Studying Arthropod Biodiversity using Light Traps in the Young and Fruiting Apple Orchards in the South of Russia

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ABSTRACT

Background: Biodiversity loss and destabilization of orchard agroecosystems are key problems in horticulture. Understanding the processes of entomofauna development is essential for developing alternative protection systems for apple trees. The aim of the experiment was to study the composition and structure of the entomocenosis in fruiting and new apple orchards.

Methods: The study was carried out in 2024 in Krasnodar Krai, Russia. The objects were new and fruiting apple orchards. Insects were collected with the light traps at four sites.

Result: The study has revealed the fact that the proportion of primary consumers is higher (Bryukhovetskaya - 1.44%, Krasnodar - 2.39%) in fruiting orchards across all experimental sites compared to new orchards, while the proportion of secondary consumers is lower (Bryukhovetskaya - 2.08%, Krasnodar - 1.22%). The total number of arthropod species is higher in new orchards than in fruiting ones. Dangerous pests of other crops that were neutral to apple trees were identified. This work will contribute to the study of the orchard agroecosystems entomofauna development.

Key words: Apple tree, Biodiversity, Garden ecosystem, Light traps, Monitoring, Triotroph.

INTRODUCTION

Apples are rated third in global fruit production, but their cultivation often requires large amounts of pesticides (Zaller *et al*., 2023). Chemical pesticides have a toxic effect on beneficial insect communities, causing their mortality and disrupting their physiology and behaviour (Serrão *et al*., 2022). Their impact reduces insect biodiversity and could lead to the extinction of 40% of species in the coming years (Mazed *et al*., 2021). The apple tree is the primary producer, determining all relationships in the apple orchard ecosystem as a system consisting of fruit trees, phytophages and entomophages of pests (Balykina, 2016). Organic farming has the best effect on predatory arthropod communities (Sattler *et al*., 2024). Studying insect biodiversity is essential for the development of new methods for biological pest control (Agasyeva *et al*., 2022). The aim of this research is to study the biodiversity of arthropods using light traps in new and fruiting apple orchards in southern Russia to understand the organization of their complexes.

MATERIALS AND METHODS

The study was carried out at the Federal Research Center of Biological Plant Protection. Insects were collected from June to September 2024 in the new and fruiting apple orchards in the central zone of Krasnodar Krai, on the outskirts of Krasnodar and in the village of Bryukhovetskaya, across four plots measuring 1 hectare each. The study subjects were new and fruiting apple orchards. Light traps developed at the Federal Research Center of Biological Plant Protection (FSBSI FRCBPP) were used (Pachkin *et al*., 2021). Insect species were identified using identification guides (Amolin, 2016).

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Counts were carried out weekly. The insect complex was assessed using various biodiversity and dominance indices proposed by different authors (Pachkin *et al*., 2021). In the studied apple orchards, the row spacing is bare fallow and periodically cultivated.

RESULTS AND DISCUSSION

To identify the processes of insect complexes development, it’s necessary to study the structure and complexity of the fauna of the apple tree monoculture. The distribution of species captured with light traps in Bryukhovetskaya Station varied slightly depending on the age of the orchard Table 1.

There were representatives of 10 orders: Trichoptera, Ephemeroptera, Odonata, Orthoptera (absent from the Bryukhovetskaya orchard), Heteroptera, Neuroptera, Coleoptera, Lepidoptera, Hymenoptera and Diptera. The greatest diversity was found in Lepidoptera: 19 families (Noctuidae, Pyraustidae, Sphingidae, Cossidae, Lasiocampidae, Erebidae, Crambidae, Tortricidae, Yponomeutidae, Phicitidae, Geometridae, Geometridae, Psychidae, Gelechiidae, Tineidae, Pterophoridae, Nolidae, Pyralidae, Plutellidae). Of these, Pyralidae and Plutellidae were not found in Bryukhovetskaya; Lasiocampidae, Psychidae, Nolidae and Pterophoridae were not encountered in Krasnodar. Most of the captured species belonged to the noctuid family (Noctuidae) - 24 species in Bryukhovetskaya and 15 in Krasnodar. The second most numerous families were Crambidae - 8 species in Bryukhovetskaya – and Pyraustidae - 4 in Krasnodar. Some species found in the new orchards may have been absent in the fruiting orchards and vice versa.

A total of 4,049 individuals of the noctuid moth family were captured in Bryukhovetskaya, including 1,279 in the fruiting orchard and 2,770 in the new one. The most numerous individuals in Bryukhovetskaya were: *Helicoverpa armigera* - 595 individuals in the fruiting orchard and 1,418 in the new one; and *Emmelia trabealis* - 182 and 437, respectively. More individuals of these families were observed in the new orchard in Bryukhovetskaya than in the fruiting one.

In the apple orchards of Krasnodar, the noctuid moth population totaled 854 individuals, including 499 in the fruiting orchard and 355 in the new one. The most numerous was *E. trabealis* - 114 individuals in the fruiting orchard and 98 in the new one. The number of *H. armigera* was 66 and 54 individuals in the fruiting and new orchards, respectively.

Cydia pomonella was found in both locations. During the season, 39 individuals were captured in the fruiting orchard in Bryukhovetskaya and 14 in the new one; in the fruiting orchard in Krasnodar 0 individuals were captured and 2 in the new orchard.

Among the orders Coleoptera (14 families), representatives of the following orders are quite numerous: Scarabaeidae, Dytiscidae, Cerambycidae, Elateridae, Carabidae, Heteroceridae, Coccinellidae, Hydrophillidae, Chrysomelidae, Curculionidae, Haliplidae, Staphylinidae, Cantharidae and Tenebrionidae. No lamellicorn beetles were recorded in the fruiting orchard in Bryukhovetskaya, while Silphidae and Cerambycidae were found in the new orchard in Krasnodar. The total number of Coleoptera species in the new orchards was 5,424, while in fruiting orchards - 3,159. Heteroceridae constituted more than half of all beetles. Only a few species of Carabidae, Coccinellidae, Staphylinidae and Cantharidae were entomophagous, with total numbers not exceeding 100 individuals.

As a result of species identification and determination of the trophic status of Table 2 insects, it was found that in the orchards in Bryukhovetskaya, over 70% of insects were primary consumers; over 20% were secondary consumers. In Krasnodar, over 56% of insects are primary consumers and over 35% are secondary consumers.

In all fruiting orchards, primary insects predominate compared to new orchards.

The Simpson and Shannon-Weiner Table 3 indices indicate heterogeneity and impoverishment of the entomofauna, but in fruiting orchards homogenity was higher than in new ones. The Berger-Parker index indicates the presence of absolutely dominant species; in fruiting orchards, this indicator was higher, as well as the impoverishment of the entomofauna of the agroecosystem. The Margalef index reflects high species density, especially in fruiting orchards and the Pielou index indicates a well-balanced population.

Table 1: Total number of taxa captured by light traps in young and fruiting orchards, 2024.

Apple orchards	Species	Orders
	Bryukhovetskaya	
Fruiting orchard	94	9
Young orchard	107	10
	Krasnodar	
Fruiting orchard	71	10
Young orchard	74	10

Table 2: Ecological groups collected by light traps, 2024.

Ecological groups	Bryukhovetskaya		Krasnodar	
	Fruiting orchard	Young orchard	Fruiting orchard	Young orchard
Consumers I	73.4%	71.96%	59.15%	56.76%
Consumers II	21.28%	23.36%	36.62%	37.84

Table 3: Representatives of insect orders captured with light traps, 2024.

Index	Bryukhovetskaya		Krasnodar	
	Fruiting garden	Young garden	Fruiting garden	Young garden
Shannon-weiner diversity index	2.3±0.2	2.1±0.2	2.6±0.2	2.2±0.8
Margalef species richness	4.0±0.5	3.9±0.6	4.8±0.7	4.4±0.9
Simpson dominance index	0.2±0.0	0.2±0.1	0.1±0.1	0.2±0.1
Berger-parker dominance	3.8±0.7	3.3±0.7	4.2±0.9	3.5±1.4
Pielou's evenness index	0.7±0.1	0.7±0.1	0.8±0.1	0.7±0.1

In the new orchards, the numbers of major phytophages are lower than in the fruiting ones. A poor fauna of predators and parasitoids was found, which is not typical for balanced ecosystems.

This research confirms the negative impact of pesticides on the entomofauna of apple orchards, the environment (Kumar *et al*., 2021) and the stress tolerance of apple trees (Dhanyasree *et al*., 2022). Plant-insect interactions in orchards are diverse and essential for the stabilization of agroecosystems (Afroz *et al*., 2021). Light traps have been used in various studies to examine the entomofauna of peanut (Balamurugan and Kandasamy, 2021), to investigate different stages of insect development (Sulaimonov *et al*., 2019) and the entomofauna of field agrocenoses (Pachkin *et al*., 2021).

CONCLUSION

A weak correlation was found between the faunal composition and the age of an apple tree; most insect species were not trophically associated with it and were found migrated from other habitats. The primary goal of stabilizing orchard ecosystems and activating natural entomophagous populations is to provide them with shelter and additional food. Further research on insect biodiversity and assessment of insect abundance in orchards of different ages are needed to understand the development of entomofauna.

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Disclaimers

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Informed consent

All authors have given consent to publish this article.

Conflict of interest

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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