Natural Biological Control of Lepidopteran Pests by Ants

by

Rodrigo Soares Ramos[1], Marcelo Coutinho Picanço[1*], Paulo Antônio Santana Júnior[1], Ézio Marques da Silva[2], Leandro Bacci[3], Alfredo Henrique Rocha Gonring[4] & Gerson Adriano Silva[5]

ABSTRACT

The predatory ants (Hymenoptera: Formicidade) are social insects and important natural enemies of pests in agroecosystems. Despite the importance of these predators, little is known about their role, especially in tropical regions. Among the major Lepidopteran pests of vegetables are *Ascia monuste* (Pieridae), *Diaphania nitidalis* (Crambidae), *Neoleucinodes elegantalis* (Crambidae) and *Tuta absoluta* (Gelechiidae). Thus, this work aimed to study the natural biological control of *A. monuste*, *D. nitidalis*, *N. elegantalis* and *T. absoluta* by ants. For this, we evaluated the natural biological control of *A. monuste* on kale and *D. nitidalis* on cucumber both species in the dry season. Whilst the natural biological control of *N. elegantalis* and *T. absoluta* on tomato plants were evaluated in the rainy and dry seasons. Ants preyed on Lepidoptera in the pupa stadium. They also preyed on eggs of *D. nitidalis*. The activity of predatory ants occurred mainly during the night. The ants were the main causes of pupae mortality of *A. monuste*, *D. nitidalis* and *T. absoluta*. Beyond the ants, the physiological disturbances and birds were also important factors of pupae mortality of *N. elegantalis*. The ants *Labidus coecus* and *Solenopsis* sp. were observed preying on pupae whereas the *Paratrechina* sp. was observed preying eggs of *D. nitidalis*. The pupae mortality of *D. nitidalis* and *T. absoluta* by ants were higher than the pupae mortality of *N. elegantalis* and *A. monuste*. The rate of pupae predation of *N. elegantalis* by ants was similar in rainy and dry seasons and the same occurred with *T. absoluta*.

Keywords: Social insects, Formicidae, *Ascia monuste*, *Diaphania nitidalis*, *Neoleucinodes elegantalis*, *Tuta absoluta*.

---

[1] Federal University of Viçosa (UFV), Department of Entomology (DDE), 36570-000, Viçosa, MG, Brazil, [2] UFV, Rio Paranaíba Campus, [3] Federal University of Sergipe, [4]DuPont do Brasil S.A, [5]UFV, Plant Science Department (DFT), *E-mail: picanco@ufv.br

INTRODUCTION

The ants (Hymenoptera: Formicidae) are social insects and they constitute the largest group among the insects. Their colonies usually live in nests that have tunnels and chambers. The ant societies are organized into castes (groups where there is division of labor). The caste system enables execution of multiple tasks. In the society of ants sterile castes (workers and soldiers) are responsible for maintaining the colony (obtaining food, protection and care of offspring). The fertile castes (queens and drones) have reproductive function (Hölldobler & Wilson 1990; Ross & Keller 1995).

In agroecosystems there are species of ants which are pest and others which are predators and they act as natural enemies. Ants are generalist predators and they usually have others insects as their main prey. Ants prey on insects of various orders such as Coleoptera, Diptera, Hemiptera, Lepidoptera and Orthoptera. Ants are important predators of insect pests in annual and perennial crops such as fruits, vegetables, ornamental plants, grain crops, coffee, sugar cane and cotton. The story of ants as biological control agents of agricultural pests is from 300 B.C. However there are many aspects about the role of ants as predators of agricultural pests that need to be studied, especially in tropical regions, to enable the preservation of these agents of biological control (Way & Heong 2009, Fernandes *et al.* 2010, Choate & Drummond 2011).

Among the main lepidopteran pests of vegetables are *Ascia monuste* (Godart) (Pieridae), *Diaphania nitidalis* Cramer (Crambidae) *Neoleucinodes elegantalis* Guenée (Crambidae) and *Tuta absoluta* (Meyrick) (Gelechiidae). These four Lepidoptera species occur in the Americas (Gonring *et al.*, 2003a; Picanço *et al.*, 2007; Picanço *et al.* 2011). The *T. absoluta* in 2006 was introduced in Europe and is currently distributed by practically this entire continent. Also, *T. absoluta* invaded the Mediterranean region of Africa and Asia (Garcia-Marí & Vercher 2010, EPPO 2012). *A. monuste* is a pest of brassica and *D. nitidalis* is a pest of Cucurbitaceae family (Picanco *et al.* 2000, Picanco *et al.* 2010, Picanco *et al.* 2011) whilst *N. elegantalis* and *T. absoluta* are pests of Solanaceae, especially tomatoes (Picanco *et al.* 2007; Galdino *et al.* 2011, Moreno *et al.* 2012). Thus, this work aimed to study the natural biological control of *A. monuste*, *D. nitidalis*, *N. elegantalis* and *T. absoluta* by predatory ants.

MATERIALS AND METHODS

This work was conducted in crops of kale, cucumber and tomato located in Viçosa (20°48'45"S, 42°56'15"W, altitude of 660m), Minas Gerais State, Brazil. The tomato crop was carried out in the rainy season (January and February) and dry season (May and June) 2007. The crops of kale and cucumber were only conducted in the dry season. The cultivars used were Portuguese clone (kale), hybrid Sprint 440 II (cucumber) and Santa Clara variety (tomato). The experimental design was randomized blocks with five replications. The repetition had six rows of nine plants. The spacing used was 1 x 0.5 m. Therefore, each repetition had 54 plants. No pesticides were applied to the crop, and conventional cultivation practices were employed, according to Filgueira (2000).

The pest insects used in experiments were obtained from laboratory rearing conducted as Liu (2005) for *A. monuste*, Pratissoli *et al.* (2008) for *D. nitidalis*, França *et al.* (2009) for *N. elegantalis* and Galdino *et al.* (2011) for *T. absoluta*. Kale plants were used for *A. monuste*, cucumber plants were used for *D. nitidalis* and tomato plants were used for *N. elegantalis* and *T. absoluta*. At the beginning of the experiment, 10 plants in each repetition were infested with 10 eggs and 10 larvae of each instar of Lepidoptera species. The plants were about 60 days old when they were infested. In the stadia of eggs and larvae were monitored mortalities caused by ants in each Lepidoptera species. As soon as the insects moved to the pupal stadium the mortalities caused by each factor for each Lepidoptera species were monitored.

Mortality factors of the Lepidoptera pupae were identified (number and causes). Natural enemies observed causing mortality of Lepidoptera pupae were noted according to their morphospecies. In plants unmarked, individuals of each morphospecies of these natural enemies were collected and assembled. At the end of the pupal stadium we collected those alive pupae in plastic pots of 500 mL. The pots were taken to the laboratory for evaluation of the pupae parasitism. The emerged parasitoids were collected. The natural enemies collected were identified in the Museum of Entomology at UFV. The morphospecies of ants were identified by Dr. Ivan Cardoso Nascimento (State University of Southwest of Bahia). From the experimental data the averages of Lepidoptera mortality by ants in the eggs and larvae stadia were

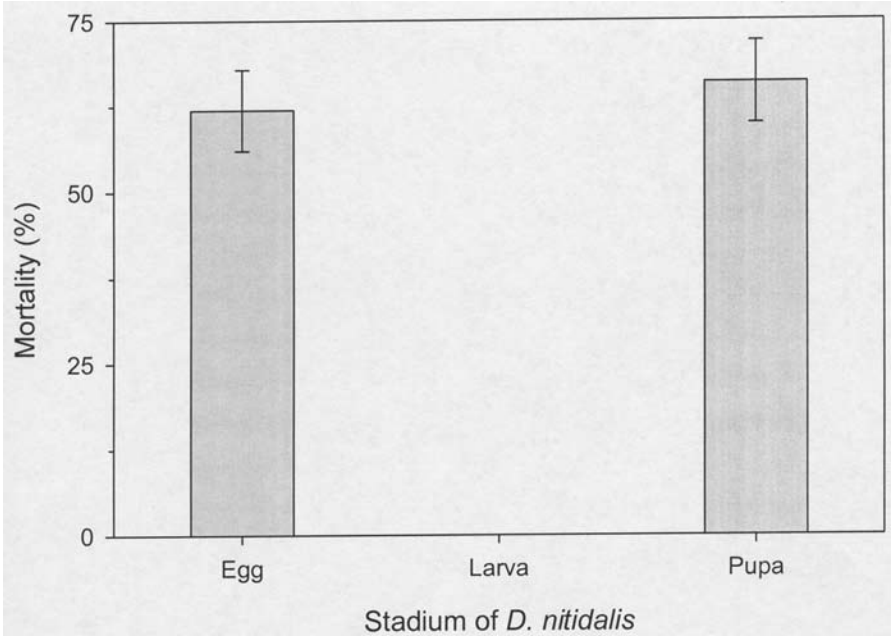

Fig. 1. Mortality of *Diaphania nitidalis* in each stadium by ants.

calculated. In the pupal stadium of each Lepidoptera species the mortalities caused by each factor were calculated. We also calculated the 95% confidence intervals of mortality rates.

RESULTS AND DISCUSSION

The ants preyed *A. monuste*, *N. elegantalis* and *T. absoluta* only in the pupal stadium. The *D. nitidalis* was preyed by ants in both eggs and pupae (Fig. 1). Pupae predation of these four species, probably occurred due to the main site of pupation of Lepidoptera and nesting of ants to be at the same spot, ie the soil. However, the eggs and larvae of *A. monuste*, *N. elegantalis* and *T. absoluta* occur in kale and tomatoes leaves that do not have contact with the soil thus hindering predation by ants. The eggs of *D. nitidalis* are in cucumber leaves that often come in contact with the soil thus enabling their predation by ants. Moreover, the larvae of *D. nitidalis* are located inside the fruit making it difficult to predation by ants (Picanco *et al.* 2000). The report of ants as predators of *A. monuste*, *N. elegantalis* and *T. absoluta* is unprec-

edented. Miranda *et al.* (2005) reported the occurrence of predatory ants in the tomato crop attacked by *N. elegantalis* and *T. absoluta* but these authors did not observe which prey those ants were preying. Whilst Gonring *et al.* (2003a) reported ants as predators of *D. nitidalis*.

The predatory activity of ants occurred in the early morning, late afternoon and mainly during the night. We did not observe predation rate of ants in periods of high temperature and low relative humidity. The high air temperatures might elevate body temperature excessively of ants causing death or reducing their performance since they are biological poikilotherm organisms (Jensen 1978). The foraging activity of predatory ants in periods of mild temperatures and low or no light might be related to the fact that these periods is low activity of predators of ants as the birds (NECR 2009, Narendra *et al.* 2010). The absence of foraging activity of ants during periods of low relative humidity is possibly due to this condition cause dehydration to these insects.

The ants were the main causes of pupae mortality of *A. monuste*, *D. nitidalis* and *T. absoluta*. Beyond the ants, the physiological disturbances and birds were also important factors of pupae mortality of *N. elegantalis*. Besides these factors, we observed mortality of pupae by rain (*N. elegantalis* and *T. absoluta*), Hymenoptera: Vespidae (*N. elegantalis*), Hymenoptera parasitoids (*T. absoluta* and *N. elegantalis*), fungi (*N. elegantalis*), spiders (*D. nitidalis*) and Heteroptera, Pentatomidae (*A. monuste*) (Fig. 2). The increased mortality of Lepidoptera pupae by ants than the other natural enemies should be, possibly, their social organization. The social organization of ants allows the division of labor between castes, efficient localization of prey and more competitive than other natural enemies. Also Knutson & Campos (2008) observed the ants were the most important predators of Lepidoptera *Helicoverpa zea* (Bod.) (Noctuidae).

Given the importance of ants as predators of Lepidoptera pests they should have preserved their populations in crops. Among the practices that enable the preservation of predators ants populations are: the reduction of pesticide applications, the application of products with physiological selectivity and selective use of pesticides. The decreased use of pesticides on crops may be obtained by adopting sampling and level of pest control (Moura *et al.* 2003, Bacci *et al.* 2006, Gusmao *et al.* 2006). The use of insecticides with physiologi-

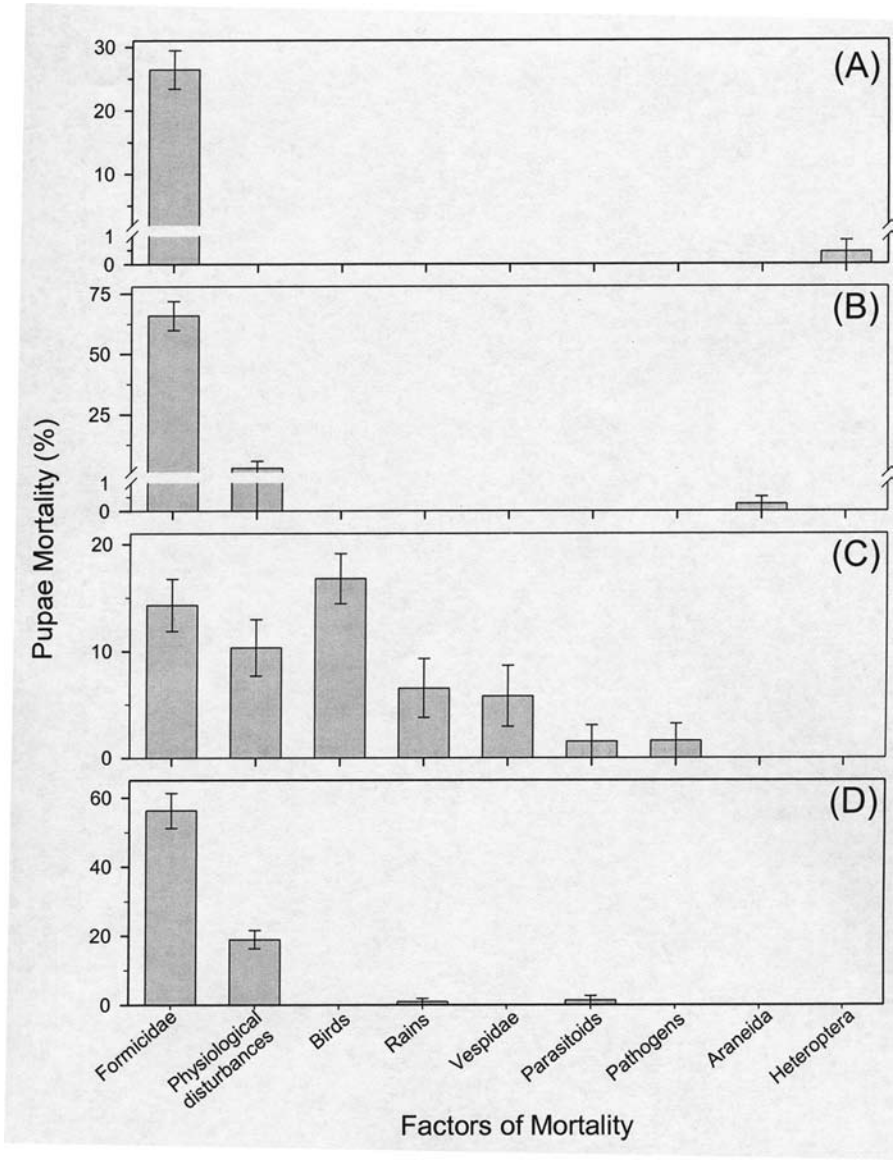

Fig. 2. Factors of pupae mortality (A) *Ascia monuste*, (B) *Diaphania nitidalis*, (C) *Neoleucinodes elegantalis* and (D) *Tuta absoluta*.

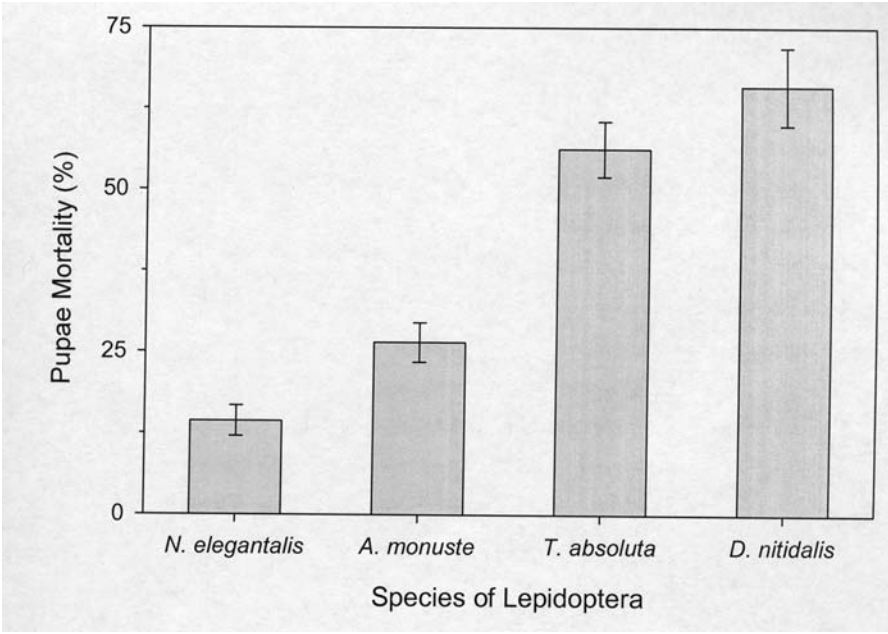

Fig. 3. Pupae mortality of *Ascia monuste, Diaphania nitidalis, Neoleucinodes elegantalis* and T*uta absoluta* by ants.

cal selectivity is important because these products are effective in controlling pests and they are somewhat toxic to natural enemies. In this context, Moreno *et al.* (2012) found that the plant extracts *Acmella oleracea* and *Azadirachta indica* were selective in favor of the predator ant *Solenopsis saevissima* (Smith) as the insecticide permethrin was not selective.

In the selective use of pesticides the aim is to reduce exposure of natural enemies with the products. For ants this must be achieved avoiding products to reach their site of the foraging, ie the soil. For this goal is reached we should avoid the application of pesticides in soil and spraying must be made using the smallest possible volume of solution to prevent much of the pesticide reaches the soil. Also, we should select pesticides that degrade rapidly when they come in contact with the ground.

Ants observed preying on pupae of *A. monuste*, *D. nitidalis*, *N. elegantalis* and *T. absoluta* were *Labidus coecus* (Latr.) and *Solenopsis* sp. Also, we observed the ant *Paratrechina* sp. preying on eggs of *D. nitidalis.* Way & Heong (2009) observed *Solenopsis* species as an important predator of insect pests

in rice whereas Gonring *et al.* (2003ab) found *L. coecus* and *Paratrechina* sp. preying *Diaphania* spp.

The pupae mortality of *D. nitidalis* and *T. absoluta* by ants were higher than the pupae mortality of *N. elegantalis* and *A. monuste* (Fig. 3). This may be due to factors such as pupae size and pupation site of the pests. As ants

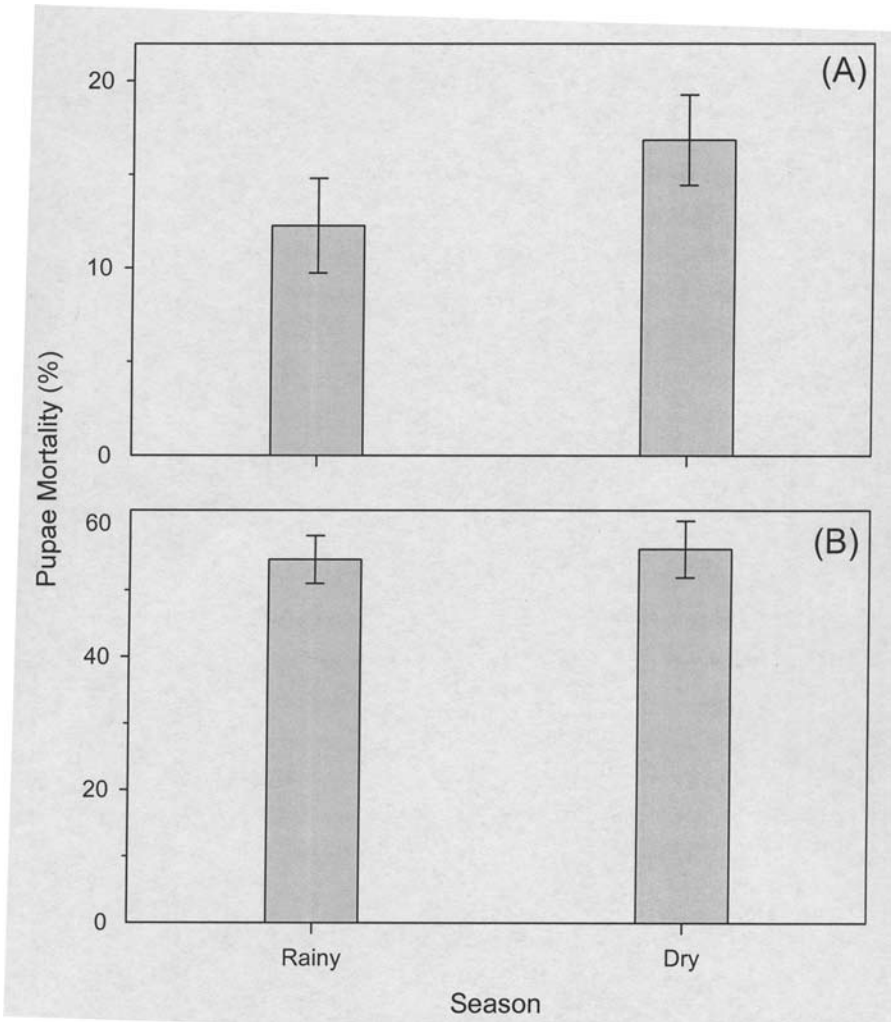

Fig. 4. Pupae mortality of (A) Neoleucinodes elegantalis and (B) Tuta absoluta in rainy and dry seasons.

forage mainly on soils (Hölldobler & Wilson 1990, Way & Heong 2009, Fernandes *et al.* 2010) they must prey more intensely on those preys which has exclusive pupation site. In this context, we found that the ants preyed more Lepidoptera pupate in the soil (*D. nitidalis* and *T. absoluta*) than those pupate in the plant and in the soil (*N. elegantalis* and *A. monuste*). Another factor that may have influenced the change in predation rate of prey species by ants is the size of the pupae. We observed increased predation of Lepidoptera pupae with smaller size (*T. absoluta* and *D. nitidalis*) than species with larger size pupae (*N. elegantalis* and *A. monuste*).

The rate of pupae predation of *N. elegantalis* by ants was similar between the rainy and dry season. The same occurred with *T. absoluta* (Fig. 4). Therefore; the rainfall did not affect predation of Lepidoptera by the ants. We did not observe predation rate of ants during rain events. In the rainy season the ants performed predation when the rains ceased.

In conclusion, our results demonstrate the importance of ants as predators of *A. monuste*, *D. nitidalis*, *N. elegantalis* and *T. absoluta*. Thus, the planning programs of pest management of vegetables it should preserve the predatory ants to maximize biological control of pests.

ACKNOWLEDGMENTS

We wish to thank CNPq, CAPES, FAPEMIG, FAPITEC and BNB by scholarships and resources granted. Dr. Ivan Cardoso Nascimento from the State University of Southwest of Bahia for identifying the ant species.

REFERENCES

Bacci, L., M.C. Picanço, M.F. Moura, T.M.C. Della Lucia & A.A. Semeão 2006. Sampling plan for *Diaphania* spp. (Lepidoptera: Pyralidae) and for Hymenoptera parasitoids on cucumber. Journal of Economic Entomology 99, 1980-1988.

Choate, B. & F. Drummond 2011. Ants as biological control agents in agricultural cropping systems. Terrestrial Arthropod Reviews 4, 157-180.

EPPO 2012. European and Mediterranean Plant Protection Organization. Reporting Service. n.1. Disponivel em: http://archives.eppo.org/EPPOReporting/2012/Rse-1201.pdf.

Fernandes, F.L., M.C. Picanço, M.E.S. Fernandes, V.M. Xavier, J.C. Martins & V.F. Silva 2010. Controle biológico natural de pragas e interações ecológicas com predadores e parasitóides em feijoeiro. Bioscience Journal 26, 6-14.

Filgueira, F.A.R. 2000. Novo manual de olericultura. Viçosa: UFV.

França, S.M., J.V. Oliveira, C.M. Oliveira, M.C. Picanço & A.P. Lôbo 2009. Efeitos ovicida e repelente de inseticidas botânicos e sintéticos em *Neoleucinodes elegantalis* (Guenée) (Lepidoptera: Crambidae). Boletín de Sanidad Vegetal. Plagas 35, 649-655.

Galdino, T.V.S., M.C. Picanço, E.G.F. Morais, N.R. Silva, G.A.R. Silva & M.C. Lopes 2011. Bioassay method for toxicity studies of insecticide formulations to *Tuta absoluta* (Meyrick, 1917). Ciência e Agrotecnologia 35, 869-877.

Garcia-Marí, F. & R. Vercher 2010. Descripción, origin y expansión de *Tuta absoluta* (Lepidoptera; Gelechiidae). Phytoma-España 20, 16-20.

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 & Horticulture 20, 365-380.

Gonring, A.H.R., M.C. Picanco, 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.

Gusmão, M.R., M.C. Picanço, R.N.C. Guedes, T.L. Galvan & E.J.G. Pereira 2006. Economic injury level and sequential sampling plan for *Bemisia tabaci* in outdoor tomato. Journal of Applied Entomology 130, 160-166.

Hölldobler, B. & E.O. Wilson 1990. The ants. Cambridge: Harvard Univiversity.

Jensen, T.F. 1978. Annual production and respiration in ant populatios. Oikos 31, 207-213.

Knutson, A.E. & M. Campos 2008. Effect of red imported fire ant, *Solenopsis invicta* on abundance of corn earworm, *Helicoverpa zea*, on maize in Texas. Southwestern Entomologist 33, 1-13.

Liu, T.X. 2005. Biology and life history of *Ascia monuste monuste* (Lepidoptera: Pieridae), a potential pest of cruciferous vegetables. Annals of the Entomological Society of America 98, 726-731.

Miranda, M.M.M, M.C. Picanço, J.C. Zanuncio, L. Bacci & E.M. Silva 2005. Impact of integrated pest management on the population of leafminers, fruit borers, and natural enemies in tomato. Ciência Rural 35, 204-208.

Moreno, S.C., G.A. Carvalho, M.C. Picanço, E.G.F. Morais & R.M. Pereira 2012. Bioactivity of compounds from *Acmella oleracea* against *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and selectivity to two non-target species. Pest Management Science 68, 386-393.

Moura, M.F., M.C. Picanço, E.M. Silva, R.N.C. Guedes & J.L. Pereira 2003. Plano de amostragem do biótipo B de *Bemisia tabaci* na cultura do pepino. Pesquisa Agropecuária Brasileira 38, 1357-1363.

Narendra, A., S.F. Reid & J.M. Hemmi 2010. The twilight zone: ambient light levels trigger activity in primitive ants. Proceedings of the Royal Society of London. Series B, Biological Sciences 277, 1531-1538.

NECR (Natural England Commissioned Report) 2009. Comparison of the abundance and distribution of birds along the northern shore of Poole Harbour by day and by night. Sheffield: Natural England (NECR017).

Picanço, M.C., M.R. Gusmão & T.L. Galvan 2000. Manejo integrado de pragas de hortaliças. In: Zambolim, L. Manejo integrado de doenças, pragas e ervas daninhas. Viçosa: UFV, p.275-324.

Picanço, M.C., L. Bacci, A.L.B. Crespo, M.M.M. Miranda & J.C. Martins 2007. Effect of integrated pest management practices on tomato production and conservation of natural enemies. Agricultural and Forest Entomology 9, 327–335.

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 56, 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.

Ross, K.G. & L. Keller 1995. Ecology and evolution of social organization: Insights from fire ants and other highly eusocial insects. Annual Review of Ecology and Systematics 26, 631-656.

Way, M.J. & K.L. Heong 2009. Significance of the tropical fire ant *Solenopsis geminata* (Hymenoptera: Formicidae) as part of the natural enemy complex responsible for successful biological control of many tropical irrigated rice pests. Bulletin of Entomological Research 99, 503-512.