

DIVERSITY OF COLEOPTERANS (COLEOPTERA: CARABIDAE, RHYSODIDAE, SILPHIDAE, SCARABAEIDAE, CUCUJIDAE, CERAMBYCIDAE) FROM THE “CODRII” SCIENTIFIC RESERVE OF THE REPUBLIC OF MOLDOVA

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Abstract. The present paper is dedicated to the research of the actual state of the diversity of species of coleopterans from the forest ecosystems of the scientific reserve “Codrii”, the trophic spectrum and rare and endangered species. As a result of the collectings made during 2004-2011, on the area of the scientific reserve “Codrii”, there were identified 103 species belonging to 52 genera and 7 families (Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Lucanidae, Cucujidae, Cerambycidae); 8 species are rare and menaced with extinction, of which 2 species are included in the 2nd edition of the Red Book of the Republic of Moldova. According to the preferable trophic system, the majority of coleopterans represents the zoophagous group, which constitutes 36% of the total number of the known species, followed by the phytophagous species (24%). The coprophagous species represent 14%, the xylophagous – 10%, the necrophagous – 9 and the mixophagous – 7%. At the same time there was studied the structure and the dynamics of the coleopterans coenoses from 3 types of forests of “Codrii” scientific reserve. There was shown how the ecological indexes (the index of diversity Shannon, Simpson, equitability) change within the whole period of vegetation of 2004-2011.

Keywords: coleopterans, diversity, trophic spectrum, zoogeography, ecology, entomophages.

Rezumat. Diversitatea coleopterelor (Coleoptera: Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Cucujidae, Cerambycidae) din rezervația științifică „Codrii”. Lucrarea de față prezintă fauna și diversitatea speciilor de coleoptere din ecosistemele forestiere ale rezervației științifice „Codrii”. Ca rezultat al colectărilor în perioada anilor 2004-2011, în ecosistemele forestiere ale rezervației științifice „Codrii” au fost identificate 103 specii de coleoptere ce aparțin la 52 genuri și 7 familii (Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Lucanidae, Cucujidae, Cerambycidae), dintre care 8 specii sunt rare și amenințate cu extincția, două dintre ele fiind incluse în ediția II a Cărții Roșii a Moldovei. După preferințele trofice, majoritatea speciilor de coleoptere identificate aparțin grupului zoofagilor – 36%, urmat de grupul fitofagilor – 24%. Coprofagii constituie 14%, xilofagii – 10%, necrofagii – 9%, iar mixofagii – 7%. De asemenea, se arată structura și dinamica cenozelor de coleoptere din 3 tipuri de păduri ale rezervației științifice „Codrii”. Astfel, valorile indicelui de diversitate Shanon, indicelui Simpson și echitabilitatea variază pe întreaga perioadă a anilor 2005-2011.

Cuvinte cheie: Coleoptera, diversitate, spectru trofic, zoogeografie, ecologie, entomofagi.

INTRODUCTION

“Codrii” forests of Moldova include various objects and natural complexes with undeniable value for the conservation of biodiversity and of natural habitats. The results of investigations in this area will allow to obtain more detailed information on coleopteran diversity of forest ecosystems, species structure and to substantiate some ways of their protection and conservation. We have to mention that special investigations of coleopterans in the scientific reserve “Codrii” have not been performed so far.

The first studies of insect fauna in the area were accomplished by MILLER and ZUBOVSKI at the beginning of the 20th century (1917). In 30's-40's of the past century new data on some carabid coleopterans from this zone were presented in the papers of ARION & PANIN (1928), IENIȘTEA (1938), KNECTEL & PANIN (1944), etc.

In the second half of the 20th century various taxonomic, faunistic works were published completed with new ecological and biological data provided by foreign and local specialists (MEDVEDEV & SHAPIRO, 1957; ADASHKEVICI, 1970; NECULISEANU, 1991, 2004, etc.). Scientific papers were also published, where new species for the fauna of R. Moldova were described, species collected in forests of “Codrii” scientific reserve (ADASHKEVICI, 1970; NECULISEANU & MATALIN, 1995, 2000; BABAN, 2005, 2006, 2009).

In the last years several studies of entomofauna from some types of deciduous woods were performed. As a result of these investigations rare and threatened species were emphasized as well (NECULISEANU *et al.*, 1992a, 1992b, 2004; BABAN & CALESTRU, 2011).

MATERIAL AND METHODS

The studies were performed in vegetation period of 2005-2011 in 3 wood types from “Codrii” scientific reserve, which present different peculiarities of soil and vegetation: mixed oak and hornbeam forest, oak and beech forest, mixed forest of oak and lime-ash.

Wood coleopterans were collected by soil Barber pitfalls, using dished with the volume of 700 ml and collection with entomological net, the manual of the various plants, shrubs, ground, etc. As fixative-preserving liquid served the concentrated solution of sodium chloride (NaCl) and acetic acid (CH₃COOH).

In total, during the three years, there were collected and analysed about 7,500 individuals.

Synecological analysis was based on the estimation of ecological synthetic indices: index of ecological diversity using Shannon function, modified by Mac Arthur corrected by Lloyd and Ghelardi, equitability according to STAN (1994), ANDREEV (2002) and SIMIONESCU (1983). Coleopteran identification was made based on the works of KRYŽANOVSKIJ (1965), PANIN (1955), FREUDE *et al.* (1976).

RESULTS AND DISCUSSION

"Codrii" scientific reserve is characterized by high faunistic heterogeneity. Coleopteran fauna found in these forest ecosystems is represented by 103 species belonging to 52 genera and 7 families, of which 8 species are rare and endangered in Moldova (*Carabus intricatus* L., *C. ullrichi* GERM., *Aptinus bombardata* ILL., *Gnorimus nobilis* L., *Cetonischema aeruginosa* DR., *Lucanus cervus* L., *Cucujus cinnaberinus* SCOP., *Morimus funereus* MULS.).

The collected species belong to the following families: Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Lucanidae, Cucujidae and Cerambycidae (Table 1).

During the research period, more representative from the diversity point of view proved to be the families: Carabidae with 60 species belonging to 22 genera and Scarabaeidae with 21 species from 7 genera. Other families were represented by a smaller number of species, as it follows: Silphidae with 9 species of 6 genera, Cerambycidae (8 species) and Lucanidae – 3 species. Rhysodidae and Cucujidae families were represented only by a single species.

Table 1. Coleopteran fauna from the forest ecosystem of "Codrii" scientific reserve.
Tabel 1. Fauna coleoptereilor din ecosistemele forestiere ale rezervației științifice „Codrii”.

No.	Species	Oak and hornbeam forest	Oak and beech forest	Oak and lime-ash forest	Trophic spectrum
Family Carabidae					
1.	<i>Calosoma inquisitor</i> (LINNAEUS 1758)	+	+	+	Zoophagous
2.	<i>Nebria transsylvanica</i> (GERMAR 1824)	+	+	+	Zoophagous
3.	<i>Notiophilus laticollis</i> CHAUDOIR 1850	-	+	-	Zoophagous
4.	<i>N. biguttatus</i> (FABRICIUS 1779)	+	+	+	Zoophagous
5.	<i>Carabus convexus</i> FABRICIUS 1775	+	+	+	Zoophagous
6.	<i>C. excellens</i> KRAATZ 1887	+	+	+	Zoophagous
7.	<i>C. arvensis</i> HERBST 1784	+	+	+	Zoophagous
8.	<i>C. ullrichi</i> GERMAR 1824	+	+	+	Zoophagous
9.	<i>C. cancellatus</i> ILIGER 1798	+	+	+	Zoophagous
10.	<i>C. intricatus</i> LINNAEUS 1761	+	-	-	Zoophagous
11.	<i>C. coriaceus</i> KRAATZ 1877	+	+	+	Zoophagous
12.	<i>Cychrus caraboides</i> (LINNAEUS 1758)	-	-	+	Zoophagous
13.	<i>C. semigranosus</i> PALLIARDI 1825	+	-	-	Zoophagous
14.	<i>Clivina fossor</i> (LINNAEUS 1758)	+	-	-	Mixophagous
15.	<i>Pterostichus niger</i> (SHALLER 1783)	+	+	+	Mixophagous
16.	<i>Pt. chamaeleon</i> MOTSHULSKY 1865	+	-	-	Zoophagous
17.	<i>Pt. oblogopunctatus</i> (FABRICIUS 1787)	+	+	+	Zoophagous
18.	<i>Pt. melanarius</i> (ILLIGER 1798)	+	+	+	Zoophagous
19.	<i>Pt. melas</i> (CREUTZER 1799)	+	+	+	Mixophagous
20.	<i>Pt. hungaricus</i> DEJEAN 1828	-	+	+	Zoophagous
21.	<i>Pt. anthracinus</i> (ILLIGER 1798)	+	-	-	Zoophagous
22.	<i>Pt. strenuus</i> (PANZER 1797)	+	-	-	Zoophagous
23.	<i>Pt. ovoideus</i> (STURM 1824)	+	+	+	Zoophagous
24.	<i>Abax parallelopedus</i> (PILLER 1783)	+	+	+	Zoophagous
25.	<i>A. carinatus</i> (DUFTSCHMID 1812)	+	+	+	Zoophagous
26.	<i>A. parallelus</i> (DUFTSCHMID 1812)	+	+	+	Zoophagous
27.	<i>Molops piceus</i> (PANZER 1793)	+	+	+	Zoophagous
28.	<i>Calathus distinguendus</i> CHAUDOIR 1846	+	+	+	Mixophagous
29.	<i>C. fuscipes</i> (GOEZE 1777)	-	-	+	Mixophagous
30.	<i>C. ambiguus</i> (PAYKULL 1790)	+	-	-	Mixophagous
31.	<i>Agonum duftschmidti</i> SCHMIDT 1994	+	-	-	Zoophagous
32.	<i>A. viduum</i> (PANZER 1797)	+	+	-	Zoophagous
33.	<i>Platynus assimile</i> (PAYKULL 1790)	+	+	+	Zoophagous
34.	<i>Pl. krynickii</i> (SPERK 1835)	+	+	+	Zoophagous
35.	<i>Anchomenus dorsale</i> (PONTOPPIDAN 1763)	+	-	+	Zoophagous
36.	<i>Amara eurynota</i> (PANZER 1797)	+	-	-	Phytophagous
37.	<i>A. familiaris</i> (DUFTSCHMID 1812)	+	-	+	Phytophagous

1	2	3	4	5	6
38.	<i>A. ovata</i> (FABRICIUS 1792)	+	+	+	Phytophagous
39.	<i>Stenolophus discophorus</i> FISCHER, WALDHEIM 1823	-	-	+	Zoophagous
40.	<i>Harpalus rufipes</i> (DE GEER 1774)	+	+	+	Phytophagous
41.	<i>H. tenebrosus</i> DEJEAN 1829	+	+	+	Phytophagous
42.	<i>H. atratus</i> LATREILLE 1804	+	+	+	Phytophagous
43.	<i>H. flavicornis</i> DEJEAN 1829	+	+	-	Phytophagous
44.	<i>H. calathoides</i> MOTSKULSKZ 1844	+	+	-	Phytophagous
45.	<i>H. tardus</i> (PANZER 1797)	+	+	-	Phytophagous
46.	<i>H. latus</i> (LINNAEUS 1758)	+	-	+	Phytophagous
47.	<i>H. quadripunctatus</i> DEJEAN 1829	-	-	+	Phytophagous
48.	<i>Ophonus gammeli</i> (SHAUBERGER 1933)	-	+	+	Phytophagous
49.	<i>O. puncticollis</i> (PAYKULL 1798)	-	-	+	Phytophagous
50.	<i>O. rufibarbis</i> (FABRICIUS 1792)	+	+	+	Phytophagous
51.	<i>O. diffinis</i> (DEJEAN 1829)	+	-	-	Phytophagous
52.	<i>O. nitidulus</i> STEPHENS 1828	+	-	-	Phytophagous
53.	<i>Panagaeus cruxmajor</i> LINNAEUS 1758	+	-	-	Zoophagous
54.	<i>Licinus cassideus</i> (FABRICIUS 1792)	-	+	-	Zoophagous
55.	<i>L. depressus</i> (PAYKULL 1790)	+	-	-	Zoophagous
56.	<i>Cymindis humeralis</i> (FOURCROY 1785)	-	+	-	Zoophagous
57.	<i>C. macularis</i> FISCHER & WALDHEIM 1824	-	-	+	Zoophagous
58.	<i>Drypta dentata</i> (ROSSI 1790)	+	+	-	Zoophagous
59.	<i>Aptinus bombardia</i> (ILLIGER 1800)	-	-	+	Zoophagous
60.	<i>Brachinus crepitans</i> (LINNAEUS 1758)	+	+	+	Mixophagous
Family Rhysodidae					
61.	<i>Rhysodes sulcatus</i> (FABRICIUS 1787)	+	-	-	Xylophagous
Family Silphidae					
62.	<i>Nicrophorus vespilloides</i> HERBST 1784	+	+	+	Necrophagous
63.	<i>N. fossor</i> ERICHSON 1837	+	-	-	Necrophagous
64.	<i>N. investigator</i> (ZETT. 1824)	+	-	+	Necrophagous
65.	<i>Necrodes littoralis</i> LINNAEUS 1758	+	-	-	Necrophagous
66.	<i>Tanatophilus rugosus</i> (LINNAEUS 1758)	+	-	-	Necrophagous
67.	<i>Oiceoptoma thoracicum</i> (LINNAEUS 1758)	+	-	-	Necrophagous
68.	<i>Phosphuga atrata</i> (LINNAEUS 1758)	+	-	-	Necrophagous
69.	<i>Silpha carinata</i> HERBST 1783	+	-	+	Necrophagous
70.	<i>S. tristis</i> ILLIGER 1798	+	-	-	Necrophagous
Family Scarabaeidae					
71.	<i>Geotrupes stercorarius</i> (LINNAEUS 1758)	+	-	+	Coprophagous
72.	<i>G. stercorosus</i> SCRIBA 1791	+	+	+	Coprophagous
73.	<i>Aphodius fimetarius</i> (LINNAEUS 1758)	+	-	-	Coprophagous
74.	<i>A. luridus</i> FABRICIUS 1775	+	-	-	Coprophagous
75.	<i>A. rufipes</i> LINNAEUS 1758	+	-	-	Coprophagous
76.	<i>Caccobius schreberi</i> (LINNAEUS 1761)	+	-	-	Coprophagous
77.	<i>Onthophagus coenobita</i> (HERBST 1783)	+	-	-	Coprophagous
78.	<i>O. fracticornis</i> PREYSSLER 1790	+	-	-	Coprophagous
79.	<i>O. illyricus</i> SCOPOLI 1763	+	-	-	Coprophagous
80.	<i>O. ovatus</i> (LINNAEUS 1758)	+	-	-	Coprophagous
81.	<i>O. ruficapillus</i> BRULLE 1832	+	-	-	Coprophagous
82.	<i>O. taurus</i> SCHREBER 1759	+	-	-	Coprophagous
83.	<i>O. vacca</i> (LINNAEUS 1767)	+	-	-	Coprophagous
84.	<i>O. verticicornis</i> LEICHTING 1781	+	-	-	Coprophagous
85.	<i>Melolontha melolontha</i> LINNAEUS 1758	-	+	+	Phytophagous
86.	<i>Gnorimus nobilis</i> LINNAEUS 1758	-	+	+	Phytophagous
87.	<i>Epicometis hirta</i> (PODA 1761)	-	-	+	Phytophagous
88.	<i>Oxythyrea funesta</i> (PODA 1761)	-	-	+	Phytophagous
89.	<i>Cetonia aurata</i> (LINNAEUS 1758)	+	+	+	Phytophagous
90.	<i>Liocola lugubris</i> HERBST 1786	-	-	+	Phytophagous
91.	<i>Cetonischema aeruginosa</i> DRURY 1770	+	-	+	Xylophagous

Family Lucanidae					
92.	<i>Lucanus cervus</i> LINNAEUS 1758	+	+	+	Xylophagous
93.	<i>Dorcus paralellopedus</i> (LINNAEUS 1758)	+	+	+	Xylophagous
94.	<i>Platycerus caraboides</i> (LINNAEUS 1758)	+	-	-	Xylophagous
Family Cucujidae					
95.	<i>Cucujus cinnaberinus</i> SCOPOLI 1763	+	-	+	Xylophagous
Family Cerambycidae					
96.	<i>Rhagium mordax</i> (DE GEER 1775)	-	-	+	Xylophagous
97.	<i>Rh. sycophanta</i> (SCHRANK 1781)	-	-	+	Xylophagous
98.	<i>Cerambyx scopoli</i> FUSSLINS 1775	-	-	+	Xylophagous
99.	<i>Monochamus sutor</i> (FABRICIUS 1787)	+	-	-	Xylophagous
100.	<i>Morimus funereus</i> MULSANT 1863	+	+	-	Xylophagous
101.	<i>Dorcadion pedestre</i> PODA 1761	-	-	+	Phytophagous
102.	<i>D. equestre</i> (LAXMANN 1770)	-	-	+	Phytophagous
103.	<i>Agapanthia maculicornis</i> (GYLLENHAL 1817)	+	-	-	Phytophagous

In terms of quality, the highest number of species was recorded in mixed oak and hornbeam forest (86 species, 57 genera and 7 families), followed by oak forest with lime-ash (59 species) and mixed oak and beech forest (45 species).

After examining the coleopterans composition in the investigated forest types, we found that after the food spectrum, coleopteran fauna in forest ecosystems of the reserve “Codrii” are grouped into six trophic groups: zoophagous, mixophagous, phytophagous, xylophagous, necrophagous and coprophagous species. The majority of species belong to the zoophagous group - 36%, followed by phytophagous 24%. In decreasing order, there are the coprophagous (14%), xylophagous (10%), necrophagous (9%) and mixophagous (7%) (Fig. 1).

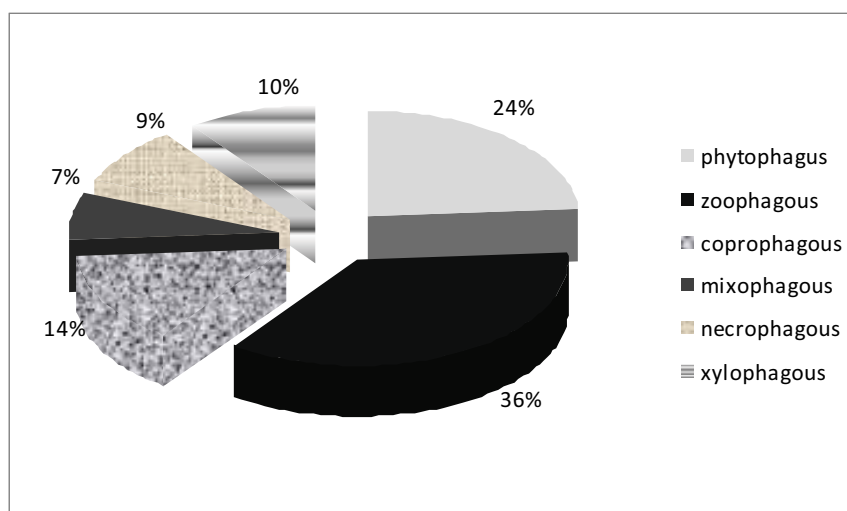


Figure 1. Trophic spectrum of coleopterans from the forest ecosystems.
 Figura 1. Spectrul trofic al coleopterelor din ecosistemele forestiere.

At the same time, as a result of the analysis of calculated diversity indices in relation to the investigated forest types it results: the highest value of Shannon diversity index (Ish) was registered in mixed forest of oak and lime-ash (1.09) and in oak and beech mixed forest (1.06), while the diversity with the lowest value was recorded in mixed forest of oak and hornbeam (0.98).

Table 2. Values of diversity indexes of indicator coleopteran group (Carabidae) in studied stations.
 Tabel 2. Valorile indicilor de diversitate a grupei de coleoptere indicatoare (Carabidae) în stațiunile investigate.

Ecological index	Oak and hornbeam forest	Oak and beech forest	Oak and lime-ash forest
If ε	0.14	0.24	0.34
%	15	24	34
Simpson index	0.20	0.13	0.11
%	-20	-13	-11
Shannon diversity index	0.98	1.06	1.09
%	65	16	73
Σ %	60	27	96
Species number.	77	49	61

Legend: ε – equity.

Another very important aspect of diversity is the equity index (ϵ), which characterizes the uniformity of distribution of individual by species. If $\epsilon = 1$, then equity would be ideal and all species of studied biocoenosis would have the same number of individuals.

From the analysis of the degree of balancing of coleopteran groups, it results that the greatest similarity is observed between oak with lime-ash forest and oak with beech forest, while oak mixed with hornbeam forest is characterized by a greater inequality in the distribution of individual by species, with the equity index value of 0.15.

As a result of summing these three indices, full data can be obtained regarding the stability of biocoenoses in the ecosystem and also its deterioration. Thus, as a result of summing up, it was emphasized that the oak with lime-ash forest has a high diversity, which demonstrates that it is more stable compared to other investigated ecosystems.

Given that the question of secular forest stands at European level, it is necessary that the Republic of Moldova intensify the work on conservation of these forests and urgent action are necessary to stop deforestation in places where they are still preserved. We believe that this problem can be solved only through close cooperation between policy makers, scientists and society.

CONCLUSIONS

1. The coleopteran fauna of "Codrii" Scientific Reserve is represented by 103 species belonging to 52 genera and 7 families, of which the species *Carabus intricatus* L., *Aptinus bombardata* ILL., *Cetonischema aeruginosa* DR., *Lucanus cervus* L., *Cucujus cinnaberinus* SCOP., *Morimus fumereus* MULS. are rare and endangered.

2. In terms of quality, the highest number of species was registered in the mixed oak and hornbeam forest (86 species, 37 genera and 4 families), followed by the oak forest mixed with lime-ash (59 species) and oak and beech mixed forest (45 species).

3. Most coleopteran collected species are zoophagous, constituting 36%, followed by phytophagous 24%. In accordance with the food spectrum, in decreasing order are the coprophagous species (14%), xylophagous (10%), necrophagous (9%) and mixophagous (7%).

4. In "Codrii" Scientific Reserve, the Shannon diversity index H' showed high values in the mixed forest of oak and lime-ash (1.088) and in the mixed oak and beech forest (1.059), while the diversity value was the lowest in the mixed forest of oak and hornbeam (0.975).

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