Note

New record of *Tetrastichus howardi* (Olliff) as a parasitoid of *Diatraea saccharalis* (Fabr.) on maize

Ivan Cruz[1]*; Ana Carolina Redoan[1]; Rafael Braga da Silva[2]; Maria de Lourdes Corrêa Figueiredo[1]; Angélica Maria Penteado-Dias[2]

[1]*Embrapa Milho e Sorgo – Laboratório de Criação de Insetos, C.P. 151 – 35701-970 – Sete Lagoas, MG – Brasil.*
[2]*UFSCar – Programa de Pós-graduação em Ecologia e Recursos Naturais, C.P. 676 – 13565-905 – São Carlos, SP – Brasil.*
**Corresponding author <ivancruz@cnpms.embrapa.br>*

ABSTRACT: *Diatraea saccharalis* (Fabr.) (Lepidoptera: Pyralidae) spends the largest part of its life cycle inside the stalk of the host plant,which provides protection against the action of conventional control methods. Biological control has been considered a viable alternative to control this pest in sugarcane (*Saccharum officinarum* L.) and corn (*Zea mays* L.), two pest preferential hosts. This paper reports the occurrence in Brazil of *Tetrastichus howardi* (Olliff) (Hymenoptera; Chalcidoidea: Eulophidae) parasitizing pupae of *D. saccharalis* obtained from corn plants. It also includes preliminary biological data about the insect. A single female of *T. howardi* is able to produce up to 66 offspring using a single pupa of the host *D. Saccharalis* and apparently does not distinguish between the host pupae of different ages. The life cycle of the parasitoid was around 25.5 days. The presence of the parasitoid in Brazil opens a new perspective on suppression of the sugarcane borer, considering the promising results already obtained in Asian countries. The insect is well adapted to laboratory conditions, can be produced in large scale and may became an additional option for the integrated pest management in those crops where *D. saccharalis* is a key pest such as the sugarcane, corn and sorghum (*Sorghum bicolor* (L.) Moench).
Key words: biological control, host-parasitoid interactions, maize pest, sugarcane borer, parasitism

Novo registro de *Tetrastichus howardi* (Olliff) como parasitóide de *Diatraea saccharalis* (Fabr.) em milho

RESUMO: *Diatraea saccharalis* (Fabr.) (Lepidoptera: Pyralidae) passa a maior parte de seu ciclo biológico no interior do colmo da planta hospedeira, onde fica protegida contra a ação dos métodos convencionais de controle. O controle biológico tem sido considerado uma alternativa viável para o controle desta praga em cana-de-açúcar (*Saccharum officinarum* L.) e milho (*Zea mays* L.), dois hospedeiros preferenciais. Este trabalho relata a ocorrência no Brasil de *Tetrastichus howardi* (Olliff) (Hymenoptera, Chalcidoidea: Eulophidae) parasitando pupas de *D. saccharalis* em colmos de plantas de milho. Ele também inclui dados preliminares sobre alguns aspectos biológicos do parasitóide. Uma fêmea de *T. howardi* foi capaz de produzir até 66 descendentes em uma única pupa do hospedeiro e, aparentemente, não faz distinção entre diferentes idades da pupa. O ciclo de vida do parasitóide foi ao redor de 25,5 dias. A presença do parasitóide no Brasil abre uma nova perspectiva sobre a supressão da broca da cana, considerando os resultados promissores já obtidos em países asiáticos. O inseto é bem adaptado à condição de laboratório, podendo ser produzido em grande número, tornando assim, uma opção adicional para o manejo integrado nas culturas onde *D. saccharalis* é praga chave, tais como a cana-de-açúcar, milho e sorgo (*Sorghum bicolor* (L.) Moench).
Palavras-chave: controle biológico, interação parasitóide-hospedeiro, pragas de milho, broca da cana-de-açúcar, parasitismo

Introduction

The demand for corn (*Zea mays* L.) and sorghum (*Sorghum bicolor* (L.) Moench) has increased the cultivated area of these cereals as well as the problems with their insect pests (Sertkaya et al., 2004; Figueiredo et al., 2006ab). *Diatraea saccharalis* (Fabr.) (Lepidoptera: Pyralidae) is a key pest of sugarcane (*Saccharum officinarum* L.) and has also become a very important pest for corn and sorghum in Brazil (Cruz, 2007). Due to its main habit of feeding inside the plant stalk, conventional control measures through chemical foliar spraying have not achieved sufficient control levels. In sugarcane fields in Brazil the control of this pest is achieved through the release of natural enemies. Biological control programs for *D. saccharalis* in Brazilian regions, covering a total area of 2.3 million hectares, have been implemented with the parasitoids *Cotesia flavipes* Cameron (Hymenoptera: Braconidae), *Metagonistylum minense* Towns and *Paratheresia claripalpis* Wulp (Diptera: Tachinidae) (Botelho, 1992).

Tetrastichinae is the largest subfamily of Eulophidae with hosts in more than 100 families of insects of different orders (La Salle, 1994; La Salle and Schauff, 1995).

Tetrastichus howardi (Olliff) (Hymenoptera; Chalcidoidea: Eulophidae) is a gregarious pupal parasitoid which has been recorded as a primary parasitoid or facultative hyperparasitoid associated with a great number of Lepidoptera pest species of important crops (Baitha et al., 2004; Prasad et al., 2007; La Salle and Polaszek, 2007). The parasitoid was introduced in South Africa for the control of two key Lepidoptera pests, the borers *C. partellus* and *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), both species being severe pests of corn and sorghum in that country (Skoroszewski and Van Hamburg, 1987; Kfir, 2001; Rao et al., 2001).

This study reports the occurrence of *T. howardi* from pupa of *D. saccharalis* collected in maize stalks in Brazil. It also includes preliminary data about the insect biology.

Material and Methods

Routine surveys in maize fields were conducted in Sete Lagoas, Minas Gerais State, Brazil. *Diatraea saccharalis* were collected at different phases of development, during November 2007, resulting in two pupae which were parasitized. Specimens of the parasitoid were identified by Dra. Angélica M. Penteado-Dias and Dr. John La Salle as *Tetrastichus howardi* (Olliff) (Hymenoptera; Chalcidoidea: Eulophidae). Since then, a culture of this species has been maintained on pupae of *D. saccharalis* and *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae).

Three experiments were conducted. In the first one, twenty pupae of *D. saccharalis* obtained from larvae reared on artificial diet were placed in individual test tubes (10 × 2.5 cm, closed with cotton) together with one female and one male of *T. howardi* for a 24 h period. Pupae were replaced daily for four consecutive days. After each 24 h period the parasitized pupae were removed to other similar tubes and kept in the same environment in which they were previously. After emergence, parasitoids were sexed and counted. The second experiment was conducted to evaluate the effect of the age of *D. saccharalis* pupa on the number of emerging parasitoid adults. Using methodology similar to the one used in the previous experiment, twenty pupae of *D. saccharalis* of one, two, four and six days-old were placed in individual test tubes together with a pair of recently emerged adults of *T. howardi*, for a period of 24 h. The experiments were conducted in an acclimatized room (temperature of 25 ± 1ºC, UR of 70 ± 10% and photophase of 12 hours). Finally, in the third experiment ten males and ten females newly-emerged from host were individually placed inside test tube without food and host to determine longevity. The experimental design for all experiments was a complete randomized design with 20 replications and four treatments in the first and second experiments (respectively, infestation time and pupa age) and ten replications and two treatments (sex longevity) in the last experiment.

The data were analyzed by one-way Analysis of Variance (ANOVA) through the computer program SISVAR (Ferreira, 2000) and treatment means were compared with the Scott-Knott test ($p = 0.05$) (Scott and Knott, 1974).

Results and Discussion

The average number of parasitoids which emerged from each *D. saccharalis* pupa was 66.4 ± 22.7, 36.0 ± 11.0, 21.3 ± 12.3 and 47.7 ± 28.0, for days one to four of the experiment, respectively. The number of parasitoids obtained in the first day was higher than that obtained in the remaining days ($p < 0.05$). There was no difference between the number of parasitoids obtained from infestation held in the second and fourth day ($p > 0.05$). According to Moore and Kfir (1995a), 35% of female *T. howardi* lay eggs in the first 24 h after emergence. After 48 h that index was up to 80%. Moore and Kfir (1995a) concluded that *T. howardi* has a pre-oviposition period varying of 2 h to five days.

No effect of pupal age on number of emerged parasitoids was observed in the second experiment: 49.2 ± 13.0, 41.5 ± 11.3, 50.3 ± 12.5 and 54.7 ± 12.0 individuals per pupa of *D. saccharalis*, respectively ($p > 0.05$). According to Moore and Kfir (1995b), the parasitoid also did not show any preference for the age of the host pupa, when comparing pupae from one to five days old of the species *C. partellus* and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae).

The sex ratio was strongly female biased at 0.81 ± 0.12. Males of *T. howardi* emerge first and stay close to the host pupa waiting the emergence of the females to mate, as pointed out by González et al. (2003). However, Moore and Kfir (1995a) observed that 35.3% of emerged females which were separated from males at emergence still produced both female and male offspring, indicating mating inside the host pupa before the female emerged. Unfertilized female produce only male offspring.

The life cycle of the parasitoid (considered the period from oviposition to adult emergence) was 25.5 ± 3.2 days. The longevity of male (4.3 ± 1.0 days) was lower than the longevity of female (10.0 ± 1.0 days) ($p < 0.05$). According to Kfir et al. (1993), without host contact, but with regular feeding with honey and water, females survived 19.4 ± 1.1 days and males 12.6 ± 0.9 days. On the other hand, in the presence of the host, the values were 23.6 ± 2.8 for females and 16.7 ± 3.4 days for males. According to González et al. (2003) the female of *T. howardi* deposits about 30 eggs inside the pupa of *D. saccharalis*. After hatching, the larva molts three times before transforming into a pupa. The pupal period of the parasitoid represents more than 50% of the life cycle of the insect, being therefore, an interesting characteristic of its biology that can be explored in the mass rearing procedure.

Tetrastichus howardi is a primary parasitoid or facultative hyperparasitoid associated with insect pests of the

order Lepidoptera, especially various cereal stem borers. These include *D. saccharalis*, as well as important pests which do not currently occur in Brazil, such as *Eldana* sp. (Lepidoptera: Pyralidae) (La Salle and Polaszek, 2007; Moore and Kfir, 1995a; Polaszek and La Salle, 1995) and *C. partellus* (Rao et al., 2001).

Although this parasitoid is capable of acting as a hyperparasitoid, there is evidence that facultative hyperparasitoids can still be effective components of successful biological control systems (Polaszek and La Salle, 1995). The insect is adapted to its host search strategy and is able to penetrate plant and search for hosts the galleries produced by the pests. This is a characteristic suggested as a pre-requirement to be a good biological control agent of borers (Kfir et al., 1993). Additional important attributes of the parasitoid are its short life cycle, high fecundity rate and longevity, preponderance of females and relative easy for mass rearing in laboratory condition as pointed out by Kfir et al. (1993), Baitha et al. (2004) and Prasad et al. (2007).

Conclusion

The species *T. howardi*, found in association with the corn borer *D. saccharalis* in Brazil, can be an additional option for the integrated pest management in those crops where the insect is a key pest such as the sugarcane, corn and sorghum.

Acknowledgements

To Brazilian Institute of Science and Technology - Hymenoptera Parasitoid of Southeast Region (HYMPAR/ Sudeste-CNPq/FAPESP/CAPES) and FAPEMIG, for the financial support. Thanks to Dr. John La Salle for helping in species identification.

References

Baitha, A.; Jalali, S.K.; Rabindra, R.J.; Venkatesan, T.; Rao, N.S. 2004. Parasitizing efficiency of the pupal parasitoid, *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae) on *Chilo partellus* (Swinhoe) at different exposure periods. Journal of Biological Control 18: 65-68.

Botelho, P.S.M. 1992. Fifteen years of biological control of *Diatraea saccharalis* using parasitoids. Pesquisa Agropecuária Brasileira 27: 255-262. (in Portuguese, with abstract in English).

Cruz, I. 2007. The Sugarcane Borer, *Diatraea saccharalis*, in Corn in Brazil. Embrapa-CNPMS, Sete Lagoas, MG, Brazil. 12 p. (Embrapa-CNPMS (Circular Técnica, 91). (in Portuguese).

Ferreira, D.F. 2000. SISVAR system for statistical analysis: a handbook for guidance. UFLA, Lavras, MG, Brazil. 37 p. (in Portuguese).

Figueiredo, M.L.C.; Martins-Dias, A.M.P.; Cruz, I. 2006a. *Exasticolus fuscicornis* in *Spodoptera frugiperda* larvae. Pesquisa Agropecuária Brasileira 41: 1321-1323. (in Portuguese, with abstract in English).

Figueiredo, M.L.C.; Martins-Dias, A.M.P.; Cruz, I. 2006b. Relationship between fall armyworm larvae and its natural biological control agents in maize yield. Pesquisa Agropecuária Brasileira 41: 1693-1698. (in Portuguese, with abstract in English).

González, J.F.A.; Oca, F.N.M.; Ravelo, H.G. 2003. Bio-ecological studies of *Tetrastichus howardi* Olliff. (Hymenoptera: Eulophidae), pupal parasite of *Diatraea saccharalis* (Fabr) (Lepidoptera: Crambidae) in Cuba. Centro Agricola 30: 37-41. (in Spanish, with abstract in English).

Kfir, R.; Gouws, J.; Moore, S.D. 1993. Biology of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae): a facultative hyperparasitoid of stem borers. Biocontrol Science and Technology 3: 149-159.

Kfir, R. 2001. Prospects for biological control of the stem borer *Chilo partellus* in grain crops in South Africa. Insect Science and its Application 21: 275-280.

La Salle, J. 1994. North American genera of Tetrastichinae (Hymenoptera: Eulophidae). Journal of Natural History 28: 109-236.

La Salle, J.; Polaszek, A. 2007. Afrotropical species of the *Tetrastichus howardi* species group (Hymenoptera: Eulophidae). African Entomology 15: 45-56.

La Salle, J.; Schauff, M.E. 1995. The Chalcidoid families. Eulophidae. In: Hanson, P.E.; Gauld, I.D., eds. The Hymenoptera of Costa Rica. Oxford University Press, New York, NY, USA.

Moore, S.D.; Kfir, R. 1995a. Aspects of the biology of the parasitoid, *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). Journal of African Zoology 109: 455-466.

Moore, S.D.; Kfir, R. 1995b. Host preference of the facultative hyperparasitoid *Tetrastichus howardi* (Hym.: Eulophidae). Entomophaga 40: 69-76.

Polaszek, A.; La Salle, J. 1995. The hyperparasitoids of cereal stem borers in Africa (Hymenoptera: Ceraphronidae, Encyrtidae, Eulophidae, Eurytomidae; Lepidoptera: Noctuidae, Pyralidae. African Entomology 3: 131-146.

Prasad, K.S.; Aruna, A.S.; Kumar, V.; Kariappa, B.K. 2007. Feasibility of mass production of *Tetrastichus howardi* (Olliff), a parasitoid of leaf roller (*Diaphania pulverulentalis*), on *Musca domestica* (L.). Indian Journal of Sericiculture 46: 89-91.

Rao, G.M.V.P.; Ramani, S.; Singh, S.P. 2001. Field parasitization of the maize stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in Bangalore. Journal of Biological Control 15: 193-195.

Scott, A.J.; Knott, M.A. 1974. A cluster analysis method for grouping means in the analysis of variance. Biometrics 30: 507-512.

Sertkaya, E.; Bayram, A.; Kornosor, S. 2004. Egg and larval parasitoids of the beet armyworm *Spodoptera exigua* on maize in Turkey. Phytoparasitica 32: 305-312.

Skoroszewski, R.W.; Van Hamburg, H. 1987. The release of *Apanteles flavipes* (Cameron) (Hymenoptera: Braconidae) against stalk-borers of maize and grain sorghum in South Africa. Journal of the Entomological Society of Southern Africa 50: 249-255.

Received November 23, 2009
Accepted August 18, 2010