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Diversity of the Entomocomplex of the Grass Stand of a Hemp Field in The North-Eastern Forest-Steppe of Ukraine

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Abstract. The agrobiocenosis of the grass stand of hemp field is a specific plant biotope, which is a place of shelter, feeding, resettlement, and breeding for many insect populations, which in one way or another affecting the growth, development and yield of hemp plsnts. Taking this into consideration awareness of the species composition of phytophagous insects as well as the complex of their natural enemies and neutral species became especially relevant awareness due to the necessary to develop an effective system of protection of hemp in the context of current conditions. The aim of the research is to improve the ecologically oriented system of hemp protection by means of studying the taxonomic composition of entomofauna in the grass stand, as well as the trophic and ecological structure of insect groups associated with that habitat. The studies was conducted in 2019-2021 on the basis of the Northeast Agricultural Institute of the National Academy of Agrarian Sciences out during the vegetation of plants by means of mowing with a standard entomological net every ten days, from 10.00 till 15.00 o'clock when the insects were the most active. The current taxonomic composition of entomocomplex of the grass stand in hemp field is represented by 174 species of insects that belong to 76 families and 9 orders. The Coleoptera turned out to be the largest in terms of the species diversity and the number of individuals (56 species from 16 families and 74.6% of the number of captured insects). Were also detected insects from the orders Hymenoptera (31 species from 15 families), Hemiptera (30 species from 11 families), Diptera (20 species from 12 families), Homoptera (17 species from 8 families), Lepidoptera (12 species from 8 families), Orthoptera (4 species from 3 families), Neuroptera (3 species from 2 families), Thysanoptera (one species) were also detected. In the trophic structure of the entomofauna in grass stand of hemp field, 85.9% of the number and 59.8% of the species diversity account for phytophagous insects. Pests of hemp were 39 species of insects from 22 families, and 6 orders. Among them, 36 species, which accounted for 18.7% of the total number of specimens, were polyphagous and three, or 81.3%, were specialized species. The presence of insect pests in the grass stand of hemp field was characterized by oligodominance, as evidenced by quantitative and qualitative data, and indices of species diversity. Thus, the dominance structure is represented by one eudominant (*Psylliodes attenuata* – 81.1%), one subdominant (*Mordellistena parvula* – 4.72%), four recedents (*Lygus pratensis, L. rugulipennis, Lygocoris pabulinus, Stictocephala bisonia* – 8.6%) and, 33 subrecedents (5.58%). The obtained research results will be used in order to solve the problems related to the danger of basic phytophagous insects during the vegetation period of cannabis sativa plants and to develop a modern environmentally-oriented strategy to control their numbers and harmfulness

Keywords: agrobiocenosis, species composition, trophic structure, insect pests, dominance classes

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INTRODUCTION

Hemp seeds (*Cannabis sativa* L.) are a highly valuable fibre crop, the history of cultivation and comprehensive use of which began in ancient times (Clark & Merlin, 2016; Long *et al.*, 2017). The wide importance and benefits of hemp are determined by economically valuable characteristics, which allows the full use of all the components of the plant for the production of numerous environmentally friendly products with many applications, which every day occupy leading positions in the world and Ukrainian markets (Crini *et al.*, 2020; Bojko *et al.*, 2018). The issues of healing biocenoses and remediation of areas contaminated with radionuclides, heavy metals, and chemical compounds by cultivating hemp in such areas are becoming increasingly relevant (Placido & Lee, 2022; Wu *et al.*, 2021).

Growing crops is fraught with risks. Along with a natural disaster (drought, flood, hail, fires, etc.), cultivated plants are at risk from their natural consumers — pests. It is known that more than 10,000 species of insect pests can damage cultivated plants worldwide (Dhaliwal *et al.*, 2007). Phytophagous insects are thought to destroy about 18-20 % of the global crop yield per year (Oerke, 2006; Sharma *et al.*, 2017). Hemp is no exception and has crop losses from harmful insect species.

Thousands of years of specialisation and intensification of crop production against the background of the influence of global climate change in particular environmental conditions contributed not only to the development of a certain species composition of insects, changes of the dominant phytophages, but also to the expansion of new areas of their existence. Every year, the entomocomplex of hemp is supplemented by introduced species that are more adapted to new trophic conditions, which previously did not have considerable economic importance (Küçüktopçu *et al.*, 2020; Ajayi & Samuel-Foo, 2021).

As the acreage under hemp continues to grow both in the world and in Ukraine (Zuk-Golaszewska & Golaszewski, 2018; Gruzinska *et al.*, 2020), considering the specific features of the hemp industry, the concentration of crops increases, and therefore a harmful entomocomplex accumulates. Given this, it is relevant to determine the species composition of insect pests, as well as the complex of their natural enemies and neutral species inhabiting plants. Knowledge of the species composition and harmful stages of phytophagous insects at various stages of hemp development is necessary for the development of efficient environmentally oriented control of their abundance and harmfulness.

The purpose of this study is to improve the environmentally oriented system of protection of hemp crops by investigating the taxonomic composition, the number of general and harmful entomofauna in the herbage, as well as the trophic and ecological structure of insect groups during the growing season of the crop in the north-eastern part of the Left-Bank Forest-Steppe of Ukraine.

LITERATURE REVIEW

Due to the morphological and biological characteristics of plants, the herbage of hemp is particularly attractive for a diverse entomological fauna and is a plant biotope for the existence of numerous populations of arthropods. The diversity of ecological niches is primarily determined by the trophic relationships of insects in hemp agrocenosis (Cranshaw *et al.*, 2019).

It is known that the entomofauna of hemp seeds can include 180-300 species (lago & Stanford, 1989; McPartland, 1996) and, depending on the geographical area, number about 20-150 specialised and polivorous phytophagous insects (McPartland *et al.*, 2000; Trotus & Naie, 2008; Fedorenko *et al.*, 2016), which can considerably harm the germinating seed and root system in the soil, and the aboveground vegetative and reproductive part of the plant in the herbage (Cranshaw *et al.*, 2019; Pivtoraiko *et al.*, 2020).

Climate change due to the global increase in air temperature and uneven precipitation in particular soil and climatic conditions of the region largely determine the distribution features and changes in the population density of serious insect pests (Skendžić *et al.*, 2021), including in agrocenoses of hemp seeds (Ajayi & Samuel-Foo, 2021). Taking this into account, in different geographical areas of hemp cultivation, there are differences in the species composition of entomofauna and the structure of dominance of phytophagous insects in the hemp field. Thus, on the American continent, the entomocomplex is represented by a richer species diversity, which is confirmed by studies in the United States in the southern state of Mississippi, where more than 300 species of insects have been identified. Among them, 69 species were identified that used hemp plants as a source of physiological nutrition. The majority (43 species) fed on sap, 15 species were leaf eaters, nine collected or fed on pollen, and the rest — on plant roots (Lago & Stanford, 1989). Similar studies in eastern Colorado identified harmful, beneficial, and neutral insects from 142 genera that belonged to 73 families and 15 orders. The most harmful insects include *Helicoverpa zea* Bodd., *Grapholitta delineana* Walk., and *Phorodon cannabis* Pass (Schreiner & Cranshaw, 2021).

The entomocomplex of the hemp field in Europe is characterised by a slightly smaller variety of species. For example, in Germany, 129 species of insects were recorded, among which 51 species are potentially dangerous for hemp plants. Special attention should be paid to *Autographa gamma* L., *Agromyza strigata* Meig., *Eupteryx atropunctata* Goeze, *Lygus rugulipennis* Popp., *Tipula paludosa* Meig., *P. cannabis* Pass., and *Psylliodes attenuata* Koch. (Gottwald, 2002). In Poland, there are 27 species of phytophagous insects of hemp seeds (Barko *et al.*, 2018). The dominant and most dangerous species include *Phorodon humuli* Schr., *Ostrinia nubilalis* Hbn., *P. attenuata* Koch., and *A. gamma* L. In the central regions of the Irkutsk region, in Russia, the fauna of insect pests in the hemp stand includes about 18 species, and the main ones are bedbugs (Hemiptera) from the genus *Lygus* spp. (50% of the total population) and representatives of the

family Pentatomidae (15.7%). A high number of *Cardipennis rubripes* Hust., *Trichiocampus cannabis* Xiao & Huang and *P. attenuata* Koch is also noted. (Shylenkov & Tolstonogova, 2006). About seven main insect pest species of hemp were noted in Slovenia, of which *P. attenuata* Koch., *G. delineana* Walk., *O. nubilalis* Hbn., *P. cannabis* Pass and several species of leafhoppers caused the most economically significant losses of hemp production (Lepidoptera: Noctuidae) (Cizej & Policnik, 2018).

MATERIALS AND METHODS

The research was conducted during the vegetating season of 2019-2021 in the conditions of the research and trial facility of the Institute of Agriculture of the North-East of the National Academy of Agrarian Sciences (IANE NAAS), Sumy Oblast, Sumy district, the village of Sad. The research site is geographically located in the north-eastern part of the Left-Bank Forest-Steppe of Ukraine at geographical coordinates 50.8846°N, 34.6961°E. The climate is temperate continental with warm long summers and moderately cold winters and frequent thaws, the average annual air temperature is +7.4°C. The average annual precipitation is about 593 mm. The average long-term relative humidity is within 77%. Monitoring of the entomocomplex was carried out in seed-growing hemp crops of Ukrainian selection — Glesia. Hemp was grown for bilateral use with 45 cm between rows. The seeding rate was 1.0 million pcs/ha. Its predecessor is winter wheat.

The total number of insect species in the entomofauna of the hemp grass stand was determined during the spring-summer vegetating season by mowing with a standard entomological net. Accounting began with the phase of two pairs of real leaves of the culture. For this, the authors of this study carried out decadal mowing from 10:00 to 15:00, when insects were most active. Each sample comprised 100 strokes (10 strokes in 10 places on two diagonals of the field). After each sample, all insects were selected from the net and soaked with acetic acid ether (ethyl acetate). The collected entomological material from the stain was disassembled separately for each sample on a sheet of white paper, then the insects were laid out on cotton mattresses measuring 12x20 cm and 3-5 mm thick. Each mattress was placed in a paper envelope with a label insert (Poljakov *et al.*, 1984; Omeliuta *et al.*, 1986). The reliability of determining the species affiliation of insects was confirmed by specialists of the I.I. Schmalhausen Institute of Zoology of the National Academy of Sciences of Ukraine.

To characterise the species structure of the entomocomplex of the hemp field, the total number of individuals and the degree of dominance were determined for each individual species (Fasulaty, 1971). Dominance classes for detected insect pests in the grass stand of a hemp field were set on a scale as follows: mass species, or eudominants (31.7-100%), common or dominants (10.1-31.6%), infrequent or subdominants (3.2-10.0%), rare, or recedents (1.1-3.1%), random, or subrecedents (<1.0%) (Stöcker & Bergmann, 1977). Generally accepted indices were used to characterise the species diversity of insects (Lebedeva *et al.*, 2004).

The Margalef's species richness index was calculated according to the Formula (1):

$$D_{Mg} = \frac{S-1}{lnN} \quad (1)$$

where S is the number of types, pcs; N is the total number of individuals of all species, specimen.

The value of the Shannon's index was determined according to the Formula (2):

$$H' = -\sum Pi\ lnPi \quad (2)$$

where Pi is the proportion of individuals of each species.

The Simpson's index indicators were calculated according to the Formula (3):

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right) \quad (3)$$

where n is the number of individuals for each species, specimen; N is the total number of individuals of all species, specimen.

The value of the Berger-Parker's index was determined according to the Formula (4):

$$d = 1 / \frac{N_{max}}{N} \quad (4)$$

where N_{max} is the number of individuals of the most numerous species, specimen; N is the total number of individuals of all species, specimen.

The Piel alignment index was calculated according to the formula (5):

$$E = \frac{H'}{lnS} \quad (5)$$

where N'is the Shannon index; S is the number of types.

Mathematical calculations and visualisation of the obtained data were performed using the Microsoft Office Excel 2016 software package.

RESULTS AND DISCUSSION

174 species of insects belonging to 76 families and 9 orders were caught in the grass stand of a hemp field. The greatest diversity of species was characterised by an order of Coleoptera (Coleoptera), which was represented by 56 species (32.2% of the total entomocomplex) from 16 families. The main number of representatives of this order was the leaf-eating family (Chrysomelidae) — 16 species (28.6 % of the total number of the order). Curculionidae — seven species (12.5%), Coccinellidae — six species (10.7%), Mordellidae — four species (7.1%) were also noted for their considerable species diversity. The families Anthicidae, Elateridae, Malachiidae, Oedemeridae, Scarabaeidae had three species each (or 5.4% each), Staphylinidae — two species (3.6%), Bruchidae, Cantharidae, Carabidae, Cerambycidae, Lathridiidae, Nitidulidae — one species each, which was 1.8% each, respectively. The order of Hymenoptera (Hymenoptera) included 31 species (17.8% of the entomofauna biodiversity) from 15 families. The largest species diversity was observed in the following families: Ichneumonidae — six species (19.4%), Braconidae — five species (16.1%), and Chalcididae — four species (12.9% of all representatives of the order). Andrenidae, Formicidae,

Halictidae, Proctotrupidae included two species, or 6.5% each. Apidae, Aphelinidae, Chrysididae, Cynipidae, Megachilidae, Pompilidae, Sphecidae, Tenthredinidae accounted for one species, or 3.2 % of all hymenopteran insects (Fig. 1).

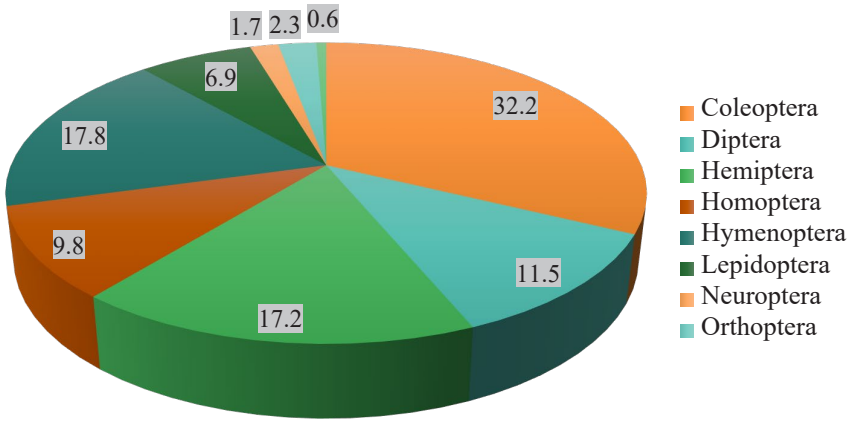

Figure 1. *Diversity of entomocomplex in the grass stand of a hemp field (mowing with an entomological net, total for 2019-2021), %*

Hemiptera in the herbaceous entomocomplex of the hemp agrobiocenosis were represented by 30 species (17.2% of the total diversity) from 11 families. Among the insects of this order, the Miridae family was most fully represented — 12 species (or 40.0% of the total number). The Pentatomidae family was also distinguished by a considerable variety — five species (16.7%). Lygaeidae included three species (10.0%), Rhopalidae and Piesmatidae — two species each (6.7% each). Other families (Anthocoridae, Coreidae, Cydnidae, Nabidae, Pyrrhocoridae, Tingidae) were represented by one species, or 3.3% each. The order of Diptera was characterised by a considerable diversity — 20 species (11.5%) from 12 families. It was based on the families Anthomyidae and Syrphidae — three species each (or 15.0% each). Other families (Agromyzidae, Asilidae, Tachinidae, Tephritidae) included two species of flies (or 10.0% each). Bibionidae, Calliphoridae, Chloropidae, Opomizidae, Sarcophagidae and Tipulidae were represented by one species (or 5.0% each).

The order of Homoptera in the grass stand of a hemp field numbered 17 species (9.8% of the total) from 8 families. The most diverse (6 species or 35.3%) was the family of Cicadelidae. Aphididae was represented by three species (17.6%). Psyllidae and Jassidae included two species each (11.8% each). Cercopidae, Delphacidae, Dictyopharidae, and Membracidae accounted for one species, or each for 5.9% of the insects of this order. The order of Lepidoptera was represented by 12 species (6.9%) from eight families in the structure of the entomocomplex. Among the order, the families Noctuidae, Pyralidae, Tineidae, Tischeriidae were the most complete in terms of the number of species — two species each (or 16.7%). The families of Geometridae, Nymphalidae, Plutellidae, and Tortricidae were represented by one species, or 8.3% each. Substantially fewer species diversity were found in the following orders: Orthoptera — four species (2.3%) from three families and Neuroptera — three species (1.7%) from two families. The smallest share of species diversity (0.6%) in the agrobiocenosis of the hemp field was made up of the order of Thysanoptera, which had one species.

In terms of the number of insects in the grass of the hemp field, the order of Coleoptera prevailed — 74.6% of all insects. The highest number of individuals was represented by the Chrysomelidae family, which accounted for 88.8% of all Coleoptera insects and 66.3% of the total entomocomplex of the hemp agrobiocenosis. In this family there were a lot of earth fleas, mainly from the genera *Altica* sp., *Chaetochnema* sp., *Longitarsus* sp., *Phyllotreta* sp., *Psylliodes* sp. The Mordellidae family had a fairly considerable number of specimens, with a share of 4.3% in the total entomocomplex. A slightly smaller number of insects were represented by the families of Lathridiidae and Coccinellidae. Representatives of the following families were found singly: Carabidae, Cerambycidae, Malachiidae, Oedemeridae, Bruchidae, Staphylinidae, Cantharidae, Elateridae, Anthicidae, Nitidulidae, Scarabaeidae, and Curculionidae (Table 1).

***Table 1**. Composition and abundance of entomofauna in the grass stand of sown hemp (mowing with an entomological net, total for 2019-2021)*

Order	Family	Number of instances	Share, %
Coleoptera	Anthicidae	10	0.04
	Bruchidae	6	0.02
	Cantharidae	7	0.03
	Carabidae	1	0.004
	Cerambycidae	2	0.01
	Chrysomelidae	17760	66.26
	Coccinellidae	395	1.47
	Curculionidae	63	0.24
	Elateridae	7	0.03
	Lathridiidae	545	2.03
	Malachiidae	4	0.01
	Mordellidae	1145	4.27
	Nitidulidae	14	0.05
	Oedemeridae	4	0.01
	Scarabaeidae	27	0.10
	Staphylinidae	6	0.02
Diptera	Agromyzidae	165	0.62
	Anthomyidae	560	2.09
	Asilidae	32	0.12
	Bibionidae	2	0.007
	Calliphoridae	3	0.01
	Chloropidae	48	0.17
	Opomizidae	13	0.05
	Sarcophagidae	1	0.004
	Syrphidae	13	0.05
	Tachinidae	13	0.05
	Tephritidae	7	0.03
	Tipulidae	2	0.007
Hemiptera	Anthocoridae	1032	3.85
	Coreidae	24	0.09
	Cydnidae	1	0.004
	Lygaeidae	15	0.06
	Miridae	1884	7.02
	Nabidae	35	0.13
	Piesmatidae	10	0.04
	Pyrrhocoridae	6	0.02
Hemiptera	Pentatomidae	281	1.05
	Rhopalidae	74	0.28
	Tingidae	2	0.007
Homoptera	Aphididae	275	1.03
	Cercopidae	15	0.06
	Cicadelidae	106	0.40
	Delphacidae	3	0.01
	Dictyopharidae	1	0.004
	Jassidae	14	0.05
	Membracidae	368	1.37
	Psyllidae	87	0.32

Table 1, Continued

Order	Family	Number of instances	Share, %
Hymenoptera	Apidae	13	0.05
	Andrenidae	2	0.007
	Aphelinidae	1	0.004
	Braconidae	139	0.52
	Chalcididae	153	0.57
	Chrysididae	44	0.16
	Synipidae	46	0.17
	Formicidae	203	0.76
	Ichneumonidae	77	0.30
	Halictidae	9	0.03
	Megachilidae	1	0.004
	Pompilidae	1	0.004
	Proctotrupidae	7	0.026
	Sphecidae	7	0.026
	Tenthredinidae	4	0.01
Lepidoptera	Geometridae	1	0.004
	Noctuidae	162	0.60
	Nymphalidae	12	0.04
	Pyralidae	29	0.11
	Plutellidae	49	0.20
	Tineidae	44	0.16
	Tischeriida	22	0.08
	Tortricidae	10	0.04
Neuroptera	Chrysopidae	187	0.70
	Hemerobiidae	4	0.01
Orthoptera	Acrididae	6	0.02
	Phaneropteridae	8	0.04
	Tettigoniidae	33	0.12
Thysanoptera	Aeolothripidae	442	1.65
Total		26804	100.0

The order of Hemiptera also had high rates of occurrence of individuals, the share of which was 12.6%. The basis was the families Miridae — 7.0%, and Anthocoridae — 3.9% of the complete collection of the herbaceous entomocomplex. Other representatives (Cydnidae, Tingidae Pyrrhocoridae Piesmatidae, Lygaeidae, Coreidae, Nabidae, and Rhopalidae) had smaller numbers. Homoptera and Diptera insects were also quite noticeable in the herbage of agrocenosis, which comprised 3.2% each of the total entomofauna of hemp seeds. Among the order of Homoptera, the families of Membracidae, Aphididae, and Cicadelidae were the most numerous from the total entomofauna of the herbage with a share of 1.4%, 1.0%, and 0.4%, respectively. Among the Diptera insects, the Anthomyidae species was the most numerous — 2.1%.

The number of insects was smaller in the orders of Hymenoptera — 2.6% and Thysanoptera — 1.7% of the total collection. Most of them were represented by entomophages — parasites and predatory species. The population density of Lepidoptera insects was not high and accounted for 1.2% of the total collection. The highest number of individuals was represented by the Noctuidae family — 0.6%. The number of insects of other orders (Neuroptera and Orthoptera) was less than 1.0% in the total entomocomplex of the hemp field.

Notably, apart from the identified insects, spiders (Araneae: Thomisidae) also inhabited the grassland. Their share in the total collection was 1.8%. Over the years of research, the value of the Margalef's species richness index in the grass stand of hemp agrocenosis was 16.97; the Shannon's index indicator was 1.916; the Simpson's index value was 0.573; the Berger-Parker's index indicator was 0.649; the Piel's alignment index was 0.371 (Table 2).

***Table 2**. Indicators of biodiversity of the entomocomplex registered in the herbage of a hemp field (mowing with an entomological net, total for 2019-2021)*

Biodiversity indices	Indicator
Total number of families	76
Total number of types	174
D_{Mg}	16.97
H'	1.916
D	0.573
d	0.649
E	0.371

***Note**: D_{Mg} is the Margalef's diversity index; H' is the Shannon's diversity index; D is the Simpson's dominance index; d is the Berger-Parker's dominance index; E is the Piel's alignment index*

Considering the specific features of life and eating habits of individual insect species, the captured entomocomplex of hemp herbage was divided into ecological groups according to the type of food and trophic specialisation of insects. Thus, the highest diversity (104 species or 59.8%) and population size (85.9%) were noted among phytophagous insects, of which 37.5% of species can harm hemp plants. The group of entomophages was represented by 50 species (28.7% of the diversity), and their share was 11.0%. Neutral species included 20 representatives (11.5%) with a share of 3.1%. The ratio of the number of entomophages to phytophages in the herbage of hemp seeds was 1:8 (Table 3).

***Table 3**. Trophic structure of the entomocomplex of the herbage of the hemp field (mowing with an entomological net, total for 2019-2021)*

Trophic specialisation	Number of types	%	Number of instances	%
Phytophages	104	59.8	23022	85.9
Entomophages	50	28.7	2945	11.0
Neutral species	20	11.5	837	3.1
Total	174	100.0	26804	100.0

Among the harmful entomofauna caught in the grass stand of hemp agrobiocenosis, a considerable diversity of the species composition of hemp pests was found, including 39 species from 22 families and 6 orders. Among them, Coleoptera accounted for 28.2%, Diptera — 7.7%, Hemiptera — 25.6%, Homoptera — 12.8%, Lepidoptera — 15.4%, and Orthoptera — 10.3% (Fig. 2). Among the identified species diversity, the majority of insects (36 species or 92.3%) are polyphages, whose nutrition and reproduction occurs on many species of cultivated and wild plants, and three species (7.7%) are specialised phytophagous insects of hemp plants. Therewith, the share of the former two accounts for 18.7% and 81.3% of the total number of insect pests in the hemp stand.

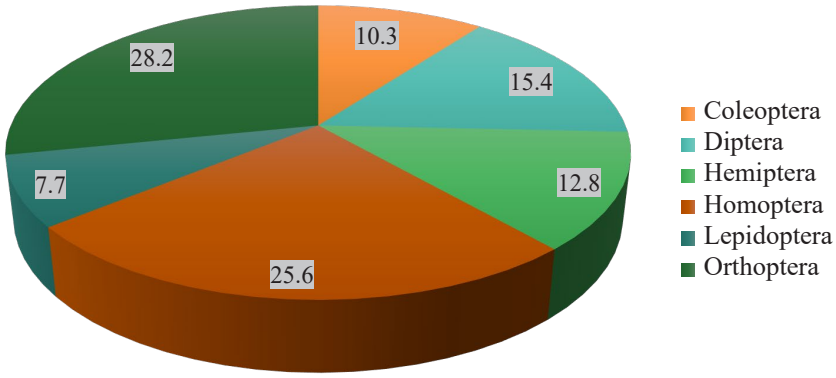

***Figure 2**. Taxonomic structure of the harmful entomocomplex of hemp grass stand (mowing with an entomological net, total for 2019-2021), %*

It was established that among the complex of insect pests of hemp sown, the largest both in terms of the number and quantitative composition of species is the order of Coleoptera. Thus, a total of 18,609 specimens (86.74% of the harmful entomocomplex), 11 species and 5 families were identified. The largest species

diversity (three species each) was observed in the family of Elateridae, Mordellidae, and Scarabaeidae. Curculionidae and Chrysomelidae included one species each (Table 4). Among the representatives of this order, the largest number of specialised phytophages was noted — the *Psylliodes attenuata*, being eudodominant in the entomocomplex with a share of 81.1%. The subdominant was *Mordellistena parvula* — 4.72%. Other beetles: Curculionidae — one species (*Tanymecus palliatus*), Elateridae — three species (*Agriotes sputator*, *Lacon murinus* and *Melanotus brunnipes*), Mordellidae — two species (*Mordellistena connata* and *M. variegata*), Scarabaeidae — three species (*Cetonia aurata*, *Oxythyrea funesta*, and *Maladera holosericea*) were sub-recedents.

***Table 4**. Species composition and dominance of insect pests in the hemp field stand (mowing with an entomological net, total for 2019-2021)*

Order	Family	Species	Number of instances	%	Dominance class
Coleoptera	Chrysomelidae	Psylliodes attenuata (Koch, 1803)	17398	81.10	E
	Curculionidae	Tanymecus palliatus (Fabricius, 1787)	33	0.15	SR
	Elateridae	Agriotes sputator (Linnaeus, 1758)	3	0.01	SR
		Agrypnus murinus (Linnaeus, 1758)	3	0.01	SR
		Melanotus brunnipes (Germar, 1824)	1	0.005	SR
	Mordellidae	Mordellistena connata (Ermisch, 1969)	125	0.58	SR
		M. parvula (Gyllenhal, 1827)	1013	4.72	SD
		M. variegata (Fabricius, 1798)	6	0.03	SR
Coleoptera	Scarabaeidae	Cetonia aurata (Linnaeus, 1758)	1	0.005	SR
		Oxythyrea funesta (Poda, 1761)	25	0.12	SR
		Maladera holosericea (Scopoli, 1772)	1	0.005	SR
Diptera	Agromyzidae	*Liriomyza* sp. (1)	62	0.29	SR
		Phytomyza atricornis (Meigen, 1838)	103	0.48	SR
	Tipulidae	Tipula paludosa (Meigen, 1830)	2	0.01	SR
Hemiptera	Coreidae	Coreus marginatus (Linnaeus, 1758)	24	0.11	SR
	Lygaeidae	Sphragisticus nebulosus (Fallen, 1807)	5	0.02	SR
	Miridae	Adelphocoris lineolatus (Goeze, 1778)	49	0.23	SR
		Lygus pratensis (Linnaeus, 1758)	465	2.17	R.
		L. rugulipennis (Poppius 1911)	673	3.14	R.
		Lygocoris pabulinus (Linnaeus, 1761)	339	1.58	R.
		Polymerus cognatus (Fieber, 1858)	2	0.01	SR
		P. vulneratus (Panzer, 1806)	20	0.09	SR
	Pentatomidae	Dolycoris baccarum (Linnaeus, 1758)	148	0.69	SR
		Palomena prasina (Linnaeus, 1761)	54	0.25	SR

Table 4, Continued

Order	Family	Species	Number of instances	%	Dominance class
Homoptera	Aphididae	Aphis fabae (Scopoli, 1763)	168	0.78	SR
		Phorodon cannabis (Passerini, 1860)	41	0.19	SR
	Cercopidae	Philaenus spumarius (Linnaeus, 1758)	15	0.07	SR
	Cicadellidae	Eupteryx atropunctata (Goeze, 1778)	47	0.22	SR
	Membracidae	Stictocephala bisonia (Kopp & Yonke, 1977)	368	1.72	R.
Lepidoptera	Noctuidae	Autographa gamma (Linnaeus, 1758)	27	0.13	SR
		Helicoverpa armigera (Hübner, 1808)	136	0.63	SR
	Nymphalidae	Vanessa cardui (Linnaeus, 1758)	12	0.06	SR
Lepidoptera	Pyralidae	Ostrinia nubilalis (Hübner, 1796)	17	0.08	SR
		Loxostege sticticalis (Linnaeus, 1761)	11	0.05	SR
	Tortricidae	Grapholitta delineana (Walker, 1863)	10	0.05	SR
Orthoptera	Acrididae	*Chortippus* sp. (2)	6	0.03	SR
	Tettigoniidae	Tettigonia viridissima (Linnaeus, 1758)	33	0.15	SR
	Phaneropteridae	Phaneroptera falcata (Poda, 1761)	8	0.04	SR
Total:			21454	100.0	–

Note: *E — eudominant (31.7-100%); D — dominant (10.1-31.6%); SD — subdominant (3.2-10.0%); R — recedent (1.1-3.1%); SR — subrecedent (<1.0%)*

The species composition of insect pests of the order of Hemiptera was represented by 10 species from four families and numbered 1,779 specimens (8.29%). Among them, most insects (six species) belonged to the family of Miridae. The diversity of shield bugs (Pentatomidae) included two species, edge bugs (Coreidae) and ground bugs (Lygaeidae) — one species each. Three species of Miridae were found to be the regulars — *Lygus rugulipennis*, *L. pratensis*, and *Lygocoris pabulinus*. The other seven species of bugs are classified as subrecedents: Coreidae — one species (*Coreus marginatus*), Lygaeidae — one species (*Sphragisticus nebulosus*), Pentatomidae — two species (*Palomena prasina* and *Dolycoris baccarum*), Miridae — three species (*Adelphocoris lineolatus*, *Polymerus cognatus* and *P. vulneratus*).

The order of Homoptera numbered 639 specimens of phytophagous insects (2.98%) — five species from four families. The greatest diversity was found in the family of Aphididae — two species. The families of Cercopidae, Cicadellidae, and Membracidae had one species each. Among the Homoptera, one species was a recedent: Membracidae — *Stictocephala bisonia* (1.72%). The other four types were classified as sub-recedents: Aphididae — two species (*Aphis fabae* and *Phorodon cannabis*), Cicadellidae — one species (*Eupteryx atropunctata*), Cercopidae — one species (*Philaenus spumarius*).

Among the Lepidoptera, 213 specimens (0.99%) of phytophagous insects were caught — six species of insects from four families. The families of Noctuidae and Pyralidae comprised two species each, Nymphalidae and Tortricidae — one species each. All representatives of this order were few, that is, they belonged to sub-recedents.

Diptera phytophages numbered 167 specimens (0.78%) and were represented by three insect species from two families. Most of the representatives were a small family of Agromyzidae. All insects in this series were sub-recedents.

Among the Orthoptera hemp pests, 47 specimens (0.22%) of four insect species from three families were caught. All four representatives were sub-recedents: Tettigoniidae — one species (*Tettigonia viridissima*), Phaneropteridae — one species (*Phaneroptera falcata*), Acrididae — two species (*Chortippus* sp.)

Over the years of research, the main indices of the species diversity of the complex of insect pests of the herbage of seed hemp had low values, which indicates oligodominance in the station, that is, the predominance of several species. Thus, the Margalef's species richness index was 3.810, while the Shannon's index value was 0.960, the Simpson's index value was 0.337, the Berger-Parker's index value was 0.811, and the Piel's alignment index was 0.262 (Table 5).

***Table 5**. Indicators of biodiversity of the insect pest complex in the herbage of a hemp field (mowing with an entomological net, total for 2019-2021)*

Biodiversity indices	Indicator
Total number of families	22
Total number of types	39
D_{Mg}	3.810
H'	0.960
D	0.338
d	0.811
E	0.262

***Note**: D_{Mg} is the Margalef's diversity index; H' is the Shannon's diversity index; D is the Simpson's dominance index; d is the Berger-Parker's dominance index; E is the Piel's alignment index*

Analysing the dominance distribution of insect pests of seed hemp, it was established that in the structure the eudominant (*Psylliodes attenuata*) made up 81.1%, the subdominant (*Mordellistena parvula*) — 4.72%, recedents — 8.6%, subrecedents — 5.58% (Fig. 3).

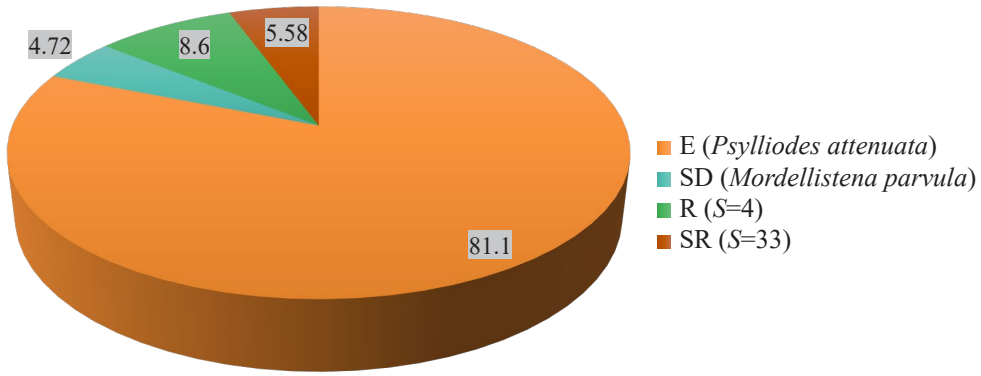

***Figure 3**. Structure of dominance of insect pests in the herbage of a hemp field (mowing with an entomological net, total for 2019-2021), %*

Thus, the study indicates a high population adaptability and dominance of the main specialised insects in the grass stand of hemp agrocenosis.

Similar data were obtained upon investigating the entomofauna of hemp sown in Central Moldova, where 20 species of phytophagous insects feeding on these plants were found in the herbage. Among them, Coleoptera accounted for 35%, Lepidoptera — 30%, Diptera — 15%, Homoptera and Heteroptera — 10% each. Of these, there were 16 species (75%) of sub-recedents, two (10%) recedents, one (3%) subdominant, and two (10%) eudominants (Trotus *et al*., 2011). The study of the entomocoplex of the grass stand of a hemp field and the analysis of its trophic structure in the Eastern Polissia of Ukraine, where hemp farming is a traditional industry, revealed 117 species of insects from 57 families and eight orders, including 18 species — phytophages of hemp. Notably, polivorous insect pests in the entomocomplex of hemp grass stand are represented by 15 species, specialised — by three. The dominant and particularly dangerous was the hemp flea (*P. attenuata*) (Fedorenko *et al*., 2016; Kabanets, 2013; Kabanets & Fedorenko, 2014).

Notably, there has been a tendency to increase the species diversity and abundance of harmful entomocomplex. The authors of this study believe that this may be due to both climatic (an increase in the average annual air temperature) and agrotechnological factors (due to non-compliance with scientifically sound crop rotations, optimal land use structure, area expansion, and an increase in the concentration of thick-stemmed crops (corn, sunflower)), which have insect pests in common with hemp.

CONCLUSIONS

In the conditions of the north-eastern part of the Left-Bank Forest-Steppe of Ukraine in 2019-2021, the structure of the entomological complex of the grass stand of a hemp field, the trophic specialisation of insects in it were studied, the most numerous species and the degree of their dominance were identified.

It was established that the modern entomocomplex in the north-eastern part of the Left-Bank Forest-Steppe of Ukraine is represented by 174 species of insects belonging to 76 families and 9 orders, of which the largest species diversity (32.2%) and the number of insects (74.6% in the structure of the entire entomocomplex) was characterised by the order of Coleoptera. In terms of trophic specialisation, most species (59.8% of the total diversity) and the highest number (859 %) were phytophagous insects. The main pests in the grass stand

of a hemp field were 39 species from 22 families and 6 orders. Most of the species (36 or 92.3%) belonged to polyphages, and three species (7.7 %) were specialised with their share of numbers in the harmful entomocomplex — 18.7% and 81.3%, respectively. Biodiversity indices of phytophagous insects indicate an oligodominant structure of the entomocomplex. According to the degree of dominance, the study distinguished one eudominant — *Psylliodes attenuata* (81.1%), one sub-recedent — *Mordellistena parvula* (4.72%), four recedents (*Lygus pratensis, L. rugulipennis, Lygocoris pabulinus, Stictocephala bisonia*), which comprised a total of 8.6% and 33 sub-recedents with a share of 5.58% in the general structure of insect pests of the herbaceous agrobiocenosis of seed hemp.

The obtained research results will be used upon solving problems related to the danger of the main phytophagous insects during the growing season of cannabis plants and developing a modern environmentally oriented strategy for controlling their abundance and harmfulness.

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REFERENCES

[1] Ajayi, O.S., & Samuel-Foo, M. (2021). Hemp pest spectrum and potential relationship between *Helicoverpa zea* infestation and hemp production in the United States in the face of climate change. *Insects*, 12(10), article number 940. doi: 10.3390/insects12100940.
[2] Bakro, F., Wielgusz, K., Bunalski, M., & Jedryczka, M. (2018). An overview of pathogen and insect threats to fibre and oilseed hemp (*Cannabis sativa* L.) and methods for their biocontrol. *Integrated Control in Oilseed Crops*, 136, 9-20.
[3] Bojko, G., Tihosova, G., & Kutasov, A. (2018). Technological hemp: Prospects of development in Ukraine. *Commodities and Markets*, 1(25), 110-120.
[4] Cizej, M.R., & Policnik, F. (2018). Pests on industrial hemp (*Cannabis sativa* L.) in Slovenia. *Hmeljarski Bilten*, 25, 36-43.
[5] Clarke, R.C., & Merlin, M.D. (2016). Cannabis domestication, breeding history, present-day genetic diversity, and future prospects. *Critical Reviews in Plant Sciences*, 35(5-6), 293-327. doi: 10.1080/07352689.2016.1267498.
[6] Cranshaw, W., Schreiner, M., Britt, K., Kuhar, T.P., McPartland, J., & Grant, J. (2019). Developing insect pest management systems for hemp in the United States: A work in progress. *Journal of Integrated Pest Management*, 10(1), article number 26. doi: 10.1093/jipm/pmz023.
[7] Crini, G., Lichtfouse, E., Chanet, G., & Morin-Crini, N. (2020). Applications of hemp in textiles, paper industry, insulation and building materials, horticulture, animal nutrition, food and beverages, nutraceuticals, cosmetics and hygiene, medicine, agrochemistry, energy production and environment: A review. *Environmental Chemistry Letters*, 18(1), 1451-1476. doi: 10.1007/s10311-020-01029-2.
[8] Dhaliwal, G.S., Dhawan, A.K., & Singh, R. (2007). Biodiversity and ecological agriculture: Issues and perspectives. *Indian Journal of Ecology*, 34(2), 100-109.
[9] Fasulaty, K.K. (1971). *A field study of terrestrial invertebrates*. Moscow: Vyysshaja shkola.
[10] Fedorenko, V.P., Kabanets, V.V., & Kabanets, V.M. (2016). *Pests of hemp*. Sumy: FOP Shherbyna I.V.
[11] Gottwald, R. (2002). Entomological studies on hemp (*Cannabis sativa* L.). *Gesunde Pflanzen*, 54(5), 146-152.
[12] Gruzinska, I., Smagina, A., Perepelycja, O., Gerasymenko, M., & Popsuj, A. (2020). *Green Book. Industrial hemp market*. Kyiv: Better Regulation Delivery Office.
[13] Kabanets, V.V. (2013). Entomofauna of hemp agrobiocenosis. *Bulletin of Sumy National Agrarian University*, 3, 26-29.
[14] Kabanets, V.V., & Fedorenko, V.P. (2014). Entomocomplex of herbage in hemp field. *Protection and Quarantine of Plants*, 12, 30-33.
[15] Küçüktopçu, Y., Saruhan, I., & Yiğit, Ş. (2020). Integrated management of hemp pests. *Journal of the Institute of Science and Technology*, 10(2), 732-747. doi: 10.21597/jist.633412.
[16] Lago, P.K., & Stanford, D.F. (1989). Phytophagous insects associated with cultivated marijuana (*Cannabis sativa* L.) in northern Mississippi. *Journal-of-entomological-science*, 24(4), 437-445. doi: 10.18474/0749-8004-24.4.437.
[17] Lebedeva, N.V., Drozdov, N.N., & Kryvoluckyj, D.A. (2004). *Biological diversity and methods for its assessment*. Moscow: VLADOS.
[18] Long, T., Wagner, M., Demske, D., Leipe, C., & Tarasov, P.E. (2017). Cannabis in Eurasia: Origin of human use and Bronze Age trans-continental connections. *Vegetation History and Archaeobotany*, 26, 245-258. doi: 10.1007/s00334-016-0579-6.
[19] McPartland, J.M. (1996). Cannabis pests. *Journal of the International Hemp Association*, 3(2), article number 49.
[20] McPartland, J.M., Clarke, R.C., & Watson, D.P. (2000). *Hemp diseases and pests: Management and biological control. An advanced treatise*. United Kingdom: CABI Publishing.
[21] Oerke, E.C. (2006). Crop losses to pests. *The Journal of Agricultural Science*, 144(1), 31-43. doi: 10.1017/S0021859605005708.
[22] Omeliuta, V.P., Grygorovych, I.V., Chaban, V.S., Pidoplichko, V.N., Kalenych, F.S., Petruha, O.Y., Antoniuk, S.I., Pozhar, E.A., Tyshchenko, J.I., Grygorenko, V.G., Koval, M.K, & Chernenko, O.O. (1986). *Calculation of pests and diseases of agricultural crops*. Kyiv: Urozhaj.

[23] Pivtoraiko, V., Kabanets, V., & Vlasenko, V. (2020). Harmful entomofauna of hemp *Cannabis sativa* L. (analytical overview). *Quarantine and Plant Protection*, 262(7-9), 20-25. doi: 10.36495/2312-0614.2020.7-9.20-25.
[24] Placido, D.F., & Lee, C.C. (2022). Potential of industrial hemp for phytoremediation of heavy metals. *Plants*, 11(5), 595, 1-9. doi: 10.3390/plants11050595.
[25] Poljakov, Y.J., Persov, M.P., & Smyrnov, V.A. (1984). *Forecast of pests and diseases of agricultural crops (with a workshop)*. Lenyngrad: Kolos.
[26] Schreiner, M., & Cranshaw, W.A. (2021). Survey of the arthropod fauna associated with hemp (*Cannabis sativa* L.) grown in Eastern Colorado. *Journal of the Kansas Entomological Society*, 93(2), 113-131.
[27] Sharma, S., Kooner, R., & Arora, R. (2017). Insect pests and crop losses. In R. Arora, & S. Sandhu (Eds.). *Breeding insect resistant crops for sustainable agriculture* (pp. 45-66). Singapore: Springer. doi: 10.1007/978-981-10-6056-4_2.
[28] Shylenkov, V.G., & Tolstonogova, E.V. (2006). Phytophagous insects on cannabis in Baikal region. *Bjulleten' VSNC SO RAMN*, 2(48), 159-160.
[29] Skendžić, S., Zovko, M., Živković, I., Lešić, V., & Lemić, D. (2021). The impact of climate change on agricultural insect pests. *Insects*, 12(5), article number 440. doi: 10.3390/insects12050440.
[30] Stöcker, G., & Bergmann, A. (1977). Model of dominance structure and its application. *Archiv für Naturschutz und Landschaftforsch*, 17(1), 1-26.
[31] Trotus, E., & Naie, M. (2008). Data on the knowledge of injurious organisms in hemp crops from the Central Moldavia. *Cercetari Agronomice in Moldova*, 41(3), 51-57.
[32] Trotuş, E., Naie, M., & Buburuz, A. (2011). Hemp crop protection against pathogen agents and pests. *Analele INCDA Fundulea*, 79(1), 161-170.
[33] Wu, Y., Trejo, H.X., Chen, G., & Li, S. (2021). Phytoremediation of contaminants of emerging concern from soil with industrial hemp (*Cannabis sativa* L.): A review. *Environment, Development and Sustainability*, 23(10), 14405-14435. doi: 10.1007/s10668-021-01289-0.
[34] Zuk-Golaszewska, K., & Golaszewski, J. (2018). *Cannabis sativa* L. — cultivation and quality of raw material. *Journal of Elementology*, 23(3), 971-984. doi: 10.5601/jelem.2017.22.3.1500.

Різноманіття ентомокомплексу травостою конопляного поля у північно-східному лісостепу України

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Анотація. Агробіоценоз травостою конопляного поля являє собою специфічний рослинний біотоп, який є місцем укриття, живлення, розселення та розмноження численних популяцій комах, які тою чи іншою мірою впливають на ріст, розвиток і врожайність рослин конопель. З огляду на це особливої актуальності набуває знання видового складу комах-шкідників, комплексу їх природних ворогів та нейтральних видів, які заселяють травостій конопляного поля, що необхідно для розробки ефективної екологічно орієнтованої системи захисту конопель посівних у сучасних умовах. Мета дослідження — удосконалення екологічно-орієнтованої системи захисту конопель посівних за рахунок вивчення таксономічного складу, чисельності загальної та шкідливої ентомофауни у травостої, а також трофічної й екологічної структури угруповань комах, які пов'язані з цим місцем існування. Дослідження проводились упродовж вегетаційних періодів 2019–2021 рр. в умовах науково-експериментальної бази Інституту сільського господарства Північного Сходу. Обліки комах здійснювали методом косіння стандартним ентомологічним сачком один раз у декаду з 10.00 до 15.00 години дня, коли комахи були найбільш активні. Сучасний таксономічний склад ентомокомплексу травостою конопляного поля представлений 174 видами комах, які належать до 76 родин і 9 рядів. Найбільшим за різноманіттям видового складу та чисельністю особин був ряд Coleoptera (56 видів з 16 родин та 74,6 % від чисельності відловлених комах). Також виявлено комах з рядів Hymenoptera (31 вид з 15 родин), Hemiptera (30 видів з 11 родин), Diptera (20 видів з 12 родин), Homoptera (17 видів з 8 родин), Lepidoptera (12 видами з 8 родин), Orthoptera (4 види з 3 родин), Neuroptera (3 види з 2 родин), Thysanoptera (один вид). У трофічній структурі ентомофауни травостою конопляного поля 85,9 % чисельності та 59,8 % видового різноманіття припадає на комах-фітофагів. Шкідниками конопель посівних були 39 видів комах з 22 родини та 6 рядів. Поміж них 36 видів, що склали 18,7 % від загальної чисельності, є поліфагами та три або 81,3 % — спеціалізованими видами. Присутність комах-шкідників у травостої конопель характеризувалась олігодомінантністю, про що свідчать якісно-кількісні показники та індекси видового різноманіття. Так, структура домінування представлена одним еудомінантом (*Psylliodes attenuata* — 81,1 %), одним субдомінантом (*Mordellistena parvula* — 4,72 %), чотирма рецедентами (*Lygus pratensis, L. rugulipennis, Lygocoris pabulinus, Stictocephala bisonia* — 8,6 %) та 33 субрецедентами (5,58 %). Отримані результати досліджень будуть використані при вирішенні проблем, пов'язаних з небезпечністю основних комах-фітофагів під час вегетації рослин конопель посівних, та розробці сучасної екологічно-орієнтованої стратегії контролю їх чисельності й шкідливості

Ключові слова: агробіоценоз, видовий склад, трофічна структура, комахи-фітофаги, класи домінування