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THE IMPACT OF THE ENTOMOFAUNA ON THE PLANTS OF *Phacelia tanacetifolia* Benth. IN THE COLLECTION OF THE "AL. CIUBOTARU" NATIONAL BOTANICAL GARDEN (INSTITUTE)

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Abstract

The species P. tanacetifolia has high potential due to its honey, ornamental and forage value, with special properties that make it advantageous to be grown and used in beekeeping, under the environmental conditions of the Republic of Moldova. It has been considered a plant with attractive flowers for honeybees and all the associated entomofauna. Under the climatic conditions of RM, it attracts a large range of insects, with various trophic spectra, so that pollinating species predominate in the flowering stage, which is staggered (40-55 days out of a total of 104 days of the growing season) and provides a stable and long-lasting source of food for melliferous insects. The phytosanitary monitoring carried out established the presence of a significant complex of insects, represented by 23 species included in 6 orders and 17 families. The species of the order Coleoptera (7) were predominant, followed by Hymenoptera (6), Diptera (4), Hemiptera (3), Lepidoptera (2) and Homoptera (1 species). The diversity and numerical density was higher in species of bumblebees and honeybees, as specialized pollinators of flowering plants, which visited the flowers throughout the flowering period.

***Key words**: Phacelia tanacetifolia, entomofauna, trophic specialization.*

INTRODUCTION

Currently, agriculture practiced in different ways, for example in private, associative or state farms, needs more research and implementation of its results and a wider range of knowledge, to be able to cope with the many issues that arise in connection with the cultivation technologies, especially concerning newly introduced plant species (Roşca et al., 2011). The research on the cultivation of new plants, especially species with high potential for honey production and that can be used as natural fertilizers for degraded soil in anthropogenic agrocenoses, can play an important role by elucidating and applying modern methods concerning the ecological and phytosanitary impact of terrestrial insect complexes on new species of honey plants (Busuioc, 2004, Roşca, et al., 2011).

Internationally, in the European Union, research on pollinating insects has been conducted in scientific centres, focusing on the effectiveness of the application of a series of beneficial measures for monitoring pollinating entomofauna in order to protect natural and anthropogenic habitats, to offer scientific and applied support to beekeeping and to set restrictions on the excessive chemical management in the protection system of anthropogenic agrocenoses (Talmaciu, 2014, Зауралов, 1985).

The bibliographic review on the respective topic highlighted the presence of over 1000 species of honey plants, with various classifications according to such criteria as: morpho-taxonomic and bioecological criteria, potential for beekeeping, economic-productive efficiency in obtaining biological production and honey per hectare (Pîrvu, 2000, Eremia, 2014). The research on entomofauna has resulted in the estimation of various determinations and ways of formation of insect associations with different trophic specialization and adaptation to plants, as well as the elucidation of harmful and beneficial species and the balance in the system host plant - harmful organism - environmental factors (Perju, 1995; Busuioc, 2004).

Natural populations of entomophagous insects play an important role in regulating the numerical density of pests, but their frequency is insufficient for a reliable protection of crops. In such situations, a recommended biological protection measure is the additional release of useful predatory insect species in order to reduce the abundance of parasitic pests in anthropogenic agro-ecosystems (Perju, 1995, Volosciuc, 2014).

Based on the literature review, we have estimated the significant role of insect complexes on plants, where some species of predatory-omnivorous insects are used as living biological agents in combating other species of harmful insects, which are characteristic of crop plants. We would also like to mention the complex harmful effect of parasitic species that cause considerable damage to agricultural crops, being also vectors of phytopathogenic bacteria (Tălmaciu, 2014).

Our research has been conducted on *Phacelia tanacetifolia* Benth. - a species in the family Hydrophyllaceae Lindl. (=Boraginaceae Juss.), the genus *Phacelia* (=*Eutoca*), which includes over 150 species of plants occurring in the wild flora of the American continents (USA to the Andes Mountains, Chile) (Cherniavskih, 2018, Чибис, 2017). It has been known since 1832 and was brought to Europe from North America by the naturalist researcher David Douglas (Чибис, 2017).

Lacy phacelia, also known as purple tansy, is an annual herbaceous plant with multiple uses and can play an important role for natural and anthropogenic biocoenoses under the environmental conditions of the Republic of Moldova. In the NBGI, the variety 'Melifera' was created and approved and it was registered in the Catalogue of Plant Varieties of the Republic of Moldova in 2014. In 2016, the Plant Variety Patent no. 206 / 2016.05.31 was obtained. During our previous research, the chemical composition of the 'Melifera' cultivar of lacy phacelia was determined: ADF - 30.2%, NDF - 53.4%, ADL - 7.0%, cellulose - 23.2%, carbon - 48.1%, potassium - 36.8 g/kg, calcium - 43.6 g/kg, zinc - 32.8 mg/kg, organic substances - 866 g/kg (Țîței, 2017; 2019). It is remarkable that lacy phacelia possesses melliferous and productive capacities and up to 300 (556), (600-100) kg/ha can be obtained (Cherniavskih, 2018; Ion et al., 2018; http://www.eurohonig.com). The nectar of *P. tanacetifolia* contains organic substances in large quantities such as: sucrose (53.2 %), glucose (14.7 %) and fructose (21.9 %) (Зауралов, 1985), besides, the amount of nectar produced by this crop in the flowering stage is also an efficient nutritional source for 60 species of parasitoids and other species of various trophic specilaizations (Brown, 2001).

The purpose of our research was to carry out evidence and inventory studies on the impact of plants of the species *P. tanacetifolia* on the entomofauna under the influence of the climatic conditions of the Republic of Moldova. We set the following objectives: to determine the frequency diversity of the insect species identified in various phenological stages on the lacy phacelia plants; the elucidation of the spectrum of trophic specialization and the classification of insects according to this criterion and their taxonomic position.

MATERIALS AND METHODS

The research was done in the experimental sectors of the National Botanical "Al. Ciubotaru" Garden (Institute) (NBGI), 46°58'25.7" latitude and N28°52'57.8" longitude, in demonstration plots, where a wide range of plants with multiple uses has been cultivated annually and extensive research on their morpho-biological features and melliferous capacity, forage quality and efficiency in restoring the structure and fertilization of damaged soil has been conducted. The experimental plots have different areas, depending on the research criterion (10 m^2, 100 m^2) (Figure 1).

The plants of the 'Melifera' cultivar of *Phacelia tanacetifolia* Benth. served as research subjects. The seeds were sown in March, at a depth of 2-3 cm; the distance between rows was 15 cm and the seeding rate 0.6 g/m^2.

Seasonal and monthly surveys were conducted in 2019-2020, during different phenological stages of the plants (spring-summer), through manual collecting with the insect net, visual observations and findings with the digital camera, with the purpose of determining the diversity of insects on the plants of *Phacelia tanacetifolia* Benth. and the nature of their interaction.

A B

Figure 1. A - experimental plot planted with *P. tanacetifolia*; B - lacy phacelia in the flowering stage

Over 150 samples of plants and insects collected from various parts and organs of the plants, influenced by the environmental conditions in the respective stages, were analyzed. Subsequently, laboratory analyzes were performed to identify the morpho-biological features of the insects, their taxonomic affiliation and trophic specialization, confirmed by descriptions, pictures, documentation, studying guides for determining insect species, monographs, manuals and other literature on general, special and applied entomology (Бей-Биенко, 1966; Плавильщиков, 1994; Perju, 1995; Busuioc, 2001; Cozari, 2010; Talmaciu, 2014).

RESULTS AND DISCUSSIONS

Extensive research on the non-traditional plant species has been conducted at global and regional level, including the Republic of Moldova, aiming at introducing and breeding this new plant species with multiple uses, by bioecological adaptations, obtaining raw material for soil fertilization, fodder and a significant source of pollen and nectar for beekeeping. In this context, we would like to mention the importance of *P. tanacetifolia*, used and researched as a promising species that possesses productive and bioecological qualities appreciated in the agro-economy of the Republic of Moldova.

As a result of the morpho-taxonomic and bioecological research conducted in the NBGI, lacy phacelia was described as an annual herbaceous species, with the growing season of about 104 days and the flowering phase lasting 45-55 days, being initially investigated as a fodder crop, and then, after its successful adaptation to the environmental conditions, other valuable qualities were noticed, such as its melliferous potential and positive impact on soil fertility. So, the species is currently characterized as a nectar-pollen producing crop and a source of nutrition for pollinating insects dominated by honey-producing species and those of high ecological importance.

These plants stay attractive for a long time for all spontaneous terrestrial entomofauna with different trophic spectrum, noticed especially in the flowering stage, because the plants produce a large number of inflorescences, and the flowering occurs in acropetal order, is staggered, with fragrant distinct smell, thanks to the compact nectariferous disc at the flower base. Honey bees, due to their abundance and frequency, predominate the persistence area over the flowers and are also the main pollinators that help the formation of the effective mass of flowers and seeds. A study shows an increase in the number of seeds on average by 24 %, in the number of flowers in inflorescence - by 1.4 times, and their presence was observed throughout the growing season (Васильева, 2017).

Our studies indicate the start of the growing season with the seeds being sown in early March, followed by germination and formation of vegetative and generative organs until mid-April-May, depending on environmental factors. The plants are erect, branched, producing up to 20-25 shoots, with lateral branches, the stem is juicy-fibrous, the leaves - alternate, sessile, pinnately-lobed, green and with shades of blue. The inflorescences are fan-shaped, 15-20 on each plant, consist of up to 70 flowers on the main shoots and up to 30-40 flowers on the lateral ones. The inflorescences consist of 4-8 one-sided coiling cymes (curls), with 18-22 flowers each (Figure 2).

Figure 2. Aspects of the inflorescence of *P. tanacetifolia*

The flowers are bell-shaped, of blue-lavender colour, with attractive scent and a lifespan of up to 2 days.

At the same time, monitoring surveys were carried out to identify the entomofauna present in the experimental plot during the growing season and its interaction with the lacy phacelia plants. Insects and invaded plant organs were sampled for further analysis in the laboratory.

Visually and microscopically, we determined some aspects related to the morpho-taxonomic characteristics, preparing some classifications of the trophic spectrum of the insects from the samples taken from various parts and organs of plants. As a result of this preliminary research on entomofauna and on the impact of environmental conditions on it (2019-2020), 23 species of terrestrial insects were identified in various stages of development of *P. tanacetifolia* plants, taxonomically belonging to 17 families and 6 orders, estimated in Table 1, where the classification of the trophic specialization was also given.

Table 1. The diversity of entomofauna in the plantations of *P. tanacetifolia* and the systematization of the taxonomic units classified according to the trophic spectrum

No	Order	Family	Species	Trophic spectrum
1	Hymenoptera	Apidae	*Apis mellifera* (Linnaeus, 1758)	Pollen and nectar
2			*Bombus terrestris* (Linnaeus, 1758)	Pollen and nectar
3			*B. lapidarius* (Linnaeus, 1758)	Pollen and nectar
4			*B. hortorum* (Linnaeus, 1761)	Pollen and nectar
5		Halictidae	*Lasioglossum malachurus* (Kirby, 1802	Pollen and nectar
6		Megachilidae	*Xylocopa valga* (Gerstaecker, 1872)	Pollen and nectar
7	Hemiptera	Coreidae	*Tritomegas bicolor* (Linnaeus, 1758)	Phytophagous, nectariphagous
8		Rhopalidae	*Corizus hyoscyami* (Linnaeus, 1758)	Phytophagous
9		Miridae	*Liocoris tripustulatus* (Fabricius, 1781)	Omnivorous
10	Homoptera	Cicadidae	*Cercopis arcuata* (Fieber, 1844)	Phytophagous
11	Coleoptera	Cerambycidae	*Agapanthia violacea* (Fabricius, 1775)	Phytophagous
12		Mordelidae	*Mordella aculeata* (Linnaeus, 1758)	Phytophagous
13		Coccinellidae	*Coccinella septempunctata* (Linnaeus, 1758)	Zoophagous, phytophagous Entomophagous, aphidophagous
14		Scarabaeidae	*Epicometis hirta* (Poda, 1716)	Phytophagous, nectariphagous
15			*Valgus hemipterus* (Linnaeus, 1758)	Phytophagous
16			*Cetonia aurata* (Linnaeus, 1758)	Phytophagous
17		Crhysomelidae	*Cryptocephalus sericeus* (Linnaeus, 1758)	Phytophagous
18	Diptera	Syrphidae	*Syrphus pyrastri* (Linnaeus, 1758)	Pollen, plant liquids, zoophagous
19			*S. ribesii* (Linnaeus, 1758)	Pollen, plant liquids, zoophagous
20		Sarcophagidae	*Sarcophaga carnaria* (Linnaeus, 1758)	Plant liquids
21		Tachinidae	*Xylota segnis* (Linnaeus, 1758)	Plant liquids
22	Lepidoptera	Satyridae	*Lasiommata maera* (Linnaeus, 1758)	Nectariphagous
23		Lycaenidae	*Polyommatus icarus* (Rottenburg, 1775)	Nectariphagous

These were significant results for the identification of species that are efficient nectar-feeding pollinators. At the same time, we would like to mention the presence and the predominance of honey-producing species belonging to the Apidae family (*Apis mellifera*, species of *Bombus*, *Lasioglossum malachurus*, *Xylocopa valga*) (Figure 3).

The collected material, which was morphologically analyzed and the taxonomic affiliation was established, was subsequently classified based on the obtained results to estimate the comparative share (%), in systematic terms, according to the orders, density and abundance of the determined insect species.

Figure 3. A - the species *X. valga*; B - *B. terrestris* found on the flowers of *P. tanacetifolia*

The obtained ratio reflects the presence of insects according to their orders: Coleoptera - 7 species (31%), followed by Hymenoptera - 6 species (26%), Diptera - 4 species (17%), Hemiptera - 3 species (13%), Lepidoptera - 2 species (9%), and the order Homoptera (4%) was represented by only one species (Figure 4).
Adult individuals predominated in insect associations; most of them were phytophagous, preferentially feeding on nectar and flower pollen, mixed with liquids, exudates, dew and other plant metabolic products useful for the vitality of insects that play an important role as pollinators and honey producers. The subsequent classification according to the trophic spectrum, showed that the group of phytophagous insects prevailed (91%), which denotes their preference for *P. tanacetifolia* and their adaptation to these plants due to the nutrition sources they provide, creating favourable conditions for their reproduction, and the ecological-biological efficiency of the interaction between the insects and the host plant.
At the same time, the omnivorous-zoophagous insect species were significantly less numerous, their share being only 9 % of the total number of analyzed species. For us, the most important result of our research is the abundance and the harmonious interaction between phytophagous insects and the host plants, as an important qualitative factor for the maintenance of phytocenoses, honey yields and production of high quality seed material. This interaction depends on the impact of insects and the response of plants (Танский, 1988).

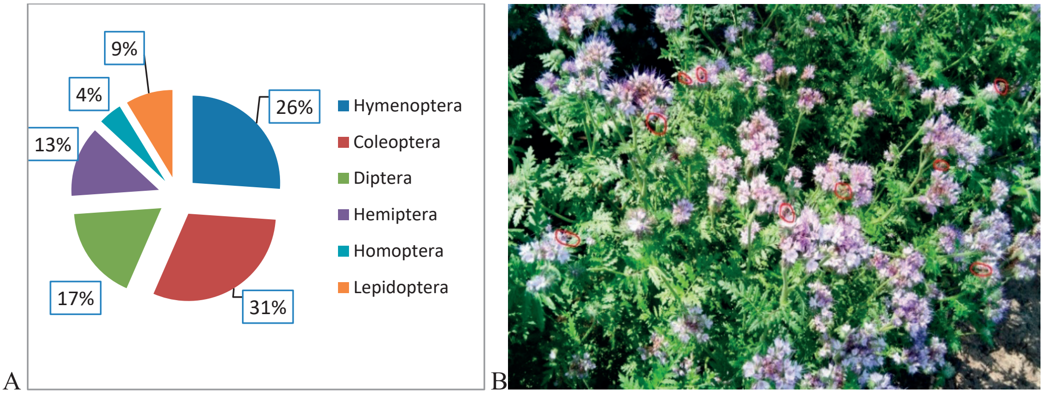

Figure 4. A - Comparative share of insect species according to orders; B - *P. tanacetifolia* in the flowering stage visited by pollinating insects

Another important finding was the establishment of the harmful impact of invasive species that partially affected the plants during some periods of the growing season, when phytoparasitic colonies of aphids (*Aphis* sp.) and thrips (*Thrips* sp.), which also occurred on plants, already as harmful species, were the most frequently and abundantly detected. In addition, we would like to mention the significance of another insect species with double trophic spectrum – *Epicometis hirta* (apple blossom beetle), detected in the flowering stage as a pollinator, but also as a pest of the developing fruits and seeds.
In this context, on plants, there was a struggle for existence determined by the nutritive factor, between the associated complexes of predatory-omnivorous (entomophagous) insects and the phytoparasitic pests, thus, the latter were devoured by entomophages that regulated the density of their populations, as a means of natural biological protection of *P. tanacetifolia* plants, making it possible to exclude pesticides totally.
Extensive analyses and evaluations of that study also established the comparative correlation between groups of parasitic insects (those with sucking-stinging and chewing mouthparts) in impact with nectarophagous species, which by their frequency and abundance dominate plants and intervene as nectarophagous pollinators that do not affect the plants and are significant for the researched

species and for other new honey-fodder species for the Republic of Moldova.

During the entire flowering stage and during the day (8:30-18.00), the most active and abundant species observed on plants were *Apis mellifera* L. and the bumblebees *Bombus terrestris* L., *B. lapidarius* L., *B. hortorum* L., regardless of the weather conditions (sunny, cloudy and even drizzle). However, at noon, from 11:30 to 12:30, they were the most active and productive. We estimated that the productive efficiency of a honeybee was on average 4-12 seconds on an inflorescence, depending on the size of the inflorescence, and of a bumblebee 8-10 seconds, and up to 5-9 insects could be simultaneously present on a flowering plant.

According to the research conducted by Vasilieva (2017), in the lacy phacelia plantations, along with the honeybees (2 individuals/m^2), there were other species of pollinating insects, which were not detected by us in the collection of the NBGI, such as *Myatropa florea* L. (1.6 individuals/m^2), *Vespula vulgaris* L. (1 individual/m^2) *Bombus agrorum* L. (1 individual/m^2) etc.

In conclusion, we mention that the preliminary study has estimated the bioecological and productive significance of the insect complexes associated with the species *P. tanacetifolia* and the trophic relationships between them, determining the advantageous aspects that can be useful for beekeepers.

CONCLUSIONS

Based on the research carried out at the "Al. Ciubotaru" National Botanical Garden (Institute) on the species *P. tanacetifolia* as a crop with multiple utility, with melliferous qualities, the impact of the entomofauna on the researched plants was assessed by determining the indices of diversity, density and the trophic specialization of the researched insect complexes.

As a result of the research, insect associations belonging to 6 orders, 17 families and 23 species have been detected on *P. tanacetifolia* plants during the entire growing season. The estimated species diversity was classified comparatively according to the prevalence of insects on plants by order and trophic specialization, concluding that 91% were phytophagous species, while only 9% were omnivorous-zoophagous species. This fact indicates the preference of insects for the studied plant species and demonstrates the high potential of *P. tanacetifolia* as a honey plant, significant for the entire pollinating fauna and of interest to beekeepers.

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