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EFFECTS OF DIFFERENT NATURAL DIETS ON THE BIOLOGY OF GREEN LACEWINGS (*CHRYSOPERLA CARNEA*) ADULTS

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Abstract

A laboratory study was conducted on rearing of adult Green lacewings, *Chrysoperla carnea* (Stephens) on different natural diets. Study was conducted under laboratory conditions to determine the better natural diet for mass rearing of adult *C. carnea*. Nine diets were tested including, D1 containing water: ground beans (10ml: 4g), D2 containing water: sugar: ground beans (10ml: 7g: 4g), D3 containing water: pollen (10ml:4g), D4 containing water: sugar: pollen (10ml:7g:4g), D5 containing water: ground oatmeal (10ml: 4g), D6 containing water:sugar: ground oatmeal (10ml: 7g: 4g), D7 containing water: ground wheat (10ml: 4g), D8 containing water: sugar: ground wheat (10ml:7g: 4g), D9 containing water: sugar: yeast (10 ml:7g:4g). The results showed that the maximum oviposition period, highest fecundity, hatching percentage, highest male and female longevity, maximum larval development period (1^{st}, 2^{nd}, 3^{rd}, 4^{th}) was recorded on D4. The Maximum larval and pupal survival percentages were recorded on D4. It is concluded that D4 water: sugar: pollen (10ml:7g:4g) was found the best one for mass rearing of adult *C. carnea*.

Key words : *C. carnea*, Natural diets, Survival, Development time.

Introduction

Agricultural crops are under attack by numerous insect pests leading to loss of quantity, quality and strength. Farmers have used the *Chrysoperla carnea* to eliminate these pests instead of using chemical pesticides as they are widely reared and eliminate small-scale pests (Ulhaq *et al.,* 2006). *C. carnea* is considered a commercially supplied products in many European countries in huge numbers against many pests that affect crops in greenhouses and in fields (Danna *et al.,* 1996; Fondren *et al.,* 2004; Hoddle and Robison, 2004). The larval stage of green lacewings is a predatory stage that feeds on many arthropods while adults that feed naturally on the nectar of flowers. Adults were successfully raised on artificial diet made from honey, yeast and pollen (Riberion and Freitas, 2000). The presence of protein is important to obtain high fecundity because it is rich in amino acids as well as honey is one of the essential supplements in the diet of adults (Zheng *et al.,* 1993; Bozisk, 1995; Hagen and Tassan, 1972; Hagen, 1986; Villenave *et al.,* 2006). There is a significant effect by the processed diet on the number of eggs and periods pre-oviposition, oviposition and post-oviposition for female (Milevon *et al.,* 1999; Adane and Gautam, 2002). In order to increase of population of green lacewings, different natural diets were used.

Materials and Methods

Rearing of *Chrysoperla carnea*

The eggs of *C. carnea* were obtained from the Agricultural Research Department of the Ministry of Science and Technology, the eggs were placed in small size glass test tubes (5×3 mm). After hatching, larvae of the same age were placed under controlled conditions (25±2°C and 60-70% humidity with a 16:8 L:D photoperiod) and reared on eggs of *Ephestia cautella* (Morrison *et al.,* 1975 ; Tauber and Tauber., 1975). Newly hatched (< 2 h) larvae were shifted with the help of fine brush to plastic tubes is finely perforated transparent (3 mm diameter, 50 mm long) provided with 0.2 g *Ephestia cautella* eggs as diet to avoid cannibalism. The diet was changed every third day until pupation. After completion of the larval period of 8-11 days these larvae pupate 7-9 days in the same transparent tubes, with the completion of the larval stages. After pupation, pupae transferred to glass Petri dishes (1.5 cm height and 9 cm dia.). The

adults were emerge within 8-10 days, which were transferred from Petri dishes to cloth cages. Daily, the artificial diet (water 10 ml : sugar 7 g :yeast 4 g) in liquid form provided to *C. carnea* adults on cotton piece placed in small size Petri dishes and 10% solution of sugar provided in cotton piece in glass vials. After emergence of adults, Identified adults paired and shifted in cloth glass for this study.

Preparation of diets

Nine different diets were tested for *C. carnea* adults. The ratio of different ingredients was measured on electric weight balance according to the composition of diets. D1 containing water: ground beans (10ml:4g), D2 containing water:sugar: ground beans (10ml:7g:4g), D3 containing water: ground pollen (10 ml:4g), D4 water:sugar: ground pollen (10ml: 7g: 4g), D5 containing water: ground oatmeal (10ml:4g), D6 containing water:sugar: ground oatmeal (10 ml:7g:4g), D7 containing water: ground wheat (10ml:4g), D8 containing water:sugar: ground wheat (10ml:7g:4g), D9 containing water : sugar :yeast (10 ml:7g:4g) were tested.

Daily observation to know the fecundity, the pre-oviposition, oviposition and post-oviposition periods, the number of eggs and hatching percentage, the larval and pupal development period, the larval and pupal survival on different natural diets were measured. The collected data for statistical analysis and statistical differences existed between data sets (P<0.01), Least Significant Differences (LSD) was used to separate the differing means (SAS., 2012).

Results

The results in table 1 indicated that the maximum pre-oviposition period was recorded as 4.70 days on diet D1 and D7 followed by 4.20,3.70, 3.50,3.40, 3.00, 3.00, 3.00 and 3.00 on diets D5,D3, D6 and D8, D2, D4, and D9 days, respectively. The maximum oviposition period was observed as 14.20 days on diet D4 followed by13.00, 11.80, 11.50, 10.80, 8.50, 7.30, 6.90 and 6.80 days on diets D6, D9 and D8, D2, D5 and D7 and D3, D1 respectively. The highest fecundity was recorded 217.40 eggs when adults fed with diet D4 followed by 188.80, 187.30, 148.70, 106.30, 99.00, 87.60, 86.90 and 79.90 on diets D6, D9, D8, D2, D3, D7, D5 and D1, respectively. The maximum post-oviposition period was observed as 2.50 days on diet D6 followed by 2.40, 2.20, 2.00, 2.00, 1.70, 1.50 and 1.40 on diets D9, D4, D2, D8, D3, D5 and D1, respectively.

Table 1: Effect of natural diets on pre, post and oviposition periods and female fecundity of *Chrysoperla carnea* under laboratory conditions.

Diets	Biological Parameters			
	Pre-oviposition Period (Days)	Oviposition Period (Days)	Post-oviposition Period (Days)	Fecundity (No. eggs/female)
D1	4.70 ± 15.0 a	6.80 ± 29.0 e	1.40 ± 16.0 de	79.90 ± 2.94 e
D2	3.00 ± 0.00 d	10.80 ± 32.0 c	2.00 ± 00.0 bc	106.30 ± 3.11 d
D3	3.70 ± 15.0 c	6.90 ± 17.0 e	1.70 ± 15.0 cd	99.00 ± 3.78 de
D4	3.00 ± 00.0 d	14.20 ± 46.0 a	2.20 ± 13.0 ab	217.40 ± 13.84 a
D5	4.20 ± 13.0 b	8.50 ± 43.0 d	1.50 ± 16.0 de	86.90 ± 3.07 de
D6	3.50 ± 16.0 c	13.00 ± 33.0 b	2.50 ± 16.0 a	188.80 ± 2.54 b
D7	4.70 ± 15.0 a	7.30 ± 39.0 e	1.20 ± 13.0 e	87.60 ± 2.76 de
D8	3.40 ± 16.0 c	11.50 ± 50.0 c	2.00 ± 00.0 bc	148.70 ± 13.30 c
D9	3.00 ± 00.0 d	11.80 ± 46.0 c	2.40 ± 16.0 a	187.30 ± 9.80 b

Different letters within a column indicate significant difference (P< 0.05).
D1: water: beans;D2: water:sugar: beans;D3: water: pollen;D4: water:sugar: pollen;D5: water: oatmeal;D6: water:sugar: oatmeal;D7: water: wheat;D8: water:sugar: wheat;D9: water:sugar: yeast.

The results in table 2 depicted the maximum period of 1st in star larva was observed as 3.70 on the diet D4 followed by 3.40, 3.30 and 3.00 days on diets D6 as well as D2 and D1 as well as D3, respectively. Similarity the maximum period 3.25 of 2nd in star larva was recorded on the diets D4 4.70 followed by 4.40 and 4.30, 4.20, 4.00, 4.00 and 3.30 on diets D2 as well as D6, D9, D7 as well as D8 and D1, respectively. The maximum 3rd instar

Table 2: Effect of different natural diet on development (larvae and pupae) of *Chrysoperla carnea* under laboratory conditions.

Life Stages (day)	Natural diet								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
1st	3.00 ± 0.00 c	3.30 ± 15.0 b	3.00 ± 0.00 c	3.70 ± 15.0 a	3.00 ± 0.00 c	3.40 ± 16.0 b	3.00 ± 0.00 c	3.00 ± 0.00 c	3.00 ± 0.00 c
2nd	3.30 ± 15.0 e	4.40 ± 16.0 ab	4.00 ± 0.00 cd	4.70 ± 15.0 a	3.70 ± 15.0 d	4.30 ± 15.0 bc	4.00 ± 0.00 cd	4.00 ± 0.00 cd	4.30 ± 15.0 bc
3rd	5.00 ± 0.00 b	5.50 ± 16.0 c	6.00 ± 0.00 b	6.40 ± 16.0 a	5.00 ± 0.00 b	6.40 ± 16.0 a	5.30 ± 15.0 cd	6.00 ± 0.00 b	6.00 ± 0.00 b
4th	6.00 ± 0.00 d	6.80 ± 24.0 b	6.00 ± 0.00 d	7.60 ± 16.0 a	6.00 ± 0.00 d	7.40 ± 16.0 a	6.00 ± 0.00 d	6.40 ± 16.0 c	7.40 ± 16.0 a
Pupa	7.90 ± 10.0 ab	6.80 ± 13.0 c	8.00± 0.00 a	6.00 ± 0.00 e	7.70 ± 15.0 b	6.40 ± 16.0 d	7.80 ± 13.0 c	7.00 ± 0.00 c	6.00 ± 0.00 e

Different letters within a column indicate significant difference (*P< 0.05*).
D1: water: beans;D2: water:sugar: beans;D3: water: pollen;D4: water:sugar: pollen;D5: water: oatmeal;D6: water:sugar: oatmeal;D7: water: wheat;D8: water:sugar: wheat;D9: water:sugar: yeast.

Table 3: Effect of different natural diet on the longevity of male and female of *Chrysoperla carnea* under laboratory conditions.

Female longevity(days)	male longevity(days)	Diets
12.90 ± 31.0 e	11.00 ± 25.0 ef	D1
15.80 ± 32.0 c	12.90 ± 37.0 d	D2
12.30 ± 33.0 e	10.50 ± 16.0 f	D3
19.40 ± 49.0 a	16.40 ± 52.0 a	D4
14.40 ± 30.0 d	12.10 ± 35.0 de	D5
18.80 ± 35.0 a	16.10 ± 48.0 ab	D6
13.20 ± 46.0 e	10.50 ± 54.0 f	D7
17.30 ± 47.0 b	14.70 ± 47.0 c	D8
16.90 ± 54.0 bc	14.90 ± 72.0 bc	D9

Different letters within a column indicate significant difference (P< 0.05).

D1: water: beans;D2: water:sugar: beans;D3: water: pollen;D4: water:sugar: pollen;D5: water: oatmeal;D6: water:sugar: oatmeal;D7: water: wheat;D8: water:sugar: wheat;D9: water:sugar: yeast.

larva period 6.40 on the diets D4 as well as D6 as compared to 6.00, 5.50, 5.30 and 5.00 on diets D3, D8, D9, D2, D7 and D1, respectively. The results further depicted that the maximum period was seen in the pupal stage as 8.00 on the diets D3 as well as D1 7.90 followed by 7.90, 7.80 and 6.00 on diets D1, D7, D5, D2,, D6 and D9, respectively.

The results in table 3 depicted the maximum male longevity was recorded on D4 16.40 followed by 16.10, 14.90, 14.70, 12.90, 12.10 , 11.00 and 10.50 days on diets D6 as well as D6, D9, D8, D2, D5, D1 and D3, respectively. While the maximum female longevity was observed on diet D4 19.40 as well as D6 18.80 followed by 17.30, 16.90, 15.80, 14.40, 13.20, 12.90 and 12.30 on diets D8 as well as D9, D2, D5, D7, D 1 and D3, respectively.

In addition, the results in (Fig.1) showed that the highest hatchability of eggs (98.10%) was recorded on D4, followed by 92%, 90.50%, 88.10%, 88%, 84.80%, 83.60%, 83.10% and on diets D6 as well as D9, D2, D8, D3, D7, D5 and D1, respectively.

The highest survival of first larval stage was 90.2% on D4 followed by 90.1%, 90%, 88.10%, 88%, 80.80% , 79.9%, 73.10% and 70.60% on diets D9 as well as D6, D2, D8, D3, D1, D5 and D7, respectively. The highest survival of second larval stage was 88.10% on D2 followed by 87.10%, 87%, 84%, 82%, 75.20% , 73.10%, 67.00% and 59.90% on diets D4 as well as D9, D6, D8, D1, D5, D3 and D7, respectively. The highest survival of third larval stage was 88.6% on D4 followed by 87.00%, 87%, 84%, 83.40%, 76% , 75.20% and 70.40% on diets D9 as well as D8, D9, D6, D2, D3, D1 and D7, respectively. The highest survival of fourth larval stage

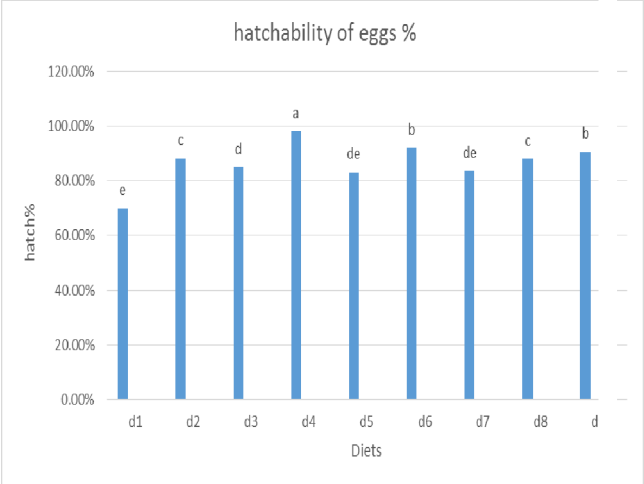

Fig.1: Effect of different natural diets on the eggs hatching percentage of *Chrysoperla carnea* under laboratory conditions.

was 93.4% on D4, followed by 92.20%, 92% , 87%, 83.40%, 76% , 75.20%, 73.10% and 70.30% on diets D9 as well as D6, D8, D2, D3, D1, D5 and D7, respectively as showed in fig. 2.

The highest survival pupal stage was 77.90% on D4 followed by 77.30% , 76%, 74%, 70.10 %, 66.20% , 63%, 61.30% and 55.40% on diets D9 as well as D6, D8, D2, D7, D5, D3 and D1, respectively (Fig. 3).

Discussion

In this study it was found that there is a relationship between adult of *C. carnea* diet and its biological functions. The dose of proteins and sugar in lacewing adults diets affects in reproductive functions and thus increases their predatory efficiency. The highest pre-oviposition period was obtained when natural diets containing water: beans (10ml:4g) ratios, and water: wheat (10ml:4g) ratios, but lowest pre-oviposition period was obtained when natural diets containing water:sugar:pollen (10ml:7g:4g) ratios, these results show that the presence of sugar with protein and water in the diet of adult increases the speed of reaching the females more than the presence of protein with water only, therefore, sugar is an important substance that increases the speed of production must be available in the diet of adult *C. carnea,* this is consistent with (Balouch *et al.,* 2016 ; Sattar., 2017).

The highest oviposition period was obtained when natural diets containing water:sugar:pollen (10ml:7g:4g) ratios, but lowest oviposition period was obtained when natural diets containing water: beans (10ml:4g) ratios, these results showed that the highest rate of ovulation was obtained from insects fed on protein, sugar and water and the lowest rate of insects fed on protein and water only that the presence of protein with sugar is more

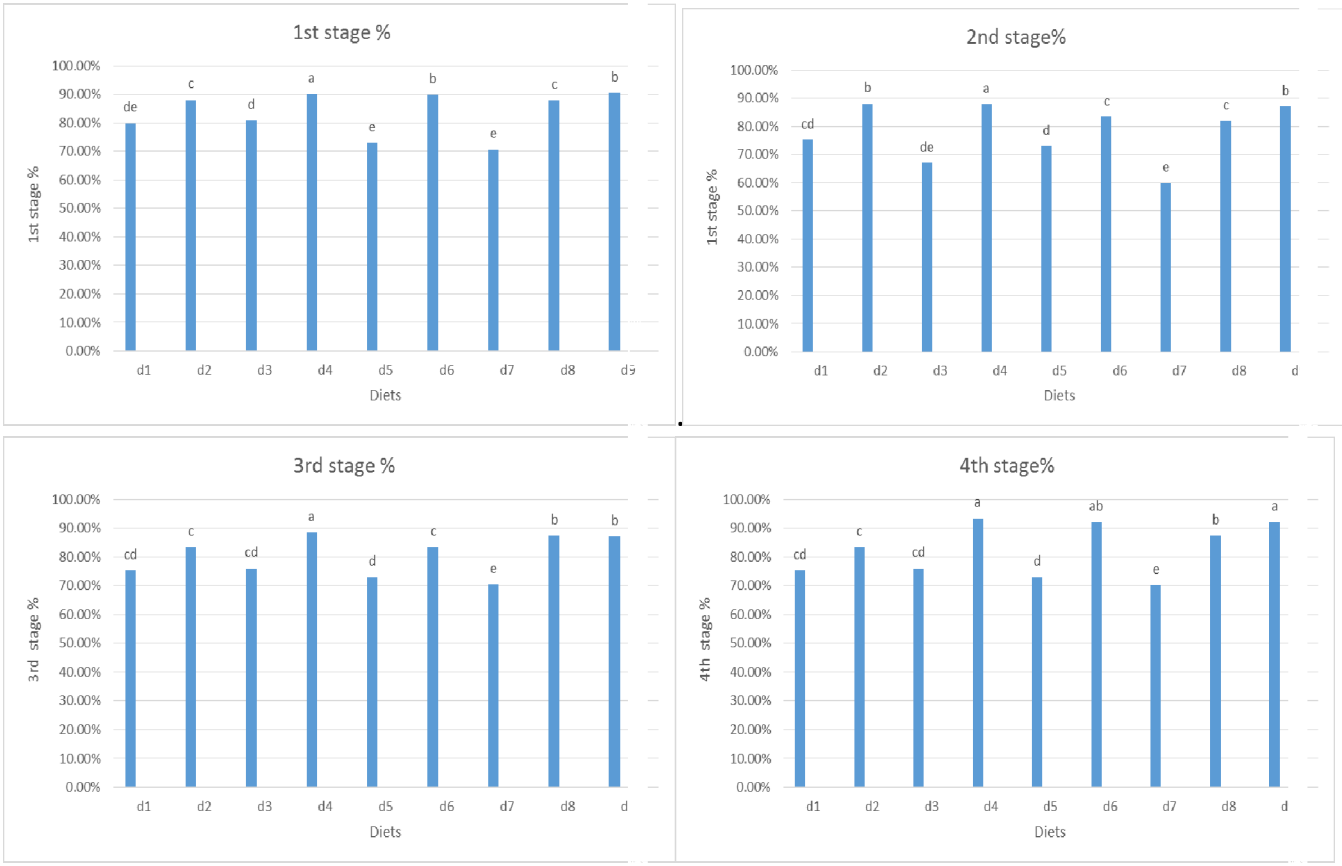

Fig. 2 : Effect of different natural diets on larvae survival (1st,2nd ,3rd,4th) stage of *Chrysoperla carnea* under laboratory conditions.

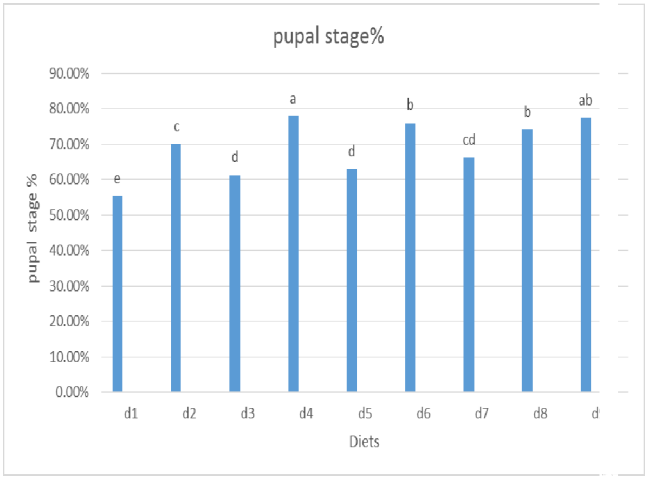

Fig. 3: Effect of different natural diets on pupal survival stage of *Chrysoperla carnea* under laboratory conditions.

effective to increase production and that pollen contains a high rate, this is consistent with (Balouch *et al.,* 2016 ; Sattar., 2017).

The highest post-oviposition period was obtained when natural diets containing water:sugar:oatmeal (10 ml:7g:4g) ratios, but lowest post-oviposition period was obtained when natural diets containing water: wheat (10ml:4g) ratios, this shows that sugar increases the life of adults and this is consistent with (Farrokhi., 2017; Sarailoo and Lazkzaei., 2014).

The highest fecundity was obtained when natural diets containing water:sugar:pollen (10ml:7g:4g) ratios, but lowest post-oviposition period was obtained when natural diets containing water: beans (10ml:4g) ratios, the results of the study showed that the highest rate of eggs was by insects, which contained protein, sugar and water, while the lowest rates were by insects, which contained only protein and water, and the presence of sugar were obtained more eggs than the presence of protein alone, this is consistent with (Ulhaq *et al.,* 2006 ; Mcewen and Kidd., 1995).

There was a correlation between larval duration and adult diet, where the highest rate of first and second larval stage was obtained when natural diets containing water:sugar:pollen (10ml:7g:4g) ratios, while maximum third and forth larval stage was obtained when natural diets containing water:sugar:pollen (10ml:7g:4g) ratios and water:sugar:oatmeal (10ml:7g:4g) ratios, therefore, pollen and oats are considered to be rich in protein and with the presence of sugar led to give the highest rate of larval phases of the predator therefore this increases the proportion of predation, this is consistent with (Sattar and

Abro., 2011). The highest pupation period was obtained when natural diets containing water:pollen (10ml:4g) ratios, but lowest pupation period was obtained when natural diets containing water:sugar:pollen (10ml:7g:4g) ratios, the shortest period of inactivity is the quickest period for obtaining adults, thus better productivity. This is obtained from exaggerations that contain protein with sugar, this is consistent with (Ulhaq *et al.,* 2006).

The natural diets containing water:sugar:pollen (10ml:7g:4g) ratios was offered as maximum longevity in males and females but the minimum longevity of males and females was recorded when natural diets containing water:pollen (10ml:4g) ratios, these results explain that the presence of protein with sugar and water gives a longer life to adult males and females thus achieving better productivity, this is consistent with (Memon *et al.,* 2016).

Studies have shown that manipulation of *C.carnea* food through artificial diet directly affects all biological parameters such as eggs number, larval period and pupation period and enhancing predation (Sattar and Abro., 2011).

The highest hatchability of eggs recorded on natural diets containing water: sugar: pollen (10ml:7g:4g) ratios but lowest hatchability of eggs recorded on artificial diets containing water: ground beans (10ml:4g) ratios, this is consistent with (Barry Dizaj *et al.,* 2012). The highest developmental percentage of larval and pupal stages were recorded on natural diets containing water: sugar: pollen (10ml:7g:4g) ratios, this is consistent with (Costa *et al.,* 2002 ; Figneira *et al.,* 2000).

Conclusion

The results of this study indicated, the adults best nutritious diet was water, suger and pollen which significantly influenced on adults both male and female enhance oviposition period, fecundity, larval period, pupae period, pre-oviposition period, eggs hatching, larval and pupal survival. From our current study, we suggest to grow flowering plants around the agricultural fields that increases the attraction of lacewing insects in order to enhance the biological control.

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