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***Short Communication***

# Comparative Effect of Various Diets on Development of *Chrysoperla carnea* (Neuroptera: Chrysopidae)

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## ABSTRACT

Nine diets were offered to *Chrysoperla carnea* larvae; out of those six diets were comprised of minerals and vitamins and remaining three were natural. Developmental time, mortality percentages, pupal weight and laid eggs were determined. Except for eggs of *Sitotroga cerealella* and chicken liver, all other diets were presented in the form of semi-solid bolls. Minimum total duration (13.9 d), total mortality (15%) and pre-oviposition period (3.4 d) along with maximum cocoon weight (0.828 g) and eggs laid (717 eggs) were recorded when eggs o f *S. cerealella* (diet 9). Diet 4 showed a maximum total duration (27.65 d) and diet3 resulted in maximum (65%) total mortality.

**Key Words:** *Chrysoperla carnea*; Chicken liver; Vitamins; Minerals; Growth

## INTRODUCTION

The genus *Chrysoperla* contains a number of important insect predators of which *Chrysoperla carnea* and *C. rufilabris* are widely distributed (Agnew *et al*., 1981; Tauber & Tauber, 1983). The effectiveness of *C. carnea,* as a biological control agent, has been demonstrated in the fields as well as in the orchards and green house (Hagley & Miles, 1987).

The predaceous larvae feed on their prey by sucking its body fluids through their sickle-shaped mouth parts. However, rearing systems that rely on insects, as the food supply, are expensive. Thus, efforts to develop artificial diets for genus *Chrysoperla* as well as the techniques for presenting that diet to the larvae began quite early. As such, Vanderzant (1969) reported a diet when presented to larvae *via* saturated pieces of cellulose sponge, produced 50-65% adults from the larvae and 85% from the *Sitotroga cerealella* eggs. Encapsulation of the diet, in an "artificial egg", is one solution. Hagen and Tassan (1965) developed a hand-made wax-capsule that was used successfully to rear *C. carnea* from the egg to the pupa. Although Cohen (1983) further mechanized the technique, the total production remained low. Ridgeway (Martin *et al*., 1978) was responsible for the development of a sophisticated device, capable of encapsulating.

In the present study, larvae of *C. carnea* were reared on different diets for the purpose of mass production. These diets contained yeast and egg-yolk (Scobba & Zibordi, 1985), choline chloride, ascorbic acid (Hagen & Tassan, 1965), honey, fresh milk (Pomonareva, 1971), cholesterol, nicotinamide, folic acid, biotin, riboflavin, Vitamin B12 (Vanderzant, 1973), cyanocobalamine, retinyl palmitate, thiamine hydrochloride [AIN vitamine Mixture 76] (Cohen, 2004) potassium hydrogen phosphate, potassium sulfate, magnesium sulfate, potassium citrate, potassium iodide, copper sulfate, zinc carbonate, sodium fluoride, ferric phosphate, cupric carbonate [Wesson salt mixture, AIN Mineral Mixture 76] (Cohen, 2004), a vitamin complex (Zaki & Gesraha, 2001) as well as chicken liver (Khan & Khan, 2002). In the present study six artificial diets offered to check the effect of minerals and vitamins. For that vitamins and minerals were used separately and in complex form. Sources of these vitamins and minerals were both natural and artificial and their combined effect was determined. Diet presentation was also the main feature of these experiments. The main objective was the preparation and presentation of artificial diets in a very easy way so this predator could be reared anywhere.

## MATERIALS AND METHODS

All the experiments were conducted under a completely randomized design (CRD). There were nine treatments, having four replications, with five larvae each, fed at 25±2°C and 65±5% RH. For each treatment, a larval rearing tray with fixed vials (3.8 cm x 1.7 cm) was used. Newly hatched larvae were fed separately in vials, which were tightly covered in order to avoid their escape. For each diet data was recorded for the larval and pupal mortality, total mortality upto adult emergence, total duration up to adult emergence, cocoon weight, pre-oviposiotion period and number of eggs produced.

Adults reared from various diets were used for

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calculating pre-oviposition time and eggs laid. For each treatment, five pairs of adults were checked. Adults were reared in glass burneys (6.3 cm×10.5 cm×11.6 cm). Top of glass burneys were covered with black linen cloth (13.0 cm×13.0 cm), while the lower portion was placed in a Petri dish (9.2 cm×1.0 cm), containing a feeding rod (1.8×3.7 cm), with three holes each 0.7 cm apart and a water soaked cotton vial (3.0 cm×1.8 cm). The replacement of adult diet and the removal of eggs, laid on the cloth as well as on the wall of burneys, were carried out daily regularly. Adult diet was yeast, honey and water 1:1:1 ratio).

**General methodology for the preparation of larval diets.** Solid ingredients, in all diets, were mixed thoroughly and ground to a fine paste, with the help of an electric grinder; Yeast and honey were mixed either with the whole egg or with the yolk as per requirement of each recipe. Homogenized solid-ingredients were added to the mixture of egg, yeast and honey and beaten well with an electric egg-beater to a homogenous mixture. Vivioptal (vitamin & mineral supplement) available in a homogenized liquid form was enclosed in a gelatin capsule and used as per requirement of the recipe. All liquid diets were made into semi-solid balls, by pouring drops on a layer of powdered milk, in a petri dish leaving there for 30 sec., followed with a careful lifting of the semi-solid pellets and their separate shifting to the vials. Each diet was replaced after an interval of 24 h. Details of diets are given below:

**Diet 1.** Yolk 2 g, vivioptal 0.45 g, honey 2 g, cholesterol 0.5 g.

**Diet 2.** Whole egg 12 g, cholesterol l 0.5 g, vivioptal, 0.45 g, cupric carbonate 3.6 g, cholesterol 5 g, yeast 2 g.

**Diet 3.** Potassium hydrogen phosphate 3.72 g, potassium sulfate 0.624 g, magnesium sulfate 1.08 g, potassium citrate 64 g, potassium iodide 0.0006 g, copper sulfate 4.66 g, zinc carbonates 3.6 g, sodium fluoride 0.007 g, ferric phosphate 0.17 g, calcium pentothenate 0.012 g, honey 5 g.

**Diet 4.** Vivioptal 0.45 g, yeast 2 g, honey 5 g, cholesterol 0.5 g, fresh milk 12 mL.

**Diet 5.** Ascorbic acid 12.15 g, inositol 0.9 g, cyanocobalamine 0.0005 g, retinyl palmitate 0.725 g, thiamine hydrochloride 0.01125 g, yeast 2 g, choline chloride 0.5 g, whole egg 12 g.

**Diet 6.** Ascorbic acid 12.15 g, inositol 0.9 g, cyanocobalamine 0.0005 g, retinyl palmitate 0.725 g, thiamine hydrochloride 0.01125 g, choline chloride 0.5 g, potassium hydrogen phosphate 3.72 g, potasium sulfate 0.624 g, magnesium sulhate 1.08 g, potassium citrate 2.64 g, potassium iodide 0.0006 g, copper sulfate 4.66 g, zinc carbonate 3.6 g, sodium fluoride 0.007 g, ferric phosphate 0.17 g, calcium pentothenate 0.012 g, cupric carbonate 3.6 g, cholesterol 0.5 g, whole egg 24 g, yeast 4 g, honey 5 g.

**Diet 7.** Chicken liver, vinegar. Chicken liver was meshed well and vinegar was sprinkled on it. It was placed in refrigerator for an hour before using as larval diet.

**Diet 8.** Chicken liver. With the help of fine blade, chicken liver was sliced into smaller pieces and directly used as diet.

**D9 (control).** Eggs of Sitotroga cerealella. Data were analyzed using one-way Anova and means were compared through DMR test.

## RESULTS

Table I shows that during 1st larval instar ($L_1$) minimum duration days were observed in diet 7 (2.25 d) and diet 9 (2 d) and maximum in diet 4 (5.05 d) and diet 1 (4.8 d). Percent mortality in this instar was statistically similar in all diets. In 2nd instar ($L_2$) minimum duration days were observed in diet 8 (3.9 d) and diet 9 (3.6 d) and maximum in diet 4 (7.45 d). Highest mortality was observed in diet 7 (30%), while in rest of the diets percent mortality was statistically similar. In 3rd instar ($L_3$) minimum duration days were observed in diet 9 (3.95 d) and maximum in diet 5 (7.2 d) and diet 7 (6.95 d). Highest percent mortality was observed in diet 3 (50%) followed by diet 4 (30%) and diet 6 (20%).

Table II shows that diet 9, with highest pupal weight (0.828 g), laid eggs (717 eggs) and minimum total duration up to adult emergence (13.9 d), percent mortality up to adult emergence (15%) and pre-oviposition period (3.4 d), was the best of all diets. Diet 8 was next to this diet. Among artificial diets diet 3 with maxinim pupal weight(0.811 g), laid eggs (672.2 eggs) and minimum pre-oviposition period(3.4 d) and total duration up to adult emergence (23.3 d) but this diet showed highest percent mortality up to adult emergence (65%).

**Table I. A comparison of means for the interactions between larval instars ($L_1$ to $L_3$) and different diets ($D_1$ to $D_9$), at 25±2°C and 60±5% RH**

| Treatments | Duration (days) | Mortality (%) |
|---|---|---|
| $L_1D_1$ | 4.80ef | 15.0bc |
| $L_1D_2$ | 3.90gh | 5.0c |
| $L_1D_3$ | 4.70ef | 15.0bc |
| $L_1D_4$ | 5.05def | 10.0c |
| $L_1D_5$ | 4.75ef | 15.0bc |
| $L_1D_6$ | 3.90gh | 5.0c |
| $L_1D_7$ | 2.25i | 5.0c |
| $L_1D_8$ | 3.40h | 5.0c |
| $L_1D_9$ | 2.00i | 0.0c |
| $L_2D_1$ | 6.90a | 10.0c |
| $L_2D_2$ | 5.55bcd | 0.0c |
| $L_2D_3$ | 5.80bc | 5.0c |
| $L_2D_4$ | 7.45a | 5.0c |
| $L_2D_5$ | 5.60bcd | 10.0c |
| $L_2D_6$ | 4.50fg | 0.0c |
| $L_2D_7$ | 5.95b | 30.0b |
| $L_2D_8$ | 3.90gh | 10.0c |
| $L_2D_9$ | 3.60h | 5.0c |
| $L_3D_1$ | 4.45fg | 15.0bc |
| $L_3D_2$ | 5.70bc | 15.0bc |
| $L_3D_3$ | 5.30cde | 50.0a |
| $L_3D_4$ | 6.05b | 30.0b |
| $L_3D_5$ | 7.20a | 15.0bc |
| $L_3D_6$ | 5.90bc | 20.0bc |
| $L_3D_7$ | 6.95a | 0.0c |
| $L_3D_8$ | 5.00def | 0.0c |
| $L_3D_9$ | 3.95gh | 5.0c |

Means (compared by DMR Test) sharing same letter in a column are not significantly different at $\alpha$ =5%

**Table II. Comparison of means for the interactions between total duration up to the adult emergence, pupal mortality(%), percent-mortality up to adult emergence, pupal-weight (x100), the pre-oviposition period and number of eggs and different diets ($D_1$ to $D_9$) at 25±2°C and 60±5% RH**

| Diets | Total duration up to the adult emergence | Pupal mortality (%) | Mortality up to adult emergence (%) | Pupal-weight (×100 g) | Pre-oviposition period | Number of eggs |
|---|---|---|---|---|---|---|
| $D_1$ | 24.10 C | 10.00 | 50abc | 0.374c | 8.8a | 256.0f |
| $D_2$ | 23.30 C | 10.00 | 30bcd | 0.622ab | 5.2c | 434.4d |
| $D_3$ | 23.75 C | 5.000 | 65a | 0.811a | 3.4e | 672.2b |
| $D_4$ | 27.65 A | 0.000 | 55ab | 0.494c | 6.6b | 360.2e |
| $D_5$ | 25.47 B | 5.000 | 55ab | 0.549b | 6.2b | 355.6e |
| $D_6$ | 23.10 C | 0.000 | 25cd | 0.672ab | 4.4cd | 582.0c |
| $D_7$ | 21.35 D | 0.000 | 35bcd | 0.711a | 5.2c | 428.6d |
| $D_8$ | 17.55 E | 1.00 | 20d | 0.730a | 3.6de | 677.6b |
| $D_9$ | 13.90 F | 10.00 | 15d | 0.828a | 3.4e | 717.0a |

Means (compared by DMR Test) sharing same letter in a column are not significantly different at α =5%

## DISCUSSION

The present studies were conducted to evaluate the effect of different diets mainly composed of minerals and vitamins on the growth rate of *C. carnea*. Results showed that these diets act differently and growth rate differ significantly. Vanderzant (1969) reported an improved artificial diet for larvae and adults of *C. carnea*. The diet was based on casein hydrolysate, soy hydrolysate, yeast hydrolysate, sucrose, casein, $K_2HPO_4$, $NaH_2PO_4.H_2O$, $MgSO_4.7H_2O$, $FeSO_4.7H_2O$, soybean, lecithin and oil, cholesterol, B-vitamins, choline, inositol and water. Total larval period of *C. carnea* was 17–20 days. In the present studies when a combination of minerals (diet 3) was used the total duration up to adult emergence was 23 d. The diet was further improved by adding some vitamins (diet 6) but the result obtained was non-significant, which showed that addition of vitamins did not improve the condition. When vitamins were used alone (diet 5) the duration was 25 d. This indicated that this insect needs minerals along with vitamins for faster growth.

Pomonareva (1971) developed a larval diet for *C. carnea*. The diet consisted of dried ground adults of *S. cerealella*, honey, autolyzed brewer's yeast and fresh milk. Larval development took 17 d. In the present studies eggs of *S. cerealella* (diet 9) completed this duration in just 13 d. Cai *et al*. (1985) successfully reared larvae *C. septempunctata* on the artificial diets. The larval diet was mainly based on the soybean hydrolysate with yeast. The larval period and adult emergence rate, on this diet, were found to be 10.9 – 15.8 d and 62.5–91%, respectively as compared to 17.9 d and 62.5%. Cohen and Smith (1998) developed an artificial diet for the rearing of *C. rufilabris*. The protein, lipid, carbohydrate and water contents of the diet were kept to be 17, 15, 5 and 62%, respectively. The cholesterol contents were 2600 mg $Kg^{-1}$ of the diet. Fifteen continuous generations of Chrysoperla rufilabris, were produced on this diet. The larval period was 10.9 ± 0.15 days. Zaki and Gesraha (2001) prepared a semi-artificial diet based on the *Chlorella vulgaris* algae for the larvae of *C. carnea*. The larval duration was extended up to 30 d and they failed to pupate, when fed on water extract of algae. The addition of carbohydrates, salts and vitamins, was found necessary for the larvae to complete their development. In the present studies chicken liver was used and the duration up to adult emergence was 17 d.

In summary, it is possible to rear this predator on different diets, among, which chicken liver seemed to be more easily handled diet while for other diets semi-solid balls preparation was quiet successful.

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