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Effect of Adult Nutrition on some Biological Parameters of the Green Lacewing *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae)

Salwa S. M. Abdel-Samad
Biological Control Res. Dept., Plant Protection Res. Institute, Agric. Res. Center, Giza, Egypt
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ABSTRACT

Effect of different adult diets on development of the green lacewing *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae) was studied. Four adult diets namely; (A) honey distilled water, (B) pollen grains added to honey distilled water, (C) royal jelly added to honey distilled water, (D) royal jelly and pollen grains added to honey distilled water were tested. Treatment D gave the best results for egg hatching (89.3%), larval survival rate (92.6%), pupal survival rate (95.1%), adult emergence (98.1%) and overall developmental period (egg- adult) (77%). As well, it gave the optimum results as shortest pre-ovipositional period (3.6 days), a long ovipositional period (14 days) and the shortest total developmental duration (19.3 days). Highest values of Ro (the net reproductive rate) , r_m (the intrinsic rate of natural increase) and e^{rm} (the finite rate of increase) were obtained when the predator was fed on treatment D. Rate of survival ((Lx) and maximum ovipositional rate / female /day(Mx) were high using diet D. Sex ratio deviated towards females in treatment D.

Key words: *Chrysoperla carnea*, Artificial diets, Biological parameters.

INTRODUCTION

Biological control is a permanent, safe, economic and environmental friendly control method. This safety of biological control is outstanding because many natural enemies are host-specific or restricted to a few closely related species (DeBach, 1964).

Chrysoperla carnea Stephens (Green lacewing) (Neuroptera: Chrysopidae) is a quite common predator in agricultural ecosystem in most of the world countries. The adults feed on pollen, nectar or honeydew of aphids etc. Its larvae are voracious predators of aphids, mites, thrips, mealy bugs and immature whiteflies (Abdel-Salam, 1995 and Carrillo *et al.*, 2004). It is a very useful biological control agent of such insect pests and, therefore, it needs enhancement of its population by all possible means (Amjad *et al.* 2006). Several species of chrysopids have elicited interest as biological control agents and have consequently been reared in the laboratory. Many attempts were made to use *C. carnea* in the field of biological control (Nordlund and Morrison, 1992). Moreover many laboratory studies were undertaken for rearing *C. carnea*, in order to be used for controlling insect pests (El Arnaouty, 1995 and El Arnaouty and Sewify, 1998). A high biological success of *C. carnea* was obtained when adults fed on suitable diet, a key factor in mass rearing program, (Nordlund and Morrison, 1992; Chang *et al.*, 1995 and McEwen *et al.* 1999).

For enhancing fertile egg production of the females of *C. carnea*, many authors adopted different adult diets, *e.g.* honey (White, 1992), yeast and honey (Ribeiro and Freitas, 2000), yeast and sugar (McEwen and Kidd, 1995), egg yolk and honey (Norioka *et al.*, 1984) and milk, eggs, fruit-sugar and yeast (Milevoj, 1999).

However, life table parameters are fundamental to general biology as they are insect demography. Developmental times, survival, longevity and fecundity are basic data for life table analysis (Hulting *et al.*, 1990).

The present study aimed to throw more light on the essential biological parameters of the *C. carnea,* by using novel diets for adults, which may consider very important for mass rearing of the predator.

MATERIALS AND METHODS

Experiments were conducted under laboratory conditions at the Department of Biological Control Research, Plant Protection Research Institute, Agriculture Research Center, Giza, Egypt.

Rearing of *Chrysoperla carnea*

Parent adults of *C. carnea* were obtained from "*Chrysopa* mass rearing unit" at the Faculty of Agriculture, Cairo University, Egypt. Adults of *C. carnea* were confined in glass chimneys (6 cm dia. x8 cm dia.), placed upon a Petri dish (9.0 cm. dia.) and covered with black muslin cloth on the top. Each chimney was provided with adult food and a piece of cotton soaked in distilled water, placed at the top of glass chimney over muslin cloth to maintain moisture. Eggs laid were collected and placed singly in a glass tubes (7.5 x 1 cm. dia.). A newly hatched larva in each glass tube was provided with fresh eggs of *Sitotroga cerealella* Olivier, (Gelechiidae: Lepidoptera) as a larval food. Every 2 days, fresh eggs were provided in each glass tube. This process was continued up to cocoon formation. Two pairs (2 males and 2 females) were confined in each glass chimney and provided with the tested adult diets for one generation. Female progeny from these adults (fed on four different adult diets) was separately reared as mentioned by feeding the larvae on eggs of *S. cerealella*. Adults of F_1 were fed on each of the following four different adult diets and the studied biological parameters were recorded.

Adults' regimes:

A- 5 g honey + 5 ml distilled water.

B- 1 g pollen grains + 5 g honey + 5 ml distilled water.

C- 1 g royal jelly + 5 g honey + 5 ml distilled water.

D- 1 g royal jelly + 1 g pollen grains + 5 g honey + 5 ml distilled water.

Fifteen drops of each diet were placed on separate cards (8.5W. x 6.2 L. cm), with the help of a syringe then left for 3 to 5 minutes to be semi-dried. One card of each diet was placed in a glass chimney, contained a pair of freshly emerged adults of *C. carnea*. The food cards were replaced daily with fresh ones. The eggs in each chimney were collected, counted and recorded regularly. Each of the previous 4 treatments was represented by 3 replications. The experiment was conducted at 25±2°C and 60±5 % RH as done by Ashfaq *et al.*, (2002). Daily observations were done to record; number of eggs per female(Fecundity), percent of egg hatching, percent survived larvae, larval duration, percent pupation, pupal duration, percent adult emergence and adult longevity, pre ovipositional period, ovipositional period and sex ratio. The life cycle, extended from egg deposition till adult emergence (days) was calculated.

All the previous biological parameters were statistically analyzed using a computer software program Costat (1990).

Prediction parameters

Life table data were analyzed by using the life 48 basic computer program (Abou-Setta *et al.*, 1986).

Input data for the program included name of target insect ,temperature used, number of observations, time intervals between observations, developmental time from egg to adult female as the number of observation intervals, initial number of females, fraction of eggs laid reaching maturity, sex ratio as females per total and number of eggs laid for each interval.

The program had output data included information on adult female such as: total progeny per interval (egg laying rate) (M), number of females alive at age x (L), mean female age at each interval mid-point(X), female progeny per female produced during the day x (Mx), rate of survival (Lx), the product of [(Mx) (Lx)] as (MxLx) and the final values of RML(the product of (Mx) (Lx) is then divided by the value of e (the base of natural logarithm to the power of (r_m)).

Finally, the program outputs the precise life table sheet parameters of the study as the sum of RML, the generation time (T) was calculated by [((X) (Lx) (Mx)/Ro] ,the net reproductive rate (Ro) by[((Lx) (Mx))], the doubling time (DT) resulted from dividing the normal logarithm on r_m, the intrinsic rate of natural increase (r_m) by[ln (Ro) /T] and the finite rate of increase (e^{rm}) as the natural antilogarithm of the intrinsic rate of increase and gave the number of times which the population multiplies in a unit time (doubling time, DT). Also, the sex ratio was estimated.

RESULTS AND DISCUSSION

Biological parameters of *C. carnea*

Effect of different adult diets on the biology of *C. carnea* was recorded in table (1). The data revealed that adult diet (D) which contained royal jelly, pollen grains, honey and distilled water was recorded as the best, as it recorded highest number of total eggs per female (196±11.8), with a maximum egg hatching of 175± 17.0, (89.3%), numbers of survived larvae 162± 25.6, (92.6%), numbers of pupae 154± 21.9, (95.1%), adult emergence 151±29.6, (98.1 %) and percentage of total developmental period was (77%) compared to the other tested diets. Adult diet (C) came in the second order, respective data were 174±16.5 eggs/ female, hatched 141± 16.1, (80.4 %), survived larvae 121± 22.5, (85.8%), number of pupa 111± 14.2, (91.7 %), adult emergence 108±19.0, (97.3 %) and percentage of total developmental period was (62.1%) . The diets B and A had the least total number of eggs (147±14.0 and 98±10.1) per female, egg hatching 111± 12.1 (75.5%) and 54±9.2 (55.1%), numbers of survived larvae 84.0±15.7 (75.6%), 36.0±14.1 (66.7%), number of pupae 72.0± 16.5(85.7%) and 29.0±9.2 (80.6%), number adult emerged 66.0±13.5 (91.7%) and 24.0±7.5(82.7%), and percentage of total developmental period (44.9 and 24.5%), respectively.

As shown in table (2), the duration of *C. carnea* was affected significantly by diet regimes of adults. Diet (D) recorded the shortest total duration time (19.3±0.8 days) and were (4.3±0.6, 8.1±0.9 and 6.9±0.4 days) for eggs, larval and pupal stages, respectively. On the other hand diet (A) recorded longest total duration (22.8±0.5 days) and were (4.7±0.6, 9.9±0.3 and 8.2±0.5 days) for eggs, larval and pupal stages, respectively. Diets C and B ranked in between, without significant differences between each other. They recorded (4.7and 4.3, 8.9 and

Table (I): Some biological parameters of *Chrysoperla carnea* when fed on different adult diets

Adult Regimes	Egg: Total No. of eggs /♀	Egg hatching: No.	Egg hatching: %	Larva survival: No.	Larva survival: %	Pupa survival: No.	Pupa survival: %	Adult emergence: No.	Adult emergence: %	Adult emergence: ♀	Adult emergence: ♂	% Total developmental period	Sex Ratio
A	98[d]	54[d]	55.1[c]	36[d]	66.7[d]	29[d]	80.6[c]	24[d]	82.7[b]	15[d]	9[d]	24.5[d]	0.62[ab]
B	147[c]	111[c]	75.5[b]	84[c]	75.6[c]	72[c]	85.7[bc]	66[c]	91.7[a]	35[c]	31[c]	44.9[c]	0.53[c]
C	174[b]	141[b]	80.4[b]	121[b]	85.8[b]	111[b]	91.7[ab]	108[b]	97.3[a]	64[b]	44[b]	62.1[b]	0.59[b]
D	196[a]	175[a]	89.3[a]	162[a]	92.6[a]	154[a]	95.1[a]	151[a]	98.1[a]	99[a]	52[a]	77[a]	0.65[a]
L.S.D$_{0.05}$	6.589	10.36	7.169	4.707	6.101	27.08	7.877	9.693	7.169	6.918	4.707	5.954	0.054

Means in column followed by different letters are not significantly different at 5% level of significance.
A= Honey B = Pollen + Honey C = Royal jelly + Honey D= Royal jelly+ Pollen+ Honey

Table (2): Duration (days) of the green lacewing, *Chrysoperla carnea* when fed on different adult diets

Adult Regimes	Duration (days): Egg	Larva	pupa	Total	Adult Longevity (days)	Pre-ovipositional period	Ovipositional period
A	4.7[a]	9.9[a]	8.2[a]	22.8[a]	17.9[b]	5.3±1.5[c]	7±1.7[c]
B	4.3[a]	9.4[a]	7.7[a]	21.4[ab]	20.1[ab]	4.7±0.7[bc]	9±2.6[bc]
C	4.7[a]	8.9[a]	7.3[a]	21[ab]	22.4[ab]	4.1±1.4[ab]	12±2.0[ab]
D	4.3[a]	8.1[a]	6.9[a]	19.3[b]	24.6[a]	3.6±0.5[a]	14±1.0[a]
L.S.D$_{0.05}$	2.977	3.766	3.394	2.977	5.726	1.051	3.766

Means in column followed by different letters are not significantly different at 5% level of significance.
A= Honey B = Pollen + Honey C = Royal jelly + Honey D= Royal jelly+ Pollen+ Honey

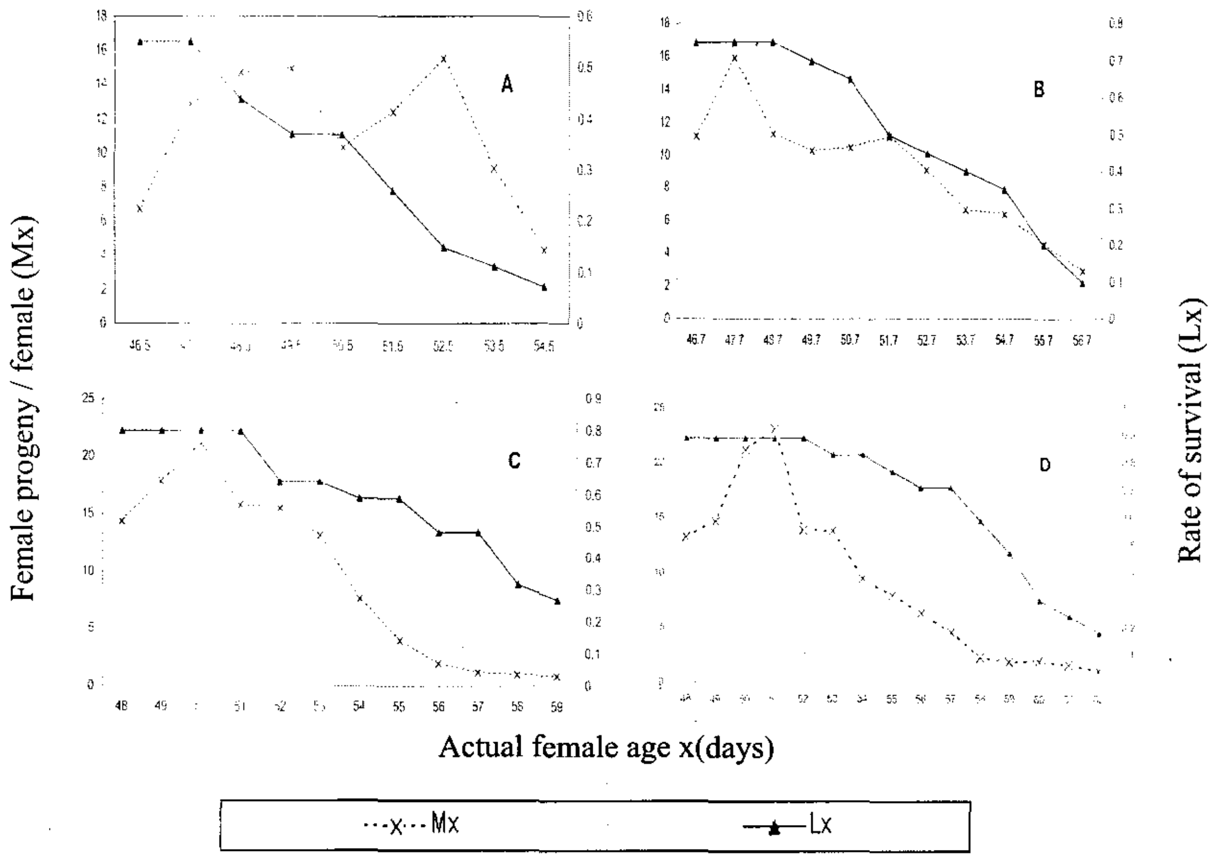

Fig. (1): Effect of tested food diets on the female progeny/female (Mx) and survival rate (Lx) of the green lacewing, *C. carnea*

9.4, 7.3 and 7.7) for eggs, larval and pupal stages, respectively .The vitality and viability of *C. carnea* females was greatly affected by essential food requirement, which encourage the adult females to start laying eggs faster. Pre-ovipositional period recorded (3.6±0.5, 4.1± 1.4, 4.7±0.7 and 5.3±1.5 days), for the D, C, B and A diets, respectively. Moreover the ovipositional period extended from 7 days in case of diet A to reach 9 days in diet B, 12 days in diet C and 14 days in diet D (Table 2).

At the same manner, longevity (life span) of adults was affected by food intake as (24.6±1.2, 22.6±0.7, 20.1±0.9 and 17.9±1.1 days) for D, C, B and A, respectively was recorded.

Biological success of *C. carnea* depends mainly upon the nutrition elements, as they are very important factors for egg production and longevity in case of many insects (Morales *et al.*, 1996). Therefore, an artificial adult diet containing royal jelly, pollen grains and honey was expected to be the best adult food regime, as it had an enhancing effect on all biological characteristics as it is considered a complete diet regime because it contained fundamental sources of protein, vitamins and carbohydrate that offer the adults the essential food requirements needed to encourage vitality and viability of *C. carnea*.

In a broad sense, the present work is consistent with the other scientific studies in spite of the fact that different sources of proteins either yeast (Ribeiro and Freitas, 2000 and Muhammad *et al.*, 2008) or egg yolk (Norioka *et al.*, 1984) or both (Milevoj, 1999) were used.

Prediction (Life table) parameters

Female progeny/ female (Mx) and rate of survival (Lx)

Figure (1) illustrates the female progeny/female (Mx) according to treatments, the highest increase was observed in females developed from newly hatched larvae with treatment D as it ranged between 1.08 to 23.18 progeny/ female. Moreover, it ranged between 0.83 to 21.08 in treatment C, 2.92 to 15.90 in treatment B and 4.34 to 15.50 in treatment A.

Concerning the (Lx) parameter (rate of survival), females treated as newly hatched larvae with diet D had survival rates ranged between 0.18 and 0.89%, while in diet C it ranged from 0.27 to 0.80%, 0.10 to 0.75% in diet B and 0.07 to 0.55% in diet A.

Generation period (T)

Results in table (3) showed that the value of generation time (T) was the longest (51.339 days), when *C. carnea* females were fed on diet D, while it was the shortest (49.096 days), when they were fed on diet A. In diets B and C, the generation period (T) was in between.

Net reproductive rate (Ro)

The diet D caused high value of reproductive rate (Ro) (113.386 females/ female in one generation, while it decreased to 82.128, 58.432 and 33.258 females/ female, when females were fed on the diets C, B and A, respectively.

Increase rate

a- Intrinsic rate of natural increase (r_m)

As shown in table (3), intrinsic rate of natural increase (r_m), the ability of inheriting increased when females were reared on the diet D and reached 0.092 fold/ female/ day. It decreased to 0.087, 0.082 and 0.071 fold/ female/ day, when the females were reared on the diets C, B and A, respectively.

b- Finite rate of increase (e^{rm})

Daily population (e^{rm}) of *C. carnea* maximum value obtained showed that the survivorship (Lx) for female age intervals was high (1.096 fold/ female/ day) on treatment D, while it was 1.091, 1.085 and 1.073 fold/ female/ day, in the diets C, B and A, respectively, (Table 3).

Doubling time (DT)

Calculated time for population to reach two fold its initial value is called doubling time (DT). It depends on the intrinsic rate of natural increase (r_m) which was affected by many factors as the rate of survival, generation time, female in progeny and fecundity. *C. carnea* population in diet D multiplied every 7.526 days (Table 3). It increased to 7.958 and 8.442 days in diets C and B, respectively. In diet A, it had the longest time (9.712 days).

The aforementioned results were in agreement with El-Serafi (2000) who reported that the total developmental time from egg hatching to adults' eclosion of two chrysopids on four aphids' species and survivorship rate (Lx) and maximum ovipositional rate per female per day (Mx) of *C. carnea* were high.

Table (3): Life table parameters of the green lacewing, *Chrysoperla carnea* when fed on different adult diets

Adult Regimes	T (days)	Ro	Increase rate r_m	Increase rate e^{rm}	DT (days)
A	49.096	33.258	0.071	1.0739	9.712
B	49.506	58.432	0.082	1.0856	8.442
C	50.491	82.128	0.087	1.0910	7.958
D	51.339	113.386	0.092	1.0965	7.526

A= Honey C = Royal jelly + Honey
B = Pollen + Honey D= Royal jelly+ Pollen+ Honey
T = generation time Ro = net reproduction rate
DT = doubling time e^{rm} = finite rate of increase
r_m = Intrinsic rate of natural increase

In conclusion, all the parameters obtained from the adult diet contained royal jelly, pollen grains and honey(diet D) seemed to be the best among all other diets for resulting highest fecundity, shortest larval and pupal periods and for longer longevity of *C. carnea* adults. This is maybe because this diet contained high proteins, lipids, carbohydrates, vitamins and minerals. Hence, this diet is recommended for mass production of *C. carnea*.

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