Bol. San. Veg. Plagas, 33: 153-161, 2007

Population dynamics of aphids (Homoptera: Aphididae) and beneficial organisms on protected strawberry crops

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In protected strawberry crops, aphids are one of the most important pests and can cause serious losses on strawberry production. The knowledge of aphid population dynamics and beneficial organisms is very useful to reduce damage.

To study the aphid population dynamics and beneficial organisms, assays were carried out, in two greenhouses, during the years 2002/2003 and 2003/2004, in the west region of Portugal. The protected strawberry crops were submitted to an IPM (Integrated Pest Management) programme. Biological control and cultural control were selected to allow the observation of interactions between aphid populations and beneficial organisms. Aphids and natural enemies were quantified and identified weekly during the crop period. Predators (coccinellids) were released in order to control aphid populations.

The aphid species that reached the economic threshold were *Aphis gossypii* Glover and *Aphis ruborum* (Börner). *A. gossypii* reached much higher population levels than other species. *Aphis craccivora* Koch, *Aulacorthum solani* (Kaltenbach) and *Macrosiphum euphorbiae* (Thomas) were also identified.

Primary parasitism by the families Aphidiidae and Aphelinidae was observed, as well as parasitism by entomopathogenic fungi. Predator activity (anthocorids, cecidomyiids, coccinellids, chrysopids, spiders and syrphids) was the most efficient in controlling aphid populations.

Aphid population levels always reached high values in the two years of assays, especially *A. gossypii*. Beneficial organisms and cultural control by periodically removal of old leaves, contributed to reduce the pest populations. However, were insufficient to prevent harmful levels on fruits and consequently releases of predators were justified.

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Key words: Aphids, beneficial organisms, biological control, cultural control, greenhouse, strawberry.

INTRODUCTION

The damage caused by aphids on protected strawberry crops can result from the honeydew production on the fruits. The presence of this sticky secretion induces the appearance of sooty mould that grows on it, and fixes the aphid exuviae making the fruits unmarketable (STRAND, 1994, RONDON *et al.*, 2005, VALÉRIO *et al.*, 2004c, 2005).

Several aphid species are reported for the strawberry crop, namely, *Pentatrichopus fragaefolii* (T.D.A. Cockerell) (SHANKS, 1970, STRAND, 1994, RONDON, 2004, VALÉRIO *et al.*, 2004a, 2004b, 2004c, 2005), *Myzus persicae* Sulzer (STRAND, 1994), *Macrosiphum euphorbiae* (Thomas) (STRAND, 1994, VALÉ-

RIO *et al.*, 2004a, 2004b, 2004c, 2005), *Aphis ruborum* (Börner) (VALÉRIO *et al.*, 2004a, 2004b, 2004c, 2005). However, in protected crops, *Aphis gossypii* Glover has been mentioned as the most important (RONDON *et al.*, 2003, 2005, VALÉRIO *et al.*, 2004a, 2004c, 2005).

The key for successful management of insects in strawberries is the detection of potentially damaging populations before they reach harmful levels (STRAND, 1994). It is important to understand the life cycle and behaviour of insect pests in order to develop an effective control strategy (GREER *et al.*, 1999; DUFOUR, 2001). Although several control methods are available when economic thresholds are reached, chemical control can be costly both for farmers, public health and environment, particularly in terms of negative effects on beneficial organisms (ILHARCO, 1992; ZHANG, 2000; ÖSTMAN, 2001). For this reason, control methods like cultural control and biological control are being preferentially used. RONDON (2003) reports that adequate sanitation, elimination of crop residues, detection of early infestations of pests and releases of beneficial organisms, can be sufficient to keep pest populations below the economic threshold level on strawberry crops.

Strawberry crops in greenhouse environments provide favourable conditions for introduction of beneficial organisms (CROSS, 2001). Nevertheless, proper identification of aphid species is very important and must be done before a control programme using beneficial organisms is initiated (GREER, 2000; VALÉRIO *et al.*, 2004c). Precautions for minimizing the non-target effects of biological control, namely the extinguishing of native species, the unbalance of ecosystems and other effects, are very important and must be taken into account (SIMBERLOFF, 1996; FOLLETT *et al.* ed., 2000; BARRATT, 2003; LOUDA, 2003).

Predators are the most suitable tools for controlling the very dense colonies, characteristic of *A. gossypii*, the aphid target (RAMAKERS, 1989). In this work we selected coccinellids to be released because of its proven efficiency in controlling high levels of aphids in various crops (FERRARI, 1994, OBRYCKI, 1998; TRILTSCH, 1999; MINORETTI, 2000, EVANS, 2003), including the strawberry crop (VALÉRIO, 2004a).

Two coccinellids were introduced to control aphid populations in greenhouses. One of them was *Harmonia axyridis* (Pallas) and besides its non target impacts frequently mentioned (KOCH, 2003, OSAWA, 2003, KURODA, 2003 FERNANDES, 2005), it has a greater suppressive effect on the density of *A. gossypii* (KURODA, 2003, RONDON, 2005) and of other aphids in strawberry crops (KOCH, 2003).Moreover, its acquirement has been easy due to its availability on commercial suppliers. *Coccinella septempunctata* L. was selected, especially due to its availability near the protected strawberry crops, on potato crops and in shrubs and hedges that can serve as hibernation places and local food supply, when other crops are not available.

In order to define a protected control programme for aphids, the population dynamics of aphids and natural enemies were studied on strawberry greenhouses. This study also provides a basis for developing a biological control programme for aphids, especially *A. gossypii*, in protected strawberry crop.

MATERIALS AND METHODS

The assays were conducted, during the years 2002/2003 and 2003/2004, on protected strawberry crops, in the west region of Portugal.

Two greenhouses were sampled every year and submitted to Integrated Pest Management. Cultural control, by periodical removal of old leaves (Table 1), and biological control were adopted to control aphid populations. Each year, a release of predators (coccinellids) was made in one of the greenhouses and, in the other, natural control of aphid population was used without any release of beneficial organisms. No insecticide was used.

Table 1. **Dates of periodical removal of old leaves in strawberry protected crop.**

Year	2002/2003		2003/2004	
/Month	Greenhouse 1	Greenhouse 2	Greenhouse 1	Greenhouse 2
September			30	30
October	18	20, 29	17	
November	05, 19	13, 22	08	08
December	10	27	27	
January		20*	08	15
February	05, 08*			
March			01, 25*	01, 25*

* Every week after the date

Aphid sampling was made weekly since the beginning on twenty strawberry plants randomly chosen in each greenhouse. When the conditions were favourable to the development of aphid populations, the frequency of sampling was intensified.

Sampling aphids and beneficial organisms in protected strawberry crops

Every week, twenty trifoliate leaves and ten flowers or fruits were collected. Samples were analysed in laboratory. Aphid species and parasitized aphids (mummies) were quantified and identified.

Monitoring predators in protected strawberry crops

The predatory activity was monitored on twenty plants by visual observation. The whole aerial part of the strawberry plant was observed and the presence of larvae, pupae, adult stages of predators (anthocorids, cecidomyiids, coccinellids, chrysopids, spiders and syrphids) were registered.

Introduction of beneficial organisms

To control *A. gossypii* populations in flowers and fruits, two predators (coccinellids) were introduced: *Harmonia axyridis* (Pallas), in 2002/2003 and *Coccinella septempunctata* L. in 2003/2004.

H. axyridis was acquired in a biological control supplier and *C. septempunctata* was captured in potato crops near the greenhouses.

RESULTS AND DISCUSSION

Biodiversity of aphid species and natural enemies

During the assays, five aphid species were identified: *Aphis craccivora* Koch, *Aphis gossypii* Glover, *Aphis ruborum* (Börner), *Aulacorthum solani* (Kaltenbach) and *Macrosiphum euphorbiae* (Thomas).The aphid species that reached the economic threshold were *Aphis gossypii* Glover and *Aphis ruborum* (Börner). *A. gossypii* was the dominant species and reached higher population levels than the other species, being the observation of its presence always higher than 70% (Figure 1). *M. euphorbiae* was only observed in the first year (3%) (Figure 1). *A. craccivora* and *A. solani* were rarely observed being present in less than 1% of the observations.

Primary parasitism by the families Aphidiidae and Aphelinidae and parasitism by entomopathogenic fungi were observed. *A. ruborum* was the most susceptible to entomopathogenic fungi. Indigenous predator activity by anthocorids, cecidomyiids, coccinellids, chrysopids, spiders and syrphids were frequently observed, and was important to control aphid populations.

Population dynamics of aphids and beneficial organisms

During the assays conducted in 2002/2003 and 2003/2004, aphid populations, especially *A. gossypii*, reached high

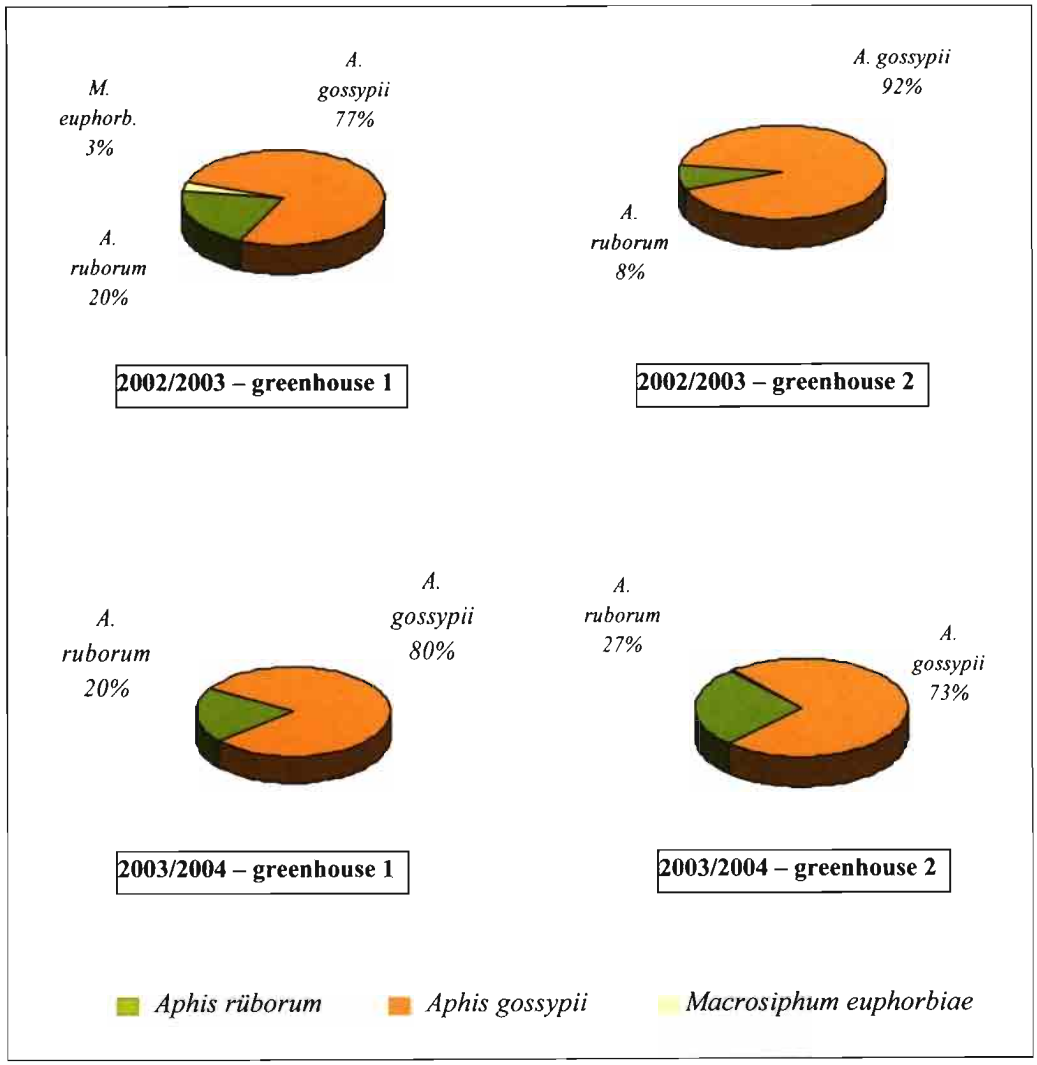

Figure 1. Percentage of aphid species observed on strawberry plants in the greenhouses. Samples were collected weekly, since the beginning.

levels. The parasitoid activity was low but indigenous predators were frequently observed, controlling this aphid species during the strawberry crop development. On the other hand, the periodic removal of old leaves can contribute to reduce aphid population levels (Figures 2, 3, 4 and 5).

In the greenhouse 1 (2002/2003) variation of the aphid population levels occurred and was associated to the presence of predators (cecidomyiids and spiders) together with the removal of old leaves (Figure 2).

In early February, aphid populations reached high levels on the leaves and an increase of *A. gossypii* colonies was observed in flowers and fruits. This fact justified a release of coccinellid *H. axyridis* (8 Feb.) to prevent production losses. *H. axyridis* had a

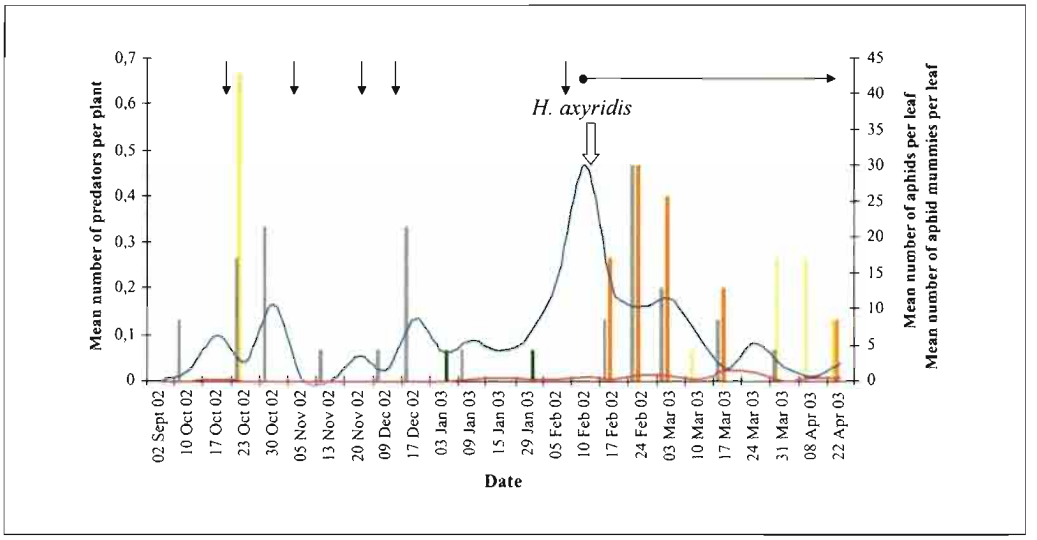

Figure 2. Greenhouse 1. Mean number of predators per plant, mean number of aphids and aphid mummies per leaf during 2002/2003. The arrow indicates the *Harmonia axyridis* release.

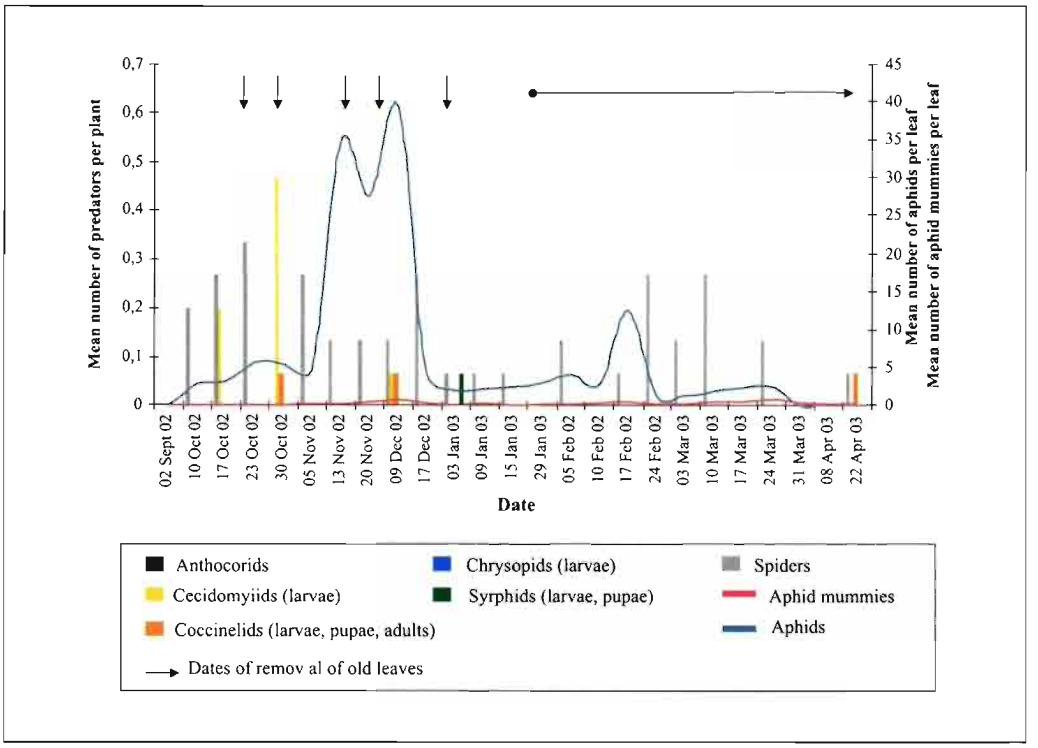

Figure 3. Greenhouse 2. Mean number of predators per plant, mean number of aphids and aphid mummies per leaf during 2002/2003.

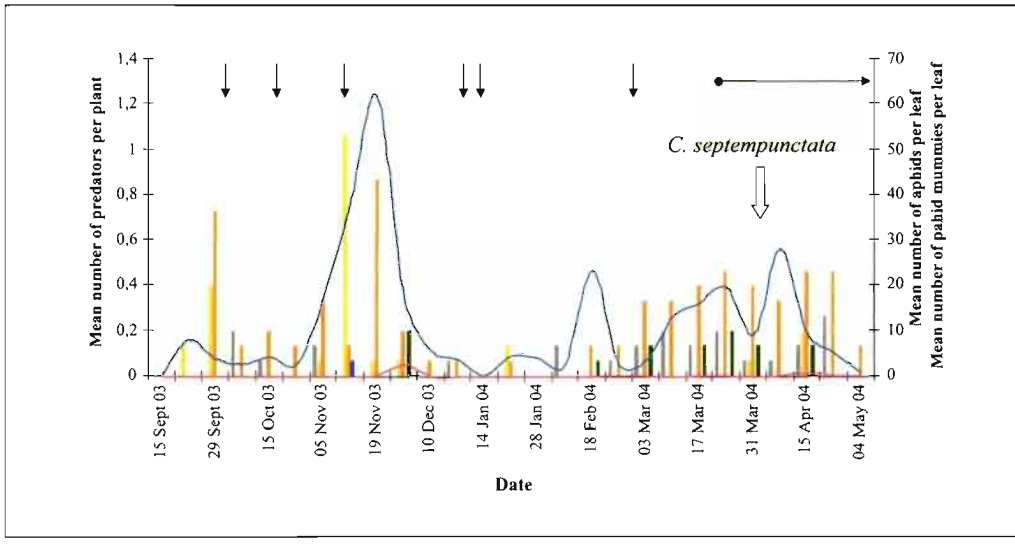

Figure 4. Greenhouse 1. Mean number of predators per plant, mean number of aphids and aphid mummies per leaf during 2003/2004. The arrow indicates the release of *Coccinella septempunctata.*

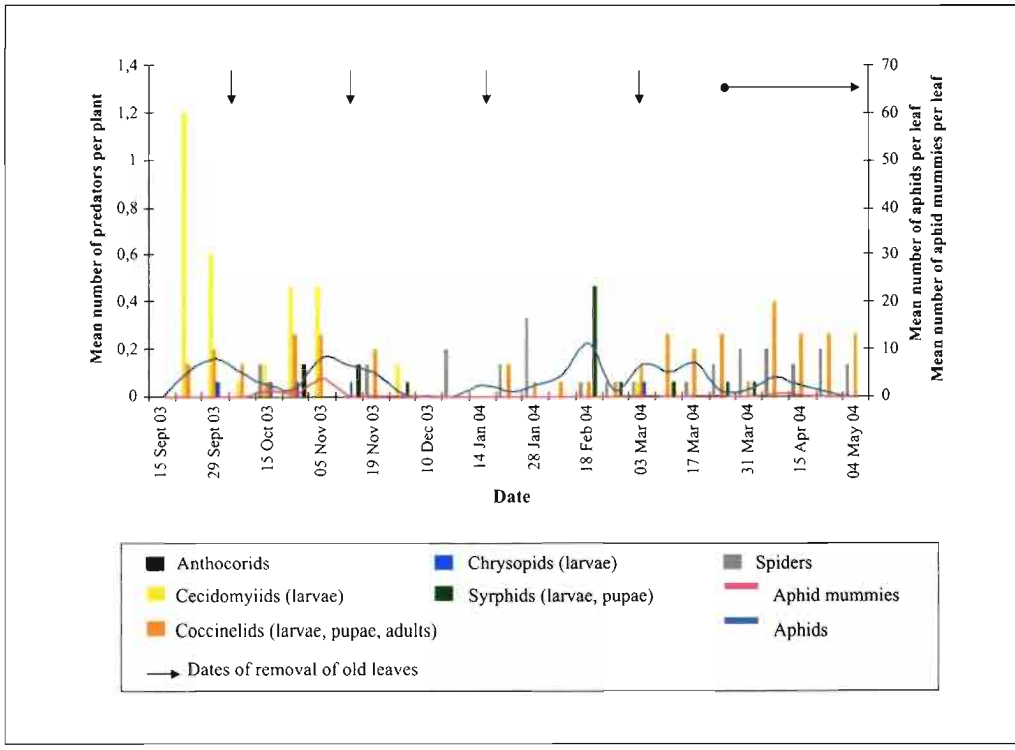

Figure 5. Greenhouse 2. Mean number of predators per plant, mean number of aphids and aphid mummies per leaf during 2003/2004.

good adaptation to the greenhouse conditions, which contributed for the *A. gossypii* population decrease (Figure 2). On the other hand, this predator didn't remain in the agro system as verified by KURODA, 2003, who mentions the escape from the greenhouse, natural mortality of larvae, cannibalism and other factors, as possible reasons for that fact.

In the second greenhouse (Figure 3), even with the cecidomyiids and spiders presence, and the cultural control practice, we couldn't prevent an *A. gossypii* population peak when the first flowers appeared. This peak, however, didn't become a concern because, at that time, crop production was reduced and not appropriate for marketing. In December the aphid population was reduced and kept at low levels during all the crop development.

In the second cultural period (2003/2004), high aphid population levels were reached in November, at early blooming (greenhouse 1). However, predator activity, especially cecidomyiids and coccinellids, contributed to the aphid population decrease (Figure 4).

The natural enemies kept active control of the aphid populations during the first stage of the plant development. However, they couldn't prevent the aphid population increase in flowers and fruits at early April, when the crop was in full production. Releases of a coccinellid (*C. septempunctata*) were made (6 Apr.) to reduce aphid populations and avoid production losses. When the following crop in the same greenhouse was observed, the presence of this coccinellid was registered again, suggesting that this predator has been maintained in the ecosystem probably due to the presence of hibernation places and local food supplies near the greenhouses.

In the greenhouse 2 (Figure 5) natural control and the removal of old leaves kept aphid populations at acceptable levels.

CONCLUSIONS

In protected strawberry crops, the aphid *Aphis gossypii* Glover is one of the most important pests and can cause high losses in crop production. The high density of aphid populations that can develop on flowers and fruits and the honeydew production, induces the appearance of sooty mould that grows on them and fixes the aphid exuviae making the fruits unmarketable.

The natural enemies' activity, especially predators, and the cultural control, by removing old leaves, can contribute to maintain aphid populations at low levels. However, when *A. gossypii* populations increase on flowers and fruits, predator releases should be made to prevent fruit production losses.

We recommend releases with indigenous predators or predators captured near the crop, when they are available, because of the success in adaptation and maintenance on the ecosystem.

ACKNOWLEDGEMENTS

This study was supported by the national research project PO AGRO DE&D nº 193: "Tecnologias de produção integrada no morangueiro visando a expansão da cultura e a reconquista do mercado" and also FCT (Fundação para a Ciência e a Tecnologia). We want to thank to Dr. J. Constantino Sequeira for the critical revision of the manuscript.

RESUMEN

VALÉRIO E., A. CECÍLIO, A. MEXIA. 2007. Dinámica de las poblaciones de áfidos (Homoptera: Aphididae) y organismos beneficiosos en cultivos protegidos de fresa. *Bol. San. Veg. Plagas*, **33**: 153-161.

En cultivo protegido de la fresa, los áfidos son una de las plagas más importantes y pueden causar pérdidas serias en la producción. El conocimiento de la dinámica de la población de áfidos y enemigos naturales es muy útil para reducir el daño.

En este estudio, los ensayos fueron realizados durante los años 2002/2003 y 2003/2004, en la región del oeste de Portugal y dos invernaderos por año fueron muestreados. El cultivo protegido de la fresa fue sometida a un programa de producción integrada. El control biológico y el control cultural fueron favorecidos para permitir las interacciones entre las poblaciones de áfidos y los enemigos naturales. Las introducciones de los depredadores (coccinelidos) fueron hechos en uno de los invernaderos estudiados por año. Los áfidos y los enemigos naturales fueron semanalmente cuantificados e identificados.

Las especies de pulgón que alcanzaron el umbral económico fueran *Aphis gossypii* Glover y *Aphis ruborum* (Börner). *A. gossypii* alcanzó los niveles poblacionales más elevados por encima del 70 %. En lo referente a otras especies; *Aphis Craccivora* Koch, *Aulacorthum solani* (Kaltenbach) y *Macrosiphum euphorbiae* (Thomas) también fueran identificados.

El parasitismo primario de las familias Aphidiidae y Aphelinidae fue observado, y también el parasitismo de hongos entomopatógenos. Sin embargo, la actividad depredadora (antocóridos, cecidómidos, coccinélidos, crisópidos, arañas y sírfidos) fueran más eficientes en control de las poblaciones de áfidos.

Las poblaciones de áfidos alcanzaran niveles elevados en los dos años de observación, especialmente *A. gossypii*. Los organismos beneficiosos combinados con el manejo cultural (retirada periódica de hojas viejas) han contribuido a reducir las poblaciones de la plaga, pero, no fueron suficientes para disminuir a niveles de daños satisfactorios en las frutas. Las introducciones de depredadores estuvieron justificados.

Palabras clave: Áfidos, organismos beneficiosos, control biológico, control cultural, invernadero, fresa.

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(Recepción: 18 enero 2006)
(Aceptación: 3 mayo 2007)