

## THE GENUS *CARABUS* (COLEOPTERA: CARABIDAE) IN SOME POTATO CROPS FROM ROMANIA, 1978-1999

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**Abstract.** The paper synthesizes an extensive material of the *Carabus* species pitfall-trapped during 18 years (1978-1999) in potato crops in 10 counties and 13 sites Romania in various soil and climate conditions. In each site 5-17 (11 in average) Barber traps were exposed for 20-183 days (108 in average). Altogether 1175 individuals of 11 *Carabus* species were collected. The most abundant were *Carabus (Trachycarabus) scabriusculus* OLIVIER 1795 (46.60%), *Carabus (Tachypus) cancellatus* ILLIGER 1798 (25.77%), *Carabus (Eucarabus) ullrichii* GERMAR 1824 (20.80%), *Carabus (Megodontus) violaceus* LINNAEUS 1758 (5.10%). The remaining 7 species represented 0.09-0.43% of the entire material. The spring breeders (54.55%), mezophilous (90.91%), forest (63.64%) and zoophagous species (100%) predominated. The species recorded have palaeartical, westpalaeartical, Eurosiberian, European, Central European, and East European distributional areas.

**Keywords:** Romania, Moldova, Țara Bârsei country, Târgu Jiu basin, potato crops, *Carabus*, species, ecological requirements.

**Rezumat. Genul *Carabus* (Coleoptera: Carabidae) în unele culturi de cartofi din România, 1978-1999.** Lucrarea este o sinteză a colectării materialului original privind speciile genului *Carabus* din unele culturi de cartofi din 10 județe ale României și 13 localități în condițiile pedo-climatice ale celor 18 ani (1978-1999). Pentru colectarea materialului epigeic s-au folosit capcane Barber. În fiecare staționar și an au funcționat 11 capcane în medie (limite, 5-17). Capcanele au funcționat permanent 108 zile în medie, (limite între 20 și 183). În total, s-au colectat 1175 indivizi, aparținând la 11 specii ale genului *Carabus*. Ierarhizarea procentuală, conform numărului de indivizi ale fiecărei specii colectate, a fost: *Carabus (Trachycarabus) scabriusculus* OLIVIER 1795, (46,60%), *Carabus (Tachypus) cancellatus* ILLIGER 1798, (25,77%), *Carabus (Eucarabus) ullrichii* GERMAR 1824, (20,80%), *Carabus (Megodontus) violaceus* LINNAEUS 1758, (5,10%). Restul de șapte specii au avut procente între 0,09-0,43%. Au predominat speciile cu reproducere în primăvară (54,55%), mezofile (90,91%) și cu preferințe pentru biotopul de pădure (63,64%), zoofage (100%). Predominanța distribuirii geografice a fost: paleartică, euro-siberiană, vest-paleartică, europeană, central-europeană și est-europeană.

**Cuvinte cheie:** România, Moldova, Țara Bârsei, depresiunea Târgu Jiu, cultura de cartofi, *Carabus*, specii, cerințe ecologice.

### INTRODUCTION

In the conception of ecological agriculture, edaphic invertebrates play an important role in production of humus and circulation of organic matter to the plants in form of chemical elements or substances, while epigeic predatory or mixophagous beetles (Carabidae) act as a biological filter, consuming diverse species of invertebrates and their developmental stages. In field ecosystems, climate, soil, crop plant, treatment of the soil, control of diseases and pests influence qualitatively and quantitatively epigeic arthropods in a complex system of interactions between organisms and their environment.

The crop plant *Solanum tuberosum* is a mesophilous, agricultural plant. Annual precipitations of 650-800 mm favor its productivity per hectare owing to a positive correlation between soil humidity and potato production. An optimum production is reached at a soil humidity of 60- 80 % of its capacity (BERINDEI, 1983).

Papers on carabids in the potato crops from Romania were published by VARVARA et al. (1990), DONESCU & ENOIU (1995), VARVARA et al. (1999).

Various approaches to study of carabids living in different crops in Europe, are well summarized by PORHAJAŠOVÁ et al. (2008). Similarly as the studies by SKUHRAVÝ & NOVÁK 1957; SKUHRAVÝ et al., 1959; ŠTEPANOVIČOVÁ & BELÁKOVÁ, 1960; ŠTUSÁK, 1962; PETRUŠKA, 1966, 1971, 1986, 1987, 1988; OBRTEL, 1969; NOVÁK, 1972; ANDERSEN, 1999; BASEDOW et al., 1976; SEKULIČ et al., 1973; ERICSON, 1978; SHAROVA, 1983; HONĚK, 1997; PETŘVALSKÝ & PORHAJAŠOVÁ, 2002 and PORHAJAŠOVÁ, 2002 (cited after PORHAJAŠOVÁ et al., 2008). Our paper focuses on study of population and community structure in different potato crops. Its purpose is to achieve a synthesis of original data on occurrence of the *Carabus* species in these crops of Moldavia, the Țara Bârsei county and the Târgu Jiu basin and the variation of number of individuals and species in dependence on different habitat conditions in regional and local scales.

### MATERIAL AND METHODS

The material was collected in the following regions: Moldavia (counties Bacău, Iași, Neamț, Botoșani and Suceava), Transylvania (counties Brașov and Covasna), Muntenia (Argeș county), Oltenia (Dolj county), Dobruđea (Tulcea county).

Moldavia is a zoogeographical district (KISS, 1970) characterized by a continental climate, with annual average temperature between 7 and 9.0°C, average annual precipitation of 450-650 mm. The climate of Moldavia is temperate continental. Correlatively with the rising of the altitude, two zones are evident here. The cooler western zone of

Moldavia with an annual average temperature of 8.5°C and precipitations of 600-700 mm and the eastern zone with the annual average temperature of 9.5°C and precipitations of 450-550 mm. Within these zones three climatic districts are differentiated. The northern one with the southern limit southerly of Iasi; the central one with the southern limit southerly of the Huși town and the southern one. They differ each from other by annual average temperature and precipitations.

The Țara Bârsei country basin has an area of 2406 km<sup>2</sup>. The altitude varies between 504 m (the Feldioara zone) and 723 m (the Brașov zone). Due to its geographical position within of Romania, the climate of the Țara Bârsei country basin is temperate continental with average annual temperature of 7.8°C, the average annual rainfall varies between 548-782 mm, reaching a maximum in the Brașov area. In this region, summers are cool because of the mountain influence. The warmest months are July and August, when the temperature rises to 25°C.

The Târgu Jiu basin comprises river meadows and terraces. 80% of the basin's area has a temperate continental climate. Annual average air temperature is 10.2°C at Târgu Jiu. Annual average rainfall is 753.0 mm. In the Târgu Jiu basin, the brown alluvial soils dominate on the extensive Jiu river floodplain. The crop plants occupy large surfaces in the center and south of the county: cereals, potatoes and vegetables. The average yields are below the Romanian average.

For this paper, the effort, scope, and minuteness made in time to collect the material are given in Table 1 and detailed data for each locality in Table 2 (localities, period of operation of the traps, all days of operation, total number of traps used, total number of collections, total number of samples examined, locality and year). To know the diversity of the *Carabus* species, the variation of the relative abundance of the material collected, there was collected from the Brașov locality for 11 years (1984-1998), from the Târgu Jiu locality for 10 years (1987-1998), and from Moldova for six years (1978-1999). The synthetic data for the material collected are shown in Table 1.

Table 1. Synthetic table referring to the collection of the material from the potato crops.

Tabel 1. Tabel sintetic privind colectarea materialului din culturile de cartofi.

No.	Specifications	Potato crops
1	Years of sampling	1978-1999
2	Effective years of sampling	18
3	Total number of pitfalls used	420
4	Average of pitfalls per site	11
5	Limits of number of pitfalls used	5-17
6	Total number of effective days of pitfalls exposition	3992
7	Average length of pitfalls exposition per site	108
8	Limits	20-183
9	Total number of one year samples	730
10	Total number of analyzed samples	8179
11	Average per locality	221
12	Limits	24-520

The species were identified and their nomenclature was adopted according to FREUDE et al. (1976). For the characterization of the *Carabus* species we used the following parameters: relative abundance, ecological requirements (time of reproduction, preference for moisture, biotope, food, and geographical distribution). To characterize the species of the genus *Carabus* from the potato crop ecosystem, referring to the breeding season, preferences for humidity, biotope, food regime, geographical distribution, we used some personal observation in the field and information from the literature (TURIN et al., 1991; NECULISEANU, 2003; ȘUSTEK, 2000; VARVARA, 2005).

Table 2. General data on the collection of material.

Tabel 2. Date generale asupra colectării materialului.

	Locality	Length of traps exposition			Traps number	Catches number	Samples total
		From	To	Days			
1	Brașov 1984 (Brașov County)	May 29	September 12	107	13	20	260
2	Brașov 1985	April 16	September 4	141	13	31	403
3	Brașov 1986	May 29	October 12	137	13	30	390
4	Brașov 1987	May 29	September 12	107	13	30	390
5	Brașov 1988	May 1	September 12	135	13	29	464
6	Brașov 1989	May 1	September 30	153	10	6	60
7	Brașov 1991	June 10	August 14	65	17	20	340
8	Brașov 1992	June 1	September 15	107	12	20	240
9	Brașov 1993	June 1	September 15	107	12	20	240
10	Brașov 1997	May 24	June 13	20	12	2	24
11	Brașov 1998	June 1	September 18	110	12	15	180
12	Mârșani, 1987	May 1	August 30	122	13	40	520
13	Mârșani 1988 (Dolj County)	April 15	August 27	124	13	22	286
14	Mârșani 1989	April 15	June 29	75	10	6	60
15	Târgu Jiu 1987 (Gorj County)	May 5	September 13	131	13	21	273

16	Târgu Jiu 1988	June 1	September 13	105	13	37	481
17	Târgu Jiu 1989	May 10	August 26	108	13	32	416
18	Târgu Jiu 1991	July 1	August 30	61	10	10	100
19	Tîrgu Jiu 1993	May 25	August 30	97	12	18	216
20	Târgu Jiu 1994	May 3	August 19	109	12	18	216
21	Târgu Jiu 1995	May 1	August 16	108	12	32	384
22	Târgu Jiu 1996	May 1	September 1	124	12	28	336
23	Târgu Jiu 1997	May 25	July 19	55	12	21	252
24	Târgu Jiu 1998	May 1	August 16	108	12	32	384
25	Tulcea 1987 (Tulcea County)	May 12	September 9	120	5	31	155
26	Podul Dâmboviței 1988 (Argeș County)	April 1	September 30	183	5	4	20
27	Târgu Secuiesc 1986 (Covasna County)	May 3	August 24	114	7	23	161
28	Doftana 1978 (Bacău County)	May 1	September 15	138	12	18	216
29	Secuieni 1997 (Neamț County)	May 11	July 30	80	12	6	72
30	Zvoriștea 1993 (Suceava County)	April 26	July 25	91	12	8	96
31	Zvoriștea 1995	May 15	August 25	102	12	10	120
32	Zvoriștea 1998	May 15	September 5	113	6	9	54
33	Dorna Arini, 1993	May 10	July 30	76	10	7	70
34	Dragomirna 1995	May 1	August 20	112	12	8	96
35	Vicovul de Jos 1998	May 15	August 30	107	12	7	84
36	Vânători 1999 (Iași County)	May 20	September 15	118	12	7	84
37	Sârbi 1999 (Botoșani County)	June 1	September 30	122	6	6	36
	<b>Total</b>			<b>3992</b>	<b>420</b>	<b>738</b>	<b>8179</b>
	<b>Media</b>			<b>108</b>	<b>11</b>	<b>20</b>	<b>221</b>
	<b>Limits</b>			<b>20 - 183</b>	<b>5 - 17</b>	<b>2 - 40</b>	<b>24 - 520</b>

Table 3. Relative abundance of species of the genus *Carabus* in some potato crops from Romania.  
Tabel 3. Abundența relativă a speciilor genului *Carabus* în unele culturi de cartofi din România.

No.	Locality	<i>C. cancellatus</i>	<i>C. convexus</i>	<i>C. glabratus</i>	<i>C. rothi</i>	<i>C. scabriusculus</i>	<i>C. ulrichi</i>	<i>C. variolosus</i>	<i>C. granulatus</i>	<i>C. violaceus</i>	<i>C. besseeri</i>	<i>C. corticeus</i>	Species number	Individuals	%
1	Brașov, 1984	44	-	-	-	-	141	-	-	1	-	-	3	186	15.83
2	Brașov, 1985	7	-	-	-	-	29	-	-	-	-	-	2	36	3.06
3	Brașov, 1986	7	-	-	-	-	29	-	-	1	-	-	3	37	3.15
4	Brașov, 1987	7	-	-	4	-	17	-	-	-	-	-	3	28	2.38
5	Brașov, 1988	1	-	-	-	-	2	-	-	-	-	-	2	3	0.26
6	Brasov, 1989	-	-	-	-	-	4	-	-	-	-	-	1	4	0.34
7	Brașov, 1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Brașov, 1992	1	-	-	-	10	2	-	-	-	-	-	3	13	1.11
9	Brasov, 1993	-	-	-	-	-	12	-	-	2	-	-	2	14	1.19
10	Brasov, 1996	-	-	-	-	-	1	-	-	1	-	-	2	2	0.17
11	Brașov, 1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Brasov, 1998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Marsani, 1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Mârșani, 1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Mârșani, 1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Târgu Jiu, 1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Târgu Jiu, 1988	-	-	-	-	41	6	-	-	-	-	-	2	47	4.00
18	Târgu Jiu, 1989	-	-	-	-	13	-	-	-	-	-	-	1	13	1.11
19	Târgu Jiu, 1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	Tîrgu Jiu, 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	Târgu Jiu, 1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Târgu Jiu, 1995	-	-	-	-	3	-	-	-	-	-	-	1	3	0.26
23	Târgu Jiu, 1996	-	-	-	-	19	2	-	-	-	-	-	2	21	1.79
24	Târgu Jiu, 1997	-	-	-	-	4	-	-	-	-	-	-	1	4	0.34
25	Târgu Jiu, 1998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Tulcea, 1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	Podul Dâmboviței, 1988	-	-	-	-	-	-	-	-	4	-	-	1	4	0.34
28	Tg. Secuiesc, 1986	-	-	-	-	-	-	-	-	1	-	-	1	1	0.09
29	Doftana, 1978	10	-	-	-	-	-	-	-	-	-	2	2	12	1.02
30	Secuieni, 1997	-	-	-	-	-	-	-	-	1	1	-	2	2	0.17
31	Zvoriștea, 1993	-	-	-	-	68	-	-	-	-	-	-	1	68	5.79
32	Zvoriștea, 1995	40	-	-	-	112	-	-	-	-	-	-	2	152	12.94
33	Zvoriștea, 1998	8	-	-	-	41	-	-	-	3	-	-	3	52	4.43
34	Dorna Arini, 1993	-	2	4	-	-	-	-	-	10	-	-	3	16	1.36

35	Dragomirna, 1995	-	-	-	-	68	-	-	-	2	-	-	2	70	5.96
36	Vicovu de Jos, 1998	-	-	-	-	-	-	1	1	34	-	-	3	36	3.06
37	Vânători, 1999	178	-	-	-	169	-	-	-	-	-	-	2	347	29.53
38	Sârbi, 1999	-	-	-	-	-	-	-	-	-	4	-	1	4	0.34
	<b>Total</b>	<b>303</b>	<b>2</b>	<b>4</b>	<b>4</b>	<b>548</b>	<b>245</b>	<b>1</b>	<b>1</b>	<b>60</b>	<b>5</b>	<b>2</b>		<b>1175</b>	<b>100.0</b>
	<b>%</b>	25.79	0.17	0.34	0.34	46.64	20.85	0.09	0.09	5.11	0.43	0.17			

Table 4. Breeding type, humidity, habitat and food preference and zoogeographical distribution of the *Carabus* species collected in potato crops.

Tabel 4. Timpul de reproducere, preferință pentru umiditate, biotope, regimul de hrană, distribuția geografică ale speciilor genului *Carabus* colectate din culturi de cartofi.

No.	Species	Breeding	Humidity	Habitat	Food	Distribution
1	<i>Carabus cancellatus</i> ILLIGER 1798	Sp	M	F	Z	P
2	<i>C. convexus</i> FABRICIUS 1775	Sp	M	F	Z	ES
3	<i>C. glabratus</i> PAYKULL 1790	S	M	F	Z	ES
4	<i>C. rothi</i> DEJEAN 1829	?	M	Cr	Z	R
5	<i>C. scabriusculus</i> OLIVIER 1795	Sp	M	St, Cr.	Z	E
6	<i>C. ullrichi</i> GERMAR 1824	Sp	M	F	Z	CE
7	<i>C. variolosus</i> FABRICIUS 1787	Sp	H	F	Z	E
8	<i>C. violaceus</i> LINNAEUS 1758	A	M	F	Z	WP
9	<i>C. besseri</i> FISCHER VON WALDHEIM 1822	S-A	M	St Cr	Z	EE
10	<i>C. granulatus</i> LINNAEUS 1758	Sp	H-M	Eu	Z	PL
11	<i>C. coriaceus</i> LINNAEUS 1758	A	M	F	Z	E

**Legend:** Sp = Spring; S = Summer; S-A = Summer–Autum; A = Autumnal; M = Mesophilous; M-X = Mesoxerophilous; H = Hygrophilous; H-M Hygromesophilous; F = Forest; St, Cr = Steppe, crops; Eu = Eurytopic; Cr, St = Crops, steppe; Z = Zoophagous; E = European; CE = Central European; ES = Eurosiberian; EE = East-European; P = Palaearctic; R = Romania; WP = West Palaearctic.

**Legendă:** Sp = Primăvară; S = Vară; S-A = Vară–Toamnă; A = Toamnă; M = Mesofil; M-X = Meso-xerofil; H = Higrofil; H-M Higro-mesofil; F = Pădure; Eu = Eurytopic; St, Cr = Stepă, culturi; Z = Zoofag; E = European; CE = Central European; ES = Euro-siberian; EE = Est-European; P = Palaearctic; R = Romania; WP = Vest Palaearctic.

## RESULTS

As a result of sampling of the genus *Carabus* species in the potato crop ecosystem (Moldavia, the Țara Bârsei Country, the Târgu Jiu basin etc.), ten counties (five from Moldavia), 13 localities for 18 years, 1978-1999), using 12 Barber traps in each locality, performing 738 samples and examining 8179 catches from each pitfall, there were collected 1175 individuals belonging to 11 species of the genus *Carabus* (35.48% of all species in Romania). In Romania, the genus *Carabus* is represented by 31 species (GÂDEI & POPESCU, 2009).

The species, arranged descendantly according to total number of individuals, were represented as follows *Carabus (Trachycarabus) scabriusculus* OLIVIER 1795, 548 ind. (46.64%), *C. (Tachipus) cancellatus* ILLIGER 1798, 303 (25.79%). *C. (Eucarabus) ullrichi* GERMAR 1824, 245 (20.85%), *C. (Megodontus) violaceus* LINNAEUS 1758, 60 (5.11), *C. (Trachycarabus) besseri* FISCHER VON WALDHEIM 1822, 5 (0.43%), *C. (Oreocarabus) glabratus* PAYKULL 1790, 4 (0.34%), *C. (Morphocarabus) rothi* DEJEAN 1829, 4 (0.34%), *C. (Tomocarabus) convexus* FABRICIUS 1775, 2 (0.17%), *C. (Procrustes) coriaceus* LINNAEUS 1758, 2 (0.17%). *C. (Hygrocarabus) variolosus* FABRICIUS 1787, *C. (Carabus) granulatus* LINNAEUS 1758 were captured in one individual each, representing 0.09% (Fig. 1).

**1. *Carabus (Trachycarabus) scabriusculus* OLIVIER 1795** is a common species in Romania distributed from the lowlands to mountains, absenting in the subalpine and alpine zones (PANIN, 1955, GÂDEI & POPESCU, 2009). It is a spring breeder, xerophilous and thermophilous, eurytopic (TURIN et al., 2003), zoophagous, European.

In the potato crops, 548 (46.60%) individuals were found in 11 sites (30.56 %) of 38. The number of individuals in each site varied from three individuals (0.55%) at Târgu Jiu in 1995 (Dolj County) to 169 individuals (30.84%) at Vânători, 1999, (Iași County). It also depended on years of collecting within the same region. Thus, in the Brașov site 10 individuals (1.82%) were collected during 12 years (1984-1998). At Târgu Jiu, 80 individuals (14.60%) were collected during 10 years (1987-1998). In Moldavia during seven years of collecting (1993-1999), 458 individuals (83.58%) were collected Fig. 2.

**Dynamics.** In three localities, Dragomirna (1995), Zvoriștea (1995) and Vânători (1999) there were caught between 68 and 167 individuals.

Monthly, numerical and percentage dynamics of the individuals from these three localities is presented in Table 6. In May, in the three localities there were collected between 44.12% and 59.88%, in June, between 7.19% and 17.65%, in July, between 14.71 and 38.24%, and in August, between 2.99 and 25.0%.

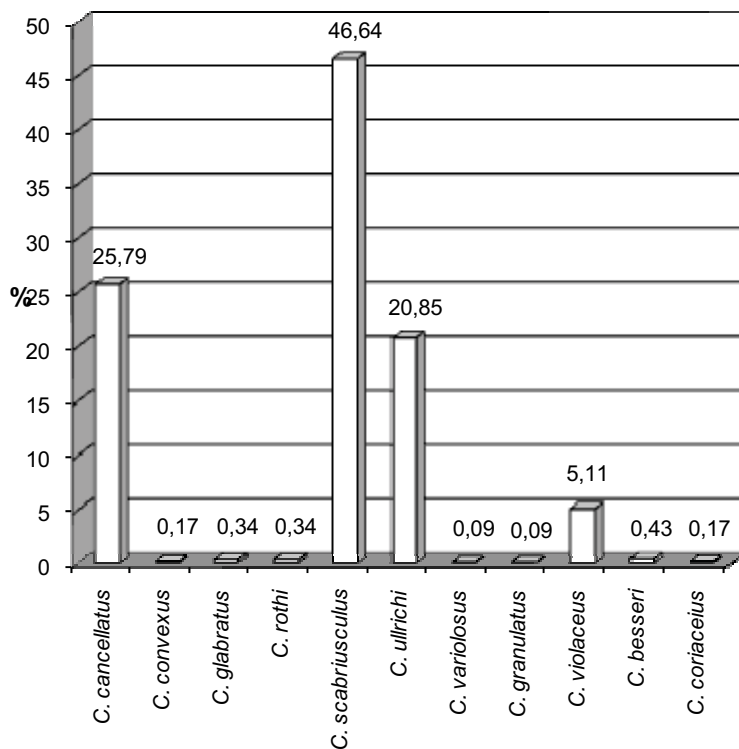


Figure 1. Percentages of *Carabus* species found in some potato crops, from România in 1978-1999.  
 Figura 1. Procentajele comparative ale speciilor genului *Carabus* găsite în culturile de cartofi, România 1978-1999.

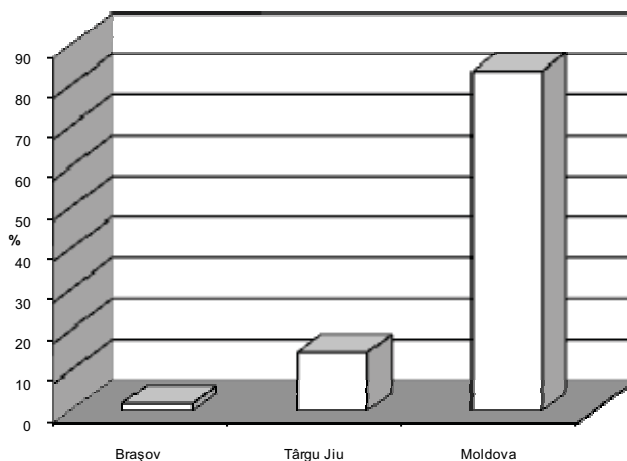


Figure 2. *Carabus scabriusculus*. Percentage of the individuals collected per regions.  
 Figura 2. *Carabus scabriusculus*. Raporturile procentuale ale indivizilor colectați pe regiuni.

Table 5. *Carabus scabriusculus*. The annual variation of the number of individuals within two localities, Târgu Jiu and Zvoriştea (Moldova).  
 Tabel 5. *Carabus scabriusculus*. Variația anuală a numărului de indivizi în cadrul a două localități Târgu Jiu și Zvoriştea (Moldova).

		Years										Total
Years		1987	1988	1989	1991	1993	1994	1995	1996	1997	1998	
Târgu Jiu	No.	N	41	13	N	N	N	3	19	4	N	80
	%	N	51.52	16.25	N	N	N	3.75	23.75	5.00	N	100
Zvoriştea	No.	N	N	N	N	68	N	112	N	N	41	221
	%	N	N	N	N	30.77	N	50.68	N	N	18.55	100

Legend: (N – not sampled)  
 Legenda: (N – nu s-a colectat)

Table 6. Numerical and percentage dynamics of *Carabus scabriusculus* in the potato crops from three localities of Moldova (1995-1999).Tabel 6. Dinamica numerică și procentuală a indivizilor speciei *Carabus scabriusculus* în cultura de cartofi din trei localități ale Moldovei (1995-1999).

	Sites		May	June	July	August	Total
1	Dragomirna, 1995	No.	32	9	10	17	68
		%	<b>47.06</b>	<b>13.24</b>	<b>14.71</b>	<b>25.0</b>	<b>100</b>
2	Zvoriștea, 1995	No.	30	12	26	-	68
		%	<b>44.12</b>	<b>17.65</b>	<b>38.24</b>	-	<b>100</b>
3	Vânători, 1999	No.	100	12	50	5	167
		%	<b>59.88</b>	<b>7.19</b>	<b>29.94</b>	<b>2.99</b>	<b>100</b>

**Sex ratio**

In the material collected from localities Dragomirna (1995, Suceava County) and Vânători, (1999, Iași County) all individuals collected were sexed. The results are in Table 7.

Table 7. *Carabus scabriusculus*. Sex ratio in two localities in the potato crop.  
Tabel 7. *Carabus scabriusculus*. Sex ratio în două localități în cultura de cartofi.

	Localities		Females	Males	Total
1	Dragomirna, 1995	No	44	24	68
		%	<b>64.71</b>	<b>35.29</b>	<b>100</b>
2	Vânători, 1999	No	105	64	169
		%	<b>62.13</b>	<b>37.87</b>	<b>100</b>

In the Dragomirna locality out of the 68 individuals collected, 44 (64.71%) were females, while 24 (35.29%) males. In the Vânători locality out of the 169 specimens collected, 105 (62.13%) were females and 64 (37.87%) males Table 7.

**2. *Carabus (Tachypus) cancellatus* ILLIGER 1798** is a common species in Romania from lowlands to mountain areas (GÂDEI & POPESCU, 2009) and alpine zone (PANIN, 1955). All the individuals collected belong to the red femored subspecies *Carabus cancellatus tuberculatus* (PANIN, 1955), belonging after TURIN et al. (2003) to the subspecies *Carabus cancellatus cancellatus* ILLIGER 1798. It is a spring breeder, mesophilous, eurytopic, forest and open landscape species (TURIN et al., 2003), zoophagous, distributed in the Palearctic region.

The species was found in 10 sites (27.03%). The number of individuals varied from one individual 0.33% found in Brașov (1992, Brașov County) to 178 (50.75%, Vânători, 1999, Iași County).

There was a strong variation of the number of individuals depending on the region of collecting. Table 8.

Table 8. *Carabus cancellatus*. Variation of the number of individuals collected depending on the region.  
Tabel 8. *Carabus cancellatus*. Variația numărului de indivizi colectați în funcție de regiune.

No.	Collecting sites	Total individuals	%
1	Brașov (1984 - 1998)	67	22.11
2.	Târgu Jiu ( 1987 - 1998 )	0	0
3	Moldova (1978 - 1999)	236	77.89
	<b>Total</b>	<b>303</b>	<b>100.00</b>

These differences are explained by the humidity of the region and of soil.

Monthly, numerical and percentage dynamics of *Carabus cancellatus* in the potato crop, Vânători, 1999, Iași County is given in Table 9.

Table 9. Seasonal, numerical and percentage dynamics of the individuals of *Carabus cancellatus* in the potato crop, Vânători, 1999.  
Tabel 9. Dinamica sezonieră, numerică și procentuală a indivizilor speciei *Carabus cancellatus* în cultura de cartofi, Vânători, 1999.

	Sites		May	June	July	August	Sept.	Total
1	Vânători 1999	No.	12	3	71	88	4	178
		%	<b>6.74</b>	<b>1.69</b>	<b>39.89</b>	<b>49.64</b>	<b>2.23</b>	<b>100</b>

**Sex ratio.** In the potato crop from two localities, Dragomirna and Vânători the individuals were sexed, too. The results are in Table 10.

Table 10. *Carabus cancellatus*. Sex ratio in two potato crops.  
Tabel 10. *Carabus cancellatus*. sex ratio în două culturi de cartofi.

	Locality		No. females	No males	Total
1	Dragomirna, 1995 (Suceava County)	No	44	24	68
		%	<b>64.71</b>	<b>35.29</b>	<b>100</b>
2	Vânători, 1999 (Iași County)	No	93	85	178
		%	<b>52.25</b>	<b>47.75</b>	<b>100</b>

**3. *Carabus (Eucarabus) ullrichii*** GERMAR 1824 is spread both at lowlands and uplands, being absent in the subalpine and alpine zone. It was found in 11 sites (28.95%). It is a spring breeder, mesophilous, forest, zoophagous, Central-European.

The number of individuals collected varied from 1 (0.41%) (Brașov 1996) to 141 (57.55%), (Brașov 1984). The total number of individuals collected is region-dependent. In the Brașov region there were collected 237 individuals (96.73%), in the Târgu Jiu basin, 8 individuals (3.27%). Any individual was not found in the Moldavia region (Fig. 3).

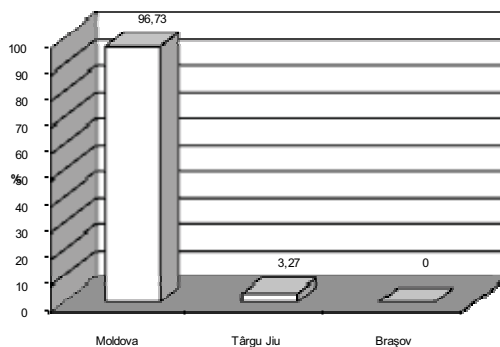


Figure 3. Numerical ratios of the individuals of *Carabus ullrichii* collected, on regions.  
 Figura 3. Raporturile numerice ale indivizilor de *Carabus ullrichii* colectați, pe regiuni.

During the years a strong annual variation was found, between 1 and 141 (Table 11, Fig. 4).

Table 11. Seasonal, numerical and percentage variation of the individuals of *Carabus ullrichii*, collected at Brașov. Legend as in figure 4.

Tabel 11. Variația sezonieră, numerică și procentuală a indivizilor de *Carabus ullrichii* în localitatea Brașov. Legenda ca în figura 4.

	Years										Total
Brașov	1984	1985	1986	1987	1988	1989	1992	1993	1996		
Nr.	141	29	29	17	2	4	2	12	1		237
%	59.50	12.24	12.24	7.17	0.84	1.69	0.84	5.06	0.42		100.0

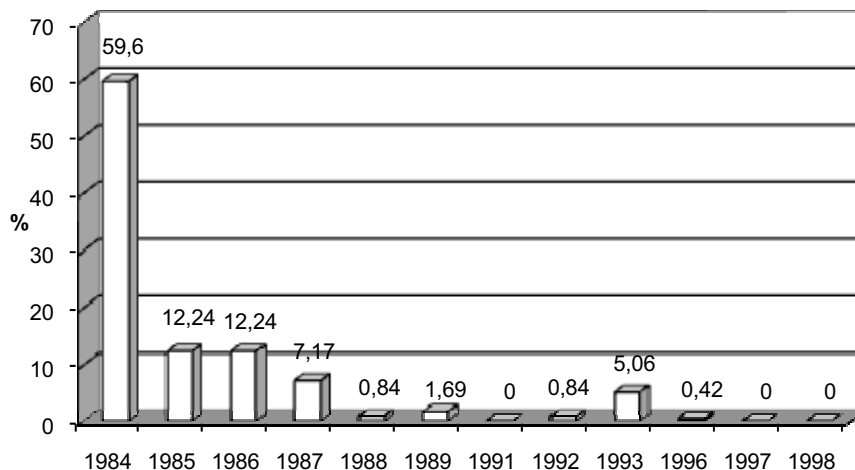


Figure 4. *Carabus ullrichii*. Percentage variation of the number of individuals collected in 1984-1998 at Brașov.  
 Figura 4. *Carabus ullrichii*. Variația procentuală a numărului de indivizi colectați în anii 1984-1998 la Brașov.

**4. *Carabus (Megodontus) violaceus*** LINNAEUS 1758 is a common species in Romania, from lowlands to the mountain areas (PANIN, 1955; GADEI & POPESCU, 2009). *Carabus violaceus* forms many subspecies (TURIN et al., 2003), of which *C. violaceus wolfii* DEJEAN 1926 and *C. violaceus andrezejuscii* FISCHER 1823 occur in Romania. *C. violaceus wolfii* occurs in forests and open landscape as well. It is autumn breeder, mesoxerophilous, eurytopic (TURIN et al., 2003), zoophagous, distributed in the West Palearctic region.

In potato crops, a total of 60 individuals (5.10%) was found in 11 sites (2.89%). In each site, number of individuals varied from 1 (1.67%) (Brașov 1984) to 34 (56.67%) (Vicovu de Jos 1998, Suceava County).

**5. *Carabus (Trachycarabus) besseri*** FISCHER VON WALDHEIM 1822 occurs only in Eastern Europe, including Ukraine westerly of the Dnieper, the Republic of Moldova, N.E. România, S.E. Poland (TURIN et al. 2003). It is an autumn breeder, mesophilous, occurs in the steppe, agricultural crops (cereals) and orchards, zoophagous. In Romania, it is distributed in Moldavia (PANIN, 1955), where it was found in two potato fields (5.26%), being collected 5 individuals; among which 1 individual in Secuieni, (1997, Neamț County), and 4 in Sârbi (1999, Botoșani County).

**6. *Carabus (Oreocarabus) glabratus*** PAYKULL 1790. In Romania it is spread from lowlands to mountains (GÂDEI & POPESCU, 2009). It is a summer breeder, mesophilous, predominantly forest, zoophagous, with a Euro-Siberian geographical distribution. Only four specimens were caught at Dorna Arini, 1993, a mountain region, the potato crop was placed near a coniferous forest.

**7. *Carabus (Morphocarabus) rothi*** DEJEAN 1829 is an endemic in Romania (TURIN et al., 2003), where it occurs in the forest-steppe zone, reaching to the zone of coniferous forests (GÂDEI & POPESCU, 2009). It breeds in summer, it is a mesophilous, open-land species, zoophagous. Four individuals were collected just in potato crop, Brașov, 1987. From other potato crops (Târgu Jiu basin and Moldova), it has not been recorded for 21 years, from 1978 to 1999.

**8. *Carabus (Tomocarabus) convexus*** FABRICIUS 1775 occurs in Romania in oak, beech and coniferous forests (PANIN, 1955, GÂDEI & POPESCU, 2009). It is a spring breeder, mesophilous, forest, zoophagous and with geographical distribution in Euro-Siberian region.

Only two individuals were collected in Dorna Arini (1993, Suceava County) near a coniferous forest.

**9. *Carabus (Procrustes) coriaceus*** LINNAEUS 1758 is common in Romania, especially in moderately humid forests, from lowlands to uplands (PANIN, 1955; GÂDEI & POPESCU, 2009), being represented by the subspecies *Carabus coriaceus rugifer* KRAATZ, 1877 (TURIN et al., 2003) It is an autumn breeder, mesophilous, forest, zoophagous, European. Two individuals were collected in the Dofteana locality in 1978.

**10. *Carabus (Hygrocarabus) variolosus*** FABRICIUS 1787 lives in Romania, in forests, in soaked litter along brooks (PANIN, 1955; GÂDEI & POPESCU, 2009). It is a spring breeder, hygrophilous, indiferent to shadowing, zoophagous, distributed in Europe and West Asia. In the potato crops a single individual was found in Vicovu de Jos (1998, Suceava County). Its occurrence was correlated with that of *Carabus granulatus*.

**11. *Carabus (Eucarabus) granulatus*** LINNAEUS 1758 occurs in whole România from the lowlands to uplands (PANIN, 1955, GÂDEI & POPESCU, 2009). It is a spring breeder, hygromesophilous, eurytopic, zoophagous, Palearctic (TURIN et al., 2003). In the potato crop only one individual was found in Vicovu de Jos, (1998, Suceava County). Its occurrence was correlated with that of *Carabus variolosus*.

## DISCUSSIONS

The species of epigeic arthropods as ectothermic invertebrates act in concrete conditions of habitats (pedoclimate and phytoclimate) in accordance with their ecological valences (preferences for temperature, humidity, food, competitiveness). Abundance of a species in an ecosystem is an important parameter that favors its survival. Abundance overlays to the law of tolerance. Changes in number of individuals of a species take form of a curve. In accordance with the Shelford's law of, most individuals concentrate 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, soil type and humidity (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 potato crops studied, 11 *Carabus* species were recorded. Their number in a site varied from 1-3 (Brașov 1984-1998: *Carabus cancellatus*, *C. scabriusculus*, *C. rothi*, *C. violaceus*; Moldova 1978-1999: *C. convexus*, *C. glabratus*, *C. scabriusculus*, *C. ullrichii*, *C. violaceus* and *C. besseri*, or 1-2 species (Târgu Jiu 1989-1998: *C. scabriusculus*, *C. ullrichii*). In the whole Brașov region four *Carabus* species were found in potato crops, while in Moldova six. This difference is explained by the different soil moisture and demonstrated biologically by presence of the mesophilous species, *C. cancellatus* and *C. ullrichii*.

In the Târgu Jiu basin the material was collected for 10 years, but only in five years there were also recorded the species *Carabus scabriusculus* and *C. ullrichii*. *C. scabriusculus*, a mixo-xerophilous species, living in the steppe and agricultural crops, was collected in 80 specimens, with a seasonal numerical variation ranging from 3 (1995) to 41 individuals (1988), while *C. ullrichii*, a mesophilous species, of moderately wet places, especially forests, was collected only in eight individuals.

The potato is a mesophilous crop. Its productivity in this area is below the national average, because of lower humidity of the soil correlated with the rainfalls, although the soil is of alluvial type; good productions are obtained at Brașov and in the Northern of Moldavia. Generally, in the potato crops, four species, *Carabus scabriusculus*, *C. cancellatus*, *C. ullrichii*, *C. violaceus* have the number of individuals (relative abundance) ranging from 5.11% (*C. violaceus*) and 46.64% (*C. scabriusculus*). Number of species and their relative abundance are determined by local, regional conditions of the habitat under the influence of the climate and of humidity.



Variation of abundance of a species is determined by local pedo-climatic conditions and season (spring, summer). The three regions, Braşov, Moldova and the Târgu Jiu basin differ in average temperature and annual precipitations. At Braşov, annual average temperature is 7.8°C, Moldova 8.5°C, Târgu Jiu 10.2°C, annual average precipitations are 548-782 mm Braşov, 450-550 mm in Moldova and 753 mm in Târgu Jiu. Comparing our data obtained referring to both the number of species but especially the relative abundance of some species, a positive correlation is observed between the abundance of species on regions and the quantity of precipitations at Braşov and the North of Moldova in comparison with the Târgu Jiu basin.

In *Carabus cancellatus* and *C. ullrichii*, in the Braşov region, a reduction in number of the individuals was observed. Thus, in *C. cancellatus*, in 1984, 44 individuals were collected (66.67 out of all individuals collected in the region); in *C. ullrichii* 141 (59.49%). Immediately, the next year (1985), in *C. cancellatus* the capturing percentage was 10.61% (six times lower than in the previous year) and in *C. ullrichii* 12.27% (four times lower than in 1984).

In the European and Central European zoogeographical regions with continental temperate climate the dynamics of species has a seasonal character recorded in the heredity of each species.

*Carabus scabriusculus* winters as adult and is active in spring. Most individuals were caught in potato crops in May, between 44.12% (Zvoriştea 1955, Suceava County) and 59.88% (Vânători, Iasi County).

*Carabus cancellatus* winters as adult. It is a spring species. Most individuals (Vânători, 1999) occurred in July and August, when 89.33% of all individuals collected were captured. Natural selection outlined the limits and intensity of activity in the ecosystem.

Natural selection has maintained and favored the sexual reproduction in the genetic benefit of descendents with 2n chromosomes. There are three natural sex ratio: Sex ratio equal to 1, sex ratio with the predominance of females, sex ratio with the predominance of males.

In the species *Carabus scabriusculus* (Dragomirna, 1995) the sex ratio was 64.71% females and 35.29% males, with 29.42% in females' favor. In the Vânători locality, 1999, 62.13% females and 32.87% males, with 24.16% in favor of females. The predominance of females favors the encounter between sexes and reduces the competition between males for females.

In the species, *Carabus cancellatus* (Dragomirna, 1995) the sex ratio was 64.71% females and 35.29% males, with 29.42% in favor of females; in the locality Vânători, 1999, the sex ratio was 52.25% females and 47.75% males, with 4.50% in favor of females.

Comparing the diversity of species of the genus *Carabus* in the potato crops with that in wheat crops in Romania (Moldavia, Banat, Wallachia) (VARVARA, 2009) similarities and differences appear. In the potato crops there were found 11 species of the genus *Carabus*, between 1-3 per locality, in the wheat crop, only seven species with 1-4 species per locality. The species found in both kinds of crops are *C. cancellatus*, *C. scabriusculus*, *C. violaceus*, *C. besseri*, *C. garnulatus*, *C. coriaceus*. Relative abundance of common species differs between the two crops because of preferences for moisture of the wheat crop and of the potato crop. The first three species are the main species by their abundance both in wheat crops and in potato crops. *Carabus besseri* is more spread in the wheat crops in Moldova, and less spread in the potato crops

The *Carabus* species, in both crops, breed predominantly in spring, they are mesophilous and zoofagous

## CONCLUSIONS

In the potato crops of Moldavia 11 species of the genus *Carabus* were found. In order of the number of individuals collected, the species are. *Carabus (Trachycarabus) scabriusculus* (46.60%), *C. (Tachypus) cancellatus tuberculatus* (25.77%), *C. (Eucarabus) ullrichii*, (20.83%), *C. (Megodontus) violaceus*, (5.10%), *C. (Trachycarabus) besseri*, (0.43%), *C. (Oreocarabus) glabratus*, (0.34%), *C. (Morphocarabus) rothi*, (0.34%), *C. (Tomocarabus) convexus*, (0.17%), *C. (Procrustes) coriaceus*, (0.17%), *C. (Hygrocarabus) variolosus*, (0.09%), *C. (Eucarabus) granulatus*, (0.09%).

Number of species of the genus *Carabus* varied between 1 and 3 species per locality, depending on the adjacent ecosystems, too (forest ecosystems, mesophilous vegetation). 54.55% of the species have their reproduction in spring and 27.27% are species reproducing in autumn. 81.82% of the species are mesophilous, all the specie are zoophagous.

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