

EVALUATION OF THE ROLE OF THE NESTING DEVICES,
ATTRACTANT AND NECTARIC PLANTS IN THE ACTIVATION,
ATTRACTION AND ACCUMULATION OF *CHRYSOPA*
(NEUROPTERA) SPECIES IN THE ORCHARD AGROECOSYSTEM

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KEYWORDS	ABSTRACT
Attractant Entomophages of the genus <i>Chrysopa</i> Nesting devices for wintering insects	In order to effectively manipulate the behavior of predators and parasitoids in the field, luring them into crops earlier and with greater density, we used the following methods: overseeding aromatic plants (omnivorous lacewings are attracted to a number of plant species, which they use to enhance reproduction, nutrition or rest); attractants, which increase the effectiveness of biological management by raising the level of predation or parasitism; nesting devices providing monitoring and safe wintering of <i>Chrysopa</i> entomophages. In the orchard nesting devices 8,1 times more <i>Chrysopa</i> individuals remained for the wintering, than in the control plot of the Botanical Garden. <i>Ch. carnea</i> was dominant among the species that overwintered in nesting devices. The maximum number of <i>Chrysopa</i> individuals, overwintered in the nesting devices, placed at a distance of 5-20 meters from attractant baits (16,7%; 22,2%; 27,8%). A significant number of entomophages was accumulated in the nesting devices in the orchard plot with oversowing of nectariferous crops (11,1%).

INTRODUCTION

The perspective of the sustainable agriculture in the Republic of Moldova development is based on the extensive use promotion of integrated plant protection, planning and taking measures regarding the effective management of pests and vectors of their distribution (HG 123, 2018). Biological control involves using natural enemies to control pest populations. In order to preserve and more actively use natural enemies, it is necessary to create the most optimal habitat for the development and reproduction of natural enemies. In order to effectively manipulate the behavior of predators and parasitoids in the field, luring them into crops earlier and with greater density, we used:

- A) overseeding aromatic plants (omnivorous *Chrysopa* entomophages are attracted to a number of plant species, which they use to enhance reproduction, nutrition or rest);
- B) attractant baits, that increase the effectiveness of biological management by raising the level of predation or parasitism;
- C) nesting devices, providing monitoring and safe wintering of *Chrysopa* entomophages.

While the behavioral manipulation of biocontrol agents is certainly not a new topic, the concept has taken on renewed interest with the discovery of herbivore-induced plant volatiles (hereafter, HIPVs) as potential attractants for entomophagous arthropods, and speculation has since run rampant that HIPVs can be deployed to enhance the control of agricultural pests. By comparing the VOC profiles of aphid infested vs. aphid-free soybeans, followed by coupled GC-EAG analyses for aphid-infested plants, the authors found that *A. glycines* feeding induces the emission of methyl salicylate (hereafter, MeSA) and that MeSA also elicits a strong EAG response in lady beetles. A field experiment then confirmed that synthetic MeSA is indeed attractive to aphidophagous predators and is a broad-spectrum attractant and found significant field responses for key beneficial insect groups including *Anthoridae*, *Coccinellidae*, *Syrphidae*, parasitic *Hymenoptera*, predaceous *Heteroptera*, and lacewings (Kaplan, 2012).

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<https://doi.org/10.29081/scsb.2024.33.1.03>

The aim of our research was to evaluate the method of using nesting devices in combination with attractant baits as a means of attracting and accumulating beneficial insect species in the agroecosystem of an orchard.

MATERIALS AND METHODS

The objects of research were entomophages of agricultural crops pests - lacewings (*Neuroptera: Chrysopidae*). They are an important component of natural and anthropogenic ecosystems and they are predators of various inactive invertebrates with relatively soft body covers. Most lacewing adults feed exclusively on pollen, nectar or honeydew, however, all lacewing larvae are predators and prey on small insects (especially aphids, mealybugs, mites). One lacewing larvae consumes for the entire period of development 500-600 aphids, or over 11 thousand spider mites (Belyakova et al., 2017).

In order to activate and attract *Chrysopa* entomophages for wintering in the agroecosystem of the garden, nesting devices were used in combination with attractant baits and underseeding of nectar-bearing plants. Nesting devices are a wooden body, filled with special fillers, that are attractive to *Chrysopa* entomophages (walnut shells, rhubarb stems). Attractants are biologically active substances, that affect individuals of other species. For example, attractants include odorous substances, that attract predators and parasites to individuals of this species. These substances cause a certain behavioural reaction in insects: a controlled concentration of entomophages in certain areas of the territory in order to enhance their activity; increasing the search ability of parasites in the entomophages mass breeding.

Nesting devices were used in close proximity to attractant baits (dispensers with the semiochemicals phenylethanol (PEA) and methyl salicylate (MeSA)), thus creating two "odour clouds" to compare the attractiveness of these two organic compounds.

Our research was carried out in 2022 on the territory of the Botanical Garden, the orchard and the site of mixed cultivation of essential oil and fruit crops of the Institute of Genetics, Physiology and Plant Protection (Chisinau, Republic of Moldova). The first stage of research preparation was the collection of natural materials for the construction of nesting devices for insects. We used a wooden frame, provided a waterproof roof structure, and filled individual sections in the nesting devices with various types of filler materials (walnut shells, straw, tubular stems). The second stage was the placement of nesting devices in the spring in the field. The third stage - at the end of the season, we dismantled the nest structures and stored them in a cold room so, that the insects would not come out of diapause. Accounting allowed us to determine the most attractive experimental areas of the bioecosystem for lacewings (Figure 1).



Figure 1. Nesting devices placement in the agroecosystem a) of Botanical Garden; b) of an orchard

The methodology of experiments and statistical processing of the results were carried out according to known methods (Ponomarev, 2014).

RESULTS AND DISCUSSION

During the vegetation period of 2022, a research of the genus *Chrysopa* natural population was carried out using light traps, located in the vicinity of the orchard. Based on sexual dimorphism, the sex ratio of the genus *Chrysopa* summer population species was determined. There were 10% more males than females (Figure 2).

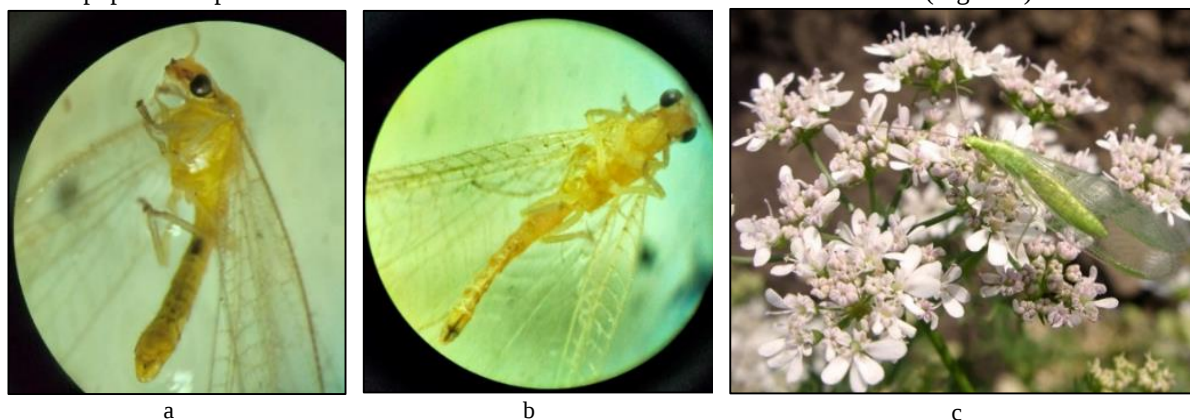


Figure 2. a, b) Sexual dimorphism (♀♀ and ♂♂), c) *Chrysopa carnea* Steph. on the inflorescence of *Coriandrum sativum* L.

Starting number of *Chrysopa* adults in the summer population was high (14 adults per 1 light trap), as a result of the high population numbers of lacewings in the previous year. As a result of a long dry period of high temperatures (June-August 2022), the peak number of *Chrysopa* adults in July was 27 per 1 light trap. In September, the lacewing's number decreased to three adults (Figure 3 (a)).

The taxonomy and quantitative ratio of the genus *Chrysopa* species were determined. More than half (53,7%) of the summer population was *Ch. carnea* Steph. In species *Ch. carnea* Steph. and *Ch. ciliata* Wesm. adults are palinophages (feed on pollen in flowers), wintering in the imago stage. In species *Ch. perla* L., *Ch. septempunctata* Wesm., *Ch. formosa* Br. adults are predators, which increases their importance as entomophages. The quantitative ratio of these three species is 28,8% (Figure 3 (b)).

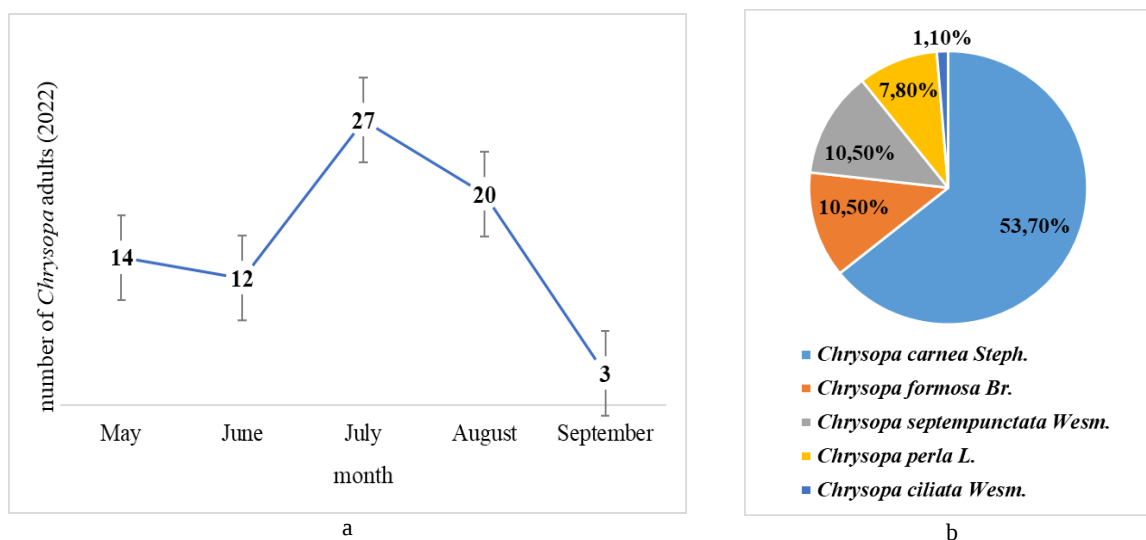


Figure 3. Characteristics of the genus *Chrysopa* summer population in 2022: a) seasonal population dynamics of *Chrysopa* adults in 2022 (per 1 light trap); b) quantitative ratio of the genus *Chrysopa* species

As a result of the research, conducted in 2022 analysis, it was found, that the lacewings were attracted to the nesting devices unevenly. The smallest population of the genus *Chrysopa* entomophages settled down for wintering in the area of the natural biotope of the Botanical Garden, which we used, as a control (7,1%). The flower conveyor of essential oil plants, which acts as a food resource for the entomophages nutrition and reproduction, accumulated a significant number of adults in the area of mixed cultivation (34,5%).

The maximum number of individuals and the maximum diversity of lacewing entomophages species, were attracted and remained for wintering in the orchard nesting devices (58,3%), despite the use of chemical treatments in some parts of the orchard. This ratio can only be explained by the fact, that effective agents were used in the orchard to attract and accumulate entomophages, in addition to the presence of the local population (Figure 4).



Figure 4. a) The ratio of the entomophages's number, attracted to nesting devices in various ecosystems (%);
b) *Chrysopa* sp.

The main lacewing species, wintered in nesting devices were: *Chrysoperla carnea* (Stephens, 1836), *Chrysopa septempunctata* (Wesmael, 1841), *Nineta* sp. (Navas, 1912). The highest lacewing species biodiversity was observed in the orchard, although the biodiversity of the wintering population of lacewings is 2 times less, than the summer population. The overwhelming majority of overwintered lacewings belonged to the species *Ch. carnea* (86,4%) (Table 1).

Table 1. Percentage of lacewing species wintering in the nesting devices in 2022

Percentage of lacewing species	Botanical Garden, %	Orchard, %	Mixed cultures, %	Average value, %
<i>Chrysoperla carnea</i>	75	80	92	86,4
<i>Chrysopa septempunctata</i>	25	6,7	8	8,8
<i>Nineta</i> sp.	0	13,3	0	4,8

Entomophages placement within the orchard is discussed further. On the scheme of the orchard plot nesting devices, where the chemical method of protection was applied, we noted an insignificant number of lacewings individuals (5.6%), which is explained by the lack of food (aphids) and the effect of chemicals on entomophages. In the area, where attractants were used, 5.6% of the total number of lacewings also remained for wintering. This phenomenon can be explained by an excessive amount of attractant, which, in this case, played the role of a repellent and made the plot uncomfortable for wintering lacewings. The maximum number of entomophages overwintered in nesting devices, located at a distance of 5-20 meters from attractant baits (16.7%; 22.2%; 27.8%). A significant number of entomophages accumulated in nesting devices in the orchard plot with oversowing of nectariferous crops (11.1%) (Figure 5).

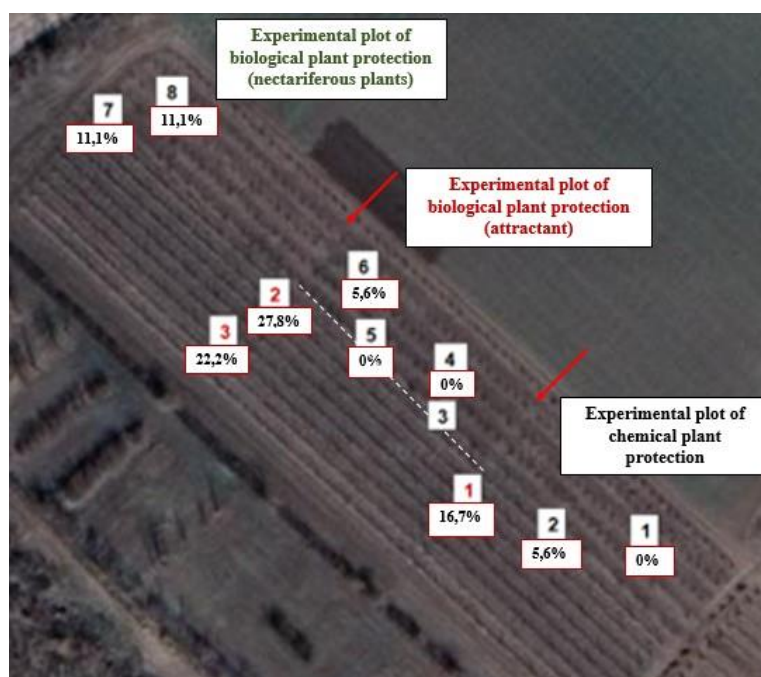


Figure 5. Spatial distribution of adult *Chrysopa* in nesting devices, placed in the orchard in 2022
(1-8 plum orchard, 1-3 apple orchard)

It can be concluded, that the attractant allure entomophages, but the excess of attractant, apparently, scared them away from the bioprotection plot, and the population, settled around, at some distance from the source of the attractant. The area of the orchard, where chemical protection was applied, turned out to be unattractive for entomophages, while the mixed culture's area expanded the location of the lacewing's population and contributed to its prosperity (well-being). The results of our research are consistent with the statement, that attractant-based baits are used to improve biological control strategies by attracting and retaining natural enemies to reduce insect pest populations (Ayelo et al., 2021). Attraction and reward technique consists of the combined use of an attractant and a reward component, such as flowering companion plants. This method has attracted considerable attention as it promotes early colonization of natural enemies in crop fields and reduces their subsequent emigration from those crop areas.

Ian Kaplan (2012) asks the key question in his work "Last, and most importantly, if natural enemies are attracted and convinced to stay in an area?" We managed to give a convincing answer to this question by supplementing the method of using attractants with the method of nesting devices, that attract beneficial insects for wintering and accumulate them in the ecosystem. The great advantage of using nesting devices is that the method allows us to study closely the trophic interactions of species, and easily quantify and qualitatively determine them, which makes it a promising tool for research in the field of biological plant protection, ecology and entomology.

CONCLUSION

The species diversity of the summer population of lacewings is two times greater, than the population of lacewings, wintering in nesting devices. In the orchard nesting devices 8,1 times more *Chrysopa* individuals remained for the wintering, than in the control plot of the Botanical Garden. *Ch. carnea* was dominant among the species that overwintered in nesting devices. The maximum number of *Chrysopa* individuals, overwintered in the nesting devices, placed at a distance of 5-20 meters from attractant baits (16.7%; 22.2%; 27.8%). A significant number of entomophages accumulated in the nesting devices in the orchard plot with oversowing of nectariferous crops (11.1%).

ACKNOWLEDGEMENTS

Research was carried out within the project of the State Program 20.80009.5107.27 "Elaboration of the alternative methods based on environmentally friendly means and procedures for harmful arthropods control in different agricultural crops", financed by the National Agency for Research and Development.

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