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The Reproduction and Activity Coordination Methods of Chrysopa Carnea Sterh. in a Biological Laboratory against Pests in Agriculture

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Annotation: This article explores the cultivation standards of Chrysopa carnea (common green lacewing) as a biological control agent under laboratory and field conditions in Uzbekistan. The main quality indicators of the bioproduct, including the body and wing lengths of mature individuals, egg-laying activity, survival rate, damage indicators, and sex ratio, were determined. The study confirmed that optimal parameters for using C. carnea as a high-quality biological agent in agro-ecosystems were identified, making it possible to develop an effective biological control system based on

these findings. The results are of significant importance in organising environmentally safe and sustainable pest control.

Keywords: Chrysopa carnea, biological control, bioproduct, morphological indicators, survival rate, laboratory propagation, sex ratio, pests, ecological safety.

Introduction

The need for environmentally safe and long-term methods to control harmful insects in modern agroecosystems has significantly increased the scientific and practical importance of biological control methods. Unlike pesticides, this method does not harm human health, beneficial entomofauna, or the environment. Therefore, biological control methods are being promoted as the primary approach to ensure ecological sustainability [1,2].

This approach has proven to be highly effective, especially in controlling major economic pests such as the autumnal cutworm (*Agrotis segetum*), armyworm (*Spodoptera exigua*), spider mites (*Tetranychus urticae*), and various aphids (*Aphididae*). Research has shown that it is possible to effectively control the population of these pests through their natural enemies, namely, predatory and parasitic entomofauna [3,4].

One of the key bioagents in biological control is lacewings (family *Chrysopidae*), specifically *Chrysoperla carnea*. This entomophagous organism is a predator that actively consumes the eggs, first and second instar larvae, and nymphs of various harmful insects and is capable of suppressing large numbers of pests simultaneously [5]. Therefore, its inclusion in integrated pest management systems is considered promising.

Recent scientific studies have evaluated the predatory activity of *C. carnea* larvae against the major agricultural pest *Spodoptera littoralis* under experimental conditions. Bioagents used at different densities (2, 3, and 4 larvae/m²) have significantly reduced the population of this pest. This confirms that *C. carnea* has practical value as a biological agent in agroecosystems [6].

Additionally, the impact of different types of eggs used as food on the development time, survival rate, and reproductive parameters of *C. carnea* larvae has been studied in detail. Larvae fed eggs of *Sitotroga cerealella*, *Corcyra cephalonica*, and *Galleria mellonella* showed faster development, lower mortality rates, and higher reproductive activity in females. These eggs are considered optimal food sources for *C. carnea* [7].

Biological control is being viewed as a primary strategic direction for plant protection in integrated pest management systems in many countries. This approach is based on using natural enemies, such as predatory and parasitic organisms, to maintain pest populations below their economic damage threshold. This reduces the frequency of pesticide applications and helps preserve soil, water, and air quality [8].

The effectiveness of biological control largely depends on the successful propagation of bioagents under both laboratory and field conditions. In this regard, factors influencing the egg-laying behaviour of female *C. carnea* have been studied. Research has shown that the colour of the substrate is important for egg-laying. Females prefer to lay their eggs on dark-colored surfaces (91%), which should be considered in biotechnological production processes. Analyses of different cage types have shown that wooden cages produce the highest egg-laying rates, while glass cages offer advantages in terms of technical service, feeding, and egg collection [9].

Furthermore, the impact of various host organisms on the biological development of *C. carnea* larvae has been thoroughly studied. Samples fed eggs of different pests (*Aphis gossypii*,

Helicoverpa armigera, *Pectinophora gossypiella*, *Phenacoccus solenopsis*, and *S. cerealella*) exhibited significant differences in larval development time, survival rate, female fecundity, and egg fertility (P<0.001). Particularly, *S. cerealella* eggs showed the best biological indicators: 100% larval survival, 503.3 ± 9.17 eggs produced by females, and 88.61 ± 0.68% egg fertility, indicating the optimal suitability of this food source for *C. carnea* [10].

The use of *Chrysoperla carnea* as a bioagent is scientifically substantiated, and its effectiveness significantly varies depending on the food source, environmental conditions, and technological factors. This requires a comprehensive scientific approach to creating ecological pest control systems.

Results and Discussion

The effective application of *Chrysopa carnea* (common green lacewing) as a biological control agent under Uzbekistan's conditions has been determined by establishing the breeding standards in laboratory conditions and their release into field conditions. These parameters play a critical role in evaluating *Chrysopa carnea* as a quality bioproduct and ensuring its successful integration into agro-ecosystems.

The *C. carnea* samples raised under laboratory conditions are selected based on production capacity: for a production capacity of up to 3 million, 100 samples are chosen; up to 5 million, 200 samples; up to 8 million, 300 samples; up to 10 million, 400 samples; and for those producing more than 10 million, 500 samples are selected (Figure 1).

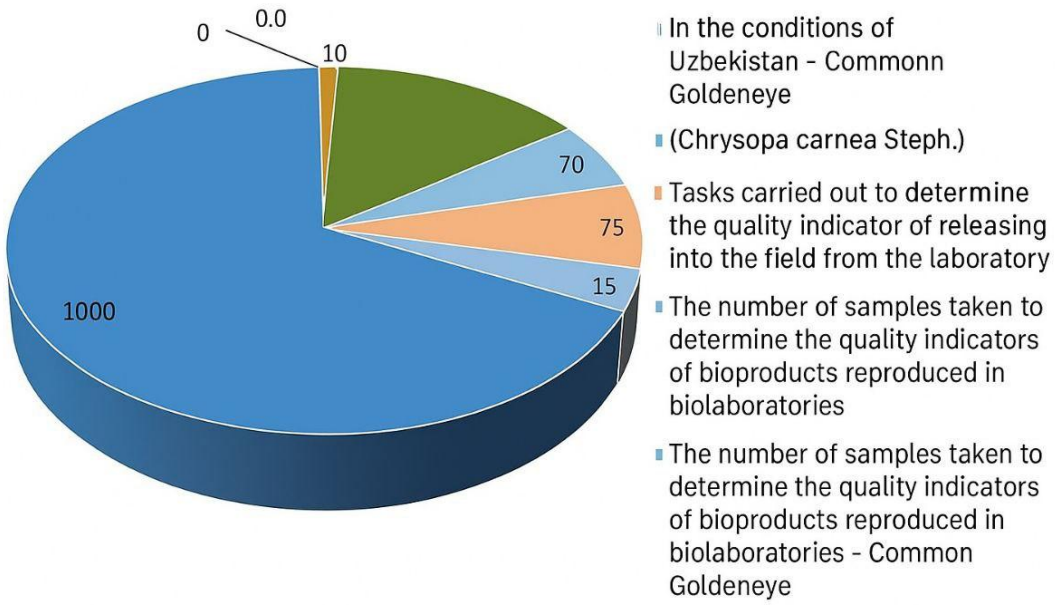

Figure 1. Chrysopa carnea Steph. Quality Indicators of Bioproducts in Laboratory Conditions and Release Standards into the Field

The quality indicators of the bioproduct are tested in accordance with the Uzbekistan State Standard O‘z DSt 2918:2015. The following key parameters are evaluated under laboratory conditions:

- The length of a mature *C. carnea* individual must be at least 10 mm, and the wing span when fully extended must not be less than 25 mm. These measurements are taken under a binocular microscope using a coordinate measuring sheet.

- Each female must lay at least 200 eggs. Egg-laying activity and the hatching rate must be at least 70%.
- The effectiveness of pupae producing mature imagos should be at least 75%.
- The damage rate must not exceed 8%, indicating the high physical condition and quality of the product.
- The lifespan of the female imago should be at least 15 days, which is an important indicator for reproduction and bioproduct quality.
- Egg-laying activity should be at least 80%, meaning that the female should lay a sufficient number of eggs during her lifespan.
- The sex ratio should be balanced (♀:♂ = 1:1), which is essential for the healthy development of the population.

Based on the quality indicators of the *C. carnea* bioproduct raised in the laboratory, they are classified into five categories. The bioproduct in the first category has all the above parameters at optimal levels, and in the subsequent categories, these indicators gradually decrease. For example, in the first category, the body length of the product is at least 10 mm, the wing span is 25 mm, the female lays no fewer than 200 eggs, the hatching rate is 70%, the pupae's emergence as mature imagos is 75%, and the damage rate is less than 8%. The sex ratio is 1:1 (see Table 1).

Table 1. Tasks for Determining the Quality Indicators and Standards for Releasing *Chrysopa carnea* (Common Green Lacewing) into the Field under Laboratory Conditions in Uzbekistan

<table>
<tr><th>№</th><th>Task to be Performed</th><th>Duration</th><th>Work to be Done</th><th>Equipment</th></tr>
<tr><td colspan="5">Quantity of samples taken to determine the quality indicators of bioproducts propagated in biolaboratories.</td></tr>
<tr><td>1</td><td>Oltinko‘z<table><tr><th>Lacewing Production Capacity</th><th>Sample Quantity</th></tr><tr><td>Up to 3 million
Up to 5 million
Up to 8 million
Up to 10 million
More than 10 million</td><td>100 individuals
200 individua
300 individua
400 individua
500 individua</td></tr></table></td><td>from March 20</td><td>Samples are taken for analysis based on the production capacity of golden-eyed insect bioproducts being propagated in biolaboratories.</td><td>Glass cylinder, test tube, special refrigerator, and freezers</td></tr>
<tr><td colspan="5">Oddiy Oltinko‘z O‘z DSt 2918:2015 ni (5.1.2 bandini) davlat standarti talablariga muvofiq sinovlar o‘tkazish</td></tr>
<tr><td>2.1</td><td>Test Samples for C. carnea</td><td></td><td>Temperature:26°C
Relative Humidity: 60%</td><td></td></tr>
<tr><td>2.2</td><td>Dimensions, mm not less than:
- Adult insect length - 10 mm.
- wingspan - 25 mm.</td><td>Throughout the season</td><td>The size of C. carnea is determined under a binocular microscope using scale-coordinated paper.</td><td>Binocular, scale-coordinated paper.</td></tr>
<tr><td>2.3</td><td>Egg-laying activity (minimum 200 eggs per female)</td><td>Throughout the season</td><td>The lacewing adults are placed in five glass jars, one pair per jar, and fed regularly. The jars are sealed with cloth and rubber rings and numbered. The eggs laid are counted daily.
P = N:K
Where:
N = Total number of eggs laid (individuals);
K = Number of females (individuals).</td><td>Glass jar, thread gauze, rubber ring.</td></tr>
<tr><td>2.4</td><td>- Egg hatching rate (minimum 70%)</td><td>Throughout the season</td><td>Qo‘yilgan tuxumlarning, unib chiqishi hisoblanib boriladi.
T=N:K*100% bunda
T-tuxumdan unib chiqishi, foiz
N-tuxumdan chiqqan lichinklar, soni</td><td>Lupa</td></tr>
</table>

№	Task to be Performed	Duration	Work to be Done	Equipment
			K-qo'yilan tuxumlar soni.	
2.5	- Emergence from pupae (minimum 75%)	Throughout the season	The hatching rate of the eggs is calculated. **T = (N:K) * 100%** Where: T = Hatching rate (%); N = Number of larvae that hatched (individuals); K = Number of eggs laid (individuals).	Lupa
2.6	- Damage rate (maximum 8%).	Throughout the season	The total number of adults emerging from the pupae is counted. **B = (V:K) * 100%** Where: V = Average number of adults emerging from the pupae (individuals); S = Total number of adults emerged (individuals); K = Total number of pupae (individuals).	Lupa
2.7	- Female lifespan (minimum 15 days)	Throughout the season	The number of damaged *C. carnea* individuals is counted using a lupa. **D = (M:S) * 100%** Where: M = Number of damaged individuals; S = Total number of adults that emerged (individuals). To determine the female's lifespan, 10 test tubes of adults are fed and observed until natural death. The lifespan is calculated using the following formula: **X = (N1 + N2 + ... + N10) / A** Where: **X = Lifespan of the individuals (days);** **N = Lifespan (days);** **A = Total number of females (individuals).**	Test tubes
3.1	- Female egg-laying activity (minimum 80%)	Throughout the season	The lacewing adults are placed in five glass jars, one pair per jar, and are regularly fed. The jars are sealed with cloth and rubber rings and numbered. The eggs laid are counted daily. The female should lay no fewer than 200 eggs during her lifespan.	Glass jar, thread gauze, rubber ring.
3.2	- Sex ratio (♀:♂ = 1:1)	Throughout the season	To determine the sex ratio of the adult individuals, 100 mature male and female lacewings are counted. They are distinguished by their morphological appearance, where the female can be distinguished from the male by the size of her abdomen. Once the males and females are counted, the sex ratio is determined using the following formula: **S2:S1**	Lupa

3.3	**Quality Indicators for *C. carnea* Categories**	**Categories of Common Green Lacewing**					
		First	**Second**	**Third**	**Fourth**	**Fifth**	

№	Task to be Performed	Duration	Work to be Done			Equipment
	Size, mm minimum: Body length of the adult insect Wing span when fully extended	 10 25	 9 24	 8 23	 7 22	 6 21
	Female egg-laying capacity, minimum number of eggs	200	170	140	110	80
	Hatching rate, minimum %	70	65	60	55	50
	Emergence from pupae, minimum %	75	70	65	60	55
	Damage rate, maximum %	8	9	10	12	14
	Female lifespan, minimum days	15	14	12	10	8
	Female egg-laying activity, minimum %	80	75	70	65	60
	Sex ratio (♀: ♂)	1:1	1:1,1	1:1,3	1:1,5	1:1,8
	Release quantity per hectare, minimum number of individuals	1000	1100	1200	1300	1400

The recommended release rate of *C. carnea* bioproduct per hectare in field conditions varies depending on the quality category, with the first category suggesting 1,000 individuals, while subsequent categories recommend between 1,100 and 1,400 individuals. These parameters are essential in ensuring the effective use of *C. carnea* as a high-quality biological agent and play a key role in creating environmentally safe and sustainable pest control systems.

Bioecological Characteristics of *Chrysopa carnea* (Common Green Lacewing)

Lacewings (order Neuroptera, family Chrysopidae) are widely distributed insects, with 24 species recorded in Central Asia. In Uzbekistan, 11 species are known. These species are found in cotton fields, orchards, and vegetable and melon crops. The adult species measures between 23-30 mm in size and has two pairs of wings. The radial-medial veins on the wings of this species do not align in a triangular cell and instead extend to the outer edge of the medial vein. The head, thorax, and abdomen are green, with reddish-brown stripes running along the neck (Figures 2-3).

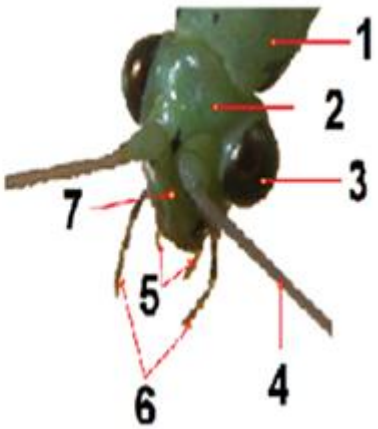

Figure 2. General Appearance of the Green Lacewing Imago

Figure 3. General Appearance of the Head of the Green Lacewing

1. Anterior and posterior parts; 2) Head capsule; 3) Compound eyes; 4) Antennae; 5-6) Upper and lower jaw palp; 7) Clypeus (covering).

The adult insects overwinter under the bark, among plants, and in other sheltered places. The overwintering individuals turn pale yellow. They begin to move when the air temperature reaches 10-15°C in spring. After emerging from overwintering, the adults feed on nectar from various plant flowers, as well as on cotton aphid honeydew and the sugary substances released

by the flowers, and partly from the sweet substances secreted by aphids.

The eggs are flat in shape, measuring 0.9 x 0.4 mm, and are attached at the tip of a stalk that is 5-7 mm long. Newly laid eggs are green, and by the time the embryo develops, they turn gray-brown (Figure 4).

Figure 4. Cluster of Green Lacewing Eggs

The development of green lacewing eggs varies among species. For example, the common green lacewing (*Chrysopa carnea* Steph.) develops in 4 days, while the seven-spotted green lacewing (*Chrysopa septempunctata* Wesm.) takes 6-7 days. The size of the egg and its stalk varies across species (2-10mm), with the egg itself measuring 0.8-2.5mm.

The eggs are laid individually or in small clusters on the leaves, stems, or branches of plants. The development of one generation of lacewings depends on natural conditions and takes 26-36 days, with the egg stage lasting 4-6 days, the larval stage 11-14 days, and the pupal stage 12-16 days. The total development of one generation lasts between 50-52 days.

The larvae are predatory, with the body narrowing towards the posterior end. The head is flattened, and the mandibles are hook-shaped, sharp, and angled (Figure 5).

Figure 5. Time of Larval Emergence from the Eggs

The larvae feed on different prey depending on their age; first-instar larvae feed on aphid honeydew, second-instar larvae consume both aphid honeydew and young caterpillars, while third-instar larvae feed on small caterpillars and eggs. *C. carnea* larvae are highly predatory and feed on over 70 species of arthropods. They particularly enjoy feeding on various plant aphids, spider mites, comstock scale, phytophagous mites, and the larvae of beetles. The larvae are capable of searching for food over an area of up to $3m^2$ in one hour, attacking up to 150 insects and capturing their prey within 7-8 seconds. Additionally, during their developmental stage, a third-instar larva can consume approximately 300 plant aphids or nearly 1,000 spider mites. Sometimes, they also feed on small caterpillars. During its development, a female *C. carnea* larva will consume around 1,108 aphid eggs, while a male larva consumes about 980 eggs.

Before transitioning to the pupal stage, the larva creates a white, round (3mm in diameter), thin

cocoon. The pupa is free and green in color (Figure 6). For the development of all stages of *C. carnea*, a temperature range of 20-30°C and relative humidity of 55-80% is considered sufficient.

Figure 6. 1) Pre-pupal stage (last instar larva), 2) Green lacewing pupa (*Chrysoperla carnea*).

The main food source for these insects under laboratory conditions is the eggs of the cotton aphid. The initial egg-laying of the lacewing occurs 3-4 days after emerging from the pupa, with the peak egg-laying period lasting from 15 to 25 days. The final egg-laying occurs 4-5 days before the death of the adult.

To achieve high efficiency when using this insect for pest control, it is necessary to release it into the field in a ratio of 1:20, 1:15, or 1:10 against the pest population. In bean plants, lacewings appear in mid-April when the air temperature reaches 11°C. Additionally, they feed on aphid honeydew, phytophagous mites, and the larvae of *Phytomus*. In nature, a single female lacewing lays an average of 200-400 eggs, while under laboratory conditions, it lays 100-150 eggs. Currently, large-scale production of *C. carnea* in laboratory conditions has been established, and it can produce 3-4 generations per year.

Conclusion

The standards for breeding and releasing *Chrysopa carnea* (common green lacewing) as a biological control agent in laboratory and field conditions have been clearly defined for effective application in Uzbekistan. The research has identified the minimum allowable standards for key quality indicators such as body size, wing length, egg-laying activity, viability, and sex ratio of mature individuals. These parameters are crucial in evaluating *C. carnea* as a high-quality bioproduct and play a key role in ensuring its successful integration into agro-ecosystems. Based on the established standards, the biological agents prepared are important in implementing effective and environmentally safe pest control strategies.

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