THE GENUS CARABUS (COLEOPTERA: CARABIDAE) IN THE WHEAT CROPS OF MOLDAVIA (ROMANIA)

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Abstract. *The content of the paper is a synthesis of the data of collecting of the species of the genus Carabus that act in the wheat crops of Moldavia, 1977-2002.*

Keywords: *Moldavia, wheat crop, Carabus, species, ecological requirements.*

Rezumat. Genul Carabus (Coleoptera: Carabidae în culturile de grâu din Moldova (România). *Lucrarea de faţă este o sinteză a colectării speciilor genului Carabus din culturile de grâu din opt judeţe şi 15 localităţi ale Moldovei în condiţiile meteorologice ale celor 10 ani (1977-2002). Pentru colectarea materialului entomologic epigeic s-a folosit metoda clasică de colectare, 12 capcane Barber în fiecare localitate (staţionar). Capcanele au funcţionat permanent între 51 şi 137 zile în staţionare. În total, s-au colectat 290 indivizi, aparţinând la 7 specii ale genului Carabus. Din totalul indivizilor colectaţi se evidenţiază speciile: Carabus cancellatus* ILLIGER, *1798 (37,93%), C. scabriusculus* OLIVIER, *1795 (29,31%), C. besseri* FISCHER VON WALDHEIM, *1822 (25,86%). În ce priveşte principalele cerinţe ecologice ale speciilor găsite, ele s-au caracterizat prin predominarea speciilor cu reproducere în primăvară (57,14%), mezofile (71,43%) cu preferinţe pentru biotopul de pădure (42,86%), culturi, stepă (28,57%), euritopice (28,57%), zoofage (100%), distribuite geografic în Europa (28,57%), Palearctic (42,86) etc.*

Cuvinte cheie: *Moldova, cultura de grâu, Carabus, specii, cerinţe ecologice.*

INTRODUCTION

Movement and organization characterizes the living world and the nonliving world. Biosphere and Ecosphere are structured in the organization levels. Hierarchical levels of organization of the Biosphere are: the individual level, the population level (or of the species) and the biocoenotic level.

The functional unit of the Biosphere is the ecosystem, concretized in the unity and interaction between biotope and biocoenosis. The biotope with its natural attributes has a priority status and determines the characters of the biocoenosis.

Our research took place in wheat crops of Moldavia. Moldavia, by its geographical location in eastern Romania, is a zoogeographical region (KISS, 1970). The climate of Moldavia is temperate continental, with average annual temperatures between 7 (in the north) and 9 C degrees (in the south) and annual average precipitations between 450 and 650 mm, depending on altitude, lower at lower altitude and higher at higher altitude.

In the past, the hilly region of Moldavia was covered by deciduous forests, from south to north: oak, common oak and beech, then replaced by meadows and cultivated land. This fact helps us to understand the evolution and adaptation of the fauna to the new conditions (VARVARA & BRUDEA, 1983).

In Moldavia, as in the rest of Romania, the wheat crop is a main crop for the food needs of the population.

The wheat crop ecosystem gets a microclimate in the form of pedoclimate in connection with the characters of the soil (slope, exposure etc.) and a phytoclimate determined by the crop plant (density and size of plants, phases of vegetation), both characterized by more reduced particular values of temperature, luminosity, compared with the outside and a higher humidity of the soil and air.

At the level of the soil a fauna of epigeic arthropods is structured in which the following taxa predominate: Insecta, Arachnida, Coleoptera, Carabidae, Staphylinidae.

In the concrete conditions of the wheat crop ecosystems from Moldavia, for knowing the diversity and structure of the epigeic arthropods: classes, orders, families, species, the relative abundance of the species of Carabidae, the Shannon-Wiever diversity index of the coenosis of Carabidae, the following authors published certain papers: VARVARA et al., (1991), VARVARA & BULIMAR (2003), VARVARA & MOGLAN (1993), CÂRLAN & VARVARA (1999), VARVARA (1991, 2001, 2005).

The authors CHIRECEANU et al. (2009) in the paper "The Invertebrate Fauna Associated with the Wheat Agrocoenosis in Amzacea, Constanţa County" mention the papers in the rest of Romania which have content related to the fauna in the wheat crop ecosystem.

In Banat, BICĂ realized a doctorate thesis (2005) related to the epigeic coleopterans (Carabidae) from the wheat, barley and maize crops.

In the Republic of Moldavia, dr. habilitat NECULISEANU in his thesis to obtain the title of doctor habilitat (2003) synthetized the data from all his papers referring to the study of the Carabidae family in the space of the Republic of Moldavia, among which the carabids from the wheat crops in the vegetation periods of the years (1979-2003) from over 170 localities of collecting from natural and agricultural ecosystems.

In Europe, researching directions on carabids living in different crops are very well synthetized in the paper "Long-termed changes in ground beetle (Coleoptera: Carabidae) assemblages in a field treated by organic fertilizers" (2008).

Our paper may be included in the first direction " (1) study of population and community structure in different crops (SKUHRAVÝ & NOVÁK 1957; SKUHRAVÝ et al., 1959; ŠTEPANOVIČOVÁ & BELÁKOVÁ, 1960; ŠTUSÁK 1962; PETRUŠKA 1966, 1971, 1986, 1987, 1988; OBRTEL 1969; NOVÁK 1972; ANDERSEN 1999A; BASEDOW et al., 1976; SEKULI´C et al., 1973; ERICSON 1978; SHAROVA 1983; HONĚK 1997; PETŘVALSKÝ & PORHAJAŠOVÁ 2002, PORHAJAŠOVÁ 2002 (cited according to paper, 2008).

The purpose of our paper is to achieve a synthesis of personal data on the presence of species of the genus *Carabus* in the wheat crops of Moldavia.

MATERIAL AND METHODS

The rigorous, appropriate, objective, relevant collecting of the zoological material is important for knowledge of the taxonomic structure, the relative abundance and dynamics of constant, abundant and dominant taxa.

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

The most used, classical and standard method in collecting the ground beetles is the use of soil pitfalls with preserving liquid (Barber) and protected from rainfalls. This method permits the collecting 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 taxonomic diversity of the populations of carabids, the relative abundance of the species, their constancy and dominance, the dynamics of a population of a species in connection with the natural characteristics of the biotope, comparisons among sites of collecting and the discussions of results.

The material was collected from Moldavia, from eight counties, beginning from south to north of Moldavia (Brăila, Galați, Vaslui, Vrancea, Iași, Bacău, Botoşani, Suceava) from 16 localities (sites with wheat crops) in the interval of the years, 1977-2002 (May, June, July) (Table 1). For the collecting of the individuals of carabids, 12 pitfalls were used, as an optimum number, with an exception in the wheat crop, Chirița, Iași (Iaşi County) where seven sites were chosen with five pitfalls in each site. Each soil pitfall had a volume of 800 cubic centimetres, 7 centimetres in diameter and 11 centimetres in height, being protected from rainfalls.

The pitfalls were set in the ecosystem of wheat crops at the dates shown in Table no.1, on three rows with four pitfalls on each row. The distance between rows and pitfalls was of three meters. The pitfalls functioned continuously a number of days between 51 (May, June, July, August) and 137. As preserving liquid a solution of 3-4 % formol was used.

Collecting of the material

In the temperate area, climate influences the activity of the ectothermic invertebrates. We collected the material twice a month 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.

The first collecting was made around the middle of each month, (May-July) and the second one at the end of each month, mentioned above in the Table no.1. The last collecting was made at the end of the first half of July, with some exceptions. The material was collected from each pitfall, recording the main data of the site, number of the pitfall, collecting date. In the whole period of the years 1977-2002, 112 collections were made, and 1,488 samples were examined (Table 1).

Identification of species, their nomenclature were made according to FREUDE et al. (1976).

For the characterization of the species of the genus *Carabus* we used the following parameters: relative abundance, ecological requirements (time of reproduction, preference for moisture, biotope, food, and geographical distribution). Nomenclature of the species was used according to FREUDE et al. (1976).

To characterize the species of the genus *Carabus* from the ecosystem crop of autumn wheat, referring to reproduction, preferences for humidity, biotope, 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, VARVARA, 2005).

Table 1. General data on the collecting of the material.
Tabel 1. Datele generale asupra colectării materialului.

1	2	3	4	5	6	7
1	Brăila,Terasă, 1985 (Brăila)	April 10 – July 10, 1985	91	12	7	84
2	Corod, 1983 (Galați)	April 25 – July 10, 1983	77	12	7	84
3	Vaslui, 1977 (Vaslui)	May 1 – July 20, 1977	81	12	7	84
4	Perieni, 1989 (Vaslui)	April 24 – July 28, 1989	95	12	8	96
5	Căbeşti, 1983 (Bacău)	April 25 – June 25, 1983	62	12	6	78
6	Pogoneşti, 1983 (Vaslui)	April 15 – August 30, 1983	137	12	12	144
7	Leţcani, 1981 (Iaşi)	May 10 – July 17, 1981	69	12	7	84
8	Leţcani,1982 (Iaşi)	May 10 – July 16,1982	68	12	7	84
9	Miroslava,1981 (Iaşi)	May 20 – July 15, 1981	97	12	8	96

10	Chiriţa (Iaşi), 1999 (Iaşi)	May 1 – July 15, 1999	76	35	6	210
11	Hemeiusi,1980 (Bacău)	May 1 – August 29, 1980	120	12	12	144
12	Letea -Veche, 1996 (Bacău)	May 1 – July 17, 1995	78	12	5	60
13	Adjud, 1978 (Vrancea)	April 15 – July 30, 1978	106	12	8	96
14	Zvoriştea, 1993 (Suceava)	May 5 – July 25, 1993	81	12	9	108
15	Santa Mare, 2002 (Botoşani)	May 10 – June 30, 2002	51	12	3	36
		Total	**1,289**	**203**	**112**	**1,488**
		Limits	**51-137**	**12-35**	**3-12**	**36-210**

Legend: 1. Current number; **2**. Sites of collecting; **3**. Interval of functioning; **4**. Total days of functioning; **5**. Total pitfalls used; **6**. Total number of collectings; **7**. Total number of examined samples.

RESULTS

Table 2. The relative abundance of species of the genus *Carabus* in the wheat crops of Moldavia.
Tabel 2. Abundenţa relativă a speciilor genului *Carabus* în culturile de grâu din Moldova, 1977-2002.

	Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Brăila,Terasă, 1985			1					1	1
2	Corod, 1983							2	1	2
3	Vaslui, 1977	3	1			5	1		4	10
4	Perieni, 1980		1			1			1	1
5	Pogoneşti, 1983				1	1			2	2
6	Pogana, 1989					1				1
7	Perieni, 1989					1			1	1
8	Leţcani, 1981					22		1	2	23
9	Leţcani, 1982					4			1	
10	Miroslava, 1981					1		12	2	13
11	Chiriţa (Iaşi), 1999		2		31	12		7	4	52
12	Hemeiuşi, 1980		2		3			24	3	29
13	Letea –Veche, 1995		1		7				2	8
14	Adjud, 1978				43	27	8		3	78
15	Zvoriştea, 1993				7			22	2	29
16	Santa Mare, 2002				18			17	2	35
	Total individuals	**3**	**7**	**1**	**110**	**75**	**9**	**85**		290
	% of total	**1.03**	**2.41**	**0.34**	**37.93**	**25.86**	**3.10**	**29.31**		

Legend: 1. *Carabus coriaceus;* **2**. *C. violaceus*; **3**. *C. clathratus*; **4**. *C. cancellatus*; **5**. *C. besseri*; **6**. *C. granulatus;* **7**. *C. scabriusculus*; **8**. Total species; **9**. Total specimens.

Table 3. Main ecological requirements of the species of the genus *Carabus* in the wheat crop ecosystem from Moldavia (Romania).
Tabel 3. Principalele cerinţe ecologice ale speciilor genului *Carabus* în ecosistemul culturii de grâu din Moldova (România).

	Name of the species	**1**	**2**	**3**	**4**	**5**
1	*Carabus coriaceus* LINNAEUS,1758	A	M	F	Z	E
2	*C. violaceus* LINNAEUS, 1758	A	M-X	F	Z	Wp
3	*C. clathratus* LINNAEUS, 1761	Sp	H	Eu	Z	Pl
4	C. *cancellatus* ILLIGER, 1798	Sp	M	F	Z	Pl
5	*C. besseri* FISCHER VON WALDHEIM,1822	A	M	St,Cr	Z	EstE
6	*C. granulatus* LINNAEUS,1758	Sp	H-M	Eu	Z	Pl
7	*C. scabriusculus* OLIVIER,1795	Sp	X	Cr,St	Z	E

Legend: 1 = Breeding type; **2** = Humidity preference; **3** = Biotope preference; **4** = Food regime; **5** = Zoogeographical distribution
Sp = Spring; **A** = Autumnal; **M** = Mesophilous; **M-X** = Mesoxerophilous; H = Hygrophilous; H-M Hygromesophilous; **F** = Forest; Eu = Eurytopic; **St, Cr.** = Steppe, crops; **Eu** = Eurytopic; **Cr, St** = Crops, steppe; **Z** = Zoophagous;
E = European; **Wp** = West Palaearctic; **Pl** = Palaearctic; **EstE** = East-European.

As a result of the collecting of species of the genus *Carabus* from the wheat crop ecosystem (Moldavia) (eight counties, 15 localities for 12 years, 1977-2002), using 12 Barber pitfalls in each locality, performing 112 collectings and examining 1,488 samples (collecting from each pitfall), there were collected 290 individuals belonging to 7 species of the genus *Carabus* (22.58% of all the species in Romania). The genus *Carabus* is represented by 31 species in Romania (GÂDEI & POPESCU, 2009).

In order of their frequency, the collected species are: *Carabus cancellatus tuberculatus* 110 individuals (37.93%, *C. besseri*, 75 (25.641*%), C. scabriusculus*, 85 (29.31%), *C. granulatus* 9, (3.10%), *C. violaceus* 7 (2.41%), *C. coriaceus rugifer* 3 (1.03%) and *C. clathratus* 1 (0.34).

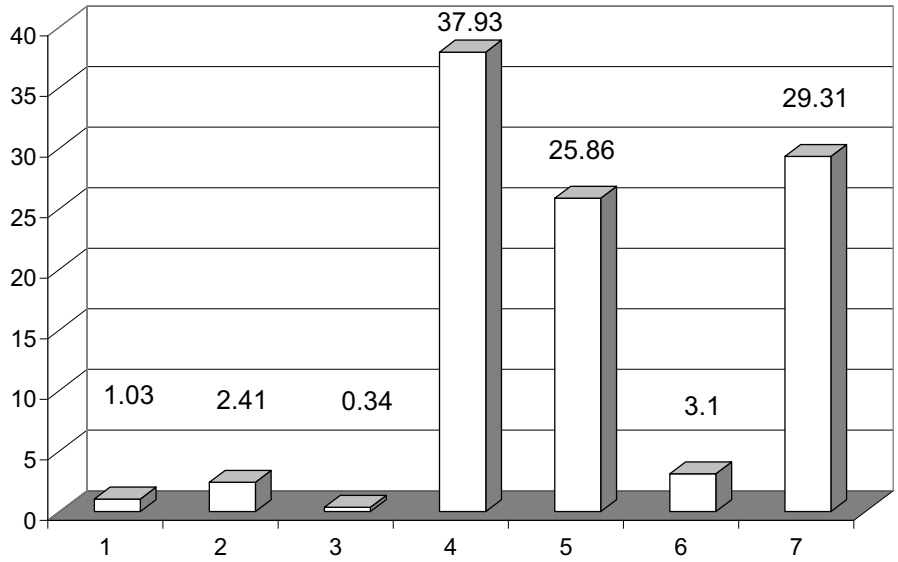

Figure 1. Comparative percentages of species of the genus *Carabus* found in the wheat crops, Moldavia, 1977-2002.
Figura 1. Procentajele comparative ale speciilor genului *Carabus* găsite în culturile de grâu, Moldova, 1977-2002.

Legend: 1. *Carabus coriaceus*; **2**. *C. violaceus*; **3**. *C. clathratus;* **4.** *C. cancellatus*; **5**. *C. besseri*; **6**. *C. granulatus*; **7**. C. *scabriusculus.*

Carabus cancellatus ILLIGER, 1798 is a common species in Romania from plain to mountainous areas (GÂDEI & POPESCU, 2009) and Alpine (PANIN, 1955). All the specimens collected from the wheat crops (Moldavia) belong to the race *Carabus cancellatus tuberculatus* with red femurs (PANIN*,* 1955), but TURIN et al. (2003) include this race in the subspecies *Carabus cancellatus cancellatus* ILLIGER, 1798.

The species was found in six localities (46.15%). 43 specimens (39.09%) were collected from the locality Adjud, (the wheat crop was on a plain soil) and 31 specimens (28.18%) were collected from the locality Chirița (Iaşi County) where the crop was bordered by a mesophilous vegetation.

Carabus cancellatus is a species with reproduction in the spring, mesophilous, forestry, but praticole too (TURIN et al., 2003), zoophagous, with the geographical distribution in the Palearctic region .

Carabus besseri FISCHER VON WALDHEIM, 1822 has a limited geographical area only in Eastern Europe, including Ukraine W. of the Dnieper, the Republic of Moldova, N.E. Romania, S.E. Poland (TURIN et al. 2003 p.158).

In Romania, the species is spread in Moldavia (PANIN, 1955). The specimens of the species were collected from 10 wheat crops (66.67%) in the period 1977-1983 totalizing 75 individuals. In the locality Leţcani, 1981, 22 specimens were collected (29.33% of total) and in the locality Adjud, 1978, 27 specimens were collected (36%).

In the wheat crops from which the species was collected, the species is subrecedent, usually recedent and subdominant. In the Republic of Moldavia, in the wheat crops Durleşti, the species is recedent (DĂNILĂ, 2005).

Carabus besseri is a species that reproduces in the autumn, mesophilous, spread in the steppe, agricultural crops) (cereals, orchards), zoophagous, with the area in the Eastern Europe. According to personal observations the species is present in the ecosystem in June, July and August. The peak of activity and capture is recorded in the second half of July (VARVARA, 2001).

Carabus scabriusculus OLIVIER, 1795 is a common species in Romania from the plain to mountains (GÂDEI & POPESCU, 2009, PANIN, 1955). In the wheat crops, the species was found in seven localities (43.75%), a total of 85 specimens (29.31%). There were collected only two specimens (2.35%) in southern Moldavia (Corod, Galați County), but the species is more common in central and northern Moldavia. At Hemeiuşi (Bacău County) 24 specimens were collected (28.24%), Svorişţea (Suceava County) 22 specimens (25.88%), Santa Mare (Botoşani County) 17 specimens (20.00%).

Carabus scabriusculus is a species that reproduces in the spring, xerophilous and thermophilous, eurytopic (TURIN et al., 2003), zoophagous, European.

Carabus granulatus LINNAEUS, 1758 is a species present in the whole of Romania from the plain to the mountain (PANIN, 1955, GÂDEI & POPESCU, 2009). There were collected only 9 specimens (3.53%) from two localities (13.33%). One specimen, Vaslui (1977), the wheat crop being bordered by a deciduous forest, 9 specimens (Adjud, 1978), the wheat crop with alluvial soil of plain.

Carabus granulatus is a species that reproduces in the spring, hygromesophilous (TURIN et al*.,* 2003), eurytopic, zoophagous, Palaearctic.

Carabus violaceus LINNAEUS, 1758 is a common species in Romania, from plain to the mountainous areas (PANIN, 1955, GÂDEI & POPESCU, 2009). *Carabus violaceus,* on the area of the species, is a complex of subspecies

(TURIN et al*.,* 2003) of which *Carabus violaceus wolfii* DEJEAN, 1926 and *C. violaceus andrezejuscii* FISCHER, 1823 are also present in Romania. *Carabus violaceus wolfii* is present in the forest ecosystems.

In wheat crops, the species was found in five crops (33.33%), a total of only 7 specimens (2.75%), 1-2 specimens in each crop.

Carabus violaceus is a species that reproduces in the autumn, mesoxerophilous, eurytopic (TURIN et al*.,* 2003), zoophagous, distributed in the West Palearctic region.

Carabus coriaceus LINNAEUS, 1758 is a common species in Romania, especially in wet forests, from plain to mountainous areas (PANIN, 1955, GÂDEI & POPESCU, 2009). The species was found only in a single wheat crop, Vaslui 1977, the crop being bordered by a deciduous forest. Three specimens were collected belonging to the subspecies *Carabus coriaceus rugifer,* KRAATZ, 1877 (TURIN et al., 2003, pg. 278).

Carabus coriaceus rugifer is a subspecies that reproduces in the autumn, mesophilous, forestry, zoophagous, European.

Carabus clathratus LINNAEUS, 1761 is a species that is found in Romania in very humid lowlands, especially on sandy edges of rivers, or in swampy forests (PANIN, 1955, GÂDEI & POPESCU, 2009). It was found only a single specimen in a single locality, Brăila, 1985, in a wheat crop on an alluvial terrace.

Carabus clahtratus is a species that reproduces in the spring, hygrophilous, eurytopic, zoophagous, Palaearctic.

DISCUSSIONS

The species of epigeic arthropods as ectothermic invertebrates act in the concrete conditions of biotopes and habitats (pedoclimate and phytoclimate) in accordance with their ecological valences (preferences for temperature, humidity, food, competition pressure). The abundance of a species in an ecosystem is an important parameter that favours its survival. This parameter is under the influence of Shelford's law of tolerance. The change in number of individuals takes the form of a curve. In accordance with the law of tolerance, most individuals of a species are found around the optimum of a factor. Factors in an ecosystem act and interact together. All ecological factors are necessary for the existence of a species, but most important are: temperature, humidity of soil (within the pedoclimate), food, competition. Variation of the ecological factors is a concrete characteristic of each ecosystem, natural or agricultural.

A species may be eudominant, dominant, subdominant, recedent and subrecedent depending on its abundance in the same kind of ecosystem, but in different localities.

In the wheat crops of Moldavia, seven species of the genus *Carabus* are present. The Alpha diversity of this genus varied from 1-4 species. In two wheat crops, Vaslui, 1977 and Chirița, 1999, there were found four species each of the genus *Carabus* (Table 2), a fact explained by the influence of the adjacent ecosystems: (deciduous forest, Vaslui, 1977) and (mesophilous vegetation, Chirița, 1999). Three species are more frequent and with a bigger number of individuals. In order of their number of individuals, they are: *Carabus cancellatus cancellatus* ILLIGER, 1798. *Carabus besseri* FISCHER VON WALDHEIM, 1822 and *Carabus scabriusculus* OLIVIER, 1795 (Table 2, Fig. 1).

In Moldavia, *Carabus besseri* is a species spread in the wheat crops and the number of individuals is variable, the species having different positions within the epigeic entomocoenosis, thus: subrecedent, recedent, subdominant (VARVARA, 2001).

In the Republic of Moldavia, only four species of the genus *Carabus* are present in the wheat crops: *Carabus excellens* FABRICIUS, 1798, *C. convexus* FABRICIUS, 1775 and *C. coriaceus* LINNAEUS; 1758 (NECULISEANU, 2003) and *C. besseri* FISCHER VON WALDHEIM, 1822 (DĂNILĂ, 2005). Surely, the wheat crops, in which the species *Carabus excellens* and *C. convexus* were found, were bordered by a deciduous forest.

In Romania, BICĂ in her doctoral thesis "Research on the Carabids from the Cereal Crops Cultivated in the West Plain" (2005) investigated the epigeic carabids of three ecosystems: Wheat, barley and maize crops. In the wheat crop, the carabids were collected from four localities in the Banat area, using five Barber pitfalls in each locality and year. The material was collected for four years (1999-2002). The genus *Carabus* was represented by two species: *Carabus ullrichi* GERMAR, 1824 and *C. coriaceus* LINNAEUS, 1758. *Carabus ullrichi* was dominant (1999), eudominant (2000, 2001) and subrecedent only in one locality, being absent in other three localities. The drastic reduction of the relative abundance of the species *Carabus ullrichi* from the dominant and eudominant positions in the localities Lugoj, Sag and Becicherec was caused by the climatic conditions.

In the book "Natural Capital Management, Case Studies (TEODORESCU et al*.,* 2001) (based on the collecting of epigeic arthropods from wheat crops, 13 localities (May, June, July 1994-1999), using five Barber pitfalls in each locality, there were found three species of the genus *Carabus*: *Carabus coriaceus* LINNAEUS,1758, *C. scabriusculus* OLIVIER,1795 and *C. intricatus* LINNAEUS, 1761.

CONCLUSIONS

In the wheat crops of Moldavia seven species of the genus *Carabus* were found. In order of their frequency and relative abundance, they are: *Carabus cancellatus cancellatus* ILLIGER,1798; *C. besseri* FISCHER VON WALDHEIM, 1822; *C. scabriusculus* OLIVIER, 1795; *C. violaceus* LINNAEUS, 1758; *C. granulatus* LINNAEUS, 1758; *C. coriaceus* LINNAEUS, 1758; *C. clathratus* LINNAEUS, 1761.

The Alpha diversity of the genus *Carabus* varied between 1 and 4 depending on the adjacent ecosystems too (forest ecosystems, mesophilous vegetation).

57.14% of the species have their reproduction in spring and 42.86% are species reproducing in autumn.

57.14 % of the species are mesophilous.

All the species living in the wheat crops are large species and zoophagous.

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