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MASS REARING, STORAGE TECHNOLOGY AND BIOLOGICAL EFFICIENCY OF GREEN LACEWING (*CHRYSOPERLA CARNEA*) IN AGROBIOCENOSES

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Abstract. The present study investigated the mass rearing, storage technology, and biological efficiency of the entomophagous insects *Chrysoperla carnea* (Stephens) and *Chrysopa septempunctata* (Neuroptera: Chrysopidae) under laboratory and agrobiocenosis conditions. During the research, the rearing technology based on *Sitotroga cerealella* (Olivier) was optimized, and the optimal storage parameters for different developmental stages were evaluated. Under laboratory conditions, 0.5 g of *Sitotroga cerealella* eggs were placed into 3-liter glass containers and maintained at 25-27°C temperature and 60-70% relative humidity. Subsequently, 400-500 eggs of *Chrysoperla carnea* were introduced into each container, and larval development as well as adult emergence were monitored.

The results demonstrated that *Chrysoperla carnea* eggs could be successfully stored for 30-35 days at 5-8°C and 60-85% relative humidity. Under these conditions, 70-80% viable larvae successfully emerged from the stored eggs. In addition, adult insects maintained at 8°C and 85-90% relative humidity remained viable for up to 6 months. Photoperiod reduction to 10 hours induced diapause, resulting in decreased physiological activity of adults.

Laboratory observations revealed a high predatory capacity of *Chrysoperla carnea* larvae. Third instar larvae consumed an average of 40-80 aphids (Aphididae) per day. Furthermore, *Chrysopa septempunctata* larvae exhibited high biological efficiency in vegetable and melon agrobiocenoses, significantly reducing pest populations when released at a ratio of 1:50.

The obtained results indicate that *Chrysoperla carnea* and *Chrysopa septempunctata* can serve as effective biological control agents and provide an important scientific basis for their mass production, long-term storage, and application in Integrated Pest Management (IPM) systems.

Keywords: *Chrysoperla carnea, Chrysopa septempunctata, Sitotroga cerealella*, Chrysopidae, entomophagous insect, biological control, mass rearing, cold storage, diapause, IPM, agrobiocenosis.

Annotatsiya. Mazkur tadqiqotda *Chrysoperla carnea (Stephens)* va *Chrysopa septempunctata (Neuroptera: Chrysopidae)* entomofaglarini laboratoriya va agrobiotsenoz sharoitida ommaviy ko‘paytirish, saqlash texnologiyasi hamda biologik samaradorligi o‘rganildi. Tadqiqotlar davomida *Sitotroga cerealella (Olivier)* asosida ko‘paytirish texnologiyasi takomillashtirildi hamda turli rivojlanish bosqichlarini saqlashning maqbul parametrlari baholandi. Laboratoriya sharoitida 0,5 g Sitotroga cerealella tuxumlari 3 litrli shisha ballonlarga joylashtirilib, 25–27°C harorat va 60–70% nisbiy havo namligida saqlandi. Keyinchalik har bir ballonga 400–500 ta Chrysoperla carnea tuxumlari kiritilib, lichinkalarning rivojlanishi va imagolar chiqishi kuzatildi.

Tadqiqot natijalari Chrysoperla carnea tuxumlarini 5–8°C harorat va 60–85% nisbiy havo namligida 30–35 kun davomida muvaffaqiyatli saqlash mumkinligini ko‘rsatdi. Bunday sharoitda saqlangan tuxumlardan 70–80% hayotchan lichinkalar ochib chiqqanligi qayd etildi. Shuningdek, 8°C harorat va 85–90% nisbiy havo namligida saqlangan imagolar 6 oygacha yashovchanligini saqlab qoldi. Fotoperiodni 10 soatgacha qisqartirish diapauza induksiyasini chaqirib, imagolar fiziologik faolligining pasayishiga olib keldi.

Laboratoriya kuzatuvlari *Chrysoperla carnea* lichinkalari yuqori yirtqichlik xususiyatiga ega ekanligini ko‘rsatdi. III yosh lichinkalari bir sutkada o‘rtacha 40–80 ta shira (*Aphididae*) bilan oziqlanishi aniqlandi. Shuningdek, *Chrysopa septempunctata* lichinkalari sabzavot va poliz agrobiotsenozlarida yuqori biologik samaradorlik ko‘rsatib, 1:50 nisbatda tarqatilganda zararkunanda populyatsiyalarini keskin kamaytirishi qayd etildi.

Olingan natijalar *Chrysoperla carnea* va *Chrysopa septempunctata* entomofaglarini samarali biologik agent sifatida baholash imkonini berib, ularni ommaviy ko‘paytirish, uzoq muddat saqlash va integrallashgan himoya (IPM) tizimlarida qo‘llash uchun muhim ilmiy asos bo‘lib xizmat qilishi mumkin.

Kalit so‘zlar: *Chrysoperla carnea, Chrysopa septempunctata, Sitotroga cerealella, Chrysopidae,* entomofag, biologik kurash, ommaviy ko‘paytirish, sovuqda saqlash, diapauza, IPM, agrobiotsenoz.

Аннотация. В данном исследовании изучены технологии массового разведения, хранения и биологическая эффективность энтомофагов *Chrysoperla carnea* (Stephens) и *Chrysopa septempunctata* (Neuroptera: Chrysopidae) в лабораторных условиях и агробиоценозах. В ходе исследований была усовершенствована технология разведения на основе *Sitotroga cerealella* (Olivier), а также определены оптимальные параметры хранения различных стадий развития. В лабораторных условиях 0,5 г яиц *Sitotroga cerealella* помещали в стеклянные ёмкости объёмом 3 литра и содержали при температуре 25-27°C и относительной влажности воздуха 60-70%. Затем в

каждую ёмкость вводили 400-500 яиц *Chrysoperla carnea*, после чего наблюдали за развитием личинок и выходом имаго.

Результаты исследований показали, что яйца *Chrysoperla carnea* могут успешно храниться в течение 30-35 суток при температуре 5–8°C и относительной влажности воздуха 60-85%. В данных условиях из сохранённых яиц выводилось 70-80% жизнеспособных личинок. Кроме того, имаго, содержащиеся при температуре 8°C и относительной влажности воздуха 85-90%, сохраняли жизнеспособность до 6 месяцев. Сокращение фотопериода до 10 часов индуцировало диапаузу, что сопровождалось снижением физиологической активности имаго.

Лабораторные наблюдения показали высокую хищническую активность личинок *Chrysoperla carnea*. Личинки III возраста потребляли в среднем 40–80 тлей (Aphididae) в сутки. Также личинки *Chrysopa septempunctata* продемонстрировали высокую биологическую эффективность в овощных и бахчевых агробиоценозах, значительно снижая численность вредителей при выпуске в соотношении 1:50.

Полученные результаты свидетельствуют о том, что *Chrysoperla carnea* и *Chrysopa septempunctata* могут служить эффективными агентами биологической защиты растений и представляют важную научную основу для их массового разведения, длительного хранения и применения в системах интегрированной защиты растений (IPM).

Ключевые слова: *Chrysoperla carnea*, *Chrysopa septempunctata*, *Sitotroga cerealella*, Chrysopidae, энтомофаг, биологическая борьба, массовое разведение, холодовое хранение, диапауза, IPM, агробиоценоз.

INTRODUCTION

In recent years, the development of environmentally safe and sustainable plant protection systems has become one of the most important challenges in global agriculture. The long-term and excessive use of chemical pesticides against agricultural pests has resulted in ecological imbalance within agrobiocenoses, a sharp decline in beneficial entomophagous insects, the development of resistance in pest species, and environmental pollution. In particular, the массовое occurrence of aphids (Aphididae), whiteflies (*Bemisia tabaci Genn., Trialeurodes vaporariorum* West.), thrips (Thripidae), and spider mites (Tetranychidae) in vegetable, melon, and greenhouse agrobiocenoses causes significant economic losses. In this regard, considerable attention has been paid worldwide to the implementation of Integrated Pest Management (IPM) systems. Biological control methods are considered one of the major components of IPM, and the use of parasitic and predatory entomophages is recognized as an environmentally friendly approach to pest regulation. Among beneficial insects, representatives of the family Chrysopidae are of particular importance. Especially *Chrysoperla carnea* (Stephens) and *Chrysopa septempunctata* are distinguished by their high predatory capacity, polyphagy, and adaptability to various agrobiocenotic conditions.

Chrysoperla carnea is one of the most widely used entomophagous insects in biological control programs worldwide. Its larvae actively feed on aphids, whiteflies, thrips, spider mites, and other soft-bodied insect pests. According to various studies, third instar larvae are capable of consuming up to 40-80 aphids per day. Furthermore, this entomophagous species is considered a suitable object for insectaries due to its high survival rate, rapid development, and ability to be mass reared under artificial conditions. At present, technologies for the mass rearing and application of *Chrysoperla carnea* in IPM systems have been widely implemented in countries such as the United States, China, India, Turkey, the Netherlands, and Israel. International studies have reported important scientific achievements regarding the rearing of this entomophagous insect on Sitotroga cerealella (Olivier), Ephestia kuehniella, and Galleria mellonella, as well as cold storage techniques, diapause induction, and the development of artificial diets. However, under the conditions of Uzbekistan, technologies for the mass production, long-term storage, and application of local populations in agrobiocenoses remain insufficiently studied. One of the most critical stages in mass rearing technology is the long-term storage of entomophages. Determining optimal temperature, humidity, and photoperiod conditions is essential for year-round maintenance, seasonal release planning, and transportation of entomophages in biological laboratories. Therefore, improving storage technologies for the eggs, larvae, pupae, and adults of Chrysoperla carnea is considered an important factor for increasing the efficiency of biological control.

Accordingly, the main objective of the present study was to improve the laboratory mass rearing technology of *Chrysoperla carnea* and *Chrysopa septempunctata*, determine the optimal storage parameters for different developmental stages, and evaluate their biological efficiency in agrobiocenoses.

MATERIALS AND METHODS

The studies were conducted during 2025 in vegetable and melon agrobiocenoses of the Tashkent region as well as under laboratory conditions. The research focused on the mass rearing technology, storage methods, and biological efficiency of the entomophagous species *Chrysoperla carnea* (Stephens) and Chrysopa septempunctata (Neuroptera: Chrysopidae).

The research objects included, *Chrysoperla carnea* (Stephens), *Chrysopa septempunctata, Sitotroga cerealella* (Olivier), aphids (Aphididae), whiteflies (*Bemisia tabaci, Trialeurodes vaporariorum*) commonly distributed in vegetable crops. Eggs of Sitotroga cerealella were used as the primary food source for the mass rearing of entomophages. For this purpose, 0.5 g of grain moth eggs were placed into 3-liter glass containers and maintained at a temperature of 25-27°C and relative humidity of 65-70%. For the development of Sitotroga cerealella larvae, 400-500 g of previously prepared barley or wheat grains were added to each container.

During grain preparation, the grains were first mechanically cleaned and then sterilized by immersing them in boiling water for 3 minutes, repeated 3-4 times.

Subsequently, the grains were incubated for 24 hours before being transferred into containers containing developing Sitotroga cerealella larvae. The upper part of the containers was covered with moist cloth material to maintain stable humidity conditions.

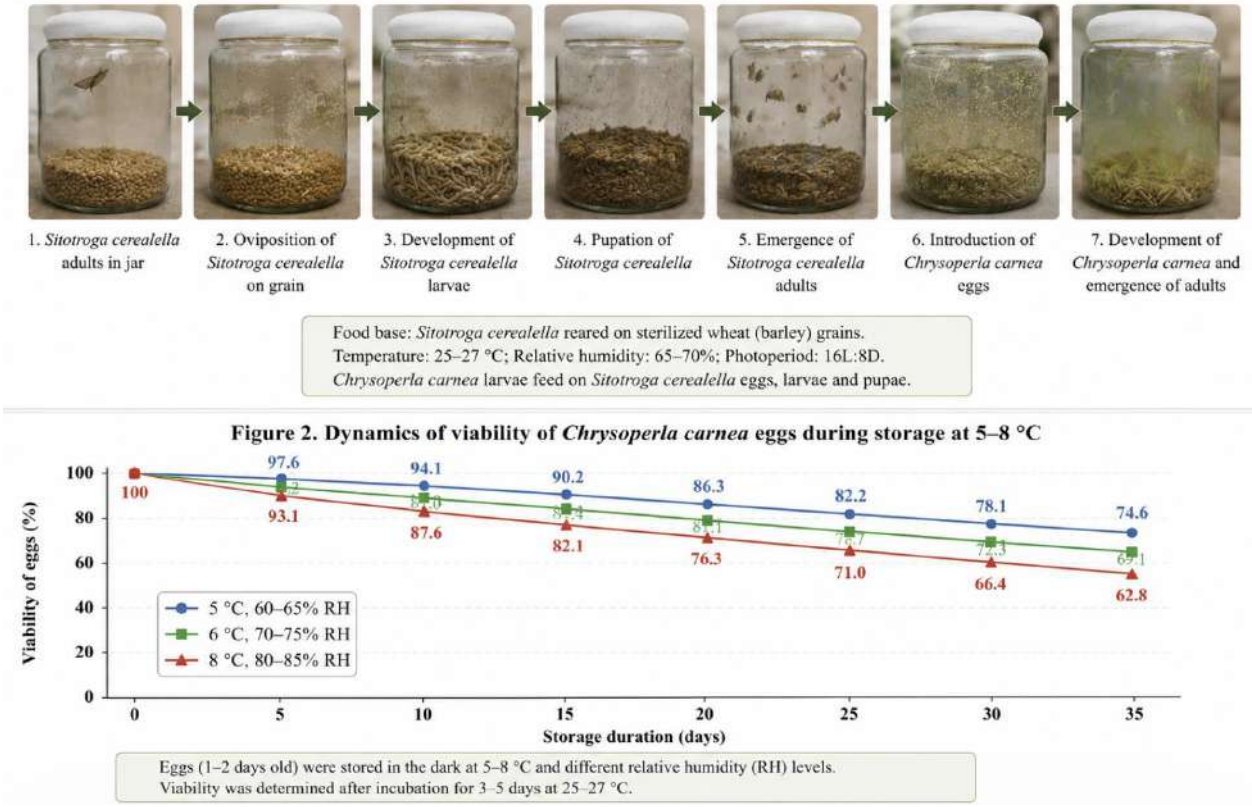

Figure 1. Mass rearing of *Chrysoperla carnea* on wheat (barley) grain in glass jars under laboratory conditions.

After 20-23 days, when Sitotroga cerealella adults emerged and initiated oviposition, 400-500 eggs of Chrysoperla carnea were introduced into each container. The entomophagous larvae developed within the same environment and subsequently passed through pupal and adult stages. Emerged adults were collected daily and transferred into separate rearing containers for egg production. Storage technology of the entomophages under laboratory conditions was also investigated. Eggs were stored at 5-8°C and 60-85% relative humidity, while adults were maintained at 8°C and 85-90% relative humidity. Larval and pupal stages were preserved under different temperature regimes in order to determine optimal storage conditions.

RESULTS AND DISCUSSION

The conducted studies demonstrated that the technologies for mass rearing and long-term storage of *Chrysoperla carnea* and *Chrysopa septempunctata* under laboratory conditions were highly effective. During the experiments, the food medium based on *Sitotroga cerealella* proved to be suitable for establishing stable

populations of the entomophagous insects. According to the obtained results, at a temperature of 25-27°C and relative humidity of 65-70%, the egg hatching rate of *Chrysoperla carnea* averaged 91.4-94.6%. Larval survival ranged between 87.2-90.8%, while the developmental period lasted approximately 18-22 days. These indicators confirmed the high adaptability of the entomophagous species to laboratory conditions. During the observations, third instar larvae exhibited the highest predatory activity. A single third instar larva consumed an average of 40-80 aphids (Aphididae) per day. In some highly active individuals, this indicator reached 95-110 aphids per day.

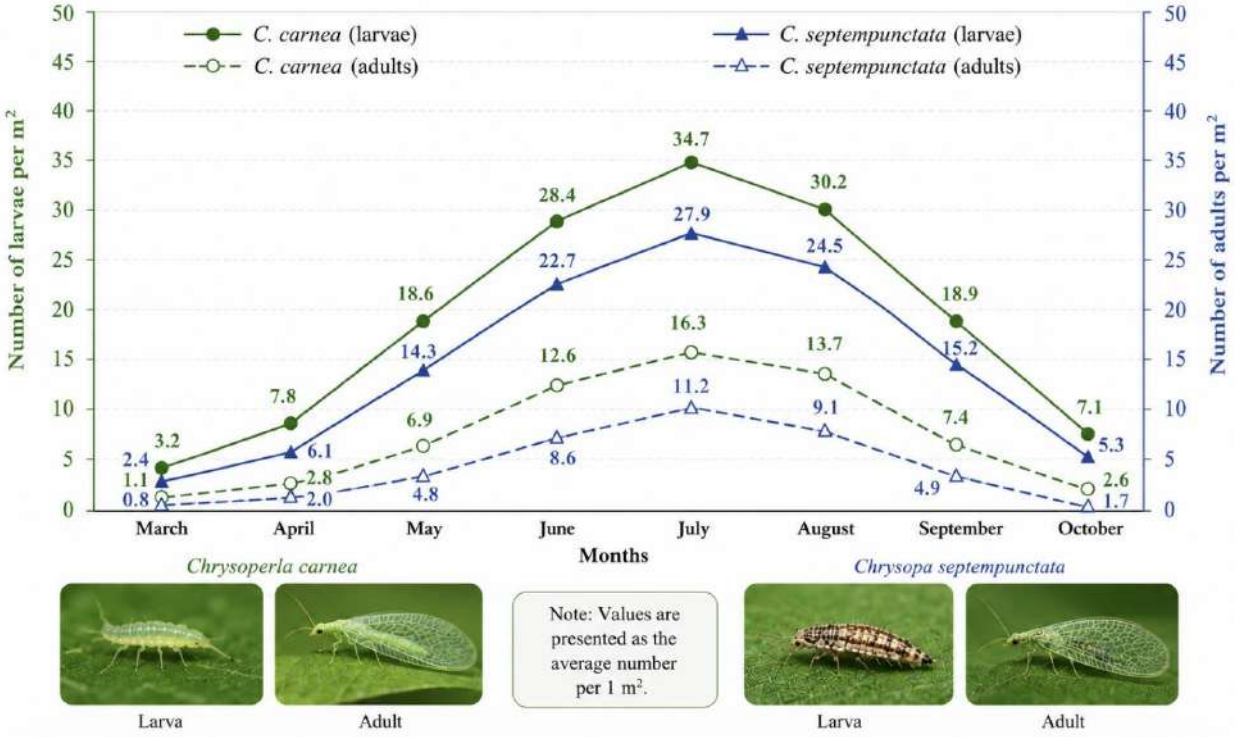

Figure 3. Dynamics of natural population increase of green lacewing (*Chrysopidae*) species in agroecosystems of the Tashkent region during the 2025 vegetation period.

These findings indicate that *Chrysoperla carnea* may serve as a highly effective biological control agent in vegetable agrobiocenoses. High fecundity of adults was also observed in environments supplied with *Sitotroga cerealella*. Female adults laid an average of 320-470 eggs during their reproductive period. Furthermore, adults provided with additional protein-rich diets showed an increase in oviposition activity by 18-22%. Experiments on egg storage demonstrated that temperatures of 5-8°C and relative humidity of 60-85% represented optimal storage conditions. Under these parameters, 1-2-day-old eggs could be successfully stored for 30-35 days. After storage, larval viability remained at 70-80%. Temperatures below 4°C negatively affected embryonic development and significantly reduced survival rates.

Studies on adult storage revealed that 8°C temperature and 85-90% relative humidity were the most suitable conditions. Under these parameters, adult viability

was maintained for up to 5-6 months. Adults periodically transferred to optimal environmental conditions and additionally fed every 15 days maintained high physiological activity. Experiments on diapause induction showed that reducing the photoperiod to 10 hours triggered physiological changes in the entomophages. Adults entering diapause exhibited a color change of wings from green to pale pink, accompanied by reduced mobility and feeding activity. These findings suggest that diapause induction may play an important role in improving long-term storage technology of entomophagous insects. High biological efficiency of *Chrysopa septempunctata* was also observed under agrobiocenosis conditions. Larvae released against aphids in vegetable and melon crops at a ratio of 1:50 reduced pest populations by 72-85% within 7-10 days. High entomological efficiency was also recorded when adults were released at ratios ranging from 1:20 to 1:100.

Figure 4. Establishment of agrobiocenosis and release of mass-reared *Chrysoperla carnea* in field conditions for biological control of agricultural pests.

During the experiments, it was observed that in variants treated with entomophages, pest populations remained below the economic threshold even without the application of chemical pesticides. This confirms the potential application of *Chrysoperla carnea* and *Chrysopa septempunctata* as important biological agents within Integrated Pest Management (IPM) systems. Comparison of the obtained results with international studies demonstrated that local populations under Central Asian conditions possess high adaptive potential. Moreover, the findings indicate significant opportunities for further improvement of mass rearing technologies for entomophagous insects under local biolaboratory conditions.

CONCLUSION

The conducted studies demonstrated that the technologies for mass rearing, storage, and application of *Chrysoperla carnea* (Stephens) and *Chrysopa septempunctata* under laboratory and agrobiocenosis conditions are highly effective. The results confirmed that the food medium based on Sitotroga cerealella is suitable

for establishing stable populations of these entomophagous insects. Under laboratory conditions at a temperature of 25-27°C and relative humidity of 65-70%, the egg hatching rate of Chrysoperla carnea reached 91.4-94.6%, while larval survival ranged from 87.2-90.8%. Female adults exhibited high reproductive capacity, laying an average of 320-470 eggs during their lifetime. Third instar larvae demonstrated strong predatory activity, consuming 40-80 aphids per day. The investigations revealed that eggs could be successfully stored for 30-35 days at 5-8°C and 60-85% relative humidity. Under these conditions, 70-80% viable larvae successfully emerged after storage. Adult insects maintained at 8°C and 85-90% relative humidity retained viability for up to 5-6 months.

Diapause induction was successfully achieved by reducing the photoperiod to 10 hours. Adults entering diapause exhibited decreased physiological activity and a characteristic wing color change from green to pale pink. These findings indicate that diapause induction plays an important role in improving long-term storage technology of entomophagous insects. Under agrobiocenosis conditions, the release of *Chrysopa septempunctata* larvae at a ratio of 1:50 reduced aphid populations by 72-85%. High biological efficiency was also observed when adults were released at ratios ranging from 1:20 to 1:100. In experimental variants treated with entomophages, pest populations remained below the economic threshold level without the application of chemical pesticides. The obtained results may serve as an important scientific and practical basis for the mass production, long term storage, and wide application of *Chrysoperla carnea* and *Chrysopa septempunctata* in local biolaboratories and Integrated Pest Management (IPM) systems. Furthermore, these technologies may contribute to reducing pesticide use, promoting environmentally safe agriculture, and maintaining biological balance within agrobiocenoses.

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