

Natural Biological Control of *Diaphania* spp. (Lepidoptera: Crambidae) by Social Wasps

by

Paulo Antônio Santana Júnior¹, Alfredo Henrique Rocha Gonring², Marcelo Coutinho Picanço¹, Rodrigo Soares Ramos¹, Júlio Cláudio Martins¹
& Dalton de Oliveira Ferreira¹

ABSTRACT

The social wasps (Hymenoptera: Vespidae) are important agents of biological control for agricultural pests. *Diaphania hyalinata* L. and *Diaphania nitidalis* Cramer (Lepidoptera: Crambidae) are among the main pests of plants in the Cucurbitaceae family. Although the importance of social wasps is acknowledged, little is known about their activity as biological control agents in *Diaphania* spp. Thus, this work aimed to study the natural biological control of the caterpillars *D. hyalinata* and *D. nitidalis* by social wasps. We studied the natural biological control of caterpillars of *D. hyalinata* and *D. nitidalis* on cucumber hybrids Sprint 440 II and Vlasstar. The main predators of *Diaphania* caterpillars were the social wasps, followed by Diptera: Syrphidae; Hemiptera: Anthocoridae; Coleoptera: Coccinellidae, Anthicidae; Neuroptera: Chrysopidae and Arachnida: Araneae. Predation of *D. hyalinata* caterpillars by social wasps was high from the second to fifth instar. The predation of *D. nitidalis* caterpillars by social wasps was high from the second to fourth instar. There was no predation by social wasps on the first instar larvae of *Diaphania* spp. The cucumber hybrids did not influence the predation of *Diaphania* spp. by social wasps. The main social wasp predator of *Diaphania* spp. was *Polybia ignobilis* (Haliday). Also, we observed the social wasp *Polybia scutellaris* (White) preying on *D. hyalinata* but at low intensity.

Key words: Social insects, Vespidae, *Diaphania hyalinata*, *Diaphania nitidalis*, Cucurbitaceae, predators.

INTRODUCTION

The family Vespidae has social and solitary species. The social Vespidae belong to three subfamilies: Stenogastrinae, Polistinae and Vespinae (Car-

¹ Federal University of Viçosa, Department of Entomology, 36570-000, Viçosa, MG, Brazil, ²DuPont do Brasil S.A. *E-mail: picanço@ufv.br

penter 1991). Stenogastrinae is the smallest of social subfamilies and it has about 50 species and six genera. It occurs in Asia and Oceania (Carpenter & Kojima 1997). The subfamily Polistinae has more than 900 described species and it occurs in Europe and the Americas (Carpenter *et al.* 1996). The Vespinae have about 60 species and 40 genera and occur in the Northern Hemisphere (O'Donnell 1998).

The colonies of social Vespidae are arranged in nests that have few or hundreds of individuals. In the social organization of individuals Vespidae belongs to castes. In this social organization there is a division of labor that allows greater efficiency in caring for their offspring and in locating and gathering resources. In the nests there are one or few queens, sterile workers (who usually do not differ morphologically from queens), young (eggs, larvae and pupae) and drones. The queens have reproductive function and control of the colony. The workers look after the colony and collect the resources used in the nests. The drones mate with queens during nuptial flights and afterwards they die (Richter 2000, Kasper *et al.* 2004).

During foraging, Vespidae workers collect water, plant fibers, carbohydrates and proteins. Water and fiber are used for nest building. The carbohydrate sources used by Vespidae are: nectar, fruit pulp and plant sap. The nectar can be converted into honey. Honey is a source of food reserves. The adult workers chew their prey and feed the larvae by trophallaxis. As adults are unable to eat solid food the larvae regurgitate a solution containing carbohydrates and protein for the feeding of adult workers (Richter 2000, Kasper *et al.* 2004).

The food consumed by the social Vespidae is important in maintaining the colonies, especially protein intake. The proteins used by the social Vespidae are obtained mainly by predation on insects by their workers. Their main prey are insects of the order Diptera, Hemiptera, Hymenoptera and Lepidoptera (Gobbi & Machado 1986, Richter 2000). Thus, the social Vespidae are considered important agents of biological pest control (Picanço *et al.* 2010, Picanço *et al.* 2011). Among the major pests of Cucurbitaceae (pumpkin, squash, luffa plant, bur cucumber, cucumber, melon and watermelon) are *Diaphania hyalinata* L. and *Diaphania nitidalis* Cramer (Lepidoptera: Crambidae) (Bacci *et al.* 2006). The caterpillars of these species cause damage to plants by feeding on leaves, stems, flowers and fruits. These pests occur in South America (Gonring *et al.* 2003a, 2003b), Central America

(King & Saunders 1984) and North America (Penã *et al.* 1987). Although the importance of social wasps is acknowledged, little is known about their activity as biological control agents of *Diaphania* spp. Thus, this work aimed to study the natural biological control in the caterpillars of *D. hyalinata* and *D. nitidalis* by social Vespidae.

MATERIAL AND METHODS

This work was conducted in a cucumber crop in Viçosa (20°48'45"S, 42°56'15"W, altitude of 660m), Minas Gerais State, Brazil from April to July 2000. In the cultivation of cucumber hybrids Sprint II 440 (dark green fruit for fresh consumption) and Vlasstar (light green fruit for fresh consumption or as pickles) were used. The experimental design was randomized blocks with five replications. The repetition had six rows of nine plants. Thus, each repetition had 54 plants. No pesticides were applied to the crop, and conventional cultivation practices were employed, according to Filgueira (2000).

In each repetition, 20 plants were infested with caterpillars. The plants were about 60 days old when they were infested. Ten of these plants were infested with *D. hyalinata* and the other 10 plants were infested with *D. nitidalis*. The plants were subdivided into five groups of two plants. Each plant in the group was infested with 10 larvae from one of five larval instars. Therefore, each repetition received 100 larvae of each *Diaphania* species. The infestation was carried out in the third leaf from the top of the branch. Those plants received a tag identifying the species and instar of *Diaphania* with which it was infested. The caterpillars used were obtained from laboratory rearing. This creation was conducted according to Pratisoli *et al.* (2008).

During each instar, the mortality of *Diaphania* caterpillars was monitored. From sunrise to sunset we evaluated the causes of death to each caterpillar. Predators observed preying on caterpillars were recorded according to their morphospecies. In unmarked plants, individuals of the predator morphospecies were collected and assembled. Later on, after the change of instar, the caterpillars that were not dead were collected in plastic pots of 500 mL. The pots were taken to laboratory for evaluation of parasitized caterpillars. The emerged parasitoids were collected. In the laboratory the caterpillars were reared according Pratisoli *et al.* (2008). Specimens of predators and parasitoids were identified in the Entomological Museum of the Federal University

of Viçosa. The average mortality of *Diaphania* caterpillars were calculated from the experimental data. We also calculated the 95% confidence intervals of mortality rates.

RESULTS AND DISCUSSION

Predators were the group of natural enemy that caused higher mortality in *Diaphania* spp. caterpillars. These natural enemies were responsible for 98% of the natural mortality of larvae of *D. hyalinata* and *D. nitidalis* (Fig. 1A). The observation of a higher natural biological control in *Diaphania* by predators than by parasitoids is due to several factors. Among the factors that contribute to the high efficiency of the predators are: search capability, consumption of prey, adaptability to the environment and competitiveness. The increased competitiveness of predators makes them often prefer to consume parasitized prey (Reis Jr. *et al.* 2000), or they consume larvae of parasitoids within herbivorous insects (Leite *et al.* 2001).

We observed that the main group of predators of *Diaphania* spp. caterpillars were the social Vespidae, followed by Diptera: Syrphidae; Hemiptera: Anthocoridae; Coleoptera: Coccinellidae, Anthicidae; Neuroptera: Chrysopidae and Arachnida: Araneae. We also observed parasitism on caterpillars by Diptera: Tachinidae and Hymenoptera: Braconidae (Fig. 1B). The superiority of natural control in *Diaphania* spp. by the social Vespidae is likely due to their social organization, search capabilities and competitiveness. The social organization of Vespidae enables the division of labor between the components of the colony. This fact allows the wasps to locate their prey more efficiently and they capture a greater number of prey. Other authors found that the social Vespidae are also the most important predators of caterpillars such as *Ascia monuste* (Godart) (Pieridae) (Picanço *et al.* 2010), *Leucoptera coffeella* (Guérin-Ménéville) (Lyonetiidae) (Pereira *et al.* 2007a, Pereira *et al.* 2007b) and *Tuta absoluta* (Meyrick) (Gelechiidae) (Picanço *et al.* 2011).

Due to the importance of social Vespidae as natural enemies of *Diaphania* spp. caterpillars their populations should be preserved or even increased in crops. Among the practices for preserving these predators are: the application of insecticides with physiological selectivity, the selective use of pesticides and reduced applications. The use of insecticides that show physiological selectivity is important because these products are effective in controlling pests and

they are somewhat toxic to natural enemies. In this context, Picanço *et al.* (1998) found that deltamethrin, permethrin and trichlorfon show ecological selectivity in favor of the social Vespidae.

The selective use of insecticides reduces the contact of natural enemies with these products. For the social wasps this can be achieved by the ap-

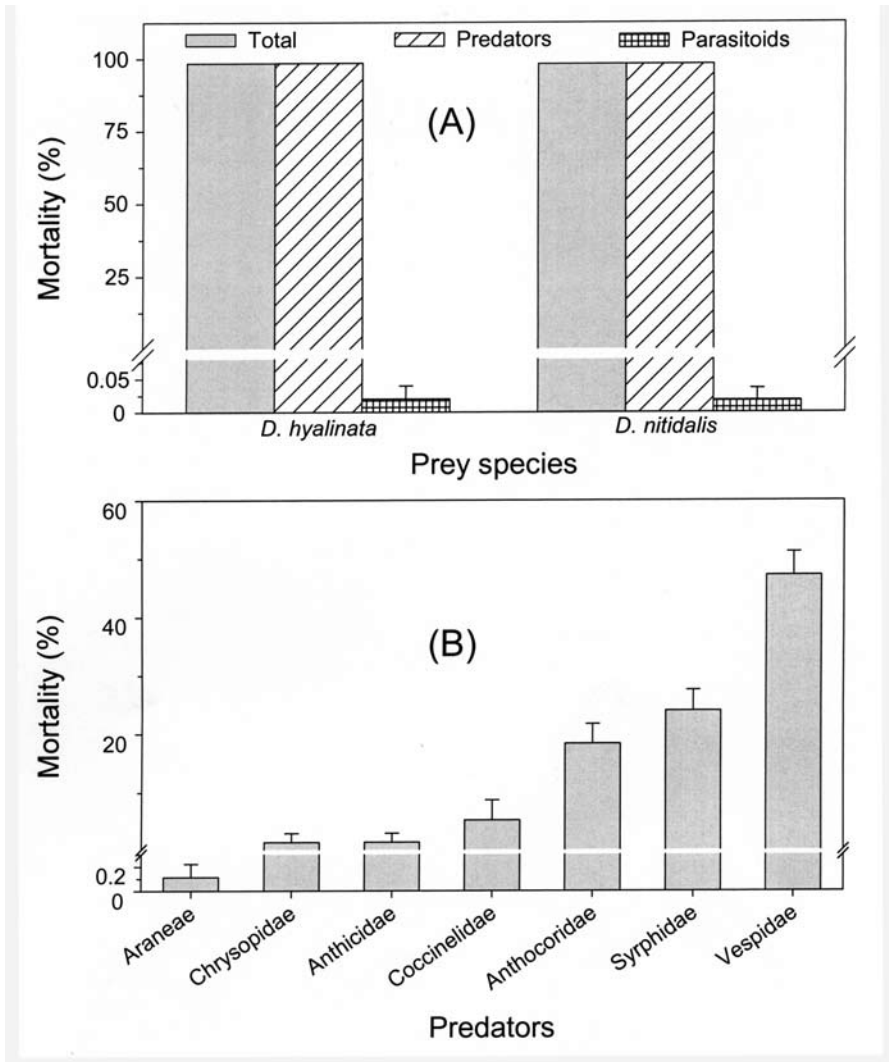


Fig. 1. (A) Factors of mortality and (B) predators of *Diaphania* spp. caterpillars. Brackets indicate 95% Confidence interval.

plication of pesticides during periods of low visitation of these predators to crops such as during times of lower air temperature (Picanço *et al.* 2010 Picanço *et al.* 2011). The reduction of pesticide use can be obtained by the use of decision-making systems to control application of pesticides (Bacci *et al.* 2008). Vespidae populations can be increased by providing food for these predators by planting flowering plants next to crops (Paula *et al.* 2004), preserving the forests that have trees that are the main nesting sites of the wasps (Picanço *et al.* 2010, Picanço *et al.* 2011) and transferring of Vespidae nests to crop sites (Prezoto & Machado 1999).

Predation of *D. hyalinata* by social wasps was high for 2nd, 3rd, 4th and 5th instar caterpillars. The predation of *D. nitidalis* by social wasps was high for 2nd, 3rd and 4th instars. There was no predation of first instar larvae in either *Diaphania* species by social wasps (Fig. 2A and 2B). The caterpillars increase the body mass as they grow and the wasps preferentially prey on the larger caterpillars, which represent a greater food resource and are more easily located. Corroborating this hypothesis Picanço *et al.* (2010) and Picanço *et al.* (2011) also observed that Vespidae do not catch first instar larvae of *A. monuste* and *T. absoluta*.

Among the fifth instar caterpillars, there was higher predation in *D. hyalinata* than *D. nitidalis* (Figs. 2A and 2B). This was possibly due to the location of these two species of *Diaphania* caterpillars during their larval instars. Caterpillars of *D. hyalinata* in all instars remain on the leaves, and are thus exposed to predation by social wasps (Gonring *et al.* 2003b). Conversely, *D. nitidalis* caterpillars in the last instar migrate into the interior of the fruit (Gonring *et al.* 2003a) thereby minimizing exposure to predation by social Vespidae.

The type of cucumber hybrid did not influence predation of *D. hyalinata* and *D. nitidalis* caterpillars by social wasps (Fig. 3A). This is possibly due to the fact that these predators primarily use chemical and visual cues in prey location and selection of prey. Corroborating this hypothesis Picanço *et al.* (2011) found that social Vespidae use visual and tactile signals in location and selection of *T. absoluta* larvae on tomato plants.

The main species of social Vespidae we observed preying on larvae of *D. hyalinata* and *D. nitidalis* was *Polybia ignobilis* (Haliday). We also observed the wasp *Polybia scutellaris* (White) preying on larvae of *D. hyalinata* at low

intensity, and this wasp was not observed preying *D. nitidalis* (Fig. 3B). The predominance of predation of *Diaphania* by *P. ignobilis* is possibly due to the abundance of this wasp in various vegetation in both natural and cultivated areas (Hermes & Köhler 2006, Elpino-Campos *et al.* 2007, Picanço *et al.*

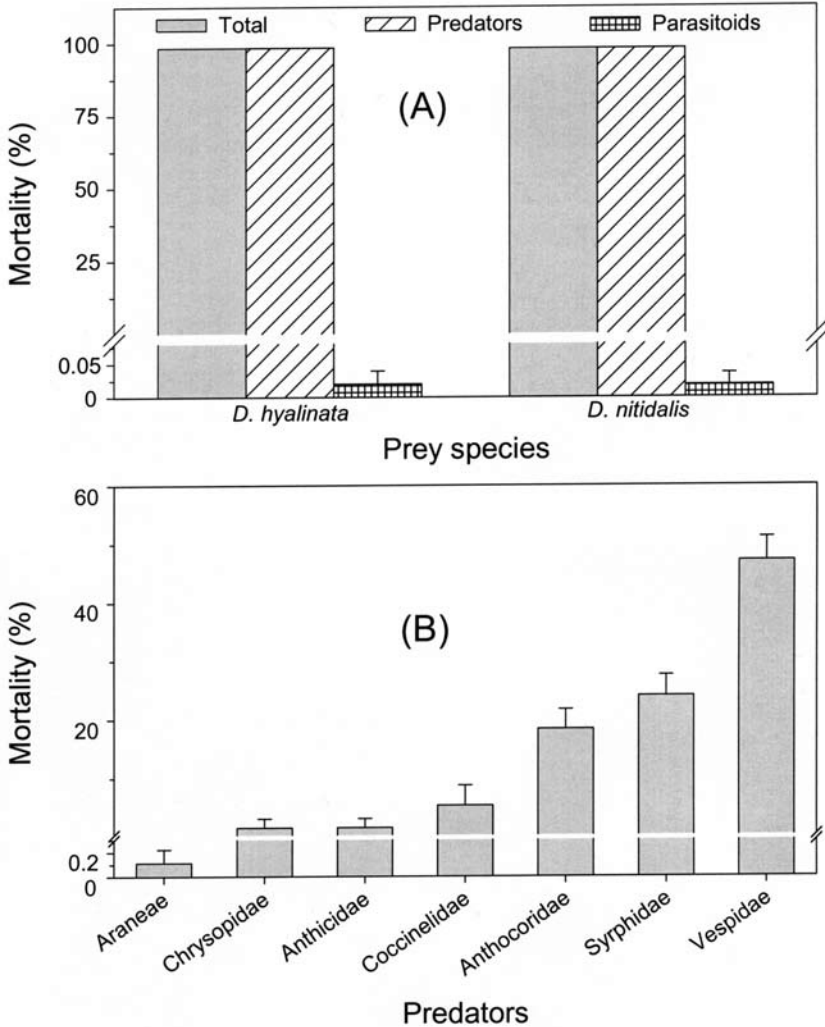


Fig. 2. Mortality in the larval instars of (A) *Diaphania hyalinata* and (B) *Diaphania nitidalis* caused by social wasps. Brackets indicate 95% Confidence interval.

2010). *P. scutellaris* occurs mainly in areas close to forests (Machado & Parra 1984). Moreover, *P. ignobilis* has a large foraging area which has a radius greater than 500m (Raw 1998) while the foraging area of *P. scutellaris* has a radius of 150m (Machado & Parra 1984). The colonies of *P. ignobilis* have more workers than *P. scutellaris* (Raw 1998, Santos *et al.* 2007). As seen in

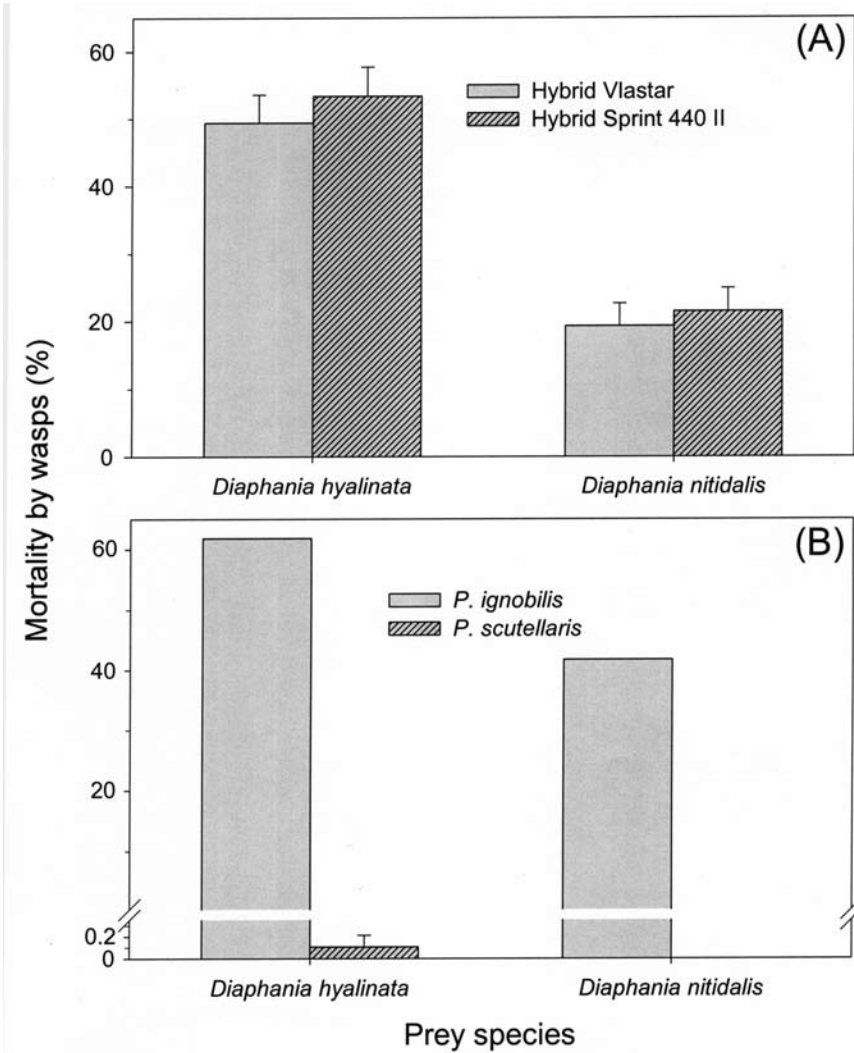


Fig. 3. Mortality of *Diaphania hyalinata* and *Diaphania nitidalis* caused by wasps as a function of (A) cucumber hybrids and (B) species of Vespidae. Brackets indicate 95% Confidence interval.

this work for *Diaphania* spp., Gomes *et al.* (2007) (for fly larvae) and Picanço *et al.* (2010) (for *A. monuste* caterpillars) observed high efficiency of insect predation by *P. ignobilis*.

In conclusion, our results demonstrate the importance of social wasps as natural enemies of *D. hyalinata* and *D. nitidalis* and allowed the identification of key species of Vespidae predators of these pests. This knowledge should be considered when planning pest management programs in order to preserve these predators and maximize their performance in biological pest control.

ACKNOWLEDGMENT

We wish to thank CAPES, CNPq and FAPEMIG for their financial support.

REFERENCES

- Bacci, L., M.C. Picanço, A.H.R. Gonring, R.N.C. Guedes & A.L.B. Crespo 2006. Critical yield components and key loss factors of tropical cucumber crops. *Crop Protection* 25: 1117-1125.
- Bacci, L., M.C. Picanço, M.F. Moura, A.A. Semeão, F.L. Fernandes & E.G.F. Moraes 2008. Sampling plan for thrips (Thysanoptera: Thripidae) on cucumber. *Neotropical Entomology* 37: 582-590.
- Carpenter, J.M. 1991. Phylogenetic relationships and the origin of social behavior in the Vespidae. In: Ross, K.G. & R.W. Matthews. *The social biology of wasps*. Ithaca: Cornell University.
- Carpenter, J.M. & J. Kojima 1997. Checklist of the subfamily Stenogastrinae (Hymenoptera: Vespidae). *Journal of the New York Entomological Society* 104: 21-36.
- Carpenter, J.M., J.W. Wenzel & J. Kojima 1996. Synonymy of the genus *Occipitalia* Richards, 1978, with *Chypearia* De Saussure, 1854 (Hymenoptera: Vespidae, Polistinae, Epiponini). *Journal of Hymenoptera Research* 5: 157- 165.
- Elpino-Campos, A., K. Del-Claro & F. Prezoto 2007. Diversity of social wasps (Hymenoptera, Vespidae) in Cerrado fragments of Uberlândia, Minas Gerais State, Brazil. *Neotropical Entomology* 36: 685-692.
- Filgueira, F.A.R. 2000. *Novo manual de Olericultura: Agrotecnologia moderna na produção e comercialização de hortaliças*. Viçosa: Universidade Federal de Viçosa.
- Gobbi, N. & V.L.L. Machado 1986. Material capturado e utilizado na alimentação de *Polybia* (*Trichothorax*) *ignobilis* (Haliday, 1836) (Hymenoptera, Vespidae). *Anais da Sociedade Entomológica do Brasil* 15: 117-124.
- Gomes, L., G. Gomes, H.G. Oliveira, J.J. Morlin Jr, I.C. Desuó, I.M. Silva, S.N. Shima & C.J.V. Zuben 2007. Foraging by *Polybia* (*Trichothorax*) *ignobilis* (Hymenoptera, Vespidae) on flies at animal carcasses. *Revista Brasileira de Entomologia* 51: 389-393.

- Gonring, A.H.R., M.C. Picanço, J.C. Zanuncio, M. Puiatti & A.A. Semeão 2003a. Natural biological control and key mortality factors of the pickleworm, *Diaphania nitidalis* Stoll (Lepidoptera: Pyralidae), in cucumber. *Biological Agriculture and Horticulture* 20: 365-380.
- Gonring, A.H.R., M.C. Picanço, R.N.C. Guedes & E.M. Silva 2003b. Natural biological control and key mortality factors of *Diaphania hyalinata* (Lepidoptera: Pyralidae) in cucumber. *Biocontrol Science and Technology* 13: 361-366.
- Hermes, M.G. & A. Köhler. 2006. The flower-visiting wasps (Hymenoptera, Vespidae, Polistinae) in two areas of Rio Grande do Sul State, Southern Brazil. *Revista Brasileira de Entomologia* 50: 268-274.
- Kasper, M.L., A.F. Reeson, S.J.B. Cooper, K.D. Perry & A.D. Austin 2004. Assessment of prey overlap between a native (*Polistes humilis*) and an introduced (*Vespula germanica*) social wasp using morphology and phylogenetic analyses of 16S rDNA. *Molecular Ecology* 13: 2037-2048.
- King, A.B.S. & J.L. Saunders 1984. The invertebrate pests of annual food crops in Central America. London: Overseas Development Administration.
- Leite, G.L.D., I.R. Oliveira, R.N.C. Guedes & M.C. Picanço 2001. Comportamento de predação de *Protonectarina sylveirae* (Saussure) (Hymenoptera: Vespidae) em mostarda. *Agro-Ciencia* 17: 93-96.
- Machado, V.L.L. & J.R.P. Parra 1984. Capacidade de retorno ao ninho de operárias de *Polybia (Myrapetra) scutellaris* (White, 1841). *Anais da Sociedade Entomológica do Brasil* 13: 13-18.
- O'Donnell S. 1998. Reproductive caste determination in eusocial wasps (Hymenoptera: Vespidae). *Annual Review of Entomology* 43: 323-346.
- Paula, S.V., M.C. Picanço, I.R. Oliveira, M.R. Gusmão 2004. Controle de broqueadores de frutos de tomateiro com uso de faixas de culturas circundantes. *Bioscience Journal* 20: 33-39.
- Penã, J.E., V.H. Waddill & K.D. Elsey 1987. Survey of native parasites of the pickleworm, *Diaphania nitidalis* Stoll, and melonworm, *Diaphania hyalinata* (L.) (Lepidoptera: Pyralidae), in Southern and Central Florida. *Environmental Entomology* 16: 1062-1066.
- Pereira, E.J.G., M.C. Picanço, L. Bacci, A.L.B. Crespo & R.N.C. Guedes 2007a. Seasonal mortality factors of the coffee leafminer, *Leucoptera coffeella*. *Bulletin of Entomological Research* 97: 421-432.
- Pereira, E.J.G., M.C. Picanço, L. Bacci, T.M.C. Della Lucia, E.M. Silva, F.L. Fernandes 2007b. Natural mortality factors of *Leucoptera coffeella* (Lepidoptera: Lyonetiidae) on *Coffea arabica*. *Biocontrol Science and Technology* 17: 441-455.
- Picanço, M.C., L.J. Ribeiro, G.L.D. Leite, M.R. Gusmão 1998. Seletividade de inseticidas a *Polybia ignobilis* (Haliday) (Hymenoptera: Vespidae) predador de *Ascia monuste orseis* (Godart) (Lepidoptera: Pieridae). *Anais da Sociedade Entomológica do Brasil* 27: 85-90.

- Picanço, M.C., I.R. Oliveira, J.F. Rosado, F.M. Silva, P.C. Gontijo & R.S. Silva 2010. Natural biological control of *Ascia monuste* by the social wasp *Polybia ignobilis* (Hymenoptera: Vespidae). *Sociobiology* 55: 67-76.
- Picanço, M.C., L. Bacci, R.B. Queiroz, G.A. Silva, M.M.M. Miranda, G.L.D. Leite & F.A. Suinaga 2011. Social wasp predators of *Tuta absoluta*. *Sociobiology* 58: 621-634.
- Pratissoli, D., R.A. Polanczyk, A.M. Holtz, T. Tamanhoni, F.N. Celestino & R.C. Borges Filho 2008. Influência do substrato alimentar sobre o desenvolvimento de *Diaphania hyalinata* L. (Lepidoptera: Crambidae). *Neotropical Entomology* 37:361-364.
- Prezoto, F. & V.L.L. Machado 1999. Transferência de colônias de vespas (*Polistes simillimus* Zikan, 1951) (Hymenoptera, Vespidae) para abrigos artificiais e sua manutenção em uma cultura de *Zea mays*. *Revista Brasileira de Entomologia* 43: 239-241.
- Raw, A. 1998. Population densities and biomass of Neotropical social wasps (Hymenoptera, Vespidae) related to colony size, hunting range and wasps size. *Revista Brasileira de Zoologia* 15: 815-822.
- Reis Jr., R., O. DeSouza, E.F. Vilela 2000. Predators impairing the natural biological control of parasitoids. *Anais da Sociedade Entomológica do Brasil. Neotropical Entomology* 29: 507-514.
- Richter, M.R. Social wasp (Hymenoptera: Vespidae) foraging behavior 2000. *Annual Review of Entomology* 45: 121-150.
- Santos, G.M.M., C.C. Bichara Filho, J.J. Resende, J.D. Cruz & O.M. Marques 2007. Diversity and community structure of social wasps (Hymenoptera, Vespidae) in three ecosystems in Itaparica Island, Bahia State, Brazil. *Neotropical Entomology* 36: 180-185.



