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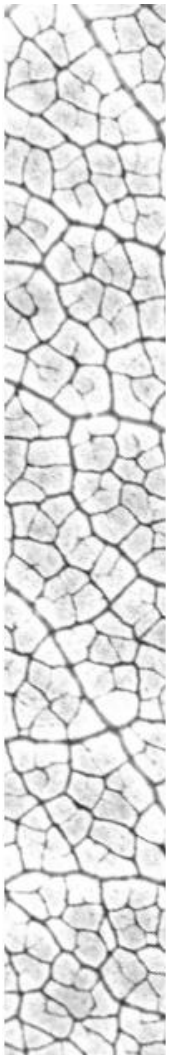

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Ecological features of species diversity and pollinator species on *m. sativa* seed crops

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Abstract
The condition and dynamics of the entomophilic fauna of *Medicago sativa* L. seeds in the cultivated lands of the Belgorod region were studied, using insecticides and without treatment. The species composition of pests, entomophages and pollinators on seed crops *M. sativa* is found. 17% of pollinator species have been found to belong to the family *Megachilidae*. The species density of the entomofauna of potential pollinators after treatment with insecticide decreased by a factor of 2. The Menhinick index is also down on 50%, indicating a decrease in species diversity. It has been proved that with the correct dosage of insecticide, as well as under the conditions of treatment (from 22-00 to 05-00 – during the absence of flying's of pollinator insects), part of the entomofauna of pollinators remains, while most of the pests die.

Keywords: entomophilic plants, insecticide treatment, *Medicago*, pollinator species density, Menhinick index, Berger-Parker index

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INTRODUCTION

Entomophilic plants play a major role in Russian agriculture (Lucas et al. 2017, Krishna and Keasar 2018, Dumacheva et al. 2017, 2018).

Insect pollinators play an important role in the conservation of plant biodiversity in regions (Degtyar and Chernyavskikh 2004, Losapio et al. 2016, Maurice et al. 2020, Ollerton 2017).

The cultivation of entomophilic crops has a number of features, especially in arid periods. The ever-increasing anthropogenic impact negatively affects the productivity of crops closely associated with pollinators, especially in the conditions of abnormal weather, which has been recorded in recent years. The relationship between entomophilic plants and their pollinators, which has become particularly important in recent decades, is relevant in view of the mass use of insecticides in crop production (Alexander and Michener 2015, Dikmen 2011, Rotchés-Ribalta et al. 2018, Forrest 2016).

Most of the entomophilic agricultural plants are effectively pollinated by *Apismellifeira*, and therefore the development of beekeeping should be given one of the most important places in agricultural production. However, the "wild" members of this class also play an important role in this process. However, in recent decades, entomophilic fauna has experienced strong press from humans, leading to the decline and sometimes total destruction of their populations in some areas (Szentgyörgyi et al. 2017, Kozin 2011, Popov 2019, Salehi and Farahbakhsh 2014).

The aim of the study is to study the state and dynamics of the entomophilic fauna of *Medicago sativa* L. seed crops in the cultivated lands of the Belgorod region with and without insecticides.

MATERIAL AND METHODS

The objects of the research were the species composition of *M. sativa* pollinators and its change depending on the geographical location of crops and the level of insecticidal load. Field experiments were placed according to Dospekhov 's method (2012). The species composition of pollinators was studied in 2017-2019. The research was carried out in the last decade of July – the first decade of August in Chernyansky and Novokolsky districts of the Belgorod region on the fields of ZAO «Krasnoyaruzhskaya Grain Company» and ZAO

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«Novokolskaya Grain Company». The material for research work was the collection of insects produced during the period of mass flowering of *M. sativa*.

The collection of insects was carried out on insecticide-treated crops ("Bi 58 new" at a dose of 1.2 l/ha in the budding phase) and on fields not treated with insecticides (control fields) according to standard procedures (Popov 2019, Fasulati 1971, Pasenko 1972). Excel 7.0 and Statistica 6.0 computer programs were used to process the results.

RESULTS AND DISCUSSION

The research was carried out at the places of seed crops *M. sativa* in Chernyansky and Novooskolsky districts of the Belgorod region. The growth density of *M. sativa* was about 100%, since the test areas are artificial crops, and therefore practically do not contain other plant species. On sunny days, at a sufficiently high ambient temperature and in the absence of strong wind, massive insect collecting was obtained from the fields, among which pollinators, pests and a small number of entomophages were noted.

In collections from *M. sativa* seed crops, a large proportion of pests, about 64%, belonged to insects such as *Phytonomusvariabilis Herbst, Adelphocorislineolatus Goeze* and *Bruchophagusroddi Guss*. A slightly smaller amount – 36% – was discovered by *Tychiusmedicaginis* Brisoutde Barneville, *Aphis cracciuvora* Koch. and *Bruchophagusroddi* Guss.

As entomophages collecting from lucerne acted *Coccinellidae, Nabidae* and *Chrysopidae*.

Pollinator insects are represented by three families – *Hymenoptera, Diptera* and *Lepidoptera*.

The bulk of the seized copies classified as pollinators were from *Hymenoptera*. 313 copies of *Megahilla, Apis* and *Halictidae* were caught on 500 waves by entomological butterfly net (1 field under study). At the same time, most of them – 64.1% – belonged to the family *Megachilidae* (201 individuals); 31.7% belonged to the family *Apidae* (99 individuals) and only 4.2% belonged to *Halictidae*, which was 13 individuals.

The low proportion of participation in the pollination process of species of the family Bialate and Lepidopteran is due to the lack of adaptation of the oral apparatus of members of these insects to the flower structure of plants of the family *Fabaceae*.

It has been found that 17% of the species of possible pollinators belong to the family *Megachilidae*, they also predominate in terms of the number of individuals.

The peak in the number of most bees is in late June-early July, when there is a massive flowering of lucerne and other entomophilic plants of different families.

The peculiarities of the structure of the lucerne flowers force *A. mellifeira* to produce only nectar collection. Plant pollination is a concomitant phenomenon. At the same time bees have to pass a proboscis to nectars on the side of the crown, in connection with which only occasionally the «carina» is affected. Thus, from 2 to 6%, maximum – up to 15% are opened from visited flowers. Moreover, *A. mellifeira* visits the fields of the lucerne only if the colors have a sufficiently nectar-forming capacity.

For the wild bees, the level of nectar-forming capacity is not the main indicator, so their pollination of perennial legume herbs, in particular *M.sativa*, is observed at lower temperatures and at less humidity. It is humidity that ensures the inflow of nutrients to the flower, which creates the necessary level of nectar-forming capacity. In a dry weather, the nectar formation slows or may cease, which will significantly reduce the percentage of pollination of plants.

To characterize the entomofauna of seed crops *M.sativa,* we determined insect numbers per unit area. In the test crops, which did not use insecticides, the number of insects that are potential pollinators from all the listed groups was: 1 field – 55.2±1.12 individuals per $1m^2$; 2nd field – 46.4±0.07; 3rd field – 63.8±0.20 and 4th field – 41±0.51 individuals per $1m^2$. On an average 51.6±0.51 individuals per $1m^2$ comes from untreated fields of seed lucerne.

By species composition in all collections from lucerne there was a clear superiority in the number of *Hymenoptera*. So *A. mellifeira* had an average population of 2.0±0.30 individuals per $1m^2$; *M. rotundata* – 3.0±0.41; *X. osmia; Bombuspascuorum, B. fragrans; Vespula vulgaris and R. idescanus* - had numbers of – 0.5±0.10; 2.0±0.42; 0.2±0.14; 3.0±0.52 and 0.2±0.11 samples per $1m^2$, respectively. The smallest number of individuals was represented by *Lepidoptera*– 0.1±0.09 sample per $1m^2$.

In addition to the detected biological resources of possible pollinators on entomophilic plants, representatives of pests of this culture, such as *Ph. variabilis, A. lineolatus, B. roddi, T. medicaginis, A. cracciuvora* have been collected by the method of mowing by entomological butterfly net. Since pests cause significant damage to the biological resources of lucerne, both green mass and seed products, contributing to the reduction of yield, various insecticides are used to reduce losses. At the same time, many researchers note that the weak damage of the lucerne practically did not affect the budding and further development of seed productivity of the culture, while in severely damaged plants the terms of flowering onset are shifted and, in general, the rest phases of the development are lagged. All this directly affects the seed productivity of *M. sativa.*

A feature of the seed Lucerne growing and obtaining a good harvest is timely determination of the presence of Apions and their malevolence. Since the Apions has a sufficiently long egg-laying period, lasting almost until the seeds mature in the upper part of the plants, the

Table 1. Indices of entomofauna biodiversity of potential pollinators in *M. sativa* crops

Studied options	Species density	Menhinick index	Berger-Parker index
Fields without insecticidal treatment	0.64±0.02*	0.28±0.02**	0.05±0.01
Fields processed by an insecticide	0.34±0.01*	0.14±0.01**	0.02± 0.01

Note – *differences are significant at 99% significance level; ** – differences are significant at 95% significance level; $t_{st0.05}$=3.18, $t_{st\ 0.01}$=5.84

insecticide treatment of the lucerne seed crops is carried out twice per season.

The "B 58 new" preparation was used in the experimental fields. This insecticide is thought to be highly toxic to invertebrate animals.

Entomological collection on preparation-treated agrocoenoses was performed on the 10th day after insecticide application.

Despite the sufficient time after a treatment, there was a significant decrease in insect activity. In addition, when counting individuals removed from the natural environment, a decrease in the species composition of pollinators was also found, which could affect the biological productivity of the perennial grass studied.

Species density and Menhinick index were determined to assess the biodiversity within each of the habitats (non-insecticidal fields and insecticide treated). By means of the Berger-Parker index, the dominant species of a given biocenosis was determined. The data obtained are shown in **Table 1**.

From the data shown in the table, it can be seen that the species density of the entomofauna of potential pollinators has decreased by a factor of 2 after the insecticide treatment. The Menhinick index also declined by 50%, indicating a decrease in species diversity.

At the same time, the dominant type of pollinator has changed. Prior to the treatment of "Bi-58 new" the *M.rotundata* was the most numerous species on the lucerne crops. Its occurrence was defined as 3.0±0.41 sample per 1m^2.

After the treatment the frequency of its occurrence was only 0.2±0.15 individuals per 1m^2. *Vespula vulgaris* became the dominant species on the preparation-treated lucerne seed crops – the occurrence was 3.0±0.52 samples per 1m^2.

For this species, however, the pollination process is more of a concomitant function. Since more *A. mellifeira* appeared in the fields after seed crops were processed, it is logical to assume that the main function of *V. vulgaris* is to hunt for these insects. And in parallel there is also repollination of lucerne flowers.

V. vulgaris can hunt on the fly, or attack nectar-collecting insects. It is at such moments that flowering plants are intercrossed.

A slightly smaller number, relative to the number of *V. vulgaris*, had *A. mellifeira*, the occurrence of which reached 2.0±0.12 samples per 1m^2. At the same time, the largest number of samples were collected at a distance of 50m from the edge of the fields. The smallest amount of *A. mellifeira* was obtained at a distance of 250m from natural phytocenoses. While instances of *V. vulgaris* were caught with enviable regularity at different distances from natural coenopopulations (50m, 150m and 250m from the edge of the field).

Some species of *Hymenoptera* have not been found in collections from insecticide-treated fields at all, such as *Xylocopavalga Osmia Panzer, Bombuspascuorum, B. fragrans and Rophitoidescanus*. A very small number - only about two dozen samples of *M. rotundata* are recorded in all four treated fields of lucerne. And all seized individuals were obtained from phytocenoses located near the fields with seed crops of lucerne, i.e. from natural lands. The total number decreased and *A. mellifeira* from all treated crops received only 51 individuals of this species. This suggests significant toxicity of the preparation used.

In the recalculation of the obtained samples after treatment with the insecticide "Bi58 new", it was found that the total number of all potential pollinators on the seed crops of the lucerne decreased to 27.9±0.22 per 1m^2. At the same time, the number of individuals of some species per 1m^2 has increased slightly. For example, after a treatment with this product, the occurrence of some species of the family *Syrphidae–Chrysotoxum and Volucellapellucens*–has slightly increased – 0.5 and 0.7 individuals per 1m^2, respectively. This figure has not changed in *A. mellifeira* and *V. vulgaris*. Thus, *A. mellifeira* encountered approximately 2.0±0.23 individuals per 1m^2, and *V. vulgaris*– 3.0±1.52 samples per 1m^2.

Consequently, the most vulnerable species were unable to adapt to these environmental conditions, which determined the change of dominant species and the total number of pollinator insects on the seed crops of the crop by insecticide treatment.

With the help of the Jackar Index, the entomofauna of pollinators in the fields of lucerne seed crops, which were not treated with insecticide in both districts of the Belgorod region (Chernyansky and Novooskolsky), were compared. According to our observations, lucerne crops in both areas of the region had the same species as possible pollinators. As a result of the calculation of the Jaccar index, a value of 1 was obtained, which means that the species composition of the lucerne pollinators of the investigated areas of the Belgorod region is completely similar.

The result of the calculation of the Jacquar coefficient from the data obtained from the fields treated with the product was also a unit.

However, when comparing pollinator faunas from lucerne fields, treated and untreated sites to each other, the Jacquard index was 0.5, which shows a 50% match of pollinator species.

CONCLUSION

1. It has been found that 17% of the species of possible pollinators belong to the family *Megachilidae*, they also predominate in terms of the number of individuals. *M. rotundata* belonged to the largest number of *Megachilidae* samples seized from insecticide-untreated lucerne seed crops

2. The species density of the entomofauna of potential pollinators after insecticide treatment decreased 2 times. The Menhinick index is also down on 50%, indicating a decrease in species diversity.

3. With the correct dosage of insecticide, as well as with the conditions of treatment (from 22-00 to 05-00 – during the absence of flying of pollinators), a part of the entomofauna of pollinators remains, while most of the pests die.

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