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Research Article

# Effect of different diets on some biological parameters of *Chrysoperla carnea* (Neuroptera: Chrysopidae)

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**Abstract:** *Chrysoperla carnea* is a voracious predator. It is currently mass-reared and released for biological control programs. This study was aimed at finding out the effect of different diets on biological characteristics of adult predator, and to introduce a better and cheaper artificial diet for its mass-rearing. In order to obtain a pure and physiologically homogenous population, the predator was reared for seven successive generations in laboratory conditions. The effect of six different diets [a mixture of 30% concentrations of glucose, fructose and sucrose (1: 1: 1);, glucose, fructose, sucrose plus extract of *Sitotroga cerealella* eggs (1: 1); glucose, fructose, sucrose plus extract of *Anagasta 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)] was studied on biological parameters (Pre-oviposition, oviposition and post-oviposition period, longevity of males and females, fecundity, egg hatchability and eggs remained in the ovary of females after death) of the seventh generation. Experiments were conducted under laboratory conditions (25 ± 2 ºC, 60 ± 10% RH and 16L: 8Dh) with four replications and five observations. Results revealed that the mixture of honey, yeast and extract of *A. kuehniella* eggs (1: 1: 1), influenced the biological traits of the predator more effectively and favorably than all other diets, considering the average longevity, oviposition period and fecundity of female (37.73 ± 0.59, 28.57 ± 1.09 days, 795.0 ± 23.05 eggs, respectively), and egg hatchability (84.98 ± 0.71 %) compared to those of other diet treatments. Minimum pre-oviposition period (6.66 ± 0.49 days) was also found in adults fed by this diet.

**Keywords**: Diet, *Chrysoperla carnea*, biological parameters, extract, *Anagasta kuehniella, Sitotroga cerealella*

## Introduction

The green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) is an important predator of soft bodied insects such as aphids, thrips, mealy bugs, immature stages of white flies, small caterpillars as well as eggs of many insects. Rearing and releasing this predator is an effective control measure for many insect pests (Tulisalo, 1984). When the adults of *C. carnea* fed on artificial diets (Yeast products, sugar and water), their populations increased to a great extent (McEwen and Kidd, 1995). The supplementary artificial diet has been shown to significantly influence oviposition, post oviposition period and fecundity of females

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(Milevoj, 1999). This method is important for mass rearing program and can be economical to reduce the costs of rearing and increasing the population of this predator (McEwen *et al.,* 1999). Not only artificial diet but also natural diets can influence adult life. According to Sarode and Sonalkar (1999), highest average pupal weight (8.42 mg), average fecundity (350.75 eggs) and adult longevity (46.50 days), were obtained when natural food, the eggs of *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae), was offered in abundance as compared to scanty food supply (25 eggs per day). Ribeiro and Freitas (2000) obtained high biological success of *C. carnea* when adults were fed on diet based on honey, yeast and pollen. Adane and Gautam (2002) examined the effects of different combinations of 50% honey solution, castor pollens and yeast on the longevity, fecundity, reproductive age and other reproductive attributes of *C. carnea*. The biological parameters varied as different food supplements offered. Nawaz *et al*. (2008) added vitamin E as a supplement to diet (honey, yeast and water). Vitamin E increased fitness of the adults of *C. carnea*. The aims of this study were to find out the effect of different artificial diets (as a supplement food) on biological parameters (Pre-oviposition, oviposition and post-oviposition periods, longevity of males and females, fecundity, egg hatchability and number of eggs remaining in the ovary of females after death) of adult predator and to introduce a better and cheaper artificial food regime with high performance for mass rearing of the predator.

## Materials and Methods

### Collection and rearing of insects

Two adult females of *C. carnea* were collected from soybean fields in Gorgan region, Iran and transferred to insectariums. To get a pure and physiologically homogeneous population, the predators were reared on *Sitotroga cerealella* (Olivier) eggs for seven successive generations before using in experiments (Barri Dizaj *et al.,* 2012). Adults were fed on yeast and sucrose (2: 1) (Faez *et al.,* 2000). The insects were maintained at 25 ± 2 ºC, 60 ± 10% RH, under a photoperiod of 16L:8D h. Experiment was done at 14L: 10D h., 25 ± 2 ºC and 60 ± 5% RH (Hatami and Sobhani (2000), Fathipour and Jafari (2004). To feed adult insects, small pieces of sponge or cotton wool balls were wetted by artificial food regimes (The treatments of present study) and hanged from roof of rearing containers. They were replaced daily to offer fresh food.

### Studied treatments

Six different combinations of artificial diets used in this research were as follows:

1. Mixture of 30% concentrations of glucose, fructose and sucrose (GFS) with the proportion of 1: 1: 1
2. Mixture of 30% concentrations of glucose, fructose, sucrose plus extract of *S. cerealella* (GFS + SC) eggs with the proportion of 1:1
3. Mixture of 30% concentrations of glucose, fructose, sucrose plus extract of *Anagasta kuehniella* (Zeller) (GFS + AK) eggs with the proportion of 1:1
4. Mixture of honey, yeast and distilled water (HYW) with the proportion of 1:1:1
5. Mixture of honey, yeast plus extract of *S. cerealella* (HY + SC) eggs with the proportion of 1: 1: 1
6. Mixture of honey, yeast plus extract of *A. kuehniella* (HY + AK) eggs with the proportion of 1: 1: 1

For extraction of eggs (1 ml of distilled water per 0.01 gr. egg), they were crushed with the help of homogenizer for 3 minutes. The obtained mixture was left for one hour in order the eggshell particles to be settled. After settlement of eggshell particles, the obtained solution was disparted gently with the help of a sampler and used as extract of eggs in the experiments. This procedure was done in laboratory at room temperature without any difficulty.

**Statistical analysis**

The experiment was conducted under Completely Randomized Design (CRD) with 4 replications. The analysis of variance (ANOVA) procedure was used using SAS software (SAS Institute, 2003) to compare the effect of treatments. The Duncan's multiple range test was used for the mean comparison.

**Results**

Analysis of variance revealed that the effect of different diets was significant on pre-oviposition, oviposition and post-oviposition periods of *C. carnea* ($p \leq 0.01$). The ranking of pre-oviposition period according to treatments was as: GFS > GFS + SC > GFS + AK > HY + SC > HYW > HY + AK (Table 1). The results also revealed that the pre-oviposition period was maximum (26.4 days) in GFS. The minimum pre-oviposition period (6.66 days) was obtained in HY + AK, where, honey + yeast + extract of *A. kuehniella* eggs were offered to the predator and this combination did not show significant difference with HYW where, honey + yeast + water were offered as diet. The pre-oviposition period (12.15 days) in GFS + AK did not differ significantly from HY + SC and GFS + SC (10.68 and 13.68 days), respectively. The treatment HY + SC showed significant difference with GFS + SC.

**Different food regimes**

The maximum oviposition period (28.57 days) was obtained in HY + AK (Table 1), showing significant difference with other treatments. The oviposition period in HYW (23.68 days) did not differ significantly from HY + SC (21.5 days). The oviposition period in other treatments [GFS + AK (12.84 days), GFS + SC (5.75 days) and GFS (1.73 days)] showed significant differences among themselves. On the basis of these results, it is clear that yeast and egg extract of *A. kuehniella,* as supplement diet prolonged the oviposition period of *C. carnea*. The results (Table, 1) indicated that maximum post-oviposition period (9.52 days) was observed in GFS + AK, followed by GFS + SC, GFS and HY + Ak (3.75, 3.5 and 3.06 days), respectively. The minimum post-oviposition period (1.72 days) was recorded in HYW, that did not show significant difference with HY + SC.

**Longevity of males and females**

The egg extract of *A. kuehniella* + GFS offered as a artificial diet resulted in maximum longevity (40.0 days) in females, followed by 37.73 and 36.1 days in HY + AK and GFS, respectively. The last two treatments had no significant differences with HY + SC (32.73 days) and HYW (32.35 days). The minimum longevity (26.35 days) of females was observed in GFS + SC (Table 1). Similarly, the egg extract of *A. kuehniella* (GFS + AK) as a supplement diet was offered to the males. It proved to be the most suitable diet which resulted in maximum longevity (49.7 days) in males, followed by HY + AK (45.73 days). The minimum longevity of males was recorded to be 32.8 days in GFS + SC and this combination did not show significant difference with GFS (38.35 days). The treatment HYW did not show significant difference with HY + SC.

**Fecundity**

The maximum average number of eggs (795.0 eggs per female) was found in HY + AK and differed significantly from others. The minimum fecundity (3.26 eggs per female) was observed in GFS, followed by GFS + SC and GFS + AK (11.9 and 24.5 eggs), respectively. The number of eggs laid by *C. carnea* female in HY + Sc and HYW was 534.61 and 414.89 eggs, respectively. Other treatments did not show significant differences.

**Table 1** Effect of different diets on biological parameters of *Chrysoperla carnea* under laboratory conditions.

| Parameters | GFS[1] | GFS + SC[1] | GFS + AK[1] | HYW[1] | HY + SC[1] | HY + AK[1] |
|---|---|---|---|---|---|---|
| Pre oviposition period (day)[2] | 26.4 ± 1.05[a] | 13.684 ± 0.34[b] | 12.154 ± 0.53[bc] | 7.304 ± 0.60[d] | 10.684 ± 0.55[c] | 6.664 ± 0.49[d] |
| Oviposition period (day)[2] | 1.734 ± 0.34[e] | 5.754 ± 0.33[d] | 12.844 ± 0.58[c] | 23.684 ± 0.92[b] | 21.54 ± 0.53[b] | 28.574 ± 1.09[a] |
| Post oviposition period (day)[2] | 3.504 ± 0.46[b] | 3.754 ± 0.16[b] | 9.524 ± 0.41[a] | 1.724 ± 0.17[d] | 1.894 ± 0.17[cd] | 3.064 ± 0.24[bc] |
| Longevity of female (day)[2] | 36.14 ± 1.02[ab] | 26.354 ± 1.35[c] | 40.04 ± 1.17[a] | 32.354 ± 1.03[b] | 32.734 ± 0.80[b] | 37.734 ± 0.59[ab] |
| Longevity of male (day)[2] | 38.354 ± 0.96[cd] | 32.84 ± 1.36[d] | 49.74 ± 0.90[a] | 42.94 ± 1.08[bc] | 39.734 ± 1.10[c] | 45.734 ± 0.89[ab] |
| Fecundity (egg)[2] | 3.264 ± 0.23[d] | 11.94 ± 0.33[d] | 24.54 ± 0.74[d] | 414.894 ± 7.49[c] | 534.614 ± 17.72 | 795.04 ± 23.05[a] |
| Egg viability (%) | 78.944 ± 2.28[ab] | 68.764 ± 1.72[bc] | 76.814 ± 1.77[ab] | 76.24 ± 2.75[ab] | 64.214 ± 1.36[bc] | 84.984 ± 0.71[a] |

[1] For abbreviations see Materials and Methods.
[2] Means followed by the same letter in each row are not significantly different (Duncan's multiple range test, $p < 0.05$).

**Egg hatchability**

The maximum egg hatchability was recorded in HY + AK. It differed significantly from GFS + SC (68.76%) and HY + SC (64.21%). The latter was statistically different with others. Other treatments did not show significant differences.

**Eggs remained in the ovary of females after death**

Similar to other parameters, analysis of variance showed significant differences ($p \leq 0.01$) on number of eggs remaining in the ovary of females fed on different diets

The maximum number of eggs in ovary (47.46 eggs) was recorded in HY + AK, whereas, the minimum number of eggs in ovary was observed in GFS (1.3 eggs), followed by GFS + SC and GFS + AK (1.85 and 3.8 eggs) treatments respectively. The number of remaining eggs in ovary of female due-to HY + SC and HYW was 27.94 and 24.05 eggs, respectively, that were significantly different**.**

**Discussion**

When adults emerge, their gonads have not yet developed well and therefore can not mate and lay eggs. The time needed for both sexes to obtain their reproduction ability, depend on species, temperature, relative humidity, light duration, quality and quantity of food available (Canard and Principi, 1984), oviposition period (Canard and Principi, 1984; Rousset, 1984). Post-oviposition period (Nawaz *et al.,* 2008), fecundity and longevity of adults (McEwen and Kidd, 1995; Canard and Principi, 1984; Rousset, 1984; Ulhaq *et al.,* 2006 and Usman *et al.,* 2006) also depend on those same factors.

According to the results obtained by Ulhaq *et al*. (2006); Usman *et al*. (2006); Rousset, (1984); Canard and Principi (1984), high protein (amino acids), lipids, carbohydrates, minerals, vitamins and cholesterol in food, increased the longevity and fecundity of *C. carnea* adults.

In this experiment the egg extracts of *S. cerealella* and *A. kuehniella* were used as a food supplement. These extracts contain protein and lipid that are expected to have favorable effects on all parameters measured. The HY + AK diet increased fecundity of *C. carnea* (around twice). It also had the best outcome on longevity of female, pre-oviposition, oviposition periods and eggs hatchability. Similar results were obtained by Barri Dizaj, *et al.* (2012), as the average longevity (51.85 days) of adult females, average oviposition period (46.71 days), average fecundity (917.71

eggs) and average weight (9.03 mg) of pupa were increased significantly, when the adults were fed on eggs (only eggs) of *S. cerealella*, as compared to those reared on dead bodies of *S. cerealella* (45.00 days, 41.00 days, 891.83 eggs, 6.02 mg, respectively), cotton green aphids (41.66 days, 36.83 days, 800.83 eggs, 8.33 mg, respectively) and citrus mealy bugs (48.42 days, 44.85 days, 905.57, 7.74 mg, respectively). It proves that eggs contain some valuable materials which have positive effects on some biological parameters of insects. The maximum number of eggs remained in ovary (47.46 eggs per female) was recorded in HY + AK. by getting the ratio between total number of eggs laid and genesis of eggs, it is understood that the females fed on GFS, were able to lay significantly less eggs than in other treatments. Similarly, HY + AK and HY + SC, highly increased the fecundity of *C. carnea*, but decreased the egg hatchability.

In this research for the first time, we studied the effects of egg extracts of *S. cerealella* and *A. kuehniella*, on biological parameters of *C. carnea* adults. Therefore, to find out undesirable effects of *S. cerealella* egg extract, it requires further studies using different combinations of extracts.

As the eggs of *S. cerealella* and *A. kuehniella* are used in laboratories and insectariums for rearing the larvae of lace wing, the results obtained here can be very useful, as they will be able to increase the yield and consequently reduce the cost of production.

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# اثر رژیم‌های غذایی مختلف روی برخی از فراسنجه‌های زیستی بالتوری سبز، *Chrysoperla carnea* (Neuroptera: Chrysopidae)

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**چکیده:** بالتوری سبز *Chrysoperla carnea* شکارگر حریصی است که جهت مهار زیستی آفات به‌طور انبوه پرورش و تکثیر می‌شود. این پژوهش به‌منظور بررسی تأثیر رژیم‌های غذایی مختلف بر ویژگی‌های زیستی حشرات کامل و یافتن غذایی بهتر و ارزان‌تر برای پرورش انبوه آن انجام شد. به‌منظور خالص‌سازی شکارگر و همگن کردن آن ازنظر فیزیولوژیک، شکارگرهای جمع‌آوری شده به‌مدت ۷ نسل متوالی پرورش یافتند. ویژگی‌های زیستی حشرات کامل نسل هفتم تحت تأثیر شش رژیم غذایی مختلف شامل مخلوط ۱: ۱: ۱ غلظت‌های ۳۰ درصد گلوکز، فروکتوز و ساکارز، مخلوط ۱: ۱: ۱ غلظت‌های ۳۰ درصد گلوکز، فروکتوز و ساکارز به اضافه‌ی عصاره‌ی تخم بید غلات *Sitotroga cerealella*، مخلوط ۱: ۱: ۱ غلظت‌های ۳۰ درصد گلوکز، فروکتوز و ساکارز به‌اضافه‌ی عصاره‌ی تخم شب‌پره‌ی مدیترانه‌ای آرد *Anagasta kuehniella*، مخلوط ۱: ۱: ۱ عسل، مخمر و آب مقطر، مخلوط ۱: ۱: ۱ عسل، مخمر و عصاره‌ی تخم بید غلات و مخلوط ۱: ۱: ۱ عسل، مخمر و عصاره‌ی تخم شب‌پره‌ی آرد مورد بررسی قرار گرفت. آزمایش با ۴ تکرار انجام شد. نتایج نشان دادند که رژیم غذایی عسل، مخمر و عصاره‌ی تخم شب‌پره‌ی آرد (۱:۱:۱)، از رژیم‌های غذایی دیگر بهتر بود. میانگین طول عمر حشرات ماده (۰/۵۹± ۳۷/۷۳ روز)، طول دوره‌ی تخم‌ریزی (۱/۰۹ ± ۲۸/۵۷ روز)، میزان باروری (۲۳/۰۵ ± ۷۹۵/۰ تخم) و درصد تفریخ تخم‌ها (۰/۷۱ ± ۸۴/۹۸ درصد) در این رژیم غذایی از سایر رژیم‌های غذایی مورد استفاده، در سطح احتمال یک درصد بیش‌تر بود. همچنین، در حشرات تغذیه شده از این رژیم غذایی، طول دوره‌ی پیش از تخم‌ریزی (۰/۴۹ ± ۶/۶۶ روز) به‌طور معنی‌داری نسبت به سایر حشرات مورد آزمایش کوتاه‌تر بود.

**واژگان کلیدی**: *Chrysoperla carnea*، رژیم غذایی، پارامترهای زیستی، عصاره‌ی تخم