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SPECIES COMPOSITION OF PESTS OF GRAIN STOCKS DURING GRAIN STORAGE

Analyzed phytosanitary state of warehouses and silos for storing grain and grain products. Determined the species composition of the most common types of pests of grain stocks in different types of storage. Generalized the results of studies, found the main dominant species.

pests of grain stocks, species composition, harm, dominating species

Insects and mites are able to cause significant economic damage to grain and products of grain stocks during storage. In practice, the nature and extent of damage from harmful arthropods is sometimes difficult to determine, because, in many cases, damage to grain is hidden. Arthropod grain stocks pests cause direct and indirect losses. Direct losses are loss of grain mass, deterioration of its quality, reducing sowing performance, damage of equipment polluted by excrements and remnants of life activity. Indirect damage linked to the fact that insects can promote spontaneous heating of grain, micro flora spread, sometimes agents of various diseases [1].

Some species are active vectors of different micro organisms: fusarium, potato bacillus and bacteria that cause spontaneous heating and spoilage of grain stocks [8].

Harmful insects destroy 10 — 50% of grain of different cultures in many countries annually, in some countries it makes millions of tons. From 10 to 30% of collected crops is lost in Ukraine because of them. The most common and harmful are pantry (*Sitophilus granarius* L.) and rice (*Sitophilus oryzae* L.) weevils. In laboratory conditions two pairs of beetles of these species for the first 9 months spent in wheat grain produce offspring of 3211 and 7978 individuals respectively, significantly lowering weight of grain [5].

For artificial infection of wheat grain by weevils and grain moths, six months after losses exceeded 40%, the grain batch is not suitable for further baking purposes under such damage.

Most harmful arthropods (rice and pantry weevils, grain moth grain fretter) eat away grain endosperm. Thus, over time the larvae of rice and pantry weevils, grain fretter destroy 24, 41 and 28% of grain weight accordingly.

Under contamination of grain by the mentioned species for 10.5 and 19.2% accordingly, no significant changes in gluten indexes has been spotted, but decrease of hydration, has been spotted, increase of grain acidity, including fat acidity value of flour gained from this grain.

In grain infected with insects the number of microorganisms, including bacteria and fungi increases ten times. IF 20% of grain infected with rice weevil are present, total flour output decreases for more than 4%, while its average ash content increases [2].

In case of contamination of seed grain stocks with pests, its viability significantly decreases, including: because of pantry and rice weevil of wheat for 92 and 75% accordingly, from tenebrionid beetles for 60%, from cucuid beetle for more than 30%, from mites for up to 20% [10].

Seeds of peas, in which pea maggot undergoes a full cycle of growth, loses weight from 12 to 35% as compared with control. Grain contaminated with tenebrionid beetles changes its amino acid and mineral composition. Pantry moth reduces weight of grain to 50%, at this, viability indexes of grain decrease significantly [9].

Taking into consideration damage character caused by insects and mites, two main indexes of grain and grain products condition were defined: contamination and infection of grain stocks.

Contamination is defined by the presence of live insects and mites. This index is technological and characterizes stability of grain storage and possibility of its further deterioration. Contamination is characterized by presence of dead and live pests. This figure is hygienic characterizing suitability of grain for food purposes. Hazard ratio (K_h) for the main types of pests, taking into account the maximal acceptable level of 15.0, ranges from 0.05 to 1.7. [10].

In addition to weight loss, deteriorating quality and technological advantages, insects and mites emit substances toxic to human into grain. So, at a certain density of infection of grain with insects and mites, it is unsuitable for food purposes. Deterioration of sanitary condition of grain during infection of insects and mites arouses need of strict regulation of density of infection by certain types of pests, and its total value, i. e. establishing the maximum acceptable level (MAL) of the number of insects per 1 kg of grain.

Taking into consideration harm brought by insects and mites, the prominent meaning is gained by phytosanitary analysis of grain storages, establishing species composition of pests and implementation of necessary preventive and eliminating measures to reduce their number.

Typically, private households use the most common method of sampling and screening to identify grain pests adults. When storages and containers are empty, they are being visually inspected. But this is too few to assess the real phytosanitary condition.

For the last time, more actual is the method of food baits and phero-

mone monitoring. These methods are the most profitable for timely detection, monitoring and evaluation of spread of pests. To identify hidden forms of infection, caryopsis splitting method and corks painting method is usually used. Also convenient is the flotation method.

Pheromone traps with synthetic sex pheromones detect insects quickly enough, incl. cases of low pest population when they are difficult to be detected by other means. Early detection allows them to increase effectiveness of protective measures to reduce pesticide load [7].

Traps are easy to install in various types of silos, which allows to quickly identify insect pests, identify their species composition, identify sources of their distribution and apply necessary measures of protection. If during the day more than three butterflies get into a pheromone trap, a local survey of products is conducted in the center of the outbreak, and a local chemical treatment is necessary too. In the case of increasing of number of insects for 10 days and their numbers exceeds 15 units per trap a day, chemical disinfection of previous cleaning facilities and equipment should be carried out.

A common method of males disorientation, or creation of so-called male vacuum using males capture leads to significant reduction in population density due to absence of females fertilization. Method of disorientation of pyralids (mill, grain moths, South Collar etc.) became widespread in the former Czechoslovakia from 1984 after synthesis of pheromone of these herbivores — Ferrokapu EP 20 Ferocap EP 20), to fight coleopterous in mills and confectioneries [10].

To identify species composition of beetles in grain mass probe type traps are used, they have a form of perforated plastic tubes of different diameters and lengths with pheromone dispenser that are dipped in a grain mass. In the USA grain frotter male pheromones are used (aggregation pheromone is being produced by males) in perforated grain probe traps. Thus, pest population that is in the layer of grain of wheat, rye, barley and other cereals reduces [8].

Also a new way to use pheromones combined with entomophages is offered. For this, trap devices are equipped in the form of an open container, which contains a microbiological preparation suspension. Insects contact with the pathogene and spread infection which infests the whole population.

There are many other methods that allow to evaluate phytosanitary state of granaries, establish the degree of contamination of grain and prevent pests outbreak to save the crop.

Research methodics.

Accounting insect has been conducted during spring and summer of 2011—2014 in the territory of granaries and elevators of Kyiv, Poltava, Kharkiv, Dnipropetrovsk, Kherson and Odessa regions.

Definitions of regulation entities conducted under procedures adopted for study and identification of pests of grain stocks, and establish the degree

of contamination of grain [3, 4, 6]. Veracity of determination of species of insects is confirmed by employees of the Schmalhausen Zoology Institute of the NASU.

Pheromone traps «ZHELANG BESTWIN GROUP LIMITED», «KILLGERM CHEMICALS LIMITED», AGRISENSE BCB Ltd. Great Britain, «PAPIRNA MOUDRY» Ltd., Czech Republic, were used. Traps consist of cardboard and plastic constructions for mass trapping, both terrestrial and so flying insects.

For grain mass probe type trap are used, they look like perforated plastic tubes of different diameter and length, equipped with a long rope with which they are immersed in a mass of grain and pulled out. Smooth surface of a tube and sharpness of its end provides a free dive in thick grain layer of several meters. The tube has many holes, each of which is made so that an insect crawls into the tube, but can not get out of it. Pheromone in dispenser is in the middle of the tube and entices insects from grain, and they swarm at the bottom of the trap. To detect insects, pheromone traps were immersed in a mass of grain onto several meters. To identify Lepidoptera insects in granaries, pheromone traps used glue cardboard and plastic construction with plates sized 58 mm × 78 mm and 111 mm × 111 mm respectively. The main location of traps were: walls, some parts of gallery stands, poles and other surfaces. Distance between traps made from 10 to 16 m. At stable average daily temperature for over 15°C traps were located according to calculation of 1—2 traps for each 100 m².

For installation of food traps on the floor, containers with baits of plastic and metal designs.

Research results.

As a result of studies on identification and accounting of arthropod pests of stocks, 69 species belonging to 26 kind and 6 rows were identified.

Conducted 726 accounts and identification of harmful insects and mites, 217 of which were sampled by increment samples, 52 samples — by food baits, 457 — by pheromone monitoring. Total number of harmful insects capture was 26 620 units.

Overall pest species composition was presented in rows: Acariformes — 6 species Thysanura — 1 species, Psocoptera — 3 species, Coleoptera — 48 species Blattodea — 2 species, Lepidoptera — 9 species.

Given peculiarities of biology and ethology of most common species, it was found that when temperature conditions of storage units change, and minor deviations of moisture inherent to different types of silos, species composition of dominant species of different pests and their greatest number was observed in warehouses (Table 1).

For example, in warehouse premises dominant species in recent years were: flour mite (*Acarus siro* L.), common hairy mite (*Glycyphagus destructor* Ouds.), pantry (*Sitophilus granarius* L.), and rice (*Sitophilus oryzae* L.)

1. Dominant species of cereal storage pests 2011–2014.

Type of grain storage	Order	Family	Dominant species
On-the-floor-storages	Akariformes	Acaridae	Flour mite (<i>Acarus siro</i> L.)
			Hay itch (<i>Glycyphagus destructor</i> Ouds.)
			Regular wild mite (<i>Cheyletus eruditus</i> Schrk.)
	Psocoptera	Atropidae	Booklouse (<i>Troctes divinatorius</i> L.)
		Psocidae	House dust mite (<i>Pterodela pedicularia</i> L.)
	Coleoptera	Curculionidae	Wheat weevil (<i>Sitophilus granarius</i> L.)
			Rice weevil (<i>Sitophilus oryzae</i> L.)
		Tenebrionidae	Confused flour beetle (<i>Tribolium confusum</i> Duv.)
			Red flour beetle (<i>Tribolium castaneum</i> Hrbst)
			Destructive flour beetle (<i>Tribolium destructor</i> Uytt.)
			Black flour beetle (<i>Tribolium madens</i> Charp.)
			Litter beetle (<i>Alphitobius diaperinus</i> Panz.)
		Cucujidae	Sawtoothed grain beetle (<i>Oryzaephilus surinamensis</i> L.)
			<i>Laemophloeus ferrugineus</i> (Steph.)
		Anobiidae	Drugstore beetle (<i>Stegobium paniceum</i> L.)
		Bostrychidae	American wheat weevil (<i>Rhizopertha dominica</i> F.)
		Bruchidae	Pea weevil (<i>Bruchus pisorum</i> L.)
		Ostomatidae	Cadelle beetle (<i>Tenebrioides mauritanicus</i> L.)
		Ptinidae	Whitemarked spider beetle (<i>Ptinus fur</i> L.)
		Dermestidae	<i>Trogoderma variabile</i> (Ball.)
			Glabrous cabinet beetle (<i>Trogoderma glabrum</i> Ball.)
	Nitidulidae	Corn sap beetle (<i>Carpophilus dimidiatus</i> F.)	
	Lepidoptera) Pyralidae	Indian meal moth (<i>Plodia interpunctella</i> Hb.)	
Cacao moth (<i>Ephestia elutella</i> Hb.)			
Mediterranean flour moth (<i>Anagasta kchmiella</i> Zell.)			
Tineidae	<i>Haplotinea ditella</i> (P.et Diak.)		

weevils, small flour tenebrionid beetle (*Tribolium confusum* Duv.), red short-horned cucuid beetle (*Laemophloeus ferrugineus* Steph.) and others.

In silo type storages of reinforced concrete the following ones dominated: Pantry weevil (*Sitophilus granarius* L.), small rhopalocera flour tenebrionid beetle (*Tribolium castaneum* Hrbst.), common hairy mite (*Glycyphagus destructor* Ouds.), flour mite (*Acarus siro* L.) grain and carpenter fretter (*Rhizopertha dominica* F.).

In silo type storages of metal the following ones dominated: rice (*Sitophilus oryzae* L.) and pantry (*Sitophilus granarius* L.) weevils, small flour (*Tribolium confusum* Duv.) and rhopalocera (*Tribolium castaneum* Hrbst) tenebrionid beetle, flour mite (*Acarus siro* L.).

Beside confused flour beetle (*Tribolium confusum* Duv.), a massive outbreak of Indian mealmoth (*Plodia interpunctella* Hb.), Mediterranean flour moth (*Ephestia kuehniella* Zell.), sawtoothed grain beetle (*Oryzaephilus surinamensis* L.), and Destructive flour beetle (*Tribolium destructor* Uytt.) was detected at the grain and its processing products storage plant, especially between 2012 and 2014.

It is necessary to mention that, for some storage units, pests of Dermestidae family are widespread, particularly *Trogoderma variabile* (Ball.). It is an important fact that the latter could acquire a dominant status due to a wider ecological valence and ability to spread under unfavorable conditions.

For many grain storages, the dominant species were wheat weevil (*Sitophilus granarius* L.), booklouse (*Liposcelis divinatorius* Mull.), regular wild mite (*Cheuletus eruditus* Schrk.), and house dust mite (*Zercoseius ometecis* Ouds.), but also a massive outbreak of Indian mealmoth (*Plodia interpunctella* Hb.) and Mediterranean flour moth (*Ephestia kuehniella* Zell.) were observed.

Numbers of most of the other species on scale of Skufin were 4 — 8% out of the total number of all detected pests, hence they were subdominant. Few in numbers and rare species were observed mostly in on-the-floor-storage areas, and their numbers were 1 — 3%.

The relative distribution of species on the point-based assessment was somewhat different for different types of grain storages. For loaded grain storages, the highest score according to the point-based assessment of species distribution was characteristic for flour mite (*Acarus siro* L.), booklouse (*Liposcelis divinatorius* Mull.), regular wild mite (*Cheuletus eruditus* Schrk.), rice weevil (*Sitophilus oryzae* L.) and wheat weevil (*Sitophilus granarius* L.), which was 5 points (40—100%).

For cereal receiving station the highest score according to the point-based assessment of species distribution was characteristic for confused flour beetle (*Tribolium confusum* Duv.) and red flour beetle (*Tribolium castaneum* Hrbst), flour mite (*Acarus siro* L.), Indian mealmoth (*Plodia interpunctella* Hb.) and Mediterranean flour moth (*Ephestia kchniella* Zell.) which was also 5 points (40—100%).

For grain and its processing products storage plants, the highest score according to the point-based assessment of species distribution was characteristic for confused flour beetle (*Tribolium confusum* Duv.), wheat weevil (*Sitophilus oryzae* L.), Indian mealmoth (*Plodia interpunctella* Hb.) and Mediterranean flour moth (*Ephestia kchniella* Zell.) with the score of 5 points. The 4 point score was characteristic for sawtoothed grain beetle (*Oryzaephilus surinamensis* L.) and regular wild mite (*Cheuletus eruditus* Schrk.). For other areas, the score of relative distribution for some dominant and subdominant species was 3 points, 3 — 16%.

As a result of selected testing, density of populations was identified, which was established through the method of calculating of average number of specimens for an accounting unit. In 2011, the highest density of population was characteristic for mites (Akariformes), of which flour mite (*Acarus siro* L.) and regular wild mite (*Cheuletus eruditus* Schrk.) in particular with the score of ($V = 8,6$ sp.) та ($V = 7,4$ sp.), as well as beetle (Coleoptera) — rice weevil (*Sitophilus oryzae* L.) with the score of ($V = 8,0$ sp.), wheat weevil (*Sitophilus granarius* L.) — ($V = 7,5$ екз.), American wheat weevil (*Rhizopertha dominica* F.). — ($V = 3,4$ sp.) and confused flour beetle (*Tribolium confusum* Duv.) — ($V = 2,8$ sp.). Among Lepidoptera, Indian mealmoth had the highest density (*Plodia interpunctella* Hb.) with the score ($V = 8,8$ sp.).

In 2012 the highest density of population was also characteristic for mites, for flour mite (*Acarus siro* L.) and hay itch (*Glycyphagus destructor* Ouds.) in particular with the scores of ($V = 8,7$ sp.) and ($V = 7,1$ екз.), and rice weevil (*Sitophilus oryzae* L.) and wheat weevil (*Sitophilus granarius* L.) with the scores of ($V = 7,0$ sp.), — ($V = 4,5$ sp.). Confused flour beetle (*Tribolium confusum* Duv.) — ($V = 2,4$ sp.). Among Lepidoptera, beside Indian mealmoth (*Plodia interpunctella* Hb.) with the score of ($V = 7,7$ sp.), Mediterranean flour moth (*Ephestia kchniella* Zell.) was also detected with the score of ($V = 6,6$ sp.).

In 2013, the density of the populations was as follows: wheat weevil (*Sitophilus granarius* L.) — ($V = 3$ sp.), American wheat weevil (*Rhizopertha dominica* F.). — ($V = 1,7$ sp.), booklouse (*Liposcelis divinatorius* Mull.) — ($V = 1,5$ sp.), regular wild mite (*Cheuletus eruditus* Schrk.) — ($V = 1,7$ sp.).

In 2014, a considerable increase in density of common species was observed. A high density of Lepidoptera is worth mentioning, of which Angoumois grain moth (*Sitotroga cerealella* Oliv.) and Indian mealmoth (*Plodia interpunctella* Hb.) in particular with the scores of ($V = 18,7$ sp.) and ($V = 15,4$ sp.) accordingly. A high density of booklouse (*Liposcelis divinatorius* Mull.) — ($V = 22$ sp.), wheat weevil (*Sitophilus granarius* L.) — ($V = 12$ екз.), and confused flour beetle (*Tribolium confusum* Duv.) — ($V = 2,8$ sp.) were observed.

To determine the species richness of cereal storage pests, indexes that

characterize the species numbers in a definite sample for a given accounting area were calculated. Considering the calculation results of species composition for cereal storage pests throughout the years of investigation, we have identified the species richness using the Margalef's and Menhinick's indexes which give an opportunity to assess the number of species in the total number of pest specimens, as well as Berger-Parker index which determines the level of dominance of the most widespread common species (Table 2).

2. Identification of species richness indexes of cereal storage pests

Accounting year	Number of detected species (S)	Total number of specimens of all detected species (N)	Number of specimens of the most dominant species (N max)	Index Dmg $\frac{(s - 1)}{\ln N}$	Index Dmn $\frac{S}{\sqrt{N}}$	Index BP $\frac{d}{N \max}$ $\frac{d}{N}$
2011	54	7917	3720	5,91	0,61	0,47
2012	32	6403	2680	3,54	0,40	0,42
2013	18	2840	1590	2,14	0,34	0,56
2014	67	9460	7378	7,22	0,69	0,78

Margalef's (Dmg) and Menhinick's (Dmn) indexes characterize the species density in a certain cereal storage area, i.e. the higher the score, the bigger their species richness. According to the Margalef's (Dmg) index, the fluctuation is 2,14 — 7,22. According to the Menhinick's (Dmn) index, the species richness was 0,34 — 0,69. According to the Berger-Parker index (BP) which characterizes the level of dominance of the most widespread common species, the scores were 0,42 — 0,78.

Thus, the investigations of entomological complex of cereal storage pests under different product storage conditions have shown that its species composition is changing depending on many factors, and taking efficient protection measures is only possible if grain storages are carefully inspected.

CONCLUSIONS

1. Arthropod found 69 species of pests which belong to 26 kind, 6 orders were detected. 726 reports were performed to determine and identify pests and mites, of which 217 samples were selected through the method of incremental sampling, 52 samples — through the food attraction method, 457 — through the method of pheromone monitoring. The total number of destructive insects catching was 26 620 specimens.
2. The most wide spread and dominant species of cereal storage pests and grain storages were identified. The major dominant species were

the following: flour mite (*Acarus siro* L.), hay itch (*Glycyphagus destructor* Ouds.), wheat weevil (*Sitophilus granarius* L.), rice weevil (*Sitophilus oryzae* L.), confused flour beetle (*Tribolium confusum* Duv.), *Laemophloeus ferrugineus* (Steph.) and sawtoothed grain beetle (*Oryzaephilus surinamensis* L.), drugstore beetle (*Stegobium paniceum* L.), Indian mealmoth (*Plodia interpunctella* Hb.), cacao moth (*Ephesia elutella* Hb.) and Mediterranean flour moth (*Anagasta kchniella* Zell.).

3. The relative distribution of species according to the point-based assessment for each grain storage type was 3 — 5 points. The density of population which was indentified through the method of each species average specimen number calculation for an accounting unit had the following scores: ($V = 1,5$ sp.) до ($V = 18,7$ sp.) accordingly.
4. The cereal storage pests richness indexes according to the Margalef's index (Dmg) were 2,14 — 7,22, according to the Menhinick's index (Dmn) — 0,34 — 0,69, according to the Berger-Parker's index (BP), the scores were 0,42 — 0,78.

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Середняк Д.П., Федоренко В.П. Видовий склад шкідників хлібних запасів за зберігання зерна

Проаналізовано фітосанітарний стан складських приміщень та елеваторів для зберігання зерна та зернопродуктів. Визначено видовий склад найбільш розповсюджених видів шкідників хлібних запасів в різних типах зерносховищ. Узагальнено результати досліджень, встановлено основні домінуючі види.

Середняк Д.П., Федоренко В.П. Видовой состав вредителей хлебных запасов при хранении зерна

Проанализировано фитосанитарное состояние складских помещений и элеваторов по хранению зерна и зернопродуктов. Определен видовой состав наиболее распространенных вредителей хлебных запасов в разных зернохранилищах. Обобщены результаты исследований, определены доминантные виды.