Evaluation of the Predatory Beetle *Serangium parcesetosum* Sicard (Coleoptera: Coccinellidae) Release Rate and Time on the Cotton Whitefly *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae)

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ABSTRACT

There is scarcity of data related to the feasibility of biological control in vegetable systems in Jordan. Therefore, this study aimed at evaluating the effect of the predator, *Serangium parcesetosum* Sicard (Col., Coccinellidae) release time and rate on the population dynamics of *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae) on caged cucumber inside greenhouses. Adults of *B. tabaci* were introduced into the caged cucumber plants at two densities of 20 or 30 adults/plant, each group had the following 3 treatments; no *S. parcesetosum*, release *S. parcesetosum* one and two weeks after *B. tabaci* infestation. Results indicated that *B. tabaci* population increased in control treatment until the 5th week of the experiment, while the population started to decrease from the third week until the end of the experiment in the 1-week and 2-week treatments. In the last experimental week, *B. tabaci* population was significantly lower in both predator treatments than control treatment at both densities. The whitefly population was significantly lower when the predator was introduced 1 week rather than 2 weeks after the whitefly infestation. A reduction of 64.92 and 61.88% (1: 30) as well as 62.24 and 60.15% (1: 20) in the whitefly population was reported in the last experimental week when the predator was introduced 1 and 2 weeks, respectively. In conclusion, a single release of one *S. parcesetosum* beetle per plant was effectively checked further increases in prey population on cucumber for up to 7 weeks.

Keywords: *Serangium parcesetosum; Bemisia tabaci*; Population Dynamics; Biological Control; Cucumber.

INTRODUCTION

The cotton whitefly, *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae) is among the most serious insect pests worldwide (Oliveira *et al.,* 2001; Ko *et al.,* 2002). This whitefly species is a polyphagous pest of a wide range of crops belonging to different botanical families (Thompson, 2002; Al-Zyoud and Sengonca, 2004a, Al-Zyoud, 2008). The pest attacks numerous vegetable crops and considered an important vector of plant viral diseases in the world (Mansour *et al.,* 1998; Sharaf and Hasan, 2003; Morales and Jones, 2004; Valverde *et al.,* 2004).

In the past, *B. tabaci* control was exclusively based on conventional insecticides (Han and Konieczny, 2000; Manzano *et al.,* 2003). However, in many cases sprays with conventional insecticides did not achieve a comprehensive control because of the presence of immature stages and adults of *B. tabaci* on the underside of the leaves. In addition, the mobility of the pest, its short life cycle and high reproductive rate (Gerling and Steinberg, 2003) has led to develop a rapid resistance to

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most insecticides (Perez *et al.,* 2000, Kranthi *et al.,* 2001). Also, in 1990s, insect growth regulators (IGRs) were found to be very effective in controlling *B. tabaci* (Nassef, 1999). But the introduction of IGRs into many countries has met with problems in registration and some times are expensive, resulting in a continued use of conventional insecticides.

However, with increasing *B. tabaci* resistance to insecticides and the emphasis on reduced usage of noxious chemicals, biological control using pathogens such as *Aschersonia aleyrodis*, *Verticillium lecanii*, *Paecilomyces fumosoroseus* and *Beauveria bassiana* (Meekes *et al.,* 1996; Mor *et al.,* 1996; Chen and Feng, 1999; James and Jaronski, 2000); parasitoids such as various *Eretmocerus* species (Urbaneja and Stansly, 2004; Otoidobiga *et al.,* 2004), and *Encarsia* species (De Barro *et al.,* 2000; Hu *et al.,* 2003, Gerling and Steinberg, 2003); and predators, e.g. the phytoseiid predators, *Euseius scutalis* (Athias-Henriot) and *Typhlodromips swirskii* (Athias-Henriot) (Nomikou *et al.,* 2003), the green lacewing, *Chrysoperla carnea* Steph. (Abd-Rabou and El-Naggar, 2003), the anthocorid bugs, *Orius laevigatus* and *O. majusculus* (Riudavets *et al.,* 2003), and the mirid bugs, *Macrolophus caliginosus* Wagner and *Nesidiocoris tenuis* (Reuter) (Nannini, 2003) were used to control *B. tabaci*.

No specific predators of *B. tabaci* are currently used in biological control programs (Castae and Gabarra, 2003). However, *Serangium parcesetosum* Sicard (Col., Coccinellidae) is an oligophagous specialist predator that has been demonstrated as potential biological control agent of some whitefly species. This predator was originally introduced from India and released as a bio-agent of citrus whitefly, *Dialeurodes citri* Ashmead in the Union of Soviet Socialist Republics (Yasnosh, 1991). It has been recorded as a predator of *B. tabaci* for the first time in India (Kapadia and Puri, 1992), and of the sugarcane whitefly, *Aleurolobus barodensis* Mask (Kapadia and Butani, 1997). *S. parcesetosum* was used to control *D. citri* in Turkey (Yigit *et al.,* 2003). Also, this predator has been investigated in the USA as a bio-agent of the silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Ellis *et al.,* 2001). In Germany, *S. parcesetosum* has demonstrated a potential for controlling *B. tabaci* (Al-Zyoud and Sengonca, 2004b; Sengonca *et al.,* 2004, 2005), and the greenhouse whitefly, *Trialeurodes vaporariorum* Westwood (Al-Zyoud *et al.,* 2005) in the laboratory.

Laboratory studies to date showed that both larvae and adults of *S. parcesetosum* are voracious feeders on immature whiteflies (Legaspi *et al.,* 1996; Sengonca *et al.,* 2005). The adults survived 2-6 months on *B. tabaci* (Sengonca *et al.,* 2004), and consumed approximately 1900–3500 nymphs just over 60 days of their longevity (Sengonca *et al.,* 2005). Due to this laboratory success, the present study was conducted to evaluate the effect of *S. parcesetosum* release time and rate on population dynamics of *B. tabaci* on caged cucumber in greenhouses. The present paper will help characterize some basis information to facilitate the release of *S. parcesetosum* in a large scale in greenhouses to suppress *B. tabaci* population.

2. MATERIALS AND METHODS

A stock culture of *S. parcesetosum* was established from forty individuals, which were introduced as adults from Plant Protection Research Institute, Adana, Turkey. A cotton leaf with *B. tabaci* immatures was included in each container for *S. parcesetosum* feeding in transit. The predator's population was built up on cucumber plants, *Cucumis sativus* L. cv. "Beit Alpha" infested with *B. tabaci* in metal meshed cages (50x50x50 cm). Each cage was sealed with gauze from their sides and top in order to provide ventilation. To maintain adequate prey supply for the predator continuously, cucumber

plants infested with *B. tabaci* were frequently replaced inside the cages. The cucumber plants were grown in a glasshouse by sowing cucumber seeds in pots of 12 cm in diameter and 12 cm in height. When the plants had grown to 15 cm in height they were transferred to another climatic chamber infested with *B. tabaci* from an ongoing laboratory culture for rearing the predator. In order to establish the stock culture of *B. tabaci*, thousands of the insect adults were collected by aspirator from cucumber plants grown under greenhouses, and were further maintained on cucumber plants under laboratory conditions. New cucumber plants were placed in the rearing chamber once a week to maintain the *B. tabaci* culture. All the three cultures; the host plant, *B. tabaci* and *S. parcesetosum* were kept in a rearing room (2x3x2m) at the Faculty of Agriculture, Mu'tah University, Jordan, at a temperature of 25±2°C, a relative humidity of 60±10% and constant light-dark regime of L14: D10 hrs.

The desired stage of *S. parcesetosum* (adult) for the experiments was obtained in Petri dishes of 9 cm in diameter and 1.5 cm in height. Each Petri dish was partially filled with 0.5 cm-thick layer of wetted cotton pad, and its lid was fitted with a meshed hole to provide suitable ventilation. Adult females and males of *S. parcesetosum* were transferred onto cucumber leaves infested with *B. tabaci* in each Petri dish. The Petri dishes were kept in the fore-mentioned rearing room. After 24 h, the adults were removed and the laid eggs were further reared and checked daily until they reached the adult stage. For obtaining the required stage of *B. tabaci*, cucumber plants were exposed to the insect infestation in the stock culture cages for 12 hours and then were incubated until reaching the convenient stage (adult) for the experiments in the rearing room under the same conditions mentioned above.

The experiments were conducted on a 3-week-old cucumber plants in the greenhouse. Six meshed cages were used in the experiments. Each cage has 50x60x80 cm. The cages were completely sealed with gauze from their sides and tops in order to provide ventilation and to prevent immigration and emigration of insects. Twenty-one potted cucumber plants, each with three fully developed true leaves, were placed in rows of seven plants in each cage. The two cotyledons were removed from all of the plants before starting the experiments. Thereafter, *B. tabaci* adults (2-3 days old) were introduced by aspirator on the caged cucumber plants at two densities of either 20 adults per plant in the first, second and third cages (equivalent to 420 adult whiteflies per cage), or 30 adults per plant in the fourth, fifth and sixth cages (equivalent to 630 adult whiteflies per cage) without determining their sex. In the first and fourth cages, no *S. parcesetosum* were introduced, which were used as control treatments. In the second and fifth cages, 21 females and males of *S. parcesetosum* adults of one-week-old, in a rate of one beetle per plant, were introduced using a fine camel-hair brush one week after the plants had been infested with *B. tabaci*.

Two weeks after the infestation with the whitefly, the same rate of *S. parcesetosum* was introduced in the third and sixth cages. Three cucumber plants were randomly selected and taken from each cage starting from the first week after the infestation with *B. tabaci* and then once weekly. The number of *B. tabaci* adults that found on the randomly selected plants was directly recorded on the plants. Thereafter, the plants were transferred to the laboratory in order to examine the number of live immature stages of *B. tabaci* overall plant under a dissecting microscope. The number of live whiteflies was grouped into four growth stages (eggs, nymphs, pupae and adults). Immature whiteflies were judged dead to be excluded from counting, when they appeared discoloured or desiccated or when the empty integument

showed evidence of *S. parcesetosum* feeding. As leaf samples were harvested, they were visually checked for *S. parcesetosum*, and all larvae and adults were returned to their respective cages. For this reason, the number of the predator individuals was not counted. Also, the reduction percentage in *B. tabaci* population in the treatment cages as compared with that one in the control cages was calculated. The experiments continued for 7 weeks until all the plants were tested.

In order to affirm the basic assumptions of the data to be analyzed, they were firstly tested for normal distribution and homogeneity of variance using the Barlett-test (Kohler *et al.,* 2002). When the data fulfilled the assumptions mentioned above, one-factor-analysis of variance was conducted to detect differences among means. In case of differences among means were detected, the second step was then to determine the significant differences among means at a probability level of 0.05 using Least Significant Differences (LSD) test (Clewer and Scarisbrick, 2001). The statistical analysis was performed using the proc GLM of the statistical package SigmaStat version 17.0 (SPSS, 1997). Also, the correlation between treatments (control, releasing *S. parcesetosum* after one week or two weeks) within each *B. tabaci* density was calculated by Pearson correlation method.

3. RESULTS

Mean weekly numbers of *B. tabaci* eggs, nymphs, pupae and adults per cucumber plant when *S. parcesetosum* was introduced at a density of 1: 30 *B. tabaci* adults per plant one and two weeks after infestation with the whiteflies and the control treatment are shown in Figure 1. The eggs, nymphs and pupae of the whitefly started to appear in all cages at the first, second and third weeks post *B. tabaci* introduction, respectively. The statistical analysis of the results indicated that there were significant differences in mean total number of *B. tabaci* among the different weeks within the same treatment. In the three treatments, the mean number of *B. tabaci* individuals started to increase significantly and reached about 17-fold at the end of the first week. The number of pest individuals continued to increase significantly during the second week of the experiment and reached to 789.0 (control, F=6.17; df=7, 16; P=0.001), 587.3 (one week, F=3.54; df=7, 16; P=0.017) and 642.7 *B. tabaci* individuals (two weeks, F=5.07; df=7, 16; P=0.003). Starting from the third week, number of the pest individuals in the control treatment increased continuously until reaching its maximum in the 5th week of the experiment with a mean of 1040.7 *B. tabaci* individuals, while in the 1-week and 2-week-treatment, which had the predator, the numbers of the prey started to decrease significantly from the third week until the end of the experiment.

Mean weekly numbers of *B. tabaci* eggs, nymphs, pupae and adults per cucumber plant when *S. parcesetosum* was introduced at a density of 1: 20 *B. tabaci* adults per plant one week and two weeks post-infestation with the whiteflies and the control treatment are demonstrated in Figure 2. The eggs, nymphs and pupae of the whitefly started to appear in all cages at the first, second and third weeks of the experiment, respectively. There were significant differences in mean total number of *B. tabaci* among the different weeks within the same treatment. In the three treatments, mean number of *B. tabaci* individuals started to increase and reached about 14-fold at the end of the first week. Number of the pest individuals continued to increase significantly during the second week of the experiment and reached to 419.7 (control, F=6.06; df=7, 16; P=0.001), 375.7 (one week, F=20.73; df=7, 16; P=0.000) and 587.3 *B. tabaci* individuals (two weeks, F=7.08; df=7, 16; P=0.001). Starting from the third

week, number of the pest individuals was increased until it reached the maximum in the 5th week of the experiment with a mean of 876.0 *B. tabaci* individuals, while in the 1-week and 2-week treatments the numbers started to decrease from the third week until the end of the experiment.

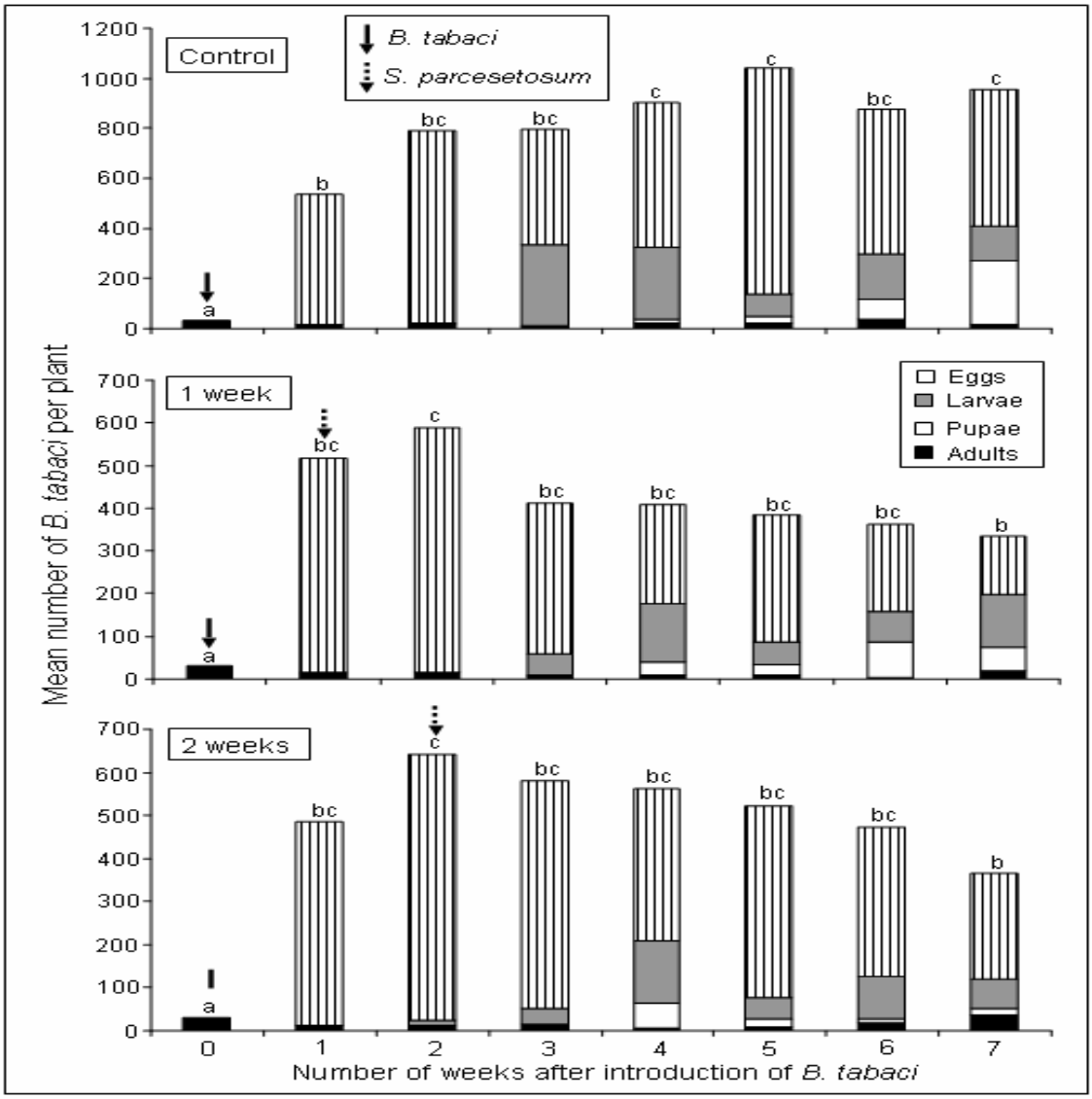

Figure 1: Mean weekly numbers of *B. tabaci* eggs, nymphs, pupae and adults per cucumber plant when *S. parcesetosum* was introduced at a density of 1:30 *B. tabaci* adults per plant one week and two weeks after the infestation with the whiteflies as well as the control treatment. (*Different letters* on the bars indicated significant differences in the mean total number of *B. tabaci* among the different weeks within the same treatment at $p<0.05$ (one-factor analysis of variance).

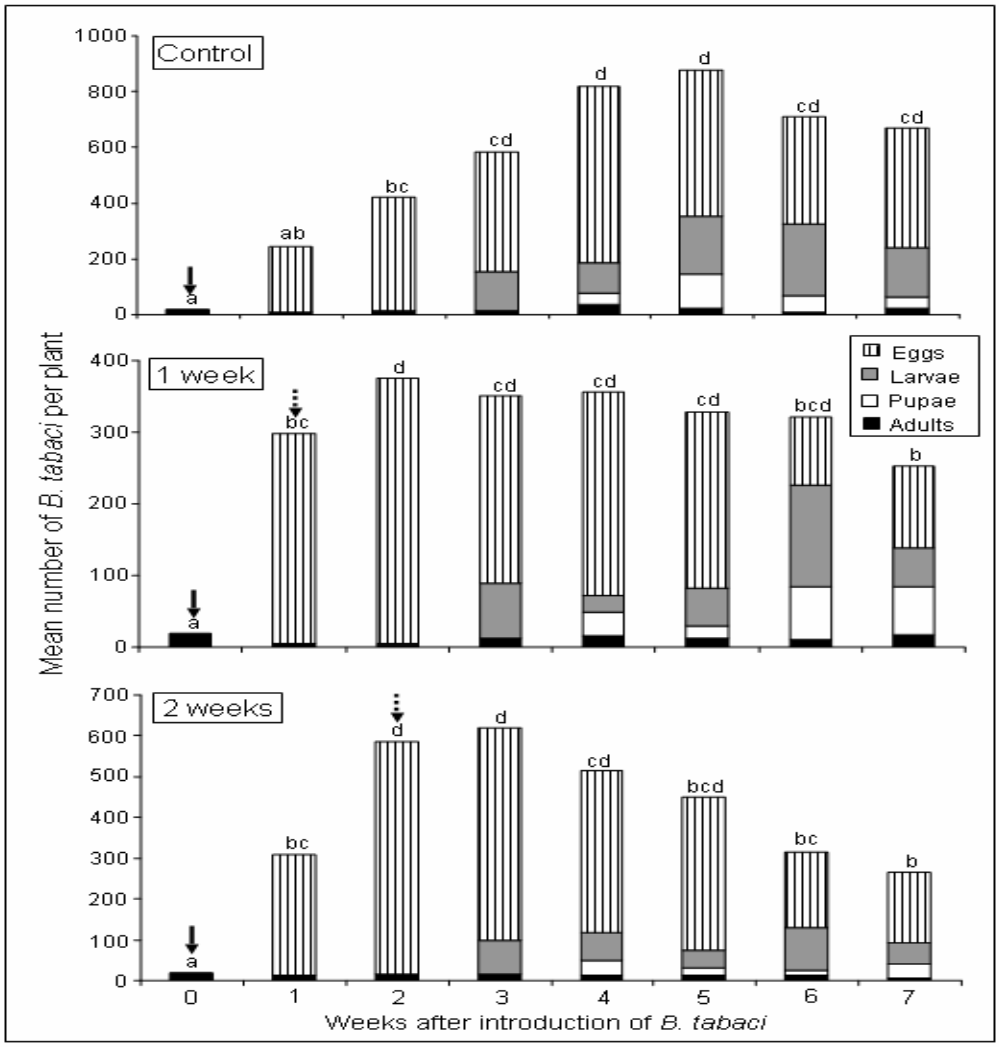

Figure 2: Mean weekly numbers of *B. tabaci* eggs, nymphs, pupae and adults per cucumber plant when *S. parcesetosum* was introduced at a density of 1:20 *B. tabaci* adults per plant one week and two weeks after the infestation with the whiteflies as well as the control treatment. (*Different letters* on the bars indicated significant differences in the mean total number of *B. tabaci* among the different weeks within the same treatment at $p<0.05$ (one-factor analysis of variance).

Mean weekly the numbers of *B. tabaci* (all stages) per cucumber plant one week and two weeks after releasing *S. parcesetosum* and the control treatments at two different densities of *B. tabaci* are shown in Figure 3. Results indicated that the mean number of *B. tabaci* different developmental stages was significantly higher in the control treatment compared with the 1-week and 2-week treatments when *S. parcesetosum* was introduced at a density of 1: 30 (F=5.30-19.83; df=2, 6; P=0.002-0.047) and at 1: 20 *B. tabaci* adults/plant (F=13.48-37.17; df=2, 6; P=0.000-0.006), and this was clear starting from the 4th experimental week. In addition, the mean number of whitefly, was lower when the predator was introduced 1 week rather than 2 weeks after the whitefly infestation at both prey densities.

Initial whitefly release rates (1: 30 or 1: 20) are greatly affected the final population densities of the whitefly. This effect was most evident when whitefly populations were left uncontrolled, in which *B. tabaci* numbers in the last experimental week were means of 955.0, 335.7 and 364.3 *B. tabaci* individuals (1: 30), and 670.0, 253.0 and 266.7 *B. tabaci* individuals (1: 20) in the control, one and two weeks after introducing *S. parcesetosum*, respectively.

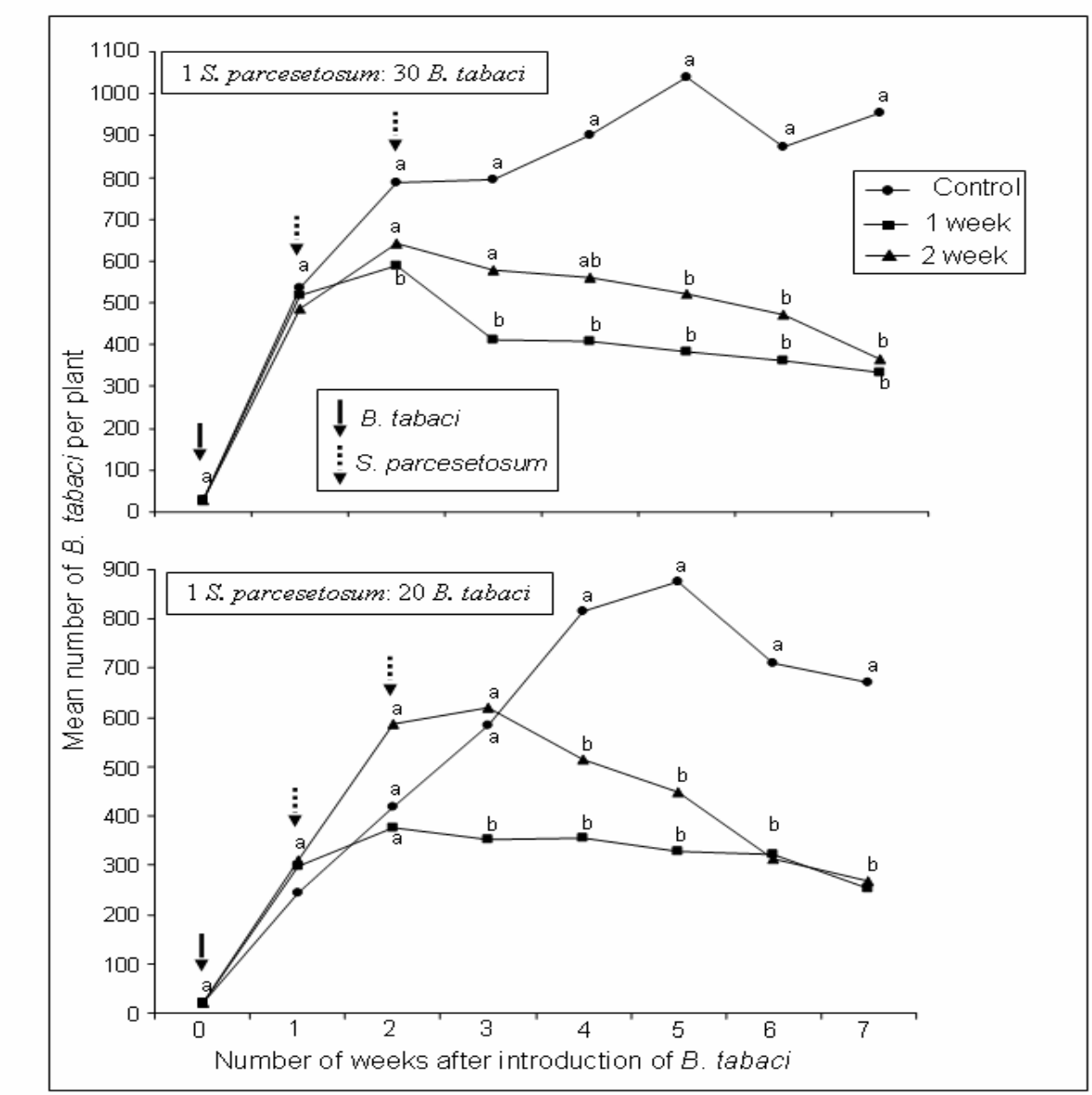

Figure 3: Mean weekly numbers of *B. tabaci* (all stages) per cucumber plant one week and two weeks after releasing *S. parcesetosum* as well as the control treatments at two different densities of *B. tabaci*. (*Different letters* on the curves indicated significant differences in the mean total number of *B. tabaci* within the same week and density among the different treatments at $p<0.05$ (one-factor analysis of variance).

Reduction percentage in *B. tabaci* population on cucumber plants when *S. parcesetosum* was introduced after one and two weeks of infestation with the whitefly, compared to control treatment at two different densities of the prey is shown in Figure 4. When *S. parcesetosum* was introduced at a density of 1: 30 *B. tabaci* adults/plant, results indicated that a reduction of 64.92 and 61.88% in the whitefly population was caused by the predator in the last week of the experiment when the predator was introduced 1 and 2 weeks, respectively. When *S. parcesetosum* was introduced at a density of 1: 20 *B. tabaci* adults per plant; a reduction of 62.24 and 60.15% in the whitefly population was obtained in the last week of the experiment, respectively. There was a negative significant correlation (-0.55; 1: 30) and (-0.46; 1: 20) among the three different treatments (control, releasing *S. parcesetosum* after one or two weeks) within each *B. tabaci* density.

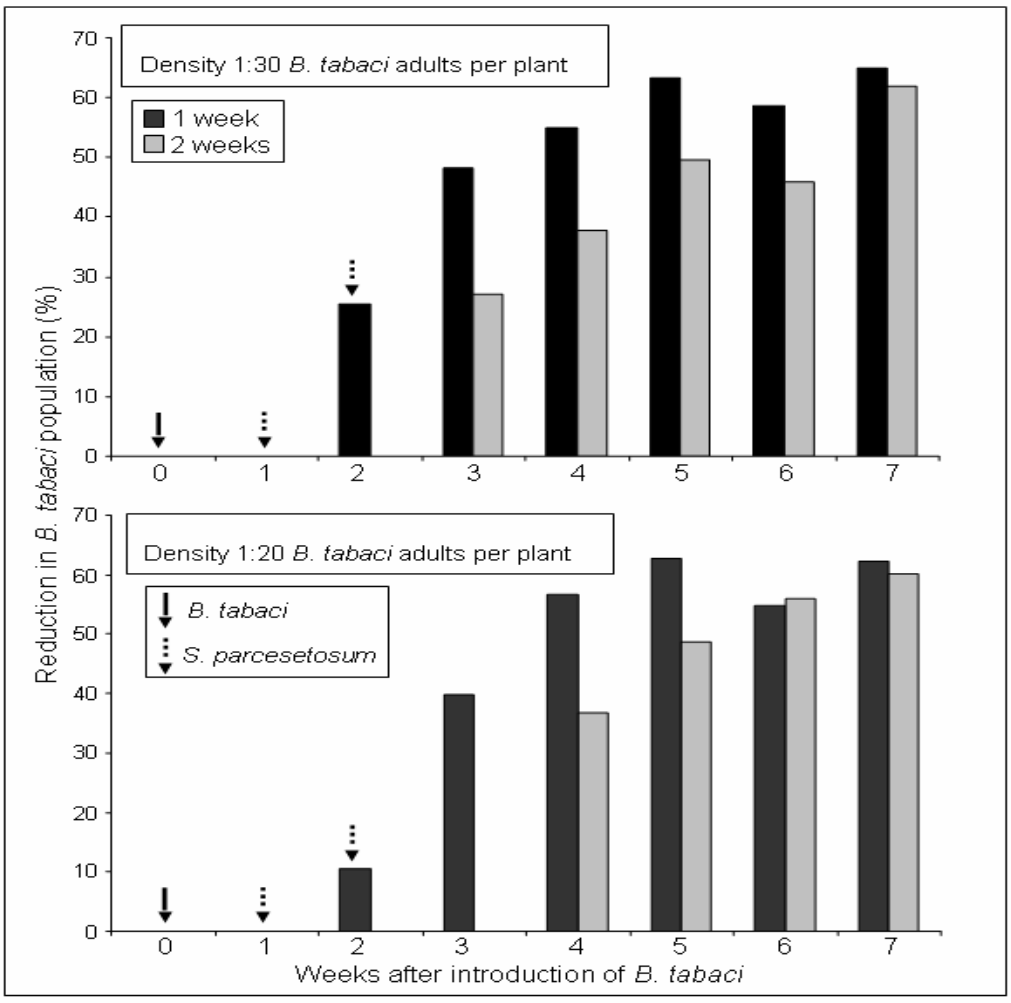

Figure 4: Reduction percentage in the population of *B. tabaci* on cucumber plants when *S. parcesetosum* was introduced after one and two weeks of the infestation with the whitefly compared to the control treatment at two different densities of the prey.

4. DISCUSSION

Vegetables are a very important food source in Jordan. However, it is important to protect these crops against pests, where the most serious one is *B. tabaci* (Sharaf and Hasan, 2003). Management of *B. tabaci* on vegetables in Jordan has primarily relied on chemical control, but insecticide resistance (Kranthi *et al.*, 2001) has spurred the development of alternative control measures. However, there is minimal information on the feasibility of biological control in vegetable systems in Jordan, therefore, this study aimed at investigating the possibility of using the predator, *S. parcesetosum* to control this severe pest.

The current results indicated that when *S. parcesetosum* was introduced at both whitefly densities, *B. tabaci* density was higher (3-fold) in the control cages compared with the cages which have *S. parcesetosum* in a 7-week-period. Our results are in line with results obtained by Ellis *et al.* (2001), who reported that *B. argentifolii* density was higher in the control cages compared with *S. parcesetosum*-cages. The number of *B. tabaci* individuals increased during the second week, and then kept a continuous increase until it reached a peak in the 5th week of the experiment in the control cages, while the density started to decrease from the third week until the end of the experiment in the 1-week and 2-week treatments, which had the predator, at both whitefly densities. In this regard, Ellis *et al.* (2001) reported that a dramatic increase in *B. argentifolii* mortality was observed within 2 weeks of *S. parcesetosum* release, which is in accordance with the current results. On cotton plants, Al-Zyoud *et al.* (2007) reported that the number of *B. tabaci* density was significantly higher in the control cabins than in cabins with *S. parcesetosum*, which is also consistent with the present results. During the seven week of the experiments in the current study, whitefly mortality rates declined in all *S. parcesetosum* treatments, which is in agreement with results obtained by Ellis *et al.* (2001) and Al-Zyoud *et al.* (2007).

In our study, the prey number was significantly lower when *S. parcesetosum* introduced 1 week rather than 2 weeks after the whitefly infestation on cucumber plants at both densities tested. In this regard, on cotton plants Al-Zyoud *et al.* (2007) mentioned that the number of whitefly was significantly lower when the predator introduced 1 week rather than 2 weeks after the whitefly infestation, which is in agreement with the results of the present study. Also, Weaver and Ciomperlik (2000a, b) released *S. parcesetosum* at a rate of 1 adult/plant to control *B. argentifolii* and they found that the earlier release of the predator had produced a more acceptable crop due to lower pest density. This indicates that an early introduction of *S. parcesetosum* while the density of *B. tabaci* population is still low would be more effective in its control.

When *S. parcesetosum* was introduced at a density of 1: 30 *B. tabaci* adults/plant, the results indicated that a reduction of 64.92% and 61.88% in the number of the whitefly was caused by the predator when it is introduced 1 and 2 weeks, respectively, while when *S. parcesetosum* was introduced at a density of 1: 20 *B. tabaci* adults/plant, a reduction of 62.24% and 60.15% was obtained, respectively. Similarly, Al-Zyoud *et al.* (2007) mentioned that *S. parcesetosum* caused a reduction of 90.7% in the population of *B. tabaci* when the predator introduced 1 week compared with 2 weeks treatment, which gave a reduction of 86.5% after *B. tabaci* infestation. In addition, one *S. parcesetosum* was released in each cage filled with citrus blackfly, *Aleurocanthus woglumi* eggs on grapefruit in a field experiment conducted in the USA, and it was found that predation by *S. parcesetosum* for 12 days reduced eggs hatch to 12.5% (Legaspi *et al.*, 2001). The variation among the different studies might be due to a fact that

different whitefly species, *B. tabaci* strains, temperatures, relative humidties, host plants and release rate of *S. parcesetosum* beetles used in the different studies. Furthermore, the reduction rate at 1: 20 is less than at 1: 30 density. This might be due to that the predator has a positive density-dependent. Therefore, at the higher rate the predator fed on more prey, and as a result, more reduction was reported at 1: 30 rather than at 1: 20. However, both densities are not enough to control *B. tabaci* but made a reduction in its population, which can be combined with other control measures to eradicate or completely control the pest.

Initial whitefly release rates greatly affected final population densities of the whitefly. This effect was most evident when whitefly populations were left uncontrolled, in which *B. tabaci* numbers in the last experimental week were 955.0 (1: 30) and 670.0 (1: 20) in the control cages. It could be concluded that release rate of 1 predator: 20 preys would be more efficient in suppressing the pest than 1: 30. In the present study, a single release of one adult *S. parcesetosum* beetle was effective at stopping the growth of *B. tabaci* populations on cucumber at both densities (1: 30 and 1: 20) tested. In this regard, Al-Zyoud *et al.* (2007) reported that release of two adults of *S. parcesetosum* beetles was effective at stopping the growth of *B. tabaci* populations on cotton at a density of 1: 50. Similarly, Ellis *et al.* (2001) have found that the introduction of *S. parcesetosum* effectively prevented *B. argentifolii* population for up to 10 weeks on poinsettias under greenhouse conditions.

However, it is to be mentioned that even without a reproductive success, introducing of *S. parcesetosum* in this study effectively prevented *B. tabaci* population from increasing over a seven-week-period on cucumber plants. 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 could be explained by the fact that laboratory studies on cucumber plants to date showed that the ladybird's adults can survive for a long period, for example approximately 3–5 months at 18°C and 2 months at 30°C (Sengonca *et al.,* 2004) and around 3 months at 25°C (Legaspi *et al.,* 1996; Al-Zyoud *et al.,* 2007). A mean total fecundity of 228 eggs/female was recorded at 25°C on cucumber (Al-Zyoud *et al.,* 2007), which can help positively in increasing the predator effectiveness. 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 consists of 20 days) to more than 1990 nymphs or 620 pupae at 18°C and 3570 nymphs or 1440 pupae at 30°C (Sengonca *et al.,* 2005). Furthermore, Al-Zyoud (2008) stated that *S. parcesetosum* larvae consumed 1542 and 1095 *B. tabaci* immatures at 25°C and 23-33°C, respectively on cucumber plants. During its whole larval duration, *S. parcesetosum* consumed around 1678 eggs or 195 pupae of *B. tabaci* on cabbage at 27°C (Ahmad and Abboud, 2001), whereas Legaspi *et al.* (1996) reported a mean life-time cumulative predation of 4909 whitefly (eggs and immature stages) for *S. parcesetosum* at 20°C. Therefore, depending on these results, it appears that this success in controlling *B. tabaci* was primary and large, in addition to the feeding of the larvae, due to the prolonged survival and voracious feeding of *S. parcesetosum* adult beetles.

Another positive feature which makes the predator, *S. parcesetosum* more distinguished and effective in controlling *B. tabaci* compared to the other predators that this predator is a specialist one of whiteflies (Abboud and Ahmad, 1998; Yigit *et al.* 2003). Legaspi *et al.* (1996) reported that *S. parcesetosum* did not consume any lepidopteran but devoured nearly all *B. argentifolii* offered. In addition, *S. parcesetosum* preferred the whiteflies, *B. tabaci*, *T.*

vaporariorum and the castor bean whitefly, *Trialeurodes ricini* (Misra) (Homoptera: Aleyrodidae) significantly to the non-whitefly species offered (Al-Zyoud and Sengonca, 2004b, Al-Zyoud, 2007). This finding is consistent with Cohen *et al.* (1995), who reported that *S. parcesetosum* seems to be a specialist predator of whiteflies. Also, it is useful to mention that *S. parcesetosum* is able to adapt itself smoothly to fluctuating in *B. tabaci* variability (Sengonca *et al.,* 2005) and it could feed on all *B. tabaci* developmental stages (Ahmad and Abboud, 2001; Al-Zyoud and Sengonca, 2004b). Also, Weaver and Ciomperlik (2000b) found that *S. parcesetosum* has the ability to disperse throughout a greenhouse crop of poinsettias infested with *B. argentifolii*. Moreover, it was observed that *S. parcesetosum* spread out throughout cotton orchards heavily infested with *D. citri* by forming a colony, and can overwinter in the conditions of the region and by building up its population throughout the summer can suppress the pest (Koclu *et al.,* 1997). An additional positive feature which makes *S. parcesetosum* a good candidate for biological control is the ability of the predator to distinguish between parasitized and unparasitized *B. tabaci*. In this regard, *S. parcesetosum* larvae and adults were significantly tended to avoid *B. tabaci* parasitized by the parasitoids, *Encarsia formosa* Gahan (Hym., Aphelinidae) (Al-Zyoud and Sengonca, 2004b) and *Eretmocerus mundus* Mercet (Hym., Aphelinidae) (Al-Zyoud, 2007) and fed on more unparasitized whiteflies. In Jordan, Hasan (1999) mentioned that a high parasitization rate was achieved when either *Eretmocerus mundus* (Hym., Aphelinidae) (72.2%) or *Encarsia* sp. (75.8%) were released against *B. tabaci* at a ratio of 1 parasitoid: 2 whiteflies. However, as an obligate whitefly predator with a voracious feeding potential (Sengonca *et al.,* 2005), *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. Thus, there is a feasible potential for integration the predator and the two parasitoids into a biological control program to suppress *B. tabaci* in Jordan. This conclusion is supported by Heinz and Nelson (1996) who found that the specific whitefly predatory beetle, *Delphastus pusillus* LeConte (Coleoptera: Coccinellidae) provided the greatest suppression of the silverleaf whitefly when used in conjunction with *Encarsia*. Also, Zapata *et al.* (2003) mentioned that *E. mundus* is the most abundant natural enemies of *B. tabaci* in the Mediterranean area. Weaver and Ciomperlik (2000a) reported that *B. argentifolii* densities within the exclusion cages were considerably greater than those of each of the *E. formosa* and *S. parcesetosum* treatments in a greenhouse crop of poinsettias.

In conclusion, a single release of one *S. parcesetosum* beetle per plant was effectively checked further increases in prey population on cucumber for up to 7 weeks. An early introduction of *S. parcesetosum*, while the density of *B. tabaci* population is still low, would be more effective in its control. Consequently, it is likely that *S. parcesetosum* could function effectively as a sole biological control agent or in conjunctions with other natural enemies to provide a great level of *B. tabaci* suppression on cucumber as well as to develop new managing strategies for successfully suppressing this worldwide pest. Based on our data and those of the previous studies, it appears that *S. parcesetosum* might be best suited for inclusion in a multiple species biological control approach to *B. tabaci* management on cucumber. As an obligate whitefly predator with a voracious feeding potential, *S. parcesetosum* is capable of checking rapid increases in whitefly populations (based on the caged studies herein), thus potentially enabling whitefly parasitoid species such as *Eretmocerus* or *Encarsia* to suppress whiteflies to acceptable thresholds. Further research is needed in order to determine if *S. parcesetosum* would be effective in interspecific interactions between predator and

parasitoid within the host species (pest/plant) and release management strategies.

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تقييم كفاءة *Serangium parcesetosum* Sicard (Col.,: Coccinellidae) كمفترس لذبابة القطن البيضاء *Bemisia tabaci* (Genn.) (Hom.,: Aleyrodidae) في البيوت المحمية

فراس احمد الزيود[1]

ملخـص

هناك معلومات قليله عن استخدام المكافحة الحيوية على الخضروات في الأردن. ولذلك هدفت هذة الدراسة الى تقييم تاثير موعد ومعدل اطلاق المفترس *Serangium parcesetosum* Sicard (Col.,: Coccinellidae) على اعداد الذبابة البيضاء *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) على الخيار فى البيوت المحمية. تم استخدام معدلين من الذبابة البيضاء/المفترس (20 : 1 أو 30 : 1) لكل نبات خيار فى أقفاص داخل البيوت المحمية، طبقت 3 معاملات: الشاهد، إطلاق المفترس بعد أسبوع أو أسبوعين من إدخال الذبابة البيضاء على النبات. أشارت النتائج إلى أن أعداد الذبابة البيضاء زادت في معاملة الشاهد حتى الأسبوع الخامس من التجربة، في حين أن الأعداد بدأت في الانخفاض من الأسبوع الثالث حتى نهاية التجربة في معاملتي إطلاق المفترس بعد أسبوع و أسبوعين من إدخال الذبابة البيضاء لكلا المعدلين. في الأسبوع الأخير من التجربة كانت أعداد الذبابة البيضاء أقل معنويا فى معاملتي إطلاق المفترس بعد أسبوع و أسبوعين من معاملة الشاهد لكلا المعدلين. كانت أعداد الذبابة البيضاء أقل معنويا عندما ادخل المفترس بعد أسبوع مقارنة مع أسبوعين بعد إدخال الذبابة البيضاء. هناك انخفاض بمعدل 64.92 و 61.88٪ (1:30) و 62.24 و 60.15٪ (1:20) عندما ادخل المفترس بعد أسبوع و أسبوعين على التوالي. في المحصلة، إن إطلاق المفترس لمرة واحده بمعدل خنفساء واحدة لكل نبات أدى الى خفض أعداد الذبابة البيضاء على الخيار لمده تصل إلى 7 أسابيع.

الكلمات الدالة: *Bemisia tabaci, Serangium parcesetosum*، ديناميكية الأعداد، المفترس، المكافحة الحيوية، الخيار.

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