# Effect of Feeding Type on Some Biological Aspects of Aphid Lion, *Chrysoperla carnea* (Neuroptera:Chrysopidae) under Laboratory Conditions

Mohamed A. Al-Eryan, Amany M. Abu-shall, Mohamed E. Tawfik and Shahenda A.S. Ibrahim[1]

## ABSTRACT

**The green lacewings, *Chrysoperla carnea* (Stephens) is a common polyphagous predator for many insect pests in different agricultural crops. Effects of different hosts (preys) on biology of *C. carnea* were carried out under laboratory conditions at 25 ± 2ºC, 60±5 % RH and 16L: 8D hours. The natural preys were: Frozen eggs of Angoumois grain moth (*Sitotroga cerealella*), the cotton aphid (*Aphis gossypii*) and both of eggs and larvae of cotton leaf worm (*Spodoptera littoralis*). Results showed that the shortest period from first instar to adult emergence was (16.90±1.09 days) when larvae fed on eggs of *S. cerealella* followed by *A. gossypii* (20.60±1.99 days), larvae and eggs of *S. littoralis* were (25.46±2.27days) and (26.83±2.24 days), respectively. The highest fecundity per female was when fed on eggs of *S. cerealella* (471.30±103.74 eggs), followed by *A. gossypii* (392.70±80.54 eggs), larvae and eggs of *S. littoralis* were (277.60±36.02 larvae) and (212.40±35.88 eggs), respectively. The highest significant hatchability observed when larvae of *C. carnea* fed on eggs of *S. cerealella* (92.97%). Therefore results indicate the possibility of the rearing of the green lacewing, *C. carnea* on eggs of *S. cerealella* to enhance its biological aspects and applying it in large –scale release operations. In addition, the biological parameters of *C. carnea* adults studied to check the effect of different diets under laboratory conditions. The three tested diets were (honey, soybean and water), (honey, pollen of corn and water) (honey, milk and water) and (honey, yeast and water) as a control. The results showed that the highest fecundity was (321.40± 14.92) eggs per female with (5.94±0.88) eggs per day per single female and highest hatchability (91.41±7.95%) when fed on (honey, soybean and water). While, the data showed that the longest mean longevity of female and male of the predator, *C. carnea* were (92.10±9.98 and 56.00±11.26 days) respectively, when adults fed on (honey, pollen of corn and water). Generally, improvement of laboratory diets for *C. carnea* may positively serve mass rearing production and biocontrol plans.**

**Key words: *Chrysoperla carnea*, Insect prey, *Sitotroga cerealella*, *Aphis gossypii*, *Spodoptera littoralis*, different food diets, biological control.**

## INTRODUCTION

Green lacewings are naturally important in most agricultural systems because of their ease to hunt the aphids, whiteflies, mites, and some other small, soft bodied insects (Golmohammadi *et al*., 2021). The green lacewings, *Chrysoperla carnea* (Stephens, 1836) is a cosmopolitan polyphagous predator, commonly found in agricultural systems. It has been recorded as an effective generalist predator of aphids, coccids, mites and mealy bugs etc. (Yuksel & Goemen, 1992; Singh & Manoj, 2000 and Zaki & Gesraha, 2001). It has been widely used for aphid bio-control (Venkatesan *et al*., 2000; 2002) and other insect pests (Obrycki *et al*., 1989) because of its ubiquitous nature, polyphagous habits, and compatibility with selected chemical insecticides, microbial agents and amenability to mass rearing (Ridgway *et al*., 1970; Ridgway & Murphy, 1984; Obrycki *et al*., 1989 and Uddin *et al*., 2005). It has been mass-reared and marketed commercially in North America and Europe (Balasubramani & Swamiappan, 1994; Tauber *et al*., 2000 and Liu & Chen, 2001) for population management of many insect pests (Ridgway *et al*., 1970; Sengonca *et al*., 1995; Daane *et al*., 1996; Legaspi *et al*., 1996 and Atakan, 2000). In the present study the influence of feeding type on development and survival of *C. carnea* was examined

## MATERIALS AND METHODS

**1- Effect of different species of preys on biology of the predator, *Chrysoperla carnea***

Eggs of lacewings (*Chrysoperla carnea*) were obtained from Prof. Dr. El-Arnaouty, S. A., Biological Control Laboratory, Faculty of Agriculture, Cairo University, Egypt. The predator, *C. carnea* was reared on *A. gossypii* in a climate controlled room at 65±5% relative humidity and a photoperiod of 16 L: 8 D hours.

Adults of *C. carnea* were reared in transparent wooden cages. Upper part of the cage was lined with black sheet made from cloth for oviposition. Adults of *C. carnea* were provided with diet (H.Y.W.) which containing honey: yeast: water in ratio (1:1:1), which offered on small pieces of cotton. The diet was changed daily. Two hours later, deposited fresh eggs were collected from black sheet at the top of the cages with razor. Collected eggs were counted under stereomicroscope then kept in Eppendorf's until hatching.

Effect of feeding predator, *C. carnea* on three different species of preys in different stages was

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[1]Cept. Applied Entomology and Zoology, Faculty of Agriculture, Alexandria University.

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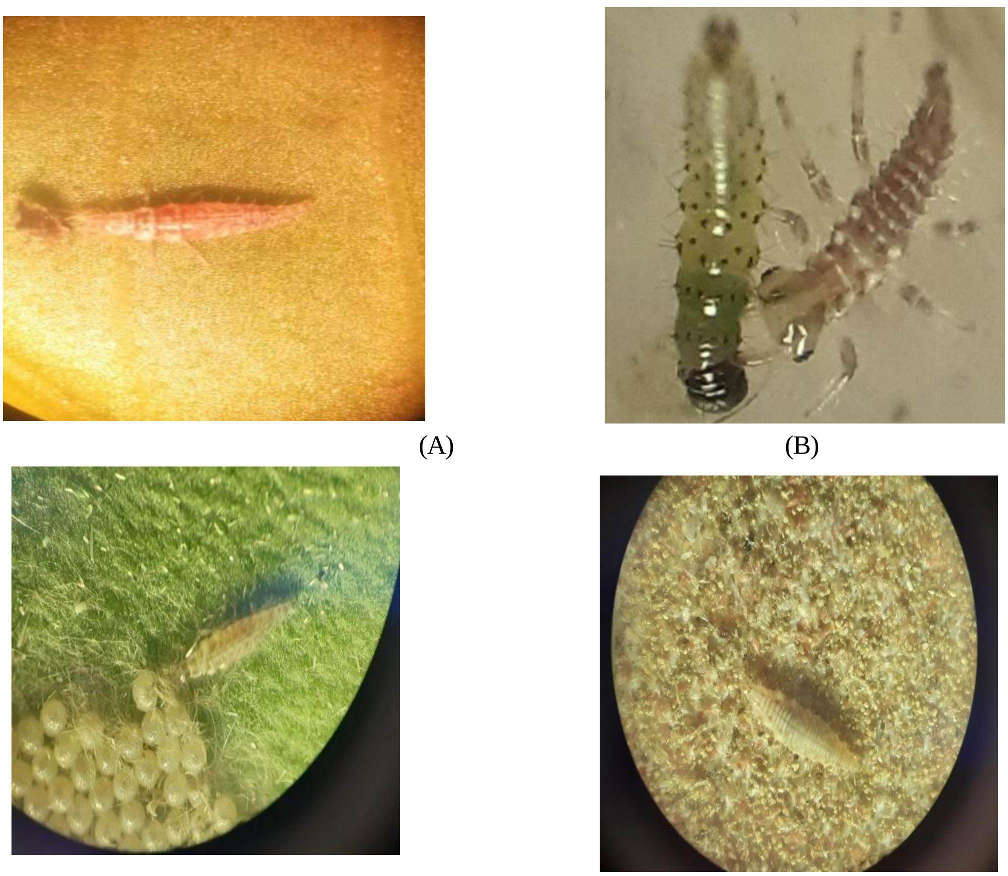
studied. The preys were cotton aphids, *Aphis gossypii* (nymphs); cotton leaf worm, *Spodoptera littolaris* (larvae and eggs) and the Angoumois grain moth, *Sitotroga cerealella* (Oliver) (frozen eggs) (Figure 1). Biology of the predator, *C. carnea* on three different preys in different stages was studied under laboratory conditions.

Sources of three different preys, nymphs and adults of *A. gossypii* were collected from culture maintained on potato plant in the laboratory. Larvae and eggs of *S. litoralis* were obtained from culture reared for experimental purpose in laboratory of Prof. Dr. Esmat Hegazi, Applied Entomology and Zoology Department, Faculty of Agriculture, Alexandria University. Eggs of *S. cerealella* were obtained from the culture maintained on wheat grains under controlled temperature 26±2°C and 60±5% R.H in the laboratory of Dr. Mona Barsom, Agricultural Research Center, Giza. The counted number eggs of *S. cerealella* were offered to *C. carnea* larvae. After 24 hours the remaining eggs were counted and replaced with new eggs, which were first exposed to 7°C in refrigerator to kill the embryo for 24 hours before using for the experiment according to Sattar (2010).

Each used stage from each prey was replicated 30 times. All biological parameters were recorded daily, this including incubation period, larval and pupal period, longevity of male and female, pre-oviposition, oviposition and post-oviposition periods and female fecundity. To avoid cannibalism, newly hatched larva of the predator, *C. carnea* (two hours old) was kept singly in plastic cups (2.5 cm diameter and 8.5 cm length) and covered with muslin cloth.



(A) (B)

(C) (D)

**Figure 1. The predator *Chrysoperla carnea* feeds on three different preys in different stages:**

(A) nymphs of the cotton aphid (*Aphis gossypii*),

(B) larva of prey (*Spodoptera littolaris*),

(C) eggs of prey (*Spodoptera littolaris*) and (D) eggs of prey (*Sitotroga cerealella*).

To study the percentage of hatchability, eggs were harvested with razor and separated along with black muslin cloth, counted and kept for hatching. Two day old virgin adults were paired in the rearing glass chimney as in the previous paragraphs, provided with standardized adults' diet on wet cotton placed in glass Petri dish in chimneys. The period of survival of each male and female was recognized regularly in order to record longevity (days) and total number of eggs laid by each female were determined.

**2- Effect of three different adult diets on the biological parameters of adult of *C. carnea***

Effect of three different adult diets on the predator was studied. The standard diet consisted of yeast (Y), honey (H), water (W) of ratio of (2Y: 1H: 2W) that was used as control (Table 1). The experiment was conducted with ten replications each having one pairs of *C. carnea* adult at 25±2ºC, 60±5 % RH and 16L: 8D hours according to Jloud *et al*. (2013). Adults were confined in the glass chimney. The different adult diets for *C. carnea* adult were put inside the glass chimney with the help of small cotton. Eggs laid by female *C. carnea* on the wall of chimneys and muslin cloth were harvested with the help of fine scissor. Some biological parameters of *C. carnea* adult were studied under laboratory conditions.

Daily observation was made and the following parameters were recorded: pre oviposition period, oviposition period, post oviposition period, Fecundity (number of deposited eggs per female), total number of deposited eggs per female per day, percentage of hatchability and adult longevity of male and female.

## RESULTS AND DISCUSSION

**1- Effect of different preys on biology of the predator, *Chrysoperla carnea***

**1.1- Duration period of larval and pupal stages of *C.carnea***

Results in Table (2) indicated that the larval instar period of *C. carnea* were fed on different preys [*A. gossypii*, *S. cerealella* (eggs), *S. littoralis* (eggs) and *S. littoralis* (larvae)] was significantly different. Duration of first larval instar was 3.33, 1.66, 3.36 and 3.46 days, while duration of second instar was 3.46, 2.06, 3.26 and 4.26 days and that of third instar was 5.10, 2.86, 4.90 and 6.23 days, respectively, on *A. gossypii*, *S. cerealella* (eggs), *S. littoralis* (eggs) and *S. littoralis* (larvae). The complete larval developmental period of *C. carnea* was 11.90, 6.66, 11.53 and 13.96 days on *A. gossypii*, *S. cerealella* (eggs), *S. littoralis* (eggs) and *S. littoralis* (larvae), respectively. On the other hand, the pupal stage period of *C. carnea* was statistically significant and different on various preys. The duration period in pupal stage of *C. carnea* was 8.70, 10.30, 16.10 and 11.50 days fed on the tested preys respectively. In general, the total period from 1st larval instar to adult emergence was statistically significant and different on various preys. The shortest period from 1st larval instar to adult emergence was (16.90 ± 1.09 days) when larvae fed on eggs of *S. cerealella*, followed by *A. gossypii* (20.60 ±1.99 days), larvae of *S. littoralis* (25.46 ± 2.27 days) and eggs of *S. littoralis* (26.83 ± 2.24 days), respectively.

The gained results agree with Shaukat (2018) who reported that the shortest larval period of *C. carnea* was recorded on *Sitotroga cerealella* eggs, while longest on *Helicoverpa armigera* eggs. Also, the longest pupal period was recorded while feeding upon *H. armigera* eggs. Similar results were reported by different authors. Balasubramani and Swamiappan (1994) recognized the development of *C. carnea* on different preys in laboratory. They reported that larval development was rapid on eggs of *Corcyra cephalonica* (8.20 days) and longest on neonates of *H. armigera* (11.10 days). Mannan *et al*. (1997) studied biology of *C. carnea* on *Aphis gossypii* and *Myzus persicae* and they observed that the larval duration of *C. carnea* was long when fed on *M. persicae*. Saminathan *et al*. (1999) and Bansod & Sarode (2000) determined the biology and feeding potential of *C. carnea* on different preys.

**Table 1. Components of adult diets for feeding adult green lacewing, *Chrysoperla carnea.***

| Type of diets | | Ingredients |
|---|---|---|
| 1st Diet (control) | (Y.H.W.) | 2 yeast : 1 honey : 2 distilled water |
| 2nd Diet | (S.H.W.) | 2 Soybean : 1 honey : 3 distilled water |
| 3rd Diet | (P.H.W.) | 2 Pollen : 1 honey: 2 distilled water |
| 4th Diet | (M.H.W.) | 2 Milk : 1 honey : 2 distilled water |

**Table 2. Mean Duration period (days) of larval and pupal stages of *Chrysoperla***

| Type of preys | Larval stage | | | Larval duration | Pupal stage | Total period Larva-adult |
|---|---|---|---|---|---|---|
| | 1st instar | 2nd instar | 3rd instar | | | |
| *Aphis gossypii* | 3.33**a**±0.47 | 3.46**b**±0.57 | 5.10**b**±1.32 | 11.90**b**±1.74 | 8.70**d**±1.31 | 20.60**c**±1.99 |
| *Sitotroga cerealella*(eggs) | 1.66**b**±0.47 | 2.06**c**±0.44 | 2.86**c**±0.57 | 6.60**c**±0.89 | 10.30**c**±0.74 | 16.90**d**±1.09 |
| *Spodoptera littioralis*(eggs) | 3.36**a**±0.49 | 3.26**b**±0.44 | 4.90**b**±0.80 | 11.53**b**±1.04 | 16.10**a**±1.82 | 26.83**a**±2.24 |
| *Spodoptera littoralis*(larvae) | 3.46**a**±0.50 | 4.26**a**±0.78 | 6.23**a**±1.00 | 13.96**a**±0.85 | 11.50**b**±2.09 | 25.46**b**±2.27 |

They noted that the developmental period of *C. carnea* ranged from 18.6 days on *Aphis cracivora* to 22.7 days on *H. armigera* neonate larvae. Giles *et al*. (2000) found that *C. carnea* larvae developed faster on pea aphid (*Acyrthosipnon pisum*) reared on alfalfa than on faba bean. While, Liu and Chen (2001) stated the duration development of *C. carnea* was significantly different on three aphid species. It was shortest when larvae were fed on *A. gossypii* followed by *M. persicae* and *Lipaphis erysimi*. Shahjahan *et al*. (2020) reported that *C. carnea* successfully completed their life stages on *Planococcus citri*. The larval duration was 9.65±0.19 days when feed on crawlers and adult mealy bug, respectively. Also, the results indicated that *C. carnea* successfully completed their life stages on *Planococcus citri*. The larval duration was 9.65±0.19 days when fed on crawlers and adult mealy bug, respectively. In this concern, Costa *et al*. (2002) stated that the duration of larval stage was longer when *C. externa* was fed on *Sitobion avenae*. The shortest period was found for *Anagasta kuehniella* eggs + *Dichelops melacanthus* eggs. Similar duration was previously reported for *C. externa* when reared using *S. cerealella* eggs (9.18 days) or the aphid, *A. gossypii* (10.62 days). The longer duration of larval period was found for the aphid, *Neotoxoptera formosana* 14.1(±0.38) days (Costa *et al*., 2012). Also, Pitwak *et al.* (2016) studied the effect of four preys (*Sitobion avenae*; *Rhopalosiphum padi*; *Anagasta kuehniella* eggs and *Dichelops melacanthus* eggs) on development of *C. externa*.

Previously, researchers have elaborated different developmental time for various stages of the predator, *C. carnea*. One of these researcher is, Chakraborty (2010) who reported that total larval duration of *C. carnea* was 6.92±0.13 days on *C. cephalonica*. Alghamdi and Sayed (2017) found that total larval developmental time was (15.13±0.35 days) and (13.60±0.31 days) on *A. fabae* and *A. kuehniella* eggs. Concisely, Sultan *et al.* (2017) noted completion of *C. carnea* larval stage in 8.2, 10.0 and 12.0 days when fed on *S. cerealella* eggs, *Chilo infuscatellus* and *Aleurolobus Barodensis*, respectively. The values reported here are quite similar to those reported when *C. externa* was fed on *S. cerealella* eggs; 3.04 (±0.02), 2.55 (±0.08) and 3.67 (±0.07) days or *A. gossypii*; 3.89 (±0.06), 2.55 (±0.09) and 4.19 (±0.07) for the first, second and third larval instars, respectively (Costa *et al*., 2002). The periods found for 2nd and 3rd instars in the *Sitobion avenae* treatment were similar to those found for the aphid *Neotoxoptera formosana* (Homoptera: Aphididae) [4.7(±0.14) and 6.0 (± 0.15) days, respectively] (Costa *et al*., 2012).

Similarly, Saminathan *et al*. (1999) and Bansod & Sarode (2000) reported that *C. carnea* completed their duration from egg to adult emergence was 18.6 and 22.7 days. Total period from larvae to pupae was longer in *Sitobion avenae* than in the other treatments. Saljoqi *et al*. (2015) reported that total developmental duration from egg to adult emergence was 23.1 days when feed on *B. brassicae* aphids. Kumari *et al*. (2016) found eggs of *C. cephalonica* were most preferred by1st instar larvae of *C. carnea* followed by mango meaitalicly bug and brinjal aphid. Similar results were reported to *C. externa* reared on *S. cerealella* eggs and *A. gossypii* (2.68 and 3.0; 7.01 and 6.73; 19.3 and 20 days for pre-pupae, pupae and larvae to pupae, respectively) (Costa *et al*., 2002). On the other hand, the results disagree with Hassan *et al*. (2014) who reported that there was no-significance difference of *C. carnea* total larval period when feeding upon each of the three preys.

**1.2- Duration period of some biological parameters of *C. carnea* adults as a result of larvae feeding on different preys.**

In the present study, larvae of *C. carnea* were fed on different preys, *A. gossypii* (nymphs), *S. cerealella* (eggs), *S. littoralis* (larvae) and *S.littoralis* (eggs). Feeding larvae of *C. carnea* on different preys significantly affected some biological parameters ($P<0.001$) such as (pre-oviposition period, oviposition period, post-oviposition period, life span, longevity of male and female, sex ratio, fecundity, number of laid egg per day and egg hatchability) (Table 3).

Analysis of data revealed that pre-oviposition period of *C. carnea* adults, emergened from larvae fed on larvae of *S. littoralis* was significantly longer (5.20±1.31 days) as compared to fed on *S. cerealella* eggs (3.30b±0.84 days) and *A. gossypii* nymphs (2.70±0.48 days), but it did not show significant difference with fed on eggs of *S. littoralis* (4.00±1.56 days).

**Table 3. Mean Duration period for some biological parameters of predator, *Chrysoperla carnea* feeding on different preys under laboratory conditions.**

| Different preys | Pre-ovi. Period (days) | Ovi. Period (days) | Post-ovi. (days) | Adult longevity (days) | | Sex ratio (F : M) | fecundity | Eggs per Female /day | Hatchability % |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Female | Male | | | | |
| *Aphis gossypii* | 2.70c±0.48 | 45.20c±2.69 | 13. 60b±2.45 | 61.40c±2.71 | 37.00a±3.05 | 5.9 : 4.1 | 392.70b±80.54 | 8.61a±1.47 | 80.32c±6.45 |
| *Sitotroga cerealella*(eggs) | 3.30bc±0.84 | 55.70a±2.86 | 16.90b±1.85 | 75.90b±1.72 | 39.90a±6.43 | 7.9 : 2.1 | 471.30a±103.74 | 8.44a±1.96 | 92.97a±6.29 |
| *Spodoptera littoralis*(eggs) | 4.00b±1.56 | 49.60b±3.94 | 23.00a±1.49 | 76.60b±3.43 | 41.30a±9.34 | 8 : 2 | 212.40d±35.88 | 4.22b±0.57 | 84.88b±7.44 |
| *Spodoptera littoralis*(larvae) | 5.20a±1.31 | 53.70a±7.86 | 24.40a±7.47 | 83.30a±12.92 | 41.40a±9.62 | 8.2 : 1.8 | 277.60c±36.02 | 5.07b±5.07 | 84.88b±7.44 |

The maximum oviposition period was observed when larvae of *C. carnea* fed on eggs of *S. cerealella* (55.70±2.86 days) and larvae of *S. littoralis* (53.70±7.86 days), followed by eggs of *S. littoralis* and *A. gossypii* (49.60±3.94 and 45.20±2.69 days), respectively. The oviposition period when larvae of *C. carnea* fed on eggs of *S. cerealella* (55.70±2.86 days) and larvae of *S. littoralis* (53.70±7.86 days) were significantly longer as compared to eggs of *S. littoralis* (49.60±3.94 days) and *A. gossypii* (45.20±2.69 days), respectively. The results indicated that maximum post- oviposition period (30.20 days) was observed when larvae of *C. carnea* fed on eggs of larvae and eggs of *S. littoralis* (23.00±1.49 and 24.40±7.47 days), followed by eggs of *S. cerealella* (16.90±1.85 days) and *A. gossypii* (13. 60±2.45 days), respectively. The minimum post-oviposition period was recorded when larvae of *C. carna* fed on *A. gossypii* and *S. cerealella* which show significant difference with larvae and eggs of *S. littoralis*, respectively (Figure 2).

Analysis of data showed that there were significant differences among longevity of female and male lacewings. The data showed that the longest mean longevity of female and male *C. carnea* were (83.30±12.92 and 41.40±9.62 days) respectively, when larvae of *C. carnea* fed on larvae of *S. littoralis*, followed by eggs of *S. littoralis* (76.60±3.43 and 41.30±9.34 days), eggs of *S. cerealella* (75.90±1.72 and 39.90a±6.43 days) and *A. gossypii* (61.40±2.71 and 37.00±3.05 days), respectively.

In this concern, Pitwak *et al*. (2016) found that longer oviposition period was recorded when larvae fed on *Rhopasosiphum padi* + *Dichelops melacanthus* than for those fed on *Sitobion avenae* larvae. Similar effectson pre-oviposition and post-oviposition periods were observed among treatments. Higher longevity was recorded for females and males reared on *R. padi* + *D. melacanthus* than on the other treatments. In previous studies, adults longevity (males and females recorded together) varied quiet similarly to the present results, ranging from 34.96 (± 7.60) to 69.75 (±4.21), depending on the host plant in which the prey was developed (Silva *et al*., 2004).

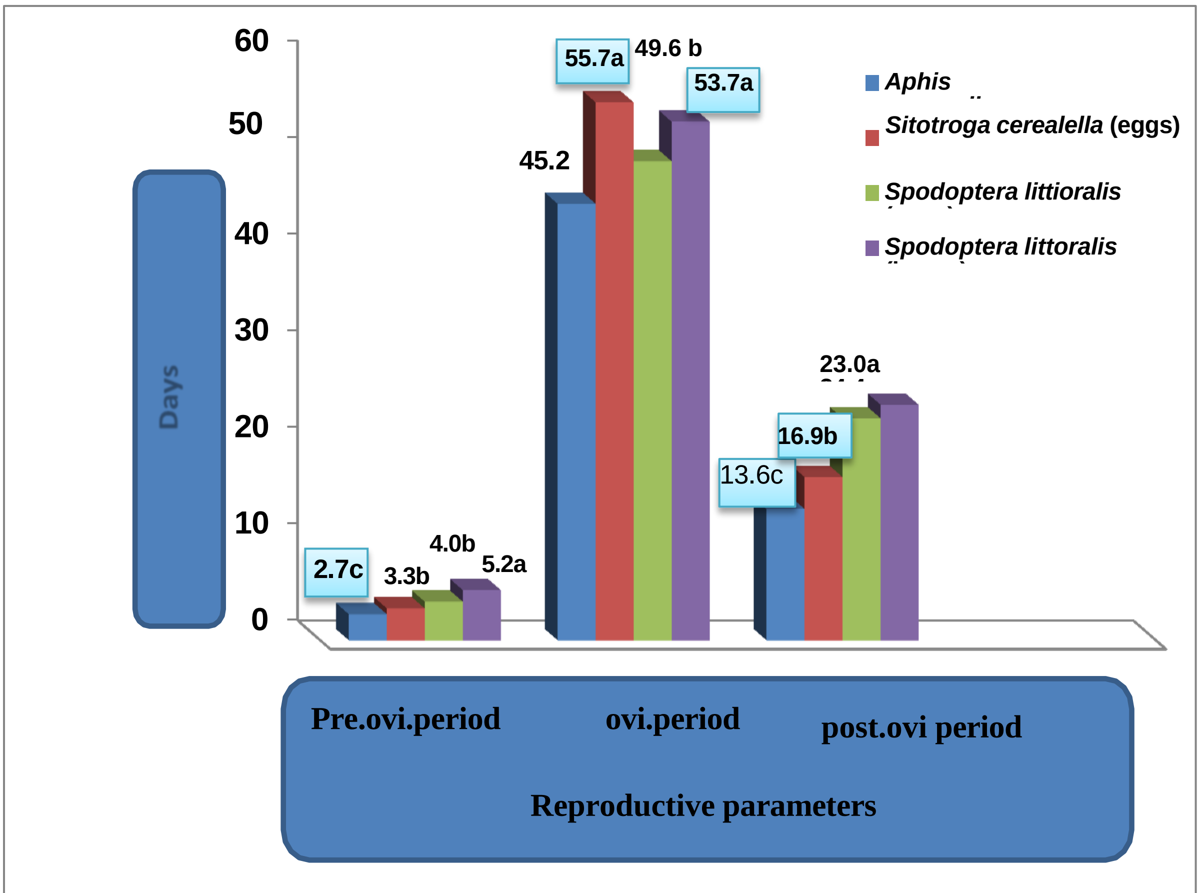



**Figure 2. Effect of different preys on pre-oviposition, oviposition, post oviposition periods of *Chrysoperla carnea***

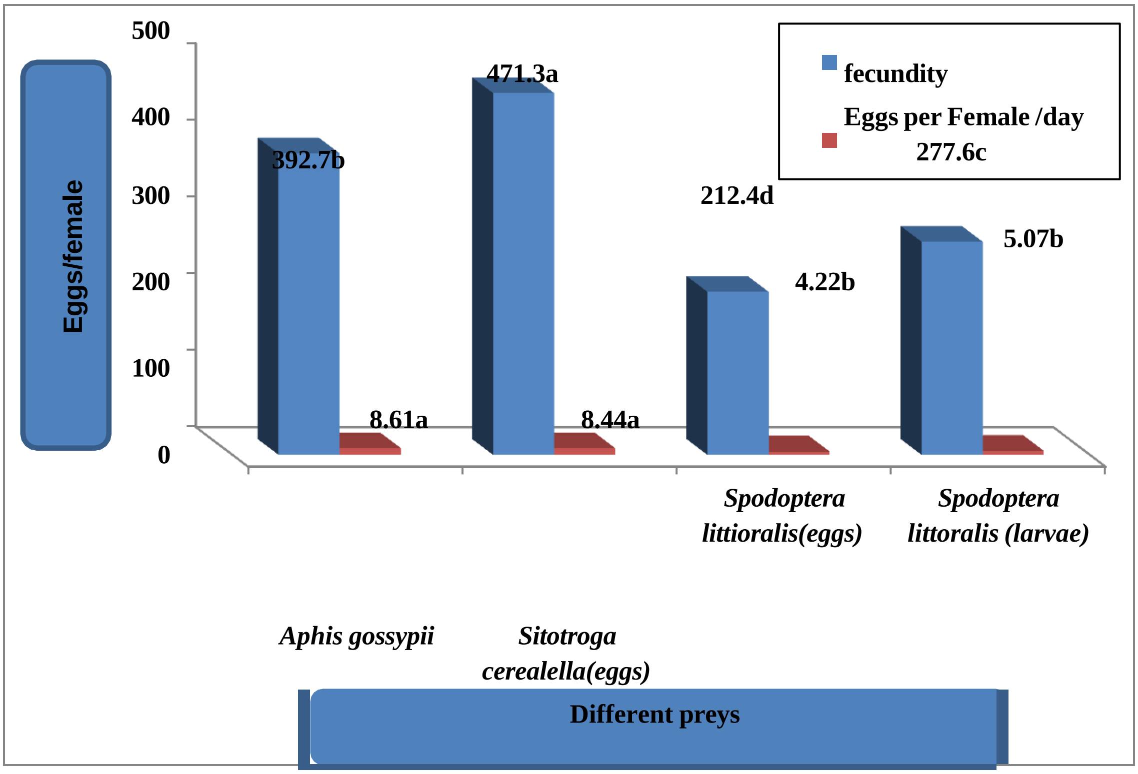



**Figure 3. Effect of different preys on female fecundity and quantity of number of eggs per day of eggs of *Chrysoperla carnea*.**

Feeding of *C. carnea* larvae on different preys significantly affected its fecundity. The number of eggs produced by females whose larvae were fed on eggs of *S. cerealella* was the highest (471.30±103.74 eggs), followed by *A. gossypii* (392.70±80.54 eggs), larvae of *S. littoralis* (277.60±36.02 eggs) and eggs of *S. littoralis* (212.40±35.88 eggs). It is obvious that fecundity was significantly different for the females, whose larvae fed on *A. gossypii*, eggs of *S. cerealella*, eggs and larvae of *S. littoralis*, respectively (Figure 3).

The above finding concurs with those reported by Osman and Selman (1993). They investigated the influence of different aphid species on larval development and fecundity of *C. carnea*. *M. persicae* and *Acyrthosiphon pisum* were suitable, while *A. fabae* was most unsuitable prey causing high juvenile mortality. *C. carnea* larvae fed on this aphid and *Macrosiphum albifrons* had reduced fecundity. The survival of larvae of *C. carnea* feeding on *A. cracivora*, *Drosophila melanogaster* and *Corcyra cephalonica* were 51.8, 80.9 and 86.7%, respectively. The adults of *C. carnea* were laid 1079, 582 and 172.8 eggs/ female when reared on *C. cephalonica*, *D. melanogaster* and *A. cracivora*, respectively (Tesfaye and Gautam, 2002). But, Obrycki *et al.* (1989) noted that feeding of *C. carnea* larvae on *Ostrinia nubilalis* and *Agrotis ipsilon* eggs,caused 26-40% larval mortality and when reared on *A. ipsilon* neonates, 65% died, while all larvae died when fed on *O. nubilalis* neonates, which was due to entanglement in silk produced by these larvae. Pitwak *et al*. (2016) found that the number of eggs produced by females whose larvae fed with *R. padis*+ *D. melacanthus* was higher than those fed with *S. avenae*. In *S. avenae* treatment, higher males than females were observed. The number of eggs reported here ranging from 763.30 (±121.88) to 1269.70 (±202.77) are higher than those previously recorded for *C. externa* reared on *B. tabaci* ranging from (293.83±97.08) to 592.08±62.96) (Silva *et al.*, 2004). But, the fecundity was 711.8 (±10.57) eggs (Auad *et al.*, 2005) and 428.5 (±85.2) eggs when reared on *A. gossypii* (Macedo *et al*., 2010). Higher mean values were previously observed for *C. externa* larvae fed with *A. kuehniella* and *A. argillacea* eggs (89.15 and 86.62 %, respectively) (Ribeiro, 1988).

Table (3) revealed that the maximum average of laid eggs by female per day was recorded when adults whose larvae fed on *A. gossypii* and eggs of *S. cerealella* (8.61±1.47 and 8.44±1.96) eggs followed by larvae of *S. littoralis* and eggs of *S. littoralis* (5.07±5.07 and 4.22±0.57) eggs per day, respectively. The effect of different preys on egg hatchability of females, *C. carnea* fed on different preys showed significant differences. *A. gossypii* differed significantly from eggs and larvae of

*S. littoralis.* The highest hatchability was observed when larvae of *C. carnea* fed on eggs of *S. cerealella* (92.97%) that was significant to other treatments. It differed significantly from eggs and larvae of *S. littoralis* (84.88%) and *A. gossypii* (80.32%), but did not show significant differences. In the same time, no significant differences were observed between all treatments in their sex ratio (female: male), when *C. carnea* larvae fed on different preys. The present study disagrees with Sarwar *et al*. (2011) who indicated that sex ratios were not affected due to the feeding upon different preys. Also, Pitwak *et al.* (2016) found that in *S. avenae* treatment, higher males than females were observed.

**2-Effect of adult diets on some biological parameters of *Chrysoperla carnea* adults**

Analysis of variance revealed that the effect of different types of adult artificial diets was significant on pre-oviposition, oviposition and post-oviposition periods of *C. carnea*. The ranking of pre-oviposition period of *C. carnea* adults according to treatments with different nutritional diets was as: S.H.W (honey, soybean and water) > Y.H.W (control) (honey, yeast and water) > H.M.W (honey, milk and water) > P.H.W (honey, pollen of corn and water) (Table 4). The results revealed that the pre-oviposition period was maximum (4.40 days) in H.S.W followed by Y.H.W (control), M.H.W and P.H.W (3.30, 2.90 and 2.50 days). Also, the minimum pre-oviposition period (2.50 days) was obtained in P.H.W. Analysis of the data indicated that pre-oviposition period of *C. carnea* adults fed on S.H.W diet was more significantly (4.40±0.96 days) as compared to Y.H.W (control), P.H.W and M.H.W diets (3.30±0.48 days), (2.50±0.52 days) and (2.90±0.73 days), respectively. But, the pre-oviposition period in M.H.W did not show significant difference with Y.H.W (control) and P.H.W. On the other hand, the maximum oviposition period (59.40 days) was appeared in P.H.W followed by S.H.W, Y.H.W (control) and M.H.W (54.60, 41.80 and 36.40 days). The oviposition period in P.H.W (59.40±9.74 days) and S.H.W (54.60±6.66days) were significantly longer (days) as compared to Y.H.W (control) (41.80±3.48 days), M.H.W (36.40±2.45 days), respectively. The results indicated that maximum post-oviposition period (30.20 days) was observed in P.H.W, followed by M.H. W, S.H.W and Y. H.W (control) (20.60, 18.90 and 13.00 days), respectively. The minimum post-oviposition period was recorded in Y.H.W (13.00±2.35 days), that did not show significant difference with S.H.W (18.90±3.47 days) and showed significant difference with P.H. W (30.20±8.97 days) and M.H.W (.20.60±5.39 days), respectively.

Analysis data showed significant differences among longevity of female and male of lacewings, *C. carnea*. The data showed that the longest mean longevity of female and male of predator were (92.10±9.98 and 56.00±11.26 days) respectively, when adults fed on P.H.W diet comparing with the shortest mean longevity of female and male of *C. carnea* (58.10±3.07and 25.00±3.46 days) respectively, when fed on the adult diet H.Y.W (control). Also, statistical analysis indicated that *C. carnea* adults who were fed on adult diet containing pollen of corn, honey and water lived significantly longer compared to the adults that were fed on other types of adult diets in the present study. Feeding of *C. carnea* adults on different diets significantly affected its fecundity**.** The maximum number of eggs laid by female of *C. carnea* was 321.40±14.92 eggs recorded when fed on adult diet H.S.W, whereas, the minimum number of eggs laid by female of *C. carnea* was 165.90±15.87 eggs when fed on adult diet M.H.W. It is obvious from these results fecundity was significantly different for the females fed on different types of adult diets S.H.W, Y.H. W, P.H.W and P.H.W. The Diet which consist of S.H.W was significantly higher than Y.H.W (control) (247.90±11.93 eggs), followed by P.H.W (195.20±29.8 eggs) and M.H.W (165.90±15.87 eggs), respectively.

The maximum average of laid eggs by female per day was recorded (5.94 eggs) in S.H.W, followed by 5. 90, 4.53 and 3.28 eggs per day in adult diets Y.H.W, M.H.W and P.H.W, respectively. While, the adult diets S.H.W and P.H.W differed significantly from Y.H.W and M.H.W. In Table (4), the effect of different types of adult diets on the percentage of egg hatchability of *C. carnea* female adults was demonstrated. The results showed significant differences on treatments. The highest percentage of egg hatchability was observed in S.H.W diet (91.41%) that was the most significant between treatments. It differed significantly from P.H.W (84.51%), Y.H.W (79.02%) and M .H.W (74.52%). While, the adult diets of Y.H.W and M.H.W treatments did not show significant differences.

Many studies have been carried out on the rearing of *C. carnea* natural diets. Tulisalo and Korpela (1973) reared *C. carnea* adults on a mixture of protein hydrolysate (yeast), sugar and water (5: 6: 10) spread as a moist paste on the walls of the cage; adults also had access to water on cotton-wool. Females laid an average of 700 eggs each, having 30-40% fertility.

**Table 4. Duration period of some biological parameters of *C. carnea* adults as a result of larvae feeding on different preys.**

| Type of Diet | Pre-ovi. Period (days) | Ovi. Period (days) | Post-ovi. (days) | Adult longevity | | Fecundity | Eggs per female/day | % Hatchability |
|---|---|---|---|---|---|---|---|---|
| | | | | Female | Male | | | |
| YHW | 3.30b±0.48 | 41.80b±3.48 | 13.00c±2.35 | 58.10c±3.07 | 25.00c±3.46 | 247.90b±11.93 | 5.90a±0.43 | 79.02c±8.22 |
| PHW | 2.50c±0.52 | 59.40a±9.74 | 30.20a±8.97 | 92.10a±9.98 | 56.00a±11.26 | 195.20c±29.86 | 3.28c±0.38 | 84.51b±10.45 |
| SHW | 4.40a±0.96 | 54.60a±6.66 | 18.90b±3.47 | 77.90b±9.67 | 42.00b±9.29 | 321.40a±14.92 | 5.94a±0.88 | 91.41a±7.95 |
| MHW | 2.90bc±0.73 | 36.40b±2.45 | 20.60b±5.39 | 59.90c±6.70 | 28.40c±6.32 | 165.90d±15.87 | 4.53b±0.56 | 74.52c±8.74 |

Hassan (1975) described the mass-rearing of *C. carnea*, with an adult diet containing brewer's yeast, honey and water. Principi and Canrad (1984) recorded that the inclusion of yeast was required for egg production, but few eggs were produced on yeast solution alone. For maximum egg production, food containing yeast and sugar must be offered on more than one occasion, compared with the insects given a diet comprising yeast, protein hydrolysate, sugar and water in the ratios 4:7:10, but significant reductions in egg production rate were noted when the amount of either yeast, or both the yeast and the sugar was halved. Duelli (1987) reported that adults of *C. carnea* were attracted to pollen but not consumed as they needed, so prepared an adult diet of *C. carnea* adults with honeydew and nectar, as a supplementary diet and a good source of yeast that increase number of laid eggs but fertility is not more than 40 percent.

The fecundity, longevity, reproductive age and many other reproductive as well as biological parameters of *C. carnea* have been examined on different diets (Adane and Gautam, 2002). Similar results were reported by different authors. Tesfaye and Gautam (2002) examined the effects of different combinations of 50 percent honey solution, castor pollens and yeast on the longevity, fecundity, reproductive age and other reproductive attributes of *C. carnea*. The highest number of eggs/female (245.2) was laid when adults were supplemented with baker's yeast granules+50% honey and castor pollen+50% honey. Sattar *et al*. (2007) used an adult diet based on casein and yeast to release *C. carnea* for controlling several insect pests of cotton and maize. The best productive age of female was observed to reach up to 8, 9, 8 and 4 weeks when fed with baker's yeast granules+50% honey, castor pollen+50% honey and 50% honey, respectively. Therefore, quantity of protein plays vital role in biological parameters and there was a close association between optimum dose of nutritious diet in mass rearing of *C. carnea* for highest fecundity and fertility of eggs (Sattar *et al.*, 2011).

Results in the present study are in agreement with those recorded for biological parameters by Saeed *et al.* (2014). They reported that high biological success of *C. carnea* when adults fed on diet based on honey, yeast and pollen as compared to other diets due to the fact that yeast is helpful in enhancing oviposition period, oviposition and adult's life thus have a positive effect on biology of *C. carnea*, if used in combination with water and honey. Also, Ulhaq *et al*. (2006) and Sattar (2017) reported that addition 3.0 mg in Casein to adult diet, gave maximum fecundity (662.40±22.54) and highest percent fertility (77.21±2.81) of *C. carrnea*. Whereas addition 3.0 and 0.5 mg protein hydrolysate to adult died recorded maximum oviposition period (41.40±0.82 and 35.90±1.48 day), respectively. Similarly, maximum percent fertility (65.25%±5.13) was recorded in Torula yeast (1.0 mg) diet, whereas highest oviposition (30.38±0.75 and 30.0±0.77) days were recorded when 5.0 and 3.0 mg when added, respectively. Also, Shahjahan *et al.* (2020) found that pre- oviposition period was 8.2±0.41 days on adult diet consisted of Honey + Sugar + Yeast. Similarly, oviposition and post-oviposition periods recorded for *C. carnea* were 31.4±0.50 and 5 ± 0.30 days. It provided a male longevity of 27.4±0.49 days and female longevity of 44.6±0.74 days. The results indicated that total number of eggs lay per female were 341.2±6.90 on this diet. Murtaza *et al.* (2020) found that pre-oviposition, oviposition and post-oviposition periods were 8.2±1.25, 30.6±1.72 and 9.4±1.02 days, respectively. The highest mortalities were occurred when reared on Water + Sugar + Yeast + Evion diets, while no mortality was observed at $H_2O$ + Sugar + Yeast + Honey. The female longevity was 51.2 ± 2.18 days. The fecundity of female was 301.31 eggs per female with 10.36 eggs per day per single female on adult diet, $H_2O$ + Sugar + Yeast + Honey. The study revealed that diet ($H_2O$ + Sugar + Yeast + Honey) was showed highest survival and fecundity while diet (Water + Sugar + Yeast + Evion) was least one.

Most studies showed that different adult diets have significant effects on the longevity of the both male and female of *C. carnea* where, McEwen and Kidd (1995) reported that adult life of *C. carnea* is affected directly by the adult diet and found that the adults receiving only sugar as adult diet lived longer than those receiving sugar and yeast (yeast was added to the adult diet for more eggs production). While, Jloud *et al*. (2013) found that female and male longevity continue to 63.57, 63.25 days when adult diet contain of water, honey and yeast in ratio of (8:8:1) respectively, In this concern, Ulhaq *et al*. (2006) recorded the longest female and male longevity that were 29.52, 28.22 days respectively, when adult fed on egg yolk diet.

In this regard, similar results were reported by McEwen and Kidd (1995). They recommended yeast and sugar for maximum egg production. Honey is a very important component regarding fertility. But, Milevoj (1999) reared adults of *C. carnea* on a diet consisting of milk, eggs, fruits sugars and yeast. They found a favorable effect on fertility. Higher fertility also observed in diet containing egg yolk because egg yolk rich in protein (amino acids). There are 15.5% amino acids as compared to egg white and mixed egg which contain 9.8% and 11.95% respectively (Norioka *et al*., 1984). The results were better by Ulhaq *et al*. (2006) where *C. carnea* female fertility was 168.30 eggs when fed on egg yolk diet and higher than results by Sumera *et al*. (2016) that the fertility was 116.25 eggs when fed on water; honey; yeast of ratio of (10:3:1). Also, confirmed that a mixture of honey and yeast autolysis is a suitable adult diet for production of fertile eggs. Last but not the least yolk is the most important component in adult diets (Kubota & Shiga, 1995; McEven & Kidd, 1995; and Jloud *et al*., 2013).

So, Feeding larvae of *C. carnea* on different preys significantly affection some biological parameters such as (pre-oviposition period, oviposition period, post-oviposition period, life span, longevity of male and female, sex ratio, fecundity, number of laid egg per day and egg hatchability). Therefore, for feeding larvae of *C. carnea*, eggs of *S. cerealella* is the best prey and for feeding adult of *C. carnea* on nutritional diet, the diet which containing soybean for obtaining high number of eggs. Generally, improvement of laboratory diets for *C. carnea* may positively serve mass rearing production of aphid lion and biocontrol programs in the field.

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## الملخص العربي

# تأثير نوع التغذية على بعض الصفات البيولوجية للمفترس أسد المن *Chrysoperla carnea* (Neuroptera:Chrysopidae) تحت الظروف المعملية

محمد عوض العريان، أمانى مصطفى أبوشال، محمد السيد توفيق، شاهنده على سمير إبراهيم

يعتبر المفترس أسد المن الأخضر *Chrysoperla carnea* (Stephens) من المفترسات الشائعة المستخدمة لعديد من الآفات الحشرية فى مختلف المحاصيل الزراعية. تم دراسة تأثير العوائل المختلفة (الفريسات) على بعض الصفات البيولوجية للمفترس تحت الظروف المعملية عند ٢٥±٢ م° ورطوبة نسبية ٦٠ ±٥% و١٦ ساعة إضاءة و٨ ساعات إظلام. وقد تم إستخدام أربعة أنواع من الفرائس (بيض فراشة الحبوب *Sitotroga cerealella* وحشرة من القطن *Aphis gossypii* وكلا من بيض ويرقات دودة ورق القطن الكبرى *Spodoptera littoralis*)، حيث تم تغذية اليرقات عليها. أشارت النتائج إلى أن أقل فترة زمنية لازمة لنمو وتطور المفترس كانت عند التغذية على بيض فراشة الحبوب حيث بلغت ١٦،٩٠±١،٠٩ يوم يليه حوريات من القطن٢٠،٦٠±١،٩٩ يوم ثم يرقات دودة ورق القطن ٢٥،٤٦±٢،٢٧ يوم ثم بيض دودة ورق القطن٢٦،٨٣±٢،٢٤ يوم على التوالى، كما أعطى بيض فراشة الحبوب أعلى خصوبة للإناث حيث كان ٤٧١،٣٠±١٠٣،٧٤ بيضة/الأنثى يليه حوريات من القطن٣٩٢،٧٠±٨٠،٥٤ حورية ثم بيض ويرقات دودة ورق القطن(٢١٢،٤٠± ٣٥،٨٨ بيضة و٢٧٧،٦٠± ٣٦،٠٢ يرقة) على التوالى. أوضحت النتائج أن هناك إختلافات معنوية فى نسبة الفقس حيث كانت أعلى مايكون عند تغذية المفترس على بيض فراشة الحبوب ٩٢،٩٧% مقارنة بالمعاملات الأخرى . ولذلك نوصى بتربية المفترس أسد المن الأخضر على بيض فراشة الحبوب كأفضل فريسة لتحسين صفاته البيولوجية وإستخدامه فى عمليات النشر الحقلى بكميات كبيرة. أيضا تم تغذية أناث الحشرات الكاملة للمفترس على ثلاثة أنواع من خلطات البيئات الغذائية الصناعية (عسل+ فول صويا + ماء، عسل+ حبوب لقاح+ ماء وعسل+ لبن+ ماء) بالإضافة إلى الكنترول (عسل+ خميرة + ماء). أوضحت النتائج أن التغذية على الخلطة المحتوية على فول الصويا أعطت أعلى خصوبة ٣٢١,٤٠ ± ١٤,٩٢ بيضة/أنثى وأعلى كمية بيض ٥,٩٤±٠,٨٨ فى اليوم الواحد/أنثى وأيضا أعلى نسبة فقس للبيض ٩١,٤١±٧,٩٥%. بينما أعلى فترة لطول عمر المفترس كان ٩٢,١٠ ± ٩,٩٨ يوم بالنسبة لإناث المفترس و٥٦,٠٠ ± ١١,٢٦ يوم بالنسبة للذكور وذلك عند التغذية على الخلطة المحتوية على حبوب اللقاح.

**الكلمات المفتاحية:** أسد المن الأخضر، الفرائس الحشرية، فراشة الحبوب، من القطن، دودة ورق القطن الكبرى، البيئات الغذائية. المكافحة البيولوجية.