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Mass production, releasing and evaluation of the lady beetle, *Coccinella undecimpunctata* (Coleoptera: Coccinellidae), for control of aphids in Egypt

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Abstract
Coccinella undecimpunctata L. (Coleoptera: Coccinellidae) is one of the most effective bioagents for control of aphids in Egypt. The present work deals with mass production, releasing and evaluation of this predator on different aphid pests including *Aphis gossypii* Glover on cotton, *Brevicoryne brassicae* (L.) on cabbage, *Aphis craccivora* Koch on potato, *Myzus persicae* (Sulzer) on apple, *Aphis nerri* (Boyer de Fonscolombe) on oleander and *Pterochloroides persica* Chlod. on peach. Experiments were carried out in four different locations of Egypt including Qalubiya, Demmyate, North Sinai and Giza. About 2.22 million eggs were released, biweekly, during 2003–2004. Eggs were assessed monthly during 2004 by counting aphid stages and larva and pupa of *C. undecimpunctata*. The results show that the populations of aphid species decreased from 3115–11, 1062–315, 2110–28, 1945–310, 1152–310 and 4350–76 individuals/10 leaves on cotton, apple, cabbage, peach, potato, oleander, respectively after releasing *C. undecimpunctata*. Significant reductions in some aphid predators and parasitoids also occurred.

Keywords: *Apple, biological control, cabbage, cotton, lady beetle, potato*

Introduction

Worldwide, the management of the aphid species depends heavily on frequent application of synthetic insecticides which often lead to resistance development in the aphid species and the development of natural enemies (Sun et al. 1994). Coccinellids or ladybird beetles are considered the most important enemies of aphids and in different parts of the world have been effectively utilized for integrated control of several aphid pests (Brown 2004). *Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae) is a common coccinellid and recorded as an effective agent for the biological control of different aphids due to its polyaphidophagous feeding habit (Ogenga-Latigo 1994). During the 20th century, eight aphidophagous coccinellid species have established and spread in North America including *C. undecimpunctata* (Gordon & Vandenberg 1991; Day et al. 1994; Hoebeke & Wheeler 1996). *Coccinella undecimpunctata* is one of the most important predators encountered in Egyptian fields. It is being considered as a potential agent for biological control of aphid

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species (Ibrahim 1955; Abbas 1985; Darwish & Ali 1991; Ahmed et al. 1999). Detailed studies of the biology, life history, feeding capacity, prey preference of its larval and adult stages, seasonal abundance, effect insecticides, its enemies and assessment of its role against aphid species have been studied extensively (Ibrahim 1955; El-Heneidy & Attia 1991; El-Ghareeb 1992; Kayapinar & Kornosor 1993; Abdel-Salam 1995). The aim of this work is to conduct mass production, manipulating, releasing and evaluating of *C. undecimpunctata* on different species of aphid in different locations in Egypt.

Materials and methods

Dry beans (Vicia *faba*) were soaked in water for two days and then planted in soil or peat moss and left to grow until they were 2 – 3 cm high. Adults of the aphid, *Aphis craccivora* Koch and infesting beans were obtained from the field and transferred to laboratory-reared bean plants by attaching infested leaves obtained from the field onto the reared plants. *Coccinella undecimpunctata* found in the field were also brought to the laboratory where they were kept in cylindrical boxes covered with muslin cloth and provided with aphids infesting bean plants and left to breed. Eggs deposited inside the box were moved to fresh bean plants, 15 cm high and 10 cm diameter, which were infested with aphids. *Coccinella undecimpunctata* eggs obtained in the laboratory were used experimentally as described below. In 2003 and 2004 about 2.22 million eggs were released 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 barbadence* L. variety Giza 57 (cotton) infested by *Aphis gossypii* Glover, *Pyrus malus* L. variety Silvestris (apple) (15 years old, 3 m high) infested by *Myzus persicae* (Sulzer), *Nerium oleander* L. (oleander) infested by *Aphis nerri* (Boyer de Fonscolombe) and *Pruns persica* Batsch variety sinewy (peach) infested by *Pterochloroides persica* Chlod. Predators were released as eggs by fixing the cards containing these eggs to plants such that newly enclosed beetle larvae could emerge and crawl onto the plants.

During 2003 – 2004, biweekly releases were made of 200 eggs per tree of apple (100 trees and 20 release times), peach (100 trees and 12 release times) and oleander (50 trees and 12 release times), and of 100 eggs per plant for cotton (400 plants and 12 release times), potato (600 plants and eight release times) and cabbage (500 plants and 10 release times), 1.11 million eggs for each year. Releases began from February to May in the case of potato, from June to October in the case of cabbage, from March to December in the case of apple and from May to October in the case of cotton, oleander and peach. The evaluation of releases was assessed monthly during 2004 by counting the stages of aphids present and larvaeand pupa of *C. undecimpunctata* present on a total of 10 leaves from each plant in each site.

Statistical analysis of the obtained data was followed using ANOVA procedures in SAS. Mean separation was conducted using Duncan Multiple range test in SAS.

Results

On Aphis gossypii *on cotton*

The population of *A. gossypii* on cotton in Demmyate was 69 individuals/10 leaves while the natural enemies were 25, 0, 190 individuals/10 leaves during June for *Chyrsoperlla carnea*, *Aphelinus abdominalis*, *C. undecimpunctata*, respectively after releases (Figure 1) while in comparison to 294 individuals/10 leaves and the natural enemies were 67, 4, and 24 individuals/10 leaves in the control experiment (Figure 2).

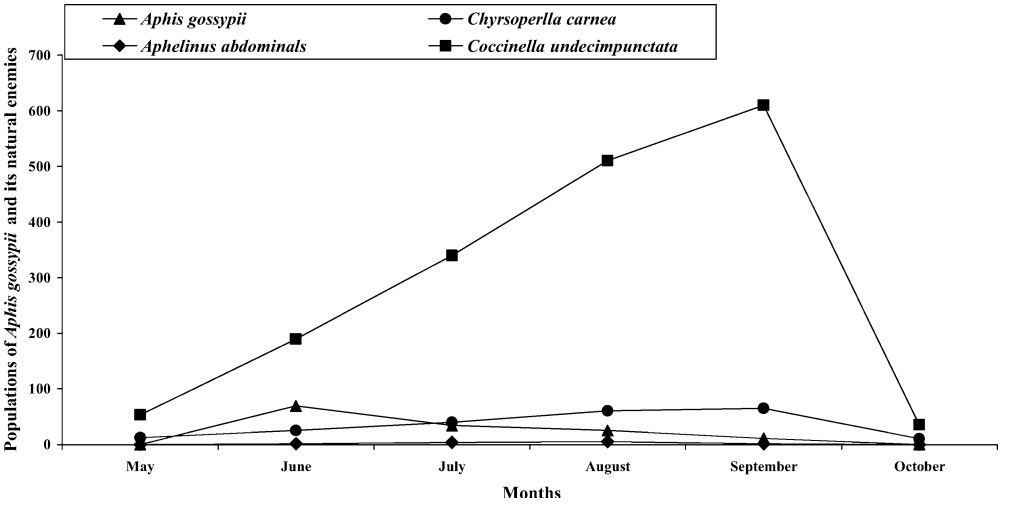

Figure 1. Number of populations of *Aphis gossypii* and natural enemies after releasing of *Coccinella undecimpunctata* on cotton.

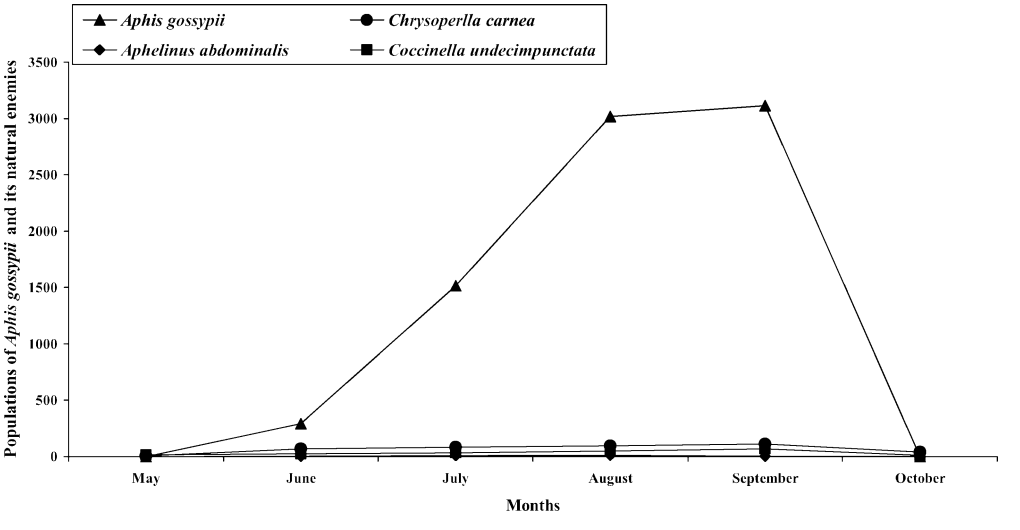

Figure 2. Number of populations of *Aphis gossypii* and natural enemies before releasing of *Coccinella undecimpunctata* on cotton.

The population of aphids decreased gradually after releasing until it reached 11 individuals/10 leaves during September, while the natural enemies were 65, 0, 610 individuals/10 leaves for *C. carnea*, *A. abdominalis*, *C. undecimpunctata*, respectively in comparison to the control experiment the aphids were 3115, while the natural enemies were 112, 2, 11 individuals/10 leaves. In this experiment the results show that the populations of aphid decreased from 3115 to 11 individuals/10 leaves while the population of *C. undecimpunctata* increased from 11 – 610 in the end of the experiment, indicating that the effective role of this coccinellid in controlling *A. gossypii* on cotton. The present work also observed the population of natural enemies decreased after releasing from 98 to 60 and 12 to 1 for *C. carnea*, *A. abdominalis*, respectively during August.

On Myzus persicae *on apple*

The population of *M. persicae* on apple in Giza was 130 individuals/10 leaves while the natural enemies were 3, 0 and 45 individuals/10 leaves during April for *C. carnea*, *Aphidius* sp., *C. undecimpunctata*, respectively after releases (Figure 3) while in comparison to 480 individuals/10 leaves and the natural enemies were 18 and 4 for *C. carnea*, *Aphidius* sp., individuals/10 leaves in the control experiment (Figure 4). The population of aphid decreased

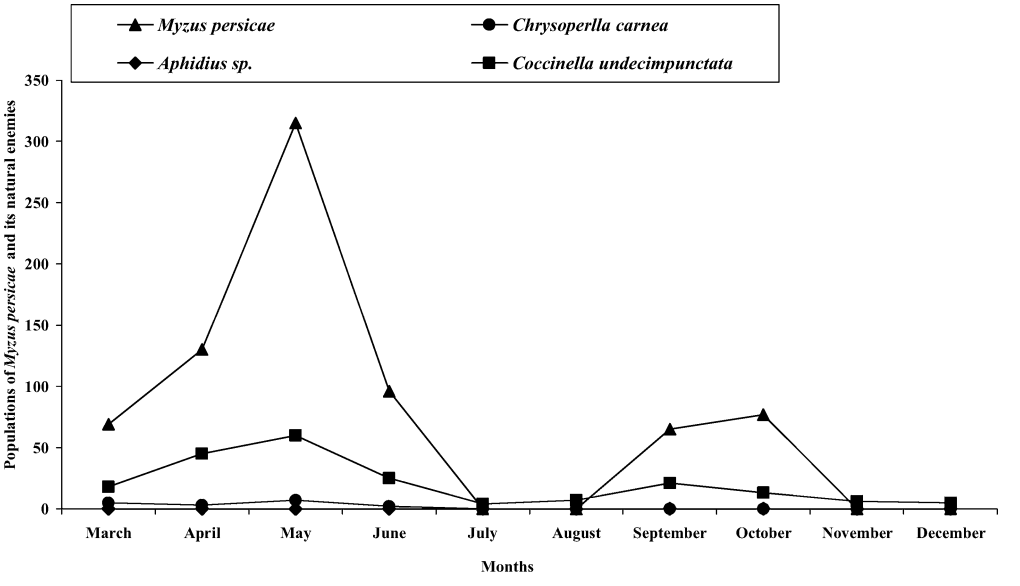

Figure 3. Number of populations of *Myzus persicae* and natural enemies after releasing of *Coccinella undecimpunctata* on apple.

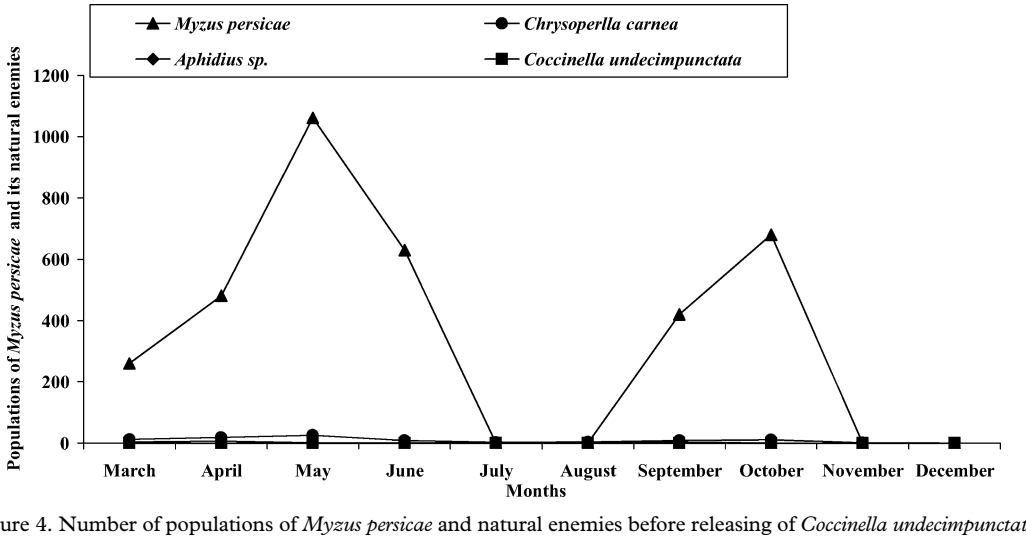

Figure 4. Number of populations of *Myzus persicae* and natural enemies before releasing of *Coccinella undecimpunctata* on apple.

gradually until it reached 630 individuals/10 leaves during June, while *C. carnea*, *Aphidius* sp. were 9 and 1 individuals/10 leaves in the control experiment. Also, during this month the numbers attained in an amount of 90 individuals/10 leaves while *C. carnea*, *Aphidius* sp., *C. undecimpunctata* were 2, 0, 25 individuals/10 leaves in treatment. From July until August, no aphids were recorded at the control experiment, this result, of course, was due to the absence of aphids at that time in the treatment experiment while *C. undecimpunctata*, the only natural enemy, was recorded in the aforementioned months with 4 and 7 individuals/10 leaves; from September to October the population of aphids began to rise again, the numbers were 77 individuals/10 leaves while *C. carnea*, *Aphidius* sp., *C. undecimpunctata* attained 0, 0, 13 individuals/10 leaves. During November and December, no population of either aphids or natural enemies occurred in the control experiment while the population of *C. undecimpunctata* was 5 individuals/10 leaves and no aphids were found at all. In this experiment the results show that the populations of aphids decreased from 1062 to 315 while the population of *C. undecimpunctata* increased from 0–60 during May. This coccinellid established on *M. persicae* in this area for the first time. The present work also observed the population of natural enemies decreased after releasing from 25, 6 to 7, 0 for C. *carnea*, *Aphidius* sp., respectively during May.

On Brevicoryne brassicae *on cabbage*

The population of *B. brassicae* on cabbage in Qalubiya was 510 individuals/10 leaves while the natural enemies were 3, 1, 24 individuals/10 leaves during July for *Scymnus* sp., *Aphidius* sp., *C. undecimpunctata*, respectively after releases (Figure 5) while in comparison to 1380 individuals/10 leaves and the natural enemies were 11, 5, 4 individuals/10 leaves for *Scymnus* sp., *Aphidius* sp., *C. undecimpunctata* respectively, in the control experiment (Figure 6). The population of aphid decreased gradually after releasing until it reached 28 individuals/10

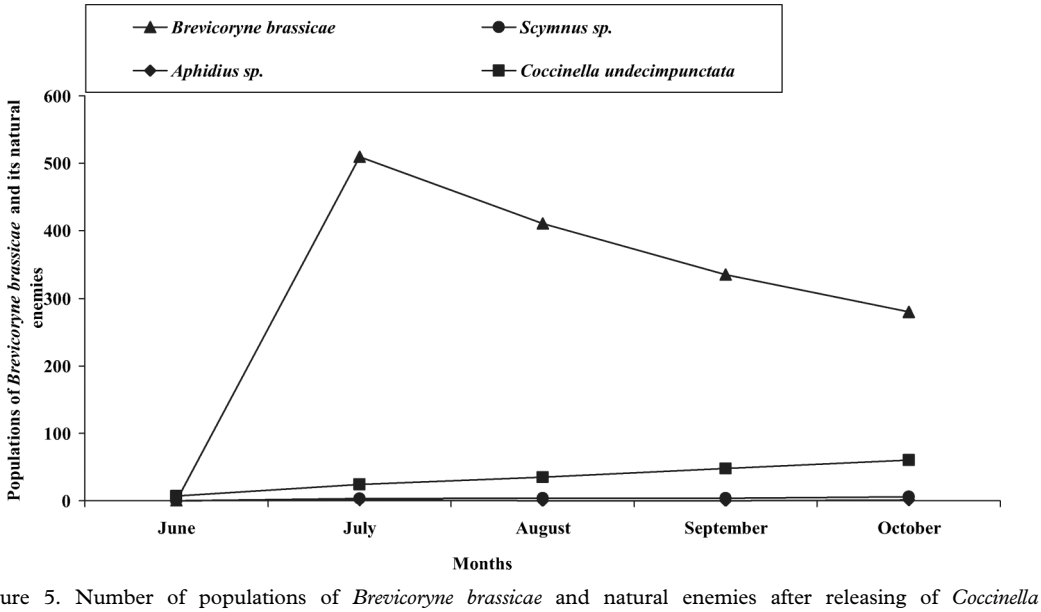

Figure 5. Number of populations of *Brevicoryne brassicae* and natural enemies after releasing of *Coccinella undecimpunctata* on cabbage.

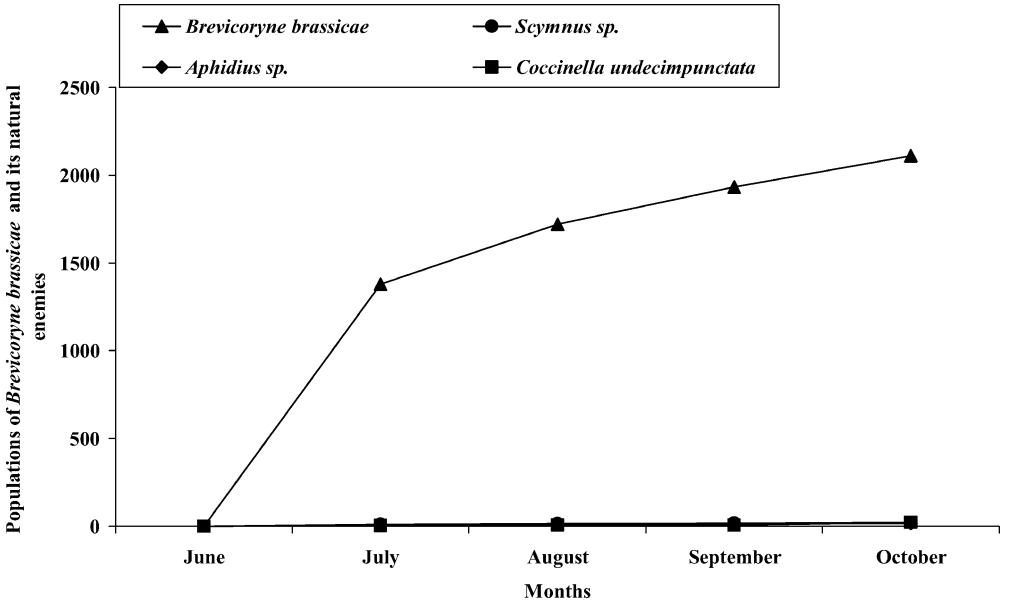

Figure 6. Number of populations of *Brevicoryne brassicae* and natural enemies before releasing of *Coccinella undecimpunctata* on cabbage.

leaves during October, while the natural enemies were 6, 1, 80 individuals/10 leaves for *Scymnus* sp., *Aphidius* sp., *C. undecimpunctata*, respectively. In comparison to the control experiment, the aphids were 2110 while the natural enemies were 22, 12, 11 individuals/10 leaves *Scymnus* sp., *Aphidius* sp., *C. undecimpunctata*, respectively. In this experiment the results show that the population of aphids decreased from 2110 to 28 individuals/10 leaves while the population of *C. undecimpunctata* increased from 11 – 80 by the end of the experiment, indicating the role of this coccinellid in controlling *B. brassicae* on cabbage. The present work also observed the population of natural enemies decreased after releasing from 22, 12 to 6, and 1 for *Scymnus* sp., *Aphidius* sp., respectively during October.

On Pterochloroides persica *on peach*

The population of *P. persica* on peach in North Sinai was 540 individuals/10 leaves while the natural enemies were 0, 43 individuals/10 leaves during May for *Aphidius* sp., *C. undecimpunctata*, respectively after releases (Figure 7) while in comparison to 850 individuals/10 leaves and the parasitoid, *Aphidius* sp.was 5 individuals/10 leaves in the control experiment (Figure 8). The population of aphid decreased gradually after releasing until it reached 310 individuals/10 leaves during August, while the natural enemies were 0, 132 individuals/10 leaves for *Aphidius* sp., *C. undecimpunctata*, respectively in comparison to the control experiment the aphids were 1945, while the parasitoid, *Aphidius* sp. was 24 individuals/10 leaves. In this experiment, the results show that the populations of aphids decreased from 1945 – 310 while the population of C. *undecimpunctata* increased from 0 – 132 during August. This coccinellid established on *P. persica* in this area for the first time. The present work also observed the population of natural enemies decreased after releasing from 24 – 0 for *Aphidius* sp. during August.

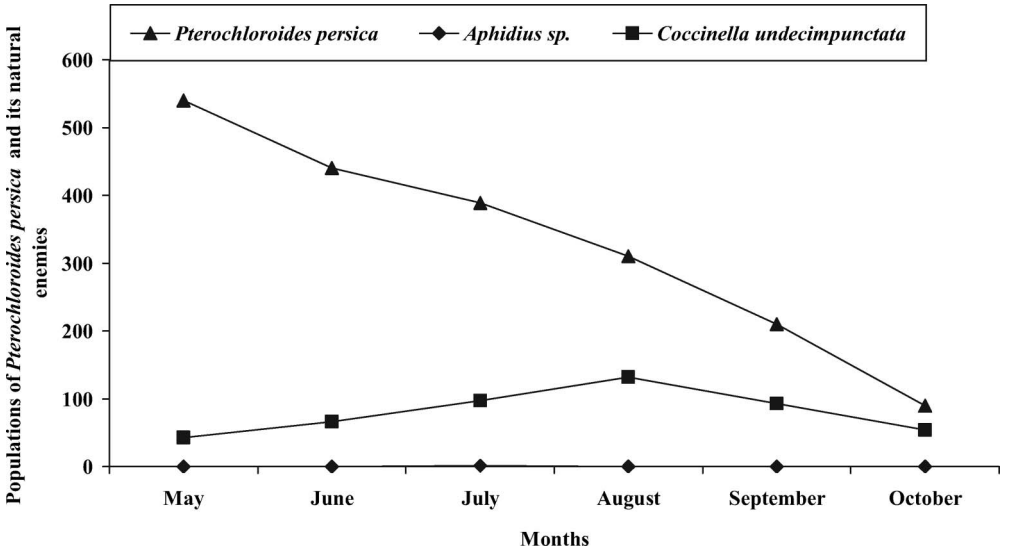

Figure 7. Number of populations of *Pterochloroides persica* and natural enemies after releasing of *Coccinella undecimpunctata* on peach.

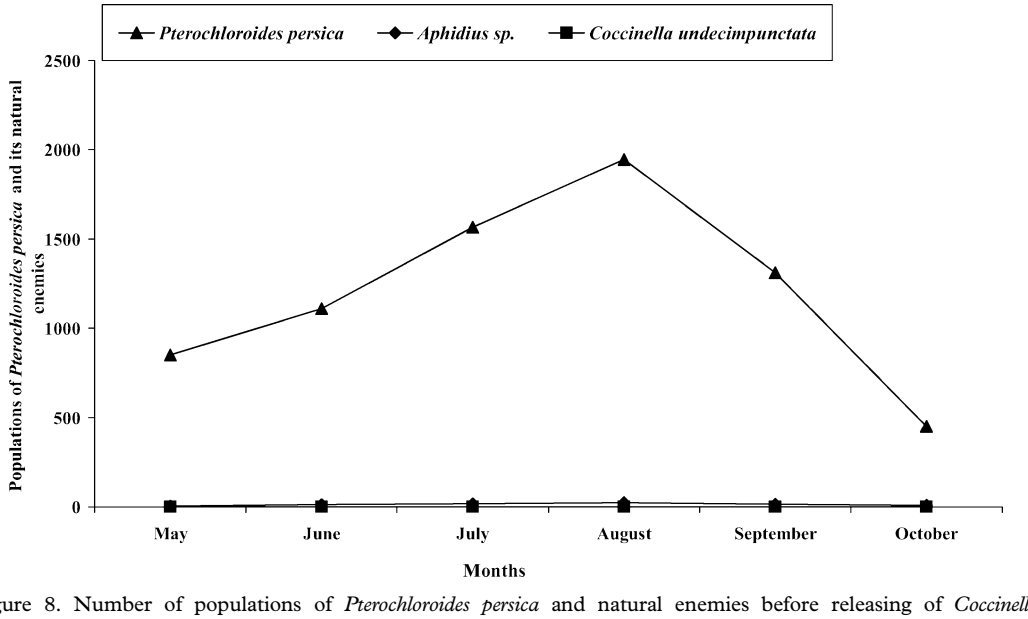

Figure 8. Number of populations of *Pterochloroides persica* and natural enemies before releasing of *Coccinella undecimpunctata* on peach.

On Aphis craccivora *on potato*

The population of *A. craccivora* on potato in Giza was 521 individuals/10 leaves while the natural enemies were 1, 0, 65 individuals/10 leaves during Feburary for *C.carnea*, *Orius albidipenis* Reuter, *C. undecimpunctata*, respectively after releases (Figure 9) while in comparison to 1692 individuals/10 leaves and the natural enemies were 11, 2, 14 individuals/10

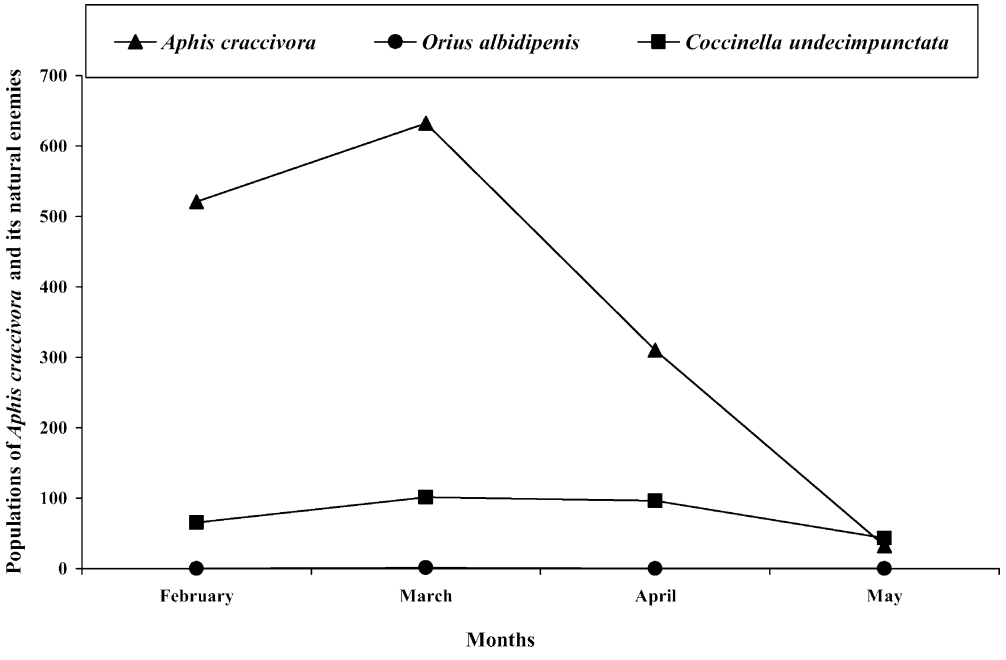

Figure 9. Number of populations of *Aphis craccivora* and natural enemies after releasing of *Coccinella undecimpunctata* on peach.

leaves in the control experiment (Figure 10). The population of aphid decreased gradually after releasing until it reached 310 individuals/10 leaves during April, while the natural enemies were 1, 0, 96 individuals/10 leaves for *C. carnea*, *O. albidipenis*, *C. undecimpunctata*, respectively in comparison to the control experiment where the aphids were 1152, while the natural enemies were 12, 1, 20 individuals/10 leaves (Figure 5). In this experiment the results show that the population of aphid decreased from 1152 – 310 individuals/10 leaves while the population of C. *undecimpunctata* increased from 20 – 96 by the end of the experiment, indicating the role of this coccinellid in controlling *A. craccivora* on potato. The present work also observed the population of natural enemies decreasing after release from 19, 5 to 3, 1 for *C. carnea*, *O. albidipenis*, respectively, during March.

On Aphis nerii *on oleander*

The population of *A. nerii* on oleander in Giza was 262 individuals/10 leaves while the natural enemies were 1, 0, 32 individuals/10 leaves during June for *Aphidoletes meridionalis* Felt, *Aphelinus mali*, *C. undecimpunctata*, respectively after releases (Figure 11) while in comparison to 465 individuals/10 leaves and the natural enemies were 23, 3 individuals/10 leaves for *A. meridionalis* Felt, *A. mali* in the control experiment (Figure 12). The population of aphid decreased gradually after releasing until it reached 40 individuals/10 leaves during September, while the natural enemies were 0, 0, 65 individuals/10 leaves for *A. meridionalis* Felt, *A. mali*, *C. undecimpunctata*, respectively. In comparison to the control experiment the aphids were 3265, while the natural enemies were 32, 3 individuals/10 leaves for *A. meridionalis* Felt, *A. mali* (Figure 6). In this experiment, the results show that the population of aphids decreased from 4350 – 76 individuals/10 leaves while the population of C. *undecimpunctata* increased from 0 – 70 during August. This coccinellid established on *A. nerii* on oleander in

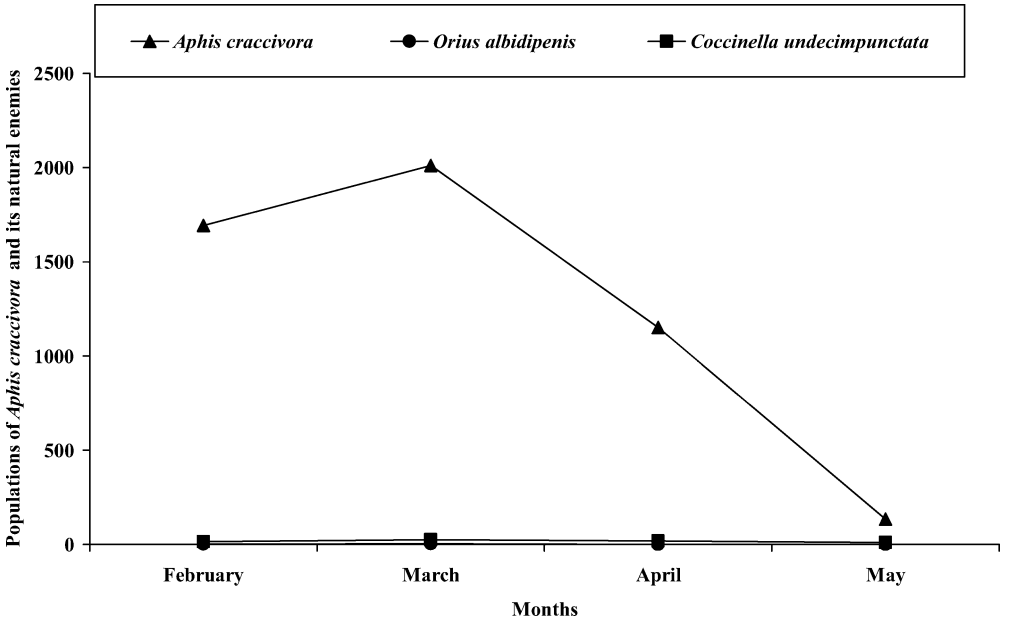

Figure 10. Number of populations of *Aphis craccivora* and natural enemies before releasing of *Coccinella undecimpunctata* on peach.

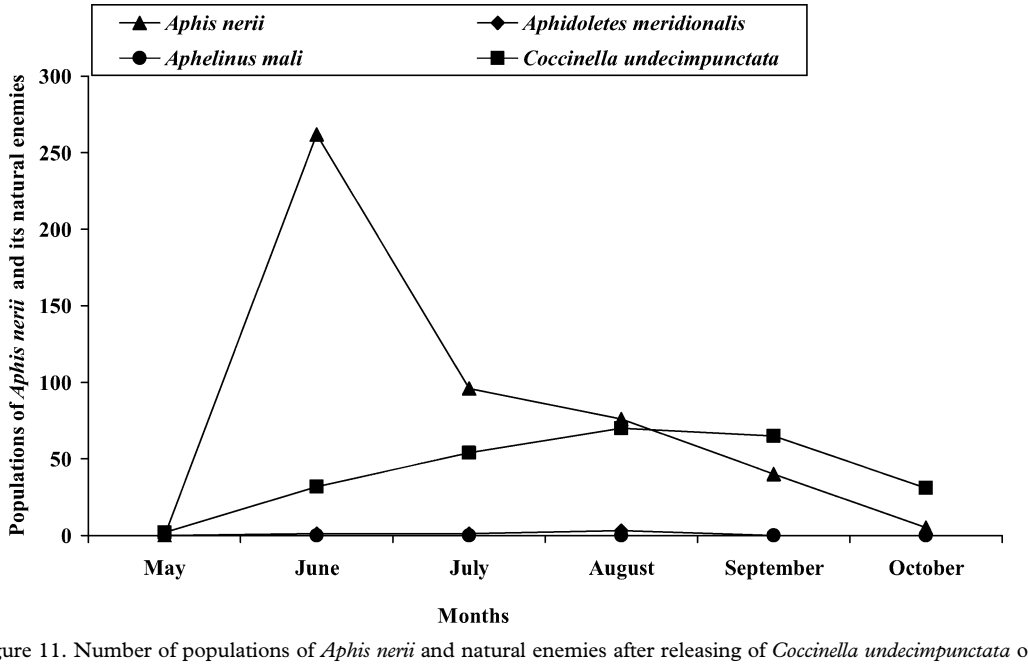

Figure 11. Number of populations of *Aphis nerii* and natural enemies after releasing of *Coccinella undecimpunctata* on oleander.

this area for the first time. The present work also observed the population of natural enemies decreasing after release from 36, 11 to 3, 0 for *A. meridionalis* Felt, *A. mali*, respectively during March.

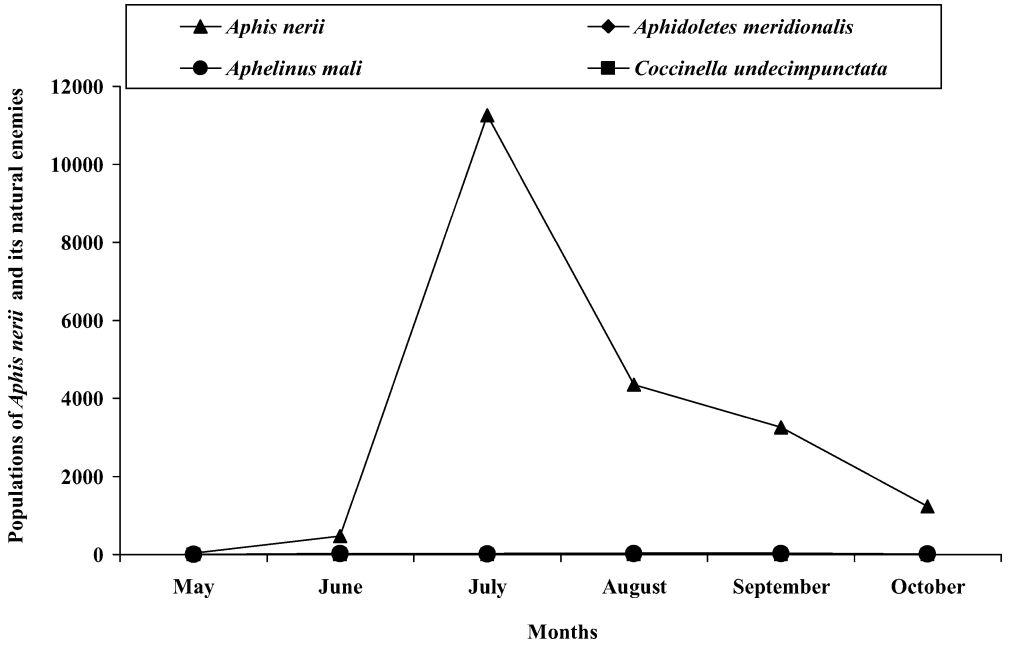

Figure 12. Number of populations of *Aphis nerii* and natural enemies before releasing of *Coccinella undecimpunctata* on oleander.

This result indicated that the population of aphid species on different host plants in different locations in Egypt decreased significantly in all experiments after the release of *C. undecimpunctata* ($p < 0.01$) and ($p < 0.05$). The effects of *C. undecimpunctata* on the numbers of some aphid predators were also seen. *Coccinella carnea* decreased significantly after releasing *C. undecimpunctata* in all experiments ($p < 0.05$). Two other predators, *Scymnus* sp. and *A. meridionalis* decreased significantly ($p < 0.05$), while *O. albidipenis* was not significantly affected. The parasitoids *A. abdominalis* that parasitized *A. gossypii, A. mali* that parasitized *A. nerii* and *Aphidius* sp. that parasitized *M. persicae* and *P. persicae* were decreased significantly in all experiments after the release of *C. undecimpunctata* ($p < 0.01$ and $p < 0.05$). The population of *C. undecimpunctata* on different host plants in different locations increased significantly during all experiments ($p < 0.01$ and $p < 0.05$).

Discussion

The results indicated that the population of aphid species was decreased after the release of *C. undecimpunctata* in all locations in Egypt. Also, the population of *C. undecimpunctata* was increased in all experiments after releasing while the populations associated with natural enemies was decreased. During the present work *C. undecimpunctata* was established in Sinai associated with the population of *P. persica* on peach for the first time, an area that was characterized by vast desert area, mild temperature and high humidity. Evaluations of augmentative releases of coccinellids have focused on immediate reductions of target pest densities (Hagen & Van den Bosch 1968; Abd-Rabou 2000). During the 20th century, eight aphidophagous coccinellid species have established and spread in North America including *C. undecimpunctata* (Gordon 1985; Gordon & Vandenberg 1991).

Hagen (1974) stated that coccinellids played an important role in the control of aphids and Obrycki and Kring (1998) observed the fast spread of Coccinella on aphid populations in different parts of the world and detected excellent results in the control of aphids by this coccinellid species. The present work agrees with the findings of the aforementioned authors and confirms the effective role of C. *undecimpunctata* after rearing and releasing in different locations in Egypt. This work indicates that the populations of some natural enemies also decreased after the releasing of *C. undecimpunctata*. These findings agree with Rosenheim et al. (1994), who found that most species of coccinellids, including *C. undecimpunctata*, feed on more than one prey. Wheeler et al. (1968) found that coccinellids also feed on parasitized mummified aphids which could reduce aphid parasitoid populations.

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