SUMMARY PhD THESIS

Research on useful entomofauna (predators and parasites) in the agroecosystems of the Transylvanian Plain

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INTRODUCTION

In the current context, plant protection has a new approach, such that new measures to be as durable and sustainable as possible, ensuring healthy production and in sufficient quantities. Sustainability requires strict adherence to certain rules and methodologies, of which those of plant protection acquires a special importance.

CURRENT STATE OF KNOWLEDGE

The importance of wheat crop. Wheat is one of the oldest crops and the most important food plant, wheat flour bread is the staple food for a large part of the world's population (MUNTEAN et al., 2008).

Integrated plant protection. Implications of irrational pesticide application led to the emergence of resistant forms of pests, further increasing the impact of harmful organisms but also to the more intense pollution of the environment. Therefore, plant protection experts considered it necessary to develop a strategy to control harmful organisms, more environmentally friendly, which formed under the name of integrated protection (VOLOŞCIUC, 2014).

The importance of useful entomofauna. In any type of agroecosystem, along with the insects that cause damage, there are certain useful organisms capable of limiting the destructive action of pests. Of these, predatory and parasitoid insects have a relevant importance in the protection of plants and the environment. Together they form the so-called auxiliary entomofauna (ELENA PRELIPCEAN et MOGLAN, 2016).

Systematic of useful entomofauna. Observations made in cereal agroecosystems have shown that, throughout the vegetation period, field crops are colonized by entomophagous populations, being identified several known groups of useful arthropods, both parasites but especially predators, the most important being: *Coccinella septempunctata* and *Propylaea 14-punctata* from the family Coccinellidae, *Nabis ferus* (Nabidae), *Chrysopa carnea* (Chrysopidae), *Cantharis fusca* (Cantharidae), species of the family Syrphidae, Empididae, species of spiders belonging to the Araneae parasite species such as *Aphydius avenae* (family Braconidae), but also other parasites of the Hymenoptera type (DANA MALSCHI, 2007).

The main pests of wheat. Wheat is the host and therefore the preferred food for most species of pests specific to grain cereals. From the pest complex that affects the production of wheat crops in the Transylvanian Plain area, the most important are: buzzard beetle (*Oulema melanopus* L.), wheat thrips (*Haplothrips tritici* K.), cereal bedbugs (*Eurygaster* spp. and *Aelia* spp.), wireworms (*Agriotes* spp.), straw wasp (*Chepus pygmaeus* L.), aphids (*Schizaphis graminum* R., *Sitobion avenae* F.) (DANA MALSCHI, 2007).

PERSONAL CONTRIBUTION

The objectives. In the dynamics of biotic components within an agroecosystem, the anthropic factor, along with other abiotic and biotic ecological factors, often plays a decisive role. Knowing the impact of these factors on the zoophagous entomofauna is imperative.

As such, the purpose of the research carried out during the doctoral period, was the study of useful species from wheat crops in the Transylvanian Plain in correlation with the experimental variants during the years 2016-2018, the objectives of the doctoral thesis being the following:

- The influence of the agroecosystem on the useful entomofauna.
- The impact of chemical treatments on useful entomofauna.
- Assessing the diversity of entomophagous in the two agroecosystems.
- The influence of treatments on some components of production.

The natural setting in which the experimentation took place. The research was carried out in two agroecosystems in central Transylvania, Turda and Bolduț, on the experimental lands of the Turda Agricultural Research and Development Station, which is located in the Transylvanian Plateau, at an altitude between 345-493 m above sea level.

Material and method. The research within the doctoral thesis were carried out in two quite close locations in terms of distance, but very different in terms of territorial organization, the farm from Bolduț being framed by a network of agroforestry curtains. In Turda, the soils are located in open field conditions and are protected from rare spontaneous marginal edges, the biological material used being represented by the Andrada wheat variety.

Results and discussions. Numerous papers suggest the important role of polyphagous predators in the natural limitation of pests. There is a dynamic balance between the populations of harmful and useful arthropods which can be modified under the action of numerous biotic and abiotic factors. Experiments conducted over the years have shown that agro cereal are populated during the growing season of many entomophagous.

1. Peculiarities of useful and harmful entomofauna in two cereal agroecosystems in central Transylvania

Dynamics and diversity of arthropod populations in semi-artificial biocenoses(biological communities in which anthropogenic intervention is major but still preserves some species from natural biocenoses), they reflect their particularities

and allow the most pertinent decisions to be taken in the specific management of each biocenocesis.

1.1. Assessment of the diversity of entomophages in the two agroecosystems

Sustainable exploitation, by implementing sustainable agricultural practices, can make an important contribution to the proper functioning of the ecosystem. These good agricultural practices also include the provision of natural habitats for useful entomophagous species as well as biological pest control.

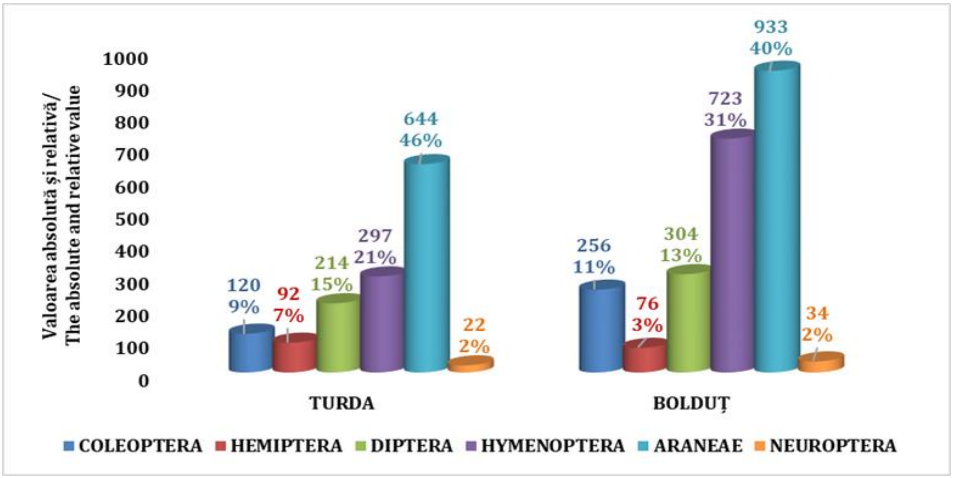

Fig. 1. Participation of insect orders in the structure of useful entomofauna collected in the three years of experimentation

The presence of entomophagous in both agrobiocenoses reflects the predominance of spiders with relative values of 40% and 46%, the absolute difference between the two agroecosystems being 289 individuals. The second most important differences from the group of spiders is occupied by Hymenoptera with percentage values of 31 and 21, the differences between the two agroecosystems being more pronounced, of 10% in favor of the system with forest curtains from Bolduț.

Expressed in absolute values, the gap of hymenoptera in the two locations is 426 individuals. Entomophagous diptera registers an almost similar distribution in the two agroecosystems, the relative differences being only 2%, and the absolute ones being 90 individuals, in favor of the system with forest curtains from Bolduț. Coleoptera order, occupies a rather important place in the palette of entomophagous diversity, with almost analogous distributions in the two agroecosystems, the difference being only 2% (fig. 1.).

Therefore we could conclude that in the two agricultural lands, the distribution of entomophagous has a high degree of annual and territorial variability with a

numerical level superior to the agroecosystem from Bolduţ and especially in the case of the more representative entomophagous.

Table 1

Ecological indices of entomophagous species from wheat culture in two agroecosystems, under the conditions of non-application insecticides

Indici ecologici Ecological indices	2016		2017		2018	
	Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ
Nr. total indivizi/No total individuals	**197**	**297**	**462**	**691**	**730**	**1338**
Shanon	**1.94**	**1.96**	**1.89**	**1.96**	**1.55**	**1.58**
Simpson	**4.00**	**4.87**	**4.13**	**4.17**	**3.25**	**3.31**
Echitabilitatea/Equitability	**0.70**	**0.74**	**0.70**	**0.69**	**0.53**	**0.53**
Jaccard	**76,47%**		**88,23%**		**85,71%**	

The biodiversity parameters used for the mathematical quantification of the diversity of the species from the two biocenoses are differentiated. The possibility that two individuals selected at random from a sample may belong to different species, or Shannon index values, does not show significant differences between the two agroecosystems. However, in Bolduţ the thresholds of this indicator are slightly higher than in Turda in all three years. Simpson diversity index, a synthetic parameter of diversity that encompasses both the abundance and the number of individuals, suggests by its values, a slight dominance of the diversity of entomophagous in the agroforestry system from Bolduţ compared to Turda (table 1).

Also, the relative abundance of the species characterized by another index, namely equitability, reflects a rather pronounced similarity regarding the abundance of entomophaous in the two agroecosystems. Morover, the Jaccard similarity index highlights a fairly pronounced affinity regarding the diversity of entomophages between the two agroecosystems. The values are quite close to this parameter in the three years suggests a fairly pronounced stability of the diversity of entomophagous in the two biocenoses.

Table 2

Ecological indices of entomophagous species from wheat culture in two agroecosystems, under the conditions of application insecticides

Indici ecologici Ecological indices	2016		2017		2018	
	Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ
Nr. total indivizi/No total individuals	**94**	**264**	**318**	**525**	**543**	**885**
Shanon	**1.58**	**2.00**	**1.64**	**1.72**	**1.39**	**1.40**
Simpson	3,02	6,28	**3,22**	**3.86**	**2,81**	**3,02**
Echitabilitatea/ Equitability	**0.66**	**0.87**	**0.64**	**0.61**	**0.48**	**0.50**
Jaccard	**61.53%**		**76.47%**		**84.21 %**	

The Shannon index reflects a greater impact of treatments on the diversity of useful arthropods in the agroecosystem from Turda compared to that from Bolduț. Another mathematical parameter of diversity, namely the Simpson index, presents at the level of the two localities a trend similar to that of the Shannon parameter, in the sense that in all three years the values of the two parameters are superior in the agroecosystem from Bolduț.

In the case of equitability, it seems that in the variant in which insecticide treatments were applied, useful arthropods show a rather pronounced similarity in both locations with the smallest differences of 0,21 in 2016.

If they are compared in terms of value variability parameters for useful arthropods, it can be seen from tables 1 and 2 that they have higher values if no insecticides have been applied, compared to the variant in which treatments were performed. The superior variation of entomophagous in the situation of non-application of insecticides is registered in all three experimental years and for both agroecosystems.

The application of the treatments also causes disturbances in the entomophagous common to the two biocenoses, this is reflected in the differentiated values of the Jaccard coefficient from the two variants, In all three experimental years, the Jaccard coefficient has considerably higher values in the untreated version compared to the treated version.

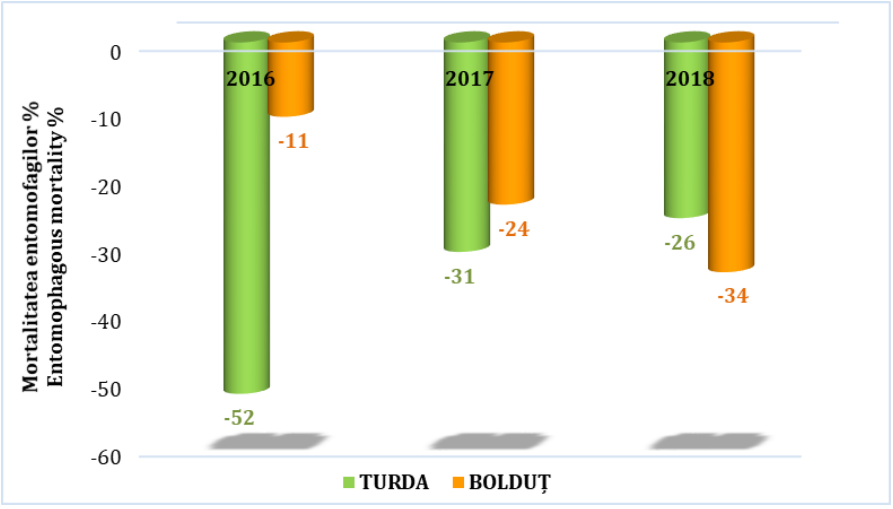

Fig. 2. Mortality rate of entomophagous in the two agroecosystems

During the three years and in both agroecosystems, the application of the two treatments in the two phenophases of wheat (cul elongation and in the booting phenophase), reduces the number of entomophagous by an average of about 36%. In the conditions of the agroecosystem from Turda, entomophagous mortality is more

pronounced in two of the three years, with 41% in 2016 and 7% in 2017. Therefore, the most pronounced gap regarding the effect of treatments on useful arthropods in the two agroecosystems is recorded in 2016. The atypical climatic conditions of 2016 (the rainiest year in the last 59) possibly contributed to the rapid restoration of the biological reserve of entomophagous, recovery which was enhanced by the fact that the agroecosystem from Bolduț ensures a high degree of conservative protection. Therefore, climatic conditions and the type of agroecosystem interacting with the application of insecticide treatments, have an important impact in increasing or decreasing the mortality rate of entomophagous, as shown by figure 2.

1.2. Assessment of phytophagous diversity in the two agroecosystems

The variations of the number of phytophagous captured, and the parameters of diversity in the conditions in which the main limiting factor of the populations represented by the insecticide was abandoned, show remarkable oscillations in both the years and the biocenoses. The results of the annual collections show the ascending evolution of pest populations from one year to another, in both biocenoses.

If we refer to the total number of individuals, in both agroegosystems, the evolution of the population dynamics of phytophagous is increasing from one year to the next, the most sudden increase being in 2018 and especially in the Bolduț biocenosis. The large increase in this year is probably due to the increase of the average daily temperatures during the winter but also to the increasing evolution of the multiannual temperatures in the last years. In this context, monitoring pest populations and determining when to reach economic damage thresholds (EDT), for performing treatments, become essential components in limiting the decrease of yield quantity.

1.3. The influence of agroecosystems in the realization of autumn wheat productions

The biology of wheat crop formation is in close interdependence with climatic conditions, therefore, the year factor has a major involvement in the quantitative and qualitative formation of wheat crops. In this sense it can be seen that out of the three years studied, only 2017 was very favorable for the production potential of the Andrada variety. Thus, this year the production increases were very significant compared to the average of the three years. The most unfavorable year was 2018, when production was about 10% below average, with very significant negative differences (table 3).

Among the technological factors, crop protection against pests resulted in an average increase of about 10% representing around 781 kg / ha, compared to non-application of insecticides during the growing season (table 3).

There were no quantitative differences between the two agroecosystems, however, a slight increase in production can be observed in the case of the agroecosystem from Turda by about 1% compared to the control represented by the average of the two locations (table 3).

Table 3

The influence of experimental factors years, treatment and agroecosystems in the formation of wheat production

Nr. crt	Anul Year	Producția (kg/ha) Yield (kg/ha)	%	Diferența Diferences	Semnificații Significance
1.	Media (Mt.)/Mean (control)	7854	100,0	0.00	Mt.
2.	2016	7744	98,6	-109,94	-
3.	2017	8717	111,0	862,72	***
4.	2018	7101	90,4	-752,78	000
	DL (p 5%) DL (p 1%) DL (p 0,1%)			194,86 322,44 603,52	
1.	Tratat (Mt.)/Treated (control)	8244	100,0	0,00	Mt.
2.	Netratat/Untreated	7464	90,5	-780,78	000
	DL (p 5%) DL (p 1%) DL (p 0,1%)			216,30 327,55 526,19	
1.	Media (Mt.)/Mean (control)	7854	100,0	0,00	Mt.
2.	Turda	7935	101,0	80,56	-
3.	Bolduț	7773	99,0	-80,56	-
	DL (p 5%) DL (p 1%) DL (p 0,1%)			164,07 230,29 325,12	

The verage wheat yields obtained in both locations, both treated and untreated, were quite close, 7935 kg/ha in Turda, and 7774 in Bolduț, the differences between them being only 161 kg/ha. From the data presented in table 4, the considerable influence of climatic factors on the formation of wheat production can be deduced. The year 2017 showed a positive interaction on the productions, the differences from the control being distinctly positive in both variants in Turda. In Bolduț, the highest productions were also obtained in 2017, the differences in production compared to the control being ensured statistically at distinctly significant thresholds. The lowest productions were obtained in 2018 in Bolduț, the differences from the control in both variants being very significant negative.

Table 4

Influence of triple interaction (year x treatment x agroecosystem) in the formation of wheat production

Netratat Turda/Untreated Turda			**Tratat Turda/Treated Turda**		
Anul/Year	Producția/Yield	Diferența/ Diferences	Anul/Year	Producția/Yield	Diferența/ Diferences
Media (mt)/ Mean (control)	7596,11	0,00	Media (mt)/ Mean (control	8272,89	0,00
2016	6605,67	-990,44^{00}	2016	7485,00	-787,89^{00}
2017	8416,33	820,22**	2017	9122,00	849,11**
2018	7766,33	170,22	2018	8211,67	-61,22
Netratat Bolduț/Untreated Bolduț			**Tratat Bolduț/Treated Bolduț**		
Media (mt)/ Mean (control)	7331,00	0,00	Media (mt)/ Mean (control)	8215,78	0,00
2016	7687,33	356,33	2016	9198,00	982,22**
2017	8295,67	964,67**	2017	9032,67	816,89**
2018	6010,00	-1321,00^{000}	2018	6416,67	-1799,11^{000}
DL (p 5%) DL (p 1%) DL (p 0,1%)				432,89 643,63 1011,44	

1. Conclusions and Recommendations

2.1. Conclusions on the diversity of useful entomofauna from two cereal-type agroecosystems in the Transylvanian Plateau

Biodiversity parameters (Shanon, Simpson, Equitability and Jaccard), used for the mathematical quantification of species diversity in the two biocenoses, suggests the existence of slightly superior biodiversity in the Bolduț agroecosystem, which recommends the favorability of agroforestry curtains in protecting useful entomofauna.

The most widespread group of entomophagous caught in both agroecosystems is that of spiders, followed by parasites of the Hymenopterae type. The share of spiders in the total entomophagous captured is 46% in Turda and 40% in Bolduț, hymenoptera being present in proportion of 21% in Turda and 31% in Bolduț.

Research has shown that the application of insecticide treatments significantly reduces the population of entomophagous, population that subsequently begins to recover at a pace closely related to the particularities of agrobiocenosis and climate. Chemical treatments applied only to the threat do not irreversibly reduce the population of entomophagous, both in terms of number and diversity.

2.2. Conclusions on the diversity of phytophagous in the two agroecosystems

Fluctuation of wheat crop pests in the two locations in non-insecticide variants, shows pronounced interspecific variability with wide fluctuations between maximum and minimum values. The most present harmful insects in the conditions of Turda are part of the Hemiptera type (36%), followed by the Diptera type (32%).

In the conditions from Bolduţ, the same structure regarding the dominance of pests is kept, hemipterele predominate in a very high percentage (61%), followed by diptere (17%).

Pest monitoring has shown that in certain years, their populations can grow causing significant crop losses or in special cases can plague wheat crops.

2.3. Conclusions on the monitoring of useful entomofauna in two agroecosystems in the Transylvanian Plain

By the threading method, from the untreated variant, in 2016, 197 arthropods useful in the agroecosystem from Turda and 297 from Bolduţ were collected. In 2017 the number of entomophagous collected in Turda was 462, and 691 in Bolduţ. In 2018, 730 individuals were captured in Turda and 1338 in Bolduţ, this year being registered the most pronounced differences, with a considerable increase of 608 individuals in favor of the agroecosystem from Bolduţ.

In the variant treated with insecticides at the two moments of application, the number of entomophagous captured is lower. In 2016, 94 individuals were collected in Turda and 264 in Bolduţ. In 2017 the number of useful arthropods collected in Turda was 318, and 525 in Bolduţ, and in 2018, 543 individuals were captured in Turda and 885 in Bolduţ.

Significant numerical differentiation of useful arthropods from one year to another within the same agroecosystem (both untreated and untreated), reflects the active role of the environment in restoring the number of useful arthropods. This shows that annual monitoring of entomophagous populations is of major importance in making the most relevant decisions on integrated pest management.

2.4. Conclusions on the role of agroecosystems in the formation of wheat production and quality indices

The average wheat production in the three years was not significantly influenced by the two agroecosystems due to the similarity of the climatic conditions in the two locations.

If the locations did not eloquently affect wheat production, the calendar years had a remarkable impact on it.

In both locations, the application of protective treatments resulted in an average increase of 780 kg / ha.

The protein content is an important qualitative parameter of wheat, being influenced in a decisive way by the agroecosystem and the annual climatic conditions. Insecticide treatments do not make a significant contribution to fluctuations in protein content.

Gluten being in a direct relationship with the protein shows a significant variation depending on the agroecosystem and annual conditions. Pest protection treatments do not significantly affect this important quality component.

2.5. Recommendation

The farm with agroforestry curtains from Bolduț is a model farm that was initially established to prevent soil degradation by erosion.

The implementation of measures for sustainable agriculture must also include crop protection issues. The research carried out for the elaboration of this doctoral thesis highlighted the multitude of phytophagous but also of the entomophagous present in the wheat culture from the Transylvanian Plateau.

Based on the results obtained, we can recommend that the application of insecticide treatments to wheat be carried out only when the economic damage threshold is exceeded.

The application of a single warning treatment at the same time as the herbicide can ensure, depending on the climatic conditions, the necessary protection for the wheat crop. The use of environmentally friendly products can also significantly reduce the impact on entomophagous populations present in wheat cultivation at the time of treatment.

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