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DIVERSITY OF PREDATORY CARABID SPECIES (*Coleoptera*, *Carabidae*) FROM CORN CROPS IN NORTHEAST ROMANIA

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Abstract

This research was carried out in 2020-2022, from May to September in each year. The entomological material that is the object of this study was collected from three corn agroecosystems located in three stationary from Iasi County, Romania: Ezăreni, Trifeşti, and Schitu Duca. To achieve the objectives of the research, four variants were used: V1, superficial tillage in the spring and untreated seeds; V2, deep tillage during autumn plowing and untreated seeds; V3, superficial tillage in the spring and treated seeds; and V4, deep tillage during autumn plowing and treated seeds. Biodiversity characterization indexes, namely the biodiversity index, the Shannon diversity index, equity, and the Simpson diversity index, were used to quantify biodiversity in the habitats. Data analysis and interpretation were carried out with the help of the BIODIV application to calculate the main biodiversity indicators. In our opinion, these comparative studies on the Carabidae fauna in relation to current pest control methods are useful in agricultural practice.

***Key words**: carabids, pest control, Shannon index, plowing, biodiversity.*

INTRODUCTION

Among the *Coleoptera* order, one of the most important families is *Carabidae*, which groups almost 400,000 species of insects spread all over the globe (Krell and Schawaller, 2011). As species of variable sizes, carabids have a specific external appearance that makes them easy to distinguish (Ponge et al., 2013). Their body color is dark, often with metallic reflections. Globally, the *Carabidae* family contains 36,472 species and is classified into 34 subfamilies, which in turn include 96 tribes, 129 subtribes, 1,993 genera, 1,467 subgenera, and 7,319 subspecies (Cividanes, 2021).

As predatory insects, carabids play a crucial role among insects, participating in the numerical regulation of harmful insects in natural and anthropogenic coenoses (Virić Gašparić et al., 2017). However, it is impossible to develop new methods of combating harmful insects through biological methods without detailed knowledge of the problems related to the ecology of entomophagous species and without understanding the interspecific relationships in ecosystems (Kulkarni et al., 2015). The need for clear reasoning concerning the relationships observed in nature forces researchers to use experimental methods in ecological research, and each group of insects requires a separate approach, as well as specific research methods (Gardiner et al., 2010).

Carabid specimens play a particularly valuable role in maintaining the stability of ecosystems (Lik, 2010). They are the most numerous, both by the number of species and the number of individuals, and they are involved in the most diverse and complex ecological structures. From a numerical point of view, they are superior to other groups of insects and animals around the globe in general (Lövei and Sunderland, 1996). The *Carabidae* family represent one of the main groups of insects that are recommended for indicating the soil type, the vegetation type, and the chemistry of the environment. Carabids are very sensitive to insecticides and pesticides, and the species can be easily observed (Jaďuďová et al., 2006). In agricultural crops and even in forested areas, many carabid species are particularly important ecological indicators that respond immediately to human interventions, such as pesticides, which cause paralysis or even death of adult insects or larvae shortly after application (Virić Gašparić et al., 2022). For these reasons, many carabid species have declined, are on the verge of extinction, or have even disappeared (Lemic et al., 2017).

To use an effective control method, it is not enough to know the main crop pests and their biology, as in the case of conventional control methods. It is necessary to also know about the entire complex of organisms, mainly carabid species, that take part in one way or another in their evolution within agrobiocenosis (Rainio and Niemela, 2006). The purpose of this study is to contribute data obtained from a comparative study of the Carabidae fauna according to the applied pest control technology.

MATERIALS AND METHODS

This research was carried out from 2020 to 2022, in May to September of each year. Four variants were studied at each of four corn fields located in four stations. At each stationary, there was a distance of 500-700 m between the fields. The four variants used were:

• V1 - superficial tillage in the spring and untreated seeds;

•V2 - deep tillage during autumn plowing and untreated seeds;

•V3 - superficial tillage in the spring and treated seeds; and

•V4 - deep tillage during autumn plowing and treated seeds.

In two of the four fields, deep soil mobilization was performed during the autumn plowing by turning the furrow to a depth of 35 cm. In the other two fields, the soil was processed superficially in the spring before sowing with the help of a combine consisting of two batteries of heavy discs, two rows of active claws, and a levelling roller, at a depth of 18 cm.

Entomological material was gathered using the Barber soil trap method. The material was collected periodically, with a 21 calendar days between collections between May and September in 2020-2022, for a total of 100-122 days. The samples with the collected biological material were labeled, specifying the sample number, the collection date, the station, and the soil tillage variant or the corn crop protection variant. The labeled samples were protected from sunlight and transported to the laboratory for analysis and determination.

Each year, 32 Barber traps were installed at each station, namely the Trifeşti stationary, the Ezăreni stationary, and the Schitu Duca stationary (Figure 1). Eight traps were installed for each field at each station. They were placed in two rows at a distance of about 10 m between rows and 6-8 m between traps per row. The traps were plastic jars protected by a lid, with a volume of 500 mL, a diameter of 9.5 cm, and a height of 12.5 cm. They contained acetic acid diluted to 50% as a liquid fixative and preservative (Pielou, 1978).

The samples with the collected biological material were taken to the laboratory where they were inventoried and cleaned. The collected entomological material was analyzed by using specialized entomological determiners, with the help of a microscope and a binocular magnifier.

For each tillage variant, two corn fields were sown using a different culture technology. The untreated variant involved untreated certified seeds and mechanical weed control via three mechanical harrows and one manual harrow. The treated variant involved certified seeds treated with insecticide and fungicide, and weed control was done chemically using a pre-emergence herbicide and a post-emergence herbicide (Table 1).

Table 1. Weed management and seed treatment

Locality	Cultivation practice	Weed management	Seed treatment
Trifeşti	Surface tillage in spring	Dual Gold 960 EC	Celest Extra FS
	Deep tillage during autumn plowing	Adengo 465 SC	
Ezăreni	Surface tillage in spring	Ceredin Forte 464SL	TMTD 98% Satec
	Deep tillage during autumn plowing	Nagano	
Schitu Duca	Surface tillage in spring	Principal 450G	Aatiram 65
	Deep tillage during autumn plowing	Adengo 465 SC	

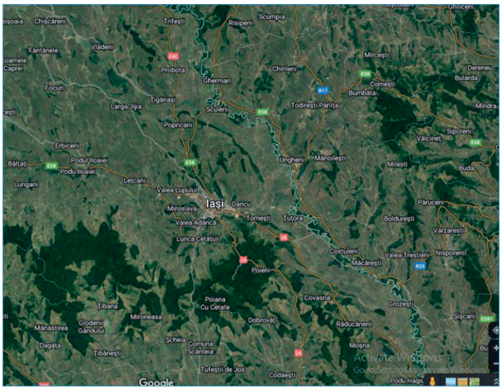

Figure 1. The territorial disposition of the three stationary (https://www.google.com/maps/@47.0830006,27.58790)

The taxonomic-ecological spectrum of a biocenosis represents only the first step toward knowing its structure. To understand the organizational structure and dynamics of a biocenosis, the collected material was subjected to mathematical analysis estimating a series of indicators that highlight the characteristics of the respective biocenosis. Biodiversity characterization indexes, namely the biodiversity index, the Shannon diversity index, equity, and the Simpson diversity index, were used to quantify biodiversity in a habitat. The analysis and interpretation of the data were carried out with the help of the BIODIV application to calculate the main biodiversity indicators (Lemić, 2021). Synecological analysis of the Carabidae coenoses from the corn agroecosystems was performed for an exact assessment of the contribution and role of each species in the respective biocenoses.

To estimate the specific diversity, the Shannon function was applied, which has the following expression:

$H = -\Sigma$ pilog2 pi, where:

- *pi* is the proportion of individuals by which species *i* is present in the biocenosis (dominance), derived from the ratio *nIN*, where *n* is the number of individuals of the species, and *N* is the total number of individuals of all species in the analysed sample.

The real (observed) diversity, H(S), was calculated by applying the Shannon calculation relation, modified from Mac Arthur and corrected by Lloyd. The maximum (hypothetical) diversity (H(S) max) was calculated as follows:

H(S) max = K log 10S,

where: $K = 3.321928$ and *S* is the total number of species and relative diversity (fairness). *Hr* was calculated as follows:

Hr = H(S) / H(S) max × 100%.

RESULTS AND DISCUSSIONS

The analyzed entomological material was collected in the warm season (May-September) in 2020-2022. The observations were carried out in corn agroecosystems of the Trifeşti, Ezăreni, and Schitu Duca stationary, Iasi County, northwest Romania.

At the Trifeşti stationary, considering the variant with untreated seeds and mechanically controlled weeds, the largest number of individuals, 303, was recorded in 2020 for superficial tillage in the spring, while the lowest number of individuals, 169, was harvested in 2021 for deep tillage during autumn plowing. Considering the variant with treated seeds and chemically controlled weeds, the largest number of specimens, 687, was harvested in 2022 for superficial tillage in the spring, while the lowest number of specimens, 395, was recorded in 2021 for deep tillage during autumn plowing.

At the Ezăreni stationary, considering the variant with untreated seeds and mechanically controlled weeds, the largest number of carabids, 101, was recorded in 2021 for superficial tillage, while the smallest number of carabids, 20, was harvested in 2020 for deep tillage during autumn plowing. Considering the variant with treated seeds and chemically controlled weeds, the largest number of specimens, 382, was harvested in 2022 for superficial tillage in the spring, while the lowest number, 97, was recorded in 2020 for deep tillage during autumn plowing.

When examining the two variants of crop protection together, the number of carabids collected in the case of untreated seeds was approximately 4 times higher than when treated seeds were used.

At the Schitu Duca stationary, considering untreated seeds and mechanically controlled weeds, the largest number of individuals, 1600, was recorded in 2022 for superficial tillage in the spring, while the lowest number of carabids, 595, was recorded in 2020 for deep tillage during autumn plowing. Considering treated seeds and chemically controlled weed, the largest number of specimens, 2852, was harvested in 2022 with superficial tillage in the spring, while the lowest number, 1009, was recorded in 2020 for deep tillage during autumn plowing.

When looking at the two variants of crop protection together, the number of carabids collected in the case of the untreated seeds is approximately double that of the variant that used treated seeds.

Figure 2 presents the number of carabids collected each year at each station when using treated seeds. Figure 3 presents the number of carabids collected each year at each station when untreated seeds were used.

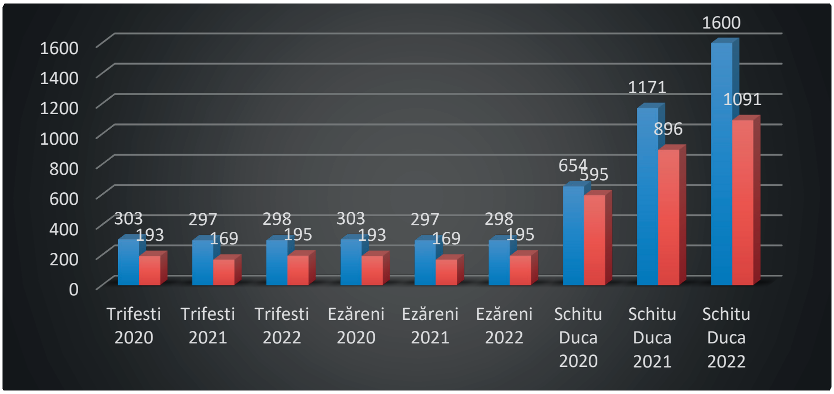

Figure 2. The change in the number of carabids collected during the 3-year study at each station when using treated seeds

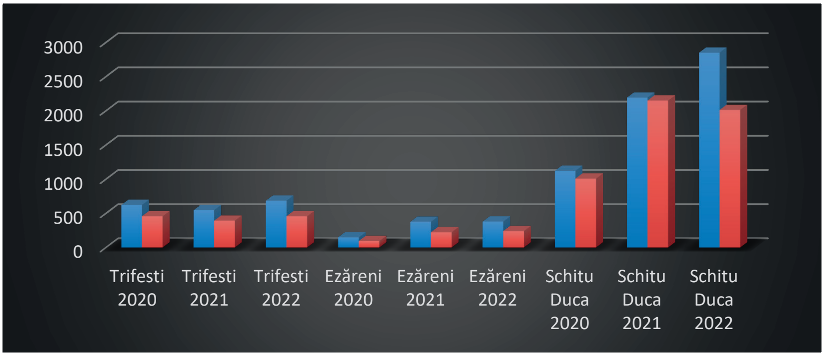

Figure 3. The change in the number of carabids collected during the 3-year study at each station when using untreated seeds

In both experimental situations, significantly more individuals were collected at the Schitu Duca stationary. This is explained by the fact that the agrocenosis of the Schitu Duca stationary is less influenced by the chemical substances used in agriculture. Indeed, the agricultural holdings in the area are relatively recent (within the past 3-5 years), unlike the other two stations where intensive agriculture has been practiced in recent decades. Another explanation is the fact that the fields used in the study were located in the immediate vicinity of a forested area, and thus were strongly influenced by its specific microclimate.

The Simpson diversity index is used in ecology to describe the diversity of a habitat and considers the number of species present and the abundance of each species. At the Ezăreni stationary, the Simpson diversity index was between 0.188 and 0.491 for superficial tillage in the spring, and between 0.203 and 0.423 for deep tillage during autumn plowing. The Shannon diversity index was between 1045 and 1929 for superficial tillage in the spring, compared with values of 1888-1104 for deep tillage during autumn plowing (Table 2).

At the Trifeşti stationary, the Simpson diversity index was between 0.087 and 0.101 for superficial tillage in the spring, compared with values of 0.088-0.107 for deep tillage during autumn plowing (Table 3). The Shannon diversity index at the Trifeşti stationary was between 2542 and 2670 for superficial tillage in the spring, compared with values of 258-2721 for deep tillage during autumn plowing (Table 3).

Table 2. Biodiversity indicators of carabid species collected at the Ezăreni station

Superficial tillage in the spring						
Biodiversity indicators	2020		2021		2022	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Specimen abundance	10000	8000	9000	8000	10000	8000
Simpson's index	0.188	0.210	0.458	0.528	0.491	0.559
Shannon index	1929	1783	1274	1069	1238	1045
Equity	0.838	0.857	0.580	0.514	0.538	0.503
Deep tillage during autumn plowing						
Specimen abundance	9000	7000	8000	7000	9000	7000
Simpson's index	0.203	0.250	0.423	0.584	0.415	0.508
Shannon index	1888	1623	1339	0946	1387	1104
Equity	0.859	0.834	0.644	0.486	0.631	0.568

Table 3. Biodiversity indicators of carabid species collected at Trifeşti stationary

Superficial tillage in the spring						
Biodiversity indicators	2020		2021		2022	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Specimen abundance	19000	19000	19000	19000	19000	19000
Simpson's index	0.090	0.137	0.101	0.122	0.087	0.110
Shannon index	2663	2434	2542	2426	2670	2483
Equity	0.904	0.827	0.863	0.824	0.907	0.843
Deep tillage during autumn plowing						
Specimen abundance	21000	19000	21000	21000	21000	21000
Simpson's index	0.107	0.153	0.091	0.113	0.088	0.110
Shannon index	2580	2351	2696	2544	2721	2570
Equity	0.847	0.799	0.885	0.835	0.894	0.844

At the Schitu Duca stationary, the Simpson diversity index was between 0.136 and 0.175 for superficial tillage in the spring, compared with values of 0.154–0.209 for deep tillage during autumn plowing (Table 4). The Shannon diversity index was between 2315 and 2457 for superficial tillage in the spring, compared with values of 2147-2360 for deep tillage during autumn plowing (Table 4).

Table 4. Biodiversity indicators of carabid species collected at the Schitu Duca stationary

Superficial tillage in the spring						
Biodiversity indicators	2019		2020		2021	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Specimen abundance	19000	18000	28000	28000	25000	25000
Simpson's index (d)	0.152	0.219	0.175	0.187	0.136	0.168
Shannon index	2315	2003	2442	2337	2457	2358
Equity	0.786	0.693	0.733	0.701	0.763	0.733
Deep tillage during autumn plowing						
Specimen abundance	19000	18000	27000	27000	23000	23000
Simpson's index (d)	0.209	0.352	0.183	0.252	0.154	0.202
Shannon index	2147	1705	2244	2058	2360	2197
Equity	0.729	0.590	0.681	0.624	0.753	0.701

CONCLUSIONS

Analyzing the data obtained, there was a significant reduction in the number of carabids collected for the variant with treated seeds and chemically controlled weeds compared with untreated seeds and mechanically controlled weeds. This can be explained by the way carabids feed: they attack the seeds and embryos of newly emerged seedlings, thus consuming the active ingredient of the insecticide.

The use of an integrated pesticide management plan through which lower amounts of pesticides can be used and greater emphasis is placed on agrotechnical measures to combat pests is important to protect the useful entomofauna in ecosystems. When carrying out chemical treatments against pests, we recommend considering the protection of the culture by using the latest generation of plant protection products and in small quantities that have a low impact on the environment.

This comparative study aimed to make a significant scientific contribution regarding the effects of pest control technology on the Carabidae fauna. Biodiversity characterization indices the biodiversity index, the Shannon diversity index, equity, and the Simpson diversity index were used to quantify biodiversity in a habitat. The analysis and interpretation of the data were carried out with the help of the BIODIV application to calculate the main indicators of biodiversity.

For the variant using untreated seed and mechanically controlled weeds, the Simpson diversity index was between 0.087 for the Trifeşti stationary in 2022 (superficial tillage in the spring) and 0.491 for the Ezăreni stationary in 2022 (superficial tillage in the spring). For the variant using treated seed and chemically controlled weeds, the Simpson diversity index was between 0.110 for the Trifeşti stationary in 2022 (for both deep tillage during autumn plowing and superficial tillage in the spring) and 0.584 for the Ezăreni stationary in 2020 (deep tillage during autumn ploughing).

Overall, significantly fewer carabids were collected for deep tillage during autumn plowing compared with superficial tillage in the spring. This fact is explained by the different depth of plowing. Some species carry out part or all of their evolutionary cycle in the soil, and the active parts of the plow destroy their habitat.

For both experimental situations, at the Schitu Duca stationary, significantly more individuals were collected compared with the other two stations. This is explained by the fact that the agrocenosis of the Schitu Duca stationary was less influenced by the chemicals used in agriculture. The agricultural holdings in the area are relatively recent (3-5 years), unlike the other two stationarys where intensive agriculture has been practiced in recent decades. Another explanation is the fact that the study fields are in the immediate vicinity of a forest, which strongly influences its specific microclimate.

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