Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 18, Issue 1, 2018
PRINT ISSN 2284-7995, E-ISSN 2285-3952

IDENTIFICATION AND MONITORING OF USEFUL ENTHOMOPHAGOUS ARTHROPODS FAUNA FROM THE WINTER WHEAT CROP IN TWO AGROECOSISTEMS FROM THE CENTER OF TRANSYLVANIA

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Abstract

Increase agricultural output is conditioned by a number of factors, among which the protection of plants against pests plays a very important role. Along with chemical methods, methods of biological and integrated control against harmful organisms in crops have recently taken on a large scale, and one of these methods is the use of entomophages (predators and parasites). In order to identify and monitor species of entomophagous arthropods from the winter wheat culture, in the years 2016, 2017, an experiment was carried out in two locations in the center of Transylvania, namely in Turda in open field agroecosystem and in Bolduţ, in agroecosystem with protective agroforestry curtains. The field results were calculated and interpreted using ecological indices (abundance, dominance, constancy, and W ecology significance index). In addition to the monitoring of the entomophages, production and some of its components were determined. Entomophagous arthropods identified in the two agroecosystems differ only in ecological indicators, belonging to the same groups of entomophagous. The positive role of the agroforestry curtains in Bolduţ reflected both on the abundance of entomophages and wheat production, obtaind an 8% production increase compared to the production made in the unprotected system in Turda.

Key words: *agroforestry curtains, ecological indices, enthomophagous, wheat culture*

INTRODUCTION

Entomophagous arthropods from wheat crops are represented by many species, having a great peculiarity for different pests, developing as a result of numerical growth of the host (the pest) and favorable conditions in agroecosystems [1,9].

Entomophagous show some remarkable particulars, including the high abundance of populations, many species present in different agroecosystems being recorded. Each pest is associated with several predatory or parasitic species that are capable of immediately or slowly destroying the various stages of its development: egg, larva, stern, or adult [15].

Maintaining biological balance of the agronomical ecosystem, play an important role in the presence and activity of entomophagus species, especially that of the predatory insects [13,19].

The entomophagous moves in a biotope for many reasons: food, reproduction, avoiding the enemies, or for better conditions of life. All these moments have a deep influence on the surviving and the reproduction rate [20,21].

In any kind of agroecosystem, with the number of pests that cause damage, certain organisms install themselves and are designed to limit the destructive action of pests. Among these, predator and parasitoid insects have a relevant importance in protection of plants and environment. Together they form the socalled auxiliary entomofauna [17].

Pesticide spraying is the main method of integrated pest control [5]. However, after repeated appli-cations and increasingly higher rates of pesticide usage for a protracted period more than 500 species of pests have now developed resistance to pesticides, leading to increasing crop losses. For example,in the USA, farmers lost 7 % of their crops to pests in the 1940's, while since the1980's, the percentage lost has increased to 13 %, even though more pesticides are being used [3].

Under the conditions of warming and aridization of current climate change, the agricultural system with forest curtains is an ecotechnology with an important effect for the anti-erosion protection and sustainable development of agriculture in the center of Transylvania. Agroforestry protection curtains have a special role in the bioremediation of damaged agricultural land and also in organic farming [6,8,11].

The diversified systems and crops bordered with different vegetation (other crop fields, weeds and forests) recorded more entomophagous predators than monocrops and crops adjacent to vegetation-free fields. Agroforestry systems may have higher potential to reduce pests because of greater diversity among the entomophagous species than mixed annual crop systems [2,7,10].

Sustainable development of agriculture, based on long-term research on crop yield factors, on biodiversity, environmental protection and use of natural resources, has been an important objective for the research institutes in Romania [12,14].

MATERIALS AND METHODS

Considering the importance of protecting entomophages, in 2016-2017 period, their evolution was followed in an experience in two types of agroecosystems in the center of Transylvania, namely Turda and Bolduţ.

In addition to the land and experimental fields it owns, the Agricultural Research and Development Station Turda manages a field crop farm located in Bolduţ arranged in anti-erosion system with agroforestry protection curtains. Located at about 15 km from Turda, Bolduţ's farm comprises 323 hectares of agricultural land, grown in small lots (10-25 ha) , framed by a 32 ha agroforestry curtain network, which include about 36 arboreal and arbustic species planted in the years 1951-1953 [4,16].

The two locations are different in the first place from the point of view of the organization of the land, because at Turda the lots are large (100-200 ha), placed under open field conditions and are protected by acacia strips having a reduced width, located at a quite large distances between them, on the main access roads.

The main objectives of the paper were to identify and monitor the evolution of the entomophagous species from the winter wheat culture, to analyze the insect populations by calculating some ecological indices, but also to determine the production in the two agroecosystems.

The experience has been structured in two variants with large areas of about 1,5 ha in both locations in which all the integrated technological and phytosanitary recommendations have been applied such as insecticides and fungicides seed treatment, treatments with herbicides, fungicides and foliar fertilizers. Variant (V1) was untreated with insecticides, and variant (V2) was treated with insecticides in two phenophases: at the end of the tillering with Biscaya 100 ml/ha (s.a. tiacloprid), and in the booting phenophase with Fastac 100 ml/ha (s.a. alfa-cypermethrin). The biological material used for this purpose was the wheat cultivator Andrada, SCDA Turda, one of the most cultivated varieties in the area. The entomophagous collection was performed decadally using entomological net, 100 double sweep-nets for each sample. The filleting began in the first decade of April and continued until the physiological maturity of the wheat. Applied culture technology was the one specific to seed production with strict observance of a three-year rotation.

According to [16], field results were calculated and interpreted using different ecological parameters: abundance (A), dominance (D), constancy (C) and ecological significance index (W).

Abundance (A) is the total of individuals of a species in the catch from a certain place on a given date. Based on the value of this indicator, the other indicators are calculated.

Dominance (D) shows the percentage of participation of each species in the catch. Explains the relationship of a species with the sum of the individuals of the other associated species. This indicator is calculated according to the formula:

$$D_A = \frac{N_A x\ 100}{N_1}$$

N_A = total number of individuals of species A;
N_1 = the total number of individuals of all species collected.

Dominance classes include species whose percentage of spread falls within the next values:

D_1 – subrecedente species (<1.1%);
D_2 – recedente species (1.2 – 2.0%);
D_3 – subdominant species (2.1 – 5.0%);
D_4 – dominant species (5.1 – 10.0%);
D_5 – eudominant species (>101%).

Constancy (C) expresses the continuity of the occurrence of a species in the analyzed biotope. This characteristic is a structural indicator because it shows the proportion of participation of a species in the biocenosis structure. The higher the value of the indicator, the more the species is better adapted to the conditions offered by the biotope.

Constancy is calculated according to the mathematical formula:

$$C_A = \frac{n_p A}{N_P} x100$$

C_A – the constancy of species A;
$n_P A$ – the number of samples in which the species A is present;
N_P – total number of investigated samples.

Depending on the value of this indicator, the species is distributed in the following classes:

C_1 – accidental species (1 – 25%);
C_2 – accessory species (25.1 – 50%);
C_3 – constant species (50.1 – 75%);
C_4 – euconstant species (75.1 – 100%).

Ecological significance index (W) is the relationship between structural indicator (C) and the productive (D). The ecological significance index is calculated according to the formula:

$$W_A = \frac{C_A x D_A x100}{10{,}000}$$

W_A = the ecological significance of species A.
C_A = constancy of species A;
D_A = dominance of species A.

Depending on the values obtained, species are divided into the following classes:

W_1 – (<0.1%);
W_2 – (0.1 – 1.0%);
W_3 – (1.1 – 5.0%);
W_4 – (5,1 – 10.0%);
W_5 – (>10.0%).

Class W1 corresponds to accidental species, classes W2 and W3 of accessory species and classes W4 and W5 correspond to species characteristic for the given cenosis.

RESULTS AND DISCUSSIONS

The questionnaires on organic products consumption have been applied to a number of 488 respondents.

In both agroecosystems the same groups of entomophagous were identified, they differ only in terms of the environmental indicators (Tables 1 and 2).

Both in Turda and Bolduț the most abundant entomophagous are represented by the *Aranea* group, the oscillation of abundance between the two localities being accentuated. Another category well represented in the two areas is represented by parasite entomophagous, namely *Hymenoptera*. In this group the oscillation of abundance is much lower (compared to *Aranea*), so at Bolduţ the average abundance is 62, while in Turda it is slightly lower than only 43. Another well represented family and favorably influenced by the agroforestry curtains from Bolduţ is *Cantharidae*, the value of abundance being 54. In Turda agroecosystems, the species in this family have a much lower presence. *Nabidaele* find better development conditions at Turda, the abundance of 32 compared to Bolduț, where their abundance decreases considerably reaching only the value of 9 individuals. Between other groups of entomophagous there is a fairly stable equilibrium between the two biotopes with growth or decrease tendencies in the two locations.

The eudominant species of the two agroecosystems are obviously spiders, followed by parasites. Another eudominant family but only in the system protected by the agroforestry curtains of Bolduţ is *Cantharidae*. In the unprotected Turda system, ants are also eudominant. Among the dominant species that have been identified are *Nabidae* and *Empididae* in Turda, and in Boltuţ *Syrphidae*. Other entomophagous are less well represented and represent only subdominant species (D3), recedent species (D2) or subrecedent species (D1). The euconstant species in both locations are represented by the group of spiders (C4). Although the parasites are more abundant in Bolduţ, the highest constancy is in Turda, classifying as euconstant species in this location. The species belonging to the *Cantharidae* family are classified as constant species (C3) in both localities. In Turda agroecosystem, another family belonging to class C3 is *Empididae*, and in the system with agroforestry curtains from Bolduţ the constant species are those of the *Syrphidae* family. Other groups of entomophagous have a lower constancy in both areas being accidental species (C1) or accessories (C2).

Table 1. Ecological parameter analysis of the species collected in the wheat culture, in untreated variant at Turda from 2016-2017 period (average)

Crt. No.	Entomophagous	A	D		C		W	
			%	Class	%	Class	%	Class
1	*Coccinellidae*	13.5	4.07	D3	45.71	C2	1.86	W3
2	*Cantharidae*	16.5	4.98	D3	53.57	C3	2.67	W3
3	*Malachiidae*	6	1.81	D2	36.43	C2	0.66	W2
4	*Nabidae*	32	9.65	D4	46.43	C2	4.48	W3
5	*Staphylinidae*	2.5	0.75	D1	17.14	C1	0.13	W2
6	*Chrysopidae*	6.5	1.96	D2	41.43	C2	0.81	W2
7	*Syrphidae*	14	4.22	D3	38.57	C2	1.63	W3
8	*Empididae*	28	8.45	D4	53.57	C3	4.52	W3
9	*Hymenoptere* parasitic	43	12.97	D5	80.71	C4	10.47	W5
10	*Formicidae*	39.5	11.92	D5	22.14	C2	2.64	W3
11	*Aranea*	130	39.22	D5	95.00	C4	37.25	W5

Source: Own results.

Table 2. Ecological parameter analysis of the species collected in the wheat culture, in untreated variant at Bolduț from 2016-2017 period (average)

Crt. No.	Entomophagous	A	D		C		W	
			%	Class	%	Class	%	Class
1	*Coccinellidae*	11	2.66	D3	35.71	C2	0.95	W2
2	*Cantharidae*	54	13.06	D5	64.29	C3	8.40	W4
3	*Malachiidae*	1	0.24	D1	14.29	C1	0.03	W1
4	*Nabidae*	9	2.18	D3	42.86	C2	0.93	W2
5	*Staphylinidae*	8	1.93	D2	28.57	C2	0.55	W2
6	*Chrysopidae*	9.5	2.30	D3	42.86	C2	0.98	W2
7	*Syrphidae*	37	8.95	D4	57.14	C3	5.11	W4
8	*Empididae*	20.5	4.96	D3	42.86	C2	2.12	W3
9	*Hymenoptere* parasitic	62	14.99	D5	50.00	C2	7.50	W4
10	*Formicidae*	11	2.66	D3	35.71	C2	0.95	W2
11	*Aranea*	190.5	46.07	D5	85.71	C4	39.49	W5

Source: Own results.

According to the classification of ecological index W, in both areas, spiders are those that correspond to characteristic species along with the parasitic *Hymenoptera*. In Bolduț, families are also classified as characteristic species is *Syrphidae* and *Cantharidae*. The other groups of enthomophagous qualify as accidental and accessories species (Table 1 and 2).

In addition, to the monitoring of entomophagous, some components of wheat production have been determined, but we will only present the role of agroecosystem, year, and insecticide treatments in production formation.

Of the three experimental factors represented by agroecosystem, treatment and year, the biggest role in harvesting is the year factor followed by treatment. All this is reflected in the value s^2 (Table 3).

Moreover, the "F" test is statistically assured for these two factors as being very significant.

An important contribution in the formation and realization of the productions is also the agroecosystem factor, but with a lower involvement, the value of the "F" sample being for this factor only significant. Reducing the involvement of the agroecosystem in production control is due to the fact that the two localities are located at a relatively close distance (about 15 km).

It can be said that there are no obvious differences between the two localities of the climatic factor.

Among the interactions, the most significant participation in the wheat production fluctuation is evident between the agroecosystem and the year (s^2 = 3.39), the value of the "F" test being very significant.

The positive role of Bolduţ agroforestry curtains extends to the production of wheat by an increase of 8% compared to the average production in Turda unprotected system (Table 4).

Table 3**.** The variance of the wheat production in the two types of agroecosystems (Turda and Bolduț, 2016, 2017)

No. crt.	Source of variance	SPA	GL	s^2	F Test
1.	Total	18.74	21		
2.	Agroecosystem (Ag)	2.51	1	2.51	80.17^{*}
3.	Treatment (T)	5.51	1	5.51	71.01^{***}
4.	AgxT	0.16	1	0.16	2.12^{ns}
5.	Year (Y)	5.68	1	5.68	68.95^{***}
6.	AgxY	3.39	1	3.39	41.12^{***}
7.	TxY	0.34	1	0.34	4.08^{ns}
8.	AgxTxY	0.14	1	0.14	1.64^{ns}
9.	Error Ag	0.06	2	0.03	
10.	Error T	0.31	4	0.08	
11.	Error A	0.66	8	0.08	

Source: Own results.

A microclimate with is created around the agroforestry curtains which is conducive to agricultural crops and it is also created conditions favorable to the development and efficient activity of auxiliary entomophages.

Application of the treatment increases yields of 12% (960 kg/ha) over the control untreated with insecticides (Table 4). Therefore, we can say that this production increase leads to a considerable profit.

However, we still need to make efforts to implement crop protection measures that have the least impact on agroecosystems, on auxiliary entomophages and ultimately the environment.

Of course, the year factor has the largest contribution to crop production, of the two experimental years in 2017 in both locations and in both variants (treated, untreated) the production increase was very significant, about 500 kg compared to the control (average years) (Table 4).

The role of agroforestry curtains from Bolduţ also derives from the data presented in Table 5. Average production of Andrada variety made in Bolduţ is 8.55 t/ha, superior to Turda of only 7.91. Also, the fluctuation of production from one year to another is much lower in Bolduţ (between the two years there are no statistically insured differentials) compared to the one from Turda (in 2017 cultivar Andrada registers very significant increases). Therefore, we can say that agroforestry curtains also play an important role in stabilizing the productions by reducing the oscillations of the annual values.

Table 4. Influence of factors: type of agroecosystem, insecticide treatments and year in production formation, to the Andrada variety

No. crt.	The type of agroecosystem	Yield t/ha	The relative value	The difference	Significance
1.	Turda	7.91	100.0	0.00	Mt.
2.	Bolduț	8.55	108.2	0.65	*
	DL (p 5%)	0.31			
	DL (p 1%)	0.72			
	DL (p 0.1%)	2.28			
No. crt.	Treatments with insecticides	Yield t/ha	The relative value	The difference	Significance
1.	Untreated	7.75	100.0	0.00	Mt.
2.	Treated	8.71	112.4	0.96	**
	DL (p 5%)	0.32			
	DL (p 1%)	0.52			
	DL (p 0.1%)	0.98			
No. crt.	Year	Yield t/ha	The relative value	The difference	Significance
1.	Average	8.23	100.0	0.00	Mt.
2.	2016	7.74	94.1	-0.49	00
3.	2017	8.72	105.9	0.49	**
	DL (p 5%)	0.27			
	DL (p 1%)	0.39			
	DL (p 0.1%)	0.59			

Source: Own results.

Table 5. The influence of double interaction (year x agroecosystem) in the formation of wheat production

No. crt.	**Variant**	**Yeld t/ha**	**The relative value**	**The difference**	**Significance**
1.	Turda average	7.91	100.0	0.00	Mt.
2.	Turda 2016	7.05	89.1	-0.86	000
3.	Turda 2017	8.77	110.9	0.86	***
1.	Bolduț average	8.55	100.0	0.00	Mt.
2.	Bolduț 2016	8.44	98.7	-0.11	-
3.	Bolduț 2017	8.66	101.3	0.11	-
	DL (p 5%)	0.38			
	DL (p 1%)	0.56			
	DL (p 0.1%)	0.83			

Source: Own results.

CONCLUSIONS

In field cereal agroecosystem open from the Turda area, in years 2016 and 2017 the most abundant group of entomophagous is represented by *Aranea*.

Organizing and arranging farmland with agroforestry protection curtains is an important means of the protection of fauna arthropod entomophagous and for the stability of productions one year to another.

Integrated protection of wheat crops against phytophagus is an important means of increasing production.

Application of insecticide treatments should be based on abundance of phytophagus in relation to the activity of natural fond of entomophagous in crops, at optimum times of application and only on warning within the integrated combat system. This is an important measure to reduce the impact of insecticides on the environment and useful entomofauna.

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