Pakistan Journal of Biological Sciences 10 (13): 2159-2165, 2007
ISSN 1028-8880

Prey Species Preference of the Predator *Serangium parcesetosum* Sicard (Col., Coccinellidae) and Its Interaction with Another Natural Enemy

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Abstract: This study aimed to determine *Serangium parcesetosum* preference for different prey species and parasitized *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) by the parasitoid, *Eretmocerus mundus* Mercet (Hym., Aphelinidae). The results on *S. parcesetosum* preference by feeding on different prey species offered separately and together indicated that the predatory larvae and adults preferred significantly the cotton whitefly, *B. tabaci* and the castor bean whitefly, *Trialeurodes ricini* (Misra) (Hom., Aleyrodidae) rather than the two-spotted spider mite, *Tetranychus urticae* Koch (Acari, Tetranychidae); melon aphid, *Aphis gossypii* Glover (Hom., Aphididae) and pea leafminer, *Liriomyza huidobrensis* (Blanchard) (Dip., Agromyzidae). The results on *S. parcesetosum* preference for the whitefly species, *B. tabaci* and *T. ricini* demonstrated that there were no significant differences in the preference of both predatory larvae and adults for any whitefly species. Moreover, *S. parcesetosum* larvae and adults were significantly tended to avoid parasitized puparia of *B. tabaci* by *E. mundus* and fed instead on unparasitized ones. Thus, there is a feasible potential for integration the predator and the parasitoid into a biological control program to suppress *B. tabaci*.

Key words: *Serangium parcesetosum*, *Bemisia tabaci*, *Eretmocerus mundus*, preference, biological control, whiteflies

INTRODUCTION

Vegetables are one of the main crops grown in Jordan and the planted area is estimated to be around 401,700 dunums (dunum = 1000 m^2) (Agricultural Statistical Book, 2005). However, there are many pest species attacking vegetable crops in Jordan. The most dangerous is the cotton whitefly, *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae), which attacks numerous plant species and transmits many viral plant diseases (Sharaf and Hasan, 2003). In addition to this pest, the castor bean whitefly, *Trialeurodes ricini* (Misra) (Hom., Aleyrodidae); the two-spotted spider mite, *Tetranychus urticae* Koch (Acari, Tetranychidae); the melon aphid, *Aphis gossypii* Glover (Hom., Aphididae) and the leafminer, *Liriomyza huidobrensis* (Blanchard) (Dip., Agromyzidae) are locally and cosmopolitan polyphagous pests attacking many vegetable crops (Hagvar and Hofsvang, 1994; Abd-Rabou, 1999; Scheffer, 2000; Gerling *et al.*, 2001; Aucejo *et al.*, 2003).

Currently, all the fore-mentioned pest species are increasingly becoming more important pests, because the effectiveness of chemical pesticides applied to these pests have been dogged by the development of resistance within pest populations (Kranthi *et al.*, 2001; Civelek and Yoldas, 2003; Sato *et al.*, 2005). Predators and parasitoids have a key role in regulating pest populations (Necetic *et al.*, 2001; Civelek *et al.*, 2002; Jazzar and Hammad, 2004). However, *Serangium parcesetosum* Sicard (Col., Coccinellidae) is an important predator of whiteflies. It was found feeding voraciously on the woolly whitefly, *Aleurothrixus floccosus* Maskell (Argov, 1994); the sugarcane whitefly, *Aleurolobus barodensis* Mask. (Patel *et al.*, 1996); the silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Ellis *et al.*, 2001); the citrus whitefly, *Dialeurodes citri* (Ashmead) (Yigit *et al.*, 2003); as well as *B. tabaci* and the greenhouse whitefly, *Trialeurodes vaporariorum* Westwood (Al-Zyoud *et al.*, 2005). The parasitoid, *Eretmocerus mundus* Mercet (Hym., Aphelinidae) has been used worldwide to control *B. tabaci* (Urbaneja and Stansly, 2004) and it is a native parasitoid in Jordan (Hassan, 1999), as well as its parasitism on *B. tabaci* accounted for 71% (Sharaf and Batta, 1996).

Concomitantly, in order to locally achieve a successful management of the previously mentioned pests, especially *B. tabaci* in vegetables, which has relied on insecticides and to escape of the developed resistance to insecticides by pests, it was important to check the predation ability of *S. parcesetosum* on these pests. Moreover, in comparison with the previous findings, this study is expected to increase the host pest spectrum of *S. parcesetosum* and to investigate its discrimination ability to the whiteflies' parasitoid, *E. mundus*, since the later is a native and efficient parasitoid of *B. tabaci* in Jordan and has not been studied worldwide yet. Therefore, in the present work, the preference of *S. parcesetosum* for different pest species and parasitized *B. tabaci* by *E. mundus* at different temperatures were studied. All these experiments have the goal of comprehensively studying the potential of this promising predator to develop a new successful biological control possibility of stubborn pests in Jordan.

MATERIALS AND METHODS

A stock culture of *S. parcesetosum* was established from several individuals of the predator available at the Faculty of Agriculture, Mu'tah University. The predator's population was built up on *B. tabaci* reared on cucumber plants, *Cucumis sativus* L. in metal meshed cages (50x50x50 cm). The cages were sealed with gauze from their sides and tops 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. For rearing the parasitoid, *E. mundus*, parasitized puparia of *B. tabaci* on cabbage leaves, *Brassica oleracea* L. were collected from open fields of Al-Waleh Valley, Jordan and brought to the laboratory. The emerged parasitoids were reared further on cabbage plants infested with *B. tabaci* in similar meshed cages as mentioned before. For the experiments on prey species preference by *S. parcesetosum*, several species of arthropods, which usually attack vegetables, were reared and tested as possible prey for the predator. These were *B. tabaci*, *T. ricini*, *T. urticae*, *A. gossypii* and *L. huidobrensis*. 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. *T. ricini* was obtained from Balqa Applied University, Jordan and reared on castor bean plants, *Ricinus communis* L. The stock cultures of *T. urticae*, *A. gossypii* and *L. huidobrensis* were obtained on leaves collected from tomato, *Lycopersicon esculentum* Mill, cucumber and squash, *Cucurbita pepo* L. plants grown under greenhouses, respectively and maintained on cucumber plants. All stock cultures of the pest species were reared in metal meshed cages (80×50×50 cm) under laboratory conditions of 22-33°C at the Faculty of Agriculture, Mu'tah University, Jordan.

The desired stages of *S. parcesetosum* for the experiments were obtained in large round Plexiglas cages of 9 cm in diameter and 1.5 cm in height. Each cage was filled partially with 0.5 cm thick layer of wetted cotton pad and its lid was fitted with a meshed hole to provide suitable ventilation. Sixteen adults of *S. parcesetosum* females and males were transferred onto cucumber leaves with highly *B. tabaci* infestation in each round cage. After 24 h, the adults were removed and the laid eggs were reared further and checked daily until they reached the convenient stage. For obtaining the required stage of the whiteflies, *B. tabaci* and *T. ricini*, cucumber and castor bean plants were exposed to the insect infestation, respectively in the stock culture cages for 12 h and then incubated until reaching the convenient stage for the experiments. In order to obtain *T. urticae*, *A. gossypii* and *L. huidobrensis* in their appropriate stages for the experiments, the required stages from the different prey species were identified under a binocular microscope in the laboratory on leaves obtained from the different host plants in the different stock cultures and picked up gently, using a camel-hair brush. All the experiments were conducted in small round Plexiglas cages (5 cm-diameter and 1 cm-height) filled with 0.5 cm thick wetted cotton pad, in which cucumber leaf discs were placed upside down onto the wetted cotton pad. All experiments on prey species preference and parasitized prey were conducted in summer, 2006 at a constant temperature of 25±1°C and a range one of 22-33°C, in which the later one represents temperature regimes frequently encountered between April and November in Jordan, a period where the infestation by all the prey species mostly occurs, as well as relative humidity of 60±15%. All experimental groups were replicated twenty times with each predatory stage, prey species and temperature.

Multi-choice experiments were conducted to determine the predation preference by *S. parcesetosum* for different prey species and parasitized prey. To investigate the predator preference for different prey species, fourth larval instars (L_4) or one-week-old adults of *S. parcesetosum* were separately kept on a cucumber leaf disc (3 cm in diameter) in the small round Plexiglas cages with ten individuals of each *B. tabaci* (puparia), *T. ricini* (puparia), *T. urticae* (adults), *A. gossypii* (1-2 days old) or *L. huidobrensis* (puparia) separately. The predatory individuals were transferred daily to new round cages, which contain fresh prey from the five different species separately. The number of consumed prey of each species was daily recorded. A second group of experiments was carried out to evaluate the preference of *S. parcesetosum* L_4 instars and one-week-old adults for the same five prey species, when they were offered together in the round Plexiglas cages on a cucumber leaf disc (3 cm in diameter). Each predatory stage tested was kept with fifty individuals; ten of each *B. tabaci* puparia, *T. ricini* puparia, *T. urticae* adults, 1-2 days old of *A. gossypii* and *L. huidobrensis* puparia together in the round Plexiglas cages described above. The predator individuals were transferred daily to new round cages provided with fresh prey from the five different species together. The number of consumed prey of each species was daily recorded.

A third group of experiments was set up to test the predation preference of *S. parcesetosum* for the whiteflies; the cotton whitefly, *B. tabaci* and the castor bean whitefly, *T. ricini*. Each L_4 instar or one-week-old adult of *S. parcesetosum* was kept with ten puparia of *B. tabaci* and ten puparia of *T. ricini* together in the round Plexiglas cages on a cucumber leaf disc of 3 cm in diameter. The predatory individuals were daily transferred to new round cages, containing fresh prey from the two species together and the number of consumed individuals of each whitefly species was recorded. A fourth group of experiments was established to record the interaction between *S. parcesetosum* and *E. mundus*. For these experiments, the puparia of *B. tabaci* were used after one week of parasitism by *E. mundus*. Ten unparasitized and 10 parasitized puparia of *B. tabaci* were placed together on a cucumber leaf disc (3 cm in diameter) in the round Plexiglas cages with each L_4 instar or 7-day-old adult of *S. parcesetosum*. The puparia were arranged in rows of five puparia with unparasitized and parasitized whiteflies alternating one beneath the other in a uniform distribution in the cages. The *S. parcesetosum* larvae and adults were removed after 24 h and the number of consumed unparasitized and parasitized puparia was counted.

In order to affirm the basic assumptions of the data to be analysed, they were tested for the normal distribution and the homogeneity of variance using the Barlett-Test (Köhler *et al*., 2002). One- or two-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 the means at a probability level of 0.05. In which, among several means the LSD Test was used (Clewer and Scarisbrick, 2001), while in case of comparing between two means only, t-Test was conducted (Anonymous, 1996).

RESULTS

The results in Table 1 indicated that at both temperatures tested the predatory larvae preferred significantly the whiteflies species tested, *B. tabaci* and *T. ricini* rather than mite, *T. urticae*; aphid, *A. gossypii* and leafminer, *L. huidobrensis*. Also, the larvae preferred significantly the mite to aphid and leafminer. The predation rate of *S. parcesetosum* larvae were means of 9.25, 9.65, 1.90, 0.75 and 0.45 at 25°C as well as 9.50, 8.65,

Table 1: Predation rate of *Serangium parcesetosum* fourth larval instars by feeding on five different prey species offered separately on cucumber leaf discs at two different temperatures

Temp. (°C)	*Bemisia tabaci*	*Trialeurodes ricini*	*Tetranychus urticae*	*Aphis gossypii*	*Liriomyza huidobrensis*
25±1	9.25Aa	9.65Aa	1.90Ab	0.75Ac	0.45Ac
22-33	9.50Aa	8.65Ba	1.75Ab	0.80Ac	0.40Ac

Different capital letter(s) in columns indicate significant differences between the different temperatures within the same prey species, while different small letter(s) in rows indicate significant differences among the different prey species within the same temperature at p≤5% (Two-factor analysis of variance)

Table 2: Predation rate of *Serangium parcesetosum* adults by feeding on five different prey species offered separately on cucumber leaf discs at two different temperatures

Temp. (°C)	*Bemisia tabaci*	*Trialeurodes ricini*	*Tetranychus urticae*	*Aphis gossypii*	*Liriomyza huidobrensis*
25±1	9.40Aa	9.75Aa	1.95Ab	1.55Ab	0.40Ac
22-33	9.05Aa	8.65Ba	1.65Ab	1.40Ab	0.50Ac

Different capital letter(s) in columns indicate significant differences between the different temperatures within the same prey species, while different small letter(s) in rows indicate significant differences among the different prey species within the same temperature at p≤5% (Two-factor analysis of variance)

1.75, 0.80 and 0.40 individuals at 22-33°C from *B. tabaci*, *T. ricini*, *T. urticae*, *A. gossypii* and *L. huidobrensis*, respectively. In contrast, the predatory adults preferred significantly the whiteflies tested more than mite and aphid and the later two species were significantly preferred to leafminer at both temperatures (Table 2). The predatory adults at 25 and 22-33°C, respectively consumed daily means of 9.40 and 9.05 *B. tabaci* as well as 9.75 and 8.65 *T. ricini*. On the other hand, means of 1.95 and 1.65 *T. urticae* as well as 1.55 and 1.40 *A. gossypii* were consumed at 25°C and 22-33°C, respectively. However, a very little predation rate of 0.40 and 0.50 *L. huidobrensis* was recorded for *S. parcesetosum* adults at 25 and 22-33°C, respectively. Moreover, there were no significant differences in the mean daily predation rate by both larvae and adults of *S. parcesetosum* between the two different temperatures within the same prey species, except that one for *T. ricini*, in which both tested stages of the predator were significantly consumed more *T. ricini* at 25°C than 22-33°C (Table 1 and 2).

The predatory larvae (Table 3) at 25°C had significantly a general tendency in the prey preference toward the whitefly species used, but with greater preference for *T. ricini* than *B. tabaci* with a mean of 8.45 vs. 7.65, respectively. From the other three prey species, very few individuals were consumed, where daily means of 0.90, 0.35 and 0.05 were consumed from *T. urticae*, *A. gossypii* and *L. huidobrensis*, respectively. While at 22-33°C, the predatory larvae preferred significantly *B. tabaci* and *T. ricini* rather than mite, aphid and leafminer, also, with more preference to the mite than aphid and leafminer. The predation rates were means of 7.25, 7.90, 1.30, 0.40 and 0.05 individuals of *B. tabaci*,

Table 3: Predation rate of *Serangium parcesetosum* fourth larval instars by feeding on five different prey species offered together on cucumber leaf discs at two different temperatures

Temp. (°C)	*Bemisia tabaci*	*Trialeurodes ricini*	*Tetranychus urticae*	*Aphis gossypii*	*Liriomyza huidobrensis*
25±1	7.65Ab	8.45Aa	0.90Bc	0.35Acd	0.05Ad
22-33	7.25Aa	7.90Aa	1.30Ab	0.40Ac	0.05Ac

Different capital letter(s) in columns indicate significant differences between the different temperatures within the same prey species, while different small letter(s) in rows indicate significant differences among the different prey species within the same temperature at p≤5% (Two-factor analysis of variance)

Table 4: Predation rate of *Serangium parcesetosum* adults by feeding on five different prey species offered together on cucumber leaf discs at two different temperatures

Temp. (°C)	*Bemisia tabaci*	*Trialeurodes ricini*	*Tetranychus urticae*	*Aphis gossypii*	*Liriomyza huidobrensis*
25±1	8.75Aa	9.00Aa	1.40Ab	0.25Ac	0.10Ac
22-33	7.15Bb	7.70Ba	1.35Ac	0.45Ad	0.05Ad

Different capital letter(s) in columns indicate significant differences between the different temperatures within the same prey species, while different small letter(s) in rows indicate significant differences among the different prey species within the same temperature at p≤5% (Two-factor analysis of variance)

T. ricini, *T. urticae*, *A. gossypii* and *L. huidobrensis*, respectively. The predatory adults (Table 4) at both temperatures preferred significantly *B. tabaci* and *T. ricini* rather than mite and the later to aphid and leafminer. The predation rates were means of 8.75, 9.00, 1.40, 0.25 and 0.10 at 25°C as well as 7.15, 7.70, 1.35, 0.45 and 0.05 at 22-33°C from *B. tabaci*, *T. ricini*, *T. urticae*, *A. gossypii* and *L. huidobrensis*, respectively. In addition, the results indicated that there were no significant differences in the daily predation rate by both larvae and adults of the predator between the two different temperatures within the same prey species, except that the larvae consumed significantly more *T. urticae* at 22-33°C than at 25°C (Table 3) and the adults more *B. tabaci* and *T. ricini* at 25°C than at 22-33°C (Table 4).

Further statistical analysis on the data in Table 1 to 4 was conducted in order to find if there are significant differences when the 5 prey species were offered separately or together. The statistical analysis indicated that at 25°C the predatory larvae consumed significantly more individuals from all prey species when they offered separately rather than together. While the predatory adults consumed significantly more from the non-whitefly species when they were offered separately. On the other hand, at 22-33°C, both *S. parcesetosum* larvae and adults consumed significantly more *B. tabaci*, *A. gossypii* and *L. huidobrensis* when they offered separately and no significant differences in the predation rate from *T. ricini* and *T. urticae* were recorded when they offered separately or together.

The results in Table 5 indicated that there were no significant differences in the preference by both larvae and adults of the predator for any whitefly species. The predation rates of *S. parcesetosum* larvae were means of 7.70 and 8.55 at 25°C as well as 7.60 and 8.15 at 22-33°C from *B. tabaci* and *T. ricini*, respectively. While for *S. parcesetosum* adults, the predation rates were means of 8.75 and 9.25 at 25°C as well as 7.25 and 7.80 at 22-33°C from *B. tabaci* and *T. ricini*, respectively.

Table 5: Predation rate by fourth larval instars and adults of *Serangium parcesetosum* by feeding on *Bemisia tabaci* and *Trialeurodes ricini* offered together on cucumber leaf discs at two different temperatures

	S. parcesetosum larvae		*S. parcesetosum* adults	
Temp. (°C)	25±1	22-33	25±1	22-33
Bemisia tabaci	7.70a	7.60a	8.75a	7.25a
Trialeurodes ricini	8.55a	8.15a	9.25a	7.80a

Similar letter(s) in columns indicate no significant differences between the two whitefly species within the same *S. parcesetosum* stage and temperature at p≤5% (One-factor analysis of variance)

Table 6: Comparison of mean daily number of consumed unparasitized and parasitized puparia of *Bemisia tabaci* by *Eretmocerus mundus* kept together with *Serangium parcesetosum* fourth larval instars or adults on cucumber leaf discs at two different temperatures

	S. parcesetosum larvae		*S. parcesetosum* adults	
Temp. (°C)	25±1	22-33	25±1	22-33
Unparasitized puparia	8.30a	7.35a	8.45a	7.05a
Parasitized puparia	1.30b	1.15b	1.25b	1.05b

Different letter(s) in columns indicate significant differences between unparasitized and parasitized puparia of *B. tabaci* within the same *S. parcesetosum* stage and temperature at p≤5% (One-factor analysis of variance)

The results in Table 6 clearly showed that at both temperatures, both *S. parcesetosum* stages tested were significantly tended to avoid parasitized puparia and fed instead on unparasitized puparia of *B. tabaci*. The predation rates of *S. parcesetosum* larvae were means of 8.30 and 1.30 at 25°C as well as 7.35 and 1.15 at 22-33°C from unparasitized and parasitized puparia, respectively. While the predation rates of *S. parcesetosum* adults were means of 8.45 and 1.25 at 25°C as well as 7.05 and 1.05 at 22-33°C from unparasitized and parasitized puparia, respectively.

DISCUSSION

Due to pesticides resistance, which have been developed by agricultural pests (Kranthi *et al*., 2001), natural enemies could be an alternative method to suppress their populations (Al-Zyoud and Sengonca, 2004). Therefore, this study was set up to record new possible prey species for *S. parcesetosum* and to investigate its discrimination ability to the whiteflies' parasitoid, *E. mundus*. However, the results of the present study on *S. parcesetosum* preference when the different prey species offered either separately or together showed that *S. parcesetosum* larvae and adults had significantly a general tendency in the prey preference toward the whitefly species tested, *B. tabaci* and *T. ricini*, consuming very few individuals from the mite, aphid and leafminer. However, Al-Zyoud and Sengonca (2004) reported that *S. parcesetosum* preferred significantly *B. tabaci* and *T. vaporariorum* rather than thrips, *Frankliniella occidentalis* (Pergande) (Thys., Thripidae); aphid, *A. gossypii* and mite, *T. urticae* when the prey species offered together. While, Legaspi *et al.* (1996) mentioned that when *S. parcesetosum* offered eggs of the corn earworm, *Helicoverpa zea* (Boddie) (Lep., Noctuidae); eggs of the tobacco hornworm, *Manduca sexta* (L.) (Lep., Sphingidae) and eggs and early instars of *B. argentifolii* together, *S. parcesetosum* did not feed on the eggs of *H. zea* and *M. sexta* presented, indicating a preference for *B. argentifolii*. Further more, according to Legaspi *et al.* (2001), *S. parcesetosum* is not as voracious on citrus blackfly, *Aleurocanthus woglumi* Ashby eggs as on *B. argentifolii* nymphs. However, it might be that nutrient differences among the different prey species could have a substantial impact on predator choice. The present results are in agreement with the previous ones, in which *S. parcesetosum* has a preference toward the whitefly species.

The way of offering the prey species has affected the predation rate by *S. parcesetosum*. In general, at both temperatures, *S. parcesetosum* larvae and adults consumed more individuals from all prey species when they offered separately rather than together. At 25°C, the predatory larvae consumed significantly more from all prey species when they offered separately rather than together and the predatory adults consumed significantly more from the non-whitefly species when they offered separately rather than together. Also, at 22-33°C, both *S. parcesetosum* larvae and adults consumed significantly more *B. tabaci*, *A. gossypii* and *L. huidobrensis* when they offered separately. It might be that *S. parcesetosum* had no alternative source of food, but to feed on more individuals from the different prey species when it was kept with them separately. This may be an advantage character for this predator in order to survive for some time in case of scarcity of the main prey (whiteflies).

The results of the current work on the preference of *S. parcesetosum* for the whiteflies, *B. tabaci* and *T. ricini* indicated that there were no significant differences in the preference by both larvae and adults of the predator for any whitefly species. To the best of our knowledge, this is the first record that *S. parcesetosum* could feed on the castor bean whitefly, *T. ricini*. However, Al-Zyoud and Sengonca (2004) stated that *S. parcesetosum* preferred significantly *B. tabaci* to *T. vaporariorum*. Abboud and Ahmad (1998) tested different species of whiteflies as possible prey for *S. parcesetosum* and they found that the whitefly, *Paraleyrodes minei* Laccarino is not suitable for the development of *S. parcesetosum*, while *B. tabaci*, *D. citri* and *A. floccosus* were suitable for the predator' development. *S. parcesetosum* was developed faster on *B. tabaci* than on *D. citri* and *A. floccosus*, indicating that *B. tabaci* might be preferential to the other two-whitefly species (Abboud and Ahmad, 1998). From this study and the previous ones, it seems that *S. parcesetosum* is a specialist predator of many whitefly species. However, the degree of preference of *S. parcesetosum* for one whitefly species upon another might be due to size of the whitefly, thickness and hardness of the cuticle as well as many other physical and chemical characters of the different whitefly species. Moreover, in this regard, Patel *et al.* (1996) reported that this predator has been observed to be highly specific and feeding voraciously on the different stages of *A. barodensis*. According to Ahmad and Abboud (2001) as well as Al-Zyoud and Sengonca (2004), *S. parcesetosum* could feed on all *B. tabaci* developmental stages. Both larvae and adults of the predator are voracious feeders, capable of consuming large number of immature stages of *B. argentifolii* (Ellis *et al.*, 2001). Regardless of the whitefly species used in the different studies, the results of the present study are in agreement with the previous ones, in which *S. parcesetosum* could feed on most of the whiteflies offered.

The present results on *S. parcesetosum* preference for parasitized prey demonstrated that *S. parcesetosum* larvae and adults tested were tended to avoid parasitized puparia of *B. tabaci* by *E. mundus* and fed instead on unparasitized puparia. In this regard, Al-Zyoud and Sengonca (2004) reported that the second and fourth larval instars as well as adult females and males of *S. parcesetosum* were tended to avoid parasitized puparia of *B. tabaci* by the parasitoid, *Encarsia formosa* Gahan (Hym., Aphelinidae) and fed instead on unparasitized ones. While, according to Hoelmer *et al.* (1994), the fourth larval instar and adult female of the whitefly predator, *Delphastus pusillus* (LeConte) (Col., Coccinellidae) showed a marked tendency to avoid *B. tabaci* puparia parasitized by the two aphelinid parasitoids, *Encarsia tranvena* (Timberlake) and *Eretmocerus* sp. nr *californicus* Howard in favor of unparasitized whitefly. The present study is agreed with the previous ones, in which the coccinellid predators are tended to avoid parasitized prey by the different parasitoids. Also, since the predator, *S. parcesetosum* tended to avoid feeding on parasitized prey, there is a feasible potential for integration of *S. parcesetosum* and the well-known whiteflies' parasitoid, *E. mundus* into a biological control program in order to provide a great level of *B. tabaci* suppression in Jordan and worldwide as well.

REFERENCES

Abboud, R. and M. Ahmad, 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: 90-93.

Abd-Rabou, S., 1999. New records of whiteflies in Egypt. Egyp. J. Agric. Res., 77: 1143-1145.

Agricultural Statistical Book, 2005. Department of Statistics, Amman, Jordan, pp: 132.

Ahmad, M. and R. Abboud, 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: 40-44.

Al-Zyoud, F. and C. Sengonca, 2004. 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., P. Blaeser and C. Sengonca, 2005. 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: 485-496.

Anonymous, 1996. Reference Manual of the Statistics Program for Windows Winstat. Kalmia Company Inc., Cambridge, MA., pp: 267.

Argov, Y., 1994. The woolly whitefly, a new pest in Israel. Alon Hanotea, 48: 290-292.

Aucejo, S., M. Foo, E. Gimeno, A. Gomez-Cadenas, R. Monfort, F. Obiol, E. Prades, M. Ramis, J.L. Ripolles, V. Tirado, L. Zaragoza, J.A. Jacas and M.T. Martinez-Ferrer, 2003. Management of *Tetranychus urticae* in citrus in Spain: Acarofauna associated to weeds. Bull. OILB/SROP, 26: 213-220.

Civelek, H.S., Z. Yoldas and P. Weintraub, 2002. The parasitoid complex of *Liriomyza huidobrensis* in cucumber greenhouses in Izmir Province, Western Turkey. Phytoparasitica, 30: 1-3.

Civelek, H.S. and Z. Yoldas, 2003. Population densities of *Liriomyza huidobrensis* (Blanchard) (Dip., Agromyzidae) in insecticide-treated and non-treated cucumber producing greenhouses in the Üzmir region. Turk. J. Agric. For., 27: 43-48.

Clewer, A.G. and D.H. Scarisbrick, 2001. Practical Statistics and Experimental Design for Plant and Crop Science. John Wiley and Sons, Chichester, pp: 332.

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

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

Hagvar, E.B. and T. Hofsvang, 1994. Colonization behaviour and parasitization by *Ephedrus cerasicola* (Hym., Aphidiidae) in choice studies with two species of plants and aphids. J. Applied Entomol., 118: 23-30.

Hassan, H., 1999. Distribution, host preference, life tables and modelling approach for *Bemisia tabaci* (Hom., Aleyrodidae) and its parasitoid *Eretmocerus mundus* Mercet and *Encarsia* sp. (Hym., Aphidiidae) in Jordan Valley. M.Sc. Thesis, University of Jordan, Amman, Jordan, pp: 64.

Hoelmer, K.A., L.S. Osborne and R.K. Yokomi, 1994. Interaction of the whitefly predator *Delphastus pusillus* (Col., Coccinellidae) with parasitized sweetpotato whitefly (Hom., Aleyrodidae). Environ. Entomol., 23: 136-139.

Jazzar, C. and E.A.F. Hammad, 2004. Efficacy of multiple biocontrol agents against the sweet potato whitefly *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) on tomato. J. Applied Entomol., 128: 188-194.

Köhler, W., W. Schachtel and P. Voleske, 2002. Biostatistik. Springer-Verlag, Berlin, pp: 301.

Kranthi, K.R., D.R. Jadhav, R.R. Wanjar, A.S. Shaker and D. Russell, 2001. Carbamate and organophosphate resistance in cotton upsets in India, 1995-1999. Bull. Ent. Res., 91: 37-46.

Legaspi, J.C., B.C. Legaspi, R.L. Meagher and M.A. Ciomperlik, 1996. Evaluation of *Serangium parcesetosum* (Col., Coccinellidae) as a biological control agent of the silverleaf whitefly (Hom., Aleyrodidae). Environ. Entomol., 25: 1421-1427.

Legaspi, J.C., M.A. Ciomperlik and B.C. Legaspi, 2001. Field cage evaluation of *Serangium parcesetosum* (Col., Coccinellidae) as a predator of citrus blackfly eggs (Hom., Aleyrodidae). Southwest. Entomol. Sci. Notes, 26: 171-172.

Necetic, O., D.M. Watson, G.A.C. Beattie, A. Meats and J. Zheng, 2001. Integrated pest management of two-spotted mite *Tetranychus urticae* on green house roses using petroleum spray oil and the predatory mite *Phytoseuilus persimilis*. Environ. Applied Acarol., 25: 37-53.

Patel, C.B., A.B. Rai, J.J. Pastagia, H.M. Patel and M.B. Patel, 1996. Biology and predator potential of *Serangium parcesetosum* Sicard (Col., Coccinellidae), of sugarcane whitefly (*Aleurolobus barodensis* Mask.). GAU Res. J., 21: 56-60.

Sato, M.E., M.Z. Silva, A. Raga and M.F. Filho, 2005. Abamectin resistance in *Tetranychus urticae* Koch (Acari: Tetranychidae): Selection, cross-resistance and stability of resistance. Neotropical Entomol., 34: 991-998.

Scheffer, S.J., 2000. Molecular evidence of cryptic species within the *Liriomyza huidobrensis* (Dip., Agromyzidae). J. Econ. Entomol., 93: 1146-1151.

Sharaf, N. and Y. Batta, 1996. Effects of temperature on life of *Eretmocerus mundus* Mercet and *Encarsia* sp. (Hym., Aphidiidae). Dirasat Agric. Sci., 23: 214-219.

Sharaf, N. and H. Hasan, 2003. The identification of two biotypes of *Bemisia tabaci* in Jordan. Dirasat Agric. Sci., 30: 101-108.

Urbaneja, A. and P.A. Stansly, 2004. Host suitability of different instars of the whitefly *Bemisia tabaci* 'biotype Q' for *Eretmocerus mundus*. BioControl, 49: 153-161.

Yigit, A., R. Canhilal and U. Ekmekci, 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: 1105-1114.