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Benefits of Agroforestry Shelterbelts on Useful Arthropod Fauna from Wheat Culture in the Climate Change Context

VĂLEAN Ana Maria[1], Ioana CRIȘAN[1]*, Laura ȘOPTEREAN[1], Adina TĂRĂU[1], Loredana SUCIU[1,2]*, Felicia CHEȚAN[1], Emanuela FILIP[1], Adrian NEGREA[1]

[1]Agricultural Research and Development Station Turda, 27 Agriculturii St., 401100, Turda, Romania
[2]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Agriculture, 3-5 Mănăștur St., 400372 Cluj-Napoca, Romania
* Corresponding author e-mail: ioana.crisan@scdaturda.ro

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Abstract

Climate is the main factor in determining the yield of agricultural crops, and in the last decade research on climate change has intensified. The specialists in the field of agricultural research but also among farmers have see a solution in agroforestry or protective agroforestry belts, which improve microclimatic conditions, the soil is protected from drying and erosion, carbon is sequestered, and biodiversity is created. Besides the many advantages they have, agroforestry shelterbelts have another important role, by providing a suitable habitat for the increase and protection of useful insects. Useful arthropods have an impressive role in biodiversity conservation, due to their ecology and beneficial effect in agriculture, being a good strategy for biological control. The objective of this research is to present the entomophagous species present in wheat culture in an agroecosystem with protective agroforestry shelterbelts fromTransylvania Plain, in the context of climate changes in recent years. The most important species of entomophaous present in wheat culture in the three experimental years belong to the orders Araneae, Coleoptera, Hemiptera, Neuroptera, Diptera, and the most abundant order is that of spiders with a maximum number of 698 captured insects, in 2022.

Keywords: climate change, agroforestry shelterbelts, useful arthropods, wheat.

1. Introduction

Climate change affects the planet on a large scale and represents one of the biggest threats to ecosystems and biodiversity [19]. Recently, there has been discussion about how we can mitigate the negative consequences that climate change has on agricultural crops, changes that have intensified globally, especially through the intensification of drought and aridification.

According to some temperature analyzes carried out by NASA specialists, the effect of global warming has appeared since the 1800s, with the Industrial Revolution. The development of the industry brought a lot of advantages, by increasing the economy and at the same time the people's standard of living, but also some disadvantages because fuels began to be used more and more intensively, and by burning them, the level of gas emissions increased greenhouses, responsible for planet warming [25]. From studies carried out by the same source, it appears that since 1880 the global average temperature has increased by at least 1.1^{0}C. The year 2022 has been declared one of the warmest years, being the fifth warmest year on Earth, since the temperatures are recorded, and in Europe it is in third place [25]. In Romania, according to the National Meteorological Administration, the summer of 2022 was the third warmest in the history of meteorological measurements. The last

three decades (1991-2020), register an increase of 0.5^0C in the level of the average annual air temperature in Romania, compared to the previous period [26].

Climate change is obvious, and the specialists in the field of agricultural research but also among farmers have see a solution in agroforestry or protective agroforestry belts, which improve microclimatic conditions, the soil is protected from drying and erosion, carbon is sequestered, and biodiversity is created, reports the European Agroforestry Federation [27].

Agroforestry, also called wind curtain, represents a long and relatively narrow strip of land, artificially created, planted with different woody species of trees and shrubs, located at a certain distance from an object with the aim of protecting it from the harmful action of unfavorable climatic factors: erosion, evaporation, strong winds, blizzards, waves of overflowing water or other harmful factors [2, 12, 20]. On the world level, agroforestry has been created since 1767, between two cities in Russia, being among the first works of this kind [23].

Romania was among the first countries to raise the issue of developing protective agroforestry belts [16]. In our country, the first forest curtains were created in 1870, called "windbreaks", also used to combat drought [5].

Studies carried out over time confirm the benefits of installing protective agroforestry belts for agricultural culture [8]. First of all, they improve the microclimate by: reducing the amplitude of the air temperature by 1–4 °C of the diurnal temperature and by 1–2 °C of the annual temperature; reducing wind speed by 31-55% in the protected part and by 10-15% in the exposed part; snow retention; reducing evapotranspiration; increasing air humidity at the soil surface by 3–5% [1]. In a study conducted in China, the author reported that desertification makes the land totally unsuitable for culture, and planting trees stops or slows down the spread of the desert [7]. Shelterbelts have a very important role, not only by reducing the wind speed, but also by the fact that they capture the soil transported by it, preventing wind erosion [8]. Agroforestry shelterbelts greatly improve the structure of the soil, by draining it with the root systems [7]. It also contributes to increasing soil fertility and conservation conditions; stopping erosion and water leaks on the slopes; enriching the soil in humus and other nutrients and changing its pH due to the surplus of organic matter from leaves and roots [4].

Among the multiple advantages that shelterbelts have, also includes mitigating thermal extremes during the summer, due to shading and evapotranspiration, manifesting a cooling effect on both the air and the soil, reducing the effects of drought [17].

In a study carried out in Ukraine, it was found that on fields without shelterbelts the loss of winter wheat yield due to drought was 68%, while on fields where shelterbelts occupied 3-4% of the area, yield losses were halved [8]. Growing conditions for agriculture cultures are improved in protected areas due to the higher soil moisture, the diurnal and nighttime temperature variation is lower, and the relative air humidity and carbon dioxide level at night are higher [17]. Another important role of agroforestry shelterbelts is the increase and protecting the activity of the natural fund of entomophagous species. In any type of agroecosystem, with the number of pests causing damage, certain organisms is installing and can limit the destructive action of pests, and among these, predatory and parasitoid insects have a relevant importance in the protection of plants and the environment together forming the so-called auxiliary entomofauna [18].

Agroforestry shelterbelts ensure the protection of useful insects by providing a suitable habitat for their development [11]. Following a study on entomophagous, carried out in 1991-1992, it was observed that in the structure of the collected arthropod fauna, enthomophagous species had a share of 31% in the agroecosystem with shelterbelts, while in open field agroecosystem the share of useful arthropod fauna was only 24% [11]. The same author mentions that in the years 2000-2005, due to warming and aridification, the share of entomophagous reached 78% in the structure of the agroecosystem with shelterbelts, and on the open fields, without shelterbelts, it was only 33%.

Useful arthropods have an impressive role in biodiversity conservation, due to their ecology and beneficial effect in agriculture, health and human hygiene, but also due to their diversity. Eliminating these insects leads to biodiversity destruction and at the same time to the elimination of the livelihood base of many communities [21, 14].

In the face of the ecological disturbances observed, the best strategy for sustainable agriculture is biological control because it has economic and ecological advantages [6]. In this paper, we aimed to present the evolution of some groups of active entomophageous, present in the cereal crops of in an agroecosystem with agroforestry shelterbelts (Boldut farm), from the area of Agricultural Research and Development Station Turda (ARDS Turda), in the context of climate changes in recent years.

Research on the importance of entomophagous species in limiting phytophagous populations present in wheat culture has been carried out at ARDS Turda since 1990 (Fig. 1). The main groups of entomophagous active in limiting wheat pests reported in the studied area are part of the Insecta class with the orders: Coleoptera, Hemiptera, Diptera, Hymenoptera, and from the class Class Arachnida with the order Aranea.

Figure 1. Agroforestry system, Bolduț farm - ARDS Turda (original)

2. Material and method

Due to the importance of the useful arthropod fauna in limiting wheat pests, in the years 2017, 2018, 2022, its monitoring was carried out in the winter wheat culture, in an agroecosystem with agroforestry shelterbelts, within the Turda Agricultural Research and Development Station.

The monitoring of entomophagous species was carried out by collecting them using an entomological net, through 100 double sweeps for each sample, starting from the spring months until harvest. Insect species were determined in the laboratory, according to morphological, biological and geographical criteria.

The culture technology applied was specific to seed production, with strict observance of a three-year rotation, in which all integrated technological and phytosanitary recommendations were applied, such as seed treatment with fungicide and vegetation treatments with herbicides, fungicides and insecticides applied in two phenophases (at the end of the tillering and in the phenophase of the appearance of the boot until the emergence of the ear). The biological material used was represented by the Andrada wheat variety, a variety created at the Agricultural Research and Development Station Turda.

3. Results and discussions

Zonal climatic conditions can strongly influence the dynamics of the numerical density of entomophagous populations. Among the climatic factors, the thermal regime plays an essential role as invertebrates are poikilothermic species.Thermall, it can be observed that in all three experimental years, both in the summer and in the autumn months, temperature values above the multiannual average were recorded. And the following months are characterized as warm, especially December, which favored the increase in the number of entomophagous species (Table 1). The water regime shows high fluctuations, but the autumns of the years in which the experiences took place, recorded a generally rainy pluviometric regime, which positively influenced the germination and emergence of wheat plants. Note the year 2022, which was atypical and unfavorable for agricultural crops, at first being very dry, and then excessively dry up to and including July, followed by two excessively rainy months (Table 2). The individuals' number of a species' population, that invades crop fields, is largely determined by the number preparing to overwinter the previous fall and their overwintering survival [9].

Predatory insects from the *Cantharidae* family can be found in the entomofaunistic studies carried out in our country alongside other taxonomic groups [10]. From Fig. 2 it can be observed that among the Coleoptera, the *Cantharidae* family is the most common in all three years of experimentation, with a maximum number of individuals collected in 2017 and a total number of 149 individuals.

Table 1. Thermal regime in years 2017, 2018, 2022, ARDS Turda

Year/Month	Monthly temperature (°C)												Annual average
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2017	-6.7	1.5	8.4	9.9	15.7	20.7	20.3	22.3	15.8	11.6	4.9	1	10.5
2018	0.2	-0.3	3.3	15.3	18.7	19.4	20.4	22.3	16.7	12.7	6	-0.9	11.2
2022	-1.9	2.2	3.6	8.8	16.3	21.1	23.1	22.3	14.3	12.4	5.4	1.6	10.9
65 years	-3.3	-0.6	4.4	10	15	18.1	19.8	19.5	15.2	9.8	4	-1.2	9.2

Table 2. The rainfall regime in years 2017, 2018, 2022, ARDS Turda

Year/Month	Monthly Rainfall (mm)												Annual sum
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2017	2.6	19.2	46.1	65.2	65.4	30.6	110.2	36.1	56.2	49.2	30.8	20.7	532.3
2018	16.7	33.4	40.9	26.2	56.8	98.3	85.7	38.2	29.8	26.8	29.6	58.3	540.7
2022	10.9	5.4	8.3	42.5	82.9	41.8	25.2	94.6	119.9	16.3	43	23.6	514.4
65 years	21.7	19.2	24.3	45.6	69.4	84.6	78.0	56.1	42.4	35.4	28.2	27.6	532.5

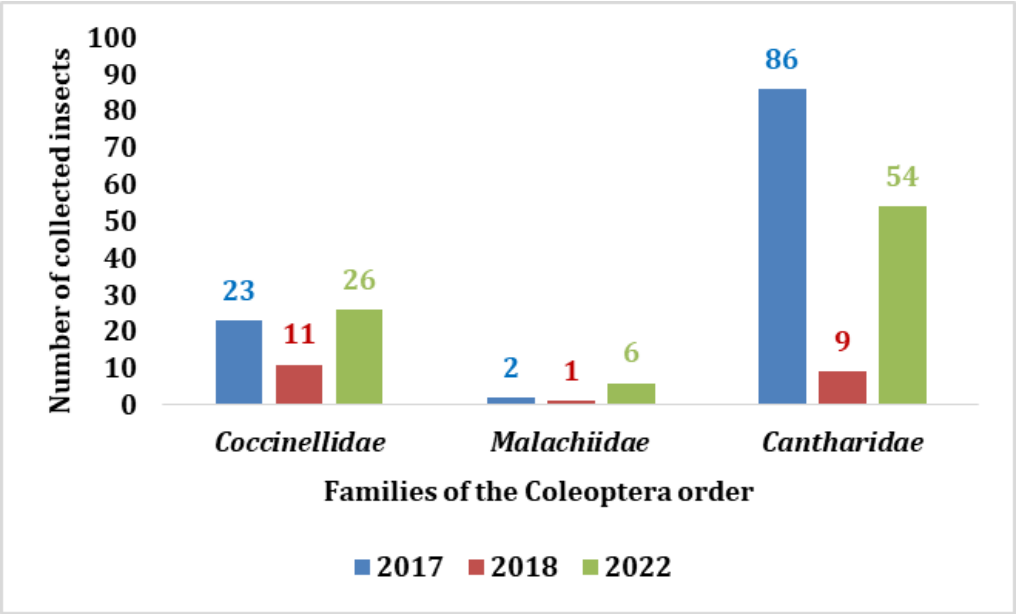

Figure 2. Evolution of species captured from the Coleoptera order, in the years 2017, 2018, 2022

The second place is represented by the *Coccinelidae* family, with a representation of 60 individuals in the three years analysed. Coccinellids are the most numerous species of arthropods, found in all agricultural crops throughout the vegetation period [24]. Among the *Coccinelidae*, the most common species in the ARDS Turda area is *Coccinella 7-punctata*. This species is also of particular importance to China's Integrated Pest Management programs [3]. Nabis genus includes a large number of species that feed on aphids, dipteran larvae or thrips larvae [11]. Considering the influence of changes temperature on insects, including useful arthropods, from Fig. 3 we can observe that although the *Nabis ferus* species was not present in significant numbers, compared to 2017 it doubled its number.

Therefore, the contribution of the environment in the appearance of species from the Hemiptera order in the wheat crops of central Transylvania is obvious. The other useful species identified in the Hemiptera order can be said to

appear sporadically, being reported only in 2018 and 2022.

From Neuroptera order, the species *Chrysopa carnea* had a fairly constant presence in 2017 and 2018 in the wheat culture from the agroecosystem with shelterbelts from Boldut, but in 2022 the number of this species increased, probably due to the incrising temperatures (Fig. 4). The structure and size of the populations of different syrphid species depend on the analyzed ecosystem and also on the analyzed period [22]. Predators from the *Syrphidae* family are also present in the studied area, with a fairly high abundance.

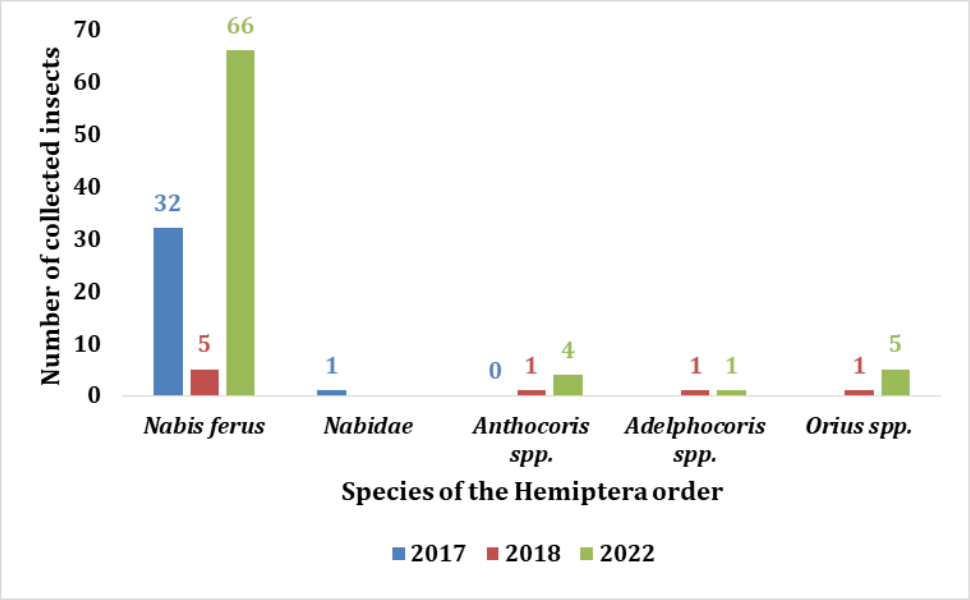

Figure 3. Evolution of species captured from the Hemiptera order, in the years 2017, 2018, 2022

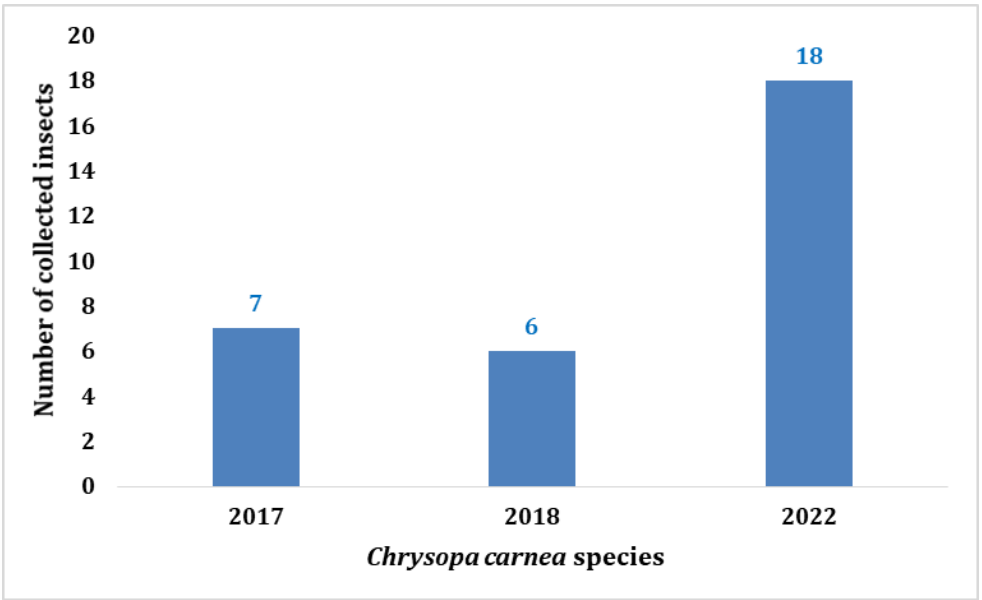

Figure 4. Evolution of species captured from the Neuroptera order, in the years 2017, 2018, 2022

About the Platypalpus genus within the entomophagous diptera, it can be said that in the specific conditions of the Bolduţ agroecosystem, they are the most predominant, but with wide variations from year to year. The maximum values for individuals of this genus were recorded in 2022, with a number of 130 individuals.

In 2017, unidentified species from the Syrphidae family were only sporadically present in the wheat crop from Bolduţ, but in 2022 their

number increased considerably. Again, it is evident that due to rising temperatures and especially mild winters, the number of useful arthropods has increased (Fig. 5).

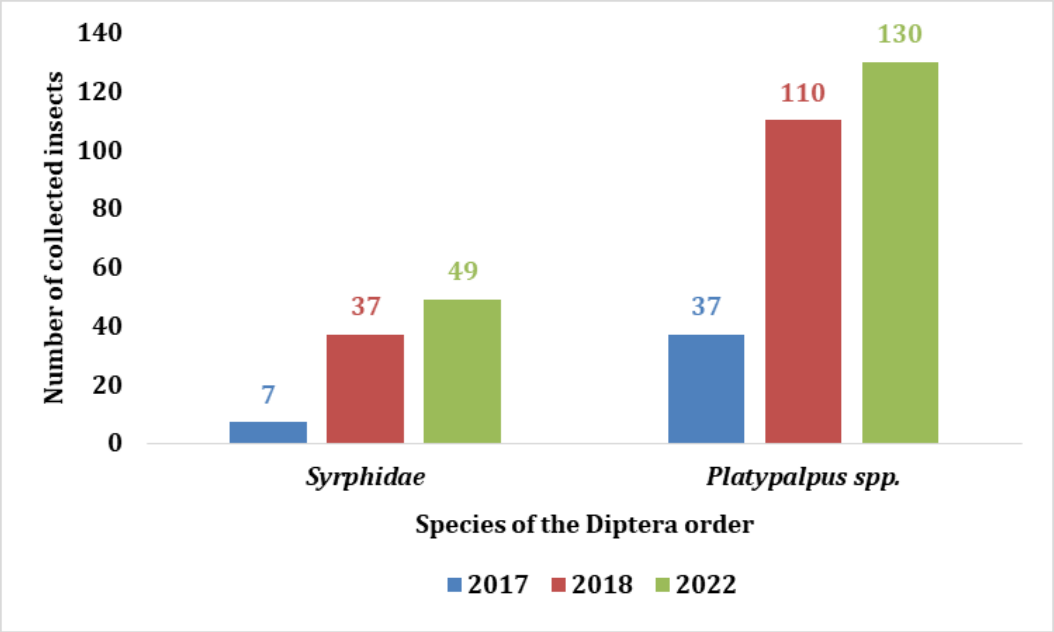

Figure 5. Evolution of species captured from the Diptera order, in the years 2017, 2018, 2022

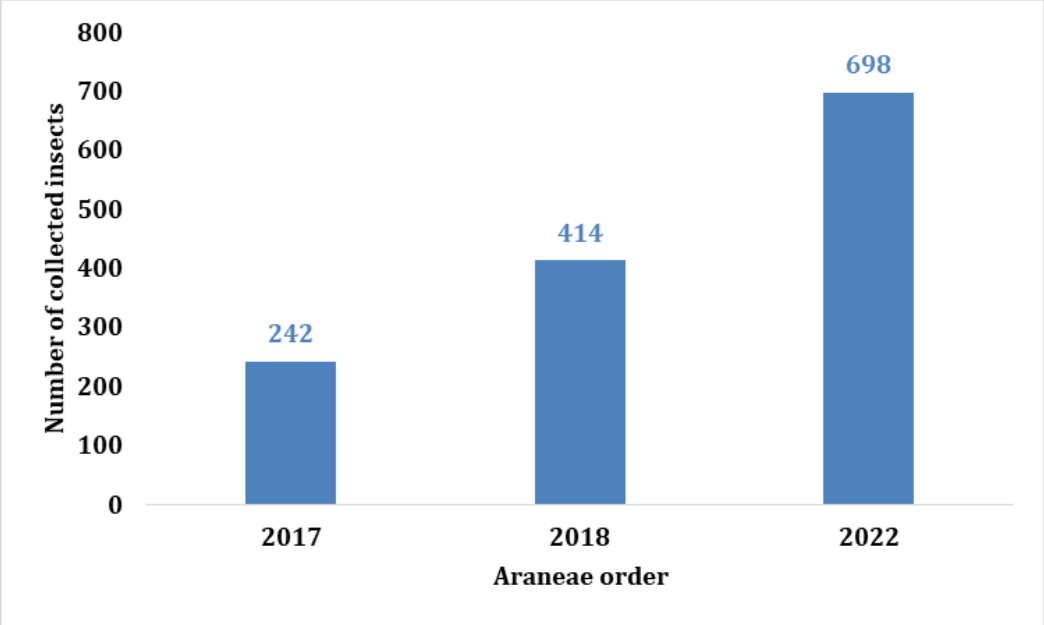

Figure 6. Evolution of species captured from the Araneae order, in the years 2017, 2018, 2022

Predatory arthropods include spiders, which can have a significant impact on insect pests of agricultural crops [15].

Among predatory insects, spiders are the most remarkable group because, with few exceptions, the vast majority are carnivores, feeding primarily on insects [13], but in many cases the application of insecticides has led to both a decrease in abundance and diversity.

From Fig. 6 we can observe that also in the wheat culture from Bolduț agroecosystem, the order Araneae recorded the highest values, with a maximum of 698 individuals for the year 2022.

4. Conclusions

Incrising average annual temperatures, the mild winters and low rainfall in late spring and early summer have led to increased enthomophagous abundance in the wheat crop.

The important numerical differentiation of useful arthropods from one year to another within the same agroecosystem, reflects the active role of the environment in restoring the number of useful arthropods so that the annual monitoring of entomophagous populations acquires a major importance in making the most pertinent decisions regarding the integrated management of pest control.

The most widespread group of entomophagous captured in agrobiocenosis with agroforestry shelterbelts is the order Araneae followed by the order Diptera

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