Bol. San. Veg. Plagas, 33: 143-152, 2007

Interactions between aphid species and beneficial organisms in sweet pepper protected crop

E. VALÉRIO, A. CECÍLIO, A. MEXIA

The interactions between different aphid species and beneficial organisms have been studied in the west region of Portugal, on sweet pepper protected crops. Assays were carried out during the years of 1998, 2002, 2003 and 2004. Aphid species and natural enemies were weekly collected, quantified and identified in laboratory.

The aphid species that reached economic thresholds were *Aphis craccivora* Koch, *Aphis gossypii* Glover and *Myzus persicae* (Sulzer). *Aulacorthum solani* (Kaltenbach) and *Macrosiphum euphorbiae* (Thomas) were also observed.

Indigenous predator activity by anthocorids, cecidomyiids, coccinelids, chrysopids, spiders, syrphids and some parasitoids, contributed to the control of aphid populations. However, in sweet pepper protected crops, aphid populations can reach high levels and the activity of natural enemies may be insufficient to control them. Introduction of beneficial enemies are mostly necessary.

A biological control programme was implemented and adapted to the conditions observed during the assays. Therefore, to control *A. craccivora* and *A. gossypii* populations, whose reproductive rate is very high in protected pepper crops, the introductions of predators, namely coccinelids, should be considered due to its efficacy in controlling these aphid species. *M. persicae* populations can be controlled with parasitoid releases when the first colonies are observed. In this study the predator *Coccinella septempunctata* L. and the parasitoid *Aphidius colemani* Viereck were used.

E. VALÉRIO, A. CECÍLIO. Estação Agronómica Nacional – INIAP, Dep. Protecção de Plantas - Entomologia, Av. da República, Nova Oeiras. 2784-505 Oeiras. elsaval@sapo.pt
A. MEXIA. Estação Agronómica Nacional – INIAP, Direcção, Av. da República, Nova Oeiras. 2784-505 Oeiras.

Key words: aphids, parasitoid, predator, biological control, greenhouse, sweet pepper.

INTRODUCTION

Aphids are an important pest in sweet pepper protected crops (VALÉRIO, 1997, 1999, 2003, 2004, 2005). They produce large amounts of honeydew which cause damage on plants and the crop production may be reduced.

In sweet pepper protected crops some aphid species can cause direct and indirect damage. The aphid species *Myzus persicae* (Sulzer) and *Aphis gossypii* Glover are frequently mentioned as the most important (GILKESON, 1990; DOMAGALA, 1992; WICK, 1992; VALÉRIO, 1997; MELLINGER, *et al.*, 2000; VASICEK, *et al.*, 2001; LEE, 2002; VALÉRIO *et al.*, 1999, 2003 and 2004). However, in the last years we have been observing the occurrence of aphid species becoming serious pests and difficult to control (GARCÍA, 2001; VALÉRIO *et al.*, 2004). In sweet pepper protected crop, *Aulacorthum solani* (Kaltenbach) has been reported as one of the most important species in some regions of Spain (HERMOSO DE MENDOZA, 2005; SÁNCHEZ, 2005) and *Aphis craccivora* Koch in

Portugal (VALÉRIO *et al.*, 2004, 2005). The aphid *Macrosiphum euphorbiae* (Thomas) has also been reported from Portugal (VALÉRIO, 1997; VALÉRIO *et al.*, 1999, 2003, 2004, 2005) however, its importance was considered as secondary.

With so many aphid species that can cause damage to sweet pepper, and the concern with chemical control that is costly for farmers and has many disadvantages either for public health or for the environment, particularly for its negative effects on beneficial organisms (ILHARCO, 1992; ZHANG, 2000; ÖSTMAN, 2001, BARRENECHEA, *et al*, 2004), alternative control methods must be considered (VAN LENTEREN, 1996).

Natural enemies present in the ecosystem reveal in most cases low efficiency in controlling aphid species in sweet pepper and, biological control can be very useful as an alternative measure (RAMÓN, 2002; WAWRZYNSKI *et al.*, 2001; GUENAOUI, 1991; GILKESON, 1990). Implementing a biological control programme in a greenhouse requires more knowledge and labour from the farmer than traditional pest control programmes (GREER *et al.*, 1999; DUFOUR, 2001). Proper aphid species identification is very important and must be done before a control programme, using predators or parasites, is initiated, (GREER, 2000; VALÉRIO *et al.*, 2005) for selection of the appropriate beneficial organism to be released, given its specificity. Other aspects should be considered, namely, release rate, timing, placement, temperature, and pesticide application that can influence the success or failure of biological control efforts (GREER *et al.*, 1999; DUFOUR, 2001), as well as the care for minimizing the non-target effects of biological control (SIMBERLOFF, 1996; FOLLETT, *et al.* ed., 2000; BARRATT, 2003; LOUDA, 2003).

In this work, two beneficial organisms were selected to be released. The parasitoid *Aphidius colemani* Viereck was selected due to the proved efficiency of this parasitoid genus in parasitizing the aphid species of sweet pepper crop (RABASSE *et al.*, 1983; GILKESON, 1990; SCHELT, 1990; WICK, 1992; DOMAGALA, 1992; VAN STEENIS *et al.*, 1996; SAMPAIO *et al.*, 2001; VALÉRIO *et al.*, 2003, 2004) and its availability in biological control suppliers. The predator *Coccinella septempunctata* L. was also selected, because of its efficiency in controlling high levels of aphids according to our own observations and reports from other authors (OBRYCKI, 1998; TRILTSCH, 1999; MINORETTI, 2000; EVANS, 2003).

With this work we intended to study interactions between aphid species and its natural enemies and obtain information for implementation of a biological control programme that can reduce the chemical input and problems associated with aphid control in sweet pepper protected crop.

MATERIALS AND METHODS

Monitoring aphid species and natural enemies in sweet pepper plants

Assays were conducted, during the years 1998, 2002, 2003 and 2004, on protected sweet pepper crops, in the west region of Portugal.

In 1998 a study of population dynamics was carried out for monitoring aphid species and their natural enemies. In the following years a biological control programme was developed to evaluate the interaction between aphid species and specific beneficial organisms to be released and also the suitable time for releases, in order to increase the effectiveness of the beneficial organisms and minimize the non-target effects of biological control.

A greenhouse with sweet pepper was sampled weekly. When the conditions were favourable to the development of aphid populations, the frequency of sampling was intensified.

Greenhouses were divided into ten sections and one sweet pepper plant of each section was sampled for monitoring aphid species. Two leaves were randomly collected from two of the three plant levels (superior, medium and inferior).

The predatory activity was monitored in twenty pepper plants. The presence of lar-

vae, pupae and adult stages of predators were registered for anthocorids, cecidomyiids, coccinelids, chrysopids, spiders and syrphids. The methodology used was adapted from previous studies on aphid population dynamics and their natural enemies, on pepper crops (VALÉRIO *et al*, 1999).

The leaves sampled were observed under microscope in laboratory for identification and quantification of aphid species and parasitoid mummies.

Introduced beneficial organisms

Two beneficial organisms were introduced to control aphid populations, the *A. colemani* parasitoid and the *C. septempunctata* predator.

The specific parasitoid *A. colemani* was obtained from a biological control supplier and released in *M. persicae* colonies to control this aphid. *C. septempunctata* was captured on potato crops near the greenhouse and released on pepper plants to control the aphid species *A. gossypii* and *A. craccivora*.

RESULTS AND DISCUSSION

During the assays, five aphid species were identified *A. craccivora*, *A. gossypii*, A. solani, *M. euphorbiae* and *M. persicae* (figure 1), the occurrence of the different aphid species had fluctuations. *A. craccivora*, *A. gossypii* and *M. persicae* were the species that reached higher populations levels. In 2003, *A. solani* was the dominant species and the aphids of the genera *Aphis* were not observed (figure 1). The occurrence of this population dynamic of the aphid species, much

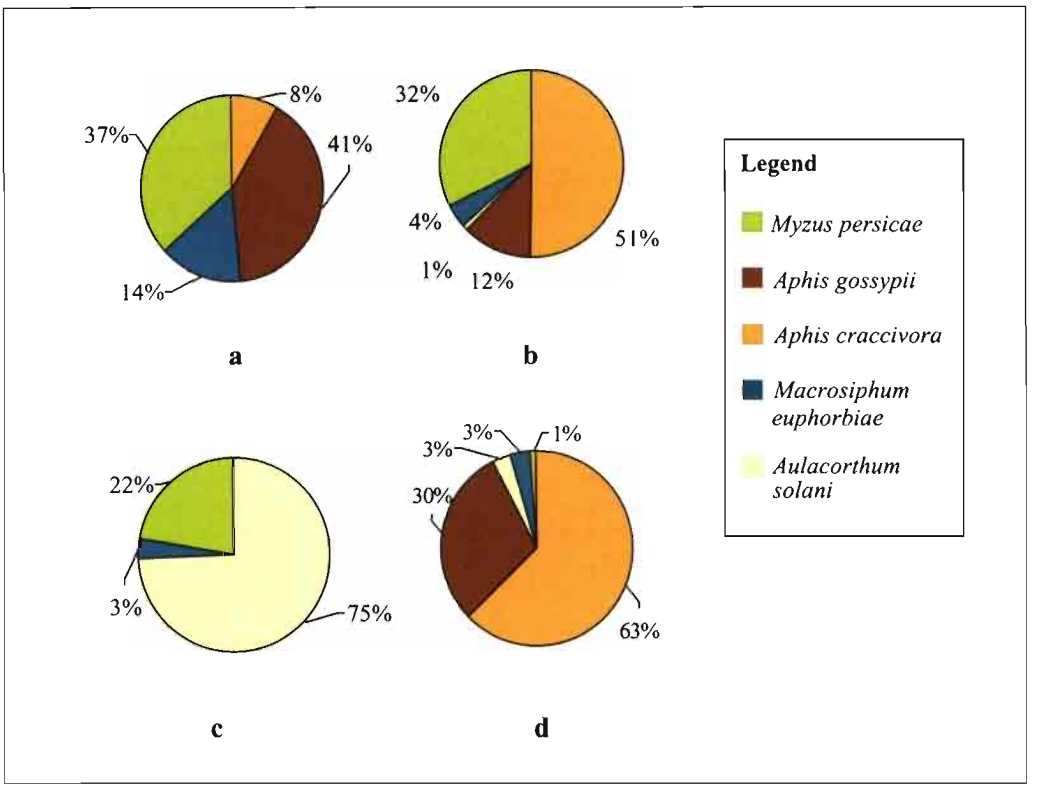

Figure 1. Percentage of aphid species per year of observation. a) 1998; b) 2002; c) 2003; d) 2004.

different from the other years, took place when problems in development of sweet pepper plants occurred associated with nutritional and pathogen issues.

In 1998 *M. persicae* with 37 % of total aphid species and *A. gossypii* with 41 % (figure 1-a) were the species that reached the economic threshold. Oscillations verified in *M. persicae* populations (figure 2) were followed by the indigenous parasitoid activity (figure 3) wich was not enough to prevent a peak of the aphid population. In early July *A. gossypii* populations reached a higher level (figure 2), however, indigenous predators populations increased (figure 3) and contributed to the control of pest populations.

The acquired information, namely the interactions between aphid species and natural enemies (anthocorids, cecidomyiids, coccinelids, chrysopids, spiders, syrphids and some parasitoids) and the natural control efficiency, was important to define the biological control strategy for the following years. In 2002, on the basis of the insufficient activity of indigenous parasitoids, since the beginning of aphid colonization, the parasitoid *A. colemani* was selected to be released on the *M. persicae* colonies (20 May) (figure 4). When the parasitoid was released (20 May), the *M. persicae* colonies were well developed and in full reproduction, and it was not possible to prevent an increase of pest population (figure 4).

A. gossypii populations reached high levels however *A. craccivora* reached even higher levels (figure 4) and caused important injury damage on the crop due to honeydew production. The natural enemy's diversity (figure 5) contributed to control the aphid populations.

Taking into account the adaptation difficulties experienced by *A. colemani*, in 2003, releases were made earlier (22 April) (figure 7), which kept the parasitoid activity until the end of the crop. In this year, the already mentioned problems with sweet pepper plants development, associated to the occurrence of nutritional and pathogen problems were unfavourable to the development of aphid populations (figure 6). *A. solani* kept its activity near the ventilation apertures, however, the aphid populations were lower (figure 6).

On the 20th of April, 2004 *A. colemani* was introduced (figure 8) and kept its activity during the crop development, parasitizing *M. persicae* which maintained the population at low levels (figure 8). Verifying that the reproductive rate of *A. gossypii* and *A. craccivora* was very high and also that parasitism and predatory activity were insufficient to control its populations, the option taken was to release predators (coccinelids) in May the 25th (figure 8 and 9). These beneficial insects had an excellent adaptation to greenhouses conditions and reduced considerably the pest populations.

CONCLUSIONS

In Portugal, on protected sweet pepper crops, high population levels of aphids are, normally, associated to *A. craccivora*, *A. gossypii* and *M. persicae* presence.

M. persicae populations must be controlled since the beginning, when the first colonies are observed. With low population levels, parasitism seems to be the better option to consider. In the region of the experiments, the activity of the indigenous parasitoids is not enough to control *M. persicae* populations and early introductions of parasitoids are necessary.

On the other hand, to control *A. craccivora* and *A. gossypii* populations, whose reproductive rate is very high in protected pepper crop, parasitism was not sufficient to control these aphid species.

Decreases in *A. craccivora* and *A. gossypii* populations correspond, usually, to predator population increase. Therefore, if indigenous predator activity is scarce to control these aphids, the introduction of predators, namely, coccinelids should be considered because of its efficacy to control those aphid species as it was observed in 2004.

The releases of the parasitoid *A. colemani* and the predator *C. septempunctata* were associated to the decrease of aphid population levels and apparently controlled the aphid species mentioned.

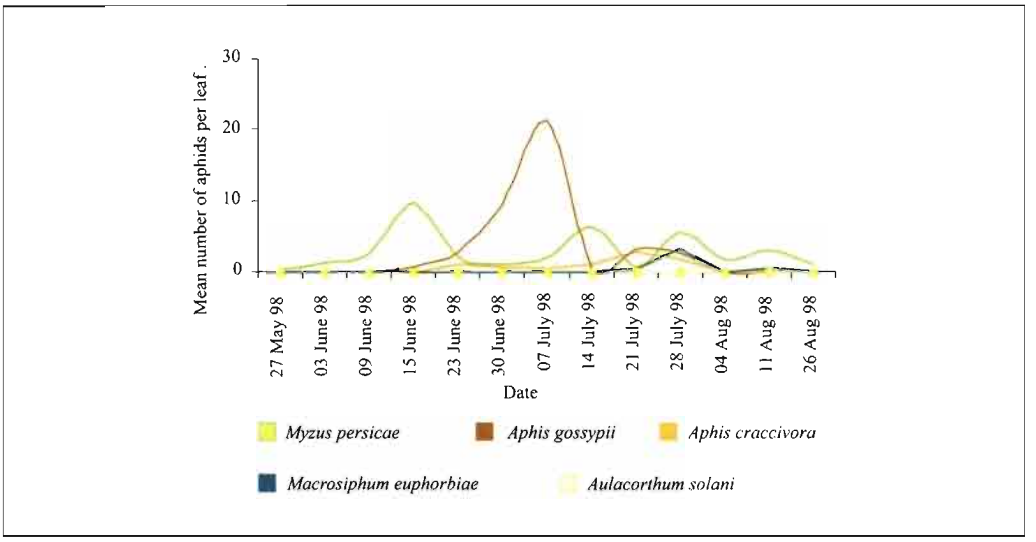

Figure 2. Evolution of mean number of aphid species during the year of 1998.

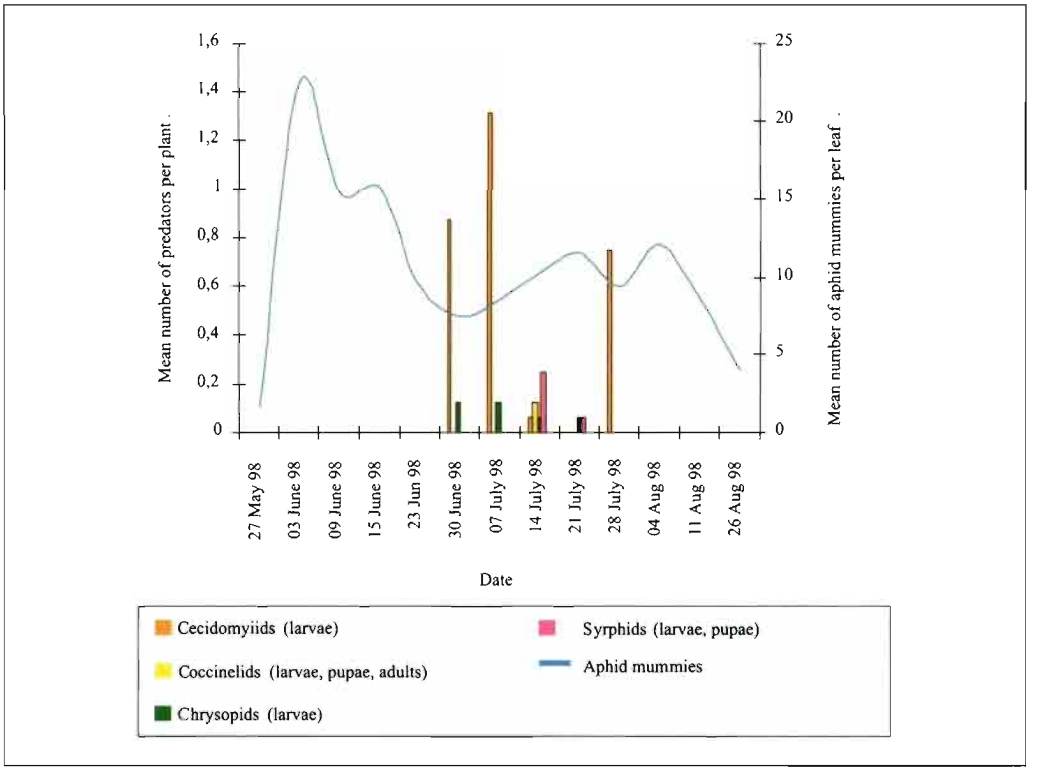

Figure 3. Mean number of predators per plant and mean number of aphid mummies per leaf, observed during the year of 1998.

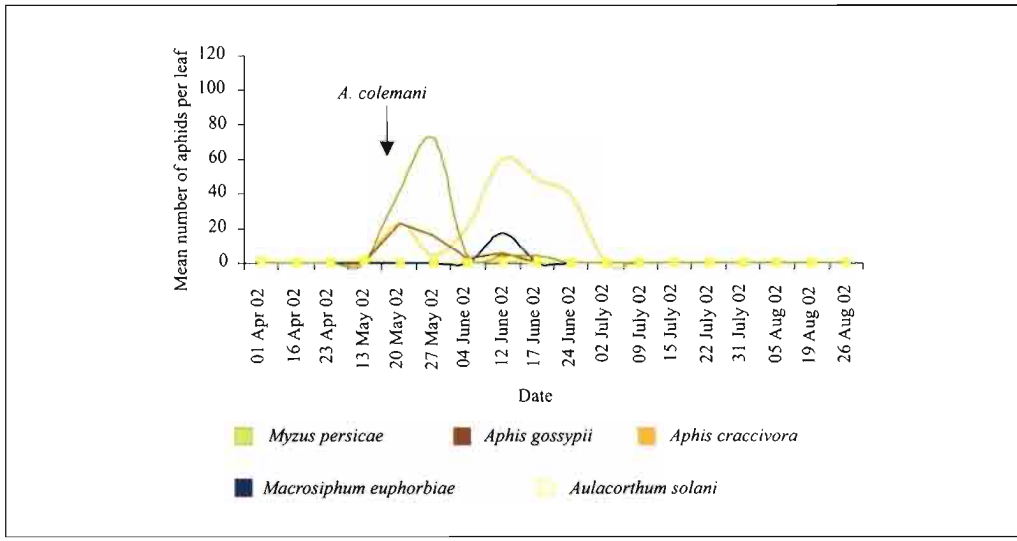

Figure 4. Evolution of mean number of aphid species during the year of 2002.

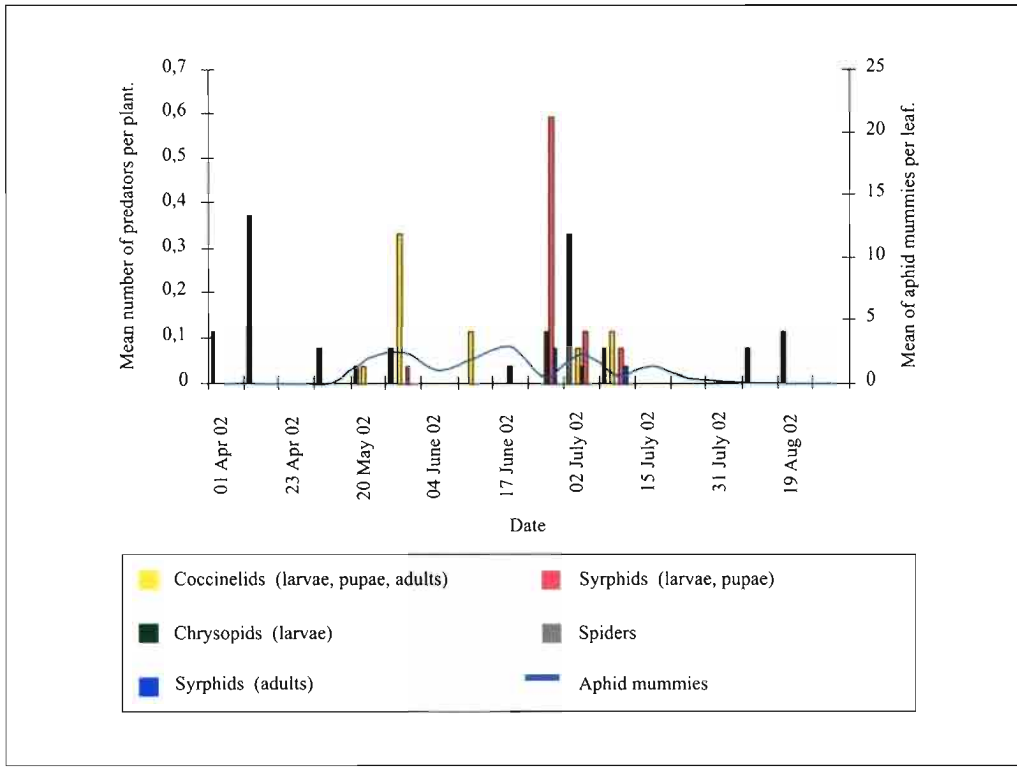

Figure 5. Mean number of predators per plant and mean number of aphid mummies per leaf, observed during the year of 2002.

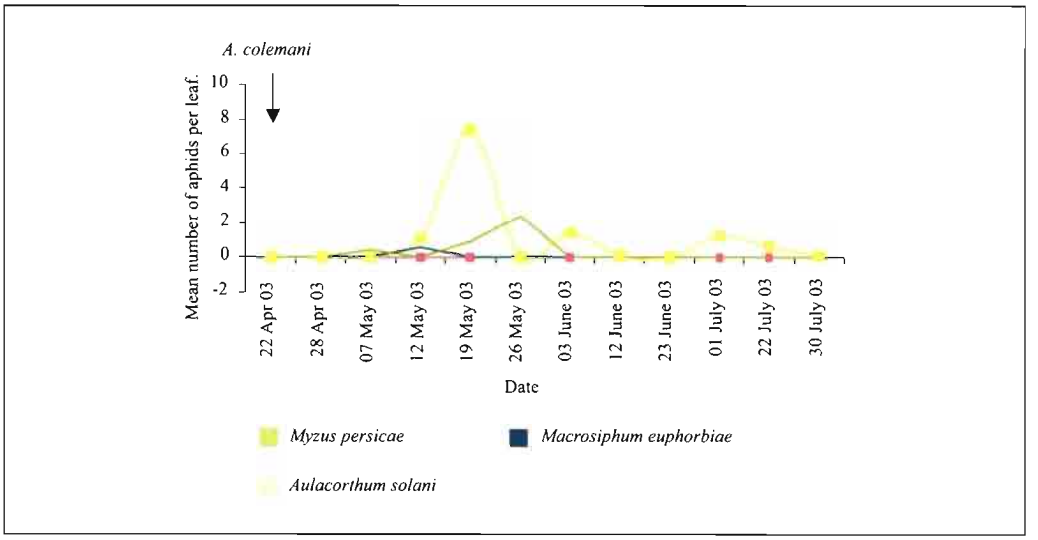

Figure 6. Evolution of mean number of aphid species during the year of 2003.

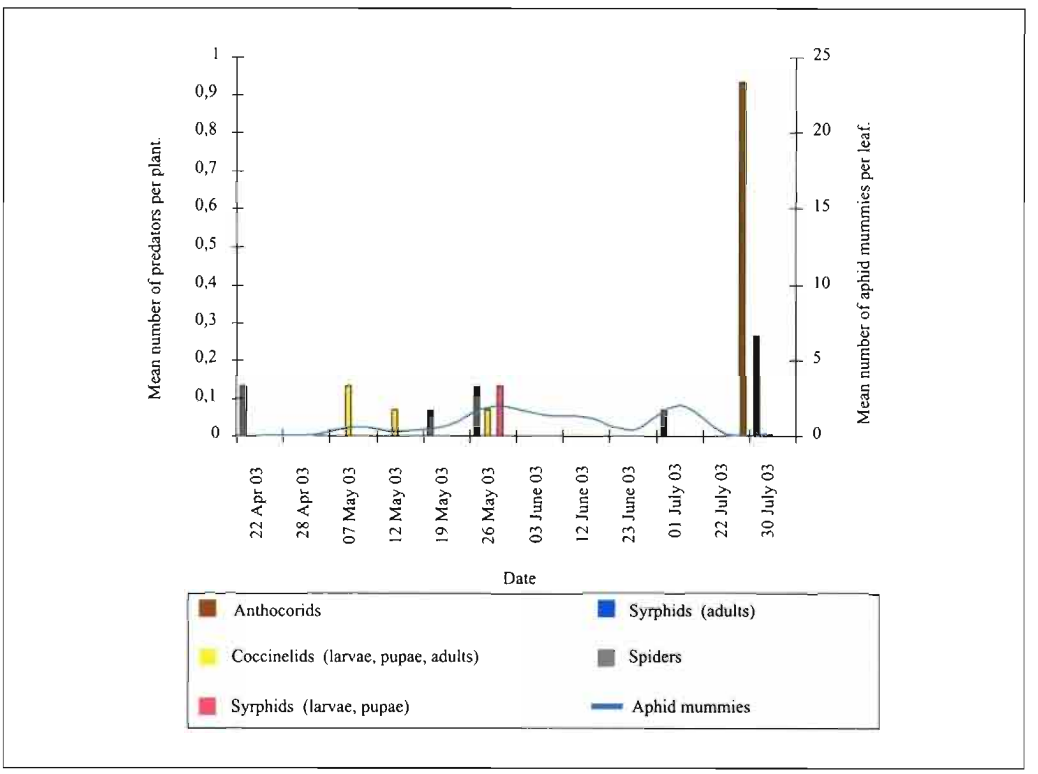

Figure 7. Mean number of predators per plant and mean number of aphid mummies per leaf, observed during the year of 2003.

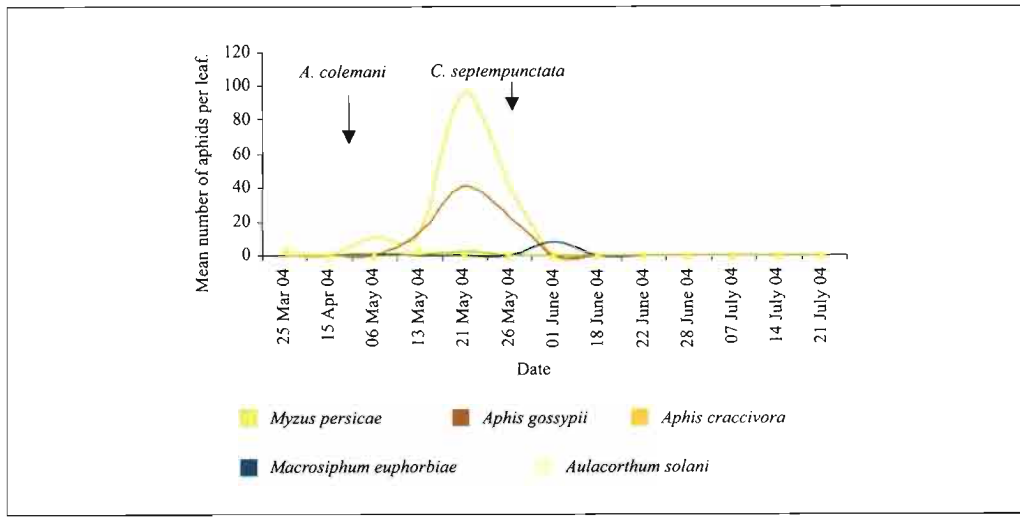

Figure 8. Evolution of mean number of aphid species during the year of 2004.

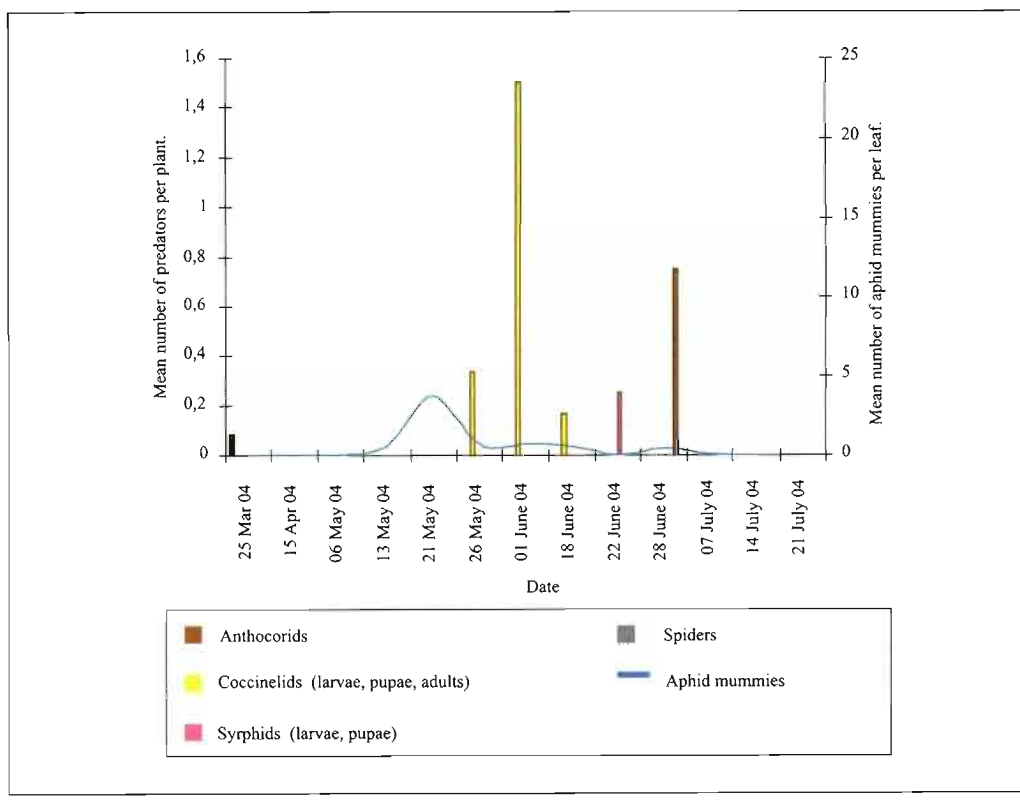

Figure 9. Mean number of predators per plant and mean number of aphid mummies per leaf, observed during the year of 2004.

ACKNOWLEDGEMENTS

This study was supported by the national research projects PIDDAC-103/02 and PRAXIS/3/3.2/HORT/2164/95 and also FCT (Fundação para a Ciência e a Tecnologia). We wish to thank José Firmino for his support and for making available greenhouses to the assays. To Dr. J. Constantino Sequeira we wish to thank the comments on the text.

RESUMEN

VALÉRIO E., A. CECÍLIO, A. MEXIA. 2007. Interacción entre especies de áfidos y organismos beneficiosos en cultivos protegidos de pimiento. *Bol. San. Veg. Plagas*, **33**: 143-152.

Las interacciones entre diversas especies de áfidos y los organismos beneficiosos se han estudiado en la región del oeste de Portugal, en cultivos protegidos de pimiento. Los ensayos fueron realizados durante los años de 1998, 2002, 2003 y 2004. Las especies de áfidos y los enemigos naturales se recogieron semanalmente, cuantificados e identificados en laboratorio.

Las especies de áfidos que alcanzaron umbrales económicos fueron *Aphis craccivora* Koch, *Aphis gossypii* Glover y *Myzus persicae* (Sulzer). También estuvieron presentes *Aulacorthum solani* (Kaltenbach) y *Macrosiphum euphorbiae* (Thomas).

La actividad depredadora indígena por los antocóridos, cecidómidos, coccinélidos, crisópidos, arañas, sírfidos y algunos parásitos, han contribuido al control de las poblaciones de áfidos. Sin embargo, en cultivo de pimiento, las poblaciones de áfidos pueden alcanzar altos niveles y la actividad de enemigos naturales es escasa para controlarlos satisfactoriamente. La introducción de enemigos beneficiosos es, por tanto, necesaria.

Un programa de control biológico fue puesto en marcha y se adaptó a las condiciones en que se desarrollaron los ensayos. Para controlar las poblaciones de *A. craccivora* y *A. gossypii* los cuales tuvieron una tasa de reproducción en nuestros ensayos, las introducciones de depredadores, (coccinélidos), fueron eficaces en el control de las especies de áfidos. Las poblaciones de *M.persicae* pueden ser controladas con las introducciones de parasitoides cuando se observan a las primeras colonias. En este estudio el depredador *Coccinella septempunctata* L y el parasitoide *Aphidius colemani* Viereck fueran utilizados.

Palabras clave: áfidos, parasitos, depredador, control biológico, invernadero, pimiento.

REFERENCES

BARRATT, B. I. P., PHILLIPS, C. B., FERGUSON C. M., GOLDSON S. L. 2003. Predicting non-target impacts of parasitoids: where to go from here? USDA Forest Service- FHTET publication. 1st International Symposium on Biological Control of Arthropods: 378-386, January. Honolulu, Hawaii, USA.

BARRENECHEA, I. V., CABALEIRO SOBRINO, C., MARTÍN LÓPEZ, B. 2004. Empleo de aceites de distinto origen, en programas de manejo integrado en pimiento para el control del pulgón *Myzus persicae* (Sulzer). *Bol. San. Veg. Plagas*, **30**: 185-195.

DOMAGALA, T.1992. Use of *Aphidius matricariae* in integrated control of *Myzus persicae* on capsicum in glasshouses. *Bull OEPP/EPPO*, **22** (3):449-453.

DUFOUR, R. 2001. Biointensive integrated pest management (IPM). Fundamentals of sustainable agriculture. ATTRA, 1-52.

EVANS, E. W. 2003. Searching and reproductive behaviour of female aphidophagous ladybirds (Coleoptera: Coccinellidae): a review. *Eur. J. Entomol.*, **100**: 1-10.

FOLLETT, P. A., DUAN, J. J. (Eds.). 2000. Nontarget effects of biological control. Kluwer Academic Publishers. Boston/Dordrecht/London. 316 pp.

GARCÍA, T. C. 2001. Problemática de plagas en cultivos hortícolas en invernaderos: evolución y situación actual. *Agricola Vergel*, **239**: 621-625.

GILKESON, L. A. 1990. Biological control of Aphids in Greenhouse Sweet Peppers and tomatoes. *Bulletin SROP/WPRS* **XIII** (5): 64-70.

GREER, L. 2000. Greenhouse IPM: sustainable aphid control. Pest Management Technical Note. ATTRA, 1-12.

GREER, L., DIVER, S. 1999. Integrated pest management for greenhouses crops. Pest management systems guide. ATTRA, 1-34.

HERMOSO DE MENDOZA, A., LA SPINA, M., MARCO, F., TABANERA, S., VINACHES, P. 2005. Nível de daño económico para *Aulacorthum solani* (Kaltenbach) (Hemiptera, Aphididae) sobre pimiento en invernadero comercial. Record of proceedings of IV Congreso Nacional de Entomología Aplicada, X Jornadas científicas de la SEEA, I Jornadas portuguesas de entomologia aplicada. Bragança (Portugal), p. 112. (Abstract).

ILHARCO, F. A. 1992. Equilíbrio Biológico de afídeos. Fundação Calouste Gulbenkian, 303 pp, Lisboa.

LEE, H. T., IDRIS, A. B., MOHAMAD ROFF, M. N. 2002. The population abundance of *Aphis gossypii* Glover (Hemiptera: Aphididae) in different chilli (*Capsicum annum*) planting densities. *Online Jour. of Biol. Scienc.*, **2** (5): 293-294.

LOUDA, S. M., PEMBERTON R. W., JOHNSON, M. T., FOLLETT, P. A. 2002. Nontarget effects-the Achille's heel of biological control? Retrospective analyses to reduce risk associated with biocontrol introductions. *Annu. Rev. Entomol.*, **48**: 365-396.

MELLINGER, H. C., BOTTENBERG, H. 2000. Commercial implementation of biointensive IPM in pepper production systems. SBIR phase II final report. 34 pp.

MINORETTI, N., WEISSER, W. W. 2000. The impact of individual ladybirds (Coccinella septempunctata, Coleoptera: Coccinellidae) on aphid colonies. *Eur. J. Entomol.*, **97**: 475-479.

OBRYCKI, J. J., KRING, T. J. 1998. Predaceous coccinellidae in biological control. *Annu. Rev. Entomol.*, **43**: 295-321.

ÖSTMAN, Ö., EKBOM, B., BENGTSSON, J..2001. Landscape heterogeneity and farming practice influence biological control. *Basic Appl. Ecol.*, **2**: 365-371.

RABASSE, J. M., LAFONT, J. P., DELPUECH, I., SILVIE, P. 1983. Progress in aphid control in protected crops. *SROP/WPRS Bulletin*, **VII** (3): 151-162.

RAMÓN, R. C. 2002. Perspectivas en el control de plagas agrícolas. *Agrícola Vergel*, 582-586.

SAMPAIO, M. V., VANDA, H. P. B., VAN LENTEREN, J. C. 2001. Preferência de *Aphidius colemani* Viereck (Hymenoptera: Aphididae) por *Myzus persicae* (Sulzer) e *Aphis gossypii* Glover (Hemiptera: Aphididae). *Neotrop. Entomol.*, **30** (4):655-660.

SÁNCHEZ, J. A., CÁNOVAS, F., LACASA, A. 2005. Estratégias de manejo y umbrales de intervención para *Aulacorthum solani* (Hemiptera: Aphididae) en cultivos de pimiento en invernadero. Record of proceedings of IV Congreso Nacional de Entomología Aplicada, X Jornadas científicas de la SEEA, I Jornadas portuguesas de entomologia aplicada. Bragança (Portugal), p. 114. (Abstract)

SIMBERLOFF, D., STILING, P. 1996. Risks of species introduced for biological control. *Biol. Conservation*, **78**: 185-192.

TRILTSCH, H. 1999. Food remains in the guts of *Coccinella septempunctata* (Coleoptera: Coccinellidae) adults and larvae. *Eur. J. Entomol.*, **96**: 355-364.

VALÉRIO, E. 1997. Os parasitóides (Hymenoptera: Aphidiidae) e o seu potencial na limitação natural de afídeos (Homoptera: Aphidoidea) em culturas protegidas na região Oeste, Universidade de Évora, 97 pp.

VALÉRIO, E., CECÍLIO, A., ILHARCO, F. A., MEXIA, A. 1999. Dinâmica das populações de afídeos (Homoptera: Aphidoidea) e seus parasitóides (Hymenoptera: Aphidiidae) em cultura protegida de pimento. *Suplement of SPEN bulletin*, N°6: 79-84.

VALÉRIO, E., CECÍLIO, A., MEXIA, A. 2003. Biodiversidade de parasitismo espontâneo de afídeos em horticultura protegida, em diferentes sistemas de protecção das plantas. Record of proceedings of 6º Encontro Nacional de Protecção Integrada., p. 14.

VALÉRIO, E., CECÍLIO, A., MEXIA, A. 2004. Interacções entre hiperparasitóides, parasitóides primários e afídeos (Homoptera, Aphididae) em cultura protegida de pimento. Record of proceedings of XI Congresso Ibérico de Entomologia, p. 153.

VALÉRIO, E., CECÍLIO, A., MEXIA, A. 2005. Estratégias de Protecção Integrada para pragas de afídeos em cultura protegida de pimento. Record of proceedings of VII Encontro Nacional de Protecção Integrada – A Produção Integrada e a Qualidade e Segurança Alimentar. Mª José Moreno da Cunha (coord.). Col. Práticas-Conhecimento-Pensamento, Ed. IPC (Instituto Politécnico de Coimbra). I (9): 98 – 105.

VAN LENTEREN, J. C. 1996. Quality control tests for natural enemies used in greenhouse biological control. *OILB/WPRS Bull.*, **19** (1): 83-86.

VAN SCHELT, J., DOUMA, J. B., RAVENSBERG, W. J. 1990. Recent developments in the control of aphids in sweet peppers and cucumbers. *SROP/WPRS Bull. XIII/5*: 190-193.

VAN STEENIS, M. J., EL-KHAWASS, K. A. M. H. 1996. Different parasitoid introduction schemes determine the success of biological control of *Aphis gossypii* with the parasitoid *Aphidius colemani*. *Bulletin IOBC/WPRS*, **19** (1):159-162.

VASICEK, A., DE LA ROSSA, F., PAGLIONI, A. 2001. Aspectos biológicos y poblacionales de *Aulacorthum solani*, *Myzus persicae* y *Macrosiphum euphorbiae* (Homoptera: Aphidoidea) en pimiento (*Capsicum annum* L.). *Bol. San. Veg. Plagas*, **27**: 439-446.

WAWRZYNSKI, R. P., ASCERNO, M. E., MCDONOUGH, M. J. 2001. A survey of biological control users in Midwest greenhouse operations. *Amer. Entomol.*, **47** (4): 228-234.

WICK, M. 1992. Release of *Aphidius matricariae* for control of *Myzus persicae* in glasshouses. *OEPP/EPPO Bulletin*, **22**: 437-444.

ZHANG, R., LIANG, H., TIAN, C., ZHANG, G. 2000. Biological mechanism of controlling cotton aphid (Homoptera: aphididae) by the marginal alfalfa zone surrounding cotton field. *Chinese Science Bull.*, **45** (4): 355-357.

(Recepción: 18 enero 2006)
(Aceptación: 30 abril 2007)