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ORIGINAL ARTICLE

Evaluation of *Serangium parcesetosum* (Col.: Coccinellidae) for biological control of *Bemisia tabaci* under greenhouse conditions

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Abstract The cotton whitefly, *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) is increasingly a very important pest on many vegetables, field crops and ornamental plants. Therefore, controlling of this pest is still needed especially under glasshouse conditions. The specialist whiteflies' predator, *Serangium parcesetosum* Sicard (Col., Coccinellidae) appears to have a great potential for the cotton whitefly control. In this study, the dynamic changes in *B. tabaci* populations in glasshouse cabins in response to *S. parcesetosum* were monitored. *B. tabaci* were introduced to cotton plants in three cabins in average of 50 adults per plant. One and two weeks later, adult females and males of *S. parcesetosum* were introduced at a rate of one female and one male per plant in the first and second cabins, respectively. The third cabin was considered as a control. The results showed that the mean number of whiteflies in the control cabin was found significantly higher than that of either when *S. parcesetosum* was introduced 1 or 2 weeks after the infestation with the whitefly. Also, the mean number of *B. tabaci* was significantly higher when the predator was introduced 2 weeks rather than 1 week after *B. tabaci* infestation. The maximum mean weekly number of whiteflies/plant was 192.3 in the second week, whereas it was 294.6 in the third week and 1136.4 in the fifth week, in first, second and control cabins, respectively. In the last experimental week, the mean weekly numbers were 74.7, 122.9 and 684.7 whiteflies/plant in the three cabins, respectively. *S. parcesetosum* has been successfully fed, reproduced and established its population on *B. tabaci* on cotton plants. The mean weekly number of the predatory individuals increased gradually with the progress of the experimental time. The results demonstrated that the maximum reduction percentage in *B. tabaci* population was 90.7 and 86.5% in the fifth week after *B. tabaci* infestation, when the predator was introduced 1 and 2 weeks after the infestation with the whiteflies, respectively. Nevertheless, it is speculated that an earlier release of *S. parcesetosum* would be more effective in the biological control of *B. tabaci*.

Keywords *Serangium parcesetosum* · *Bemisia tabaci* · Population dynamics · Predator · Biological control

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Introduction

The cotton whitefly, *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) was formerly confirmed to tropical and subtropical regions of the world (Hilje et al. 2001; Al-Zyoud and Sengonca 2004a). Nevertheless, the insect has since the late 1980's become increasingly an important pest of greenhouse crops in temperate regions (Wagner 1995). It has known as a dangerous pest of many vegetables, field crops and ornamental plants (Gerling et al. 2001). Insecticides have controlled the insect successfully in the past, but because

of its fast reproduction, which required frequency applying of chemicals; therefore, it has rapidly developed resistance to several insecticides (Kranthi et al. 2001). Therefore, it seems that biological control could be an alternative method for pest suppression.

Many natural enemies have been encountered in controlling *B. tabaci*, but most of them were parasitoids and just a few were predators. However, *Serangium parcesetosum* Sicard (Col., Coccinellidae) is a specialist predator of whiteflies (Yigit 1992b; Legaspi et al. 1996; Al-Zyoud and Sengonca 2004b). It has firstly recorded in India on *B. tabaci* (Kapadia and Puri 1992) and the sugarcane whitefly, *Aleurolobus barodensis* Mask (Patel et al. 1996). This predator was used to suppress the citrus whitefly, *Dialeurodes citri* (Ashmead) (Malausa et al. 1988; Yigit 1992a, b; Uygun et al. 1997; Yigit et al. 2003) as well as the silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Legaspi et al. 2001; Ellis et al. 2001). The woolly whitefly, *Aleurothrixus floccosus* Maskell was also found to be a suitable prey for the predator's development (Argov 1994; Abboud and Ahmad 1998). In Germany, *S. parcesetosum* has demonstrated a potential for the biological control of *B. tabaci* in the laboratory (Al-Zyoud and Sengonca 2004b; Al-Zyoud et al. 2005b, c, d; Sengonca et al. 2004, 2005) as well as the greenhouse whitefly, *Trialeurodes vaporariorum* Westwood (Al-Zyoud et al. 2005a).

Furthermore, Al-Zyoud and Sengonca (2004b) mentioned that *S. parcesetosum* preferred whiteflies rather than thrips, aphids and mites, and the predator revealed more preference for *B. tabaci* than *T. vaporariorum*. *S. parcesetosum* was found feeding successfully on *B. tabaci* as prey (Kapadia and Puri 1992). Legaspi et al. (1996) mentioned that *S. parcesetosum* adults indicated a preference for *B. argentifolii*. According to Legaspi et al. (2001), *S. parcesetosum* is a promising biological control agent against *Bemisia* whiteflies because of its voracity and preference. Moreover, *S. parcesetosum* could avoid parasitized *B. tabaci* by *Encarsia formosa* Gahan (Hym., Aphelinidae) and fed instead on unparasitized ones (Al-Zyoud and Sengonca 2004b). Both larvae and adults of *S. parcesetosum* could feed on all of the *B. tabaci* developmental stages and they were voracious feeders, capable for consuming a great number of the cotton whitefly immature stages in a short period (Kapadia and Puri 1992; Ahmad and Abboud 2001; Sengonca et al. 2005). *S. parcesetosum* larval instars consumed approximately 1440 nymphs or 250 puparia of *B. tabaci* at 18°C, and 970 nymphs or 170 puparia at 30°C (Sengonca et al. 2005). The predator's adults survived in average 5–6 months at 18°C and 2–3 months at 30°C on *B. tabaci* (Sengonca et al. 2005), and they consumed just over 60 days of their longevity approximately 1900 nymphs or 600 puparia at 18°C and 3500 nymphs or 1400 puparia at 30°C (Sengonca et al. 2005).

Because of this laboratory success of *S. parcesetosum* as a bio-agent of *B. tabaci* and its high control potential on the cotton whitefly, the present work aimed to evaluate the efficiency of this predator as a biological control agent of *B. tabaci*, where the predator was introduced at two different times. The dynamics of *B. tabaci* and *S. parcesetosum* were monitored on cotton plants. The study will help characterize some basis and provide information in order to facilitate the release of *S. parcesetosum* in a large scale in greenhouses to suppress *B. tabaci* population.

Materials and methods

The individuals of *B. tabaci* and *S. parcesetosum* used in this study were obtained from stock cultures available at the Institute of Plant Diseases, University of Bonn. *B. tabaci* were held on cotton plants, *Gossypium hirsutum* cv. "Caroline Queen". The rearing of the prey was taken place in meshed cages (80 × 50 × 60 cm) sealed with gauze from the four sides in order to provide ventilation. The rearing of *S. parcesetosum* was maintained in meshed cylindrical Plexiglas cages (19 cm in diameter and 40 cm in height) sealed with gauze from their tops to allow aeration. The rearing cages of the prey and the predator were kept in climatically controlled chambers at the Institute of Plant Diseases, University of Bonn at a temperature of 25 ± 1°C, relative humidity of 60 ± 10% and a photoperiod of 16:8 (L:D) hours with an artificial light intensity of about 4000 lux. Cotton plants infested with *B. tabaci* were served as substrate plants for rearing the predator. To maintain adequate prey supply continuously, cotton plants infested with the whiteflies were frequently replaced inside the cages. The old plants were used to infest the new ones and to feed the predator. The cotton plants were usually grown in small pots (10 cm in diameter and 8 cm in height) in a glasshouse. The plants had replaced with new ones whenever more *B. tabaci* needed for the experiments. The desired adult females and males of *S. parcesetosum* for the experiments were obtained from round Plexiglas cages (11 cm diameter and 3 cm height) filled partially with 0.5 cm thick layer of wetted cotton pad. The lid of each cage had equipped three meshed holes to provide ventilation. Several mated adult females were transferred onto cotton leaves infested with a sufficient number of different immature stages of *B. tabaci* in each cage. After 24 h, the adult females were removed and the

laid eggs were reared further, and checked daily until they reached the convenient stage for the experiments. The cages were kept in an incubator under the same conditions mentioned above.

The experiments were conducted on cotton plants (30 cm height) in three separated glass cabins; each has 3 m in length, 2 m in width and 3 m in height. The cabins were completely sealed to prevent immigration and emigration of insects. The sealing of each cabin has a meshed area of one m^2 for ventilation. Twenty-one potted cotton plants, each with three fully developed true leaves, were placed in rows of seven plants in each cabin. The two cotyledons were removed from all of the plants before starting the experiments. Total of 1,050 *B. tabaci* adults (2–3 days old) were aspirated, and then introduced in each cabin without determining their sex, which equivalent to a rate of 50 *B. tabaci* adults/plant. In the first cabin, 21 females and 21 males of *S. parcesetosum* adults (1 week-old), in a rate of one female and one male per plant, were introduced using a fine camelhair brush 1 week after the plant had been infested with *B. tabaci*. Two weeks after the infestation with the whitefly, the same rate of *S. parcesetosum* females and males was introduced in the second cabin. No *S. parcesetosum* were introduced in the third cabin, which used as a control cabin. Three cotton plants were randomly selected and taken from each cabin starting from the first week after the infestation with *B. tabaci* and then once weekly. The number of *B. tabaci* and *S. parcesetosum* adults that found on the selected plants was recorded directly on the plants. Thereafter, the plants were transferred to the laboratory in order to determine the number of immature stages of both *B. tabaci* and *S. parcesetosum* overall plant under a dissecting microscope. The experiments continued for 7 weeks until all the plants were tested.

In order to affirm the basic assumptions of the data to be analysed, they were firstly tested for the normal distribution and the homogeneity of variance using the Barlett-test (Köhler et al. 2002). When the data fulfilled the assumptions mentioned above, one-factor-analysis of variance was conducted to detect differences among the means. In case of differences among means were detected, the second step was then to determine the significant differences among the means at a probability level of ≤ 0.05 using the Tukey's honestly significant difference test (Clewer and Scarisbrick 2001).

Results

The weekly mean number of *B. tabaci* eggs, nymphs, puparia and adults per cotton plant when *S. parcesetosum* was introduced 1 week (cabin I) and 2 weeks (cabin II) after the infestation with the whiteflies as well as the control cabin is shown in Fig. 1. In cabin I, the eggs and nymphs of the predator started to appear in the first week of the experiment, where the number of *B. tabaci* was 122.3 eggs, 37.0 nymphs, 0.0 puparia and 24.7 adults. While the puparia appeared in the third week, where the number estimated at 93.0 eggs, 30.3 nymphs, 7.0 puparia and 32.0 adults. In the last experimental week, the number was 29.3 eggs, 22.7 nymphs, 7.0 puparia and 15.7 adults. The mean weekly number of *B. tabaci* eggs, nymphs, puparia and adults per cotton plant in cabin II was 106.3, 77.3, 0.0 and 28.7 in the first week of the experiment, respectively. The puparia appeared in the third week, where the number was 149.7, 85.3, 45.3 and 14.3 eggs, nymphs, puparia and adults, respectively. In the last experimental week, the number valued 57.3 eggs, 34.3 nymphs, 14.3 puparia and 17.0 adults. The mean weekly number of *B. tabaci* per cotton plant in the control cabin in the first week of the experiment was 120.3 eggs, 64.0 nymphs, 0.0 puparia and 24.0 adults. The maximum numbers were in the fifth week with 648.7 eggs, 333.7 nymphs, 81.0 puparia and 73.0 adults. In the last experimental week, the number measured at 176.3, 233.7, 209.7 and 65.0 eggs, nymphs, puparia and adults, respectively.

Also, Fig. 1 indicated that in cabin I, where *S. parcesetosum* was introduced 1 week after infestation with the whitefly, the total number of *B. tabaci* (all stages) was found 184.0 whiteflies/plant for the first week of the experiment. The mean number had increased gradually until it reached a maximum of 192.3 whiteflies/plant in the second week. The number of *B. tabaci* individuals per plant had hereafter decreased continuously, where it reached a mean of 74.7 in the last experimental week. In contrast, the number of *B. tabaci* in cabin II, where *S. parcesetosum* was introduced 2 weeks after infestation with the whitefly was 212.3 whiteflies/plant in the first week, and it increased hereafter to reach a peak of 294.6 whiteflies/plant in the third week after infestation. Then it had decreased gradually until it reached 122.9 whiteflies/plant in the last week of the experiment. The mean number of *B. tabaci* different developmental stages was significantly higher in cabin II than in cabin I. The mean number of whiteflies in the control cabin was significantly higher than both cabins I and II, especially in the last 4 weeks of the experiment. The number increased continuously from a mean of 208.3 in the first week after infestation to 1136.4 whiteflies/plant in the fifth week. It had decreased hereafter and reached a mean of 684.7 whiteflies/plant in the last week of experiment.

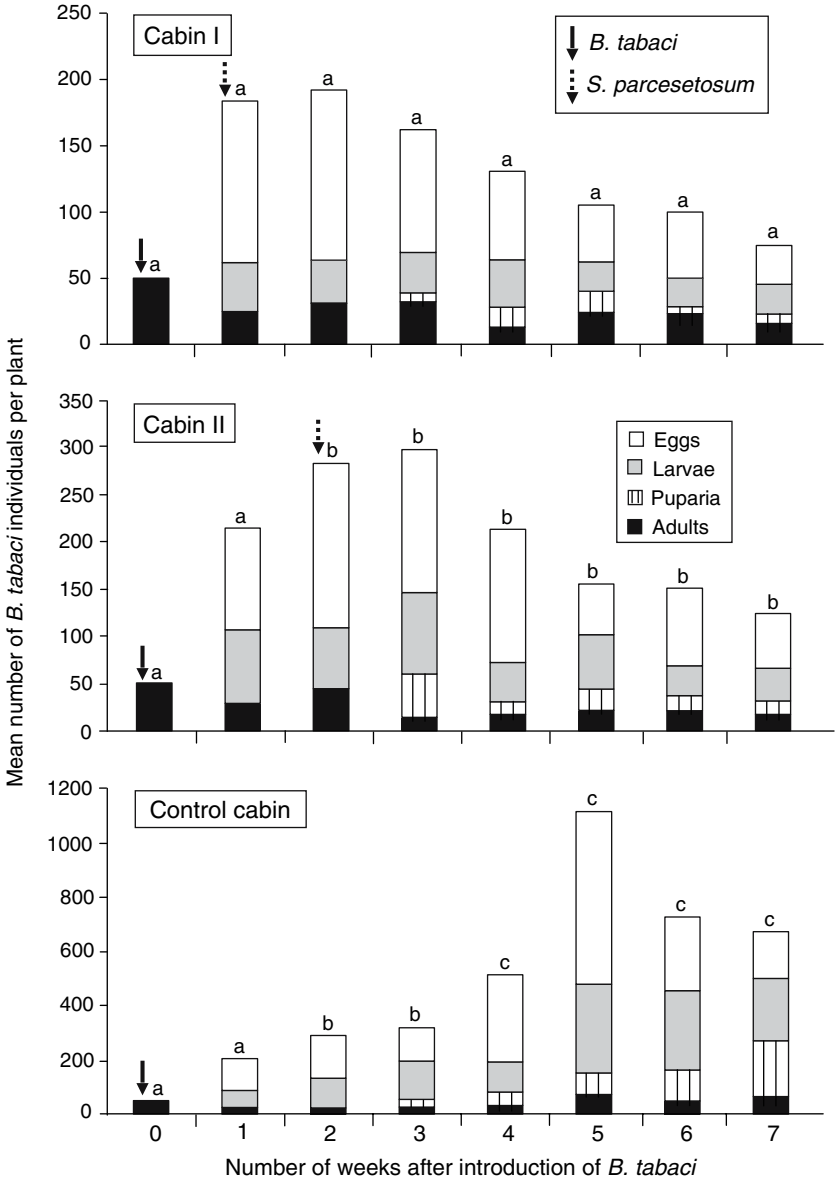

Fig. 1 Mean weekly numbers of *Bemisia tabaci* eggs, nymphs, puparia and adults per cotton plant when *Serangium parcesetosum* was introduced 1 week (cabin I) and 2 weeks (cabin II) after the infestation with the whiteflies as well as the control cabin. *Different letters* above bars indicate significant differences in the mean total number of *B. tabaci* within the same week among the three different cabins at $P < 0.05$ (one-factor analysis of variance)

S. parcesetosum has been successfully fed, reproduced and built up its population on cotton plants with *B. tabaci* as prey (Fig. 2). The number of the individuals from the different developmental stages of the predator had increased gradually with the time, where it was in cabin I a mean of 1.7 adults, 0.0 pupae, 2.3 larvae and 4.3 eggs per plant in the third week after infestation with the whitefly. Then it increased hereafter to reach a mean of 2.3, 4.7, 3.0 and 7.3 adults, pupae, larvae and eggs per plant in the last experimental week, respectively. In cabin II, the number of *S. parcesetosum* individuals was a mean of 1.3 adults, 0.0 pupae, 4.0 larvae and 3.3 eggs per plant in the third week. Number has been increasing after that, where it valued 5.0 adults, 3.3 pupae, 6.0 larvae and 2.3 eggs per plant in the sixth week of the experiment.

The reduction percentage in *B. tabaci* population in cabin I and II compared to that one in the control cabin is presented in Fig. 3. In cabin I, the whitefly population showed a reduction of 34.6% 1 week after *S. parcesetosum* introduction. Then the reduction in the whitefly population increased to reach a maximum of 90.7% in the fifth week after *B. tabaci* infestation. In the sixth and seventh weeks, the reduction decreased to 86.5 and 89.1%, respectively. In cabin II, where the predator was introduced 2 weeks after infestation with the whitefly, the reduction percentage in *B. tabaci* population was 9.1% after 1 week of the predator introduce, and thereafter it increased to reach a maximum reduction of 86.5% in the fifth week. Reductions of 79.8 and 82.1% were recorded in the six and seventh weeks, respectively after the whitefly's infestation.

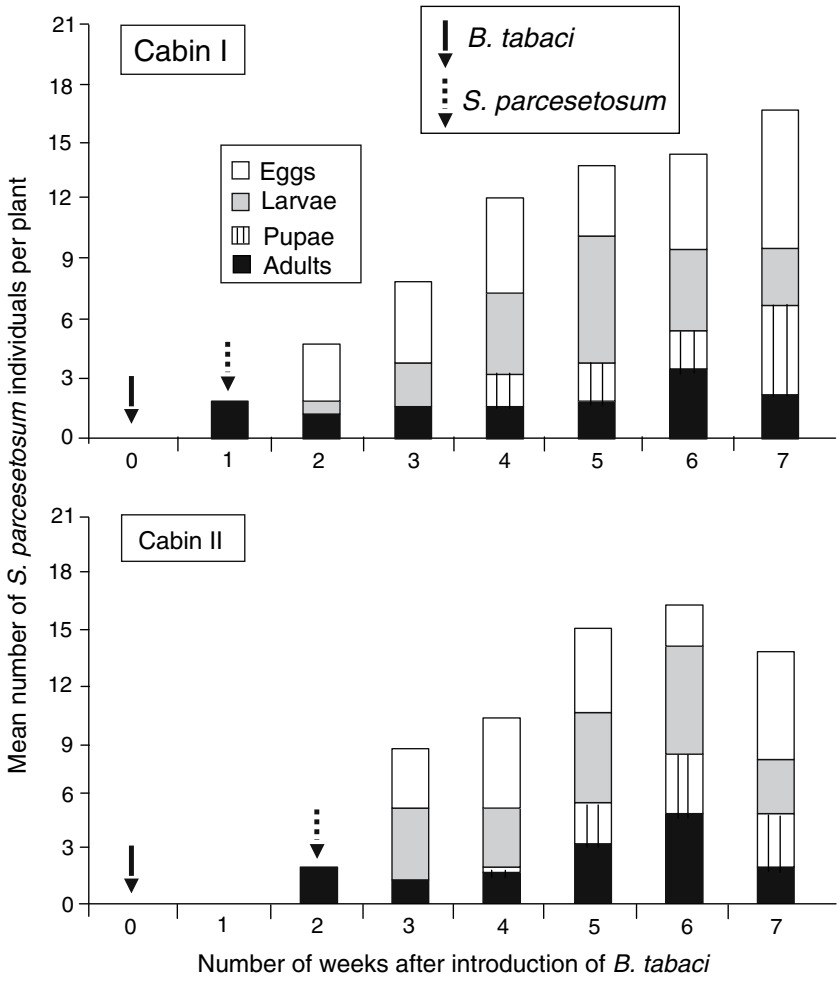

Fig. 2 Mean weekly numbers of *Serangium parcesetosum* eggs, larvae, pupae and adults per cotton plant when the predator was introduced 1 week (cabin I) and 2 weeks (cabin II) after the infestation with *Bemisia tabaci*

Discussion

The ladybird, *S. parcesetosum* is a specialist predator of whiteflies. It has demonstrated a potential for successfully developing, surviving, reproducing and consuming *B. tabaci* under laboratory conditions (Abboud and Ahmad 1998; Al-Zyoud and Sengonca 2004b Al-Zyoud et al. 2005b, c, d; Sengonca et al. 2004). Because of this success in the laboratory and in order to be considered as an efficient predator for a biological control program and to be used successfully to control *B. tabaci*, it was important to evaluate its efficiency and to check its effectiveness in reducing the population of *B. tabaci* under more natural conditions such as greenhouses.

The current results indicated that *S. parcesetosum* was able to successfully feed, reproduce and consume *B. tabaci* under greenhouse conditions. The mean total number of *B. tabaci* individuals/plant was significantly lower in the cabins with *S. parcesetosum* than in the control cabin. In addition, the mean number of whitefly was significantly lower when the predator was introduced 1 week rather than 2 weeks after the whitefly infestation. In similar fashion, Ellis et al. (2001) found that the introduction of *S. parcesetosum* adults was extremely effective at stopping the growth of *B. argentifolii* population on poinsettias under greenhouse conditions. In addition, they further mentioned that after 6 weeks of introducing *S. parcesetosum*, *B. argentifolii* population densities were dramatically lower in the cages with *S. parcesetosum* than in the control cages. This agrees with the results of the present study. *S. parcesetosum* effectively maintained immature *B. argentifolii* densities near those observed at the time of predator releasing, while nymphal densities increased up to 70 folds in 10 week-period in the control cages (Ellis et al. 2001). The efficiency of *S. parcesetosum* in reducing the population of *B. tabaci* was higher when the predator was introduced 1 week with a reduction of 90.7% compared with 2 weeks treatment, which gave a reduction of 86.5% after the infestation with *B. tabaci*. This indicates that an early introduction of *S. parcesetosum*, while the density of *B. tabaci* population is still low,

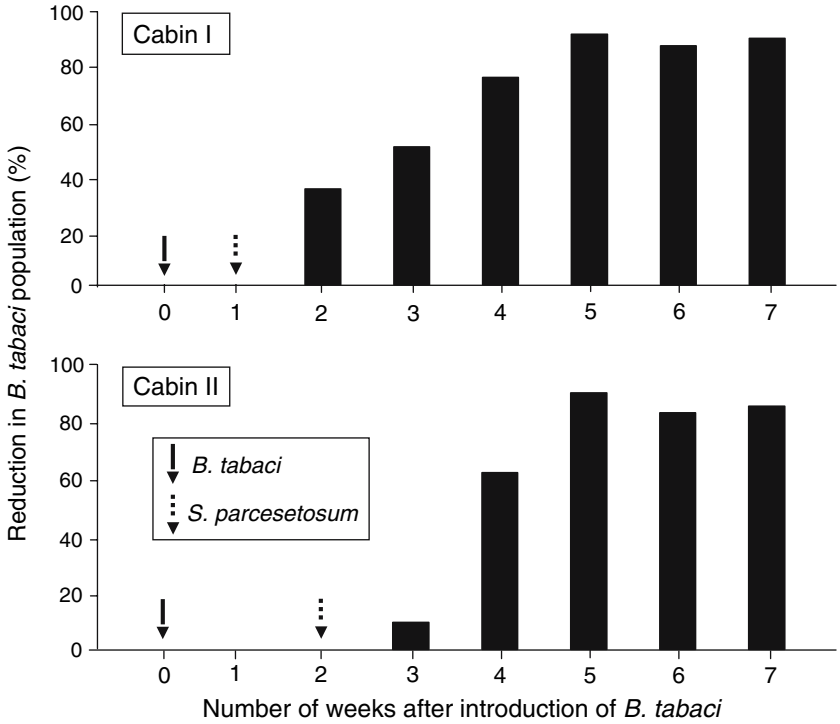

Fig. 3 Reduction percentage in the population of *Bemisia tabaci* on cotton plants when *Serangium parcesetosum* was introduced after 1 week (cabin I) and 2 weeks (cabin II) of the infestation with the whitefly compared to the control cabin

would be more effective in its control. Ellis et al. (2001) recorded that a dramatic increase in prey mortality was observed within 14 days of *S. parcesetosum* release. In this study, also there was an increase in the mortality starting from the second week after the introduction of *S. parcesetosum*. During the sixth week of the experiments, whitefly mortality rates declined in all *S. parcesetosum* treatments, which was in agreements with the results obtained by (Ellis et al. 2001).

S. parcesetosum has successfully built up its population with *B. tabaci* as prey under greenhouse conditions. In spite of the little decline in the population of *S. parcesetosum* in the last experimental week in cabin II, its numbers maintained their increasing tendency until the end of the experiment in both cabin I and II. In general, this decline is a normal case in biological control, as it is well known that when the prey population is decreased the predator population is deceased too. However, such a decline in the predator population was not occurred in cabin I. It might be a fact that the dispersion of the predator is not identical on all the plants. In addition, it is possible that the last three plants, which tested in the last experimental week were had high numbers due to the high numbers of adults, which flew to them from the other plants. However, it is to be mentioned that even without a reproductive success, the introducing of *S. parcesetosum* in this study effectively prevented *B. tabaci* population from increasing over a seven week-period. Ellis et al. (2001) obtained similar results, where the introducing of *S. parcesetosum* effectively prevented *B. argentifolii* population from increasing over a 10 week-period. This can be explained by the fact that laboratory studies to date show that the ladybird's adults could survive for a long period on cotton, for example approximately 5–6 months at 18°C and 2–3 months at 30°C (Sengonca et al. 2004). In addition, the predator's adults are voracious feeders, capable for consuming large numbers of *B. tabaci* immatures, where they reached just over three studied periods of adults' longevity (each consisted of 20 days) to more than 1990 nymphs or 620 puparia at 18°C and 3570 nymphs or 1440 puparia at 30°C (Sengonca et al. 2005). During its whole larval duration, *S. parcesetosum* consumed a mean of 1677.8 eggs or 194.8 puparia of *B. tabaci* on cabbage at 27°C (Ahmad and Abboud 2001). Therefore, depending on these results, it appears that this success in controlling *B. tabaci* was primarily, in addition to the feeding of the larvae, due to the prolonged survival and continuous feeding of *S. parcesetosum* adults.

Inundative releases of *E. formosa* can produce satisfactorily results if introduced in sufficient numbers before whitefly populations begin to build (Hoddle et al. 1997a, b). However, in instances where *E. formosa* fails to control whiteflies, alternative measures are required in order to maintain a salable plant (Parrella et al. 1991). Heinz and Parrella (1994) observed a dramatic increase in whitefly populations on greenhouse-grown plants after 9 weeks exposure to whiteflies even in the presence of weekly releases of *Encarsia luteola*.

However, a series of three weekly releases of the predatory beetle, *Delphastus pusillus* (one beetle per plant per week) effectively checked whitefly population growth until the study was ended 3 weeks after the final release. In this study, a single release of two *S. parcesetosum* per plant effectively checked further increases in prey population for up to 7 weeks as well as 10 weeks (Ellis et al. 2001). Heinz and Parrella (1994) recovered several adult *D. pusillus* three weeks after the last release, but no evidence of successful predator reproduction was reported. In our study, *S. parcesetosum* larvae were first observed 1 week after adults have been released. However, *S. parcesetosum* would be useful especially for suppressing localized pest population increases in the greenhouse. As an obligate whitefly predator with a voracious feeding potential, *S. parcesetosum* is capable for checking rapid increases in whitefly populations, thus potentially enabling whitefly parasitoid species such as *Eretmocerus* or *Encarsia* to suppress whiteflies to acceptable thresholds. Heinz and Nelson (1996) found that *D. pusillus* provided the greatest suppression of the silverleaf whitefly when used in conjunction with one or more species of *Encarsia*. In order to determine if *S. parcesetosum* would be effective in such a role, interspecific interactions between predator and parasitoid within the host species (pest/plant) as well as release management strategies, must be investigated. Also, it is useful to mention that *S. parcesetosum* exhibited many positive features as an effective predator of *B. tabaci* such as it is able to adapt itself smoothly to fluctuating in *B. tabaci* variability (Sengonca and Al-Zyoud 2005) and it could feed on all *B. tabaci* developmental stages (Ahmad and Abboud 2001; Al-Zyoud and Sengonca 2004b). In addition, *S. parcesetosum* preferred *B. tabaci* and *T. vaporariorum* significantly to the non-whitefly species offered (Al-Zyoud and Sengonca 2004a, b). This agrees with Cohen et al. (1995), who reported that *S. parcesetosum* seems to be a specialist predator of whiteflies. *S. parcesetosum* exhibited more preference for *B. tabaci* than *T. vaporariorum* and avoided feeding on parasitized *B. tabaci*, which enhances the options for the use of *S. parcesetosum* in pest management programs in conjunctions with parasitoids to provide a greater level of *B. tabaci* suppression (Al-Zyoud and Sengonca 2004b).

In conclusion, the ladybird predator, *S. parcesetosum* showed the ability to feed, survive and build up its population under greenhouse conditions as well as cause a high reduction in *B. tabaci* population. Consequently, this ladybird is a very promising predator to be used alone or in conjunctions with other natural enemies in a biological control program to provide a great level of *B. tabaci* suppression, as well as to develop new managing strategies for successfully suppress this worldwide pest.

References

Abboud R, Ahmad M (1998) Effect of temperature and prey-species on development of the immature stages of the coccinellid, *Serangium parcesetosum* Sicard (Col., Coccinellidae). Arab J Plant Prot 16(2):90–93

Ahmad M, Abboud R (2001) A comparative study of *Serangium parcesetosum* Sicard and *Clitostethus arcuatus* (Rossi) (Col., Coccinellidae): two predators of *Bemisia tabaci* (Genn.) in Syria. Arab J Plant Prot 19(1):40–44

Al-Zyoud F, Blaeser P, Sengonca C (2005a) Investigations on the biology and prey consumption of the predator *Serangium parcesetosum* Sicard (Col., Coccinellidae) by feeding on *Trialeurodes vaporariorum* Westwood (Hom., Aleyrodidae) as prey. J Plant Dis Prot 112(5):485–496

Al-Zyoud F, Blaeser P, Sengonca C (2005b) Longevity of the ladybird predator *Serangium parcesetosum* Sicard (Col., Coccinellidae) on natural and artificial nutritional sources. Mitt Dtsch Ges allg angew Entomol (Dresden) (in press)

Al-Zyoud F, Sengonca C (2004a) Development, longevity and fecundity of *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) on different host plants at two temperatures. Mitt Dtsch Ges allg angew Entomol (Halle) 14:373–376

Al-Zyoud F, Sengonca C (2004b) Prey consumption preferences of *Serangium parcesetosum* Sicard (Col., Coccinellidae) for different prey stages, species and parasitized prey. J Pest Sci 77:197–204

Al-Zyoud F, Tort N, Sengonca C (2005c) Influence of host plant species of *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) on some of the biological and ecological characteristics of the entomophagous *Serangium parcesetosum* Sicard (Col., Coccinellidae). J Pest Sci 78:25–30

Al-Zyoud F, Tort N, Sengonca C (2005d) Influence of leaf portion and plant species on the egg-laying behaviour of the ladybird *Serangium parcesetosum* Sicard (Col., Coccinellidae) under the presence of another natural enemy. J Pest Sci 78:167–174

Argov Y (1994) The woolly whitefly, a new pest in Israel. Alon Hanotea 48(6):290–292

Clewer AG, Scarisbrick DH (2001) Practical statistics and experimental design for plant and crop science. Wiley, Chichester, p 332

Cohen AC, Staten RT, Brummett D (1995) Generalist and specialist predators: how prey profitability and nutrient reward influence the two strategies or whiteflies as junk food. In: Proceedings of the beltwide cotton conference, San Antonio, TX, National cotton council TN, pp 71–72

Ellis D, McAvoy R, Abu Ayyash L, Flanagan M, Ciomperlik M (2001) Evaluation of *Serangium parcesetosum* (Col., Coccinellidae) for biological control of silverleaf whitefly, *Bemisia argentifolii* (Hom., Aleyrodidae), on poinsettia. Fla Entomol 84(2):215–221

Gerling D, Alomar O, Arno J (2001) Biological control of *Bemisia tabaci* using predators and parasitoids. Crop Prot 20:779–799

Heinz KM, Nelson JM (1996) Interspecific interactions among natural enemies of *Bemisia* in an inundative biological control program. Biol Control 6:384–393

Heinz KM, Parrella MP (1994) Biological control of *Bemisia argentifolii* (Hom.,: Aleyrodidae) infesting *Euphorbia pulcherrima*: evaluations of releases of *Encarsia luteola* (Hym.,

Aphelinidae) and *Delphastus pusillus* (Col., Coccinellidae). Environ Entomol 23:1346–1353

Hilje L, Costa HS, Stansly PA (2001) Cultural practices for managing *Bemisia tabaci* and associated viral diseases. Crop Prot 20:801–812

Hoddle MS, Van Driesche RG, Sanderson JP (1997a) Biological control of *Bemisia argentifolii* (Hom., Aleyrodidae) on poinsettia with inundative releases of *Encarsia formosa* (Hym., Aphelinidae): are higher release rates necessarily better? Biol Control 10:166–179

Hoddle MS, Van Driesche RG, Sanderson JP (1997b) Biological control of *Bemisia argentifolii* (Hom., Aleyrodidae) on poinsettia with inundative releases of *Encarsia formosa* Beltsville strain (Hym., Aphelinidae): can parasitoid reproduction augment inundative releases? J Econ Entomol 90:910–924

Kapadia MN, Puri SN (1992) Biology of *Serangium parcesetosum* as a predator of cotton whitefly. J Maharashtra Agric Univ 17(1):162–163

Köhler W, Schachtel W, Voleske P (2002) Biostatistik. Springer, Berlin, p 301

Kranthi KR, Jadhav DR, Wanjar RR, Shaker AS, Russell D (2001) Carbamate and organophosphate resistance in cotton upsets in India, 1995–1999. Bull Entomol Res 91:37–46

Legaspi JC, Ciomperlik MA, Legaspi BC (2001) Field cage evaluation of *Serangium parcesetosum* (Col., Coccinellidae) as a predator of citrus blackfly eggs (Hom., Aleyrodidae). Southw Entomol Sci Note 26(2):171–172

Legaspi JC, Legaspi BC, Meagher RL, Ciomperlik MA (1996) Evaluation of *Serangium parcesetosum* (Col., Coccinellidae) as a biological control agent of the silverleaf whitefly (Hom., Aleyrodidae). Environ Entomol 25(6):1421–1427

Malausa JC, Franco E, Brun P (1988) Establishment on the Azur coast and in Corsica of *Serangium parcesetosum* (Col., Coccinellidae), a predator of the citrus whitefly, *Dialeurodes citri* (Hom., Aleyrodidae). Entomophaga 33(4):517–519

Parrella MP, Paine TD, Bethke JA, Robb KL, Hall J (1991) Evaluation of *Encarsia formosa* (Hym., Aphelinidae) for biological control of sweetpotato whitefly (Hom., Aleyrodidae) on poinsettia. Environ Entomol 20:713–719

Patel CB, Rai AB, Pastagia JJ, Patel HM, Patel MB (1996) Biology and predator potential of *Serangium parcesetosum* Sicard (Col., Coccinellidae), of sugarcane whitefly (*Aleurolobus barodensis* Mask.). GAU Res J 21(2):56–60

Sengonca C, Al-Zyoud F, Blaeser P (2004) Life table of the entomophagous ladybird *Serangium parcesetosum* Sicard (Col., Coccinellidae) by feeding on *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) as prey at two different temperatures and plant species. J Plant Dis Prot 111:598–609

Sengonca C, Al-Zyoud F, Blaeser P (2005) Prey consumption by larval and adult stages of the entomophagous ladybird *Serangium parcesetosum* Sicard (Col., Coccinellidae) of the cotton whitefly, *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) at two different temperatures. J Pest Sci 78(3):179–186

Uygun N, Ulusoy M, Karaca Y, Kersting U (1997) Approaches to biological control of *Dialeurodes citri* (Ashmead) in Turkey. IOBC/WPRS 20:52–62

Wagner TL (1995) Temperature-dependent development, mortality, and adult size of sweetpotato whitefly biotype B (Hom., Aleyrodidae) on cotton. Environ Entomol 24(5):1179–1188

Yigit A (1992a) Method for culturing *Serangium parcesetosum* Sicard (Col., Coccinellidae) on *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae). J Plant Dis Prot 99(5):525–527

Yigit A (1992b) *Serangium parcesetosum* Sicard (Col., Coccinellidae), new record as a citrus whitefly predatory ladybird in Turkey. Türk Entomol Derg 16(3):163–167

Yigit A, Canhilal R, Ekmekci U (2003) Seasonal population fluctuations of *Serangium parcesetosum* (Col., Coccinellidae), a predator of citrus whitefly, *Dialeurodes citri* (Hom., Aleyrodidae) in Turkey's eastern mediterranean citrus groves. Environ Entomol 32(5):1105–1114