Rearing of Adult Green Lacewing, *Chrysoperla carnea* (Stephens) on Different Artificial Diets in the laboratory

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Abstract: A laboratory study was conducted on rearing of adult Green lacewing, *Chrysoperla carnea* (Stephens) on different artificial diets. Study was conducted under laboratory conditions at Department of Plant Protection, SAU, Tandojam, Sindh, Pakistan during 2013-14 to determined better artificial diet for mass rearing of adult *C. carnea*. Six diets containing water:honey:yeast i.e., D_1 (20ml:2g:2g), D_2 (20ml:4g:2g), D_3 (20ml:6g:2g), water:sugar:yeast D_4 (20ml:2g:2g), D_5 (20ml:4g:2g), D_6 (20 ml:6g:2g) and two diets containing water:gur:yeast i.e., D_7 (20ml:2g:2g), D_8 (20ml:4g:2g), D_9 (20 ml:6g:2g) were tested. The results showed that maximum pre-oviposition period (11.5 ± 3.95 days) recorded, oviposition period (18.0 ± 0.91 days) and post-oviposition period (5.0 ± 0.71 days) was recorded on D_4, D_9 and D_1, respectively. Minimum pre-oviposition period (7.25 ± 0.25 days), oviposition period (5.0 ± 1.73 days) and post-oviposition period (2.5 ± 0.87 days) was recorded on D_8, D_4, and D_7, respectively. The highest fecundity (342.5 ± 89.55 eggs) was recorded on D_9, whereas the lowest fecundity (42.5 ± 5.48 eggs) was recorded on D_4. The eggs laid by female fed on D_4 took lesser time (1.75 ± 0.66 days) to hatch. Maximum larval and pupal longevity was recorded in larvae of adults fed on D_9. The adults lived longer for 30.0 ± 0.91 days on D_9. The maximum egg hatching (55 %), larval-pupal transformation (45 %) and adults emergence (30 %) was recorded on D_9. It is concluded that D_9 was found the best one for mass rearing of adult *C. carnea*.

Keywords: *C. carnea*, Development time, Biology, Survival, Artificial diets.

INTRODUCTION

The horticultural and field crops are attacked by arthropod pests, which deteriorate the quality and quantity of yields and force. Farmers to use agrochemicals. Green lacewing, *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae) is mass-reared and used as biocontrol agent against soft bodied insect pest [1]. Its larvae feeds on insect pest of field as well as fruit crops. This predator was mass reared and augmented as biological control agents against several arthropods in American as well as European countries. It is commercially available and released as individual stages (eggs, larvae or pupae) or combined stages, according to the demand of the consumers. Adult stage of *C. carnea* mass-reared on artificial foods i.e. yeast, sugar products and water boosted their activeness at large scale [2]. Adults of *C. carnea* were successfully mass-reared when fed on artificial diets including yeast, pollen and honey [3]. The diets contained artificial ingredients significantly influenced oviposition and post-oviposition periods and fecundity of females [4,5]. However, when *C. carnea* larvae were reared on nymphs of *Shizaphis graminum, Bemisia tabaci* as well as artificial diets, significant impact was determined on fecundity, larval duration, hatchability and sex ratio (female/male). During the scarcity of natural foods the artificial diet is the best source for mass rearing of *C. carnea* [6]. The present research work was conducted on different artificial food supplements for mass rearing of *C. carnea* adults in the laboratory. The findings of present result will be beneficial for mass production and augmentation of adult *C. carnea* to regulate the insect pest populations on horticultural and field crops.

MATERIALS AND METHODS

The research experiment was conducted on "Rearing of Green lace wings, *C. carnea* on different artificial diets" during 2013-14 in the laboratory of Plant Protection Department, Sindh Agriculture University, Tandojam. The experiment was laid down as Randomized Complete Design (CRD) with five replications each having three pairs of adult *C. carnea*. These adults were confined in the glass chimney (6 cm Ø × 8 cm Ø) and placed in the petri dish (9.0 cm Ø). A small glass vial was placed inside the chimney holding cotton soaked in distilled water to maintain moisture. The upper open end of glass chimney was covered with black muslin cloth and was tightened with rubber band. The different adult diets was provided inside the glass chimney with the help of dropper on glass strips, each strip being drilled at three points to make pits for holding drops of diet. The diets were provided on daily basis to the adults. The eggs was laid by females on the walls of chimney and muslin cloth was removed

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with sharp razor and ten egg per test tube (10 × 1 cm Ø) was placed with the help of camel hair brush. The test tubes were covered with cotton swab. After hatching, the newly emerged larvae were reared on frozen eggs of *Sitotroga cerellela* (Oliver) (Lepidoptera: Gelechiidae). 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. Six diets containing water:honey:yeast i.e., D_1 (20ml:2g:2g), D_2 (20ml:4g:2g), D_3 (20 ml:6g:2g), water:sugar:yeast D_4 (20ml:2g:2g), D_5 (20ml:4g:2g), D_6 (20 ml:6g:2g) and three diets containing water:gur:yeast i.e., D_7 (20ml:2g:2g), D_8 (20ml:4g:2g), D_9 (20 ml:6g:2g) were tested. The experiment was conducted at 26±2ºC and 60±5 % RH as reported by [7]. Daily observation were carried out to know the fecundity, the duration in the days of pre-oviposition, oviposition and post-oviposition periods, the egg hatching percentage, the larval development duration, pupal duration, survival and mortality on different artificial diets. The collected data was subjected for statistical analysis and statistical differences existed between data sets (P<0.05), Fisher's Least Significant Differences (LSD) was used to separate the differing means [8].

RESULTS

The results given in Table **1** indicated that the maximum pre-oviposition period was recorded as (11.5 ± 3.95) days on diet D_4 followed by 10.75 ± 1.38, 10.0 ± 0.41, 10.0 ± 2.0, 9.0 ± 0.41, 8.0 ± 1.0, 8.0 ± 0.41, 7.25 ± 1.35 and 7.25 ± 0.25 on diets D_5, D_6 and D_7, D_2, D_3, D_1 and D_8 days, respectively. The maximum oviposition period was observed as (18.0 ± 0.91) days on diet D_9 followed by 16.5 ± 2.03, 15.0 ± 1.94, 12.5 ± 1.44, 9.5 ± 3.12 and 5.0 ± 1.73 days on diets D_3, D_7 and D_8, D_2, D_1, D_5 and D_6 and D_4, respectively. The highest fecundity was recorded 342.5 ± 89.55 eggs when adults fed with diet D_9 followed by 163.25 ± 49.40, 162.5 ± 6.37, 116.25 ± 5.39, 110.75 ± 25.81, 74.0 ± 12.42, 63.5 ± 12.59, 53.75 ± 9.28 and 42.5 ± 5.48 on diets D_8, D_7, D_7, D_3, D_1, D_6, D_5 and D_4, respectively. The maximum post-oviposition period was observed as 5.0 ± 0.71 days on diet D_1 followed by 4.5 ± 0.65, 4.0 ± 0.41, 3.75 ± 0.48, 3.5 ± 0.29, 3.0 ± 0.41 and 2.5 ± 0.87on diets D_6, D_9, D_8, D_3, D_2, D_4, D_5 and D_7, respectively. The highest adult survival (30.0 ± 0.91) days as was recorded in predators reared on the diet D_9 followed by 29.0 ± 2.69, 28.0 ± 2.65, 27.0 ± 1.29, 26.0 ± 2.55, 25.0 ± 2.80, 24.0 ± 0.41, 22.5 ± 1.50 and 19.0 ± 3.0 on diets D_7, D_3, D_8, D_2, D_1,D_6, D_5 and D_4, respectively.

The results in Table **2** depicted the maximum incubation period was observed as (6.25 ± 1.25) days of the egg laid by adult when fed on the diet D_3 followed by 5.0 ± 1.12, 4.5 ± 1.06, 4.0 ± 1.0, 3.75 ± 0.97, 3.0 ± 0.87 and 1.75 ± 0.66 on diets D_7, D_9, D_5, D_6, D_1 as well as D_2 and D_4, respectively. The data further revealed that the maximum survivorship of 1st instar larva was observed as (3.25 ± 0.90) days on the diets D_3 as well as D_3 followed by 3.0 ± 0.87 and 2.75 ± 0.83 and 1.75 ± 0.66 days on diets D_9 as well as D_1 and D_5 as well as D_6 and D_4, respectively. Similarly the maximum survivor (3.25 ± 0.90) days of 2nd instar larva was recorded on the diets D_9 as well as D_7 followed by 3.0 ± 0.87 and 2.75 ± 0.83, 2.5 ± 0.79, 2.25 ± 0.75 and 1.75 ± 0.66 days on diets D_8 as well as D_6, D_5, D_1 as well as D_3 and D_4, respectively. The 3rd instar larva lived

Table 1: Response of *Chrysoperla carnea* Adults on Different Artificial Diets Under Laboratory Conditions

Diets	Biological Parameters				
	Pre-oviposition (Days)	Oviposition (Days)	Fecundity (No. eggs/female)	Post-oviposition (Days)	Survival (Days)
D_1	7.25 ± 1.35 e	12.5 ± 1.44 d	74.0 ± 31.42 e	5.0 ± 0.71 a	25.0 ± 2.80 c
D_2	8.0 ± 1.00 d	15.0 ± 1.94 bc	110.75 ± 25.81 d	3.0 ± 0.41 c	26.0 ± 2.55 c
D_3	8.0 ± 0.41 d	16.5 ± 2.03 b	116.25 ± 5.39 c	3.5 ± 0.29 bc	28.0 ± 2.65 ab
D_4	11.5 ± 3.95 a	5.0 ± 1.73 f	42.5 ± 31.48 h	2.5 ± 0.87 c	19.0 ± 3.00 e
D_5	10.75 ± 1.38 a	9.5 ± 3.12 e	53.75 ± 23.28 g	2.5 ± 0.87 c	22.5 ± 1.50 d
D_6	10.0 ± 0.41 b	9.5 ± 0.65 e	63.5 ± 12.59 f	4.5 ± 0.65 b	24.0 ± 0.41 c
D_7	10.0 ± 2.00 b	16.5 ± 2.03 b	162.5 ± 6.37 b	2.5 ± 0.29 c	29.0 ± 2.69 a
D_8	7.25 ± 0.25 e	16.5 ± 1.55 b	163.25 ± 49.40 b	3.75 ± 0.48 b	27 ± 1.29 ab
D_9	9.0 ± 0.41c	18.0 ± 0.91 a	342.5 ± 89.55 a	4.0 ± 0.41 b	30.0 ± 0.91 a

Different letters within a row indicate significant difference (Fisher's Protected LSD test: P< 0.05).

Table 2: Mean Developmental Duration in Days of Immature Life Stages of *Chrysoperla carnea* from Females Fed on Different Artificial Diets under Laboratory Conditions

Life Stages	Artificial diets								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
Egg	3.0 ± 0.87 ijkl	3.0 ± 0.87 ijkl	6.25 ± 1.25 cd	1.75 ± 0.66 l	4.0 ± 1.00 ghi	3.75 ± 0.97 ghij	5.0 ± 1.12 defg	4.0 ± 1.00 ghi	4.5 ± 1.06 fgh
1st	2.75 ± 0.83 ijkl	3.0 ± 0.87 ijkl	3.25 ± 0.90 hijk	1.75 ± 0.66 l	2.75 ± 0.83 ijkl	2.75 ± 0.83ijkl	3.25 ± 0.90 hijk	2.75 ± 0.83 ijkl	3.0 ± 0.87 ijkl
2nd	2.5 ± 0.79 jkl	2.25 ± 0.75 kl	2.5 ± 0.79 jkl	1.75 ± 0.66 l	2.75 ± 0.83 ijkl	3.0 ± 0.87ijkl	3.25 ± 0.90 hijk	3.0 ± 0.87 ijkl	3.25 ± 0.90 hijk
3rd	2.5 ± 0.79 jkl	2.25 ± 0.75 kl	2.5 ± 0.79 jkl	1.75 ± 0.66 l	2.75 ± 0.83 ijkl	2.5 ± 0.79 jkl	3.0 ± 0.87 ijkl	3.0 ± 0.87 ijkl	2.75 ± 0.83 ijkl
Pupa	6.0 ± 1.22 cde	5.5 ± 1.17 def	4.75 ± 1.09 efg	2.5 ± 0.79 jkl	7.75 ± 1.39 ab	9.0 ± 1.50 a	8.75 ± 1.48 a	7.0 ± 1.32 bc	9.0 ± 1.50 a

Different letters within a row indicate significant difference (Fisher's Protected LSD test: *P< 0.05*).

Table 3: Egg hatching, larval-pupal transformation and adult emergence % of *Chrysoperla carnea* individuals from females fed on different artificial diets under laboratory conditions

Life stages	Artificial diets								
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
Hatch %	42.5	42.5	27.5	20.0	35.0	37.5	40.0	55.0	55.0
Pupa	17.5	20.0	15.0	12.5	30.0	30.0	32.5	45.0	40.0
Adult	17.5	12.5	10.0	7.5	17.5	22.5	20.0	27.5	30.0

for more days (3.0 ± 0.87) on the diets D_7 as well as D_8 as compared to 2.75 ± 0.83, 2.5 ± 0.79, 2.25 ± 0.75 and 1.75 ± 0.66 days on diets D_5, D_9, D_1, D_3, D_2 and D_4, respectively. The results further depicted that the maximum survivorship was seen in the pupal stage as (9.0 ± 1.50) days on the diets D_6 as well as D_9 followed by 8.75 ± 1.48, 7.75 ± 1.39, 7.0 ± 1.32, 6.0 ± 1.22, 5.5 ± 1.17, 4.75 ± 1.09 and 2.5 ± 0.79 days on diets D_7, D_5, D_8, D_1, D_5, D_3 and D_4, respectively. The result further revealed that the percentage of egg hatching, larval-pupal transformation and adult emergence was seen on different artificial diets. The data in Table **3** showed that the maximum hatching percentage was recorded 55 % on the diets D_8 as well as D_9 followed by 42.5 %, 40.0 %, 37.5 %, 35.0 %, 27.5 % and 20.0 % on diets D_1 as well as D_2, D_7, D_6, D_3 and D_4, respectively. It was further observed that the maximum pupal percentage was recorded 45 % on diet D_8 followed by 40 %, 32.5 %, 30.0 %, 20.0 %, 17.5 %,15.0 % and 12.5 % on diets D_9, D_7,D_5 as well as D_6, D_2, D_1, D_3, and D_4, respectively. The highest adult emergence was recorded as (30 %) on diet D_9 followed by 27.5 %, 22.5 %, 20.0 %, 17.5 %, 12.5 %, 10.0 % and 7.5 % on diets D_8, D_6, D_1 as well as D_5, D_2, D_3 and D_4, respectively. The analysis of variance showed that there was significant difference on diets and life stages (*P<0.05*).

DISCUSSION

The findings of present result have the conformity with McEwen and Kidd [2] who reported that *C. carnea* significantly lived longer on diet containing sugar only as compared to sugar and yeast (*P*<0.05). The highest fecundity was obtained the diet containing yeast and when artificial diets containing yeast, sugar and water (4:7:10) ratios, egg production was significantly reduced in small numbers. Our findings have partial agreements with those of Nawaz *et al*. [9] who reported that adults fed on diet contained vitamin E were found most suitable for adult *C. carnea* rearing. Both male and female adults lived longer. The same results were also achieved when adults reared on Ber honey followed by honey obtained from almond, orange and apple trees. Our findings have the partial conformity with those of Syed *et al*. [10] determined the nine diets provided to immature stages of *C. carnea,* including six

diets were containing vitamins and minerals and rest of three were natural. The result revealed that shortest total larval period 13.9 days with maximum cocoon weight (0.828 g), and fecundity were determined 717 eggs reared on Diet 9 (*S. cerealella eggs*). The highest larval duration 27.65 days were obtained on Diet 4 and maximum mortality 65%were seen on Diet 3. Sarailoo and Lakzaei [11] determined the impact of six artificial diets contained [a mixture of 30% concentrations of glucose, fructose and sucrose (1: 1: 1), glucose, fructose, sucrose plus extract of *S. cerealella* eggs (1: 1), glucose, fructose, sucrose plus extract of *A. kuehniella* eggs (1: 1), a mixture of honey, yeast and distilled water (1: 1: 1), honey, yeast plus extract of *S. cerealella* eggs (1: 1: 1) and honey, yeast plus extract of *A. kuehniella* eggs (1: 1: 1)]. The findings of this study showed that the mixture of honey, yeast and extract of *A. kuehniella* eggs (1: 1: 1), were found best results on biological aspects of the predator as compare to other diets.

CONCLUSION

The maximum pre-oviposition, oviposition and post-oviposition period was observed on diet D_4, D_9 and D_1, respectively. The highest fecundity was obtained on diet D_9, whereas, lowest on diet D_4. The minimum egg incubation period, larval and pupal development was recorded on diet D_4, whereas, maximum was recorded on diet D_9. The highest survivor of adults was seen on diet D_9, however, the lowest survivor was obtained on diet D_4. The maximum egg hatching, pupal and adult emergence percentage was observed on diet D_9, whereas, the minimum was recorded on diet D_4.

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