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Evaluation of the green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) against aphids on different crops

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ABSTRACT: The green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) is one of the most effective bioagents for the control of aphids. The present work deals with mass production, release and evaluation of this predator on different aphid pests including *Aphis craccivora* Koch on potato, *Aphis nerii* (Boyer de Fonscolombe) on oleander, *Aphis gossypii* Glover on cotton, *Brevicoryne brassicae* (L.) on cabbage, *Myzus persicae* (Sulzer) on apple, and *Pterochloroides persica* Chlod. on peach. Experiments were done at four different locations of Egypt including Qalubiya, Demmyate, North Sinai and Giza. About one million larvae were released at the rate of 100 larvae per tree and 50 larvae per individual plant, biweekly, during 2005-2006. The results showed that the populations of the aphid species decreased from 2110 to 77, 2851 to 5, 5142 to 2, 1741 to 110, 1410 to 11 and 2210 to 15 individuals / 10 leaves, on potato, cotton, oleander, cabbage, apple, peach, respectively, after releasing *C. carnea*.

KEY WORDS: Aphids, biological control, *Chrysoperla carnea*, Egypt.

INTRODUCTION

The green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) was found to be most important predator of aphids (Rosenheim *et al.*,1998), spider mites (especially red mites) (Dutton *et al.*, 2002), thrips, whiteflies (Abd-Rabou, 2000), eggs of leafhoppers, moths, and leafminers, small caterpillars, beetle eggs and larvae (Kubota and Shiga,1995), and the tobacco budworm. It is an important predator of long-tailed mealybug in greenhouses and interior plantscapes (Tauber & Tauber, 1983).

Chrysopids are important biocontrol agents of aphids and have been effectively used for the integrated control of several aphid pests in different parts of the world (Zelany, 1984; Saminathan et al., 1999; Ulhaq et al., 2006). The aim of this work was to evaluate *C. carnea* on different species of aphids in different locations in Egypt.

MATERIALS AND METHODS

One hundred (60 females and 40 males) adults of *C. carnea* were confined in a glass chimney (9 cm dia., 16 cm dia.), which was placed in a Petri dish (12cm dia). Another small Petri dish (8.0 cm dia) was placed in the bigger Petri dish for holding cotton soaked in distilled water to maintain moisture. The upper open end of the glass chimney was covered with a black muslin cloth and was tightened with a

rubber band. The adult diet [Yeast and honey, 1:1] was provided inside the glass chimney with the help of a small plexi glass strip, each strip being drilled at three points to make pits for holding drops of a diet. The diet was provided at an interval of 24 hours. Eggs laid by the females on the walls of the chimney and muslin cloth were harvested with a sharp razor and one egg per test tube (7.5 x 1 cm. dia.) was placed with the help of a camel hair brush. The test tubes were plugged with cotton swab. After hatching, the newly hatched larvae were fed on frozen eggs of *Sitotroga cerelella* (0.2 gm/tube) that were provided at the interval of four days. The temperature and humidity in the laboratory conditions were 25-27 °C and 65-70% R.H (Ulhaq et al. 2006).

In 2005 and 2006, about one million larvae were released at the rate of 100 larvae per tree and 50 larvae per individual plant [from a carton box (15 cm height and 10cm diameter) containing larvae, they were allowed to freely disperse from the containers] in Qalubiya, Demmyate, North Sinai and Giza on *Brassica oleracea* L. variety *botrytis* (cabbage) infested by *Brevicoryne brassicae* (L.), *Solanum tuberosum* L. variety Clara (potato) infested by *Aphis craccivora* Koch, *Gossypium barbadense* L. variety Giza 57 (cotton) infested by *Aphis gossypii* Glover, *Pyrus malus* L. variety Silvestris [apple (15 years old, 3 meters high)] infested by *Myzus persicae* (Sulzer), *Nerium oleander* L. (oleander) infested by *Aphis nerii* (Boyer de Fonscolombe) and *Pruns persica* Batsch variety Sinewy (peach) infested by *Pterochloroides persica* Chlod.

During 2005-2006, biweekly releases were made of 100 larvae per tree of apple (100 trees and 20 releases), peach (100 trees and 12 releases) and oleander (50 trees and 12 releases), and of 50 larvae per plant for cotton (400 plants and 12 releases), potato (600 plants and 8 releases) and cabbage (500 plants and 10 releases), amounting to 0.5 million larvae for each year. Releases were begun from February to May in case of potato, from June to October in case of cabbage, from March to December in case of apple and from May to October in case of cotton, oleander and peach. The efficacy of the releases was assessed monthly during 2006 by counting the stages of aphids present, the natural enemies recorded associated with the aphid species and eggs, larvae and pupa of *C. carnea* present and on a total of 10 middle leaves from each plant in each site. The same procedure were followed in the control experiment except for *C. carnea* releases.

Statistical analysis of the obtained data was done using Analysis of variance (ANOVA) procedures in SAS. The means were separated using Duncan's Multiple range test in SAS.

RESULTS AND DISCUSSION

Aphis craccivora on potato

The population of *A. craccivora* on potato in Giza was 98 individuals/ 10 leaves while the natural enemies were 0, 2, 165 individuals/ 10 leaves during February for *Orius albidipennis* Reuter, *Coccinella undecimpunctata* L., and *C. carnea*, respectively, after releases. The corresponding values were 1741 individuals/ 10 leaves and 1, 1, 11 individuals/ 10 leaves in the control experiment. The population of the aphid decreased gradually after releasing *C. carnea* till it reached 77 individuals/ 10 leaf during April, while the natural enemies were 1, 5, 110 individuals/ 10 leaves for *O. albidipennis*, *C. undecimpunctata* and *C. carnea*, respectively, In the control, the aphids were 1315, while the natural enemies were 1, 3, 17 individuals/ 10 leaves (Figs, 1, 2 &3). The population of the aphid decreased from 2110 to 77 individuals/ 10 leaves while the population of *C. carnea* increased from 14 to 184 in March. The population of *O. albidipennis*, decreased after releasing *C. carnea* from 3 to 2 individuals/ 10 leaves during March, while *C. undecimpunctata* increased from 3 to 5 individuals/ 10 leaves during April. The simple correlations between the population of natural enemies (*O. albidipennis*, *C. undecimpunctata*, *C.carnea*) and the mean number of *A. craccivora* population were positive ($r = 0.53, 0.60$ and 0.90) and non-significant, respectively. The simple regression for changing the population of natural enemies (a, B and C) on the mean number of *A. craccivora* population were

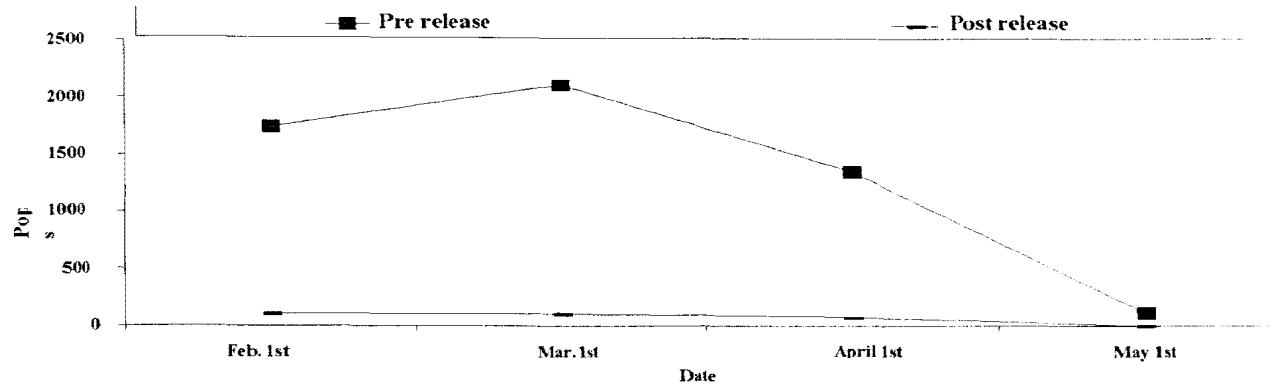

Fig. 1. Populations of *Aphis craccivora* before and after release of *Chrysoperla carnea* on potato

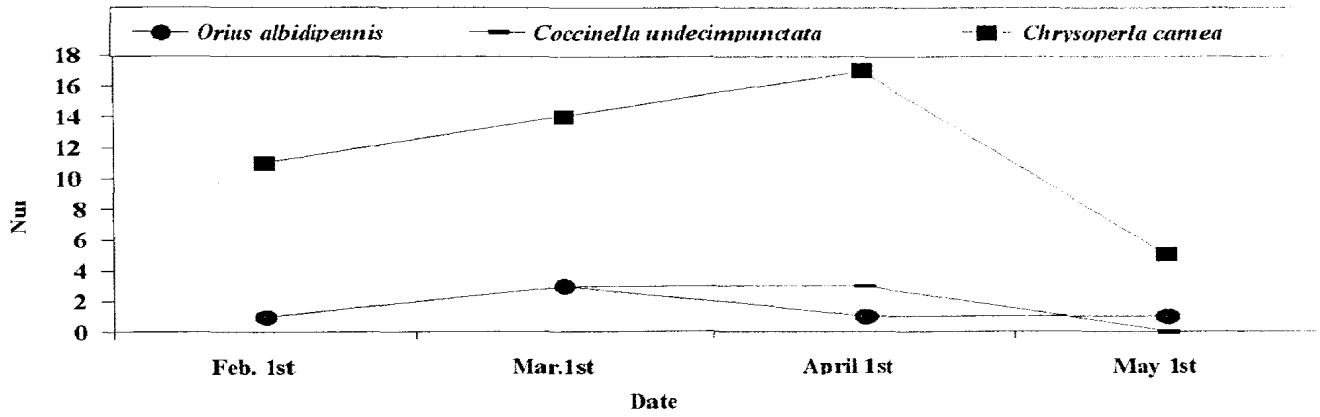

Fig. 2. Populations of natural enemies of *Aphis craccivora* before release of *Chrysoperla carnea* on potato

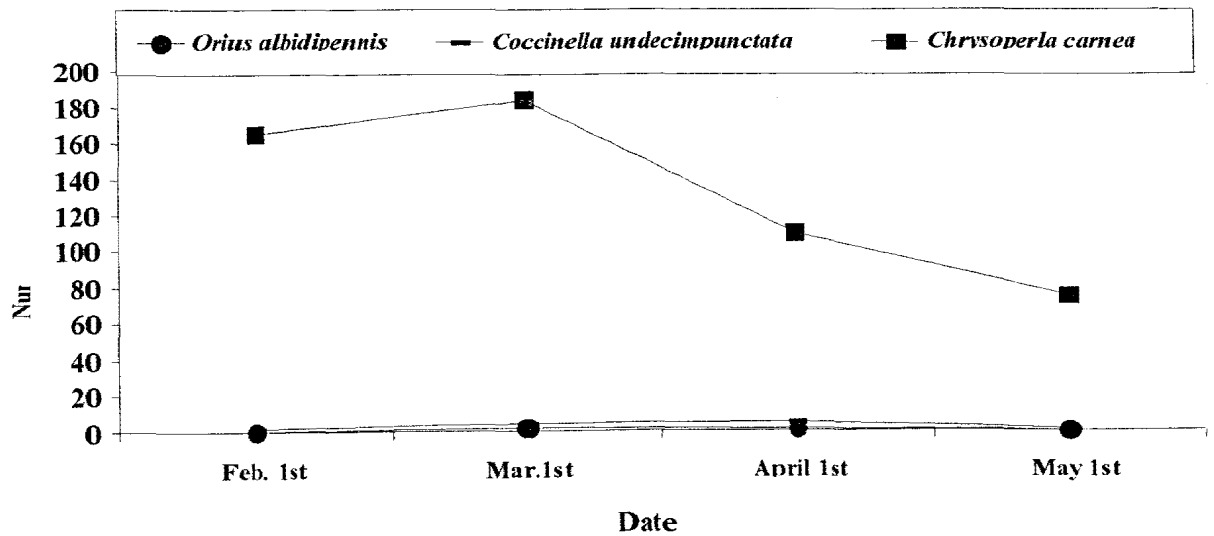

Fig. 3. Populations of natural enemies of *Aphis craccivora* after release of *Chrysoperla carnea* on potato

positive (b = 0.29, 0.93 and 0.98) and non-significant, respectively.

On *Aphis gossypii* on cotton

The population of *A. gossypii* on cotton in Demmyate was 5 individuals/ 10 leaves while the natural enemies were 0, 71, 730 individuals/ 10 leaves during September (for *Aphelinus abdominalis*, *C. undecimpunctata* and *C. carnea*, respectively) after releases. In comparison, the aphid population was 2851 individuals/ 10 leaves and the natural enemies were 2, 65, and 91 individuals/ 10 leaves in the control experiment (Figs, 4, 5 & 6). The populations of aphid decreased from 2851 to 5 individuals/ 10 leaves while the population of *C. carnea* increased from 10 to 150 at the end of the experiment, indicating the effective role of this chrysopid in controlling *A. gossypii* on cotton.

The population of *A. abdominalis* decreased after releasing *C. carnea* from 10 to 3 individuals/ 10 leaves during August, while that of *C. undecimpunctata* increased from 65 to 71 individuals/ 10 leaves during September. The simple correlations between the population of natural enemies (*A. abdominalis*, *C. undecimpunctata*, *C. carnea*) and the mean number of *A. gossypii* were positive (r = 0.30, 0.02 and 0.04) and non-significant, respectively. The simple regression for changing the population of natural enemies (*A. abdominalis*, *C. undecimpunctata*, *C. carnea*) on the mean number of *A. gossypii* were positive (b = 0.09, 0.50 and 0.65) and non-significant, respectively.

On *Aphis nerii* on oleander

The population of *A. nerii* on oleander in Giza was 155 individuals/ 10 leaves while the natural enemies were 0, 4, 56 individuals/ 10 leaves during June for *Aphidoletes meridionalis* Felt, *C. undecimpunctata* and *C. carnea*, respectively, after releases in comparison to 741 aphids/ 10 leaves and 12, 3 individuals/ 10 leaves of *A. meridionalis* and *C. undecimpunctata* in control (*C. carnea* was not found in the control experiment). The population of the aphid decreased gradually after releasing *C. carnea* till it reached 2 individuals/ 10 leaves during October, while the natural enemies were 0, 2 individuals/ 10 leaves for *A. meridionalis* and *C. undecimpunctata*, respectively. In control, the aphids were 5142, while the natural enemies were 27 and 7 individuals/ 10 leaves (*A. meridionalis*, *C. undecimpunctata*) (Figs, 7, 8 & 9). The results show that the population of aphids decreased from 5142 to 2 individuals/ 10 leaves while the population of *C. carnea* increased from 0 to 92 during August. This chrysopid established on *A. nerii* on oleander in this area for the first time.

The population of natural enemies, *A. meridionalis*, decreased after releasing *C. carnea* from 27 to 4 individuals/ 10 leaves during August, while *C. undecimpunctata* increased from 11 to 13 individuals/ 10 leaves during September. The simple correlations between the population of natural enemies (*C. undecimpunctata* , *C. carnea*) and the mean number of *A. nerii* were positive (r = 0.26 and 0.53) and non-significant, respectively. The correlation between the population of natural enemy (*A. meridionalis*) and the mean number of *A. nerii* (r = 0.73) was positive and significant. The simple regression for changing the population of natural enemies (*A. meridionalis*) on the mean number of *A. nerii* was positive (b = 0.91) and significant, while the simple regression for changing the population of natural enemies (*C. undecimpunctata* , *C. carnea*) on the mean number of *A. nerii* were also positive (b = 0.84 and 0.28) and non-significant, respectively.

On *Brevicoryne brassicae* on cabbage

The population of *B. brassicae* on cabbage in Qalubiya was 110 individuals/ 10 leaves while the natural enemies were 2, 1, 39 individuals/ 10 leaves during July for *Scymnus* sp., *Aphidius* sp., and *C. carnea*, respectively, after releases in comparison to 1278 aphids/ 10 leaves and 5, 7, 12 individuals/ 10 leaves of *Scymnus* sp., *Aphidius* sp., *C. carnea*, respectively, in the control (Figs, 10, 11 &12). In this experiment the population of aphids decreased from 1741 to 197 individuals/ 10 leaves while the population of *C. carnea* increased from 8 to 84 at the end of the experiment, indicating the efficacy of this chrysopid in controlling *B. brassicae* on cabbage.

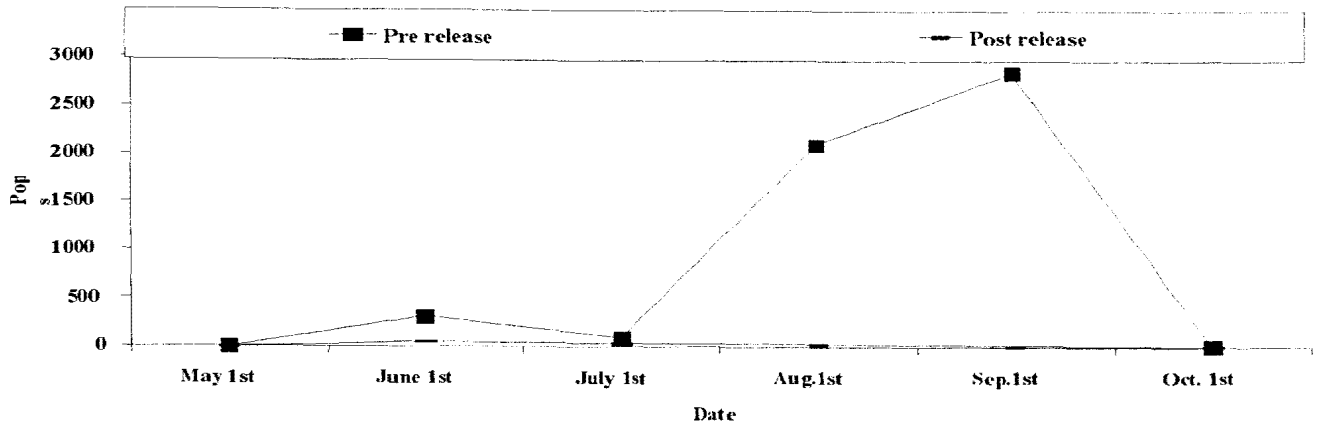

Fig. 4. Populations of *Aphis gossypii* before and after releasing of *Chrysoperla carnea* on cotton

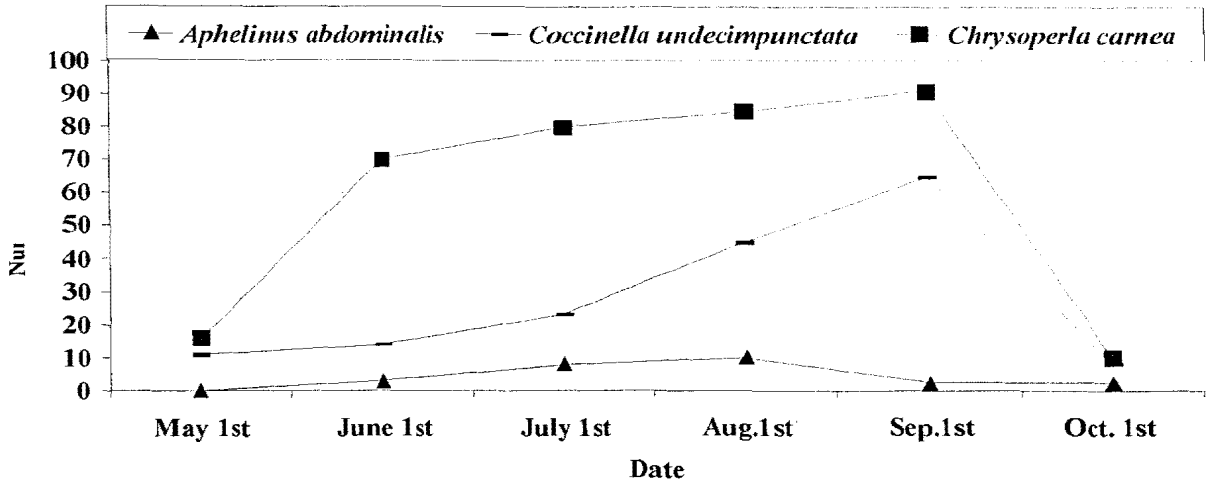

Fig. 5. Populations of natural enemies of *Aphis gossypii* before release of *Chrysoperla carnea* on cotton

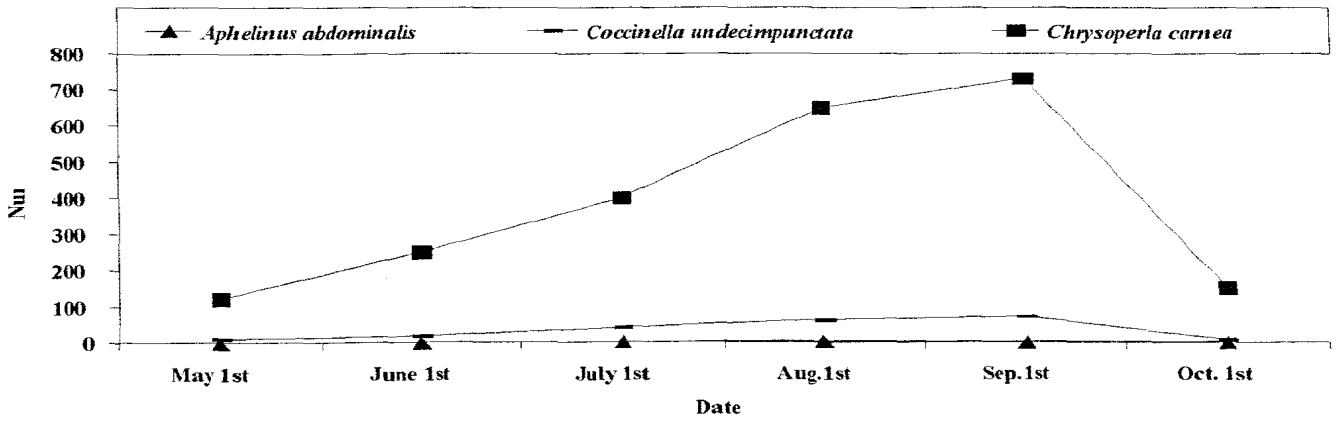

Fig. 6. Populations of natural enemies of *Aphis gossypii* after releasing *Chrysoperla carnea* on cotton

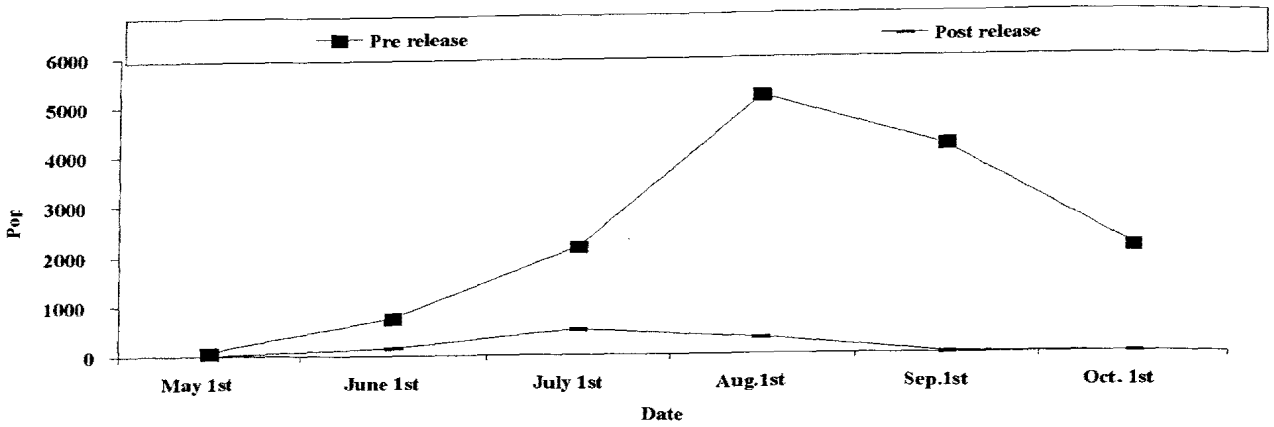

Fig. 7. Populations of *Aphis nereli* before and after release of *Chrysoperla carnea* on oleander

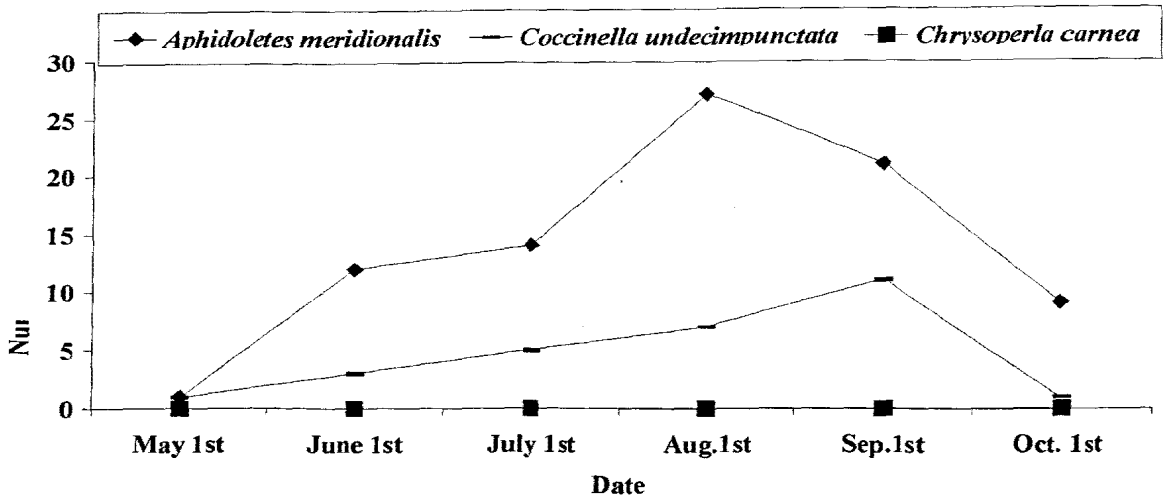

Fig. 8. Populations of natural enemies *Aphis nereli* before releasing *Chrysoperla carnea* on oleander

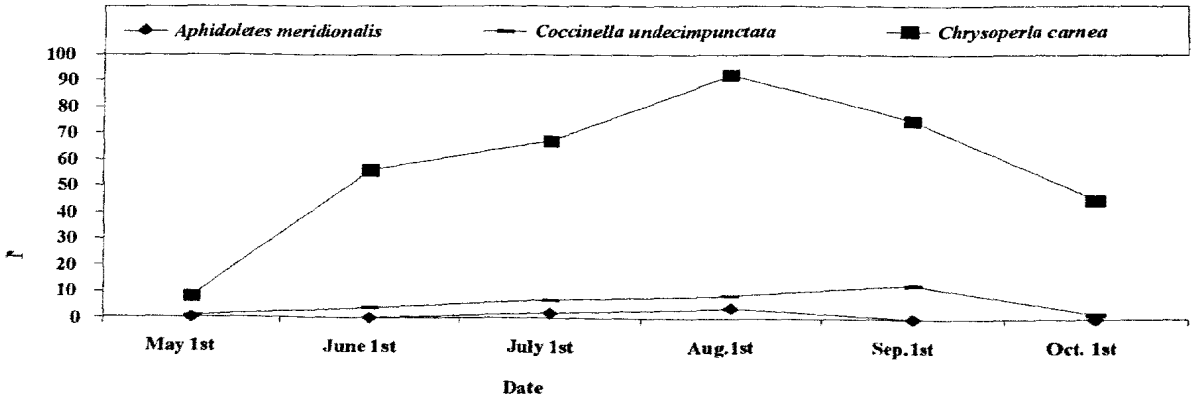

Fig. 9. Populations of natural enemies *Aphis nereli* after releasing *Chrysoperla carnea* on oleander

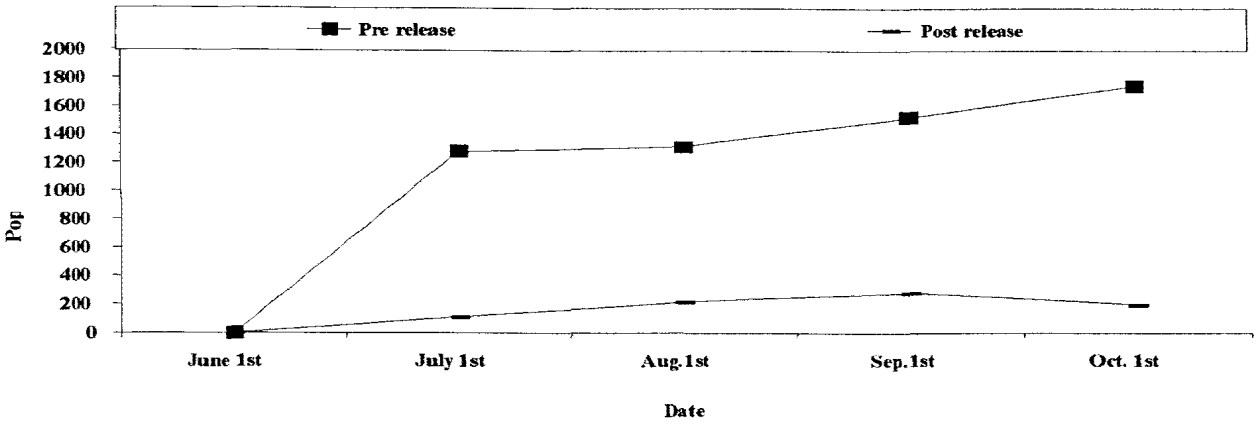

Fig. 10.Populations of *Brevicoryne brassicae* before and after releasing of *Chrysoperla carnea* on cabbage

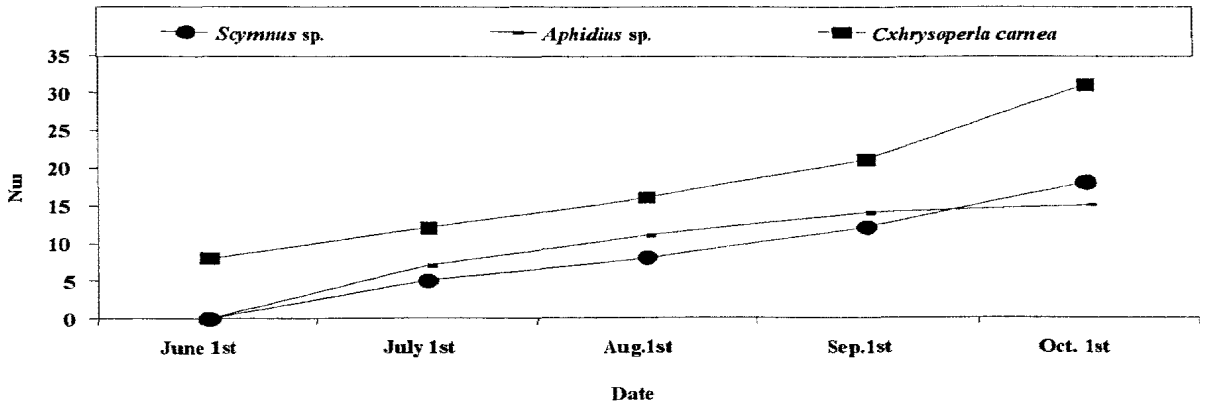

Fig. 11. Populations of natural enemies of *Brevicoryne brassicae* before releasing *Chrysoperla carnea* on cabbage

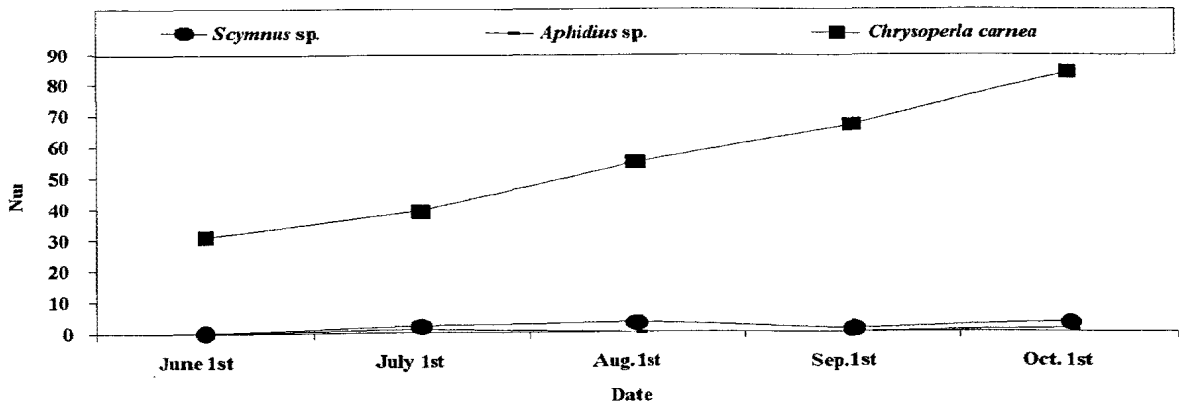

Fig. 12.Populations of natural enemies of *Brevicoryne brassicae* after releasing *Chrysoperla carnea* on cabbage

The present work also observed the population of natural enemies, *Scymnus* sp. and *Aphidius* sp. decreased after releasing *C. carnea* from 18 to 3 and 15 to 1 individuals/ 10 leaves, respectively, during October. The simple correlations between the population of natural enemies (*Scymnus* sp., *C. carnea*) and the mean number of *B. brassicae* were positive (r = 0.51 and 0.77) and non-significant, respectively. It was negative between the population of *Aphidius* sp. and the mean number of *B. brassicae* (r = -0.05) and also non-significant. The simple regression for changing the population of natural enemy (*Scymnus* sp.) on the mean number of *B. brassicae* was positive (b = 0.43) and non-significant, while the simple regressions for changing the population of natural enemies (*Aphidius* sp., *C. carnea*) on the mean number of *B. brassicae* were also positive (b = 0.96 and 0.98) and significant, respectively.

On *Myzus persicae* on apple

The population of *M. persicae* on apple in Giza was 41 individuals/ 10 leaves while the natural enemies were 0, 5 and 210 individuals/ 10 leaves during April (*Aphidius* sp., *C. undecimpunctata* and *C. carnea*, respectively) after releases in comparison to 620 aphids/ 10 leaves and 6 *Aphidius* sp./ 10 leaves in the control. The population of the aphid decreased gradually till it reached 11/ 10 leaves during September, while it was 615/ 10 leaves in the control. In this experiment, the populations of the aphids decreased from 1410 to 11 while the population of *C. carnea* increased from 0 to 311 during May. This chrysopid established on *M. persicae* in this area for the first time (Figs. 13, 14 &15). The population of *Aphidius* sp. decreased after releasing *C. carnea* from 6 to 0 individuals/ 10 leaves during April, while *C. undecimpunctata*, increased from 0 to 9 individuals/ 10 leaves during September. The simple correlation between the population of *C. undecimpunctata* and the mean number of *M. persicae* was positive (r = 0.57) and non-significant, while it was also positive between the population of *C. carnea* and the mean number of *M. persicae* r = 0.93 and highly significant. The simple regression for changing the population of *C. undecimpunctata* on the mean number of *M. persicae* was positive (b = 0.42) and non-significant, while the simple regression for changing the population of *C. carnea* on the mean number of *M. persicae* was also positive (b = 0.86) and significant.

On *Pterochloroides persica* on peach

The population of *P. persica* on peach in North Sinai was 140 individuals/ 10 leaves while the natural enemies were 2, 0, 13 individuals/ 10 leaves during May (*Scymnus* sp., *Aphidius* sp. and *C. carnea*, respectively) after releases in comparison to 910 aphids/ 10 leaves and 2 and 6 individuals of *Scymnus* sp., and *Aphidius* sp / 10 leaves, respectively, in the control. The population of the aphid decreased gradually after releasing *C. carnea* till it reached 15 individuals/ 10 leaves during October, while the natural enemies were 26,0, 74 individuals/ 10 leaves (*Scymnus* sp., *Aphidius* sp. and *C. carnea*, respectively). In the control, the aphids were 830, while *Scymnus* sp. and *Aphidius* sp. were 50 and 8 individuals/ 10 leaves, respectively (Figs. 16, 17 &18). In this experiment, the populations of the aphids decreased from 2210 to 15 while the population of *C. carnea* increased from 0 to 145 during August. This chrysopid established on *P. persica* in this area for the first time. The population of *Scymnus* sp. and *Aphidius* sp. decreased after releasing from 50 to 26 and 21 to 1 individuals/ 10 leaves during October, respectively. The simple correlation between the population of *Scymnus* sp. and the mean number of *P. persica* was negative (r = -0.40) and non-significant. It was positive between the population of natural enemies (*Aphidius* sp., *C. carnea*) and the mean number of *P. persica* (r = 0.73 and 0.46) and non-significant in case of *C. carnea*, while it was highly significant in case of *Aphidius* sp. The simple regression for changing the population of *Scymnus* sp., and *Aphidius* sp. on the mean number of *P. persica* were positive (b = 0.89 and 0.79, respectively,) and significant, while the simple regression for changing the population of *C. carnea* on the mean number of *P. persica* was also positive (b = 0.24) but non-significant.

The results indicated that the population of all these aphid species decreased after releasing *C.*

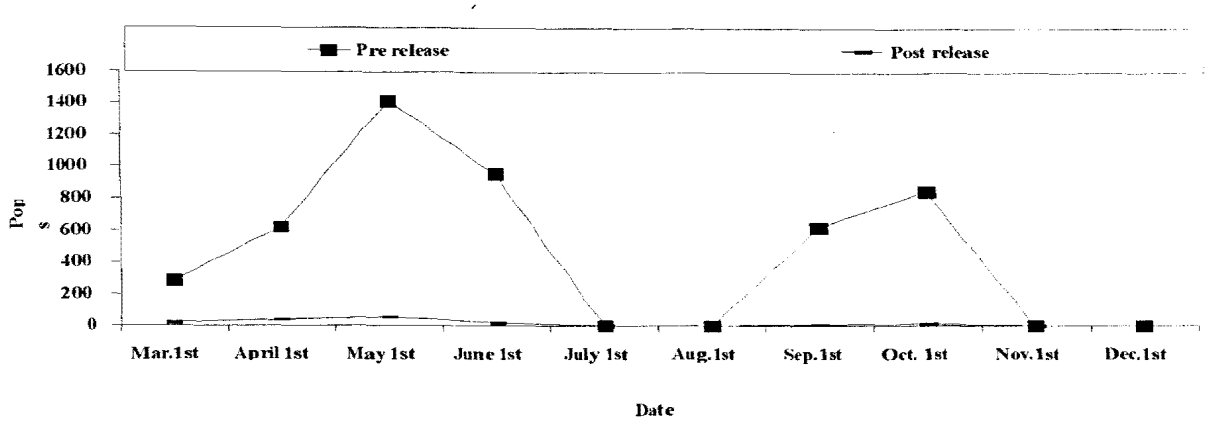

Fig. 13. Populations of *Myzus perslcae* before and after releasing of *Chrysoperla carnea* on apple

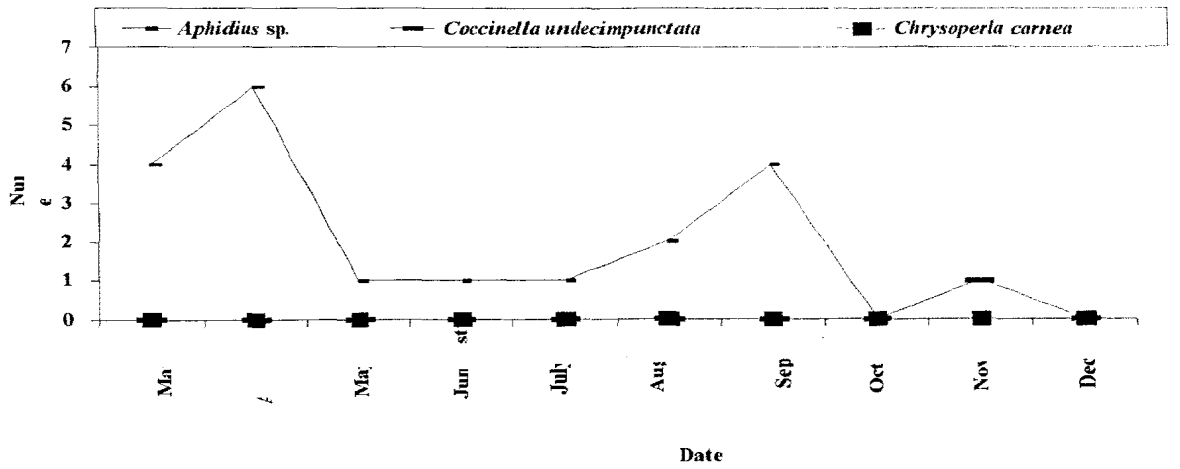

Fig. 14. Populations of natural enemies of *Myzus perslcae* before releasing *Chrysoperla carnea* on apple

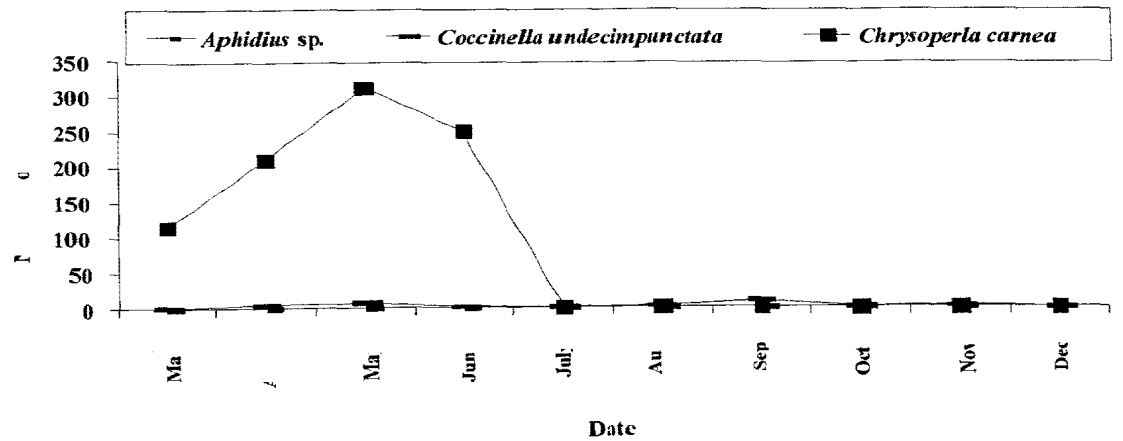

Fig. 15. Populations of natural enemies of *Myzus perslcae* after release of *Chrysoperla carnea* on apple

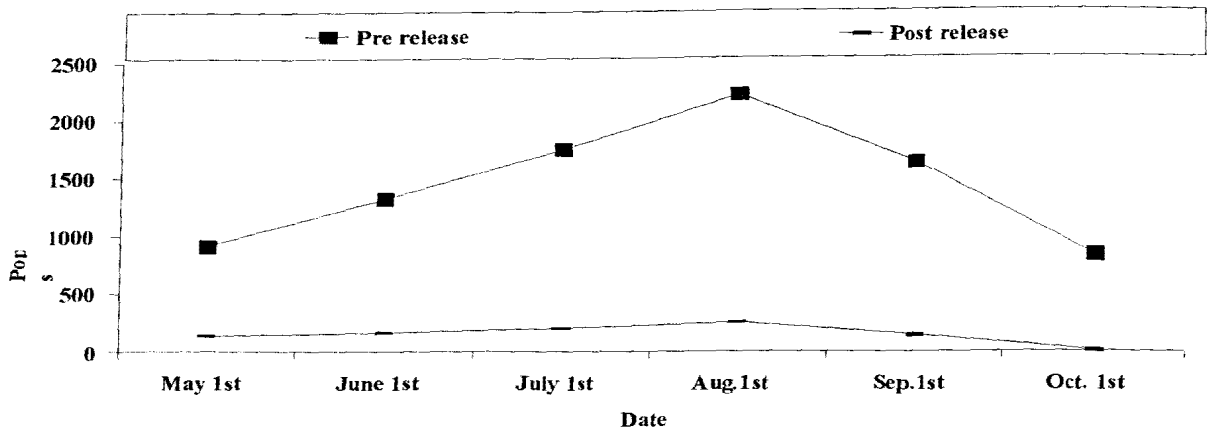

Fig. 16. Populations of *Pterochlorides periscae* before and after release of *Chrysoperla carnea* on peach

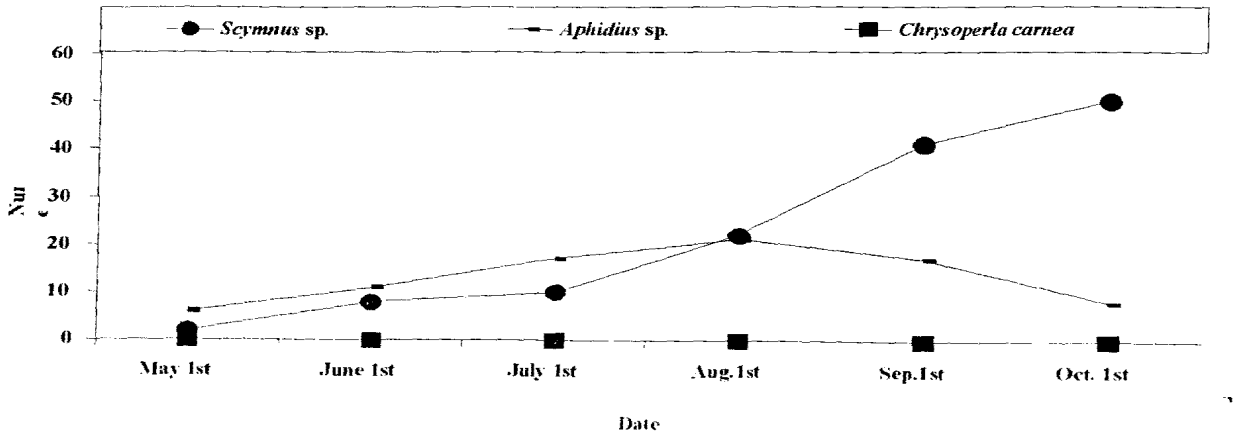

Fig. 17. Populations of natural enemies of *Pterochlorides periscae* before releasing *Chrysoperla carnea* on peach

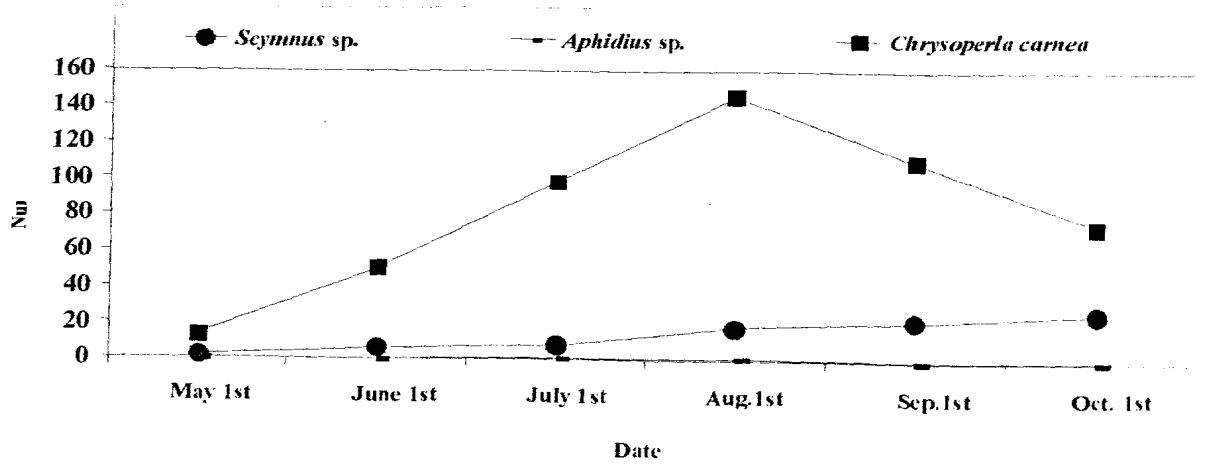

Fig. 18. Populations of natural enemies of *Pterochlorides periscae* after release of *Chrysoperla carnea* on peach

carnea in all locations in Egypt and the population of *C. carnea* increased in all experiments after release. During the present work, *C. carnea* was established in Sinai associated with the population of *P. persicae* on peach for the first time. This vast desert area is characterized by mild temperature and high humidity (7-32°C and 70-82RH%). Evaluations of augmentative releases of chrysopids have focused on immediate reductions of target pest densities. This work indicates that the populations of the natural enemies, *A. abdominalis*, *A. meridionalis*, *Aphidius* sp., *O. albidipennis* and *Scymnus* sp. decreased after releasing *C. carnea*, while the populations of *C. undecimpunctata* increased. These findings agree with those of Rosenheim *et al.* (1994, 1998) who found that *C. carnea* and others feed on more than one prey. Wheeler *et al.* (1968) found that chrysopids and coccinellids feed on parasitized aphid mummies which could reduce aphid parasitoid populations.

Chrysoperla carnea is a very important biological control agent due to its tolerance a wide range of ecological factors. It is found in different agricultural habitats and in high relative frequency of occurrence (Zelany, 1984; Abbas, 1986; Darwish and Ali, 1991; New, 1984). It has broad prey range and effective searching abilities (Ridgway and Murphey, 1984). *C. carnea* was equally effective against two clones of the aphid *M. persicae* that differed in their insecticide resistance profile (Kift *et al.*, 2005).

Rosenheim (2000) stated that aphid prey availability and higher-order predation interacted strongly in their influence on *C. carnea* survival and the larval survival in the presence of higher-order predators was 5.6% when prey availability was intermediate and 40.5% when prey were superabundant. Spatial heterogeneity in aphid prey densities modulates the intensity of higher-order predation and thereby appears to produce source–sink dynamics of *C. carnea* in cotton fields. These results agree with the findings of present work.

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