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ORIGINAL ARTICLE

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Influence of leaf portion and plant species on the egg-laying behaviour of the predatory ladybird *Serangium parcesetosum* Sicard (Col., Coccinellidae) in the presence of a natural enemy

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Abstract The effectiveness of natural enemies against arthropod herbivores can depend on the characteristics of the plant on which they are found. The influence of the plant on the egg-laying behaviour of the promising whitefly predator, *Serangium parcesetosum* Sicard (Col., Coccinellidae) was examined in order to be able to use it effectively in biological control programs. The present work investigated the possible influence of the portion of the leaf on the number of eggs laid as well as the effect of plant species on the way in which eggs are deposited by *S. parcesetosum*. The experiments were conducted on cucumber and cotton leaves with *Bemisia tabaci* (Genn .) (Hom., Aleyrodidae) as prey in the absence and presence of a natural enemy, the lacewing, *Chrysoperla carnea* (Stephens) (Neur., Chrysopidae) at two different temperatures. The results showed that at 18°C, *S. parcesetosum* females significantly preferred to lay their eggs between the veins and close to the veins of cucumber leaves, mean of 10.1 and 7.5 eggs, in the absence of *C. carnea*, respectively, while in its presence significantly more eggs were deposited close to the veins and close to the petiole. On cotton leaves, close to the petiole, a mean of 8.4 eggs in the absence of the lacewing, as well as close to the veins, mean of 6.3 eggs in the presence of the lacewing, were found to be the most suitable leaf portions for egg-laying. At 30° C, the females laid their eggs preferentially close to the veins of cucumber leaves in the absence and presence of *C. carnea*. On cotton leaves, *S. parcesetosum* females significantly preferred to lay their eggs close to the petiole, mean of 7.6 and 6.1 eggs, as well as close to the veins, mean of 6.2 and 8.7 eggs, in the absence and presence of the lacewing, respectively. At both temperatures, the ladybird females laid their eggs singly on cucumber leaves in the absence and presence of *C. carnea*. While on cotton leaves, the females had a tendency to deposit their eggs together in the absence and presence of the lacewing, except at 30°C in its absence. Within the same plant species, significant differences were found in the total number of eggs laid by *S. parcesetosum* females on cotton leaves at 18°C as well as on cucumber leaves at 30°C in the absence and presence of the natural enemy. In addition to the effects of presence and absence of *C. carnea*, and where eggs were laid, some significant differences due to plant species was found at both temperatures.

Keywords *Serangium parcesetosum* · *Chrysoperla carnea* · *Bemisia tabaci* · Egg-laying behaviour · Plant species

This article is dedicated to Prof. Dr Wolfgang Schwenke on his 84th birthday.

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Introduction

Natural enemies live in multitrophic systems. Thus, their behaviour and physiology, which determine their fitness, are influenced by the first trophic level, the plant, and the second trophic level, the prey arthropod (Takabayashi et al. 1991). When studying the the third trophic level, to determine the natural enemies' efficiency in biological control, it is important to study the interactions between them and the host plants (Van Emden 1991). The effectiveness of natural enemies against arthropod herbivores can depend on several features of the prey's host plant such as physical and chemical characteristics (Godfray 1994) as well as morphology and nutrients (Vet and Dicke 1992). Plant characteristics have been shown to affect the oviposition behaviour of natural enemies (Kareiva and Sahakian 1990; Geitzenauer and Bernays 1996) and may serve as a guide for the search paths of predators (Frazer and McGregor 1994). Plant structure can also influence a predator's residence time or searching efficiency (Kareiva and Perry 1989).

Studying egg-laying behaviour of a natural enemy is of a great value as it leads to a better understanding of its ecological parameters and helps in using it in a biological control program against a pest species. The question is where the natural enemy lays its eggs and how many eggs are laid in each area of the plant. The answers to these questions could explain the oviposition strategy which determines the growth rate of the population (Danho and Haubruge 2003a, b). In a study conducted on the egg-laying behaviour of *Cosmopolites sordidus* (Germar), the number of eggs laid by the females was affected by the part of the prey's host plant on which they were deposited (Koppenhofer 1993). According to Bhattacharya and Banerjee (2001), the physicochemical parameters in three different plants such as shape, colour, size, texture and thickness affected the egg-laying behaviour of *Callosobruchus chinensis* (L.).

Serangium parcesetosum Sicard (Col., Coccinellidae) is an important predator of some species of whiteflies. It originates from India and is very host-specific to the cotton whitefly, *Bemisia tabaci* (Genn.) (Hom., Aleyrodidae) (Kapadia and Puri 1992) and the sugarcane whitefly, *Aleurolobus barodensis* Mask. (Shah et al. 1986). This ladybird was used against the citrus whitefly, *Dialeurodes citri* (Ashmead) in Georgia (Timofeyeva and Nhuan 1979), France (Malausa et al. 1988) and Turkey (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. 1996, 2001; Ellis et al. 2001). The predator was tested for the control of the wooly whitefly, *Aleurothrixus floccosus* Maskell, in Israel and Syria (Argov 1994; Abboud and Ahmad 1998). In German studies, *S. parcesetosum* exhibited many positive features against *B. tabaci* in the laboratory (Al-Zyoud and Sengonca 2004; Al-Zyoud et al. 2004; Sengonca et al. 2004). Despite the the many studies on *S. parcesetosum* with different whitefly species, the influence of the host plant on the egg-laying behaviour of this ladybird has not been researched and information on this subject is still completely lacking in the literature.

Therefore, the present work investigates a possible influence of leaf portion on the number of eggs laid as well as the effect of plant species on the way eggs are laid by *S. parcesetosum* as a part of the evaluation of this promising whitefly predator as a candidate for biological control programs. The laboratory experiments were conducted on cucumber and cotton leaves with *B. tabaci* as prey in the absence and presence of *Chrysoperla carnea* (Stephens) (Neur., Chrysopidae) at two different temperatures.

Materials and methods

The colony of *S. parcesetosum* was started with individuals from the Institute of Phytopathology, University of Bonn. They were reared in cylindrical plexiglas cages (19 cm diameter, 40 cm height) the top covered with gauze to allow aeration. Cotton plants (*Gossypium hirsutum* L., cv. Caroline Queen) and cucumber plants (*Cucumis sativus* L., cv. Tanja) infested with *B. tabaci* were frequently replaced inside the cylindrical plexiglas cages, and served as substrate on which the predator was reared. The stock culture of *B. tabaci* was maintained on cotton plants in mesh cages (80×50×60 cm). To establish the colony of *C. carnea*, a few individuals were obtained from a stock culture at the Institute of Phytopathology, University of Bonn. The colony was reared on eggs of the grain moth, *Sitotroga cerealella* (Olivier) (Lep., Gelechiidae) in small round plexiglas cages (3.5 cm diameter, 1 cm height). All the colonies were kept in climatically controlled chambers at 25 ± 1°C, 60 ± 10% relative humidity and a photoperiod of 16:8 h (light:-dark) with an artificial light intensity of ca. 4,000 lux.

Round plexiglas cages (11 cm diameter, 3 cm height) were used to conduct all the experiments, and were filled partially with a 0.5-cm-thick layer of wetted cotton pad. The lid of each cage had three holes covered with mesh to allow ventilation. Cucumber or cotton leaves, infested with >300 eggs, nymphs and puparia of *B. tabaci* were placed upside down on the cotton pads for the predators to feed on. The *S. parcesetosum* females used in the experiments were obtained from similar round plexiglas cages, prepared for this purpose, where each cage contained five to six females. The cages were checked daily and the newly laid eggs were moved to another cage and reared further until reaching the desired stage. To obtain *C. carnea* larvae as second instars (L_2) for the experiments, the colony was checked daily and the larvae were collected by using a camel-hair brush and used directly. All the experiments were undertaken at a low temperature of 18 ± 1°C and a high temperature of 30 ± 1°C, at the same relative humidity and photoperiod mentioned above, on cucumber and cotton leaves in the absence and presence of *C. carnea*. The experiments were replicated 10 times with respect to each plant species, temperature and stage of *C. carnea*.

In order to determine the leaf portion preferred by female *S. parcesetosum* for egg laying in the absence of *C. carnea*, two mated 1-week-old adult females were kept in each of the round plexiglas cages, while in the presence of *C. carnea*, two *S. parcesetosum* females and two *C. carnea* L_2 instars were kept together in each round plexiglas cage, containing cucumber or cotton leaves infested with *B. tabaci*. Thereafter, the round plexiglas cages were incubated at the assigned temperatures. The cages were checked daily in order to replace the L_2 instars of *C. carnea* when they moulted to become L_3 instars and to supply newly moulted L_2 instars as well as to replace cucumber or cotton leaves whenever needed. The underside of the leaves was divided into four different portions; close to the petiole, close to the veins, between the veins and close to the margins. The number of eggs laid in each leaf portion was recorded using a binocular microscope after a period of 7 days. Whether the ladybirds lay their eggs singly or together was also recorded. Eggs were considered as laid singly when only one egg was laid in a particular area of the leaf, while eggs were considered as laid together when two or more eggs were attached to each other.

The data were analysed statistically using a two-factor ANOVA. When the ANOVA indicates that significant ($P < 0.05$) differences were found, means were separated by a LSD test. A *t*-test was conducted to compare pairs of means (Winstat 1996).

Results

Influence of leaf portion on the number of eggs laid by *S. parcesetosum*

Mean total number of eggs laid by two *S. parcesetosum* females on different leaf portions when feeding on *B. tabaci* for 7 days in the absence and presence of two *C. carnea* L_2instars on cucumber leaves at 18°C is shown in Fig. 1. *S. parcesetosum* females significantly preferred to lay their eggs between the veins, mean 10.1 eggs, and close to the veins, mean 7.5 eggs, in the absence of lacewing, while in its presence significantly more eggs were deposited close to the veins and close to the petiole, mean 6.5 and 5.6 eggs, respectively. On cotton leaves, close to the petiole was found to be significantly the most suitable leaf portion for laying eggs, mean 8.4, by *S. parcesetosum* females in the absence of *C. carnea* (Fig. 2). In contrast, in the presence of *C. carnea*, the ladybird females showed a significant preference to deposit their eggs close to the veins, mean of 6.3 eggs. Significantly fewer eggs were laid close to the margins, mean 0.3 and 0.9 eggs, in the absence and presence of the lacewing, respectively. There were some significant differences in the number of eggs laid by the predatory ladybird in the absence and presence of *C. carnea* within the same plant species and leaf portion. On cucumber leaves there were significant differences in the number of eggs laid on all leaf portions, except close to the veins, while on cotton leaves differences were recorded for close to the petiole and close to the leaf margins.

At 30°C, *S. parcesetosum* females lay their eggs preferentially close to the veins of cucumber leaves, with a mean of 10.9 and 10.4 eggs in the absence and presence of *C. carnea*, respectively (Fig. 3). The presence of the lacewing significantly affected the number of eggs laid close to the petiole, as in the absence of *C. carnea* fewer eggs, mean 1.7, was laid, while in its presence more eggs were deposited, mean 5.9. On cotton leaves, *S. parcesetosum* females significantly preferred to lay their eggs close to the petiole, mean 7.6 eggs, and close to the veins, mean 6.2 eggs, in the absence of the lacewing (Fig. 4), while in its presence significantly more eggs were deposited close to the veins and close to the petiole, mean 8.7 and 6.1 eggs, respectively. Significant differences were found in the number of eggs laid by the ladybird predator in the absence and presence of

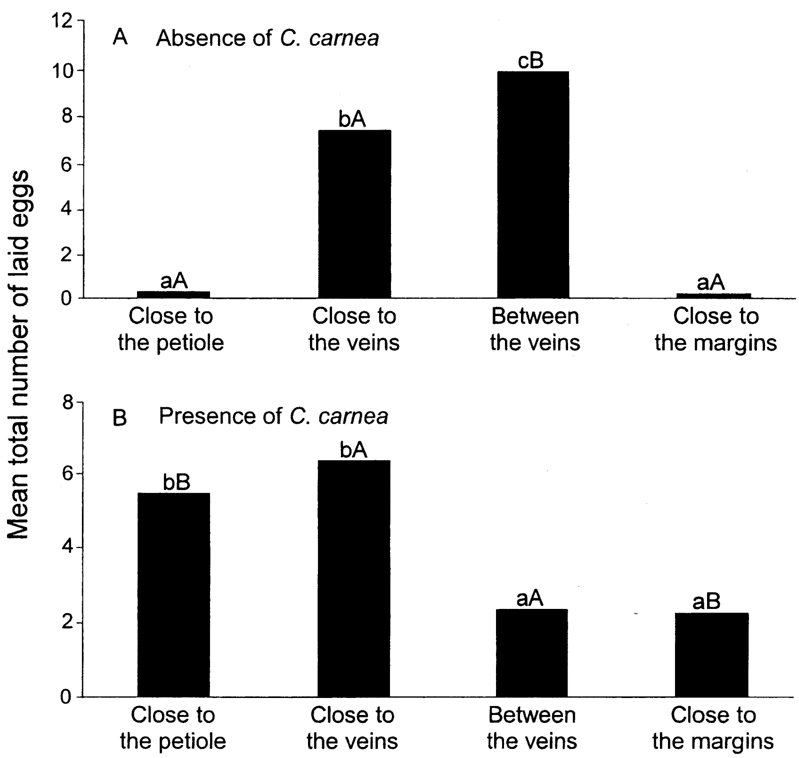

Fig. 1 Mean total number of eggs laid by two *Serangium parcesetosum* females on different cucumber leaf portions when feeding on *Bemisia tabaci* for 7 days in the absence (**A**) and presence (**B**) of two *Chrysoperla carnea* L_2 instars at 18 ± 1°C. *Bars with different small letters* indicate significant differences among the different leaf portions in the absence or presence of *C. carnea*. *Bars with different capital letters* indicate significant differences between the absence and presence of *C. carnea* within the same leaf portion at $P < 0.05$ (two-factor ANOVA)

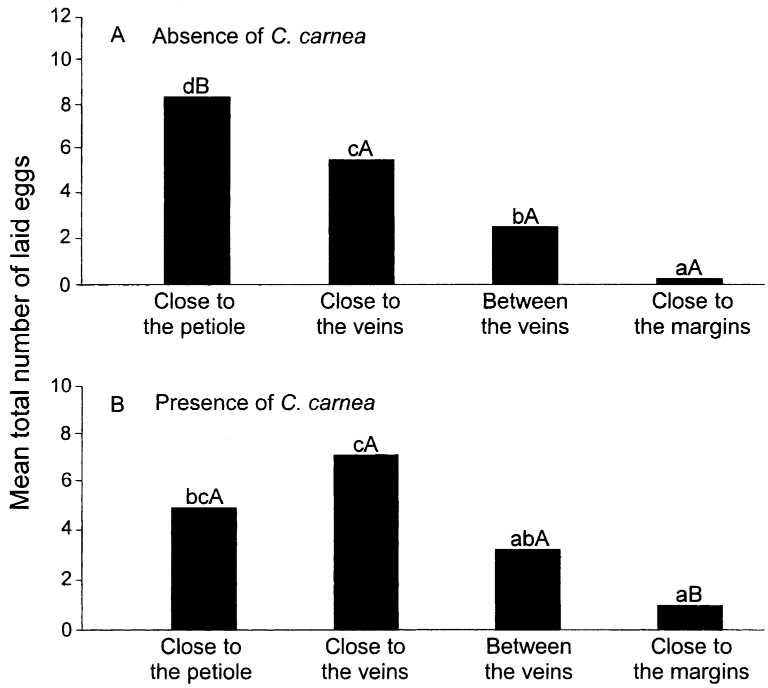

Fig. 2 Mean total number of laid eggs by two *S. parcesetosum* females on different cotton leaf portions when feeding on *B. tabaci* for 7 days in the absence (**A**) and presence (**B**) of two *C. carnea* L_2 instars at 18 ± 1°C. *Bars with different small letters* indicate significant differences among the different leaf portions in the absence or presence of *C. carnea*. *Bars with different capital letters* indicate significant differences between the absence and presence of *C. carnea* within the same leaf portion at $P < 0.05$ (two-factor ANOVA)

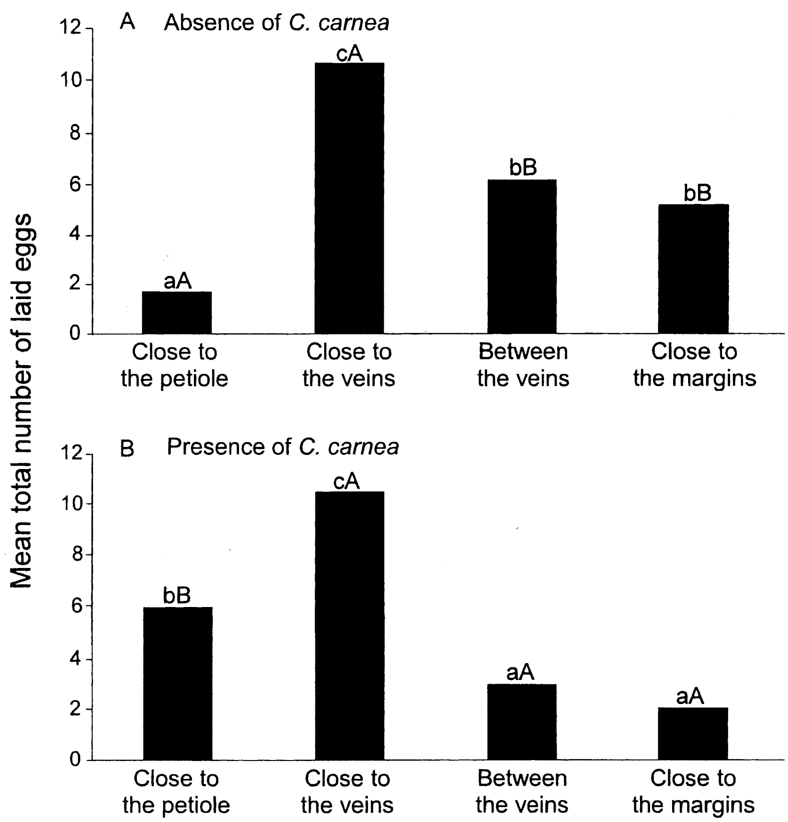

Fig. 3 Mean total number of laid eggs by two *S. parcesetosum* females on different cucumber leaf portions when feeding on *B. tabaci* for 7 days in the absence (**A**) and presence (**B**) of two *C. carnea* L_2 instars at 30 ± 1°C. *Bars with different small letters* indicate significant differences among the different leaf portions in the absence or presence of *C. carnea*. *Bars with different capital letters* indicate significant differences between the absence and presence of *C. carnea* within the same leaf portion at $P < 0.05$ (two-factor ANOVA)

C. carnea within the same plant species and leaf portion; on cucumber leaves there were significant differences in the number of laid eggs on all leaf portions, except close to the veins, while on cotton leaves they were found only close to the veins and between the veins.

Influence of plant species on the way of laying eggs by *S. parcesetosum*

The influence of plant species as well as the absence and presence of *C. carnea* on the mean total number of

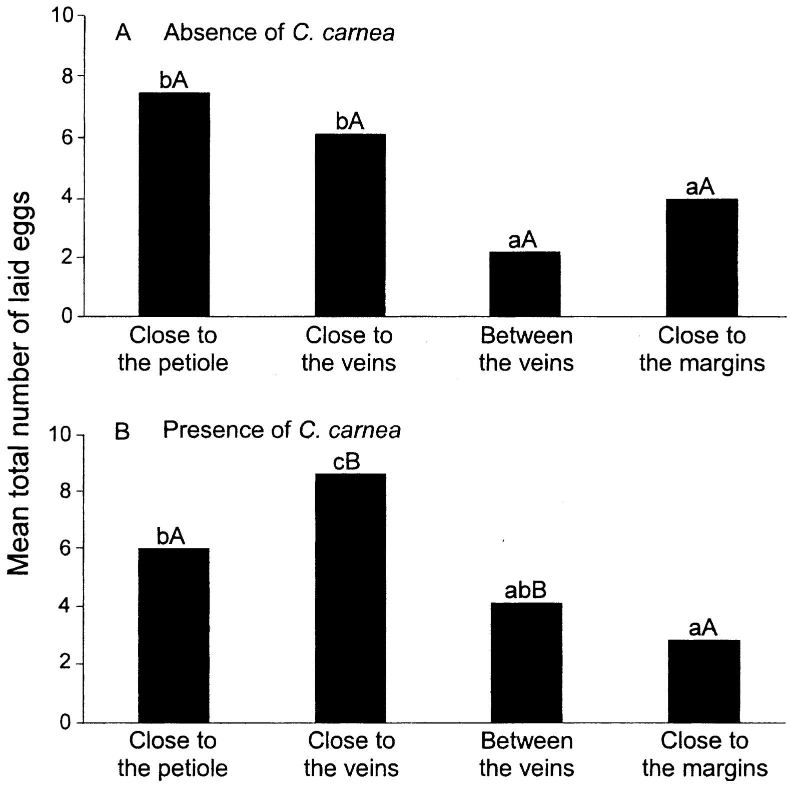

Fig. 4 Mean total number of laid eggs by two *S. parcesetosum* females on different cotton leaf portions when feeding on *B. tabaci* for 7 days in the absence (**A**) and presence (**B**) of two *C. carnea* L_2 instars at 30 ± 1°C. *Bars with different small letters* indicate significant differences among the different leaf portions in the absence or presence of *C. carnea*. *Bars with different capital letters* indicate significant differences between the absence and presence of *C. carnea* within the same leaf portion at $P < 0.05$ (two-factor ANOVA)

laid eggs by two *S. parcesetosum* females with *B. tabaci* as prey for 7 days on cucumber and cotton leaves at 18°C is summarized in Table 1. On cucumber leaves, the predatory ladybird females significantly preferred to lay their eggs singly in both the absence and presence of lacewing, mean 14.2 and 11.7 eggs, respectively. While on cotton leaves, the females showed a tendency to deposit their eggs together in the absence and presence of *C. carnea*, mean 11.1 and 9.6 eggs, respectively. In total, a mean of 18.1 and 16.8 eggs were laid on cucumber leaves and 16.9 and 14.5 eggs on cotton leaves in the absence and presence of lacewing, respectively. Within the same plant species, there were no significant differences in the total number of eggs laid in the absence and presence of *C. carnea* on cucumber leaves, but there were significant differences on cotton leaves.

S. parcesetosum females at 30°C significantly preferred to lay their eggs singly on cucumber leaves in the absence and presence of the lacewing, mean 19.7 and 14.1 eggs, respectively (Table 2). In contrast, on cotton leaves in the absence of *C. carnea* there were no significant differences between eggs deposited singly or together, mean 10.6 eggs and 9.4 eggs, respectively, while in its presence, the females laid significantly more eggs together, mean 17.4 eggs, rather than singly, mean 4.5 eggs. The presence of the lacewing predator significantly affected where *S. parcesetosum* laid its eggs, i.e. singly or together on cotton leaves. In total, on cucumber leaves a mean of 24.0 and 21.2 eggs was laid, while on cotton leaves a mean of 20.0 and 21.9 eggs was deposited in the absence and presence of *C. carnea*, respectively. Significant differences were found in the total number of eggs laid on cucumber leaves by *S. parcesetosum* females in

Table 1 Mean total numbers of eggs laid on cucumber and cotton leaves by two *Serangium parcesetosum* females when feeding on *Bemisia tabaci* for 7 days in the absence and presence of two *Chrysoperla carnea* at 18 ± 1°C. In rows, *different small letters* indicate significant differences between eggs laid singly and together within the same plant species in the absence or presence of *C. carnea*. In columns, *different capital letters* indicate significant differences between the absence and presence of *C. carnea* within the same plant species and between eggs laid singly or together ($P < 0.05$. two-factor ANOVA)

Plant species	*n*	*C. carnea*	Number of eggs laid (mean ± SE)		
			Singly	Together	Total mean
Cucumber	10	Absence	14.2 ± 4.8 bB	3.9 ± 2.7 aA	18.1 ± 3.4 aA
	10	Presence	11.7 ± 3.7 bA	5.1 ± 3.2 aA	16.8 ± 4.9 bA
Cotton	10	Absence	5.8 ± 2.7 aA	11.1 ± 3.1 bA	16.9 ± 4.0 aB
	10	Presence	4.9 ± 3.9 aA	9.6 ± 8.8 bA	14.5 ± 9.0 aA

Table 2 Mean total numbers of eggs laid on cucumber and cotton leaves by two *S. parcesetosum* females when feeding on *B. tabaci* for 7 days in the absence and presence of two *C. carnea* at 30 ± 1°C. In rows *different small letters* indicate significant differences between eggs laid singly and together within the same plant species and in the absence or presence of *C. carnea*. In columns *different capital letters* indicate significant differences between the absence and presence of *C. carnea* within the same plant species and eggs laid singly or together at $P < 0.05$ (two-factor ANOVA)

Plant species	*n*	*C.carnea*	Number of eggs laid (mean ± SE)		
			Singly	Together	Total
Cucumber	10	Absence	19.7 ± 2.8 bB	4.3 ± 2.9 aA	24.0 ± 3.7 aB
	10	Presence	14.1 ± 4.5 bA	7.1 ± 4.2 aB	21.2 ± 7.9 aA
Cotton	10	Absence	10.6 ± 3.4 aB	9.4 ± 2.5 aA	20.0 ± 5.1 bA
	10	Presence	4.5 ± 2.7 aA	17.4 ± 3.0 bB	21.9 ± 2.7 aA

the absence and presence of lacewing, but on cotton leaves there was no significant difference. Also, in the absence and presence of *C. carnea* and for area of the leaf on which eggs were laid, some significant differences were seen according to plant species at both studied temperatures.

Discussion

The tendency for a ladybird beetle to stay or leave the plant can depend on leaf morphology or plant characteristics (Frazer and McGregor 1994). Some plant characteristics influence the effectiveness of a whole suite of predators (Grevstad and Klepetka 1992) including its egg-laying behaviour. Hawkins et al. (1993) suggested that it would be useful to identify the influence of such characteristics of plants as a part of the evaluation of natural enemies as candidates for biological control. However, the results of the present study indicated that at 18°C *S. parcesetosum* females significantly preferred to lay their eggs between the veins and close to the veins in the absence of *C. carnea*, while in its presence significantly more eggs were deposited close to veins and petiole of cucumber leaves. An explanation for this may be that the ladybird lays its eggs in more protected areas of the leaf, such as close to petiole, rather than between the veins, in the presence of another predator. In contract, on cotton leaves the females significantly preferred to deposit their eggs close to the petiole and close to the veins in the absence and presence of the lacewing. At 30°C, the females had a tendency to lay significantly more eggs close to the veins of cucumber leaves in the absence and presence of *C. carnea*, while on cotton leaves *S. parcesetosum* females deposited their eggs preferentially close to the petiole and close to the veins in the absence and presence of the lacewing. Therefore, it can be concluded that the presence of *C. carnea* led to some differences in the total number of eggs laid by *S. parcesetosum* within the same plant species and leaf portion.

Previous studies on this subject are completely lacking. However, Koppenhofer (1993) in a laboratory study on the egg-laying behaviour of *C. sordidus* reported that the females lay a mean of 2.7 eggs per week in the rhizome and a mean of 0.7 eggs per week in the pseudostem of bananas. While in the field, a mean of 0.7 eggs per week was deposited in banana suckers and a mean of 1.3 eggs per week in the stumps of harvested suckers. He also found that the majority of eggs were laid in the crown area of the rhizome, followed by the remaining surface area of the rhizome, the walls of abandoned larval tunnels in rhizomes, pseudostems and leaf sheaths. This agrees with the present results, where the leaf portion or even the plant part influenced the number and distribution of the laid eggs. Danho and Haubruge (2003b) investigated the selection of oviposition sites by *Sitophilus zeamais* (Motschulsky) and the effect of the presence of egg plugs on its oviposition and found that the distribution of eggs showed a tendency for females to deposit more than one egg on the same grain. Also, the shape, colour, size, texture and thickness of the seed coat in pea, chickpea and lentil affected the egg-laying behaviour of *C. chinensis,* and a significantly higher number of eggs was deposited on pea than on chickpea or lentil (Bhattacharya and Banerjee 2001). Hirschberger (1997) reported that the presence of the yellow dungfly, *Scathophaga stercoraria* L., larvae affected the egg-laying behaviour of *Aphodius ater* Degeer. Our results and those of previous studies show that leaf morphology and the presence of another natural enemy affect the number and distribution of laid eggs. Also, the present results indicate that the plant species, presence of the natural enemy and temperature influence the distribution of the eggs laid by the ladybird predator on the undersurface of the leaves.

Apart from the studies mentioned above, there have been few investigations on *S. parcesetosum*'s preference for area of the leaf when laying eggs. However, Timofeyeva and Nhuan (1979) stated that *S. parcesetosum*, fed with *D. citri*, lays its eggs on the undersurface of citrus leaves. On aubergine, the ladybird deposited its eggs singly on the undersurface of leaves, when the predator was fed with *B. tabaci* as prey (Kapadia and Puri 1992). According to Patel et al. (1996), *S. parcesetosum* females laid their eggs singly on sugarcane leaves where *Aleurolobus barodensis* Mask was the prey. These results are in agreement with the current ones, where the ladybird could lay its eggs singly as well as on the undersurface of the leaves, although Ahmad and Abboud (2001) found that ladybirds, fed with *B. tabaci*, deposited their eggs singly or in irregular groups on cabbage leaves near the prey stages. A similar trend was found in the present study, in which the eggs could be also laid together. The current work shows that at both studied temperatures, *S. parcesetosum* females exhibited a significant preference to lay their eggs singly on cucumber leaves and together on cotton leaves in the absence and presence of *C. carnea*. This indicates that the plant species has a great effect on where eggs are laid. Also, some significant differences were found for the total number of eggs laid by *S. parcesetosum* in the absence and presence of *C. carnea* on cucumber and cotton leaves. Both the present results and the previous ones indicate that *S. parcesetosum* can lay its eggs singly or together.

In conclusion, the plant species, presence of *C. carnea* as a natural enemy, and temperature, affected the leaf portion preferred by *S. parcesetosum* females for egg-laying as well as whether eggs were laid singly or together. Also, the results suggest that differences in the location of laid eggs reflect differences in searching behaviour of *S. parcesetosum* under the different conditions. The present study has demonstrated some ecological aspects of the ladybird *S. parcesetosum* and therefore provides a better understanding of this species for its use of as a promising whitefly predator in pest management programs in conjunction with other predators in order to suppress populations of *B. tabaci*.

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 Protect 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 Protect 19(1):40–44

Al-Zyoud F, Sengonca C (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, Tort N, Sengonca C (2004) 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

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

Bhattacharya B, Banerjee TC (2001) Factors affecting egg-laying behaviour and fecundity of *Callosobruchus chinensis* (L.) (Col., Bruchidae) infesting stored pulses. Orient Insects 35:373–386

Danho M, Haubruge E (2003a) Egg-laying behaviour and reproductive strategy of *Sitophilus zeamais* (Col., Curculionidae). Phytoprotection 84:59–67

Danho M, Haubruge E (2003b) Optimal clutch size and oviposition strategy for the maize weevil, *Sitophilus zeamais*. In: Proceedings of the 8th international working conference on stored product protection. CABI, Wallingford, pp 271–275

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

Frazer BD, McGregor RR (1994) Searching behaviour of adult female coccinellidae (Coleoptera) on stem and leaf models. Can Entomol 126:389–399

Geitzenauer HL, Bernays EA (1996) Plant effects on prey choice by a vespid wasp, *Polistes arizonensis*. Ecol Entomol 21:227–234

Godfray HCJ (1994) Parasitoids: behavioural and evolutionary ecology. Princeton University Press, Princeton, N.J.

Grevstad FS, Klepetka BW (1992) The influence of plant architecture on the foraging efficiencies of a suite of ladybird beetles feeding on aphids. Oecologia 92:399–404

Hawkins BA, Thomas MB, Hochberg ME (1993) Refuge theory and biological control. Science 262:1429–1432

Hirschberger A (1997) Oviposition of the dung beetle *Aphodius ater* in the presence of the yellow dungfly *Scathophaga stercoraria*—evidence for competition? Mitt Dtsch Ges Allg Angew Entomol (Giessen) 11:429–432

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

Kareiva P, Perry R (1989) Leaf overlap and the ability of ladybird beetles to search among plants. Ecol Entomol 14:127–129

Kareiva P, Sahakian R (1990) Tritrophic effects of a simple architectural mutation in pea plants. Nature 345:433–434

Koppenhofer AM (1993) Observations on egg-laying behaviour of the banana weevil, *Cosmopolites sordidus* (Germar). Entomol Exp Appl 68:187–192

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

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

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

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 Protect 111:598–609

Shah AH, Patel MB, Patel GM (1986) Record of a coccinellid predator (*Serangium parcesetosum* Sicard) of sugarcane whitefly in South Gujarat. GAU Res J 12(1):63–64

Takabayashi J, Dicke M, Posthumus MA (1991) Variation in composition of predator-attracting allelochemicals emitted by herbivore-infested plants: relative influence of plant and herbivore. Chemoecology 2:1–6

Timofeyeva TV, Nhuan HD (1979) Morphology and biology of the Indian ladybird *Serangium parcesetosum* Sicard (Col., Coccinellidae) predacious on the citrus whitefly in Adzharia. Entomol Rev 57(2):210–214

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

Van Emden HF (1991) The role of host plant resistance in insect pest mis-management. Bull Entomol Res 81:123–126

Vet LEM, Dicke M (1992) Ecology of infochemical use by natural enemies in a tritrophic context. Annu Rev Entomol 37:141–172

Winstat (1996) Reference manual of the statistics program for Windows, Winstat. Kalmia, Cambridge, Mass.

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

Yigit A (1992b) *Serangium parcesetosum* Sicard (Col., Coccinellidae), new record as a citrus whitefly predatory ladybird in Turkey. Turk 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