INTERSPECIFIC CONNECTIONS BETWEEN INVERTEBRATES PRESENT IN MAIZE GROWN IN MONOCULTURE

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Abstract. *Invertebrate species present in a corn crop may or may not interact, fulfilling various roles. Some of them are phytophagous consuming parts of the plant, others have a carnivorous diet consuming other animal organisms and others are indifferent. Starting from the various roles that invertebrates can play, we decided to analyze the situation on these categories, in a maize crop (in monoculture) in Timis County, for a period of 2 years, respectively 2019 and 2020. Thus, bearing in mind the fact that the phytophagous species play a harmful role for the plant, the carnivorous ones can be useful by consuming the phytophagous ones and the indifferent ones do not have a defined role, we quantified all the species found both terrestrial and in the soil. We thus found that most of the species present were phytophagous. Of the 18 invertebrate species found, 61.1% were phytophagous, 22% carnivorous and 16.6% indifferent to plants or animal organisms present. In the underground environment, 8 species of invertebrates were identified, and in the terrestrial environment, the rest, 12 species remained. Predominant among the phytophagous species were the insects Diabrotica virgifera and Aphis maydis. Among the carnivores, the arthropod species Argiope bruennichii and Coccinella sp were noted, and among the indifferent ones, the annelid Lumbricus terestris and the arthropod Formica pratensis predominated. Trophic or accidental connections were observed between invertebrate species present in the analyzed corn field. Thus, trophic connections were observed between arachnid, carabids and coccinelids as predator species and many phytophagous insect species present on plants. In conclusion, we can mention that there are many categories of species in the field with analyzed corn, and the cause could be the practice of the system in monoculture, which favours the excessive multiplication of all existing invertebrates in the soil but also on plants.*

Keywords*: Invertebrate, phytophagous, carnivores, trophic connection, maize.*

INTRODUCTION

Invertebrate diversity is important for many ecosystem services but also as a component of the agri-food network (EVANS ET AL. 2016). They play significant roles by actively participating in the interactions that develop in the soil between physical, chemical and biological processes (LAVELLE ET A., 2006).

Most species present in maize crops are arthropods (GIBB AND ODETO, 2006), but may also be from other large groups such as araneids (TOTH ET AL., 2001; URACK, 2005), carabids (TALMACIU AND GEORGESCU, 1998), slugs (LAUER, 2004) and millipedes (KIME AND ENGHOFF, 2017).

Among arthropods, insects are representative (MALSCHI, 2009) and most commonly found on the corn plant, among which, as mentioned in the literature, beetles (PALAGESIU ET AL, 2001; GROZEA I, 2010), ants (VAS ET AL., 2016), lepidopterans and hemipterans (MALSCHI, 2009).

According to BUNESCU (2001), the harmful fauna of these agroecosystems is richly represented by species belonging to different systematic groups, especially invertebrates (nemathelmintes as nematodes, molluscs as snails, arthropods as mites and insects) and some

pests can be polyphagous, while others are specific to corn, like as western corn rootworm (GROZEA, 2003).

Analysing the set of invertebrate species present in corn crops in eastern Romania, phytophagous species include following: *Rhopalosiphum maydis, Tanymecus dilaticollis, Opatrum sabulosum, Heliothis armigera, Diabrotica virgifera virgifera* and *Ostrinia nubilalis* (PAUNET, 2010). In the western part, they have not been updated in the last 10 years, so we set out through this paper to bring to producer and scientists' attention the whole set of invertebrate species that can be found in crops.

MATERIAL AND METHODS

Place of study and hybrids used. The location for collecting invertebrate samples and plant analysis was established in a maize field in Grabaț (Timiș) located near the border with Serbia, ready, where we made only the observations, without analyzing the production. We chose to make the observations in a monoculture system, on one hybrid from the FAO 360 group, suitable for the Western area, in the conditions of Grabaț locality. This was P9903, and was chosen by the manufacturer because it is currently the most cultivated in Romania, as mentioned on the official website of Pioneer R/ Corteva Agriscience (***).

Observations. The period of taking the soil samples and performing the readings took place between May and August, 2019-2020. In taking the soil samples, monthly, we used 20 adapted soil traps of Barberi type (made in the research laboratory of the university) for carabids (figure 1) and for nematodes we harvested 20 corn roots together with the soil around them. We put them in paper bags, which were transported to the laboratory and analysed by the usual procedure. For the analysis of terrestrial, plant or soil samples, we used 9 coloured Csalomon panel type traps for small and medium invertebrates and box type traps for flying invertebrates. The other species of gastropods, arachnids, myriapods, annelids were observed either on the analysed plants around the traps (per 1 m^2) or in the soil samples reached by the laboratory.

Figure 1. Ground traps (left) and plant-attached traps (box type and colored panel type, right)

Quantification and identification of species. The quantification of the individuals present (from traps and soil samples) was performed at the Laboratory of Diagnosis and Phytosanitary Expertise. Using binocular magnifier, especially for soil samples. For the data analysis we considered relevant the total number, the weight and the average registered in the two years, because we followed interactions and possible connections between the present species.

RESULTS AND DISCUSSION

The invertebrates present in the analysed corn culture belong to various systematic units, namely the Nemathelminthes, Annelida, Molusca and Arthropoda branches. The identified classes were: Nematode, Gasteropoda, Annelida, Arachnida, Diplopoda and Insecta and the orders in which they were framed were Opisthopora, Pulmonata, Araneae, Diplopoda, Neuroptera, Collembola, Homoptera, Coleoptera and Lepidoptera (table 1).

The species found were associated with the families (table1): Anguinidae, Helicidae, Lumbricidae, Julidae, Chrysopidae, Aphididae, Chrysopidae, Cicadellidae, Elateridae, Chrysomelidae, Carabidae, Curculionidae and Pyraustidae.

From the category of phytophagous species present we mention: *Ditylenchus dipsaci*, *Helix pomatia*, *Aphis maidis*, *Macrosteles quadrilineatus*, *Tanymecus dilaticollis*, *Diabrotica virgifera virgifera Le Conte*, *Oulema melanopa*, *Phyllotreta vittula*, *Opatrum sabulosum* and *Ostrinia nubilalis*. From the category of those with a carnivorous diet that can consume phytophagous insects, we mention *Coccinella sp*., *Pterostichus melanarius*, *Theridion impressum*, *Argiope bruennichi*. In the category of indifferent invertebrates can be integrated the species of *Lumbricus trerestris*, *Ommatoiulus sp.* and *Formica pratensis.*

Table 1

Invertebrate species present in a corn field in monoculture, in Grabat locality from Timiș county, during 2019-2020

PHYLUM	CLASS	ORDER	FAMILY	SPECIES
Nemathelminthes	Nematoda	Tylenchida	Anguinidae	*Ditylenchus dipsaci*
Annelida	Oligochaeta	Opisthopora	Lumbricidae	*Lumbricus terestris*
Molusca	Gasteropoda	Pulmonata	Helicidae	*Helix pomatia*
Arthropoda	Diplopoda	Julida	Julidae	*Ommatoiulus sp.*
	Arachnida	Araneae	Araneidae	*Argiope bruennichi*
			Theriidae	*Theridion impressum*
	Insecta	Hemiptera	Aphididae	*Aphis maydis*
			Cicadellidae	*Macrosteles quadrilineatus*
		Hymenoptera	Formicidae	*Formica pratensis*
		Coleoptera	Curculionidae	*Tanymechus dillaticolis*
			Chrysomelidae	*Phyllotreta vittula*
				Diabrotica virgifera
				Oulema melanopa
			Elateridae	*Agriotes sp.*
			Tenebrionidae	*Opatrum sabulosum*
			Carabidae	*Pterostichus melanarius*
			Coccinelidae	*Coccinella sp.*
		Lepidoptera	Pyraustidae	*Ostrinia nubilalis*

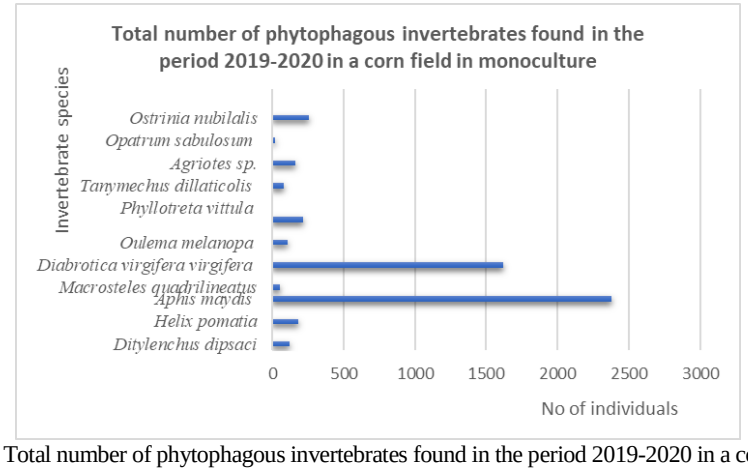

Figure 2. Total number of phytophagous invertebrates found in the period 2019-2020 in a corn field in monoculture, located in Grabat locality from Timis County

Of the phytophagous species found in culture, most were reported in *Aphis maydis* with a total of 2381 specimens, followed by *Diabrotica virgifera* with 1617 larval and adult specimens (figure 2). Over 250 specimens of *Ostrinia nubilalis* in adult form were also captured.

Most carnivorous species were *Coccinella sp.* and *Argiope bruennichi* with a total of 263 individuals and 117 observed on the analyzed plants (figure 3).

And the species considered without a clear role, phytophagous or carnivorous, were identified in the analyzed surface, among which *Formica pratensis* (with 361 individuals), *Lumbricus terestris* (with 266 ind.) and *Ommatoiulus sp.* (with 161 ind.) (figure 4).

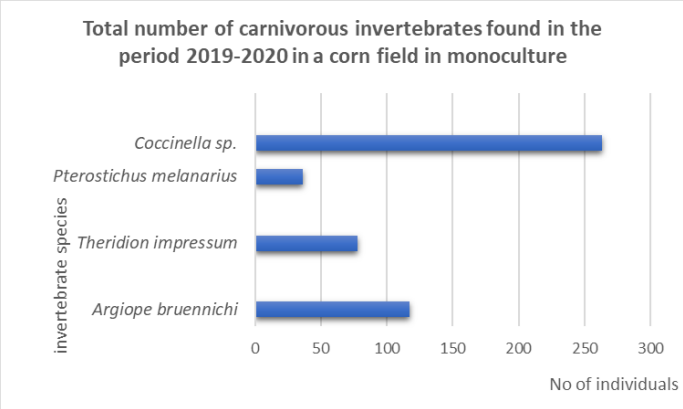

Figure 3. Total number of carnivorous invertebrates found in the period 2019-2020 in a corn field in monoculture, located in Grabat locality from Timis County

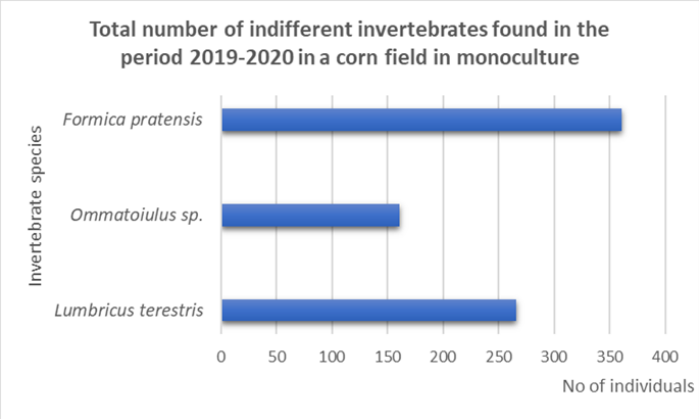

Figure 4. Total number of carnivorous invertebrates found in the period 2019-2020 in a corn field in monoculture, located in Grabat locality from Timis County

Following the analysis of soil samples with corn roots and soil traps, in the two years (2019 and 2020) the species of *Lumbricus t.* were predominant, with $\bar{x}$ = 33.25 ind., *Helix p.* with $\bar{x}$ = 22.5 ind., *Ommatoiulus sp.* with $\bar{x}$ = 20.12 ind., *Diabrotica v.* (larvae) with $\bar{x}$ = 13.25 ind. and *Agriotes sp.* (larvae) with $\bar{x}$ = 12.37 ind. (figure 5 and figure 6).

The monthly dynamics from May to August, 2019 (figure 5) showed a gradual evolution of the number of specimens found in the soil showed a gradual increase starting from an average value of $\bar{x}$ = 17.87 ind. in May, then reaching $\bar{x}$ = 20.87 ind. in June, then gradually decreasing in July and August. In 2020, the situation was different, the evolution was decreasing, starting from $\bar{x}$ =27.12 ind. in May, then at $\bar{x}$ = 22 ind. in June and gradually $\bar{x}$ =12.13 ind. in July and in August reaching $\bar{x}$ = 3.125 ind.

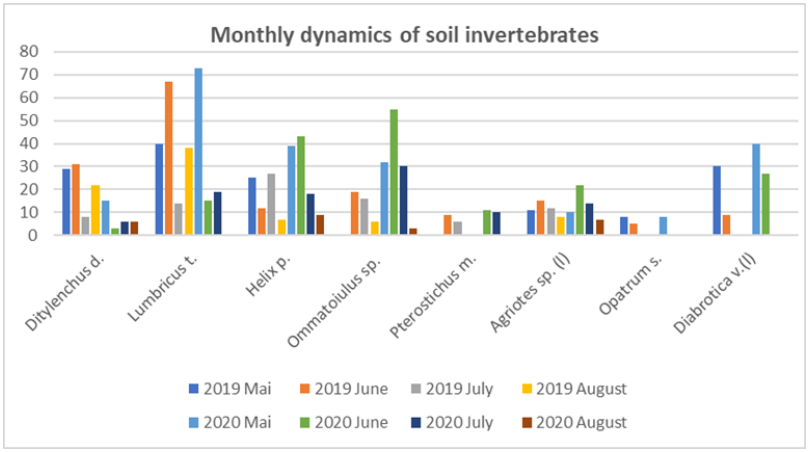

Figure 5. Monthly dynamics of soil invertebrates found in samples taken from the experimental corn field

Figure 6. Invertebrate species present in soil samples taken from the field with analyzed maize from Grabat (Timis)

From the samples captured from the traps installed on the plants (figure 7 and figure 8) we found that most specimens were recorded in the species *Aphis m.*, where $\bar{x}$ = 297.62 ind. and *Diabrotica v.* (adults) with $\bar{x}$ = 188.87 ind. At a medium level were the *Formica p* species. with $\bar{x}$ = 45.13 ind., *Coccinella sp.* with $\bar{x}$ = 32.87 ind. and *Ostrinia n.* (adults) with $\bar{x}$ = 31.63 ind.

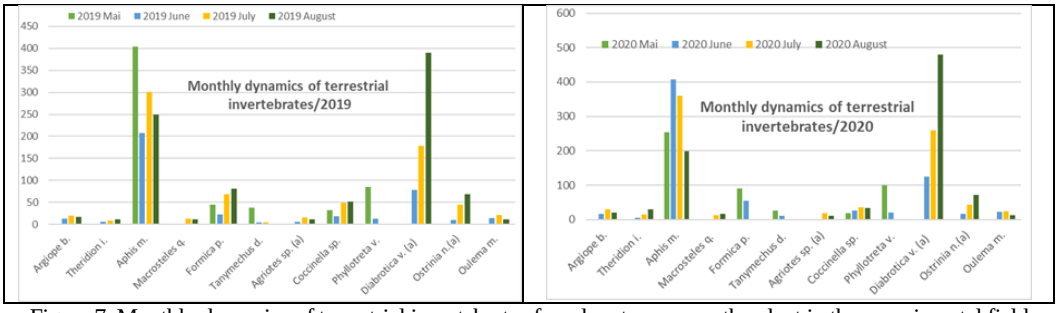

Figure 7. Monthly dynamics of terrestrial invertebrates found on traps or on the plant in the experimental field with corn, in both 2019 and 2020

The spider *Argiope b*., was not quantified from the traps, it being observed directly in the culture, especially between plants, on its canvas (figure 8). It is considered that the average value from the analyzed period of $\bar{x}$ = 14.63 ind. is high considering its size and the difficulty of capture.

Following the monthly evolution of the terrestrial species present on the aerial parts of the plants or on the ground (figure 7), we can say that since May there were quite high average values ($\bar{x}$ = 50.33 ind.), then they decreased slightly ($\bar{x}$ = 32.41 ind.), followed by a sudden increase at $\bar{x}$ = 60.16. and in august they increased to $\bar{x}$ = 75.08 ind. For 2020, the situation was different, in the sense that the average values increased gradually until August, when the values were maximum $\bar{x}$ = 72.75 ind.

Figure 8. Terrestrial invertebrate species observed on plants or traps, in the analyzed corn field from Grabat (Timis)

Interactions between invertebrate species were observed, which were then classified into three categories: trophic, accidental and partial.

The trophic ones were identified when feeding links were observed between the present species, in the sense that one species acted as a predator and another as a prey. And here enter the species of arachnids, coccinelids and carabids as predators and those of aphids, cicadas, larvae of lepidoptera and beetles but also beetles (Table 2).

Accidental connections have been associated with species that at one time interacted only by being present in the same environment, more precisely on the same plants or in the soil (Table 2). Among them we can mention nematodes, annelids, myriapods, molluscs, insects and their larvae that had accidental interactions in the soil environment or on its surface and also arachnids between them or some beetle and lepidopteran insects accidentally present on plants.

Some invertebrates compared to others had only a beneficial connection for one of them, such as ants in relation to aphids and indirectly to coccinelids (attracted by aphid populations), in the sense that ants were attracted to the sweet secretions of aphids, without any feeding interactions. (Table 2).

Table 2

Trophic or accidental connections observed between invertebrate species present in the analyzed corn field from Grabat (Timis)

Name of species/Code S1-S15	Interactions between invertebrate species found in a monoculture maize																
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17
Ditylenchus dipsaci (S1)	/	+a	-	+a	-	-	-	-	-	-	+a	-	-	-	-	-	-
Lumbricus terestris(S2)	+a	/	-	+a	+a	-	-	-	-	-	+a	-	-	-	-	-	-
Helix pomatia(S3)	-	-	/	+a	-	-	-	-	-	-	+a	-	-	-	-	-	-

Ommatoiulus sp. (S4)	+a	+a	-	/	-	-	-	-	+a	+a	+a	+a	+a	-	-	-	-
Argiope bruennichi(S5)	-	-	-	-	/	+a	+t	+t	-	-	+t	-	-	+t	+t	+t	+a
Theridion impressum (S6)	-	-	-	-	+a	/	+t	+t	-	-	+t	-	-	+t	+t	+t	-
Aphis maydis (S7)	-	-	-	-	+t	+t	/	+a	+t	-	+a	-	+t	+t	+a	+a	+a
Macrosteles quadrilineatus (S8)	-	-	-	-	+t	+t	+a	/	+t	-	+a	-	+t	+t	+a	+a	-
Formica pratensis (S9)	+a	+a	+a	+a	-	-	+p	+p	/	-	-	-	-	+p	+a	+a	-
Tanymechus dillaticolis (S10)	-	-	-	+a	-	-	-	-	-	/	-	+a	+a	-	-	-	-
Agriotes sp. (S11)	+a	+a	+a	+a	+t	+t	+a	+a	-	+a	/	-	-	+a	+a	+a	-
Opatrum sabulosum (S12)	-	-	-	+a	-	-	-	-	-	+a	-	/	+a	-	+a	+a	-
Pterostichus melanarius (S13)	-	-	-	+a	-	-	+t	+t	-	+a	-	+a	/	-	+t	+a	-
Coccinella sp. (S14)	-	-	-	-	+t	+t	+t	+t	+p	-	+a	-	-	/	+a	+t	-
Phyllotreta vittula (S 15)	-	-	-	-	+t	+t	+a	+a	+a	-	+a	+a	+t	+a	/	+a	+a
Diabrotica virgifera (S16)	-	-	-	-	+t	+t	+a	+a	+a	-	+a	+a	+a	+t	+a	/	- +a
Ostrinia nubilalis S17)	-	-	-	-	+t	+t	+a	-	-	-	-	-	-	-	+a	+a	/

S-species code; +(a) accidental connections, species in the same living environment; + (t) trophic connections, when one species consumes another species in the corn crop; +(p) partial connections with benefits only for one species; -there are no connections between species

CONCLUSIONS

Following the results obtained, it can be concluded that there are numerous species of invertebrates both in soil and in the terrestrial environment, and an important part of them is the phytophagous and carnivorous. There are connections between them and some are beneficial for corn cultivation such as trophic links between predatory and phytophagous species, the latter being considered harmful to the plant. Considering these aspects, it is important to avoid the cultivation of corn in monoculture because it favours the multiplication with predominance of phytophagous species at the disadvantage of the culture.

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