

DIVERSITY AND THE MAIN ECOLOGICAL REQUIREMENTS OF THE EPIGEIC SPECIES OF CARABIDAE (COLEOPTERA, CARABIDAE) IN THE SUN FLOWER ECOSYSTEM, BROSCĂUȚI (BOTOȘANI COUNTY)

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Abstract. The present paper deals with the epigeic ground beetles from the sun flower ecosystem Botoșani County. It presents the alpha diversity of ground beetles from one site (Broscăuți), the variation of the relative abundance of ground beetles, the Shannon index, evenness, and the main ecological requirements of the species, and the general characteristics of the coenosis of ground beetles as concerns the classes of ecological requirements.

Keywords: Sun flower ecosystem, taxonomic structure of the epigeic Coleoptera, Carabidae, alpha diversity, relative abundance, Shannon index, evenness, main ecological requirements.

Rezumat. Diversitatea și principalele cerințe ecologice ale speciilor epigeice de Carabidae (Coleoptera, Carabidae) în ecosistemul culturii de floarea-soarelui, Broscăuți (județul Botoșani). Lucrarea include aspecte ecologice asupra speciilor de carabide epigeice colectate în ecosistemul culturii de floarea soarelui în localitatea Broscăuți (Județul Botoșani, 1999). Pentru colectarea materialului s-a folosit metoda clasică de colectare, capcane de sol, câte 12 capcane în staționar, extrăgându-se 96 eşantioane de material epigeic (8 colectări x 12 capcane, (15 mai-15 septembrie, 1999). Valoarea numerică a Alfă diversității a fost de 14 specii, iar gama diversitatea (colectarea carabidelor din același fel de cultura, dar localități diferite: Broscăuți, (Județul Botoșani) și Osoi (Jud. Iași) a fost de 29. Indicele Shannon a avut valoarea de 0,51, iar echitabilitatea de 0,15 %. Cenoza de carabide în cultura de floarea soarelui, în ce privește principalele cerințe ecologice ale speciilor, se caracterizează prin predominarea speciilor cu reproducere în primăvara, mezofile, cu preferințe pentru biotopi:: culturi, culturi-stepe, pantofage și zoofage, distribuite preponderent geografic în Paleartic și vest Palearctic.

Cuvinte cheie: ecosistemul culturii de floarea soarelui, structura taxonomică a coleopterelor epigeice, Carabidae, alpha diversitate, abundență relativă, index Shannon, principalele cerințe ecologice.

Introduction

Fundamental law in biology and ecology is the unity and interaction between organisms and the environment. Natural and ecological characteristics of the ecosystems determine the dominant features of biocoenoses, coenoses, ecological parameters of populations of the epigeic species of Carabidae. There is a close connection between ecodiversity and biodiversity. Here is why it is necessary a brief presentation of the main characteristics of Botoșani County. This county is located in the northern, north-east extremity of Romania, in the north part of Moldavia.

County has an area of 4965 square km, representing 1.6 % of Romania's area. The relief is less varied than that of Suceava County: plateaus, hills, valleys etc. The relief of the county belongs in particular to two large unities of the Moldavian Plateau: The Suceava Plateau (21 % of the county's area) and the Moldavian Plain (79 % of the county's area). The hills of the Suceava Plateau have the altitude between 450 and 500 m. The Moldavian Plain is formed of the Upper Jijia Plain and the Lower Jijia Plain. The most part of the Moldavian Plain is occupied by the Upper Jijia Plain whose hills have frequently the height over 200 m.

The climate is temperate-continental with a cooler character because of the northern geographical position of the county. Multi-annual average temperature of the air (1964 –1972) ranged between 8 and 9 Celsius degrees. In the same period of time, in the Broscăuți site from where the material was collected, the multi-annual average temperature of the air was 8.5 Celsius degrees.

The annual average amount of precipitations in 1999 was 550 liters per square meter. And in the Broscăuți locality was 548.7 litres per square meter.

Within the ecological conditions of the Suceava and Botoșani Counties, faunistic research on the curculionids published: (Theodor & Dănilă, 1994).

The purpose of this paper is to present data on the alpha diversity of epigeic ground beetles, within the taxonomic structure of the Order Coleoptera, the variation of the relative abundance of the species of Carabidae, the Shannon index and evenness, and a general view on the main ecological requirements, at the level of individuals and coenosis.

Material and Methods

Methodologically, the presentation of the work method must detail answers three questions: where, when and how.

The present paper is based on the personal scientific material of ground beetles collected by one of the authors (Apostol, 1999).

The collection of the ground beetles is made by adequate methods to their biotopes, biology and ecology. The most used, classical and standard method in collecting the ground beetles is the use of soil pitfalls with preserving liquid and protected from rainfalls. This method permits the collection of qualitative and quantitative material in a given period of time established by the researcher in order to obtain data on a series of parameters, such as: The relative abundance of the species, their constancy and dominance, the diversity of the population of carabids, the dynamics of the whole population in connection with the natural characteristics of the biotops, comparisons among sites of collecting and the discussions of the results. The surface of the site in the Broscăuți site was 10,000 square meters.

The material was collected in the year 1999: May, June, July, August, and September. For the collection of the individuals of carabids, 12 pitfalls were used, as an optimum number. Each soil pitfall had a volume of 800 cubic centimeters; 7 centimeters in diameter and 11 centimeters in height, being protected from rainfalls. The pitfalls were set in the ecosystem crop of sun flower in the second half of the month of May (1999), on three rows with four pitfalls on each row. The distance between rows and pitfalls was three meters. Pitfalls functioned in the ecosystem a number of 123 days (1999 (May 15, June, July, August, September 15)). As preserving liquid a solution of 3-4 % formol was used.

The collection of the material.

In the temperate area, the climate influences the activity of the ectothermic invertebrates. To follow the seasonal variation of the specific composition, the variation of diversity, and the number of the individuals belonging to each species, the characteristic of the dynamics we collected the material twice a month.

The first collection was made around the middle of each month, (May-September) and the second one at the end of each month, mentioned above. Last collection was made on September 15. Material was collected from each pitfall, recording the main data of the site, the number of pitfall, collection date). In the whole period, eight collections were made, that is 96 samples.

The scientific identification of the material.

Identification of species, their nomenclature, and classification of the family Carabidae into subfamilies were made according to Freude *et al.* (1976).

The purpose and objectives of the paper.

Moldavia, through its geographical position and its pedo-climatic characteristics, is a zoogeographical region of Romania. Northern counties of Moldavia (Suceava, Botoșani) have some particular characteristics. The purpose of the collection of the material was to give response to a number of objectives at the family Carabidae level in ecological context of Moldavia in the concrete conditions of the ecosystem crop of sun flower, that is:

- **Taxonomic diversity** of the epigeic Order Coleoptera at the level of families, and of the family Carabidae in the year 1999; (Subfamilies, genera, species, the index of diversity, evenness);

- **Knowledge of concrete values** of relative abundance of the species of Carabidae;

- **Knowledge of concrete values** of some ecological parameters of the species of Carabidae in the concrete conditions of the ecosystem crop of sun flower in Botoșani County (dominance, the index of ecological significance, evenness);

- **Coenosis characterisation of Carabidae** in the ecosystem crop of sun flower, relating to: the type of reproduction, preferences for moisture, preferences for biotops, the food regime, geographical distribution.

For coenosis characterization of carabids we used the following parameters: relative abundance, ecological requirements (time of reproduction, preference for moisture, biotope, food, and geographical distribution), Shannon diversity index, and evenness. Nomenclature of the species was used according to Freude *et al.* (1976).

To characterize coenosis of ground beetles from the ecosystem crop of sun flower, referring to reproduction, preferences for humidity, biotopes, food regime, geographical distribution, we used some personal observation in the field and information from the literature (Petrusenko, 1970; Petrusenko & Petrusenko, 1972; Turin *et al.*, 1991; Neculiseanu, 1991, 2003; Šustek, 2000).

Results and Discussion

Qualitative and quantitative results are presented in tables 1-9 and illustrated in figures 1-7.

Scientific papers referring to ecological aspects of ground beetles in the agricultural ecosystems of Moldavia were published by Varvara and collaborators, namely: winter wheat crops ecosystem: Varvara (1991), Varvara & Bulimar (2002); clover crop ecosystem: Varvara & Brudea (1983), Turculeț & Varvara (2007); maize crop ecosystem: Varvara & Brudea (1999), potatoes crop ecosystem: Varvara *et al.* (1999), Varvara (2004); sugar beet crop ecosystem: Varvara & Andriescu (1986).

Our observations of the quoted papers showed that the number of species of Carabidae presented in those ecosystems, as well as the number of specimens of Carabidae, the value of Shannon diversity index and evenness which characterize the coenosis of Carabidae present local variations as a result of the concrete ecological determinism, as an expression of unity and interaction of ecological factors.

The 12 soil pitfalls have functioned 123 days in the sun flower crop ecosystem, Broscăuți, (Botoșani County) (May 15-September 15 included, 1999), and 96 samples were collected with a total number of 3662 individuals of epigeic coleopterans (Order Coleoptera), including 12 families of coleopterans (Table 1 and Fig. 1). The biggest number of specimens belonged to the family Carabidae, as typical epigeic species (3202 individuals (87.44%)), followed by the family Tenebrionidae: (294 individuals (8.03%)). Percentage representations of the remaining individuals of the 10 families varied between

0.03 % (Scarabaeidae, Chryptophagidae, Cerambycidae) and 2.30% (larvae and adults of Dermestidae) (Table 1 and Fig. 1)

The family Carabidae was represented by individuals belonging to seven subfamilies (Table 2). The biggest number of individuals belonged to the subfamily *Harpalinae* (2977 individuals (92.97%)), followed by *Pterostichinae* (157 specimens (4.90%)). The subfamily *Carabinae* had a number of 46 individuals (1.44%), all specimens belonged to the species *Carabus scabriusculus*) (Table 2; fig. 2). The predominance of the subfamily *Harpalinae* is in accordance with the general features of the sun flower crop.

The alpha diversity of the family Carabidae in the sun flower crop ecosystem in the site Broscăuți (1999) was 14. It may be higher in other crops of the same ecosystem. Of those 14 species, the number of the individuals of the species *Pseudophonus rufipes* was remarkable: 2947 (92.04%), *Poecilus cupreus* was subdominant: 121 specimens (3.78%) (Table 3). *Pseudophonus rufipes* is well represented in the agricultural ecosystems being a flying and open land scape species (Table 4). It is an autumnal species. According to our observations, the individuals of the new generation begin to appear in nature in the second half of the month of July. It is a pantophagous species, distributed in the Palearctic Region (Table 3).

Table 1. Taxonomic and percentage structure, relative abundance of the families of the Order of Coleoptera in the ecosystem crop of sun flower in the Broscăuți site (Botoșani County), 1999.

	Name of the families	Relative abundance	%
1	Carabidae	3202	87.44
2	Staphylinidae	20	0.55
3	Histeridae	2	0.05
4	Cantharidae	8	0.22
5	Tenebrionidae	294	8.03
6	Dermestidae (adults)	46	1.26
7	Dermestidae (larvae)	38	1.04
8	Scarabaeidae	1	0.03
9	Cryptophagidae	1	0.03
10	Cerambycidae	1	0.03
11	Chrysomelidae	27	0.74
12	Curculionidae	22	0.60
	Total	3662	100.0

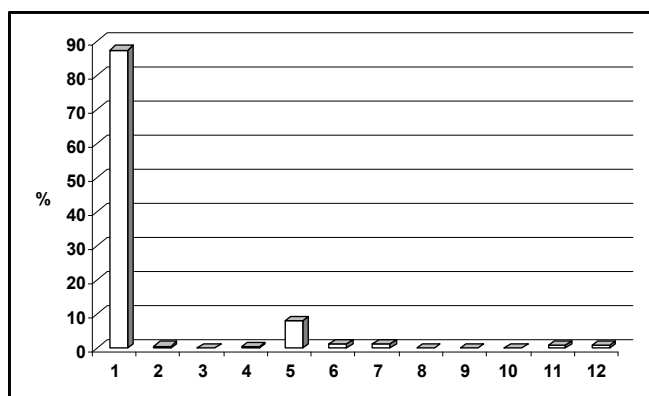


Figure 1. Taxonomic spectrum of the epigeic families of Coleoptera in the ecosystem crop of sun flower , Broscăuți, 1999. Legend in table 1.

The value of the Shannon index was 0.51 by comparison with the limits of normal variations between 1.50 and 3.50. The value of the index is determined by the number of species and especially by the value of evenness. The value of evenness was 0.15%, very low. The sun flower crop ecosystem is an arid ecosystem. 92% of the coenosis of Carabidae was represented by the specimens of the species *Pseudophonus rufipes* which determined a very low index of diversity and evenness.

Table 2. Subfamilies of the family Carabidae, their relative abundance and dominance in the sun flower crop ecosystem, Broscăuți, 1999.

	Name of the subfamilies	Relative abundance	%
1	Cicindelinae	8	0.25
2	Carabinae	46	1.44
3	Anisodactylinae	2	0.06
4	Pterostichinae	157	4.90
5	Harpalinae	2977	92.97
6	Zabrinae	7	0.22
7	Brachininae	5	0.16
8	Total	3202	100.00

Referring to main requirements of the ground beetles to the main ecological factors (reproduction, moisture, preferred biotopes, food regime and geographical distribution), we have made classifications. “One main reason for sorting and classifying is to focus our minds on patterns that suggest underlying causes”. These classifications are included in tables 5-9 and illustrated in figures 3-8.

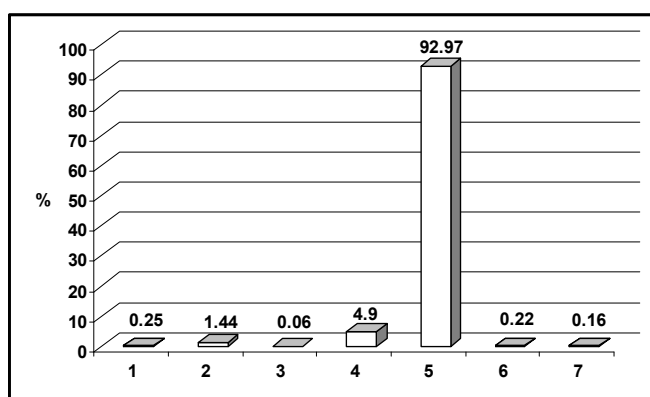


Figure 2. Taxonomic spectrum of the epigeic subfamilies of Carabidae in the sun flower crop ecosystem, Broscăuți, 1999. Legend in table 2.

Generally speaking, on the basis of conclusions published by us and collaborators in the papers quoted above and also on the basis of the present material collected from the sun flower crop ecosystem (the year 1999), the coenosis of Carabidae may be characterized as being composed of species reproducing dominantly in Spring (55.14%), followed by Autumnal species (35.71%), mesophilous species (64.29%) followed by meso-xerophilous species (35.71%) (Tables 5; 6; figs. 3; 4).

Table 3. Taxonomic structure, relative abundance and the dominance of the species of Carabidae in the sun flower crop ecosystem, Broscăuți (Botoșani County), 1999.

	Name of the species	Relative abundance	%
1	<i>Cicindela germanica</i> (L.)	8	0.25
2	<i>Carabus scabriusculus</i> (Ol.)	46	1.44
3	<i>Anisodactylus signatus</i> (Pz.)	2	0.06
4	<i>Pseudophonus rufipes</i> (De Geer)	2947	92.04
5	<i>Harpalus aeneus</i> (F.)	4	0.12
6	<i>H. distinguendus</i> (Duft.)	25	0.78
7	<i>H. calceatus</i> (Duft.)	1	0.03
8	<i>Poecilus cupreus</i> (L.)	121	3.78
9	<i>Dolichus halensis</i> (Schall.)	31	0.97
10	<i>Calathus fuscipes</i> (Goeze)	5	0.16
11	<i>Amara aulica</i> (Pz.)	1	0.03
12	<i>Zabrus tenebrioides</i> (Goeze)	6	0.19
13	<i>Brachinus crepitans</i> (L.)	2	0.06
14	<i>Brachinus explodens</i> (Duft.)	3	0.09
	Total	3202	100.00

Referring to the preferred biotopes (Table 7; fig. 5), the coenosis is formed of only 5 classes of species: (*crops-steppe; crops, open landscape, eurytopic and steppe*). Of those, the coenosis of Carabidae is characterized by the species which live in crops-steppe, crops, open landscape, in total 12 species (83.72 %).

Table 4. Main ecological requirements of the species of Carabidae in the sun flower crop ecosystem, Broscăuți (Botoșani County), 1999 (1. Reproduction type; 2. Moisture preference; 3. Biotope preference; 4. Food regime; 5. Zoogeographical distribution; Sp. Spring; A. Autumnal; S. Summer; M. Mesophilous; M-X = Mesoxerophilous; St. Steppe; Eu. Eurytopic; Cr Crops; Ols. Open landscape; Z. Zoophagous; P. Pantophagous; Fit Phytophagous; Wp. West-palaeartic; Pl. Palaeartic ; E. European ; Emd Euro- mediterranean; Ec Eurocaucasian ; Es. Eurosiberian).

	Name of the species	1	2	3	4	5
1	<i>Cicindela germanica</i>	Sp	M	St,Cr	Z	Wp
2	<i>Carabus scabriusculus</i>	Sp	M	Cr,St	Z	E
3	<i>Anisodactylus signatus</i>	Sp	M	Cr	P	Pl
4	<i>Pseudophonus rufipes</i>	A	M-X	Ols	P	Wp
5	<i>Harpalus aeneus</i>	Sp	M-X	Cr	P	Pl
6	<i>Harpalus distinguendus</i>	Sp-S	M	Ols	P	Pl
7	<i>Harpalus calceatus</i>	A	M-X	St	P	Pl
8	<i>Poecilus cupreus</i>	Sp	M	Cr	Z	Es
9	<i>Dolichus halensis</i>	A	M	Cr	P	Pl
10	<i>Calathus fuscipes</i>	A	M	Eu	P	Wp
11	<i>Amara aulica</i>	Sp	M	Cr	P	Wp
12	<i>Zabrus tenebrioides</i>	A	M	Cr	Fit	Ec
13	<i>Brachinus crepitans</i>	Sp	M-X	St.cr	Z	Wp
14	<i>Brachinus explodens</i>	Sp	M-X	St.cr	Z	E.md.

Table 5. The types of reproduction of the species of carabids in the ecosystem crop of sun flower , Broscăuți (Botoșani County), 1999 (1. Spring; 2. Autumnal; 3. Spring- Summer, 4 = Total species).

	1	2	3	4
No of species	8	5	1	14
% of total	57.14	35.71	7.14	99.99

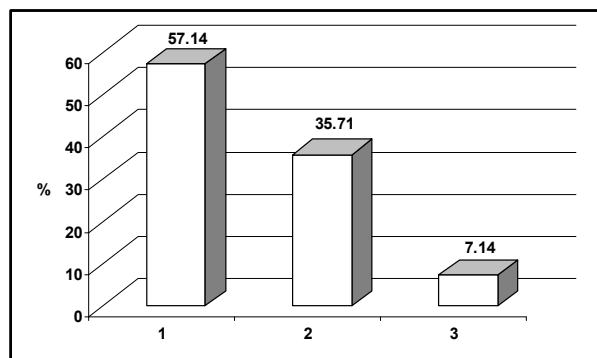


Figure 3. Percentage spectrum of the types of reproduction of the species of Carabidae in the ecosystem crop of sun flower , Broscăuți, 1999. Legend in table 5.

Table 6. General preferences for the moisture of the species of carabids in the ecosystem crop of sun flower , Broscăuți (Botoșani County), 1999 (1.Mesophilous; 2. Meso-xerophilous; 3 =Total species)

	1	2	3
No of species	9	5	14
% of total	64.29	35.71	100.00

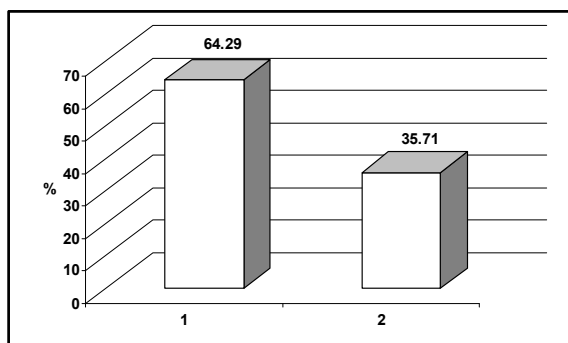


Figure 4. General preferences to the moisture of the species of Carabidae in the ecosystem crop of sun flower, Broscăuți, 1999. Legend in table 6.

Table 7. General preference to the biotope of the species of carabids in the ecosystem crop of sun flower , Broscăuți (Botoșani County), 1999 (1. Crops- Steppe; 2 Crops, 3. Open land scape, 4. Eurytopic; 5. Steppe;6 = Total species).

	1	2	3	4	5	6
No of species	4	6	2	1	1	14
% of total	28.57	42.86	14.29	7.14	7.14	100.00

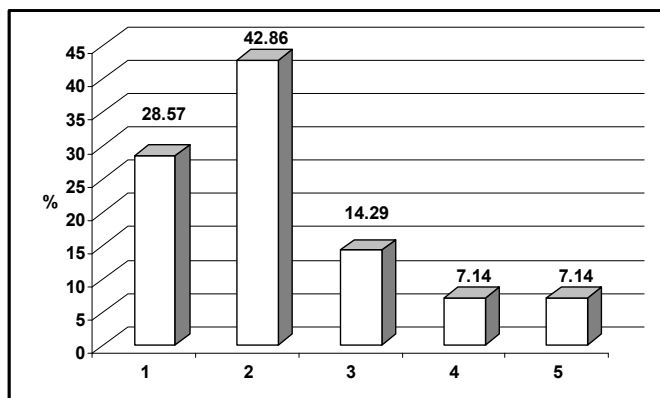


Figure 5. Percentage spectrum of preferences to the biotope of the species of Carabidae in the ecosystem crop of sun flower , Broscăuți, 1999. Legend in table 7.

The food regime of the species of carabids in the sun flower crop ecosystem from Broscăuți is predominantly pantophagous (8 species (57.14%) and zoophagous (5 species (35.71%) (Table 8; fig. 6).

With reference to the geographical distribution of the species of carabids found in the site from Broscăuți, the results are shown in table 9 and fig. 8. The big majority of species are Palaearctic (35.72%) and West palearctic (35.72%).

Table 8. General trophic regime of the species of carabids in the ecosystem crop of sun flower, Broscăuți (Botoșani County), 1999 (1. Zoophags; 2. Pantophags; 3. Phytophags; 4. Total species)

	1	2	3	4
No of species	5	8	1	14
% of total	35.71	57.14	7.14	99.99

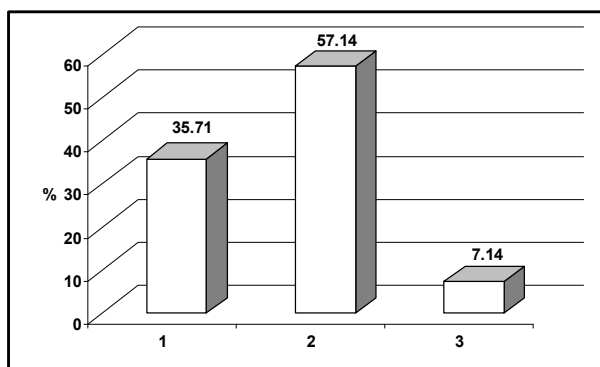


Figure 6. Percentage spectrum of the trophic regime of the species of Carabidae in the ecosystem crop of sun flower , Broscăuți, 1999. Legend in table 8.

Table 9. General geographical distribution of species of carabids in the ecosystem crop of sun flower, Broscăuți (Botoșani County, 1999) (1. Palearctic; 2. West Palearctic ; 3. European; 4. Euro-mediterranean; 5. Eurosibirian; 6. Eurocaucasian; 7 = Total species).

	1	2	3	4	5	6	7
No of species	5	5	1	1	1	1	14
%	35.72	35.72	7.14	7.14	7.14	7.14	100.00

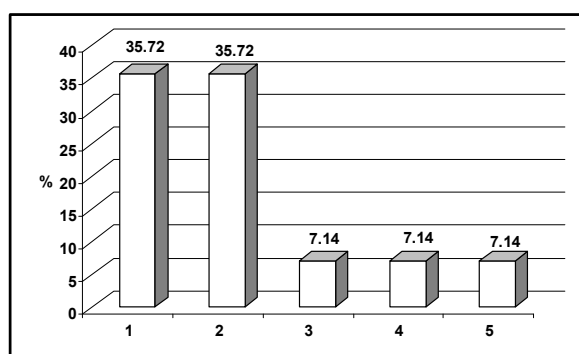


Figure 7. Percentage spectrum of the geographical distribution of species of Carabidae in the ecosystem crop of sun flower, Broscăuți, 1999. Legend in table 9.

Conclusions

- Alpha diversity of epigeic ground beetles in the site Broscăuți with sun flower (1999) was 14 species.

- Shannon index had value of 0.52 and evenness 0.15.

- 57.14 % of species reproduce in the spring and 35.71 % in autumn.

- 64.29 % of species are mesophilous and 35.71 % are meso-xerophilous.

- Pantophagous species predominate (57.14 %), followed by zoophagous species. (35.71 %) 19

- 10 species (71.43 %) in the coenosis of Carabidae prefer to live in crops and crops-steppe.

- The big majority of species (71.44 %) are Palaearctic and West Palearctic.

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