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Studies on the Predator *Chrysoperla carnea* (Stephens) in Egypt

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ABSTRACT

Chrysoperla carnea is a major predator of some white fly, aphid and thrips. Effects of *Sitotroga cerealella, Ephestia kuehniella* and *Aphis gossypii* (Glover) on biology of *C. carnea* were carried out under laboratory conditions at 23 ± 1°C and 65 ± 5% RH. Incubation period of eggs of *C. carnea* on different preys was significantly different from each other. The total developmental time form egg hatching to adult eclosion were 21.2 ± 1.67, 20.6 ± 1.28 and 23.8 ± 1.36 days for *C. carnea* when fed on *S. cerelella, E. kuehniella* and *A. gossypii*. The total consumption rate per *C. carnea* larva were 632.93 ± 50.26, 444.08 ± 34.40 and 367.31 ± 50.28 on the preys, respectively. The average number of deposited eggs per *C. carnea* female was 184.5 ± 23.36, 237.9 ± 25.61 and 316 ± 21.88 eggs when fed on the three preys, respectively. The mean reduction in aphid numbers in the three treatment at 1 : 100, 1 : 150, 1 : 200 (larva : aphid) averaged 78.9, 73.6 and 67.97% in cages at 1 : 100, 1 : 150, 1 : 200 (larvae : aphid), respectively. Finally, the highest reduction in aphid numbers was noticed at the treatment (1 : 100).

Key words: *Sitotroga cerealella, Ephestia kuehniella*, *Aphis gossypii, Chrysoperla carnea,* Preys, Biological control, Release.

Introduction

Insect predators are of the major groups of biological control agents used for aphid control. These belong to family *Coccinellidae* and *Chrysopidae*, these feed during the larval and adult stages on different sap-sucking pests including aphids, white flies, jassids and mites as well as other small insects (Shalaby *et al.,* 2008). Several studies have been carried out in different parts of the world concerning the predation activity of many predator species such as *Chrysoperla undecimpunctata* and *Chrysoperla carnea*. Among those who contributed much to these studies are Eraky and Nasser (1993) and El-Hag and Zaitoon (1996). The neuropteran predators *C. carnea* and *C. septempunctata* (Wesm). have attracted considerable attention as a biological agent to control important agricultural pests (Abou-Bakr, 1989).

Many attempts have been made by releasing some bio-control agents, particularly common *Coccinellid* and *Chrysopidae* species for controlling aphid species (Williamson and Smith 1994). The green lacewings, *Chrysoperla carnea* (Stephens) is a polyphagous predator, commonly found in agricultural systems. It has been recorded as an effective generalist predator of aphids, mites, white flies and mealy bugs etc. (Yuksel and Goemen, 1992).

Therefore, the current work was undertaken to survey of certain piercing - sucking pest and their natural enemies infesting cucumber plants during consecutive seasons of 2014 to 2016; study the biology *Chrysoperla carnea* on three preys *Sitotroga cerealella, Ephestia kuehniella* and *Aphis gossypii* and release the Chrysopid, *chrysoperla carnea* (larvae) for controlling melon-cotton aphid, *Aphid gossypii* (Glover) on cucumber plants.

Materials and Methods

Population density of piercing sucking insects and their predators on cucumber plants

Surveying major piercing sucking pests and their beneficial insects in the vegetable crop cucumber at Diarb Negim district, El-Sharkia Governorate, Egypt during the successive growing

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seasons of 2014 and 2015 on cucumber plants during summer and autumn plantation. Also, the cultivated area was half feeding in both seasons of 2014 and 2015. The seeds of cucumber were sown on the first week of October in the first season, while in the second season seeds were sown in the second week of October. Cucumber leaves samples were started after four weeks from planting and continued until the harvesting time. The size of sample was 30 cucumber leaves. Leaves were randomly chosen from ten cucumber plants. Then the count of adults injurious insects and predators on cucumber leaves was carried out directly.

Biology

Rearing of Chrysoperla carnea Steph. (Neuroptera : Chrysopidae)

Adults of *C. carnea* were collected form cucumber fields, they were placed in glass chimney cages. The adults were provided by food consists of 1 g honey + 1 ml distilled water + 1 g pollen on a food card, 2 × 3 cm. The laid eggs were counted daily and the newly hatched larvae were reared on *Sitotroga cerealella* eggs until they reached to the beginning of the second instar.

a) Laboratory experiments

The experiments were carried out under laboratory conditions 23 ± 1°C and 65 ± 5% RH to study some biological aspects of predator.

b) Feeding capacity of Chrysoperla carnea larva on eggs of different prey species

Eggs of *C. carnea* were obtained from the laboratory reared colony and placed separately in 7 x 2 cm glass vials, covered with cotton. After hatching of predator eggs, the larvae were allowed to be feed on eggs of two preys (*Sitotroga cerealella* and *Ephestia kuehniella).* Twenty replicates form *C. carnea* were reared on the two preys. The daily numbers of prey individuals that were offered for *C. carnea* larval feeding were, usually, more than the feeding capacity of the predator. The numbers of consumed prey eggs were daily recorded.

c) Feeding capacity of Chrysoperla carnea larva on melon-cotton aphid A. gosspyii

Newly hatched predators larvae *C. carnea* were put individually in a Petri dish (9 cm diameter) with a filter paper on its bottom. Twenty replicates form *C. carnea* were reared on *A.gossypii*. Knowing surplus numbers of prey species were offered and the devoured individuals were replaced daily. Attacked prey individuals were counted and recorded daily throughout the periods of the larval instars.

Adult experiments

Adults (females and males) were placed in glass chimney cage (17 cm height with 7 cm top and 8.5 cm bottom diameter). Each chimney cage was placed on 9 cm diameter Petri dish. A piece of filter paper was placed at the bottom of the Petri dishes, and the upper open end of glass chimney was covered with black muslin cloth and was tightened with rubber band. The adult diets were provided inside the glass chimney with the help of small paper strips. Each strip being drilled at three points from water + honey bee + dry yeast (6 + 3 + 1), was offered as adults food to make pits for holding drops of diet. The diets were provided with the interval of 24 hours. Each chimney was provided with a piece of cotton soaked in distilled water placed at the top of glass chimney, over muslin cloth, to maintain moisture. Laid eggs on the walls of chimney and muslin cloth were harvested daily.

Release of Chrysoperla carnea Steph. (Neuroptera : Chrysopidae)

In this experiment the second larval instar of C. *carnea* was released in caged cucumber plant with previously artificially infested with *Aphis gossypii.* The experiment was carried at Diarb Negim district, El-Sharkia Governorate, Egypt during seasons of 2014 and 2015.

Experimental technique

Fifteen cucumber plants, one plant per pot, were caged with wooden cage of 50 × 50 × 100 cm covered with muslin cloth. These plants were artificially infested with *A. gossypii* which collected from the field. The infested plants were followed until the population of the *A. gossypii* increased. Each plant was infested with 20 aphid adults. The second larval instar of *C. carnea* were released in all treatments. The releasing ratios 1 : 100, 1 : 150 and 1 : 200 predator : prey. Each treatment was represented by 5 plants per replicate. The corresponding control for each treatment (3 replicates), were kept free from releasing and the number of aphid was exacted after removing the exceeding ones.

Statistical analysis

The reduction percentage in aphids mean numbers were calculated according to the following formula reported by Abbott (1925).

$$\%R = \frac{Control - Treatment}{Control} \times 100$$

All data obtained were subjected to statistical analysis using the analysis of variance with CoStat statistics software (2005). Mean of the treatments were separated using least significant differences (LSD) test at (P≤0.05) level of significance.

Results and Discussion

Population density of insect pests infesting cucumber plant cultivated in Diarb Negim district

Results given in Table (1) showed clearly that the infestation of whitefly (*Bemisia tabaci* Genn.) was the highest followed discerningly by aphids, where the thrips infestation was very low during the autumn season of 2014and 2015.

Table 1. Mean numbers of different insect pests and the associated insect predators associated with cucumber cultivated in Diarb Negim district in autumn and summer plantation during consecutive seasons of 2014, 2015 and 2016.

Insect Pests & Predators	Autumn season 2014		Summer season 2015		Autumn season 2015		Summer season 2016	
	No.	%	No.	%	No.	%	No.	%
Insect pests								
Aphis gossypii	152.54	22.22	66.37	15.51	502.76	62.25	9.18	17.45
Thrips tabaci	2.52	0.37	131.52	30.72	1.03	0.13	28.93	51.47
Bemisia tabaci	531.54	77.42	230.2	53.77	303.85	37.62	17.47	31.07
Total	686.6	100	428.09	100	807.64	100	56.21	100
Insect predators								
Orius spp	228	50.67	437	69.25	80	18.18	166	52.87
Chrysoperla carnea	190	42.22	50	7.92	151	34.31	28	8.92
Metasyrphas corolla	15	3.33	90	14.22	87.05	19.78	22	7.016
Coccinella undecimpunctat	17	3.78	54	8.54	122	27.72	98	31.21
Total	450	100	631	100	440.05	100	314	100

In addition the obtained data indicated that the whitefly was most dangerous insect pests which represented 73.7 and 64.66% of the total number of insect pests followed by aphids 22.45 and 35.26% and thrips 3.77 and 0.07% during autumn season of 2014 and 2015, respectively. However during the summer season of 2015, the infestation with the aforementioned insect pests differed where whitefly recorded 53.77% followed by thrips 30.72% and 9.12% for aphid. Meanwhile, in 2016 the infestations were 50.12, 27.4 and 22.44% for aphid, thrips and whitefly, respectively. As shown in Table (1), the number of *Orius* spp**.** was the highest (50.84%) followed by *C. carnea* (35.69%) from total number of insect predators during autumn season of 2014. In autumn season of 2015, *C. undecimpuncta* was presented with 36.46% followed by *C. carnea* 22.09%, where *Metasyrphas corollae* was 19.88% from the total number of insect predators. While in the summer seasons of 2015 and 2016, the numbers of *Orius* spp. were presented with 74.39 and 76.59% followed by *Coccinella* sp and *C. carnea* with 7.96, 12.46% and 6.92, 10.03%, respectively, from the total number of insect predators. Three predators; namely *C.undecimpunctata, Scymnus interruptus* and *Orius albidipennis* were recorded associating with aphids on cucumber. They caused a reduction in *A.gossypii* population by 73.62% on cucumber, this indicate that *Orius albidipennis* had an effective role in decreasing *A. gossypii* on cucumber, the results also indicated that the most active period for the three predators on cucumber was during the second half of May until the end of the first week of June (Abdel-Salam, 1995).

Biology

Effect of different prey on some biological aspects of *Chrysoperla carnea*

The experiment was carried out under laboratory conditions of 23 ± 1ºC and 65 ± 5% RH to study the effect of different kind of preys (eggs of *S. cerealella, E. kuehniella* and nymph of *A. gossypii*) on the biology of the predator (*C. carnea*).

Durations of immature stages

Incubation period

The incubation period of eggs of *C. carnea* feeding on different preys were 2.31, 2.37 and 3.17 days on *S. cerealella, E. kuehniella* and *A. gossypii*, respectively.

Larval stage

By feeding the larvae of *C. carnea* on *S. cerealella and E. kuehniella* eggs, the duration of first, second and third instars lasted 2.74 ± 0.43 (23), 2.44 ± 0.50 (23), 3.67 ± 0.48 (34) and 2.64 ± 0.9 (23), 2.24 ± 0.44 (23), 3.61 ± 0.50 (3-4), respectively. While, when *C. carnea* larvae were fed on *A. gossypii*, these periods were 3.17 ± 0.38 (3-4), 3.13 ± 0.34 (3-4), 4.4 ± 0.51 (4-5) days, respectively (Table 2). Variations in the total larval periods, estimated when *C. carnea* larvae were fed on eggs of three pests, were more obvious. Feeding on eggs of *S. cerealella* and *E.kuehniella* led significantly to shorter total larval period (8.87 ± 0.78 and 8.71 ± 0.94 days, respectively) than those recorded by feeding the larvae on *Aphis gossypii* (10.69 ± 0.64 days) as shown in Table 2.

Pupal period

The shortest pupal period of *C. carnea* (8.3 ± 0.84; 7 - 9 days) was obtained when larvae of *C. carnea* were fed on *E. kuehniella* eggs. This period was found to be significant, shorter than those recorded by rearing on *A. gossypii* (9.4 ± 0.7; 8 - 10 days) and with insignificant difference than that recorded when the predators larvae were fed on eggs of *S. cerealella* (Table 2).

Total developmental period

The total developmental period (from egg deposition until adult emergence elapsed 23.5 ± 1.67 (18 - 24), 22.95 ± 1.28 (19 - 25) and 26.81 ± 1.36 (23 - 28) days when *C. carnea* larvae were fed on *S. cerealella*, *E. kuehniella* eggs and *A. gossypii*, respectively, (Table 2). From these data, it is clear that the shortest total developmental period of *C. carnea* (22.95 ± 1.28 days) was obtained by feeding the larvae on *E. kuehniella* eggs, followed, insignificantly by feeding on *S. cerealella* and then significantly by feeding on *A. gossypii* as shown in Table 2. This is in consistent with the study done by Balasubramani and Swamiappan (1994), they studied the development of *C. carnea* on different hosts in laboratory and found that larval development was rapid on egg of *C. cephalonica* (8.20 days) and longest on neonates of *H. armigera* (11.10 days). Moreover, Meannan *et al*. (1997) studied biology of *C. carnea* on *A. gossypii* and *M. persicae* and observed that larval duration was long when fed on *M. persicae*. While, it was 26.16 ± 0.56 and 24.42 ± 0.29 days when fed on *A. gossypii* and *H. pruni*, respectively (Saleh and Ali 2012).

Table 2: Mean ± S.E. of durations of *C. carnea* immature stages when fed on eggs of two *lepidopterous* insects and nymph of *A. gossypii* under laboratory conditions.

Stage	*S. cerealella*	*E. kuehniella*	*A. gossypii*	L.S.D
Incubation period	2.31 ± 0.12 ᵃ	2.35 ± 0.14 ᵃ	3.01 ± 0.09 ᵇ	0.41
1st instar	2.74 ± 0.43 ᵃ (2-3)	2.64 ± 0.9 ᵃ (2-3)	3.17 ± 0.38 ᵇ (3-4)	0.28
2nd instar	2.44 ± 0.50 ᵃ (2-3)	2.24 ± 0.44 ᵃ (2-3)	3.13 ± 0.34 ᵇ (3-4)	0.26
3rd instar	3.67 ± 0.48 ᶜ (3-4)	3.61 ± 0.50 ᶜ (3-4)	4.4 ± 0.51ᵃ (4-5)	0.31
Total larval period	8.87 ± 0.78 ᵇ (8-10)	8.71 ± 0.94 ᵇ (7-10)	10.69 ± 0.64 ᵃ (10-12)	0.52
Pupal period	8.67 ± 0.67 ᵇ (7-9)	8.3 ± 0.84 ᵇ (7-9)	9.4 ± 0.7 ᵃ (8-10)	0.68
Total developmental period	23.51 ± 1.67 ᵇ (18-24)	22.95 ± 1.28 ᵇ (19-25)	26.81 ± 1.36 ᵃ (23-28)	1.34

Feeding capacity of *C. carnea* larvae on three pests species

Data in Table (3) showed the consumption period rate of *C. carnea* larval instars when reared on three prey species *S. cerealella*, *E. kuehniella* and *A. gossypii*. The average number consumed during the larval stage were 632.93 ± 50.26, 444.08 ± 34.40 and 367.31 ± 50.28 of *S.cerealella*, *E. kuehniella* and *A. gossypii*, respectively, consumed a high percentage 70.57% of *S. cerelella* , 68.62% of *E. kuehniella* and 69.16% of *A. gossypii* then the first instar larvae 4.68, 5.21 and 5.67% of *S. cerealella*, *E. kuehniella* and *A. gossypii*, respectively. However, Liu and Chen (2001) determined the development, survival and predation of *C. carnea* on three aphid species, *A. gossypii*, *M. persicae* and *L. erysimi.* The duration of development was significantly shorter (19.8 day) when fed *A. gossypii* than *M. persicae* (22.8 day) and by *L. erysimi* (25.5 day). Similarly, *C. carnea* consumed more *A. gossypii* (292.4) and *M. persicae* (272.6) than *L. erysimi* (166.4).

Table 3. Mean number consumed (± SE) and percentage from different prey species during larval instars of predator *C. carnea* under laboratory conditions.

Prey species	Larva instares						Total
	1st		2nd		3rd		
	No.	%	No.	%	No.	%	
S. cerealella	29.6±4.26 (20-40)	4.68	156.63±30.35 (110-209)	24.75	446.7±36.9 (377-515)	70.57	632.93±50.3 (541-735)
E. kuehniella	23.11±1.75 (19-27)	5.21	116.2±19.98 (86-158)	26.17	304.71±31.05 (248-367)	68.62	444.08±34.4 (378-518)
A. gossypii	20.82±2.78 (16-28)	5.67	92.46±6.43 (83-105)	25.17	254.03±29.81 (211-330)	69.16	367.31±50.3 (326-381)

Fecundity and adults longevity of *C. carnea* in relation to larval food

Table (4) Showed the shortest pre-oviposition period of *S. cerealella* (4.9 ± 0.96 days), but with insignificant difference when compared with those of larvae fed on *E. kuehniella* and significant difference with those fed on *A. gossypii* (7.2 ± 1.36 days). The oviposition period reared on *S. cerealella*, *E. kuehniella* and *A. gossypii* were 21.1 ± 2.56, 24.6 ± 1.56 and 28.3 ± 2.23 days, respectively. As for the postoviposition period, the shortest period (3.7 ± 1.05 days) was on *S. cerealella* and the longest period (6.6 ± 2.3 days) was on *A. gossypii*. The number of eggs deposited a *C. carnea* female reared on *S. cerealella*, *E. kuehniella*, and *A. gossypii* 184.5 ± 23.36, 237.9 ± 25.61 and 361 ± 21.88 eggs, respectively. *C. carnea* females lived always longer than males. Both sexs of adults resulted from larvae fed on *S. cerealella*, *E. kuehniella* and *A. gossypii* had the longevity (19.2 ± 4.86, 22.3 ± 5.43 and 15.3 ± 4.05 days for males and 29.7 ± 2.9, 35.3 ± 4.05 and 42.1 ± 5.45 days for females, respectively). Sattar (2010) concluded that the pre-oviposition period on *C. carnea* of *A. gossypii* reached to 3.37 ± 0.18 days that is similar to the observation presented in this work. On the other hand, Zheng *et al*. (1993) reported that female fecundity of *C. pallens* was 326 eggs when fed on *A. craccivora*. Whereas, El-Serafi *et al.* (2000) summarized that female fecundity of *C. carnea* on *A.gossypii* 480.2 ± 14.2. On the other hand, Sattar (2010) stated that fecundity on *A.gossypii* was 419.8 ± 6.35 and *C. carnea* laid 1079, 582 and 172.8 eggs per female when reared on *C. cephalonica, D. melanogaster* and *A. craccivora*, respectively (Tesfaye and Gautam, 2002).

Table 4. Fecundity and longevity of *Chrysoperla carnea* adults in relation to larval feeding on eggs of two *Lepidopterous* and *Aphis gossypii*.

Period (in days)	*S. cerealella*	*E. kuehniella*	*A. gossypii*	L.S.D
Preoviposition	4.9 ± 0.96 [b] (4-6)	6.4 ± 0.77 [b] (4-6)	7.2 ± 1.36 [a] (6-9)	0.90
Oviposition	21.1 ± 2.56 [a] (17-26)	24.6 ± 1.56 [b] (23-28)	28.3 ± 2.23 [c] (23-31)	1.96
Postoviposition	3.7 ± 1.05 [b] (3-6)	4.3 ± 1.25 [b] (3-7)	6.6 ± 2.32 [a] (4-9)	1.39
Adults life-span				
Male	19.2 ± 4.86 [a] (9-26)	22.3 ± 5.43 [ab] (15-30)	15.3 ± 4.05 [b] (5-19)	3.95
Female	29.7 ± 2.9 [a] (27-36)	35.3 ± 4.05 [a] (24-37)	42.1 ± 5.45 [b] (18-45)	3.82
Total eggs/female	184.5 ± 23.36 [a] (131-216)	237.9 ± 25.61 [b] (179-267)	316 ± 21.88 [c] (261-348)	20.05

Release of *C. carnea* second instar larvae for controling of *A. gossypii* in cucumber cages

After release of *C. carnea* (24 hours), the mean number of aphids on cucumber plants averaged 52.4, 90 and 112.2 aphid in three cages, respectively, compared to 115, 180 and 210 in control cages, showing 54.43, 50.0 and 46.57% reduction in *A. gossypii* due to *C. carnea* release Table (5). The predaceous larvae gave reduction percentages (after two days release) as 75.0, 71.24 and 66.83%, while the mean counts of aphids infesting cucumber plants in cages treated with rates 1 : 100, 1 : 150 and 1 : 200 (larvae : aphid) were 35.0, 60.4 and 79.6 individuals/cage, respectively, compared to 140, 210 and 240 individuals/cage in control plant, respectively.

Four days after release,` the predaceous larvae gave reduction percentages of 90.23, 86.4 and 77.7%, while the mean number of aphids in cages treated with ratios 1 : 100, 1 : 150 and 1 : 200 (larvae : aphid) were 21.0, 48.7 and 64.5 aphids/cage, compared to 215, 360 and 290 aphids/cage in control treatment, respectively, as shown in Table 5. *C. carnea* used against several pests on various vegetable corps, most of which were carried out in greenhouses. This predator has been mainly used against aphid, where the lacewing can be transferred to the greenhouse either as eggs or as second instar larvae (El-Arnaouty *et al*., 1993). The efficacy of lacewings depended on the data of the first release, and the larvae needed to be present before the first winged aphid. El-Arnaouty and Gamal (1998) reported that the use of *C. carnea* released either at the egg or larval stage for several subsequent weeks, gave good results for the control of aphid pests on cotton. Regarding the mean number of aphids, it could be indicated that the efficacy of *C. carnea* larvae in suppressing aphid population was positively correlated to the ratios of released *C. carnea* larvae. So, the aphids population decreased by increasing the number of the released larvae. The mean reduction in aphid numbers in the three treatment averaged 78.94, 73.6 and 67.97% in cages which received 1 : 100,1 : 150 and 1 : 200 (larvae : aphid), respectively. Finally, the highest reduction in aphid numbers was recorded in treatment (1 larvae: 100 aphid). However, Abdel-Naby (2003) reported that at the lower predator : preyratios (1 : 15, 1 : 30 and 1 : 45), recorded no significant difference between the coccinellid larvae and adults as well as chrysopid larvae, whereas, at the higher ratio (1 : 60 and 1 : 75), recorded a significant difference between the predators and stages when release on *A. gossypii* .

Table 5: Efficiency of releasing 2nd instar larvae of *C. carnea* on cucumber plants for control *Aphis gossypii* population in field cages.

Date of inspection after	Release ratios of C. *carnea* 2nd instar larvae (larva : aphid)								
	1 larva : 100 aphid			1 larva : 150 aphid			1 larva : 200 aphid		
	No. of Aphid on control plants	No. of Aphid on treated plants	%Reduction	No. of Aphid on control plants	No. of Aphid on treated plants	%Reduction	No. of Aphid on control plants	No. of Aphid on treated plants	%Reduction
24 h.	115	52.4	54.43	180	90	50.0	210	112.2	46.57
48 h.	140	35	75.0	210	60.4	71.24	240	79.6	66.83
72 h.	180	7.0	96.11	280	37	86.79	260	50.0	80.77
96 h.	215	21	90.23	360	48.7	86.4	290	64.5	77.7
Mean	162.5	28.88	78.94	257.5	59.03	73.61	250	76.58	67.97

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