



Biological Performance and Predatory Capacity of *Chrysoperla carnea* Fed on *Corcyra cephalonica* and *Sitotroga cerealella* Eggs

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Abstract: *Chrysoperla carnea*, a globally important generalist predator, is a key biological control agent in Integrated Pest Management (IPM). To optimize its mass-rearing for effective field release, we investigated the suitability of two alternative host eggs: the rice moth, *Corcyra cephalonica*, and the Angoumois grain moth, *Sitotroga cerealella*. The study evaluated *C. carnea*'s biological performance and predatory capacity under controlled laboratory conditions ($26\pm 2^{\circ}\text{C}$; $65\pm 5\%$ R.H). Developmental parameters (incubation, larval, pre-pupal, pupal, and total development time), larval consumption rates, and adult longevity parameters (pre-oviposition, oviposition, post-oviposition periods, and fecundity) were assessed. *C. carnea* exhibited a significantly shorter total developmental duration when reared on *S. cerealella* eggs compared to *C. cephalonica* eggs. Additionally, the consumption rates of larval instars were significantly higher when fed on *S. cerealella* eggs. These findings highlight that the nutritional quality of the host significantly impacts the predator's biological traits and predatory efficiency. Evaluating host suitability is crucial for optimizing mass production protocols, suggesting that *S. cerealella* eggs are a more favorable alternative host for the efficient mass-rearing and enhanced effectiveness of *C. carnea* in IPM programs.

Keywords: Biological control, Integrated Pest Management (IPM), Agroecosystems and Predator

1. Introduction

Chrysoperla carnea (Stephens), or the green lacewing, is a worldwide predator of huge ecological and economical importance to agroecosystems. It is considered to be one of the most effective biological control agents that are used in Integrated Pest Management (IPM) because of its larval feeding on a broad spectrum of soft-bodied insect pests, especially aphids, whiteflies, mealybugs, thrips and larvae of lepidopterans (Gaber and El-Rahman, 2025). This polyphagous feeding capacity is an important aspect in minimizing pest occurrences without depending upon synthetic insecticides, thus supporting sustainable agriculture. Economically, mass rearing and increase of *C. carnea* are extensively practiced due to its tolerance, superior reproductive capacity, and robustness under laboratory and field conditions (Steenbergen *et al.*, 2018). Its predatory efficacy translates directly into enhanced crop output and lower production expenses, while at the same time preventing the ecological dangers of chemical pest management. In that respect, determining the feeding capability of

C. carnea on alternative host eggs *Corcyra cephalonica* and *Sitotroga cerealella* not only gives a baseline for mass rearing approach but also offers insights that can be used to improve biological control programs within IPM systems (Villa *et al.*, 2016; Jan *et al.*, 2025).

The biological traits of *Chrysoperla carnea* are at the core of its efficacy as a biological control agent. Its short developmental time makes it suitable for building a population in a brief period, thus ensuring timely synchrony with pest infestation in agricultural fields. It possesses high fecundity and long ovi-position potential to produce uninterrupted supplies of predatory larvae to build a persistent population pressure on pests (Braghini *et al.*, 2024; Jan *et al.*, 2025). The larva, commonly referred to as "aphid lions," is highly voracious and feeds on heavy prey densities during its development. In addition, the species exhibits high levels of survival under various environmental conditions, with the adults having dispersal and colonizing capabilities in a wide range of habitats, hence guaranteeing ecological resilience (Dunn *et al.*, 2020). The long lifespan of the adults, as well as their capability to use nectar, pollen, and honeydew as alternative food, boosts reproductive success and persistence within crop ecosystems. Taken together, these biological traits quick development, high reproduction, robust predatory ability, and flexibility render *C. carnea* an anchor predator in Integrated Pest Management schemes (Dupont and John Strohm, 2019; Jan *et al.*, 2025).

For effective deployment of natural enemies like *Chrysoperla carnea* in mass biological control and economical mass production is necessary. Because field-collected prey are unpredictable and not feasible for regular rearing, surrogate or factitious hosts like *Corcyra cephalonica* and *Sitotroga cerealella* offer a substitute food source under controlled conditions. (Queiroz *et al.*, 2017). The biological performance of predators, however, is closely linked to the nutritional quality and suitability of the host offered. Host eggs vary in size, nutrient content, and surface properties, which directly influence larval survival, developmental rate, fecundity, and predatory potential of *C. carnea*. A quality and nutritionally well-endowed host not only increases development and reproductive yield but also promotes strong larval predator efficiency upon field release (Liu and Zhang, 2017; Jan *et al.*, 2025). On the other hand, poor host quality may compromise growth, increase developmental time, and lower overall fitness, thus shortening effectiveness at pest control.

Therefore, assessing the feeding capacity and biological reaction of *C. carnea* on surrogate hosts varies is important to the development of mass rearing protocols to maximize and enhance its field performance in Integrated Pest Management (Abbas *et al.*, 2014).

Eggs of *Corcyra cephalonica* (rice meal moth) and *Sitotroga cerealella* (Angoumois grain moth) are widely used as surrogate hosts for the mass rearing of *Chrysoperla carnea* because of their constant availability throughout the year, simplicity of production, and high acceptability by predator larvae (Queiroz *et al.*, 2017). *C. carnea* can be reared on these hosts in a commercially viable and cost-effective manner, thereby maintaining repeated predator multiplication in Integrated Pest Management. Yet, their nutritional variations significantly affect the biological efficiency of *C. carnea*. *C. cephalonica* eggs, as they are larger and more protein and lipid rich. Tend to increase larval development, survival, fecundity and longevity which enhance predatory efficacy (Villa *et al.*, 2016). Contrarily, *S. cerealella* eggs, which are compatible, tend to cause slower growth and decreased fitness because they are smaller and contain less reserve nutrients. Therefore, host quality will significantly determine the feeding capability and efficiency of *C. carnea* as a biological control agent (Kalile *et al.*, 2020; Jan *et al.*, 2025). and this study was designed to investigate both the feeding potential of *C. carnea* reared on *C. cephalonica* and *S. cerealella* eggs and its key biological parameters under laboratory conditions.

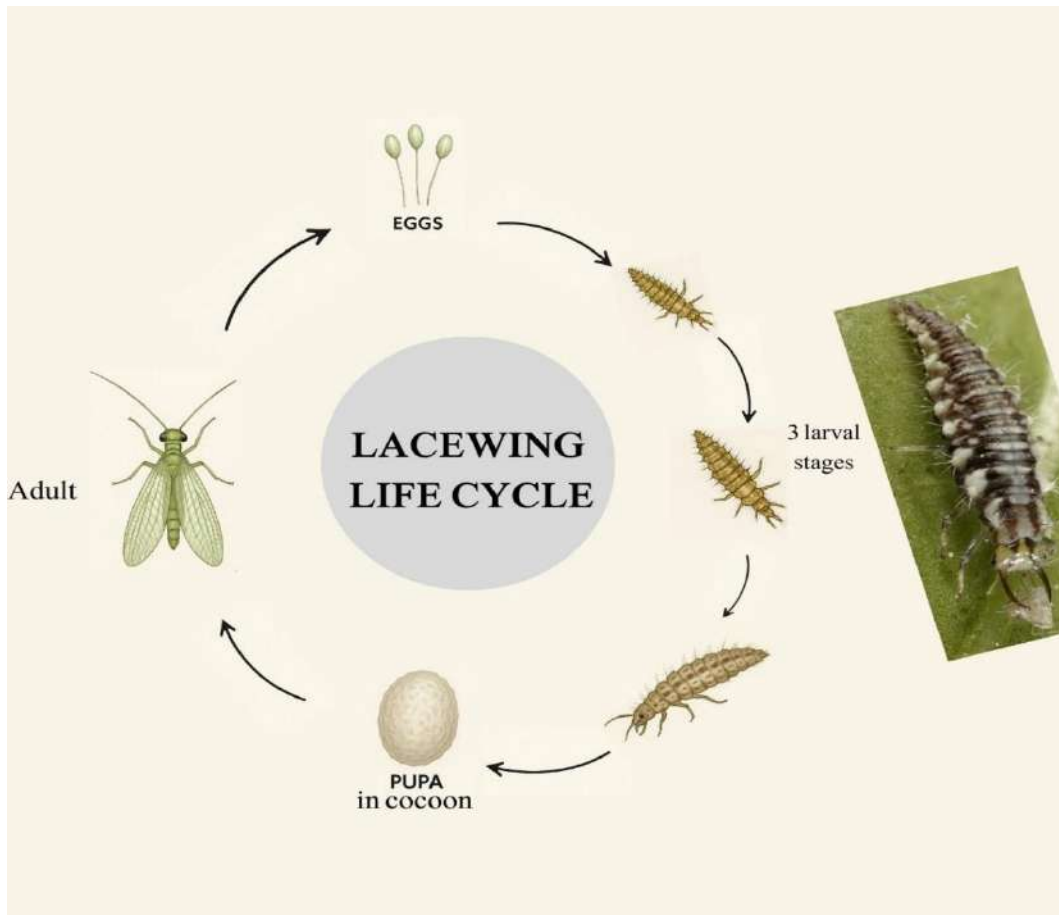


Figure1.1 Life cycle of green lacewing *Chrysoperla carnea*

2. MATERIALS AND METHODS

This controlled laboratory study was carried out during the summer of 2021 at the Bio Control Laboratory (Insectary) of the Insect Pest Management Program (IPMP) within the Institute of Plant and Environmental Protection (IPEP), National Agricultural Research Centre (NARC), Islamabad. The experiment maintained standard conditions ($26\pm 2^{\circ}\text{C}$; $65\pm 5\%$ R.H.). The primary objective was to evaluate the biological parameters and feeding capabilities of the predator *Chrysoperla carnea* when reared on the eggs of two alternative hosts: *Sitotroga cerealella* and *Corcyra cephalonica*. A key focus was to determine the suitability of each host by assessing *C. carnea*'s feeding response and subsequent developmental performance. Continuous supplies of host eggs were ensured by maintaining dedicated cultures of both surrogate species.

Rearing of *Sitotroga cerealella* 2.1

The culture of *Sitotroga cerealella* was kept in rearing chamber on wheat grains. Every morning the adults were gathered out of the chamber. The ovipositor jars with starch in which the eggs were laid were prepared after the collection of the adults of *S. cerealella*. This method of collecting eggs was to keep the ovipositor jars 24 hours on the starch and then sieve the starch every morning with 80 mesh sieve. The eggs were then transferred into a vial with lid to take out all the contaminated contents with eggs like body parts of insects, starch and some other contaminated contents. And eggs were retained under UV conditions to kill mites and destroy embryos of eggs to be fed on *C. carnea*. After this, eggs were retained in another glass jars containing wheat grains to continue with the further propagation of the culture and the procedure was repeated daily up to the end of the current internship report..

2.2 Rearing of *Corcyra cephalonica*

C. cephalonica a stored grain pest proved to be one of the most efficient surrogate hosts for rearing a wide range of biological control agents. The rice meal moth *C. cephalonica* culture was already maintained on artificial diet in the rearing cage. Artificial diet contains wheat bran, corn flour, yeast, sugar and water with ration of (57mg, 200mg, 8.55mg 20mg and 42 ml). The eggs were kept in the growth chamber for hatching. After hatching of eggs, it was shipped in to small plastic box having artificial diet for feeding. The larvae were placed in the artificial diet till all the adult emerges. After adult emergence these adults were shipped in to oviposition jar for eggs laying. The eggs were collected after every 24 hours and kept in UV light to damage their embryo and kill mites to prepare for further experiments.

2.3 Rearing of *Chrysoperla carnea*

The stock culture of predator *C. carnea* was maintained in Insectary. It collected the count no of eggs from that culture and kept in the plastic box at which furnished with tissue at (26 ± 2 °C; $65\pm 5\%$ R.H) and after 3-4 day eggs hatched. The newly hatched 1st instars larvae

of *C. carnea* were collected from that box with help of camel hair brush and kept into in transparent larval rearing vials separately (2.5 cm diameter and 8.5 cm length). The vials were covered with muslin cloth tightly containing the count number of host *C. cephalonica* and *S. cerellela* eggs according to the design of experiment. Every morning at the time of observation in each vial old diet was remove and provide new diet. This process was continued unless all larvae reached pupal stages. Feeding potential was observed after every 24 hours.

2.4 To study the biological parameters of *Chrysoperla carnea* reared on *C. cephalonica* and *S. cerellela* eggs.

Upon adult emergence, *Chrysoperla carnea* individuals were transferred from rearing vials into a transparent, rectangular mass rearing cage (35 cm×35 cm×20 cm) designed to facilitate handling through two diagonally placed, lidded round windows (13 cm diameter) on the front wall, allowing for the tallying of both sexes. The adults were maintained on a continuously supplied artificial diet (yeast, sugar, honey, and water in a 2:1:1:6 ratio) adequate for 50 adults over five days, though it was replaced every 24 hours and presented in small bowls (0.5 cm diameter) affixed to plastic rods. A black granulated paper placed on the lower half of the removable cage top served as the oviposition substrate, enabling the collection of data on key reproductive metrics: the pre-oviposition, oviposition, and post-oviposition periods, as well as the total number of eggs per female and the number of eggs per female per day

2.5 Statistical Analysis

The data in the developmental time of various stages, the feeding potential of various stages and the life time of various developmental stages were analyzed by ANOVA of two factor factorial design using the Statistix 8.1 package. Two-way ANOVA was used to compare means at 5% level of significance by use of LSD) test.

3. RESULTS

The study, focusing on the biological parameters and feeding potential of *Chrysoperla carnea*, was conducted in the summer of 2021. This laboratory experiment took place at the

Bio-control Laboratory (Insectary) of the Insect Pest Management Program (IPMP) at NARC in Islamabad, under controlled conditions ($26\pm 2^{\circ}\text{C}$; $65\pm 5\%$ R.H.). The investigation compared *C. carnea* when fed on the eggs of two host species: *Sitotroga cerealella* and *Corcyra cephalonica*.

3.1 Incubation period

The Incubation period of *C. carnea* feeding on *C. cephalonica* was recorded (3.540) days while the incubation period of *C. carnea* feeding on *S. cerealella* was recorded (3.120) days respectively (Table 1).

3.2 Larval Periods

The feeding time of 1st larval instar of *C. carnea* on *C. cephalonica* egg was measured (3.440) days and in same instar the feeding time of *C. carnes* on *S. cerealella* eggs was measured (3.120) days respectively (graph 1). The feeding entomological development period of 2 nd larval instar *C. carnea* on eggs of *C. cerealina* was measured (3.480) days and the in same instar the feeding entomological development period of *C. carnea* on eggs of *S. cerealella* was measured (3.440) days respectively (graph 1). Developmental period of 3rd larval instar *C. carnea* at feeding eggs of *C. cephalonica* was recorded (3.760) and at feeding eggs of *S. cerealella*, developmental period of *C. carnea* was recorded (3.440) days respectively (graph 1). And in total larval period the time taken by the *C. carnea* to develop on *C. cephalonica* eggs was registered (14.300) and in total larval period the time taken by *C. carnea* to develop on *S. cerealella* eggs was registered (12.860) days respectively (graph 1).

3.3 Pre-pupa

The developmental duration of the pre-pupa of *C. carnea* was (3.040) days when it fed on *C. cephalonica* eggs while the developmental duration of the pre-pupa of *C. carnea* was (2.100) days respectively when it fed on *S. cerealella* eggs (graph 1).

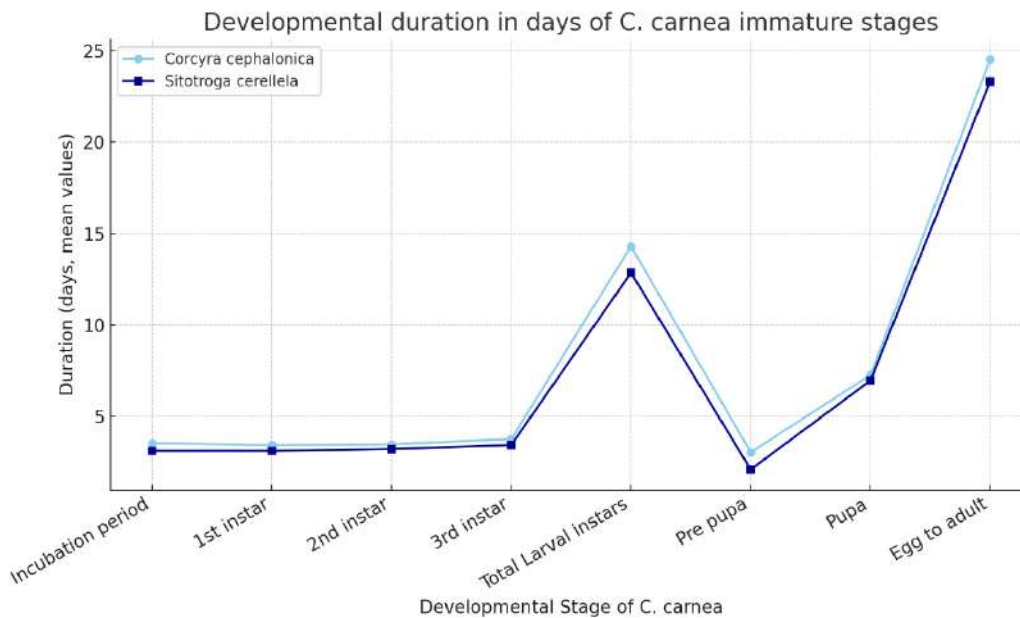
3.4 Pupa

The total duration of pupa of *C. carnea* was (7.260) days when it fed on *C. cephalonica* while the duration of pupa of *C. carnea* was (6.960) days respectively after feeding on *S. Cerealella* (graph 1).

3.5 Egg to adult:

The total developmental duration of *C. carnea* from egg stage to adult stage when it fed on *C. cephalonica* was recorded (24.520) days while the total developmental duration of *C. carnea* from egg stage to adult stage when it fed on *S. cerealella* was recorded (23.320) days respectively (graph 1).

Graph 1: Developmental duration in days of *C. carnea* immature stages fed on *Corcyra cephalonica* and *Sitotroga cereallela*.

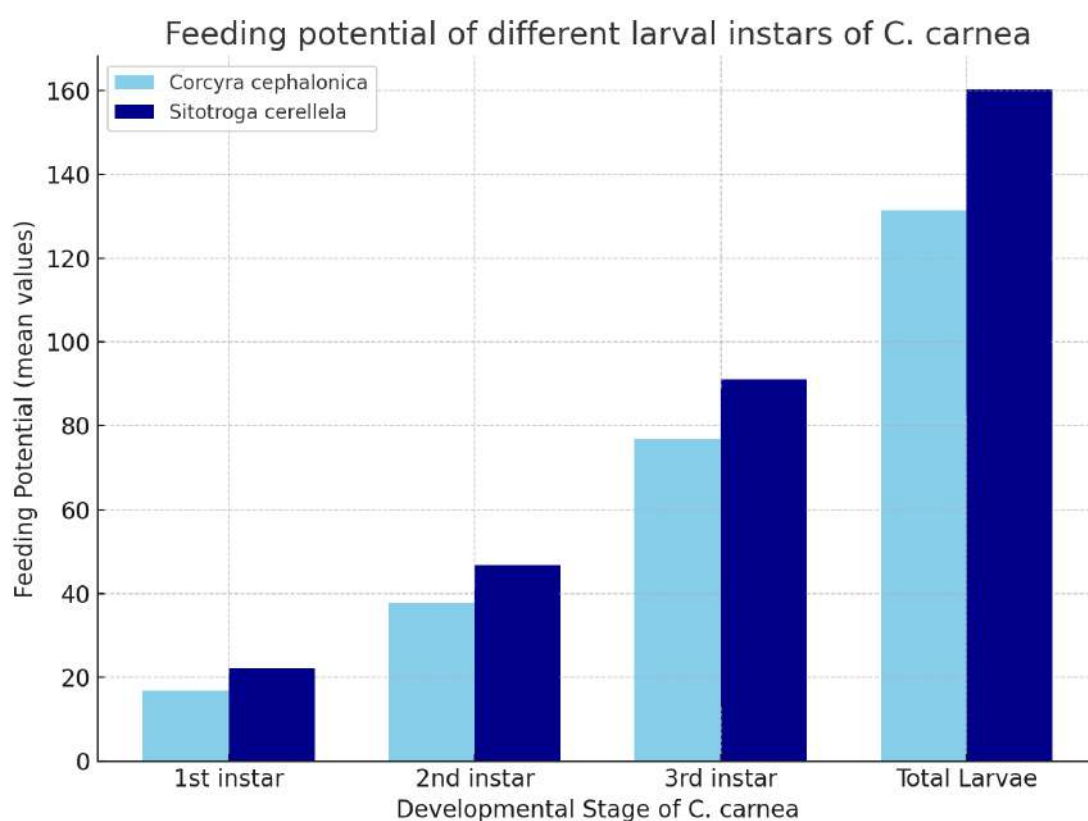


3.6 Consumption of Various Larval Periods of *C. carnea*

In 1st larval instar of *C. carnea* their consumption rate on *C. cephalonica* eggs was recorded (16.8) while their consumption rate on *S. cerealella* eggs was recorded (22.2) respectively (graph 2). In 2nd larval instar of *C. carnea* their consumption rate on *C. cephalonica* eggs was

recorded (37.80). while their consumption rate on *S. cerealella* eggs was recorded (46.8e) respectively (graph 2). In 3rd larval instar of *C. carnea* their consumption rate on *C. cephalonica* eggs was recorded (76.8d) while their consumption rate on *S. cerealella* eggs was recorded (91.2a) respectively (graph 2). And the total larval period of *C. carnea* their consumption rate on *C. cephalonica* eggs was recorded (131.40) while the total larval period of *C. carnea* their consumption rate on *S. cerealella* eggs was recorded (160.2) respectively (graph 2).

Graph 2: Feeding potential of different larval instars of *C. carnea* fed on *Corcyra cephalonica* and *Sitotroga cerellela*

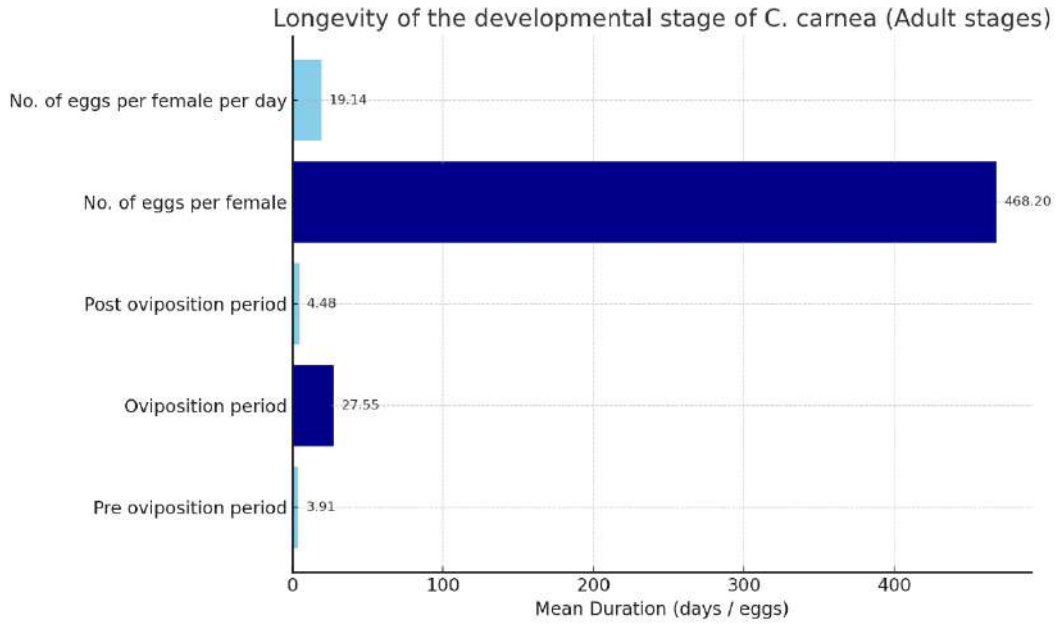


3.7 Pre and post oviposition period

The outcome showed that Pre-oviposition period of *C. carnea* was recorded (3.91276), oviposition period of *C. carnea* was recorded (27.55276), and post-oviposition period of *C.*

carnea was recorded (4.48276), number of eggs per female *C. carnea* (468.2276) was recorded and number of eggs per female per day was recorded (19.14276) (graph 3).

Graph 3: Longevity of the developmental stage of *Crysoperla carnea*



4. Conclusion

This paper examined the biological performance and predatory ability of *Chrysoperla carnea* that had been reared on *Corcyra cephalonica* and *Sitotroga cerealella* eggs in laboratory conditions. The incubation period, larval development time, pre-pupal period, and pupal period and the total time of development of the egg to adult on each host was taken. Parameters of *C. carnea* consumption rates of larval instar stages and longevity of the adults were also measured. These findings indicated that *C. carnea* had short developmental periods when bred on *S. cerealella* eggs than those reared on *C. cephalonica* eggs. Nonetheless, the feeding rates of *C. carnea* larval instar were much greater when using *S. cerealella* eggs. The researchers emphasize the need to analyze the appropriateness of the alternative hosts to the mass rearing of *C. carnea* because the nutritional value of the host directly determines the biological characteristics and predatory activity of the predator.

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