoñez, M., Bustillos, J., Loya, J., Ríos, C. and Jacobo, J. 2015 b. Parasitoides de Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae) en Chihuahua, México. Métodos en ecología y sistemática. 10(1): 67-78.

Pérez, E. 2008. Control biológico de Spodoptera frugiperda Smith en maíz. INISAV: Habana.

Rafael, J., Melo, G., de Carvalho, C., Constantino, R. 2012. Insetos do Brasil: Diversidade e Taxonomia. Holos Edit., Ribeirão Preto.

Redighieri, E. and Azevedo, C. 2006. Fauna de Dissomphalus Ashmead (Hymenoptera, Bethylidae) da Mata Atlântica Brasileira, com descrição de 23 espécies novas. Revista Brasileira de Entomologia. 50(3): 297-334.

Silva, F., Cruz, I., Figueiredo, M., Costa, M., Redoan, A. and Morato, J. 2011. Dinâmica populacional de parasitoides de Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae) en milho (Zea mays L.) cultivado no sistema orgânico de produção. Cadernos de Agroecologia. 6(2): 1 - 5.

Souza, A. 2015. Diversidade de himenópteros parasitoides en agroecossistemas. Maestria em Zoologia, Universidad de Brasilia, Brasilia, Brasil.

Wharton, R., Marsh, P. and Sharkey, M. 1997. Manual of the new world genera of the Family Braconidae (Hymenoptera). Madison: USA.

How to cite: Cabral-Antúnez, C.C., Garcete, B., Montiel-Cáceres, R.I., Gonzalez-Vega, A.B., Cárdenas S.R., Armoa, N. y María Ramírez de López, M.B. 2018. Parasitismo Natural de Spodoptera frugiperda (Smith) (Lepidoptera: Noctuidae), en cuatro departamentos de Paraguay. Intropica 13(2): 130-136. DOI: http://dx.doi.org/ 10.21676/23897864.2655.