# BRVKENTHAL. ACTA MVSEI

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*** Within this issue the article *GIS APPROACH ON USING LIDAR DATA TO ESTIMATE THE NUMBER OF THE TREES* was part of a project which participated to a USA national contest in September, 2013 organized by NISC (National Information Solutions Cooperative). Pioneer Electric Cooperative was recognized by NISC Award for Service Excellence 2013 for developing and implementing new standards in the category of Service Excellence in Technology: Technology Award, Honorable mention. This project was a team effort on behalf of this electric cooperative, realized by three of its employee: GIS Analyst: **Roxana Giușcă PhD,** GISP, Manager of Engineering: Todd Garrett, MBA and Manager of Vegetation: Danny Bagwell.

# CHECKLIST OF BEETLES (*INSECTA: COLEOPTERA*) OF THE REPUBLIC OF MOLDOVA

**Svetlana BACAL**[*]
**Natalia MUNTEANU**[**]
**Ion TODERAȘ**[***]

***Abstract.*** *The present paper is an updated list of beetle species (Coleoptera) from the Republic of Moldova. The 2512 species belong to 14 superfamilies, 69 families and 150 subfamilies. The list is based on specialized literature sources, collections and faunistic researches made by the author.*
***Key words:*** *Insecta, Coleoptera, species, checklist, Republic of Moldova.*

***Rezumat.*** *Lucrarea prezintă o listă actualizată a speciilor de coleoptere din Republica Moldova. Cele 2512 specii, aparțin la 14 suprafamilii, 69 familii și 150 subfamilii. Lista este întocmită pe baza datelor din literatura de specialitate, a colecțiilor și studiilor faunistice realizate de autori.*
***Cuvinte cheie:*** *Insecta, Coleoptera, specii, lista faunistică, Republica Moldova*

## Introduction

Beetles, the insect order Coleoptera, form the most numerous group of insects throughout the animal kingdom. In ecological terms this is a very diverse group of insects occupying a wide variety of terrestrial and freshwater ecological niches. The value of these animals to ecosystems is enormous, and thus, knowledge of fauna is of particular importance.

The first faunistic data on beetle species from the Republic of Moldova have been mentioned by Rekalo (1888), Jacobson (1905 - 1914), Mokrzhetsky (1903), Yatsentkovsky (1912). A faunistic list of beetles from the Republic of Moldova, comprising 1208 species, was for the firts time published by Miller and Zubovskiy in 1917. A second valuable work on beetles fauna of the investigated territory has been published in 1957 by Medvedev and Shapiro, the list was enlarged with 318 species. Later on, compound studies concerning ecology and faunistics, with new species records on some systematic groups of beetles in the Republic of Moldova have been conducted: on Elateridae (Ostafichuk 1968), Staphylinidae (Neculiseanu 1984, Bacal 2008), Carabidae (Neculiseanu 2003), Scarabaeidae (Cilipic 1998), Chrysomelidae (Calestru 2003), Curculionoidea (Poiras 1990, 1998, 2006, Munteanu 2009), Cerambycidae (Baban 2006), Tenebrionidae (Neculiseanu, Bacal 2005). Additional, information on some new species records are presented by Adashkevich (1970), Dănilă (2004), Bacal, Stan (2006), Munteanu (2006), Bacal, Derunkov (2010), Bacal (2011) and Derunkov, Bacal (2011).

The necessity to summarize all the available literature on beetles fauna of the Republic of Moldova was felt for a long time. A lot of information scattered in various publications was forgotten and unusable in the studies of Coleoptera. Therefore, the publication of an updated checklist became an urgent necessity. To fill up this gap a checklist of beetles (Insecta, Coleoptera) of the Republic of Moldova, summarizing all available literature sources and collections were created.

A total of 14 superfamilies, 69 families, 150 subfamilies and 2512 species are presented. The superfamilies, families and subfamilies are listed in the presumed phylogenetic position, according to Bouchard *et al.* (2011), and species in alphabetical order. The nomenclature and the systematics are given according to Kryzhanovskij (1995), Alonso-Zarazaga, Lyal (1999), Legalov (2003) and Lobl, Smetana (2004). The subspecies and the varieties are omitted.

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**List of species**

**Order Coleoptera** Linnaeus, 1758

**Suborder Adephaga** Clairville, 1806

**Superfamily Caraboidea,** Latreille, 1802

**Family Gyrinidae** Latreille, 1810
*Aulonogyrus* Motschulsky, 1853
*concinnus* Klug, 1834
*Gyrinus* Geoffroy, 1762
*natator* Linnaeus, 1758
**Family Rhysodidae** Laporte, 1840
*Rhysodes* Dalman, 1823
*sulcatus* (Fabricius, 1787)
*germari* (Ganglbauer, 1892)
**Family Carabidae** Latreille, 1802
Subfamily Cicindelinae Latreille, 1802
*Cicindela* Linnaeus, 1758
*campestris* Linnaeus, 1758
*hybrida* Linnaeus, 1758
*maritima* Latreille & Dejean, 1822
*soluta* Latreille & Dejean, 1822
*sylvatica* Linnaeus, 1758
*sylvicola* Latreille & Dejean, 1822
*Cephalota* Dokhtouroff, 1883
*chiloleuca* (Fischer, 1820)
*elegans* (Fischer, 1823)
*Cylindera* Westwood, 1831
*arenaria* (Fuessly, 1775)
*contorta* (Fischer, 1828)
*germanica* (Linnaeus, 1758)
*Calomera* Motschulsky, 1862
*littoralis* (Fabricius, 1787)
Subfamily Omophroninae Bonelli, 1810
*Omophron* Latreille, 1802
*limbatum* (Fabricius, 1777)
Subfamily Carabinae Latreille, 1802
*Leistus* Froelich, 1799
*ferrugineus* (Linnaeus, 1758)
*piceus* Froelich, 1799
*rufomarginatus* (Duftschmid, 1812)
*Nebria* Latreille, 1825
*brevicollis* (Fabricius, 1792)
*livida* (Linnaeus, 1758)
*rufescens* (Stroem, 1768)
*transsylvanica* (Germar, 1824)
*Notiophilus* Dumeril, 1806
*aestuans* Motschulsky, 1864
*aquaticus* (Linnaeus, 1758)
*biguttatus* (Fabricius, 1779)
*germinyi* Fauvel, 1863
*interstitialis* Reitter, 1889
*laticollis* Chaudoir, 1850
*palustris* (Duftschmid, 1812)
*rufipes* Curtis, 1829
*Calosoma* Weber, 1758
*auropunctatum* (Herbst, 1784)
*denticole* Gebler, 1833
*inquisitor* (Linnaeus, 1758)
*investigator* (Illiger, 1798)
*sycophanta* (Linnaeus, 1758)
*Carabus* Linnaeus, 1758
*arvensis* Herbst, 1784
*bessarabicus* Fischer & Waldheim, 1823
*besseri* Fischer & Waldheim, 1822
*cancellatus* Illiger, 1798
*clathratus* Linnaeus, 1761
*convexus* Fabricius, 1775
*coriaceus* Kraatz, 1877
*estreicheri* Fischer & Waldheim, 1822
*excellens* Kraatz, 1887
*glabratus* Kraatz, 1885
*granulatus* Linnaeus, 1758
*haeres* Fischer & Waldheim, 1823
*hortensis* Linnaeus, 1758
*hungaricus* Motschulsky, 1847
*intricatus* Linnaeus, 1761
*linnei* Panzer, 1812
*marginalis* Fabricius, 1794
*nemoralis* Muller, 1764
*obsoletus* Palliardi, 1825
*scabriusculus* Olivier, 1795
*ullrichi* Germar, 1824
*variolosus* Linnaeus, 1787
*violaceus* Dejean, 1826
*Cychrus* Fabricius, 1774
*attenuatus* Fabricius, 1792
*caraboides* (Linnaeus, 1758)
*semigranosus* Palliardi, 1825
*Elaphrus* Fabricius, 1775
*angusticollis* Sahlberg, 1844
*aureus* Muller, 1821
*riparius* (Linnaeus, 1758)
*uliginosus* Fabricius, 1775
*Loricera* Latreille, 1802
*pilicornis* (Fabricius, 1775)
*Scarites* Fabricius, 1775
*terricola* Bonelli, 1813
*Clivina* Latreille, 1802
*collaris* (Herbst, 1784)
*fossor* (Linnaeus, 1758)
*laevifrons* Chaudoir, 1842
*ypsilon* Dejean, 182
*Dyschirius* Bonelli, 1810
*angustatus* (Ahrens, 1830)
*caspius* Putzeys, 1866
*Dyschiriodes* Jeannel, 1941
*aeneus* (Dejean, 1825)
*agnatus* Motschulsky, 1844
*apicalis* (Putzeys, 1846)

*chalceus* (Erichson, 1837)
*chalybeus* (Apfelbeck, 1899)
*cylindricus* (Fleischer, 1905)
*globosus* (Herbst, 1783)
*impunctipennis* (Dawson, 1854)
*intermedius* (Putzeys, 1846)
*iportunus* (Schaum, 1857)
*laeviusculus* (Putzeys, 1846)
*lafertei* (Putzeys, 1846)
*luticola* (Chaudoir, 1850)
*macroderus* (Chaudoir, 1850)
*nitidus* Dejean, 1825
*parallelus* (Putzeys, 1846)
*politus* (Dejean, 1825)
*pusillus* (Dejean, 1825)
*rufipes* Dejean, 1825
*salinus* (Putzeys, 1846)
*strumosus* (Erichson, 1837)
*tristis* (Stephens, 1827)
*Broscus* Panzer, 1813
*cephalotes* (Linnaeus, 1758)
*semistriatus* (Dejean, 1828)
*Perileptus* Schaum, 1860
*areolatus* (Creutzer, 1799)
*Thalassophilus* Wollaston, 1854
*longicornis* (Sturm, 1825)
*Blemus* Dejean, 1821
*discus* (Fabricius, 1792)
*Trechus* Clairville, 1806
*austriacus* Dejean, 1831
*quadristriatus* (Schrank, 1781)
*secalis* (Paykull, 1790)
*Tachys* Stephens, 1821
*scutellaris* (Stephens, 1828)
*Paratachys* Casey, 1918
*bistriatus* (Duftschmid, 1812)
*centriustatus* Reitter, 1894
*fulvicollis* (Dejean, 1831)
*micros* (Fischer, 1828)
*turkestanicus* Reitter, 1894
*Elaphropus* Motschulsky, 1839
*hoemorrhoidalis* (Ponza, 1805)
*parvulus* (Dejean, 1831)
*quadrisignatus* (Duftschmid, 1812)
*sexstriatus* (Duftschmid, 1812)
*Porotachys* Netolitzky, 1914
*bisulcatus* (Nicolai, 1822)
*Tachyta* Kirby, 1837
*nana* (Gyllenhal, 1810)
*Asaphidion* Gozis, 1886
*flavipes* (Linnaeus, 1761)
*pallipes* (Duftschmid, 1812)
*Bembidion* Latreille, 1802
*aeneum* Germar, 1824
*andrea* Muller, 1830
*articulatum* (Panzer, 1796)
*assimile* Gyllenhal, 1810
*atlanticum* Wollaston, 1854
*atroviolaceus* Dufour, 1820
*azurescens* Torre, 1877
*biguttatum* (Fabricius, 1779)
*bipunctatum* (Linnaeus, 1761)
*dalmatinum* Dejean, 1831
*decorum* (Panzer, 1799)
*deletum* Serville, 1821
*dentellum* (Thunberg, 1787)
*distinguendum* Jacquelin du Val, 1852
*doderoi* Ganglbauer, 1892
*doris* (Panzer, 1797)
*ellipticocurtum* Netolitzky, 1935
*ephippium* (Marsham, 1802)
*femoratum* Sturm, 1825
*fluviatile* Dejean, 1931
*fumigatum* (Duftschmid, 1812)
*genei* Netolitzky, 1914
*geniculatum* Heer, 1837
*guttula* (Fabricius, 1792)
*guttulatum* Chaudoir, 1850
*inoptatum* Schaum, 1857
*lampros* Herbst 1784
*laticolle* (Duftschmid, 1812)
*latiplaga* Chaudoir, 1850
*litorale* (Olivier, 1790)
*lunatum* (Duftschmid, 1812)
*lunulatum* (Geoffroy, 1785)
*mannerheimii* Sahlberg, 1827
*milleri* Jacquelin du Val, 1852
*minimum* (Fabricius, 1792)
*modestum* (Fabricius, 1801)
*normannum* Dejean, 1831
*obliquum* Sturm, 1825
*octomaculatum* (Goeze, 1777)
*persicum* Menetries, 1832
*properans* (Stephens, 1829)
*punctulatum* Drapiez, 1820
*pygmaeum* (Fabricius, 1792)
*quadrimaculatum* (Linnaeus, 1761)
*quadripustulatum* Serville, 1821
*rivulare* Apfelbeck, 1904
*ruficolle* (Panzer, 1797)
*saxatile* Gyllenhal, 1827
*schueppelii* Dejean, 1831
*semipunctatum* (Donovan, 1806)
*splendidum* Sturm, 1825
*stephensii* Crotch, 1866
*striatum* (Fabricius, 1792)
*subcostatum* (Motschulsky, 1850)
*tenellum* Erichson, 1837
*testaceum* Duftschmid, 1812
*tetracolum* Say, 1823
*tetragrammum* Chaudoir, 1846
*tetrasemum* Chaudoir, 1846

*tibiale* (Duftschmid, 1812)
*varium* (Olivier, 1795)
*velox* (Linnaeus, 1761)
*Pogonus* Dejean, 1821
*cumanus* Lutshik, 1916
*iridipennis* Nicolai, 1822
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*meridionalis* Dejean, 1828
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*Stomis* Clairville, 1806
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*aenea* (De Geer, 1774)
*anthobia* Villa & Villa, 1833
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*bifrons* (Gyllenhal, 1810)
*brunnea* (Gyllenhal, 1810)
*chaudoiri* Putzeys, 1858
*communis* (Panzer, 1797)
*consularis* (Duftschmid, 1812)
*convexior* Stephens, 1828
*crenata* Dejean, 1828
*curta* Dejean, 1828
*diaphana* Tschitscherine, 1894
*equestris* (Duftschmid, 1812)
*eurynota* (Panzer, 1797)
*familiaris* (Duftschmid, 1812)
*fulva* (Muller, 1776)
*fusca* Dejean, 1828
*infima* (Duftschmid, 1812)
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*praetermissa* (Sahlberg, 1827)
*sabulosa* (Serville, 1821)
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*saxicola* Zimmermann, 1831
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*binotatus* (Fabricius, 1787)
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*steveni* Krynicki, 1832
*teutonus* (Schrank, 1781)
*Acupalpus* Latreille, 1829
*brunnipes* (Sturm, 1825)
*dubius* Schilsky, 1888
*elegans* (Dejean, 1829)
*exiguus* (Dejean, 1829)
*flavicollis* (Sturm, 1825)
*interstitialis* Reitter, 1884
*luteatus* (Duftschmid, 1812)
*maculatus* (Schaum, 1860)
*meridianus* (Linnaeus, 1767)
*parvulus* (Sturm, 1825)
*suturalis* Dejean, 1829
*Anthracus* Motschulsky, 1850
*consputus* (Duftschmid, 1812)
*longicornis* (Schaum, 1857)
*transversalis* (Schaum, 1862)
*Daptus* Fischer, 1823
*vittatus* Fischer, 1823
*Trichotichnus* Morawitz, 1863
*laevicolis* (Duftschmid, 1812)
*Parophonus* Ganglbauer, 1891
*hirsutulus* (Dejean, 1829)
*maculicornis* (Duftschmid, 1812)
*mendax* (Rossi, 1790)
*Harpalus* Latreille, 1802
*affinis* (Schrank, 1781)
*albanicus* Reitter, 1900
*amplicollis* Menetries, 1848

*angulatus* Macleay, 1871
*anxius* (Duftschmid, 1812)
*atratus* Latreille, 1804
*autumnalis* (Duftschmid, 1812)
*calathoides* Motschulsky, 1844
*calceatus* (Duftschmid, 1812)
*caspius* (Steven, 1806)
*cephalotes* Fairmaire & Laboulbene, 1854
*dispar* Dejean, 1829
*distinguendus* (Duftschmid, 1812)
*flavescens* (Piller & Mitterpacher, 1783)
*flavicornis* Dejean, 1829
*froelichi* Sturm, 1818
*fuscipalpis* Sturm, 1818
*griseus* (Panzer, 1797)
*hirtipes* (Panzer, 1797)
*hospes* Sturm, 1818
*inexspectatus* Kataev, 1989
*latus* (Linnaeus, 1758)
*luteicornis* (Duftschmid, 1812)
*melancholicus* Dejean, 1829
*modestus* Dejean, 1829
*neglectus* Serville, 1821
*oblitus* Dejean, 1829
*picipennis* (Duftschmid, 1812)
*politus* Dejean, 1829
*progrediens* Schauberger, 1922
*pumilus* Sturm, 1818
*pygmaeus* Dejean, 1829
*rubripes* (Duftschmid, 1812)
*rufipalpis* Sturm, 1818
*rufipes* (De Geer, 1774)
*serripes* (Quensel, 1806)
*servus* (Duftschmid, 1812)
*signaticornis* (Duftschmid, 1812)
*smaragdinus* (Duftschmid, 1812)
*solitaris* Dejean, 1829
*stevenii* Dejean, 1829
*subcylindricus* Dejean, 1829
*tardus* (Panzer, 1797)
*tenebrosus* Dejean, 1829
*xanthopus* Gemminger & Harold, 1868
*zabroides* Dejean, 1829
*Pangus* Dejean, 1821
*scaritides* (Sturm, 1818)
*Acinopus* Dejean, 1821
*ammophilus* Dejean, 1829
*laevigatus* Menetries, 1832
*picipes* (Olivier, 1795)
*Ophonus* Dejean, 1821
*ardosiacus* (Lutshik, 1922)
*azureus* (Fabricius, 1775)
*convexicollis* Menetries, 1832
*cordatus* (Duftschmid, 1812)
*cribricollis* (Dejean, 1829)
*diffinis* (Dejean, 1829)
*gammeli* (Schauberger, 1932)
*melletii* (Heer, 1837)
*nitidulus* Stephens, 1828
*puncticeps* Stephens, 1828
*puncticollis* (Paykull, 1798)
*rufibarbis* (Fabricius, 1792)
*rupicola* (Sturm, 1818)
*sabulicola* (Panzer, 1796)
*schaubergerianus* Puel, 1937
*similis* (Dejean, 1829)
*stictus* Stephens, 1828
*subquadratus* (Dejean, 1829)
*subsinuatus* Rey, 1886
*Ditomus* Bonelli, 1810
*tricuspidatus* (Fabricius, 1792)
*Dixus* Billberg, 1820
*clypeatus* (Rossi, 1790)
*eremita* (Dejean, 1825)
*obscurus* (Dejean, 1825)
*Amblystomus* Erichson, 1837
*metallescens* (Dejean, 1829)
*niger* Heer, 1838
*Perigona* Laporte, 1835
*nigriceps* (Dejean, 1831)
*Panagaeus* Latreille, 1802
*bipustulatus* (Fabricius, 1775)
*cruxmajor* (Linnaeus, 1758)
*Callistus* Bonelli, 1809
*lunatus* (Fabricius, 1775)
*Epomis* (Bonelli, 1810)
*dejeanii* Dejean, 1831
*Dinodes* (Bonelli, 1810)
*cruralis* (Fischer, 1829)
*decipiens* (Dufour, 1820)
*Chlaenius* Bonelli, 1810
*alutaceus* Gebler, 1829
*chrysothorax* Krynicki, 1832
*festivus* (Panzer, 1796)
*nigricornis* Fabricius, 1787
*nitidulus* (Schrank, 1781)
*spoliatus* (Rossi, 1792)
*sulcicollis* (Paykull, 1798)
*terminatus* Dejean, 1826
*tristis* (Schaller, 1783)
*vestitus* (Paykull, 1790)
*Oodes* Bonelli, 1810
*gracilis* Villa & Villa, 1833
*helopioides* (Fabricius, 1792)
*Licinus* Latreille, 1802
*cassideus* (Fabricius, 1792)
*depressus* (Paykull, 1790)
*silphoides* (Rossi, 1790)
*Badister* Clairville, 1806
*bullatus* (Schrank, 1798)
*dilatatus* (Chaudoir, 1837)
*dorsiger* (Duftschmid, 1812)

*lacertosus* Sturm, 1815
*meridionalis* Puel, 1925
*peltatus* (Panzer, 1796)
*sodalis* (Duftschmid, 1812)
*unipustulatus* Bonelli, 1813
*Masoreus* Dejean, 1821
*wetterhallii* (Gyllenhal, 1813)
*Odacantha* Paykull, 1798
*melanura* (Linnaeus, 1767)
*Lebia* Latreille, 1802
*chlorocephala* (Hoffmann, 1803)
*cruxminor* (Linnaeus, 1758)
*cyanocephala* (Linnaeus, 1758)
*humeralis* Dejean, 1825
*scapulairs* (Geoffroy, 1785)
*trimaculata* (Villers, 1789)
*Demetrias* Bonelli, 1810
*imperialis* (Germar, 1824)
*monostigma* Samouelle, 1819
*Dromius* Bonelli, 1810
*agilis* (Fabricius, 1787)
*quadraticollis* Morawitz, 1862
*quadrimaculatus* (Linnaeus, 1758)
*Paradromius* Fowler, 1887
*linearis* (Olivier, 1795)
*longiceps* (Dejean, 1826)
*Philorhizus* Hope, 1838
*notatus* (Stephens, 1827)
*sigma* (Rossi, 1790)
*Microlestes* Schmidt-Goebel, 1846
*fissuralis* (Reitter, 1901)
*fulvibasis* (Reitter, 1901)
*maurus* (Sturm, 1827)
*minutulus* (Goeze, 1777)
*negrita* (Wollaston, 1854)
*plagiatus* (Duftschmid, 1812)
*schroederi* Holdhaus, 1912
*Syntomus* Hope, 1838
*obscuroguttatus* (Duftschmid, 1812)
*pallipes* (Dejean, 1825)
*truncatellus* (Linnaeus, 1761)
*Cymindis* Latreille, 1806
*axillaris* (Fabricius, 1794)
*cingulata* Dejean, 1825
*humeralis* (Geoffroy, 1785)
*lineata* (Quensel, 1806)
*macularis* Fischer, 1824
*variolosa* (Fabricius, 1794)
*Drypta* Latreille, 1796
*dentata* (Rossi, 1790)
*Polystichus* Bonelli, 1809
*connexus* (Fourcroy, 1785)
*Aptinus* Bonelli, 1810
*bombarda* (Illiger, 1800)
*Brachinus* Weber, 1801
*bipustulatus* Quensel, 1806
*brevicollis* Motschulsky, 1844
*crepitans* (Linnaeus, 1758)
*ejaculans* Fischer, 1829
*elegans* Chaudoir, 1842
*explodens* Duftschmid, 1812
*plagiatus* Reiche, 1868
*psophia* Serville, 1821
**Family Haliplidae** Aube, 1836
*Peltodytes* Regimbart, 1878
*caesus* (Duftschmid, 1805)
*Haliplus* Latreille, 1802
*ruficollis* (De Geer, 1774)
**Family Dytiscidae** Leach, 1815
*Noterus* Clairville, 1806
*clavicornis* (De Geer, 1774)
*Laccophilus* Leach, 1815
*minutus* (Linnaeus, 1758)
*Hygrotus* Stephens, 1828
*confluens* (Fabricius, 1787)
*impressopunctatus* (Schaller, 1783)
*Agabus* Leach, 1817
*uliginosus* (Linnaeus, 1761)
*Colymbetes* Clairville, 1806
*fuscus* (Linnaeus, 1758)
*Hydaticus* Leach, 1817
*transversalis* (Pontoppidan, 1763)
*Grafoderes* Dejean, 1833
*cinereus* (Linnaeus, 1758)
*Dytiscus* Linnaeus, 1758
*circumcinctus* (Ahrens, 1811)
*circumflexus* Fabricius, 1801
*dimidiatus* Bergstrasser, 1778
*Cybister* Curtis, 1827
*laterimarginalis* (De Geer, 1774)

**Suborder Polyphaga** Emery, 1886

**Superfamily Hydrophiloidea** Latreille, 1802
**Family Hydrophilidae** Latreille, 1802
Subfamily Helophorinae Leach, 1815
*Helophorus* Fabricius, 1775
*aquaticus* Linnaeus, 1758
*granularis* (Linnaeus, 1761)
Subfamily Hydrophilinae Latreille, 1802
*Berosus* Leach, 1817
*signaticollis* Charpentier, 1825
*Cercyon* Leach, 1817
*convexiusculus* Stephens, 1829
*marinus* Thomson, 1853
*quisquilius* (Linnaeus, 1760)
*unipunctatus* (Linnaeus, 1758)
*Coelostoma* Brulle, 1835
*orbiculare* (Fabricius, 1775)
*Cryptopleurum* Mulsant, 1844
*minutum* (Fabricius, 1775)
*Cymbiodyta* Bedel, 1881

*marginella* (Fabricius, 1792)
*Enochrus* Thomson, 1859
*affinis* (Thunberg, 1794)
*bicolor* (Fabricius, 1792)
*Helochares* Mulsant 1844
*lividus* (Forster, 1771)
*Hydrobius* Leach, 1815
*fuscipes* (Linnaeus, 1758)
*Hydrophilus* Geoffroy, 1762
*aterrimus* Eschscholtz, 1822
*caraboides* (Linnaeus, 1758)
*flavipes* Steven, 1808,
*piceus* Linnaeus, 1758)
*Laccobius* Erichson, 1837
*alutaceus* Thomson, 1868
*Sphaeridium* Fabricius, 1775
*bipustulatum* Fabricius, 1781
*scarabaeoides* Linnaeus, 1758
**Family Histeridae** Gyllenhal, 1808
Subfamily Abraeinae MacLeay, 1819
*Teretriius* Erichson, 1834
*picipes* (Fabricius, 1792)
Subfamily Saprininae Blanchard, 1845
*Gnathoncus* Jacquelin du Val, 1858
*punctulatus* Thomson, 1862
*Saprinus* Erichson, 1834
*cribellatus* Marseul, 1855
*semistriatus* (Scriba, 1790)
*Hypocacculus* Bickhardt, 1914
*conjungens* Paykull, 1798
*rufipes* (Kugelann, 1792)
*Paromalus* Erichson, 1834
*complanatus* Panzer, 1792
Subfamily Histerinae Gyllenhal, 1808
*Hister* Linnaeus, 1758
*cadaverinus* Hoffmann, 1803
*distinctus* Erichson, 1834
*planulus* (Menetries 1848)
*quadrimaculatus* Linnaeus,1758
*quadrinotatus* Scriba, 1790
*sepulchralis* Erichson, 1834
*stercorarius* Hoffmann, 1803
*uncinatus* Illiger, 1807
*Margarinotus* Marseul, 1854
*bipustulatus* (Schrank, 1781)
*purpurascens* (Herbst, 1792)
*ventralis* (Marseul, 1854)
*Atholus* Thomson, 1859
*corvinus* (Germar, 1817)
*duodecimstriatus* (Schrank, 1781)
*Platysoma* Leach, 1817
*angustatum* (Hoffmann, 1803)
*compressum* (Herbst, 1783)
*Hololepta* Paykull, 1811
*plana* (Sulzer, 1776)
**Superfamily Staphylinoidea** Latreille, 1802
**Family Agyrtidae** Thomson, 1859
Subfamily Agyrtinae Thomson, 1859
*Agyrtes* Frohlich, 1901
*castaneus* Fabricius, 1792
Family Leiodidae Fleming, 1821
Subfamily Leiodinae Fleming, 1821
*Amphicyllus* Erichson, 1845
*globus* (Fabricius, 1792)
*Anisotoma* Panzer, 1797
*humeralis* (Fabricius, 1792)
*Leiodes* Latreille, 1797
*cinnamomea* (Panzer, 1793)
Subfamily Cholevinae Kirby, 1837
*Catops* Paykull, 1798
*fuscus* (Panzer, 1794)
*Ptomaphagus* Hellwig, 1795
*validus* (Kraatz, 1852)
**Family Silphidae** Latreille, 1807
Subfamily Nicrophorinae Kirby, 1837
*Nicrophorus* Fabricius, 1775
*antennatus* Reitter, 1884
*fossor* Erichson, 1837
*germanicus* Linnaeus, 1758
*humator* Olivier, 1790
*investigator* Zetterstedt, 1824
*vespillo* Linnaeus, 1758
*vespilloides* Herbst, 1784
*vestigator* Herschel, 1807
Subfamily Silphinae Latreille, 1807
*Ablattaria* Reitter, 1885
*laevigata* Fabricius, 1775
*Aclypea* Reitter, 1884
*undata* Muller, 1776
*Dendroxena* Motschulsky, 1858
*quadripunctata* Linnaeus, 1758
*Necrodes* Leach, 1815
*littoralis* Linnaeus, 1761
*Oiceoptoma* Leach, 1815
*thoracica* Linnaues, 1758
*Phosphuga* Leach, 1817
*atrata* Linnaeus, 1758
*Silpha* Linnaeus, 1758
*carinata* Herbst, 1783
*obscura* Linnaeus, 1758
*tristis* Illiger, 1798
*Thanatophilus* Leach, 1815
*rugosus* Linnaeus, 1758
*sinuatus* Fabricius, 1775
*terminatus* Hummel, 1825
**Family Staphylinidae** Latreille, 1802
Subfamily Omaliinae MacLeay, 1825
*Acidota* Stephens, 1829
*cruentata* Mannerheim, 1830
*Anthobium* Leach, 1819
*atrocephalum* (Gyllenhal, 1827)

*fusculum* (Erichson, 1839)
*Anthophagus* Gravenhorst, 1802
*caraboides* (Linnaeus, 1758)
*Acrolocha* Thornson, 1858
*pliginskii* Bernhauer, 1912
*Hypopycna* Mulsant & Rey, 1880
*rufula* (Erichson, 1840)
*Omalium* Gravenhorst, 1802
*caesum* Gravenhorst, 1806
*ferrugineum* Kraatz, 1857
*rivulare* (Paykull, 1789)
Subfamily Proteininae Erichson, 1839
*Megarthrus* Curtis, 1829
*denticollis* (Beck, 1817)
Subfamily Habrocerinae Mulsant & Rey, 1877
*Habrocerus* Erichson, 1839
*capillaricornis* (Gravenhorst, 1806)
Subfamily Tachyporinae MacLeay, 1825
*Ischnosoma* Stephens, 1829
*splendidum* (Gravenhorst, 1806)
*Lordithon* Thomson, 1859
*exoletus* (Erichson, 1839)
*lunulatus* (Linnaeus, 1760)
*thoracicus* (Fabricius, 1777)
*trinotatus* (Erichson, 1839)
*Mycetoporus* Mannerheim, 1830
*baudueri* Mulsant & Rey, 1875
*eppelsheimianus* Fagel, 1968
*forticornis* Fauvel, 1875
*lepidus* (Gravenhorst, 1806)
*nigricollis* Stephens, 1835
*Parabolitobius* Li et. al., 2000
*formosus* (Gravenhorst, 1806)
*Cilea* Jacquelin du Val, 1856
*silphoides* (Linnaeus, 1767)
*Sepedophilus* Gistel, 1856
*immaculatus* (Stephens, 1832)
*marshami* (Stephens, 1832)
*obtusus* (Luze, 1902)
*testaceus* (Fabricius, 1793)
*Tachinus* Gravenhorst, 1802
*corticinus* Gravenhorst, 1802
*fimetarius* Gravenhorst, 1802
*lignorum* (Linnaeus, 1758)
*rufipes* (Linnaeus, 1758)
*signatus* Gravenhorst, 1802
*Tachyporus* Gravenhorst, 1802
*atriceps* Stephens, 1832
*abdominalis* (Fabricius, 1781)
*hypnorum* (Fabricius, 1775)
*nitidulus* (Fabricius, 1781)
*pusillus* Gravenhorst, 1806
*ruficollis* Gravenhorst, 1802
*solutus* Erichson, 1839
*transversalis* Gravenhorst, 1806
Subfamily Aleocharinae Fleming, 1821
*Aleochara* Gravenhorst, 1802
*bilineata* Gyllenhal, 1810
*bipustulata* (Linnaeus, 1761)
*curtula* (Goeze, 1777)
*grisea* Kraatz, 1856
*haematoptera* Kraatz, 1858
*intricata* Mannerheim, 1830
*laevigata* Gyllenhal, 1810
*lata* Gravenhorst, 1802
*laticornis* Kraatz, 1856
*sparsa* Heer, 1839
*Atheta* Thornson, 1858
*fungi* (Gravenhorst, 1806)
*hygrotopora* (Kraatz, 1856)
*hypnorum* (Kiesenwetter, 1850)
*longicornis* (Gravenhorst, 1802)
*marcida* (Erichson, 1837)
*oblita* (Erichson, 1839)
*orbata* (Erichson, 1837)
*picipes* (Thornson, 1856)
*Aloconota* Thornson, 1858
*gregaria* (Erichson, 1839)
*Brachyusa* Mulsant & Rey, 1874
*concolor* (Erichson, 1839)
*Dinaraea* Thornson, 1858
*aequata* (Erichson, 1837)
*angustula* (Gyllenhal, 1810)
*Geostiba* Thornson, 1858
*circellaris* (Gravenhorst, 1806)
*Liogluta* Thornson, 1858
*granigera* (Kiesenwetter, 1850)
*Lyprocorrhe* Thornson, 1859
*anceps* (Erichson, 1837)
*Nehemitropia* Lohse, 1971
*lividipennis* (Mannerheim, 1830)
*Autalia* Leach, 1819
*impressa* (Olivier, 1795)
*rivularis* (Gravenhorst, 1802)
*Anaulacaspis* Ganglbauer, 1895
*nigra* (Gravenhorst, 1802)
*Cordalia* Jacobs, 1925
*obscura* (Gravenhorst, 1802)
*Falagria* Leach, 1819
*caesa* Erichson, 1837
*splendens* Kraatz, 1858
*sulcatula* (Gravenhorst, 1806)
*Falagrioma* Casey, 1906
*thoracica* (Stephens, 1832)
*Gymnusa* Gravenhorst, 1806
*brevicollis* (Paykull, 1800)
*Bolitochara* Mannerheim, 1830
*mulsanti* Sharp, 1875
*Ischnopoda* Stephens, 1853
*constricta* Erichson, 1837
*umbratica* (Erichson, 1837)
*Gyrophaena* Mannerheim, 1830

*affinis* Mannerheim, 1830
*joyi* Wendeler, 1924
*pulchella* Heer, 1839
*Homalota* Mannerheim, 1830
*rufipes* Heer, 1839
*Leptusa* Kraatz, 1856
*fumida* (Erichson, 1839)
*Cypha* Leach, 1819
*longicornis* (Paykull, 1800)
*Holobus* Solier, 1849
*flavicornis* (Lacordaire, 1835)
*Oligota* Mannerheim, 1830
*pusillima* (Gravenhorst, 1806)
*Drusilla* Leach, 1819
*canaliculata* (Fabricius, 1787)
*Zyras* Stephens, 1835
*collaris* (Paykull, 1800)
*haworthi* (Stephens, 1832)
*Ilyobates* Kraatz, 1856
*bennetti* Donisthorpe, 1914
*mech* (Baudi di Selve, 1848)
*Ocalea* Erichson, 1837
*badia* Erichson, 1837
*Oxypoda* Mannerheim, 1830
*abdominalis* (Mannerheim, 1830)
*acuminata* (Stephens, 1832)
*elongatula* Aube, 1850
*spectabilis* Markel, 1845
*Parocyusa* Bernhauer, 1902
*rubicunda* (Erichson, 1837)
Subfamily Oxytelinae Fleming, 1821
*Coprophilus* Latreille, 1829
*pennifer* (Motschulsky, 1845)
*piceus* (Solsky, 1866)
*striatulus* (Fabricius, 1783)
*Deleaster* Erichson, 1839
*dichrous* (Gravenhorst, 1802)
*Anotylus* Thomson, 1859
*insecatus* (Gravenhorst, 1806)
*intricatus* (Erichson, 1840)
*nitidulus* (Gravenhorst, 1802)
*rugosus* (Fabricius, 1775)
*sculpturatus* (Gravenhorst, 1806)
*tetracarinatus* (Block, 1799)
*Oxytelus* Gravenhorst, 1802
*laqueatus* (Marsham, 1802)
*piceus* (Linnaeus, 1767)
*sculptus* Gravenhorst, 1806
*Platystethus* Mannerheim, 1830
*arenarius* (Geoffroy, 1785)
*cornutus* (Gravenhorst, 1802)
*nitens* (Sahlberg, 1832)
*spinosus* Erichson, 1840
*Bledius* Leach, 1819
*bicornis* (Germar, 1823)
*cribricollis* Heer, 1839
*dissimilis* Erichson, 1840
*furcatus* (Olivier, 1811)
*gallicus* (Gravenhorst, 1806)
*tricomis* (Herbst, 1784)
*Carpelimus* Leach, 1819
*anthracinus* (Mulsant & Rey, 1861)
*bilineatus* Stephens, 1834
*corticinus* (Gravenhorst, 1806)
*exiguus* (Erichson, 1839)
*fuliginosus* (Gravenhorst, 1802)
*gracilis* (Mannerheim, 1830)
*gusarovi* Gildenkov, 1997
*halophilus* (Kiesenwetter, 1844)
*nitidus* (Baudi di Selve, 1848)
*pusillus* (Gravenhorst, 1802)
*rivularis* (Motschulsky, 1860)
*Planeustomus* Jacquelin du Val, 1857
*heydeni* (Eppelsheim, 1884)
*palpalis* (Erichson, 1839)
Subfamily Scaphidiinae Latreille, 1807
*Scaphidium* Olivier, 1790
*quadrimaculatum* Olivier, 1790
*Scaphisoma* Leach, 1815
*boleti* (Panzer, 1793)
Subfamily Euaesthetinae Thomson, 1859
*Euaesthetus* Gravenhorst, 1806
*bipunctatus* (Ljungh, 1804)
Subfamily Oxyporinae Fleming, 1821
*Oxyporus* Fabricius, 1775
*rufus* (Linnaeus, 1758)
Subfamily Steninae MacLeay, 1825
*Stenus* Latreille, 1797
*argus* Gravenhorst, 1806
*ater* Mannerheim, 1830
*boops* Ljungh, 1810
*cicindeloides* (Schaller, 1783)
*claritaris* Puthz, 1971
*clavicornis* (Scopoli, 1763)
*comma* Le Conte, 1863
*flavipalpis* Thomson, 1860
*ganglbaueri* Bernhauer, 1905
*humilis* Erichson, 1839
*impressus* Germar, 1824
*longipes* Heer, 1839
*montenegrinus* Puthz, 1972
*morio* Gravenhorst, 1806
*ochropus* Kiesenwetter, 1858
*pallitarsis* Stephens, 1833
*planifrons* Rye, 1884
*proditor* Erichson, 1839
*providus* Erichson, 1839
Subfamily Paederinae Fleming, 1821
*Achenium* Leach, 1819
*depressum* (Gravenhorst, 1802)
*humile* (Nicolai, 1822)
*Astenus* Stephens, 1833

*bimaculatus* (Erichson, 1840)
*gracilis* (Paykull, 1789)
*lyonessius* (Joy, 1908)
*Ochthephilum* Stephens, 1829
*fracticorne* (Paykull, 1800)
*Lathrobium* Gravenhorst, 1802
*brunnipes* (Fabricius, 1792)
*elegantulum* Kraatz, 1857
*fovulum* Stephens, 1833
*fulvipenne* (Gravenhorst, 1806)
*furcatum* Czwalina, 1888
*geminum* Kraatz, 1857
*longulum* Gravenhorst, 1802
*taxi* Bernhauer, 1902
*Leptobium* Casey, 1905
*dimidiatum* (Gridelli, 1926)
*gracile* (Gravenhorst, 1802)
*Lithocharis* Dejean, 1833
*nigriceps* Kraatz, 1859
*ochracea* (Gravenhorst, 1802)
*Medon* Stephens, 1833
*ferrugineus* (Erichson, 1840)
*Paederus* Fabricius, 1775
*fuscipes* Curtis, 1826
*littoralis* Gravenhorst, 1802
*riparius* (Linnaeus, 1758)
*Sunius* Stephens, 1829
*fallax* (Lokay, 1919)
*melanocephalus* (Fabricius, 1792)
*Tetartopeus* Czwalina, 1888
*quadratus* (Paykull, 1789)
*scutellaris* (Nordmann, 1837)
*terminatus* (Gravenhorst, 1802)
*Rugilus* Leach, 1819
*angustatus* (Geoffroy, 1785)
*orbiculatus* (Paykull, 1789)
*rufipes* (Germar, 1836)
*similis* Erichson, 1839
*subtilis* Erichson, 1840
*Scopaeus* Erichson, 1840
*laevigatus* Gyllenhal, 1827
*longicollis* Fauvel, 1873
*minutus* Erichson, 1840
*ryei* Wollaston, 1872
Subfamily Staphylininae Latreille, 1802
*Atrecus* Jacquelin du Val, 1856
*affinis* (Paykull, 1789)
*Othius* Stephens, 1829
*punctulatus* (Goeze, 1777)
*Abemus* Mulsant & Rey, 1876
*chloropterus* (Panzer, 1796)
*Bisnius* Stephens, 1829
*fimetarius* (Gravenhorst, 1802)
*nigriventris* (Thomson, 1867)
*nitidulus* (Gravenhorst, 1802)
*parcus* (Sharp, 1874)
*scribae* (Fauvel, 1867)
*sordidus* (Gravenhorst, 1802)
*Erichsonius* Fauvel, 1874
*cinerescens* (Gravenhorst, 1802)
*Gabrius* Stephens, 1829
*exspectatus* Smetana, 1952
*femoralis* (Hochhuth, 1851)
*nigritulus* (Gravenhorst, 1802)
*osseticus* (Kolenati, 1846)
*piliger* Mulsant & Rey, 1876
*splendidulus* (Gravenhorst, 1802)
*suffragani* Joy, 1913
*Gabronthus* Tottenham, 1955
*limbatus* (Fauvel, 1900)
*Hesperus* Fauvel, 1874
*rufipennis* Gravenhorst, 1806
*Neobisnius* Ganglbauer, 1895
*procerulus* (Gravenhorst, 1806)
*Philonthus* Stephens, 1829
*addendus* Sharp, 1867
*albipes* (Gravenhorst, 1802)
*atratus* (Gravenhorst, 1802)
*carbonarius* (Gravenhorst, 1802)
*caucasicus* Nordmann, 1837
*cognatus* Stephens, 1832
*concinnus* (Gravenhorst, 1802)
*confinis* Strand, 1941
*coprophilus* Jarrige, 1949
*corruscus* (Gravenhorst, 1802)
*cruentatus* (Gmelin, 1790)
*debilis* (Gravenhorst, 1802)
*decorus* (Gravenhorst, 1802)
*discoideus* (Gravenhorst, 1802)
*diversiceps* Bernhauer, 1901
*ebeninus* (Gravenhorst, 1802)
*intermedius* (Lacordaire, 1835)
*laevicollis* (Lacordaire, 1835)
*laminatus* (Creutzer, 1799)
*longicornis* Stephens, 1832
*micans* (Gravenhorst, 1802)
*nitidicollis* (Lacordaire, 1835)
*parvicornis* (Gravenhorst, 1802)
*politus* (Linnaeus, 1758)
*punctus* (Gravenhorst, 1802)
*quisquiliarius* (Gyllenhal, 1810)
*rectangulus* Sharp, 1874
*rubripennis* Stephens, 1832
*rufipes* (Stephens, 1832)
*salinus* Kiesenwetter, 1844
*sanguinolentus* (Gravenhorst, 1802)
*spinipes* Sharp, 1874
*splendens* (Fabricius, 1793)
*succicola* Thomson, 1860
*temporalis* Mulsant & Rey, 1853
*tenuicornis* Mulsant & Rey, 1853
*umbratilis* (Gravenhorst, 1802)

*varians* (Paykull, 1789)
*ventralis* (Gravenhorst, 1802)
*virgo* (Gravenhorst, 1802)
*Astrapaeus* Gravenhorst, 1802
*ulmi* (Rossi, 1790)
*Heterothops* Stephens, 1829
*dissimilis* (Gravenhorst, 1802)
*niger* Kraatz, 1868
*quadripunctulus* (Gravenhorst, 1806)
*Quedius* Stephens, 1829
*balticus* Korge, 1960
*cinctus* (Paykull, 1790)
*cruentus* (Olivier, 1795)
*fulgidus* (Fabricius, 1793)
*fuliginosus* (Gravenhorst, 1802)
*humeralis* Stephens, 1832
*invreae* Gridelli, 1924
*lateralis* (Gravenhorst, 1802)
*limbatus* (Heer, 1839)
*lucidulus* Erichson, 1839
*maurus* (Sahlberg, 1830)
*mesomelinus* (Marsham, 1802)
*molochinus* (Gravenhorst, 1806)
*nemoralis* Baudi di Selve, 1848
*nitipennis* (Stephens, 1833)
*ochripennis* (Menetries, 1832)
*ochropterus* Erichson, 1840
*picipes* (Mannerheim, 1830)
*suturalis* Kiesenwetter, 1845
*tenellus* (Gravenhorst,1806)
*umbrinus* Erichson, 1839
*Velleius* Leach, 1819
*dilatatus* (Fabricius, 1787)
*Creophilus* Leach, 1819
*maxillosus* (Linnaeus, 1758)
*Dinothenarus* Thomson, 1858
*pubescens* (De Geer, 1774)
*Emus* Leach, 1819
*hirtus* (Linnaeus, 1758)
*Ocypus* Leach, 1819
*brunnipes* (Fabricius, 1781)
*fulvipennis* Erichson, 1840
*nitens* (Schrank, 1781)
*olens* (Muller, 1764)
*ophthalmicus* (Scopoli, 1763)
*picipennis* (Fabricius, 1793)
*tenebricosus* (Gravenhorst, 1846)
*Ontholestes* Ganglbauer, 1895
*haroldi* (Eppelsheim, 1884)
*murinus* (Linnaeus, 1758)
*tessellatus* (Geoffroy, 1785)
*Platydracus* Thomson, 1858
*chalcocephalus* (Fabricius, 1801)
*fulvipes* (Scopoli, 1763)
*latebricola* (Gravenhorst, 1806)
*stercorarius* (Olivier, 1795)
*Staphylinus* Linnaeus, 1758
*caesareus* Cederhjelm, 1798
*erythropterus* Linnaeus, 1758
*Tasgius* Stephens, 1829
*ater* (Gravenhorst, 1802)
*globulifer* (Geoffroy, 1785)
*melanarius* (Heer, 1839)
*morsitans* (Rossi, 1790)
*pedator* (Gravenhorst, 1802)
*winkleri* (Bernhauer, 1906)
*Gauropterus* Thomson, 1860
*fulgidus* (Fabricius, 1787)
*Gyrohypnus* Leach, 1819
*angustatus* Stephens, 1833
*fracticornis* (Mueller, 1776)
*liebei* Scheerpeltz, 1926
*Leptacinus* Erichson, 1839
*batychrus* (Gyllenhal, 1827)
*intermedius* Donisthorpe, 1936
*sulcifrons* (Stephens, 1833)
*Megalinus* Mulsant & Rey, 1877
*flavocinctus* Hochhuth, 1849
*Phacophallus* Coiffait, 1956
*parumpunctatus* (Gyllenhal, 1827)
*Stenistoderus* Jacquelin du Val, 1856
*cephalotes* (Kraatz, 1858)
*Xantholinus* Dejean, 182 1
*decorus* Erichson, 1839
*distans* Mulsant & Rey, 1853
*dvoraki* Coiffait, 1956
*fortepunctatus* Motschulsky, 1860
*linearis* (Olivier, 1795)
*tricolor* (Fabricius, 1787)

**Superfamily Scarabaeoidea** Latreille, 1802
**Family Geotrupidae** Latreille, 1802
Subfamily Bolboceratinae Mulsant, 1842
*Bolboceras* Kirby, 1819
*armiger* (Scopoli, 1772)
*Bolbelasmus* Boucomont, 1910
*unicornis* Schrank, 1789
Subfamily Geotrupinae Latreille, 1802
*Geotrupes* Latreille, 1796
*mutator* (Marsham, 1802)
*spiniger* (Marsham, 1802)
*stercorarius* (Linnaeus, 1758)
*stercorosus* Hartmann in Scriba, 1791
*vernalis* (Linnaeus, 1758)
Subfamily Lethrinae Mulsant & Rey, 1871
*Lethrus* Scopoli, 1777
*apterus* (Laxmann, 1770)
**Family Trogidae** MacLeay, 1819
*Trox* Fabricius, 1775
*eispidus* Pontoppidan, 1763
*eversmanni* Krynicky, 1832
*sabulosus* Linnaeus, 1758

**Family Lucanidae** Latreille, 1804
Subfamily Syndesinae MacLeay, 1819
*Sinodendron* Schneider, 1791
*cylindricum* (Linnaeus, 1758)
Subfamily Lucaninae Latreille, 1806
*Platycerus* Geoffroy, 1762
*caraboides* (Linnaeus, 1758)
*dorcus* Macleay, 1819
*parallelipipedus* (Linnaeus, 1785)
*Lucanus* Scopoli, 1763
*cervus* (Linnaeus, 1758)
**Family Scarabaeidae** Latreille, 1802
Subfamily Aphodiinae Leach, 1815
*Aphodius* Illiger, 1798
*affinis* Panzer, 1823
*ater* (De Geer, 1774)
*biguttatus* Germar, 1824
*borealis* Gyllenhal, 1827
*brevis* Erichson, 1848
*caspius* Menetries, 1832
*circumcinctus* Schmidt, 1840
*conjugatus* (Panzer, 1795)
*constans* Duftschmid, 1805
*depressus* (Kugelan, 1792)
*distinctus* (Muller, 1776)
*erraticus* (Linnaeus, 1758)
*fimetarius* (Linnaeus, 1758)
*fossor* (Linnaeus, 1758)
*granarius* (Linnaeus, 1758)
*haemorrhoidalis* (Linnaeus, 1758)
*hydrochoeris* (Fabricius, 1798)
*immundus* (Creutzer, 1799)
*kraatzi* Harold, 1868
*lividus* (Olivier, 1789)
*lugens* Creutzer, 1799
*luridus* (Fabricius, 1775)
*melanostictus* Schmidt, 1840
*merdarius* (Fabricius, 1775)
*nitidulus* Fabricius, 1792
*obscurus* (Fabricius, 1792)
*paracoenosus* Balthasar & Hrubant, 1960
*prodromus* (Brahm, 1790)
*punctatosulcatus* Sturm, 1805
*punctipennis* Erichson, 1848
*pusillus* (Herbst, 1789)
*putridus* (Herbst, 1789)
*quadriguttatus* (Herbst, 1783)
*quadrimaculatus* (Linnaeus, 1761)
*rufipes* (Linnaeus, 1758)
*satellitius* (Herbst, 1789)
*scrofa* (Fabricius, 1787)
*sordidus* (Fabricius, 1778)
*sphacelatus* (Panzer, 1798)
*sticticus* (Panzer, 1798)
*sturmi* Harold, 1780
*subterraneus* (Linnaeus, 1758)
*sulcatus* (Fabricius, 1792)
*tristis* Zenker, 1801
*varians* Duftschmidt, 1805
*Heptaulacus* Mulsant, 1842
*sus* (Herbst, 1783)
*testudinarius* (Fabricius, 1775)
*Oxyomus* Dejean, 1833
*silvestris* (Scopoli, 1763)
*Pleurophorus* Mulsant, 1842
*caesius* (Creutzer, 1796)
*sabulosus* Mulsant, 1842
*Rhyssemus* Mulsant, 1842
*asper* (Fabricius, 1775)
*germanus* (Linnaeus, 1767)
Subfamily Scarabaeinae Latreille, 1802
*Scarabaeus* Linnaeus, 1758
*typhon* (Fischer, 1824)
*Gymnopleurus* Illiger, 1803
*geoffroyi* Fuessly, 1775
*mopsus* (Pallas, 1781)
*Sisyphus* Latreille, 1807
*schaefferi* (Linnaeus, 1758)
*Onthophagus* Latreille, 1802
*amyntas* (Olivier, 1789)
*coenobita* (Herbst, 1783)
*fracticornis* (Preyssler, 1790)
*furcatus* (Fabricius, 1781)
*gibbulus* (Pallas, 1781)
*grossepunctatus* Reitter, 1905
*illyricus* (Scopoli, 1763)
*kindermanni* Harold, 1877
*lemur* (Fabricius, 1781)
*lucidus* Sturm, 1800
*nuchicornis* (Linnaeus, 1758)
*ovatus* (Linnaeus, 1767)
*ponticus* Harold, 1883
*ruficapillus* Brulle, 1832
*semicornis* (Panzer, 1798)
*taurus* (Schreber, 1759)
*vacca* (Linnaeus, 1767)
*verticicornis* (Leicharting, 1781)
*vitulus* (Fabricius, 1776)
*Caccobius* Thomson, 1863
*schreberi* (Linnaeus, 1767)
*Copris* Geoffroy, 1762
*lunaris* (Linnaeus, 1758)
*Oniticellus* Serville, 1825
*fulvus* (Goeze, 1777)
*pallipes* (Fabricius, 1781)
*Chironitis* Lansberge, 1875
*hungaricus* Herbst, 1789
*Onitis* Fabricius, 1798
*damoetas* Steven, 1806
Subfamily Melolonthinae Leach, 1819
*Hoplia* Illiger, 1803
*praticola* Duftschmidt, 1805

*Melolontha* Fabricius, 1775
*melolontha* (Linnaeus, 1758)
*Polyphylla* Harris, 1842
*fullo* (Linnaeus, 1758)
*Rhizotrogus* Berthold, 1827
*aequinoctialis* (Herbst, 1790)
*aestivus* (Olivier, 1789)
*pilicollis* (Gyllenhal, 1817)
*vernus* (Germar, 1823)
*Amphimallon* Berthold, 1827
*solstitialis* (Linnaeus, 1758)
*Serica* MacLeay, 1819
*brunnea* (Linnaeus, 1758)
*Maladera* Mulsant & Rey, 1871
*holoserica* (Scopoli, 1772)
*Omaloplia* Schonherr, 1817
*erythroptera* Frivaldszky, 1835
*spireae* (Pallas, 1773)
Subfamily Rutelinae MacLeay, 1819
*Anomala* Samouelle, 1819
*dubia* (Scopoli, 1763)
*oblonga* Fabricius, 1776
*vitis* (Fabricius, 1775)
*Phyllopertha* Reitter, 1903
*horticola* (Linnaeus, 1758)
*Blitopertha* Reitter, 1903
*lineolata* (Fabricius, 1798)
*Anisoplia* Dejean, 1821
*agricola* (Poda, 1761)
*aprica* Erichson, 1847
*austriaca* (Herbst, 1783)
*deserticola* (Fischer, 1823)
*lata* Erichson, 1847
*segetum* (Herbst, 1783)
*villosa* (Goeze, 1777)
Subfamily Dynastinae MacLeay, 1819
*Oryctes* Illiger, 1798
*nasicornis* (Linnaeus, 1758)
*Pentodon* Hope, 1837
*idiota* (Herbst, 1789)
*sulcifrons* Kuster, 1848
Subfamily CETONIINAE Leach, 1815
*Epicometis* Burmeister, 1842
*hirta* (Poda, 1761)
*Tropinota* Mulsant, 1842
*squalida* (Scopoli, 1783)
*Oxythyrea* Mulsant, 1842
*funesta* (Poda, 1761)
*Cetonia* Fabricius, 1775
*aurata* (Linnaeus, 1761)
*Protaetia* Burmeister 1842
*aeruginosa* (Drury, 1770)
*affinis* Andersch, 1797
*bessarabica* Panin, 1942
*fieberi* (Kraatz, 1880)
*hungarica* (Herbst, 1790)
*lugubris* (Herbst, 1786)
*metallica* (Herbst, 1782)
*Gnorimus* Lepeletier & Serville, 1825
*octopunctatus* (Fabricius, 1775)
*nobilis* Linnaeus, 1758
*Osmoderma* Lepeletier & Serville, 1825
*emerita* (Scopoli, 1763)
*Valgus* Scriba, 1798
*hemipterus* (Linnaeus, 1758)

**Superfamily Scirtoidea** Fleming, 1821
**Family Scirtidae** Fleming, 1821
*Cyphon* Paykull, 1799
*padi* (Linnaeus, 1758)
*variabilis* (Thunberg, 1787)
*Prionocyphon* Redtenbacher, 1858
*serricornis* (Muller, 1821)
*Scirtes* Illiger, 1807
*hemisphaericus* (Linnaeus, 1758)

**Superfamily Buprestoidea** Leach, 1815
**Family Buprestidae** Leach, 1815
Subfamily Polycestinae Lacordaire, 1857
*Acmaeodera* Eschscholtz, 1829
*taeniata* (Fabricius, 1787)
*Ptosima* Dejean, 1833
*undecimmaculata* (Herbst, 1784)
Subfamily Chrysochroinae Laporte, 1835
*Sphenoptera* Dejean, 1833
*antiqua* (Illiger, 1803)
*basalis* Morawitz, 1861
*Capnodis* Eschscholtz, 1829
*tenebrionis* (Linnaeus, 1758)
*Perotis* Dejean, 1833
*lugubris* (Fabricius, 1777)
*Dicerca* Eschscholtz, 1829
*aenea* (Linnaeus, 1766)
*berolinensis* (Herbst, 1779)
Subfamily Buprestinae Leach, 1815
*Lampra* Lacordaire, 1835
*rutilans* (Fabricius, 1777)
*Anthaxia* Eschscholtz, 1829
*aurulenta* Fabricius, 1787
*cichorii* (Olivier, 1790)
*croesus* Villers, 1789
*fulgurans* (Schrank, 1789)
*funerula* (Illiger, 1803)
*manca* (Linnaeus, 1767)
*millefolii* (Fabricius, 1801)
*nitidula* (Linnaeus, 1758)
*olympica* Kiesenwetter, 1880
*salicis* (Fabricius, 1776)
*sepulchralis* (Fabricius, 1801)
*Cratomerus* Solier, 1833
*hungarica* (Scopoli, 1772)
*Chrysobothris* Eschscholtz, 1829

*affinis* (Fabricius, 1794)
Subfamily Agrilinae Laporte, 1835
*Meliboeus* Deyrolle, 1864
*fulgidicollis* (Lucas, 1846)
*Coroebus* Agassiz, 1846
*elatus* (Fabricius, 1787)
*graminis* (Panzer, 1789)
*rubi* (Linnaeus, 1767)
*undatus* (Fabricius, 1787)
*Agrilus* Curtis, 1825
*angustulus* (Illiger, 1803)
*aurichalceus* Redtenbacher, 1849
*biguttatus* (Fabricius, 1777)
*chrysoderes* Abeille de Perrin, 1897
*convexicollis* Redtenbacher, 1849
*derasofasciatus* Boisduval & Lacordaire, 1835
*elatus* Mequignon, 1907
*graminis* Gory & Laporte, 1837
*laticornis* (Illiger, 1803)
*lineola* Redtenbacher, 1849
*obscuricollis* Kiesenwetter, 1857
*sulicicollis* Lacordaire, 1835
*viridis* (Linnaeus, 1758)
*Cylindromorphus* Kiesenwetter, 1857
*filum* (Gyllenhall, 1817)
*opacus* Abeille, 1897
*Trachys* Fabricius, 1801
*minuta* (Linnaeus, 1758)
*scrobiculata* Kiesenwetter, 1857
*troglodytes* Gyllenhal in Schonherr, 1817

**Superfamily Byrrhoidea** Latreille, 1804
**Family Byrrhidae** Latreille, 1804
Subfamily Byrrhinae Latreille, 1804
*Byrrhus* Linnaeus, 1767
*pilula* (Linnaeus, 1758)
*Lamprobyrrhulus* Ganglbauer, 1902
*nitidus* (Schaller, 1783)

**Superfamily Elateroidea** Leach, 1815
**Family Elateridae** Leach, 1815
Subfamily Agrypninae Candeze, 1857
*Agrypnus* Eschscholtz, 1829
*murinus* (Linnaeus, 1758)
*Aeolosomus* Dolin, 1982
*rossi* (Germar, 1844)
*Drasterius* Eschscholtz, 1829
*bimaculatus* (Rossi, 1790)
Subfamily LISSOMINAE Laporte, 1835
*Drapetes* Dejean, 1821
*biguttatus* (Piller & Mitterpacher, 1783)
Subfamily Dendrometrinae Gistel, 1856
*Cidnopus* Thomson, 1859
*aeruginosus* (Olivier, 1790)
*minutus* (Linnaeus, 1758)
*parvulus* (Panzer, 1799)
*pilosus* (Leske, 1785)
*Limonius* Eschscholtz, 1829
*aeneoniger* (De Geer, 1774)
*quercus* (Olivier, 1790)
*Stenagostus* Thomson, 1859
*villosus* (Fourcroy, 1785)
*Alcimathous* Reitter, 1905
*sacheri* Kiesenwetter, 1858
*Athous* Eschscholtz, 1829
*carpathophilus* Reitter, 1905
*haemorrhoidalis* (Fabricius, 1801)
*hirtus* (Herbst, 1784)
*jejunus* Kiesenwetter, 1858
*lomnickii* Reitter, 1905
*niger* (Linnaeus, 1758)
*subfuscus* (Muller, 1764)
*vittatus* (Fabricius, 1792)
*Ctenicera* Latreille, 1829
*cuprea* (Fabricius, 1775)
*Actenicerus* Kiesenwetter, 1858
*saelandicus* (Muller, 1764)
*Selatosomus* Stephens, 1830
*aeneus* (Linnaeus, 1758)
*cruciatus* (Linnaeus, 1758)
*latus* (Fabricius, 1801)
*nigricornis* (Panzer, 1799)
*Anostirus* Thomson, 1859
*globicollis* (Germar, 1843)
*Calambus* Thomson, 1859
*bipustulatus* (Linnaeus, 1767)
*Denticollis* Piller & Mitterpacher, 1783
*linearis* (Linnaeus, 1758)
*rubens* Piller & Mitterpacher, 1783
*Prosternon* Latreille, 1834
*tessellatum* (Linnaeus, 1758)
*Hypoganus* Kiesenwetter, 1863
*cinctus* (Paykull, 1800)
Subfamily Negastriinae Nakane & Kishii, 1956
*Zorochros* Thomson, 1859
*dermestoides* (Herbst, 1806)
Subfamily Elaterinae Leach, 1815
*Ampedus* Dejean, 1833
*cinnabarinus* (Eschscholtz, 1829)
*elegantulus* Schoenherr, 1817
*elongantulus* (Fabricius, 1787)
*erythrogonus* (Muller, 1821)
*nigerrimus* (Boisduval & Lacordaire, 1835)
*nigroflavus* (Goeze, 1777)
*pomonae* (Stephens, 1830)
*pomorum* (Herbst, 1784)
*praeustus* (Fabricius, 1792)
*sanguineus* (Linnaeus, 1758)
*sanguinolentus* (Schrank, 1776)
*satrapa* Kiesenwetter, 1858
*sinuatus* Germar, 1844
*Ischnodes* Germar, 1844

*sanguinicollis* (Panzer, 1793)
*Procraerus* Reitter, 1905
*tibialis* (Lacordaire, 1835)
*Megapenthes* Kiesenwetter, 1858
*lugens* (Redtenbacher, 1842)
*Porthmidius* Germar, 1847
*austriacus* (Schrank, 1781)
*Sericoderma* Dolin & Ostafitschuk, 1973
*subaeneus* (Redtenbacher, 1842)
*Elater* Linnaeus, 1758
*ferrugineus* Linnaeus, 1758
*Agriotes* Eschscholtz, 1829
*acuminatus* (Stephens, 1830)
*brevis* Candeze, 1863
*gurgistanus* (Faldermann, 1835)
*incognitus* Schwarz, 1891
*lineatus* (Linnaeus, 1767)
*medvedevi* Dolin, 1960
*obscurus* (Linnaeus, 1758)
*pilosellus* (Schonherr, 1817)
*proximus* Schwarz, 1891
*sputator* (Linnaeus, 1758)
*ustulatus* (Schaller, 1783)
*Dalopius* Eschscholtz, 1829
*marginatus* (Linnaeus, 1758)
*Synaptus* Eschscholtz, 1829
*filiformis* (Fabricius, 1781)
*Adrastus* Eschscholtz, 1829
*montanus* (Scopoli, 1763)
*rachifer* (Fourcroy, 1785)
*Melanotus* Schwarz, 1892
*brunnipes* (Germar, 1824)
*crassicollis* (Erichson, 1841)
*fusciceps* (Gyllenhal, 1817)
*niger* (Fabricius, 1792)
*rufipes* (Herbst, 1784)
Subfamily Cardiophorinae Candeze, 1859
*Cardiophorus* Eschscholtz, 1829
*cinereus* (Herbst, 1784)
*ebeninus* (Germar, 1824)
*equiseti* (Herbst, 1784)
*erichsoni* Buysson, 1901
*gramineus* (Scopoli, 1763)
*nigerrimus* Erichson, 1840
*rubripes* (Germar, 1824)
*rufipes* (Goeze, 1777)
**Family Drilidae** Blanchard, 1845
*Drilus* Olivier, 1790
*concolor* Ahrens, 1812
**Family Omalisidae** Lacordaire, 1857
*Omalisus* Geoffroy, 1762
*fontisbellaquaei* Geoffroy, 1785
**Family Cantharidae** Imhoff, 1856
Subfamily Lampyrinae Latreille, 1817
*Lampyris* Geoffroy, 1762
*noctiluca* (Linnaeus, 1758)
Subfamily Cantharinae Imhoff, 1856
*Cantharis* Linnaeus, 1758
*annularis* Menetries, 1836
*haemorrhoidalis* Fabricius, 1792
*lateralis* Linnaeus, 1758
*livida* Linnaeus, 1758
*nigricans* (Mueller, 1776)
*obscura* Linnaeus, 1758
*pellucida* Fabricius, 1792
*pulicaria* Fabricius, 1781
*quadripunctata* (Mueller, 1776)
*rufa* Linnaeus, 1758
*rustica* Fallen, 1807
*Rhagonycha* Eschscholtz, 1830
*atra* (Linnaeus, 1767)
*femoralis* (Brulle, 1832)
*fulva* (Scopoli, 1763)
*lignosa* (Mueller, 1764)
*nigriventris* Motschulsky, 1860
*testacea* (Linnaeus, 1758)
Subfamily Silinae Mulsant, 1862
*Silis* Charpentier, 1825
*ruficollis* (Fabricius, 1775)
Subfamily Malthininae Kiesenwetter, 1852
*Malthinus* Latreille, 1806
*biguttatus* (Linnaeus, 1758)
*minimus* Palm, 1975
*punctatus* (Geoffroy, 1785)

**Superfamily Bostrichoidea** Latreille, 1802
**Family Dermestidae** Latreille, 1807
Subfamily Dermestinae Latreille, 1804
*Dermestes* Linnaeus, 1758
*ater* De Geer, 1774
*bicolor* Fabricius, 1781
*frischi* Kugelann, 1792
*laniarius* Illiger, 1801
*lardarius* Linnaeus, 1758
*mustelinus* Erichson, 1846
*undulatus* Brahm, 1790
*maculatus* De Geer, 1774
Subfamily Attageninae Laporte, 1840
*Atta* Latreille, 1802
*piceus* (Olivier, 1790)
Subfamily Magatominae Leach, 1815
*Trogoderma* Dejean, 1821
*versicolor* (Creutzer, 1799)
*Anthrenus* Geoffroy, 1762
*fuscus* Olivier, 1789
*pimpinellae* Fabricius, 1775
*scrophulariae* (Linnaeus, 1758)
*verbasci* (Linnaeus, 1767)
**Family Bostrichidae** Latreille, 1802
Subfamily Bostrichinae Latreille, 1802
*Bostrichus* Geoffroy, 1762
*capucinus* (Linnaeus, 1758)

*Lichenophanes* Lesne, 1899
*varius* (Illiger 1801)
*Xylonites* Lesne, 1901
*retusus* (Olivier, 1790)
*Sinoxylon* Duftschmid, 1825
*perforans* (Schrank, 1789)
Subfamily Psoinae Blanchard, 1851
*Psoa* Herbst, 1797
*viennensis* Herbst, 1797
Subfamily Lyctinae Latreille, 1802
*Lyctus* Fabricius, 1792
*suturalis* Faldermann, 1837
**Family Ptinidae** Latreille, 1802
Subfamily Eucradinae LeConte, 1861
*Ptinomorphus* Mulsant & Rey, 1861
*imperialis* (Linnaeus, 1767)
Subfamily Ptininae Latreille, 1802
*Ptinus* Linnaeus, 1767
*fur* (Linnaeus, 1758)
*latro* Fabricius, 1775
*testaceus* Olivier, 1790
*variegatus* Rossi, 1794
*villiger* Reitter, 1884
Subfamily Dryophilinae LeConte, 1861
*Dryophilus* Chevrolat, 1832
*pusillus* (Gyllenhal, 1808)
Subfamily Ernobiinae Pic, 1912
*Xestobium* Motschulsky, 1845
*rufovillosum* (De Geer, 1774)
Subfamily Anobiinae Fleming, 1821
*Oligomerus* Redtenbacher, 1849
*brunneus* (Olivier, 1790)
*Stegobium* Motschulsky, 1860
*paniceum* (Linnaeus, 1758)
*Anobium* Fabricius, 1775
*fulvicorne* (Sturm, 1837)
*punctatum* (De Geer, 1774)
*rufipes* Fabricius, 1792
*Priobium* Motschulsky, 1845
*carpini* (Herbst, 1793)
*Ptilinus* Muller, 1776
*fuscus* Geoffroy, 1785
*pectinicornis* (Linnaeus, 1758)
Subfamily Xyletininae Gistel, 1848
*Xyletinus* Latreille, 1809
*ater* (Creutzer, 1796)
*laticollis* (Duftschmid, 1825)
*maculatus* Kiesenwetter, 1877
Subfamily Dorcatominae Thomson, 1859
*Caenocara* Thomson, 1859
*subglobosa* (Mulsant & Rey, 1864)

**Superfamily Cleroidea** Latreille, 1802
**Family Trogossitidae** Latreille, 1802
Subfamily Trogossitinae Latreille, 1802
*Nemozoma* Latreille, 1804
*elongatum* (Linnaeus, 1761)
*Tenebroides* Piller & Mitterpacher, 1783
*mauritanicus* (Linnaeus, 1758)
**Family Cleridae** Latreille, 1802
Subfamily Clerinae Latreille, 1802
*Denops* Fischer von Waldheim, 1829
*albofasciatus* (Charpentier, 1825)
*Opilo* Latreille, 1802
*pallidus* (Olivier, 1795)
*Thanasimus* Latreille, 1806
*formicarius* (Linnaeus, 1758)
*Clerus* Geoffroy, 1762
*mutillarius* Fabricius, 1775
*Trichodes* Herbst, 1792
*apiarius* (Linnaeus, 1758)
Subfamily Korynetinae Laporte, 1840
*Necrobia* Olivier, 1795
*violacea* (Linnaeus, 1758)
*Opetiopalpus* Spinola, 1844
*scutellaris* (Panzer, 1797)
**Family Melyridae** Leach, 1815
Subfamily Dasytinae Laporte, 1840
*Dasytiscus* Kiesenwetter, 1859
*affinis* Morawitz, 1861
*Danacea* Laporte, 1836
*nigritarsis* (Kuster, 1850)
*pallipes* (Panzer, 1795)
*Enicopus* Stephens, 1830
*pilosus* (Scopoli, 1763)
*Dasytes* Paykull, 1799
*flavipes* (Olivier, 1790)
*fusculus* (Illiger, 1801)
*niger* (Linnaeus, 1767)
*plumbeus* (Muller, 1776)
*subaeneus* Schonherr, 1817
*Dolichosoma* Stephens, 1830
*lineare* (Rossi, 1794)
Subfamily Malachiinae Fleming, 1821
*Charopus* Erichson, 1840
*flavipes* Paykull, 1798
*Ebaeus* Erichson, 1840
*appendiculatus* Erichson, 1840
*flavicornis* Erichson, 1840
*Sphinginus* Mulsant & Rey, 1867
*lobatus* (Olivier, 1790)
*Attalus* Erichson, 1840
*analis* (Panzer, 1796)
*Axinotarsus* Motschulsky, 1853
*marginalis* (Laporte, 1840)
*pulicarius* (Fabricius, 1775)
*Malachius* Fabricius, 1775
*aeneus* (Linnaeus, 1758)
*bipustulatus* (Linnaeus, 1758)
*geniculatus* Germar, 1824
*marginellus* Olivier, 1819
*viridis* Fabricius, 1787

*Anthocomus* Erichson, 1840
*bipunctatus* (Harrer, 1784)

**Superfamily Cucujoidea** Latreille, 1802
**Family Byturidae** Jacquelin du Val, 1858
Subfamily Byturinae Gistel, 1848
*Byturus* Latreille, 1796
*ochraceus* (Scriba, 1791)
**Family Sphindidae** Jacquelin du Val, 1860
*Aspidiphorus* Ziegler, 1821
*orbiculatus* (Gyllenhal, 1808)
**Family Erotylidae** Latreille, 1802
Subfamily Erotylinae Latreille, 1802
*Triplax* Herbst, 1793
*lepida* (Faldermann, 1837)
*Dacne* Latreille, 1796
*bipustulata* (Thunberg, 1781)
*rufifrons* (Fabricius, 1775)
**Family Monotomidae** Laporte, 1840
*Monotoma* Herbst, 1793
*brevicollis* Aube, 1838
Subfamily Rhizophaginae Redtenbacher, 1845
*Rhizophagus* Herbst, 1793
*paralellocollis* (Gyllenhal, 1827)
**Family Cryptophagidae** Kirby, 1837
Subfamily Cryptophaginae Kirby, 1837
*Telmatophilus* Heer, 1841
*caricis* (Olivier, 1790)
*sparganii* Ahrens, 1812
*Cryptophagus* Herbst, 1792
*acutangulus* Gyllenhal, 1827
*cellaris* (Scopoli, 1763)
*pilosus* Gyllenhal, 1827
**Family Silvanidae** Kirby, 1837
Subfamily Silvaninae Kirby, 1837
*Silvanus* Latreille, 1807
*fagi* Guerin-Meneville, 1844
*Oryzaephilus* Ganglbauer, 1899
*surinamensis* (Linnaeus, 1758)
*Uleiota* Latreille, 1796
*planata* (Linnaeus, 1761)
**Family Cucujidae** Latreille, 1802
Subfamily Cucujinae Latreille, 1802
*Cucujus* Fabricius, 1775
*cinnaberinus* (Scopoli, 1763)
**Family Phalacridae** Leach, 1815
Subfamily Phalacrinae Leach, 1815
*Phalacrus* Paykull, 1800
*coruscus* (Panzer, 1797)
*Olibrus* Erichson, 1845
*bicolor* (Fabricius, 1792)
*bimaculatus* Kuster, 1848
*bisignatus* (Menetries, 1849)
*corticalis* (Panzer, 1796)
*flavicornis* (Sturm, 1807)
*liquidus* Erichson, 1845
*millefolii* (Paykull, 1800)
*Stilbus* Seidlitz, 1872
*atomarius* (Linnaeus, 1767)
*oblongus* (Erichson, 1845)
*testaceus* (Panzer, 1797)
**Family Laemophloeidae** Ganglbauer, 1899
*Laemophloeus* Dejean, 1835
*monilis* (Fabricius, 1787)
*testaceus* (Fabricius, 1792)
**Family Kateretidae** Erichson, 1844
*Brachypterolus* Grouvelle, 1913
*pulicarius* (Linnaeus, 1758)
**Family Nitidulidae** Latreille, 1802
Subfamily Meligethinae Thomson, 1859
*Meligethes* Stephens, 1830
*aeneus* (Fabricius, 1775)
*coracinus* Sturm, 1845
*erythropus* (Marsham, 1802)
*flavipes* Sturm, 1845
*hebes* Erichson, 1845
*lepidii* Miller, 1852
*maurus* Sturm, 1845
*pedicularius* (Gyllenhal, 1808)
*picipes* Sturm, 1845
*viduatus* (Heer, 1841)
*Omosita* Erichson, 1843
*colon* (Linnaeus, 1758)
*discoidea* (Fabricius, 1775)
Subfamily Carpophilinae Erichson, 1843
*Carpophilus* Stephens, 1830
*hemipterus* (Linnaeus, 1758)
Subfamily Nitidulinae Latreille, 1802
*Nitidula* Fabricius, 1775
*carnaria* (Schaller, 1783)
*Soronia* Erichson, 1843
*grisea* (Linnaeus, 1758)
*punctatissima* (Illiger, 1794)
*Pocadius* Erichson, 1843
*ferrugineus* (Fabricius, 1775)
*Amphotis* Erichson, 1843
*marginata* (Fabricius, 1781)
Subfamily Epuraeinae Kirejtshuk, 1986
*Epuraea* Erichson, 1843
*guttata* (Olivier, 1790)
*silacea* (Herbst, 1784)
**Family Cerylonidae** Billberg, 1820
Subfamily Ceryloninae Billberg, 1820
*Cerylon* Latreille, 1802
*deplanatum* Gyllenhal, 1827
*histeroides* (Fabricius, 1792)
**Family Endomychidae** Leach, 1815
Subfamily Lycoperdininae Redtenbacher, 1844
*Lycoperdina* Latreille, 1807
*succincta* (Linnaeus, 1767)
**Family Coccinellidae** Latreille, 1807
Subfamily Scymninae Mulsant, 1846

*Stethorus* Weise, 1885
*punctillum* (Weise, 1891)
*Nephus* Mulsant, 1846
*quadrimaculatus* (Herbst, 1783)
*Vibidia* Mulsant, 1846
*duodecimpunctata* (Poda, 1761)
*Pullus* Mulsant, 1846
*apetzi* Mulsant, 1846
*ater* Kugelann, 1794
*auritus* Thunberg, 1795
*frontalis* (Fabricius, 1787)
*rubromaculatus* Goeze, 1777
*subvillosus* (Goeze, 1777)
*suturalis* Thunberg, 1795
*testaceus* Motschulsky, 1837
*Hyperaspis* Chevrolat, 1837
*campestris* Herbst, 1783
*pseudopustulata* Mulsant, 1853
Subfamily Chilocorinae Mulsant, 1846
*Exochomus* Redtenbacher, 1843
*flavipes* (Thunberg, 1781)
*quadripustulatus* (Linnaeus, 1758)
*Chilocorus* Leach, 1815
*bipustulatus* (Linnaeus, 1758)
*Platynaspis* Redtenbacher, 1843
*luteorubra* (Goeze, 1777)
Subfamily Coccidulinae Mulsant, 1846
*Coccidula* Kugelann, 1798
*scutellata* (Herbst, 1783)
Subfamily Coccinellinae Latreille, 1807
*Coccinula* Dobzhansky, 1925
*quatuordecimpustulata* (Linnaeus, 1758)
*Tytthaspis* Crotch, 1874
*sedecimpunctata* (Linnaeus, 1761)
*Propylea* Mulsant, 1846
*quatuordecimpunctata* (Linnaeus, 1758)
*Calvia* Mulsant, 1846
*quatuordecimguttata* (Linnaeus, 1758)
*Psyllobora* Chevrolat, 1837
*vigintiduopunctata* (Linnaeus, 1758)
*Hippodamia* Chevrolat, 1837
*tredecimpunctata* (Linnaeus, 1758)
*Semiadalia* Crotch, 1874
*undecimnotata* (Schneider, 1792)
*Adonia* Mulsant, 1846
*variegata* (Goeze, 1777)
*Coccinella* Linnaeus, 1758
*septempunctata* Linnaeus, 1758
*Synharmonia* Ganglbauer, 1899
*conglobata* Linnaeus, 1758
*Adalia* Mulsant, 1850
*bipunctata* (Linnaeus, 1758)
*decempunctata* (Linnaeus, 1758)
*Harmonia* Mulsant, 1850
*axyridis* Pallas, 1773
Subfamily Epilachninae Mulsant, 1846
*Subcoccinella* Agassiz, 1846
*vigintiquatuorpunctata* (Linnaeus, 1758)
*Cynegetis* Dejean, 1835
*impunctata* (Linnaeus, 1767)
**Family Corylophidae** LeConte, 1852
Subfamily Sericoderinae Matthews, 1888
*Sericoderus* Stephens, 1829
*lateralis* (Gyllenhal, 1827)
**Family Latridiidae** Erichson, 1842
Subfamily Latridiinae Erichson, 1842
*Latridius* Herbst, 1793
*lardarius* (De Geer, 1775)
*Enicmus* Thomson, 1859
*minutus* (Linnaeus, 1767)
*transversus* (Olivier, 1790)
*Corticaria* Marsham, 1802
*fulva* (Comolli, 1837)
*pubescens* (Gyllenhal, 1827)
*Cortinicara* Johnson, 1975
*gibbosa* (Herbst, 1793)

**Superfamily Tenebrionoidea** Latreille, 1802
**Family Mycetophagidae** Leach, 1815
Subfamily Mycetophaginae Leach, 1815
*Litargus* Erichson, 1846
*connexus* (Geoffroy, 1785)
*Mycetophagus* Fabricius, 1792
*ater* (Reitter, 1879)
*decempunctatus* Fabricius,1801
*piceus* (Fabricius, 1777)
*quadriguttatus* Mueller, 1821
*quadripustulatus* (Linnaeus, 1751)
*Typhaea* Stephens, 1829
*stercorea* (Linnaeus, 1758)
**Family Ciidae** Leach in Samouelle, 1819
Subfamily Ciinae Leach in Samouelle, 1819
*Cis* Latreille, 1796
*setiger* Mellie, 1849
*Ennearthron* Mellie, 1847
*affinis* (Gyllenhal, 1827)
**Family Tetratomidae** Billberg, 1820
Subfamily Tetratominae Billberg, 1820
*Tetratoma* Fabricius, 1790
*fungorum* Fabricius, 1790
**Family Melandryidae** Leach, 1815
Subfamily Osphyinae Mulsant, 1856 (1839)
*Osphya* Illiger, 1807
*bipunctata* (Fabricius, 1775)
**Family Mordellidae** Latreille, 1802
Subfamily Mordellinae Latreille, 1802
*Tomoxia* Costa, 1854
*bucephala* Costa, 1854
*Mordella* Linnaeus, 1758
*aculeate* Linnaeus, 1758
*fasciata* Fabricius, 1775
*perlata* Sulzer, 1776

*sulcicauda* Mulsant, 1856
*Mordellistena* Costa, 1854
*parvula* (Gyllenhal, 1827)
*parvuliformis* Stschegoleva-Barovskaja 1930
*pumila* (Gyllenhal, 1810)
*Mordellochroa* Emery, 1876
*abdominalis* (Fabricius, 1775)
**Family Ripiphoridae** Gemminger & Harold, 1870
Subfamily Ptilophorinae Gerstaecker, 1855
*Ptilophorus* Dejean, 1834
*dufouri* (Latreille, 1817)
Subfamily Ripiphorinae Gemminger & Harold, 1870
*Macrosiagon* Hentz, 1830
*tricuspidatum* Lepechin, 1774
**Family Zopheridae** Solier, 1834
Subfamily Colydiinae Erichson, 1842
*Aulonium* Erichson, 1845
*trisulcum* (Geoffroy, 1785)
*Bitoma* Herbst, 1793
*crenata* (Fabricius, 1775)
*Colobicus* Latreille, 1807
*marginatus* Latreille, 1807
*Colydium* Fabricius, 1792
*elongatum* (Fabricius, 1787)
**Family Tenebrionidae** Latreille, 1802
Subfamily Pimeliinae Latreille, 1802
*Tentyria* Latreille, 1804
*nomas* (Pallas, 1781)
*Asida* Latreille, 1804
*lutosa* Solier, 1836
*Pimelia* Fabricius, 1775
*subglobosa* (Pallas, 1781)
Subfamily Tenebrioninae Latreille, 1802
*Cryphaeus* Klug, 1833
*cornutus* (Fischer &Waldheim, 1823)
*Gnaptor* Brulle, 1832
*spinimanus* (Pallas, 1781)
*Blaps* Fabricius, 1775
*halophila* Fischer & Waldheim, 1832
*lethifera* Marsham, 1802
*mortisaga* (Linnaeus, 1758)
*Oodescelis* Motschulsky, 1845
*polita* (Sturm, 1807)
*Dendarus* Latreille, 1829
*punctatus* (Serville, 1825)
*Pedinus* Latreille, 1796
*fallax* Muls & Rey, 1853
*femoralis* (Linnaeus, 1767)
*Gonocephalum* Solier, 1834
*pusillum* (Fabricius, 1791)
*Opatrum* Fabricius, 1775
*sabulosum* (Linnaeus, 1761)
*Melanimon* Steven, 1829
*tibiale* (Fabricius, 1781)
*Bolitophagus* Illiger, 1798
*reticulatus* (Linnaeus, 1767)
*Scaphydema* Redtenbacher, 1849
*metallicum* (Fabricius, 1792)
*Tribolium* MacLeay, 1825
*castaneum* (Herbst, 1797)
*confusum* Jacquelin du Val, 1868
*destructor* Uyttenboogaart, 1933
*Uloma* Dejean, 1834
*culinaris* (Linnaeus, 1758)
*Alphitobius* Stephens, 1832
*diaperinus* (Panzer, 1797)
*Diaclina* Jacquelin du Val, 1861
*testudinea* (Piller & Mitterpacher, 1783)
*Tenebrio* Linnaeus, 1758
*molitor* Linnaeus, 1758
*obscurus* Fabricius, 1792
*opacus* Duftschmid, 1812
*Probaticus* Seidlitz, 1896
*subrugosus* (Duftschmidt, 1812)
*Cylindronotus* Faldermann, 1837
*aeneus* (Scopoli, 1763)
*dermestoides* (Illiger, 1798)
*gilvipes* Menetries, 1849
Subfamily Diaperinae Latreille, 1802
*Crypticus* Latreille, 1817
*quisquilius* (Linnaeus, 1761)
*Platydema* Castelnau & Brulle, 1831
*violaceum* (Fabricius, 1790)
*Diaperis* Geoffrroy, 1762
*boleti* (Linnaeus, 1758)
*Alphitophagus* Stephens, 1832
*bifasciatus* (Say, 1832)
*Hypophloeus* Fabricius, 1790
*bicolor* (Olivier, 1790)
*unicolor* (Piller & Mitterpacher, 1783)
Subfamily Lagriinae Latreille, 1825
*Belopus* Gebien, 1911
*procerus* (Mulsat, 1854)
*Lagria* Fabricius, 1775
*atripes* Mulsant & Guillebeau, 1855
*hirta* (Linnaeus, 1758)
Subfamily Alleculinae Laporte, 1840
*Prionychus* Solier, 1835
*ater* (Fabricius, 1775)
*Pseudocistela* Crotch, 1873
*ceramboides* (Linnaeus, 1758)
*Isomira* Mulsant, 1856
*murina* (Linnaeus, 1758)
*Mycetochara* Berthold, 1827
*axillaris* (Paykull, 1799)
*gracilis* (Faldermann, 1837)
*Podonta* Solier, 1835
*daghestanica* Reitter, 1885
*dalmatina* Baudi, 1877
*Cteniopus* Solier, 1835
*flavus* (Scopoli, 1763)
*sulphureus* (Linnaeus, 1758)

*Omophlus* Dahl, 1823
*lepturoides* (Fabricius, 1787)
*proteus* Kirsch, 1869
*Hymenalia* Mulsant, 1856
*rufipes* (Fabricius, 1792)
*Gonodera* Mulsant, 1856
*luperus* (Herbst, 1783)
**Family Oedemeridae** Latreille, 1810
Subfamily Nacerdinae Mulsant, 1858
*Nacerdes* Dejean, 1834
*melanura* (Linnaeus, 1758)
Subfamily Oedemerinae Latreille, 1810
*Ischnomera* Stephens, 1832
*caerulea* (Linnaeus, 1758)
*Oedemera* Olivier, 1789
*femorata* (Scopoli, 1763)
*lurida* (Marsham, 1802)
*podagrariae* (Linnaeus, 1767)
*virescens* (Linnaeus, 1767)
**Family Meloidae** Gyllenhal, 1810
Subfamily Meloinae Gyllenhal, 1810
*Cerocoma* Geoffroy, 1762
*muehlfeldi* Gyllenhal, 1817
*schaefferi* (Linnaeus, 1758)
*schreberi* (Fabricius, 1718)
*Epicauta* Dejean, 1834
*rufidorsum* (Goeze, 1777)
*Lydus* Dejean, 1821
*chalybaeus* (Tauscher, 1812)
*halbhuberi* Escherich, 1896
*syriacus* (Linnaeus, 1764)
*trimaculatus* Fabricius, 1775
*Lytta* Fabricius, 1775
*vesicatoria* (Linnaeus, 1778)
*Meloe* Linnaeus, 1758
*decorus* Brandt & Erichson, 1832
*hungarus* Schrank, 1776
*proscarabaeus* Linnaeus, 1758
*rugosus* Marsham, 1802
*scabriusculus* Brandt & Erichson, 1832
*variegatus* Donovan, 1776
*violaceus* Marsham, 1802
*Mylabris* Fabricius, 1775
*decempunctata* Fabricius, 1781
*polymorpha* (Pallas, 1771)
*pusilla* Olivier, 1811
*variabilis* (Pallas, 1782)
*Oenas* Latreille, 1802
*crassicornis* (Illiger, 1800)
Subfamily Nemognathinae Laporte, 1840
*Euzonitis* Semenov, 1893
*bifasciata* Schwarz, 1803
*sexmaculata* (Olivier, 1789)
*Stenodera* Eschscholtz, 1818
*caucasica* (Pallas, 1781)
*Sitaris* Latreille, 1802
*muralis* (Forster, 1771)
*Stenoria* Mulsant, 1857
*apicalis* (Latreille, 1804)
**Family Pythidae** Solier, 1834
*Rhinosimus* Latreille, 1804
*ruficollis* (Linnaeus, 1761)
*Mycterus* Clarville & Schellenberg, 1798
*umbellatarum* (Fabricius, 1787)
**Family Pyrochroidae** Latreille, 1807
Subfamily Pyrochroinae Latreille, 1806
*Pyrochroa* (Geoffroy, 1762)
*coccinea* Linnaeus, 1761
*serraticornis* Scopoli, 1763
**Family Anthicidae** Latreille, 1819
Subfamily Anthicinae Latreille, 1819
*Notoxus* Geoffroy, 1762
*monoceros* (Linnaeus, 1760)
*trifasciatus* Rossi, 1792
*Formicomus* La Ferte-Senectere, 1848
*nobilis* Faldermann, 1837
*pedestris* (Rossi, 1790)
*Anthicus* Paykull, 1798
*antherinus* (Linnaeus, 1761)
*ater* (Panzer, 1797)
*floralis* (Linnaeus, 1758)
*hispidus* (Rossi, 1792)
*Cyclodinus* Mulsant, Rey, 1866
*morawitzi* (Desbroches des Loges, 1875)
**Family Scraptiidae** Mulsant, 1856
Subfamily Anaspidinae Mulsant, 1856
*Pentaria* Mulsant, 1856
*badia* (Rosenhauer, 1847)
*Anaspis* Geoffroy, 1762
*brunnipes* Mulsant, 1856
*flava* (Linnaeus, 1758)
*frontalis* (Linnaeus, 1758)
*palpalis* Gerhardt, 1876
*ruficollis* (Fabricius, 1792)
*steppensis* Motschulsky, 1860

**Superfamily Chrysomeloidea** Latreille, 1802
**Family Cerambycidae** Latreille, 1802
Subfamily Prioninae Latreille, 1802
*Prionus* Geoffroy, 1762
*coriarius* (Linnaeus, 1758)
*Megopis* Serville, 1832
*scabricornis* (Scopoli, 1763)
Subfamily Lepturinae Latreille, 1802
*Rhamnusium* Latreille, 1829
*bicolor* (Schrank, 1781)
*Rhagium* Fabricius, 1775
*mordax* (De Geer, 1775)
*sycophanta* (Schrank, 1781)
*Stenocorus* Fabricius, 1775
*meridianus* (Linnaeus, 1758)
*quercus* (Goetz, 1783)

*Pachyta* Dejean, 1821
*quadrimaculata* (Linnaeus, 1758)
*Dinoptera* Mulsant, 1863
*collaris* (Linnaeus, 1758)
*Pidonia* Mulsant, 1863
*lurida* (Fabricius, 1792)
*suturalis* Le Conte, 1858
*Cortodera* Mulsant, 1863
*humeralis* (Schaller, 1783)
*villosa* Heyden, 1876
*Grammoptera* Serville, 1835
*ruficornis* (Fabricius, 1781)
*Alosterna* Mulsant, 1863
*tabacicolor* De Geer, 1775
*Leptura* Linnaeus, 1758
*aurulenta* Fabricius, 1792
*bisignata* Brulle, 1832
*livida* (Fabricius, 1776)
*unipunctata* Fabricius, 1787
*Pachytodes* Mulsant, 1863
*cerambyciformis* (Schrank, 1781)
*erratica* (Dalman, 1817)
*Anoplodera* Mulsant, 1839
*sexgutata* (Fabricius, 1775)
*rufipes* Schaller, 1783
*Strangalia* Serville, 1835
*attenuata* (Linnaeus, 1758)
*bifasciata* (Muller, 1776)
*maculata* (Poda, 1761)
*melanura* (Linnaeus, 1758)
*nigra* (Linnaeus, 1758)
*revestita* (Linnaeus, 1767)
*Stenurella* Villiers, 1974
*septempunctata* (Fabricius, 1792)
Subfamily Spondylidinae Serville, 1832
*Tetropium* Kirby, 1837
*fuscum* (Fabricius, 1787)
Subfamily NecydalinaE Latreille, 1825
*Necydalis* Linnaeus, 1758
*major* Linnaeus, 1758
Subfamily Cerambycinae Latreille, 1802
*Obrium* Dejean, 1821
*cantharinum* (Linnaeus, 1767)
*Cerambyx* Linnaeus, 1758
*cerdo* Linnaeus, 1758
*miles* Bonelli, 1812
*scopolii* Fusslins, 1775
*Stenopterus* Illiger, 1804
*rufus* Linnaeus, 1767
*Molorchus* Fabricius, 1792
*umbellatarum* (Schreber, 1759)
*Callimellum* Strand, 1928
*angulatum* (Schrank, 1789)
*Aromia* Serville, 1833
*moschata* (Linnaeus, 1758)
*Rosalia* Serville, 1833
*alpina* (Linnaeus, 1758)
*Hylotrupes* Serville, 1834
*bajulus* (Linnaeus, 1758)
*Ropalopus* Mulsant, 1839
*clavipes* (Fabricius, 1775)
*femoratus* (Linnaeus, 1758)
*macropus* (Germar, 1824)
*varini* (Bedel, 1870)
*Callidium* Fabricius, 1775
*coriaceum* (Paykull, 1800)
*violaceum* (Linnaeus, 1758)
*Pyrrhidium* Fairmaire, 1864
*sanguineum* (Linnaeus, 1758)
*Phymatodes* Mulsant, 1839
*fasciatus* (Villers, 1789)
*pusillus* (Fabricius, 1787)
*rufipes* (Fabricius, 1767)
*testaceus* (Linnaeus, 1758)
*Poecilium* Farmaire, 1864
*alni* (Linnaeus, 1767)
*Xylotrechus* Chevrolat, 1860
*antilope* Schenherr, 1817
*pantherinus* (Savenius, 1825)
*rusticus* (Linnaeus, 1758)
*Clytus* Laicharting, 1784
*arietis* (Linnaeus, 1758)
*rhamni* Germar, 1817
*tropicus* (Panzer, 1795)
*Cyrtoclytus* Ganglbauer, 1881
*capra* (Germar, 1824)
*Plagionotus* Mulsant, 1824
*arcuatus* (Linnaeus, 1758)
*detritus* (Linnaeus, 1758)
*floralis* (Pallas, 1733)
*Isotomus* Mulsant, 1863
*speciosus* (Schneider, 1787)
*Chlorophorus* Chevrolat, 1863
*figuratus* (Scopoli, 1763)
*herbstii* (Brahm, 1790)
*sartor* (Muller, 1766)
*varius* (Muller, 1766)
*Anaglyptus* Mulsant, 1839
*mysticus* (Linnaeus, 1758)
*Purpuricenus* Dejean, 1821
*kaehleri* (Linnaeus, 1758)
Subfamily Lamiinae Latreille, 1825
*Mesosa* Latreille, 1829
*curculionoides* (Linnaeus, 1761)
*nebulosa* (Fabricius, 1781)
*Anaesthetis* Dejean, 1835
*testacea* (Fabricius, 1781)
*Monochamus* Fabricius, 1775
*sutor* (Fabricius, 1787)
*Morimus* Brulle, 1832
*funereus* Mulsant, 1863
*Lamia* Fabricius, 1775

*textor* (Linnaeus, 1758)
*Neodorcadion* Ganglbauer, 1884
*bilineatum* (Germar, 1824)
*Dorcadion* Dalman, 1817
*aethiops* (Scopoli, 1763)
*carinatum* (Pallas, 1771)
*caucasicum* Kuster, 1847
*decipiens* Germar, 1824
*equestre* (Laxmann, 1770)
*fulvum* (Scopoli, 1763)
*holosericeum* Krynicky, 1832
*litiosum* Ganglbauer, 1884
*pedestre* Poda, 1761
*pusillum* Koster, 1847
*scopolii* (Herbst, 1784)
*tauricum* Waltl, 1838
*Pogonocherus* Dejean, 1821
*hispidulus* (Piller & Miterpacher, 1783)
*hispidus* (Linnaeus, 1758)
*Acanthocinus* Dejean, 1821
*aedilis* (Linnaeus, 1758)
*Leiopus* Serville, 1835
*nebulosus* (Linnaeus, 1758)
*Exocentrus* Mulsant, 1839
*adspersus* Mulsant, 1846
*lusitanus* (Linnaeus, 1767)
*stierlini* Ganglbauer, 1883
*Phytoecia* Dejean, 1835
*affinis* (Harrer, 1784)
*coerulea* Scopoli, 1772
*coerulescens* (Scopoli, 1763)
*cylindrica* (Linnaeus, 1758)
*icterica* (Schaller, 1783)
*nigricornis* (Fabricius, 1781)
*pustulata* (Schrank, 1776)
*rubropunctata* Goeze, 1777
*scutellata* (Fabricius, 1793)
*virgula* (Charpentier, 1825)
*Acanthoderes* Haldeman, 1847
*clavipes* (Scharnk, 1781)
*Tetrops* Kirby, 1826
*praeusta* (Linnaeus, 1758)
*starki* Chevrolat, 1859
*Saperda* Fabricius, 1775
*carcharias* (Linnaeus, 1758)
*octopunctata* (Scopoli, 1792)
*punctata* (Linnaeus, 1767)
*scalaris* (Linnaeus, 1758)
*Stenostola* Mulsant, 1839
*ferrea* (Schrank, 1776)
*Oberea* Mulsant, 1839
*erythrocephala* (Schrank, 1776)
*euphorbiae* (Germar, 1813)
*Agapanthia* Serville, 1935
*asphodeli* (Latreille, 1804)
*dahli* (Richter, 1821)
*leucaspis* (Steven, 1817)
*maculicornis* (Gyllenhal, 1817)
*villosovirieiscens* (De Geer, 1775)
*violacea* (Fabricius, 1775)
*Pilemia* Fairmaire, 1864
*hirsutula* (Frolich, 1793)
*tigrina* (Mulsant, 1851)
**Family Megalopodidae** Latreille, 1802
Subfamily Zeugophorinae Boving & Craighead, 1931
*Zeugophora* Kunze, 1818
*subspinosa* (Fabricius, 1781)
**Family Orsodacnidae** Thomson, 1859
Subfamily Orsodachinae Thomson, 1859
*Orsodache* Latreille, 1802
*cerasi* (Linnaeus, 1758)
*lineola* (Panzer, 1795)
**Family Chrysomelidae** Latreille, 1802
Subfamily Bruchinae Latreille, 1802
*Callosobruchus* Pic, 1902
*chinensis* Linnaeus, 1758
*Bruchus* Linnaeus, 1767
*affinis* Frolich, 1799
*atomarius* Linnaeus, 1761
*brachialis* Fahrens, 1839
*emarginatus* Allard, 1868
*lentis* Frolich, 1799
*loti* Paykull, 1800
*luteicornis* Illiger, 1794
*pisorum* Linnaeus, 1758
*rufimanus* Boheman, 1833
*rufipes* Herbst, 1783
*Bruchidius* Schilsky, 1905
*biguttatus* (Olivier, 1795)
*glycyrrhizae* (Gyllenhal, 1839)
*halodendri* Gebler, 1825
*mulsanti* (Brisout, 1863)
*nanus* Germar, 1824
*obscuripes* (Gyllenhal, 1839)
*seminarius* (Linnaeus, 1767)
*unicolor* Olivier, 1795
*Acanthoscelides* Schilsky, 1905
*obtectus* (Say, 1831)
*pallidipennis* (Motschulsky, 1874)
*Euspermophagus* Zacher, 1930
*sericeus* Geoffroy, 1785
Subfamily Donaciinae Kirby, 1837
*Donacia* Fabricius, 1775
*bicolor* (Zschach, 1788)
*brevicornis* (Ahrens, 1810)
*cinerea* (Herbst, 1783)
*clavipes* (Fabricius, 1792)
*polita* (Kunze, 1818)
*simplex* (Fabricius, 1775)
*versicolorea* (Brahm, 1790)
*Plateumaris* Thomson, 1859
*affinis* (Kunze, 1818)

*braccata* (Scopoli, 1772)
Subfamily Criocerinae Latreille, 1804
*Lilioceris* Reitter, 1912
*lilii* (Scopoli, 1763)
*merdigera* (Linnaeus, 1758)
*Crioceris* Muller, 1764
*asparagi* (Linnaeus, 1758)
*duodecimpunctata* (Linnaeus, 1758)
*quatuodecimpunctata* (Scopoli, 1763)
*quincuepunctata* (Scopoli, 1763)
*Oulema* Gozis, 1886
*erichsoni* (Suffrian, 1841)
*gallaeciana* (Heyden, 1870)
*melanopus* (Linnaeus, 1758)
*septentrionis* (Weise, 1880)
*tristis* (Herbst, 1786)
*Lema* Fabricius, 1798
*cyanella* (Linnaeus, 1758)
Subfamily Cassidinae Stephens, 1831
*Hispa* Linnaeus, 1767
*atra* (Linnaeus, 1758)
*Pilemastoma* Desbrochers des Loges, 1891
*fastuosa* (Schaller, 1783)
*Hypocassida* Weise, 1893
*subferruginea* (Schrank, 1776)
*Cassida* Linnaeus, 1758
*atrata* Fabricius, 1787
*azurea* Fabricius, 1801
*canaliculata* Laicharting, 1781
*denticollis* Suffrian, 1844
*ferruginea* Goeze, 1777
*flaveola* Thunberg, 1794
*margaritacea* Schaller, 1783
*murraea* Linnaeus, 1767
*nebulosa* Linnaeus, 1758
*nobilis* Linnaeus, 1758
*pannonica* Suffrian, 1844
*panzeri* Weise, 1907
*prasina* Illiger, 1798
*rubiginosa* Mueller, 1776
*sanguinolenta* Mueller, 1776
*sanguinosa* Suffrian, 1844
*stigmatica* Suffrian, 1844
*subreticulata* Suffrian, 1844
*vibex* Linnaeus, 1767
*viridis* Linnaeus, 1758
Subfamily Chrysomelinae Latreille, 1802
*Timarcha* Latreille, 1829
*pratensis* (Duftschmidt, 1825)
*rugulosa* (Herrich-Schaffer, 183)
*Leptinotarsa* Chevrolat, 1837
*decemlineata* (Say, 1824)
*Chrysolina* Motschulsky, 1860
*cerealis* (Linnaeus, 1758)
*cinctipennis* (Harold, 1847)
*fastuosa* (Scopoli, 1763)
*geminata* (Paykull, 1799)
*graminis* (Linnaeus, 1758)
*gypsophilae* (Kuster, 1845)
*haemoptera* (Linnaeus, 1758)
*herbacea* (Duftschmidt, 1825)
*limbata* (Fabricius, 1775)
*marginalis* Duftschmidt, 1825
*marginata* (Linnaeus, 1758)
*olivieri* (Bedel, 1807)
*oricalcia* (Muller, 1776)
*polita* (Linnaeus, 1758)
*quadrigemina* (Suffrain, 1851)
*reitteri* (Weise, 1767)
*sanguinolenta* (Linnaeus, 1758)
*staphylaea* (Linnaeus, 1758)
*sturmi* (Westhoff, 1892)
*varians* (Schaller, 1783)
*Colaphellus* Dahl, 1823
*hoefti* (Menetries, 1832)
*sophiae* (Schaller, 1783)
*Plagiodera* Chevrolat, 1837
*versicolora* (Laicharting, 1781)
*Linnaidea* Motschulsky, 1860
*aenea* (Linnaeus, 1758)
*Chrysomela* Linnaeus, 1758
*collaris* (Linnaeus, 1758)
*cuprea* (Fabricius, 1775)
*populi* (Linnaeus, 1758)
*saliceti* (Weise, 1884)
*tremula* (Fabricius, 1787)
*vigipunctata* (Scopoli, 1763)
*Entomoscelis* Chevrolat, 1837
*adonidis* (Pallas, 1771)
*suturalis* (Weise, 1882)
*Gastrophysa* Chevrolat, 1837
*polygoni* (Linnaeus, 1758)
*viridula* (Degeer, 1775)
*Gonioctena* Chevrolat, 1837
*decemnotata* (Marshall, 1775)
*fornicata* (Bruggeman, 1873)
*linnaeana* (Schrank, 1781)
*Phratora* Chevrolat, 1837
*atrovirens* (Cornelius, 1875)
*laticollis* (Suffrain, 1851)
*Hydrothassa* Thomson, 1866
*marginella* (Linnaeus, 1758)
*Prasocuris* Latreille, 1802
*junci* (Brahm, 1790)
*phellandrii* (Linnaeus, 1758)
*Phaedon* Latreille, 1829
*cochleariae* (Fabricius, 1792)
*puritocus* (Rossi, 1792)
Subfamily Galerucinae Latreille, 1802
*Galeruca* Muller, 1764
*interrupta* (Duftschmidt, 1825)
*pomonae* (Scopoli, 1763)

*rufa* (Germar, 1824)
*tanaceti* (Linnaeus, 1758)
*Lochmae* Weise, 1883
*caprea* (Linnaeus, 1758)
*crataegi* (Forster, 1771)
*suturalis* (Thomson, 1866)
*Galerucella* Crotch, 1873
*calmariensis* (Linnaeus, 1758)
*luteola* (Muller, 1766)
*pusilla* (Duftschmidt, 1825)
*Phyllobrotica* Chevrolat, 1837
*adusta* (Greutzer, 1799)
*elegans* (Kraatz, 1866)
*quadrimaculata* (Linnaeus, 1758)
*Calomicrus* Stephens, 1831
*circumfuscus* (Marsham, 1802)
*Luperus* Geoffroy, 1762
*cyanipennis* (Küster, 1848)
*viridipennis* (Germar, 1824)
*xanthopoda* (Schrank, 1781)
*Euluperus* Weise, 1886
*cyaneus* (Joannis, 1866)
*xanthopus* (Duftschmidt, 1825)
Subfamily Cryptocephalinae Gyllenhal, 1813
*Labidostomis* Germar, 1822
*cyunicornis* (Germar, 1817)
*huimeralis* (Schneider, 1792)
*longimata* (Linnaeus, 1761)
*lucida* (Germar, 1823)
*Lachnaia* Chevrolat, 1837
*sexpunctata* (Scopoli, 1763)
*Tituboea* Lacordaire, 1848
*macropus* (Illiger, 1800)
*Smaragdina* Chevrolat, 1837
*affinis* (Illiger, 1794)
*aurita* (Linnaeus, 1767)
*salicina* (Scopoli, 1775)
*xanthaspis* (Germar, 1824)
*Clytra* Laicharting, 1781
*appendicina* (Lacordaire, 1848)
*atraphaxidis* (Pallas, 1773)
*laeviscula* (Ratzeubyrg, 1837)
*quadripunctata* (Linnaeus, 1758)
*Coptocephala* Chevrolat, 1837
*chalybaea* (Germar, 1824)
*gebleri* (Gebler, 1841)
*quadrimaculata* (Linnaeus, 1767)
*scopolina* (Linnaeus, 1767)
*Cheilotoma* Chevrolat, 1837
*musciformis* (Goeze, 1777)
*Cryptocephalus* Muller, 1764
*apicalis* (Gebler, 1830)
*aureolus* (Suffrain, 1847)
*biguttatus* (Scopoli, 1763)
*bipunctatus* (Linnaeus, 1758)
*chrysopus* (Gmelin, 1788)
*connexus* (Oliver, 1807)
*cordiger* (Linnaeus, 1758)
*coryli* (Linnaeus, 1758)
*elongatus* (Germar, 1824)
*flavipes* (Fabricius, 1781)
*fulvus* (Goeze, 1777)
*gamma* (Herrich-Schaffer, 1829)
*hypochoeridis* (Linaeus, 1758)
*imperialis* (Laicharting, 1781)
*janthinus* (Germar, 1824)
*labiatus* (Linnaeus, 1761)
*laetus* (Fabricius, 1792)
*laevicolis* (Gebler, 1830)
*macellus* (Suffrain, 1860)
*moraei* (Linnaeus, 1758)
*nitidilus* (Fabricius, 1787)
*nitidus* (Linnaeus, 1758)
*ocellatus* (Drapiez, 1819)
*octacosmus* (Bedel, 1891)
*octomaculatus* (Rossi, 1790)
*octopunctatus* (Scopoli, 1763)
*parvulus* (Muller, 1776)
*populi* (Suffrain, 1848)
*quatuordecimmaculatus* (Schneider, 1792)
*quincuepunctatus* (Scopoli, 1763)
*schaefferi* (Schrank, 1789)
*sericeus* (Linnaeus, 1758)
*sexpunctatus* (Linnaeus, 1758)
*violaceus* (Laicharting, 1781)
*virens* (Suffrain, 1847)
*Pachybrachis* Chevrolat, 1837
*fimbriolatus* (Suffrain, 1848)
*hieroglyphicus* (Laicharting, 1781)
*probus* (Weise, 1882)
*scriptidorsum* (Marseul, 1875)
*sinuatus* (Mulsant, 1859)
*suturalis* (Weise, 1882)
*tesselatus* (Oliver, 1791)
Subfamily Eumolpinae Hope, 1840
*Bromius* Chevrolat, 1837
*obscurus* (Lionnaeus, 1775)
*Chloropterus* Morawitz, 1861
*versicolor* (Morawitz, 1860)
*Pachnephorus* Redtenbacher, 1845
*villosus* (Duftschmidt, 1825)
*Eumolpus* Illiger, 1798
*asclepiadeus* (Pallas, 1776)

**Superfamily Curculionoidea** Latreille, 1802
**Family Nemonychidae** Bedel, 1882
Subfamily Nemonychinae Bedel, 1882
*Nemonyx* Redtenbacher, 1845
*lepturoides* (Fabricius, 1801)
Family Anthribidae Billberg, 1820
Subfamily Anthribinae Billberg, 1820
*Anthribus* Geoffroy, 1762

*nebulosus* (Forster, 1771)
*scapularis* (Gebler, 1833)
*Dissoleucas* Jordan, 1925
*niveirostris* (Fabricius, 1798)
*Phaeochrotes* Pascoe, 1860
*cinctus* (Paykull, 1800)
*Platyrhinus* Clairville, 1798
*resinosus* (Scopoli, 1763)
*Tropideres* Schoenherr, 1826
*albirostris* (Herbst, 1783)
*Rhaphitropis* Reitter, 1916
*marchicus* (Herbst, 1797)
Subfamily Urodontinae Thomson, 1859
*Bruchela* Dejean, 1821
*canus* (Kuster, 1848)
*concolor* (Fahraeus, 1839)
*conformis* (Suffrian, 1845)
*pygmaeus* (Gyllenhal, 1833)
*rufipes* (Olivier, 1790)
*suturalis* (Fabricius, 1792)
**Family Attelabidae** Billberg, 1820
Subfamily Attelabinae Billberg, 1820
*Attelabus* Linnaeus, 1758
*nitens* (Scopoli, 1763)
Subfamily Apoderinae Jekel, 1860
*Apoderus* Olivier, 1807
*coryli* (Linnaeus, 1758)
Subfamily Rhynchitinae Gistel, 1856
*Rhynchites* Schneider, 1791
*aeneovirens* (Marsham, 1802)
*aequatus* (Linnaeus, 1767)
*aethiops* (Bach, 1854)
*auratus* (Scopoli, 1763)
*bacchus* (Linnaeus, 1758)
*cavifrons* (Gyllenhal, 1813)
*coeruleus* (De Geer, 1775)
*cupreus* (Linnaeus, 1761)
*germanicus* (Herbst, 1797)
*giganteus* (Krynicki, 1832)
*hungaricus* (Fussly, 1784)
*interpunctatus* (Stephens, 1831)
*olivaceus* (Gyllenhal, 1833)
*pauxillus* (Germar, 1824)
*pubescens* (Fabricius, 1775)
*ruber* (Fairmaira, 1859)
*sericeus* (Herbst, 1797)
*tomentosus* (Gyllenhal, 1839)
*Byctiscus* Thomson, 1859
*betulae* (Linnaeus, 1758)
*populi* (Linnaeus, 1758)
*Deporaus* Samouelle, 1819
*tristis* (Fabricius, 1794)
*betulae* (Linnaeus, 1758)
**Family Brentidae** Billberg, 1820
Subfamily Apioninae Schönherr, 1823
*Omphalapion* Schilsky, 1901
*hookeri* (Kirby, 1808)
*laevigatum* (Paykull, 1792)
*pseudodispar* (Wanat, 1994)
*Acanephodus* Alonso-Zarazaga, 1990
*onopordi* (Kirby, 1808)
*Ceratapoin* Schilsky, 1901
*austriacum* (Wagner, 1904)
*beckeri* (Desbrochers, 1875)
*carduorum* (Kirby, 1808)
*cylindricolle* (Gyllenhal, 1839)
*penetrans* (Germar, 1817)
*Diplapion* Reitter, 1916
*confluens* (Kirby, 1808)
*detritum* (Mulsant & Rey, 1859)
*stolidum* (Germar, 1817)
*Taphrotopium* Reitter, 1916
*sulcifrons* (Herbst, 1797)
*Aspidapion* Schilsky, 1901
*aeneum* (Fabricius, 1775)
*radiolus* (Marsham, 1802)
*validum* (Germar, 1817)
*Alocentron* Schilsky, 1901
*curvirostre* (Gyllenhal, 1833)
*Melanapion* Wagner, 1930
*minimum* (Herbst, 1797)
*Squamapion* Bokor, 1932
*cineraceum* (Wencker, 1964)
*elongatum* (Germar, 1824)
*flavimanum* (Gyllenhal, 1833)
*leucophaeatum* (Wencker, 1864)
*vicinum* (Kirby, 1800)
*Taeniapion* Schilsky, 1906
*rufulum* (Wencker, 1864)
*urticarium* (Herbst, 1784)
*Pseudapion* Schilsky, 1906
*atomarium* (Kirby, 1800)
*fulvirostre* (Gyllhenal, 1833)
*rufirostre* (Fabricius, 1775)
*Malvapion* Hoffmann, 1958
*malvae* (Fabricius, 1775)
*Rhopalapion* Schilsky, 1906
*longirostre* (Olivier, 1807)
*Trichopterapion* Wagner, 1930
*holosericeum* (Gyllhenal, 1833)
*Exapion* Bedel, 1887
*corniculatum* (Germar, 1817)
*elongatulum* (Desbrochers, 1891)
*Pseudoprotapion* Ehret, 1990
*astragali* (Paykull, 1800)
*elegantulum* (Germar, 1818)
*ergenense* (Becker, 1864)
*Protapion* Schilsky, 1906
*apricans* (Herbst, 1797)
*assimile* (Kirby, 1808)
*dissimile* (Germar, 1817)
*filirostre* (Kirby, 1808)

*fulvipies* (Fourcroy, 1785)
*nigritarse* (Kirby, 1808)
*ononidis* (Gyllenhal, 1827)
*ruficrus* (Germar, 1817)
*trifolli* (Linnaeus, 1768)
*varipes* (Germar, 1817)
*Pseudoperapion* Wagner, 1930
*brevirostre* (Herbst, 1797)
*Pseudostenapion* Wagner, 1930
*simum* (Germar, 1817)
*Aizobius* Alonso-Zarazaga, 1990
*sedi* (Germar, 1818)
*Perapion* Wagner, 1907
*affine* (Kirby, 1808)
*connexum* (Schilsky, 1902)
*curtirostre* (Germar, 1817)
*lemoroi* (Brisout, 1880)
*violaceum* (Kirby, 1808)
*Apion* Herbst, 1797
*miniatum* (Germar, 1833)
*sanguineum* (De Geer, 1775)
*Catapion* Schilsky, 1906
*meieri* (Desbrochers, 1901)
*pubescens* (Kirby, 1811)
*seniculus* (Kirby, 1808)
*Trichapion* Wagner, 1912
*simile* (Kirby, 1811)
*Stenopterapion* Bokor, 1923
*intermedium* (Eppelsheim, 1875)
*meliloti* (Kirby, 1808)
*tenue* (Kirby, 1808)
*Ischnopterapion* Bokor, 1923
*loti* (Kirby, 1808)
*virens* (Herbst, 1797)
*Holotrichapion* Gyorffy, 1956
*aestimatum* (Faust, 1891)
*aethiops* (Herbst, 1797)
*gracilicolle* (Gyllenhal, 1839)
*Hemitrichapion* Voss, 1959
*pavidum* (Germar, 1817)
*reflexum* (Gyllenhal, 1839)
*Mesotrichapion* Gyorffy, 1956
*punctirostre* (Gyllenhal, 1839)
*Cyanapion* Bokor, 1923
*columbinum* (Germar, 1817)
*platalea* (Germar, 1817)
*spencii* (Kirby, 1808)
*Oxystoma* Dumeril, 1805
*cerdo* (Gerstacker, 1854)
*craccae* (Linnaeus, 1767)
*dimidiatum* (Desbrochers, 1897)
*opeticum* (Bach, 1854)
*pomonae* (Fabricius, 1798)
*Eutrichapion* Reitter, 1916
*ervi* (Kirby, 1808)
*facetum* (Gyllenhal, 1839)
*gribodoi* (Desbrochers, 1896)
*melancholicum* (Wencker, 1864)
*punctigerum* (Paykull, 1792)
*viciae* (Paykull, 1800)
*Metapion* Schilsky, 1906
*breiti* (Wagner, 1910)
*Pseudometapion* Wagner, 1930
*gaudiale* (Faust, 1895)
Subfamily Nanophyinae Gistel, 1856
*Nanophyes* Schoenherr, 1838
*brevis* (Boheman, 1845)
*globiformis* (Kiesenwetter, 1864)
*Corimalia* des Gozis, 1885
*minutissima* (Tournier, 1867)
**Family Dryophthoridae** Schoenherr, 1833
Subfamily Dryophthorinae Schoenherr, 1833
*Sphenophorus* Schoenherr, 1838
*abbreviatus* (Fabricius, 1787)
*piceus* (Pallas, 1776)
*striatopunctatus* (Goeze, 1777)
**Family Brachyceridae** Billberg, 1820
Subfamily Brachycerinae Billberg, 1820
*Brachycerus* Olivier, 1790
*junix* (Lichtenstein, 1796)
*Brachycerus* Olivier, 1790
*foveicollis* (Gyllenhal, 1833)
Subfamily Erirhinae Schoenherr, 1826
*Dorytomus* Germar, 1817
*affinis* (Paykull, 1780)
*dejeani* (Faust, 1882)
*hirtipennis* (Bedel, 1884)
*ictor* (Herbst, 1795)
*longimanus* (Foerster, 1771)
*melanophthalmus* (Paykull, 1792)
*occallescens* (Gyllenhal, 1836)
*rufatus* (Bedel, 1888)
*salicinus* (Gyllenhal, 1827)
*suratus* (Gyllenhal, 1836)
*tremulae* (Paykull, 1780)
*Procas* Stephens, 1831
*armillatus* (Fabricius, 1801)
*Notaris* Germar, 1817
*acridulus* (Linnaeus, 1758)
*bimaculatus* (Fabricius, 1787)
*scirpi* (Fabricius, 1792)
*Lepidonotaris* Zumpt, 1933
*petax* (Sahlberg, 1829)
*Thryogenes* Bedel, 1884
*festucae* (Herbst, 1795)
*Echinocnemus* Schoenherr, 1843
*efferus* (Faust, 1887)
*globicollis* (Fairmaire, 1863)
*volgensis* (Faust, 1881)
*Acentrus* Schoenherr, 1845
*histrio* (Boheman, 1845)
*Paraphilernus* Desbrochers, 1872

*bilunulatus* (Desbrochers, 1872)
*Pseudostyphlus* Tournier, 1874
*pillumus* (Gyllenhal, 1836)
*Comasinus* Dejean, 1821
*setiger* (Beck, 1817)
*Smicronyx* Schoenherr, 1843
*brevicornis* (Solari, 1952)
*jungermanniae* (Reich, 1797)
*nebulosus* (Tournier, 1874)
*smreczynskii* (Solari, 1952)
*Ellescus* Dejean, 1821
*infirmus* (Herbst, 1795)
*scanicus* (Paykull, 1792)
*Acalyptus* Schoenherr, 1836
*carpini* (Fabricius, 1792)
*sericeus* (Gyllenhal, 1836)
Subfamily Tanysphyrinae Tournier, 1874
*Tanysphyrus* Germar, 1817
*lemnae* (Paykull, 1792)
**Family Curculionidae** Latreille, 1802
Subfamily Curculioninae Latreille, 1802
*Anthonomus* Germar, 1817
*humeralis* (Panzer, 1795)
*pedicularius* (Linnaeus, 1758)
*pomorum* (Linnaeus, 1758)
*pyri* (Kollar, 1837)
*rubi* (Herbst, 1795)
*rubripes* (Gyllenhal, 1836)
*rufus* (Gyllenhal, 1836)
*undulatus* (Gyllenhal, 1836)
*Furcipus* Desbrochers, 1868
*rectirostris* (Linnaeus, 1758)
*Bradybatus* Germar, 1824
*creutzeri* (Germar, 1824)
*kellneri* (Bach, 1854)
*seriesetosus* (Petri, 1912)
*tomentosus* (Desbrochers, 1892)
*Curculio* Linnaeus, 1758
*crux* (Fabricius, 1776)
*elephas* (Gyllenhal, 1836)
*glandium* (Marsham, 1802)
*nucum* (Linnaeus, 1758)
*pellitus* (Boheman, 1843)
*pyrrhoceras* (Marsham, 1802)
*rubidus* (Gyllenhal, 1836)
*salicivorus* (Paykull, 1792)
*venosus* (Graverhorst, 1807)
*villosus* (Fabricius, 1781)
*Mecinus* Germar, 1821
*circulatus* (Marsham, 1802)
*collaris* (Germar, 1821)
*heydeni* (Wencker, 1866)
*janthinus* (Germar, 1817)
*pyraster* (Herbst, 1795)
*Gymnetron* Schoenherr, 1826
*antirrhini* (Paykull, 1800)
*aper* (Desbrochers, 1893)
*asellus* (Gravenhorst, 1807)
*bipustulatum* (Rossi, 1794)
*collinum* (Gyllenhal, 1813)
*dieckmanni* (Behne, 1988)
*furcatum* (Desbrochers, 1893)
*ictericum* (Gyllenhal, 1837)
*labile* (Herbst, 1795)
*linariae* (Panzer, 1792)
*melanarium* (Germar, 1821)
*netum* (Germar, 1821)
*pascuorum* (Gyllenhal, 1813)
*pirazzolii* (Stierlin, 1867)
*rostellum* (Herbst, 1795)
*tetrum* (Fabricius, 1792)
*thapsicola* (Germar, 1821)
*veronicae* (Germar, 1821)
*villosulum* (Gyllenhal, 1838)
*Miarus* Schoenherr, 1826
*ajugae* (Herbst, 1795)
*campanulae* (Linnaeus, 1766)
*distinctus* (Boheman, 1845)
*graminis* (Gyllenhal, 1813)
*Cionus* Clairville & Schellenberg, 1798
*hortulanus* (Fourcroy, 1785)
*nigritarsis* (Reitter, 1904)
*olens* (Fabricius, 1792)
*olivieri* (Rosenschoeld, 1838)
*scrophulariae* (Linnaeus, 1758)
*thapsus* (Fabricius, 1792)
*tuberculosus* (Scopoli, 1763)
*Stereonychus* Suffrian, 1854
*fraxini* (De Geer, 1775)
*Lignyodes* Dejean, 1835
*bischoffi* (Blatchley & Leng, 1916)
*enucleator* (Panzer, 1798)
*muerlei* (Ferrari, 1866)
*Tychius* Germar, 1817
*aureolus* Kiesenwetter, 1851
*breviusculus* Desbrochers, 1873
*caldarai* (Dieckmann, 1986)
*crassirostris* (Kirsch, 1871)
*cuprifer* (Panzer, 1799)
*flavus* Becker, 1864
*junceus* (Reich, 1797)
*medicaginis* (Brisout, 1862)
*meliloti* (Stephens, 1831)
*picirostris* (Fabricius, 1787)
*polylineatus* (Germar, 1824)
*pumilus* (Brisout, 1862)
*qiuinquepunctatus* (Linnaeus, 1758)
*russicus* (Desbrochers, 1908)
*squamulatus* (Gyllenhal, 1836)
*stephensi* (Schoenherr, 1836)
*subsulcatus* (Tournier, 1873)
*trivialis* (Boheman, 1843)

*uralensis* (Pic, 1902)
*Sibinia* Germar, 1817
*femoralis* (Germar, 1824)
*pellucens* (Scopoli, 1772)
*phalerata* (Gyllenhal, 1836)
*subelliptica* (Desbrochers, 1873)
*tibialis* (Gyllenhal, 1836)
*variata* (Gyllenhal, 1836)
*viscariae* (Linnaeus, 1761)
*vittata* (Germar, 1824)
*Rhynchaenus* Clairville & Schellenberg, 1798
*alni* (Linnaeus, 1758)
*decoratus* (Germar, 1821)
*fagi* (Linnaeus, 1758)
*hungaricus* (Hajoss, 1938)
*michalki* (Dieckmann, 1963)
*pilosus* (Fabricius, 1781)
*populicola* Silfverberg, 1977
*pseudostigma* Tempere, 1982
*quedenfeldti* (Gerhard, 1865)
*quercus* (Linnaeus, 1758)
*rufitarsis* (Germar, 1821)
*rufus* (Schrank, 1781)
*salicis* (Linnaeus, 1758)
*signifer* (Creutzer, 1799)
*sparsus* (Fahraeus, 1843)
*subfasciatus* Gyllenhal, 1836
*Pseudorchestes* Bedel, 1894
*cinereus* Fahraeus, 1843
*ermischi* Dieckmann, 1958
*pratensis* Germar, 1821
*Rhamphus* Clairville, 1798
*oxyacanthae* (Marsham, 1802)
*pulicarius* (Herbst, 1795)
Subfamily Bagoinae Thomson, 1859
*Hydronomus* Schoenherr, 1826
*alismatis* (Marsham, 1802)
*Bagous* Germar, 1817
*argillaceus* (Gyllenhal, 1836)
*binodulus* (Herbst, 1795)
*limosus* (Gyllenhal, 1827)
*lutosus* (Gyllenhal, 1813)
*lutulentus* (Gyllenhal, 1813)
*subcarinatus* (Gyllenhal, 1836)
*validus* (Rosenhauer, 1847)
Subfamily Baridinae Schönherr, 1836
*Baris* Germar, 1824
*analis* (Olivier, 1790)
*angusta* (Brulle, 1832)
*artemisiae* (Herbst, 1795)
*atramentaria* (Boheman, 1836)
*atricolor* (Petri, 1901)
*carbonaria* (Boheman, 1836)
*chlorizans* (Germar, 1824)
*coerulescens* (Scopoli, 1763)
*concinna* (Boheman, 1836)
*janthina* (Boheman, 1836)
*laticollis* (Marsham, 1802)
*lepidii* (Germar, 1824)
*prasina* (Boheman, 1836)
*scolopacea* (Germar, 1824)
*semistriata* (Boheman, 1836)
*sulcata* (Boheman, 1836)
*timida* (Rossi, 1792)
*violaceomicans* (Solari, 1904)
*Limnobaris* Bedel, 1885
*dolorosa* (Goeze, 1777)
*t-album* (Linnaeus, 1758)
*Coryssomerus* Schoenherr, 1826
*capucinus* (Beck, 1817)
Subfamily Ceutorhynchinae Gistel, 1856
*Mononychus* Germar, 1824
*punctumalbum* (Herbst, 1784)
*Phytobius* Schoenherr, 1836
*leucogaster* (Marsham, 1802)
*Pelenomus* Thomson, 1859
*comari* (Herbst, 1795)
*Rhinoncus* Stephens, 1831
*albicinctus* (Gyllenhal, 1837)
*bosnicus* (Schultze, 1900)
*bruchoides* (Herbst, 1785)
*castor* (Fabricius, 1792)
*inconspectus* (Herbst, 1795)
*pericarpius* (Linnaeus, 1758)
*perpendicularis* (Reich, 1797)
*Homorosoma* Frivaldszky, 1893
*validirostre* (Gyllenhal, 1837)
*Amalus* Schoenherr, 1826
*scortillum* (Herbst, 1795)
*Amalorhynchus* Reitter, 1913
*melanarius* (Stephens, 1831)
*Poophagus* Schoenherr, 1837
*sisymbrii* (Fabricius, 1776)
*Coeliodes* Schoenherr, 1837
*cinctus* (Geoffroy, 1785)
*dryados* (Gmelin, 1790)
*ruber* (Marsham, 1802)
*trifasciatus* (Bach, 1854)
*Thamiocolus* Thomson, 1859
*nubeculosus* (Gyllenhal, 1837)
*pubicollis* (Gyllenhal, 1837)
*signatus* (Gyllenhal, 1837)
*uniformis* (Gyllenhal, 1837)
*viduatus* (Gyllenhal, 1813)
*virgatus* (Gyllenhal, 1837)
*Zacladus* Reitter, 1913
*geranii* (Paykull, 1800)
*Phrydiuchus* Des Gozis, 1885
*speiseri* (Schultze, 1897)
*topiarius* (Germar, 1824)
*Ceutorhynchus* Germar, 1824
*aeneicollis* (Germar, 1824)

*alliariae* (Brisout, 1860)
*angustus* (Dieckmann & Smreczynski, 1972)
*cardariae* (Korotyaev, 1992)
*carinatus* (Gyllenhal, 1837)
*chlorophanus* (Rouget, 1857)
*coarctatus* (Gyllenhal, 1837)
*cochleariae* (Gyllenhal, 1813)
*contractus* (Marsham, 1802)
*erysimi* (Fabricius, 1787)
*fallax* (Boheman, 1846)
*floralis* (Paykull, 1792)
*gallorhenanus* (Solari, 1949)
*gerhardti* (Schultze, 1899)
*hampei* (Brisout, 1869)
*hirtulus* (Germar, 1824)
*ignitus* (Germar, 1824)
*inaffectatus* (Gyllenhal, 1837)
*jakovlevi* (Schultze, 1902)
*nanus* (Gyllenhal, 1837)
*niyazii* (Hoffmann, 1957)
*obstrictus* (Marsham, 1802)
*pallidactylus* (Marsham, 1802)
*pervicax* (Weise, 1883)
*picitarsis* (Gyllenhal, 1837)
*pleurostigma* (Marsham, 1802)
*pulvinatus* (Gyllenhal, 1837)
*puncticollis* (Boheman, 1845)
*rapae* (Gyllenhal, 1837)
*roberti* (Gyllenhal, 1837)
*scrobicollis* (Neresheimer & Wagner, 1924)
*sisymbrii* (Dieckmann, 1966)
*sophiae* (Steven, 1829)
*subpilosus* (Brisout, 1869)
*sulcatus* (Brisout, 1869)
*sulcicollis* (Paykull, 1800)
*suturellus* (Gyllenhal, 1837)
*syrites* (Germar, 1824)
*talickyi* (Korotyaev, 1980)
*turbatus* (Schultze, 1903)
*wellschmiedi* (Dieckmann, 1979)
*Prisistus* Reitter, 1916
*suturalba* (Schultze, 1903)
*Ranunculiphilus* Dieckmann, 1969
*faeculentus* (Gyllenhal, 1837)
*kuntzei* (Smreczynski, 1957)
*Oprohinus* Reitter, 1916
*suturalis* (Fabricius, 1775)
*Ethelcus* Reitter, 1916
*denticulatus* (Schrank, 1781)
*verrucatus* (Gyllenhal, 1837)
*Parathelcus* Dieckmann, 1972
*pollinarius* (Foerster, 1771)
*Neoglocianus* Dieckmann, 1972
*maculaalba* (Herbst, 1795)
*Glocianus* Reitter, 1916
*distinctus* (Brisout, 1870)
*punctiger* (Gyllenhal, 1837)
*Datonychus* Wagner, 1944
*arquatus* (Herbst, 1795)
*melanostictus* (Marsham, 1802)
*Microplontus* Wagner, 1944
*figuratus* (Gyllenhal, 1837)
*rugulosus* (Herbst, 1795)
*triangulum* (Boheman, 1845)
*Hadroplontus* Thomson, 1859
*litura* (Fabricius, 1775)
*trimaculatus* (Fabricius, 1775)
*Mogulones* Reitter, 1916
*abbreviatulus* (Fabricius, 1792)
*albosignatus* (Gyllenhal, 1837)
*amplipennis* (Schultze, 1896)
*asperifoliarum* (Gyllenhal, 1813)
*austriacus* (Brisout, 1869)
*borraginis* (Fabricius, 1792)
*cruciger* (Herbst, 1784)
*euphorbiae* (Brisout, 1866)
*geographicus* (Goeze, 1777)
*hungaricus* (Brisout, 1869)
*javeti* (Brisout, 1869)
*larvatus* (Schultze, 1896)
*pallidicornis* (Brisout, 1860)
*symphyti* (Bedel, 1885)
*trisignatus* (Gyllenhal, 1837)
*Mogulonoides* Colonnelli, 1986
*radula* (Germar, 1824)
*Sirocalodes* Voss, 1958
*nigrinus* (Marsham, 1802)
*quercicola* (Paykull, 1792)
*Trichosirocalus* Colonnelli, 1979
*barnevillei* (Grenier, 1866)
*hassicus* (Schultze, 1903)
*horridus* (Panzer, 1801)
*troglodytes* (Fabricius, 1787)
*Stenocarus* Thomson, 1859
*ruficornis* (Stephens, 1831)
*Nedyus* Schoenherr, 1825
*quadrimaculatus* (Linnaeus, 1758)
*Coeliastes* Weise, 1883
*lamii* (Fabricius, 1792)
*Orobitis* Germar, 1817
*cyaneus* (Linnaeus, 1758)
Subfamily Cossoninae Schonherr, 1826
*Cossonus* Clairville, 1798
*cylindricus* (Sahlberg, 1834)
*linearis* (Fabricius, 1775)
*Stereocorynes* Wollaston, 1873
*truncorum* (Germar, 1824)
*Hexarthrum* Wollaston, 1860
*culinaris* (Germar, 1824)
Subfamily Cryptorhynchinae Schoenherr, 1825
*Gasterocercus* Laporte & Brulle, 1828

*depressirostris* (Fabricius, 1792)
*Cryptorhynchus* Illiger, 1807
*lapathi* (Linnaeus, 1758)
*Acalles* Schoenherr, 1826
*commutatus* (Dieckmann, 1982)
*Acallocrates* Reitter, 1912
*denticollis* (Germar, 1824)
*Echinodera* Wollaston, 1864
*hypocrita* (Boheman, 1837)
Subfamily Entiminae Schoenherr, 1826
*Stomodes* Schoenherr, 1826
*gyrosicollis* (Boheman, 1843)
*Parameira* Seidlitz, 1868
*setosa* (Seidlitz, 1868)
*Otiorhynchus* Germar, 1822
*albidus* (Stierlin, 1861)
*aurosparsus* (Germar, 1824)
*brunneus* (Steven, 1829)
*caucasicus* (Stierlin, 1872)
*conspersus* (Herbst, 1795)
*fullo* (Schrank, 1781)
*hungaricus* (Germar, 1824)
*laevigatus* (Fabricius, 1792)
*ligneus* (Oliver, 1808)
*ligustici* (Linnaeus, 1758)
*mandibularis* (Redtenbacher, 1842)
*montandoni* (Solari, 1904)
*multipunctatus* (Fabricius, 1792)
*ovatus* (Linnaeus, 1758)
*raucus* (Fabricius, 1776)
*rotundatus* (Siebold, 1837)
*singularis* (Linnaeus, 1767)
*smreczynskii* (Cmoluh, 1959)
*tristis* (Scopoli, 1763)
*valachiae* (Fuss, 1868)
*vielutinus* (Germar, 1824)
*Centricnemus* Germar, 1827
*leucogrammus* (Germar, 1824)
*Peritelus* Germar, 1824
*familiaris* (Boheman, 1834)
*sphaeroides* (Germar, 1824)
*Ptochus* Schoenherr, 1826
*porcellus* (Boheman, 1834)
*Pseudoptochus* Formanek, 1905
*aurochirtus* (Seidlitz, 1868)
*Elytrodon* Boheman, 1834
*bidentatus* (Steven, 1829)
*Omiamima* Silfverberg, 1977
*concinna* (Boheman, 1834)
*mollina* (Boheman, 1834)
*Omias* Germar, 1817
*borysthenicus* (Korotyaev, 1991)
*globulus* (Boheman, 1843)
*murinus* (Boheman, 1843)
*rotundatus* (Fabricius, 1792)
*verruca* (Steven, 1829)
*Urometopus* Formanek, 1904
*moczarskii* (Penecke, 1929)
*Trachyphloeus* Germar, 1817
*alternans* (Gyllenhal, 1834)
*bifoveolatus* (Beck, 1817)
*inermis* (Boheman, 1843)
*spinimanus* (Germar, 1824)
*turcicus* (Seidlitz, 1868)
*ventricosus* (Germar, 1824)
*Pseudomyllocerus* Desbrochers, 1872
*periteloides* (Fuss, 1861)
*sinuatus* (Fabricius, 1801)
*Phyllobius* Germar, 1824
*argentatus* (Linnaeus, 1758)
*betulinus* (Bechstein & Scharfenberg, 1805)
*calcaratus* (Fabricius, 1792)
*canus* (Gyllenhal, 1834)
*contemptus* (Steven, 1829)
*incanus* (Gyllenhal, 1834)
*longipilis* (Boheman, 1843)
*maculicornis* (Germar, 1824)
*oblongus* (Linnaeus, 1758)
*pictus* (Steven, 1829)
*pilicornis* (Desbrochers, 1873)
*pomaceus* (Gyllenhal, 1834)
*pyri* (Linnaeus, 1758)
*roboretanus* (Gredler, 1882)
*seladonius* (Brulle, 1832)
*thalassinus* (Gyllenhal, 1834)
*transsylvanicus* (Stierlin, 1894)
*vespertinus* (Fabricius, 1792)
*virideaeris* (Laicharting, 1781)
*Sciaphilus* Schoenherr, 1823
*asperatus* (Bonsdorff, 1785)
*Sciaphobus* Daniel, 1904
*caesius* (Hampe, 1870)
*setosulus* (Germar, 1824)
*squalidus* (Gyllenhal, 1834)
*vigo* (Yunakov, 1998)
*Eusomus* Germar, 1824
*beckeri* (Tournier, 1874)
*ovulum* (Germar, 1824)
*Barypeithes* Jacquelin du Val, 1854
*liptoviensis* (Weise, 1894)
*pellucidus* (Boheman, 1834)
*Brachysomus* Schoenherr, 1823
*echinatus* (Bonsdorff, 1785)
*hirtus* (Boheman, 1845)
*villosulus* (Germar, 1824)
*Foucartia* Jacquelin du Val, 1854
*squamulata* (Herbst, 1795)
*Psalidium* Herbst, 1795
*maxillosum* (Fabricius, 1792)
*Polydrusus* Germar, 1817
*cervinus* (Linnaeus, 1758)
*corruscus* (Germar, 1824)

*flavipes* (De Geer, 1775)
*inustus* (Germar, 1824)
*mollis* (Stroem, 1768)
*ornatus* (Gyllenhal, 1834)
*picus* (Fabricius, 1792)
*pilosus* (Gredler, 1866)
*pterygomalis* (Boheman, 1840)
*reitteri* (Stierlin, 1884)
*schwiegeri* (Reitter, 1908)
*thalassinus* (Gyllenhal, 1834)
*undatus* (Fabricius, 1781)
*viridicinctus* (Gyllenhal, 1834)
*Liophloeus* Germar, 1824
*lentus* (Germar, 1824)
*tessulatus* (Muller, 1776)
*Strophosoma* Billberg, 1820
*melanogrammum* (Foerster, 1771)
*Mesagroicus* Schoenherr, 1840
*obscurus* (Boheman, 1840)
*Tanymecus* Germar, 1817
*dilaticollis* (Gyllenhal, 1834)
*palliatus* (Fabricius, 1787)
*Megamecus* Reitter, 1903
*argentatus* (Gyllenhal, 1840)
*Chlorophanus* Sahlberg, 1823
*excisus* (Fabricius, 1801)
*gibbosus* (Paykull, 1792)
*graminicola* (Olivier, 1807)
*viridis* (Linnaeus, 1758)
*Cycloderes* Sahlberg, 1823
*canescens* (Rossi, 1792)
*pilosus* (Fabricius, 1792)
*Sitona* Germar, 1817
*ambiguus* (Gyllenhal, 1834)
*callosus* (Gyllenhal, 1834)
*concavirostris* (Hochhut, 1851)
*cylindricollis* (Fahraeus, 1840)
*griseus* (Fabricius, 1775)
*hispidulus* (Fabricius, 1776)
*humeralis* (Stephens, 1831)
*inops* (Gyllenhal, 1832)
*languidus* (Gyllenhal, 1834)
*lateralis* (Gyllenhal, 1834)
*lepidus* (Gyllenhal, 1834)
*lineatus* (Linnaeus, 1758)
*longulus* (Gyllenhal, 1834)
*macularius* (Marsham, 1802)
*puncticollis* (Stephens, 1831)
*striatellus* (Gyllenhal, 1834)
*sulcifrons* (Thunberg, 1798)
*suturalis* (Stephens, 1831)
*waterhousei* (Walton, 1846)
Subfamily Hyperinae Marseul, 1863 (1848)
*Hypera* Germar, 1817
*adspersa* (Fabricius, 1792)
*arator* (Linnaeus, 1758)
*contaminata* (Herbst, 1795)
*cumana* (Petri, 1901)
*dauci* (Olivier, 1807)
*diversipunctata* (De Geer, 1775)
*fuscocinerea* (Marsham, 1802)
*meles* (Fabricius, 1792)
*nigrirostris* (Fabricius, 1775)
*pastinacae* (Rossi, 1790)
*plantaginis* (De Geer, 1775)
*postica* (Gyllenhal, 1813)
*rogenhoferi* (Ferrari, 1866)
*rumicis* (Linnaeus, 1758)
*suspiciosa* (Herbst, 1795)
*transsylvanica* (Petri, 1901)
*viciae* (Gyllenhal, 1813)
*zoilus* (Scopoli, 1763)
*Herpes* Bedel, 1885
*porcellus* (Lacordaire, 1863)
*Tropiphorus* Schoenherr, 1842
*micans* (Boheman, 1824)
Subfamily Lixinae Schonherr, 1823
*Pachycerus* Schonherr, 1826
*cordiger* (Germar, 1819)
*Rhabdorhynchus* Motschulsky, 1860
*karelini* (Fahraeus, 1842)
*menetriesi* (Gyllenhal, 1842)
*varius* (Herbst, 1795)
*Pleurocleonus* Motschulsky, 1860
*quadrivittatus* (Zoubkoff, 1829)
*sollicitus* (Gyllenhal, 1834)
*Pseudocleonus* Chevrolat, 1873
*cinereus* (Schrank, 1781)
*Cleonis* Dejean, 1821
*pigra* (Scopoli, 1763)
*Adosomus* Faust, 1904
*roridus* (Pallas, 1781)
*Cyphocleonus* Motschulsky, 1860
*adumbratus* (Gebler, 1830)
*dealbatus* (Gmelin, 1790)
*trisulcatus* (Herbst, 1795)
*Mecaspis* Schoenherr, 1823
*alternans* (Herbst, 1795)
*Stephanocleonus* Motschulsky, 1860
*microgrammus* (Gyllenhal, 1834)
*tetragrammus* (Pallas, 1781)
*Coniocleonus* Motschulsky, 1860
*nigrosuturatus* (Goeze, 1777
*Leucosomus* Motschulsky, 1860
*pedestris* (Poda, 1761)
*Chromoderus* Motschulsky, 1860
*affinis* (Schrank, 1781)
*Stephanophorus* Chevrolat, 1873
*strabus* (Gyllenhal, 1834)
*Bothynoderes* Schoenherr, 1826
*punctiventris* (Germar, 1824)
*Rhinocyllus* Germar, 1819

*conicus* (Frolich, 1792)
*Lachnaeus* Schoenherr, 1826
*crinitus* (Boheman, 1836)
*horridus* (Reitter, 1890)
*Larinus* Germar, 1824
*adspersus* (Hochhut, 1847)
*beckeri* (Petri, 1907)
*canescens* (Gyllenhal, 1836)
*grisenscens* (Gyllenhal, 1836)
*inaequalicollis* (Capiomont & Leprieur, 1874)
*jaceae* (Fabricius, 1775)
*latus* (Herbst, 1784)
*minutus* (Gyllenhal, 1836)
*obtusus* (Gyllenhal, 1836)
*planus* (Fabricius, 1792)
*rusticanus* (Gyllenhal, 1836)
*sibiricus* (Gyllenhal, 1836)
*sturnus* (Schaller, 1783)
*turbinatus* (Gyllenhal, 1836)
*vulpes* (Olivier, 1807)
*Lixus* Fabricius, 1801
*albomarginatus* (Boheman, 1843)
*angustatus* (Fabricius, 1775)
*ascanii* (Linnaeus, 1767)
*astrachanicus* (Faust, 1883)
*bardanae* (Fabricius, 1781)
*brevipes* (Brisout, 1866)
*canescens* (Fisher & Waldheim, 1836)
*cardui* (Olivier, 1807)
*elegantulus* (Boheman, 1843)
*fasciculatus* (Boheman, 1836)
*filiformis* (Fabricius, 1801)
*incanescens* (Boheman, 1836)
*iridis* (Olivier, 1807)
*myagri* (Olivier, 1807)
*ochraceus* (Boheman, 1843)
*paraplecticus* (Linnaeus, 1758)
*rubicundus* (Zoubkoff, 1833)
*sanguineus* (Rossi, 1792)
*subtilis* (Boheman, 1836)
*vibex* (Pallas, 1781)
*vilis* (Rossi, 1790)
Subfamily Mesoptiliinae Lacordaire, 1863
*Magdalis* Germar, 1817
*armigera* (Fourcroy, 1785)
*barbicornis* (Latreille, 1804)
*cerasi* (Linnaeus, 1758)
*duplicata* (Germar, 1824)
*exarata* (Brisout, 1862)
*nitidipennis* (Boheman, 1843)
*rufa* (Germar, 1824)
*ruficornis* (Linnaeus, 1758)
*violacea* (Linnaeus, 1758)
Subfamily Molytinae Schoenherr, 1823
*Liparus* Olivier, 1807
*tenebrioides* (Pallas, 1781)
*transsylvanicus* (Petri, 1894)
*Hylobius* Germar, 1817
*transversovittatus* (Goeze, 1777)
*Lepyrus* Germar, 1817
*capucinus* (Schaller, 1783)
*palustris* (Scopoli, 1763)
*Minyops* Schoenherr, 1826
*carinatus* (Linnaeus, 1767)
*Aparopion* Hampe, 1861
*costatum* (Fahraeus, 1843)
*Alophus* Schoenherr, 1826
*agrestis* (Boheman, 1842)
*kaufmanni* (Stierlin, 1884)
*triguttatus* (Fabricius, 1775)
*Metadonus* Capiomont, 1867
*anceps* (Boheman, 1840)
*distinguendus* (Boheman, 1840)
*Coniatus* Germar, 1821
*splendidulus* (Fabricius, 1781)
*Pissodes* Germar, 1817
*castaneus* (De Geer, 1775)
*piceae* (Illiger, 1807)
Subfamily Scolytinae Latreille, 1807
*Scolytus* Geoffroy, 1762
*carpini* (Ratzeburg, 1837)
*intricatus* (Ratzeburg, 1837)
*koenigi* Schevyrew, 1890
*laevis* Chapuis, 1873
*mali* (Bechstein, 1805)
*multistriatus* (Marsham, 1802)
*pygmaeus* (Fabricius, 1787)
*rugulosus* (Ratzeburg, 1837)
*scolytus* (Fabricius, 1775)
*Taphrorynchus* Eichhoff, 1878
*villifrons* Duffoeur, 1843
*Dryocoetes* Eichhoff, 1864
*alni* (Georg, 1856)
*Xyleborus* Eichhoff, 1864
*dispar* (Fabricius, 1792)
*dryographus* (Ratzeburg, 1837)
*eurygraphus* (Ratzeburg, 1837)
*monographus* (Fabricius, 1792)
*saxeseni* (Ratzeburg, 1837)
*Pteleobius* Bedel, 1888
*kraatzii* (Eichhoff, 1864)
*vittatus* (Fabricius 1787)
*Hylesinus* Fabricius, 1801
*crenatus* (Fabricius, 1787)
*fraxini* (Panzer, 1779)
*Hylastes* Erichson, 1836
*angustatus* (Herbst, 1793)
*ater* (Paykull, 1800)
*Polygraphus* Erichson, 1836
*grandiclava* Thomson, 1886
Subfamily Platypodinae Shuckard, 1839
*Platypus* Herbst, 1793

*cylindrus* Fabricius, 1793

**Discussion**

Two species *Scarabaeus sacer* Linnaeus, 1758 and *Thorectes laevigatus* (Fabricius, 1798) recorded by Miller, Zubovskiy (1971) and Medvedev, Shapiro (1957) are not included in the list. According to Bacal and Munteanu (2012), the species *Sacarbaeus sacer*, was probably misidentified with *Scarabaeus typhon* Fischer, 1824, a common species, recorded on the territory of neighboring country Romania. The species *Thorectes laevigatus* is wide distributed in North Africa (Lobl, Smetana 2006), and it could not be found in the Republic of Moldova.

Faunistic research is essential for assessing biodiversity on a given area and also for understanding processes occurring in nature related to the increasing anthropogenic impact and climate change. Faunistic research data are important not only to fundamental sciences, but it also can be widely used in many fields of applied sciences such as agriculture, forestry, ecology, environmental protection and many others. Inventories of such data and making a checklist are the most important steps to make the data accessible and suitable for use by the general public. Moreover, faunistic studies have both scientific and social-cultural importance.

The inventory of the Republic of Moldova beetle species remains an opened subject which can be enlarged by future studies.

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# THE GENUS *LUCANUS* SCOPOLI, 1763 (*COLEOPTERA: LUCANIDAE*) IN THE NATURAL HISTORY MUSEUM COLLECTIONS OF SIBIU (ROMANIA)

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***Abstract:*** *The paper presents data regarding three Lucanus species preserved in the entomological collections of the Natural History Museum from Sibiu. Lucanus cervus, currently a protected species is of main conservation interest. Data concerning species geographical distribution based on collecting sites are also given.*
***Keywords:*** *stag beetles, genus Lucanus, natural heritage, museum collections.*

***Rezumat:*** *În studiul de faţă sunt oferite date asupra a trei specii ale genului Lucanus prezente în colecţiile entomologice ale Muzeului de Istorie Naturală din Sibiu. În prezent, Lucanus cervus este considerată a fi o specie protejată, de interes major. Date cu privire la distribuţia geografică a punctelor de colectare sunt prezentate în acest studiu.*
***Cuvinte cheie****: rădaşte, genul Lucanus, patrimoniu natural, colecţii muzeale*

## Introduction

Stag beetles (Lucanidae, Coleoptera) are a group of xylophagous or saproxylophagous beetles with more than 1500 species all over the world. It includes 18 species in Europe (Baraud, 1993; Muret, Drumont, 1999). *Lucanus cervus* (Linnaeus 1758) is a species of a major interest in the present conservation context. At European level is classified as a species of restricted abundance and conservation interest (Harvey, Gange 2011). This stag beetle is found across much of Europe, distributed in metapopulations (Harvey, Gange 2011) influenced by habitat structure. Until recently, the species was considered to inhabit especially forest ecosystems, but Thomaes *et al.* (2008) confirmed the presence of the species in gardens, parks and areas near forests.
What makes *L. cervus* special amongst European scarabaeoid beetles is its ability to subsist on dead wood in the rhizosphere, being completely dependent on wood or trees but is not arboreal (Whitehead 2007). In most of the countries the species is threatened because of habitat fragmentation and degradation.

Stag beetles have been studied in Romania since the early 1900's when data were first published by Fleck (1904). In the same period, similar studies were published by Montandon (1906). Data concerning the Transylvanian stag beetle fauna were published by Petri (1912) in a comprehensive catalogue. For different regions of Romania the work of Ochs (1921) and Marcu (1928) are worth mentioning. Moreover, Marcu (1928) gives the first record of *Lucanus cervus* in Romania (sampled from karst-dominated areas in the Mehedinţi and Gorj counties).

More recent studies are those of Szel (1995) on Transylvania's beetle fauna, Procheş (1997) and Chimişliu (2007) on the stag beetle fauna of Romania, the latter with a focus on the south-western Oltenia region.

In Romania the stag beetle fauna is represented by seven species (Chimişliu 2007). Previous to 1997, there were only six species known to occur in Romania. After the review undertaken by Procheş (1997) *Platycerus caprea* (De Geer 1774) was added to the list.

In the entomological collections of the Natural History Museum of Sibiu, considered to be one of the oldest and most valuable collections in Romania and dating since 1827 (Pascu, Schneider 1998), numerous specimens of *Lucanus* are preseved.

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This study aims to compile a list of the species and specimens in the museum's collections and to provide data regarding their distribution.

## Material

The stag beetle material of the Natural History Museum from Sibiu is comprised of several entomological collections: "Dr. Karl Petri", "Dr. Eugen Worell", "Rolf Weyrauch", "Heinrich Hann von Hannenheim" and The Transylvania Society for Natural Sciences (Siebenbürgishen Vereins für Naturwiessenschaften zu Hermannstadt).

The "Dr. Karl Petri" collection consists of more than 46.300 insects, mainly sampled from Transylvania. The collector was interested in Palaearctic beetles, but also in exotic beetles from all over the world. He is known for his Coleoptera studies, especially those looking at weevils (Curculionidae).

The "Dr. Eugen Worell" collection includes more than 93,000 specimens collected from Romania, but also from different regions including Europe, Africa, Asia, North and South America. In Romania, he collected mostly around Transylvania, with a particular interest in the surroundings of Sibiu.

The "Prof. Rolf Weyrauch" collection consists of 16.436 specimens from Transylvania, mainly from Sibiu's surroundings. In this collection the stag beetle family is represented by 282 specimens.

The material from the "Heinrich Hann von Hannenheim" collection originates in various parts of Sibiu County. The collector was one of the members of the Transylvania Society which focussed on collecting beetlesthe order Coleoptera is represented by 2000 specimens.

The "Dr. Eckbert Schneider" collection includes over 20.000 insects, collected from all over the country, especially from southern part of Transylvania.

The "Transylvania Society for Natural Sciences" is another important collection that consists of 71.567 insects. Coleoptera species are represented as follows: Palaearctic species (45.638 specimens) and exotic species (2.304 specimens) (Pascu, Schneider 1998).

The identification of the *Lucanus* species was made following the keys of: Paulian (1941) and Paulsen (2006). The nomenclature and systematic order are according to the ones used by Lawrence, Newton (1995), Maes (2005), Bouchard *et al.* (2011) and Bartolozzi (2013).

The analyzed stag beetle material is presented as follows: collection, species name, total number of males/females, localities followed by the official name and the administrative district (county) in round brackets; date of collection; the collector and collection abbreviations. In square brackets are mentioned the synonymy of the *Lucanus* species as they appear in the museum collections.

The following abbreviations are used in the present paper: leg. = legit/collected by; Mt/Mts= Mountain/s; AM= Armenia; AT= Austria; BG= Bulgaria; FR = France; IL= Israel; IT= Italy; RO=Romania; SK=Slovakia; SI=Slovenia; TR= Turkey; UA= Ukraine; R.A. = R. Albrecht; A.M. = Dr. Arnold Müller; C.O. = C. Orendi; Cz.= Czekelius; H. = Henrich H. von Hannenheim; E.R. = E. Reitter; M.P.= Mariana Pascu; Petri = Karl Petri; Sch.=Eckbert Schneider; Wo = Dr. Eugen Worell; Wey = Prof. Rolf Weyrauch, ♂- male, ♀ - female, spec. = specimen, specs. = specimens.

## List of the species

Order Coleoptera Linnaesue, 1758

Family Lucanidae, Latreille, 1804
Subfamily Lucaninae MacLeay, 1819
Tribe Lucanini MacLeay, 1819
Genus *Lucanus* Scopolii, 1763
Subgenus *Lucanus* Scopolii, 1763

***Lucanus cervus*** (Linnaeus, 1758)

***Lucanus cervus turcicus*** Sturm, 1843

***Lucanus tetraodon*** Thunberg, 1806

Subgenus *Pseudolucanus* Hope & Westwood, 1845
***Lucanus ibericus*** Motschulsky, 1845

### "Karl Petri" Collection

*Lucanus cervus* Linnaeus, 1758

♂: 1 spec., Schulergeb (Schulergebirge = Postăvaru Mts, RO), 1900; 1 spec., Schässbg (Schässburg = Sighişoara, Mureş County, RO), leg. Petri;

**[*Lucanus cervus cervus var. microcephalus*** Mulsant, 1842 syn ***Lucanus cervus v. capreolus*** Füssli**]**

♂: 1 spec., Karlsburg (Alba Iulia, Alba County, RO), leg. Cserni, 1889.

♀: 1 spec., Schässbg (Schässburg = Sighişoara, Mureş County, RO), leg. Petri;

*Lucanus ibericus* Motschulsky, 1845

♂: 1 spec., As. Mm. Riva (Asia Minor, Riva, Asia), 1898, leg. Albertall.

*Lucanus tetraodon* Thunberg, 1806

♂: 1 spec., Messina (IT), 1905, leg. Vitale.

♀: 1 spec., Messina (IT), 1905, leg. Vitale.

**Transylvania Society Collection**
*Lucanus cervus* Linnaeus, 1758

♂: 1 spec., H.dz. (Hamersdorf= Dealul Guşteriţei, Sibiu, RO), 28.VI.1891; 1 spec., Honigberg (Hărman, Braşov County, RO), leg. Deubel; 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), VI.1923, leg. A.M; 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), V.1929, leg. A.M.; 1 spec., Sibenbürgen, Michelsberg (Transylvania, Cisnădioara, Sibiu County, RO), leg. R.A.; 1 spec., Sibenbürgen, Hermannstadt (Transylvania, Sibiu, Sibiu County, RO), leg. R.A.; 1 spec., without other data;

♀: 1 spec., Honigberg (Hărman, Braşov County, RO), leg. Deubel; 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), VII.1917; 1 spec., H.dz. (Hamersdorf= Dealul Guşteriţei, Sibiu County, RO), 9.VI.1889; 1 spec., Sibenbürgen, Hermannstadt (Transylvania, Sibiu, Sibiu County, RO), leg. R.A.; 1 spec., Sibenbürgen, Michelsberg (Transylvania, Cisnădioara, Sibiu County, RO), leg. R.A.

**[*Lucanus cervus cervus var. microcephalus*** Mulsant, 1842 syn ***Lucanus cervus v. capreolus*** Füssli**]**

♂: 1 spec., Sibenbürgen, Kronstadt (Transylvania, Braşov, Braşov County, RO), leg. R.A.; 1 spec., Vargyas (Vârghiş, Covasna County, RO); 1 spec., Ban (Ban=Banat Region, RO); 1 spec., Mehadia (Caraş-Severin County, RO); 1 spec., Ban (Ban=Banat Region, RO), 25.V.1884; 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), 1.VII.1931, leg. Cz.; 1 spec., (without other data);

♀: 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), leg. R.A.; 1 spec., Vargyas (Vârghiş, Covasna County, RO);

**[*Lucanus cervus cervus var. pentaphyllus*** Reiche, 1853 syn ***Lucanus cervus* var. *pentaphyllus*]**

♂: 1 spec., Czoodtal II. Elektr. W. (Valea Sadu, Cindrel Mts, RO), VII-VIII.1929, leg.C.O.

♀: 1 spec., Fr. Ztr. Pyrenean, Vallee de Luchon (Pyrenees Mts, Luchon Valley, FR), 25-29.07.1982, leg. A.M.

*Lucanus cervus turcicus* Sturm, 1843 syn. *Lucanus cervus* var. *turcicus*

♂: 1 spec., Sophia Knjazevo (Sofia, BG), 1VIII.1931, leg. A.M.;

*Lucanus cervus syriacus* Planet, 1897 syn. *Lucanus ibericus v. syriacus*

♂: 1 spec., Asia Minor., Syria, Akbes (now placed in Turkey, Hatay vil., TR), leg. E.R.

♀: 1 spec., Syria, Akbes (now placed in Turkey, Hatay vil., TR), leg. E.R.

*Lucanus ibericus* Motschulsky, 1845

♂: 1 spec., Turcia (Turkey, TR), leg. Merkl.

♀: 1 spec., Krim (Krim, SI), leg. Kelecsényi.

**"Eugen Worell" Collection**
*Lucanus cervus* Linnaeus, 1758

♂: 1 spec., Împrejurimile Sibiului (Sibiu surroundings, Sibiu County, RO), leg. E. Worell; 1 spec., Sibiu (Sibiu, Sibiu County, RO); 1 spec., Kaschau (Kosice, SK) leg. O. U.; 7 specs, without other data;

♀: 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), leg. E. Worell; 1 spec., Împrejurimile Sibiului (Sibiu surroundings, Sibiu County, RO), leg. E. Worell; 7 specs, without other data.

**[*Lucanus cervus cervus var. microcephalus*** Mulsant, 1842 syn ***Lucanus cervus v. capreolus*** Füssli**]**

♂: 1 spec., Herkules Bad (Băile Herculane, Caraş-Severin County, RO), VI. 1927, leg. E. Worell; 5 specs., without other data; 1 spec., Alupka, Krim. (Alupka, within Crimea, Ukraine); 2 specs Herkules Bad (Băile Herculane, Caraş-Severin County, RO), VI. 1927 and VI. 1928, leg. E. Worell; 2 specs, without other data.

*Lucanus cervus turcicus* Sturm, 1843 syn. *Lucanus cervus* var. *turcicus*

♂: 1 spec., Jerusilem (Ierusalim, IL) leg. Reitter; 1 spec. without other data.

*Lucanus ibericus* Motschulsky, 1845

♂: 1 spec., Armenien (Armenia, AM) leg. E. Worell; 1 spec., Turcia (Turkey, TR), leg. E. Worell.

*Lucanus tetraodon* Thunberg, 1806

♂: 1 spec., Calabrien (Calabria region, IT), leg. E. Worell.

♀: 1 spec., Calabrien (Calabria region, IT), leg. E. Worell.

**"Rolf Weyrauch" Collection**
*Lucanus cervus* Linnaeus, 1758

♂: 2 spec. Groβp. (Grosspold = Apoldu de Sus, Sibiu County, RO), VI.1958, leg. Weyrauch; 1 spec. Herkulesbad (Băile Herculane, Caraş-Severin County, RO), 6.VI.1954 and 5.VI.1970, leg. R. Weyrauch; 1 spec., 16.VI.1955 Hstd (Hermannstadt = Sibiu, Sibiu County, RO); 3 specs Hermannstadt (Sibiu, Sibiu County, RO), 4.VI.1963 and 17.VII.1954, leg. R. Weyrauch; 1 spec., Salzbg. (Salzburg = Ocna Sibiului, Sibiu County, RO), 30.V.1962, leg. R. Weyrauch; 2 specs, Grosspold (Apoldu de Sus, RO), 14.VI.1950 leg. R.Weyrauch; 1 spec., without other data.

♀: 2 specs., Herkulesbad (Băile Herculane, Caraş-Severin County, RO), 2.V.1968 and 7.VI.1970, leg. R. Weyrauch; 2 specs, Hermannstadt (Sibiu, Sibiu County, RO) 26.VI.1954 and 17.VII.1959 leg. R. Weyrauch; 1 spec., Domogled (Domogled Mts, Caraş-Severin County, RO), 30.VI.1964 leg. R. Weyrauch.

**"Hann von Hannenheim" Collection**
*Lucanus cervus* Linnaeus, 1758

♂: 1 spec., Hermstad Garten (Hermanstad Garten = Sibiu, Sibiu County, RO), 25.VI.1958 leg. H. Hannenheim; 2 specs, Hambg (Hammersdorf Berg = Dealul Guşteriţei, Sibiu County, RO), 10.VI.1955 and 10.VI.1956, leg. H. Hannenheim;

♀: 1 spec., Hermannstadt (Sibiu, Sibiu County, RO), 26.VI.1955 leg. H. Hannenheim; 1 spec., Baumgart. (Baumgart = Bungard, Sibiu County, Romania), 17.VI.1956 leg. H. Hannenheim;

**"Eckbert Schneider" Collection**

*Lucanus cervus* Linnaeus, 1758

♂: 1 spec., Sibiu [Sibiu, Sibiu County, RO], 1974, leg. M.P.; 1 spec., Sintana (Arad) [Sintana, Arad County, RO], V.1959, leg. Sch; 1 spec., Dobrogea, Iortmac [Dobrudja, RO], 26.VI.1972, leg.Sch.; 1 spec., Dobrogea, Babadag [Dobrudja, RO], 21.VI.1972, leg. Sch.; 1 spec., Valea Iortmac, Dobrogea [D Dobrudja, RO], 26.VI.1972, leg. Sch.; 1 spec., Dobrogea, M-rea Cocoş [Cocoş Monastery, Dobrudja, RO], 29.VI.1972, leg. Sch; 1 spec., Dobrogea, Iortmac [Dobrudja, RO], 26.VI.1972, leg.Sch.; 1 spec., Şura Mare, Sibiu [Şura Mare, Sibiu, RO], 13.VI.1972, leg. Sch.; 1 spec., Hammersdorf, Sibiu [Guşteriţa, Sibiu, RO], 9.VI.1970, leg. Sch.;

♀: 1 spec., St. Anna [St.Anna = Lake Sfanta Ana, Harghita County, RO], VI.1960, leg.Sch.; 1 spec., Dobrogea, Valea Iortmac [Dobrudja, RO], 26.VI.1972, leg. Sch.; 1 spec., Hermannstadt [Sibiu, Sibiu County, RO], 18.VI.1952, leg. Sch; 1 spec., Sibiu [Sibiu, Sibiu County, RO], 1976; 1 spec., Munţii Cozia [Cozia Mts, RO], 22.VII.1956, leg. Sch.; 1 spec., Cincu [Cincu, Braşov County, RO], 1963, leg. Sch.; 2 specs., without other data.

*Lucanus cervus turcicus* Sturm, 1843

♂: 1 spec., Dobrogea, Valea Iortmac [Dobrudja, RO], 26.VI.1972, leg. Sch., det. Săvulescu in 7.X.1978;

**Results and discussions**

In this paper, data on 107 individuals are presented: 70 males and 37 females, from five entomological collections hosted at the Natural History Museum of Sibiu. The species identified are: *Lucanus cervus* (Linnaeus, 1758) (nominate subspecies, Fig. 1.a), *Lucanus ibericus* Motschulsky, 1845 (Fig. 1.d) and *Lucanus tetraodon* Thunberg, 1806 (Fig. 1.e). Additionally, in the collections two subspecies of *Lucanus cervus*: *turcicus* Sturm, 1843 (Fig. 1.b) and *syriacus* Planet, 1897 are recorded (Fig. 1.c).

*Lucanus cervus* has a protected status in most of the European countries, being listed in the 2nd Annexe of the EC Habitats Directive. In Romania, this species is a protected one according with the OUG 57/2007 and OMMDD 1964/2007 and considered "of special interest".

Mapping the collection localities of *Lucanus* species preserved in the collections represents an important contribution to the species' distribution in and outside Romania (Fig. 2-4).

Most specimens of *Lucanus cervus* listed here were collected from the southern part of Transylvania (Sibiu County, Sighişoara, Braşov County). Some specimens were collected from mountainous areas such as Postăvarul and Cindrel

Mountains. Besides these localities, a few specimens were sampled from other parts of Romania including: Alba County, Mehadia-Caraş Severin County, Banat County, Băile Herculane – Caraş-Severin County, Vârghiş – Covasna County, Dobrogea - Valea Iortmac.

*Lucanus tetraodon*, common in central and southern Italy (Nieto *et al.* 2010), was collected from the Messina and Calabria areas in 1905. *L. ibericus* is found in southern Albania and Greece. Outside Europe, it is also known from the northern slopes of the Caucasus, Georgia, Armenia, Iran, Turkey and Turkmenistan (Nieto *et al.* 2010). In the collections considered here, the species was sampled from Turkey, Armenia, Asia and Asia Minor in 1898.

The stag beetle collections, along other entomological collections of the Natural History Museum of Sibiu, make an important contribution to the knowledge of the species distribution, both for Romania and worldwide.

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*** — Annex II - *Animal and plant species of community interest whose conservation requires the designation of special areas of conservation* of Habitats Directive (92/43/EEC)

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

**a)** **b)** **c)**

**d)**

**e)**

**Fig. 1.** .a) *Lucanus cervus* Linnaeus, 1758 specimen form the Transylvania Society collection, ♂ ♀; b) *Lucanus cervus turcicus* Sturm, 1843 from the Transylvania Society collection, ♂; c) *Lucanus cervus syriacus* Planet, 1897 from the Transylvania Society collection, ♂ ♀; d) *Lucanus ibericus* Motschulsky, 1845 from the Transylvania Society collection, ♂ ♀; e) *Lucanus tetraodon* Thunberg, 1806 from the Karl Petri collection, ♂ ♀.

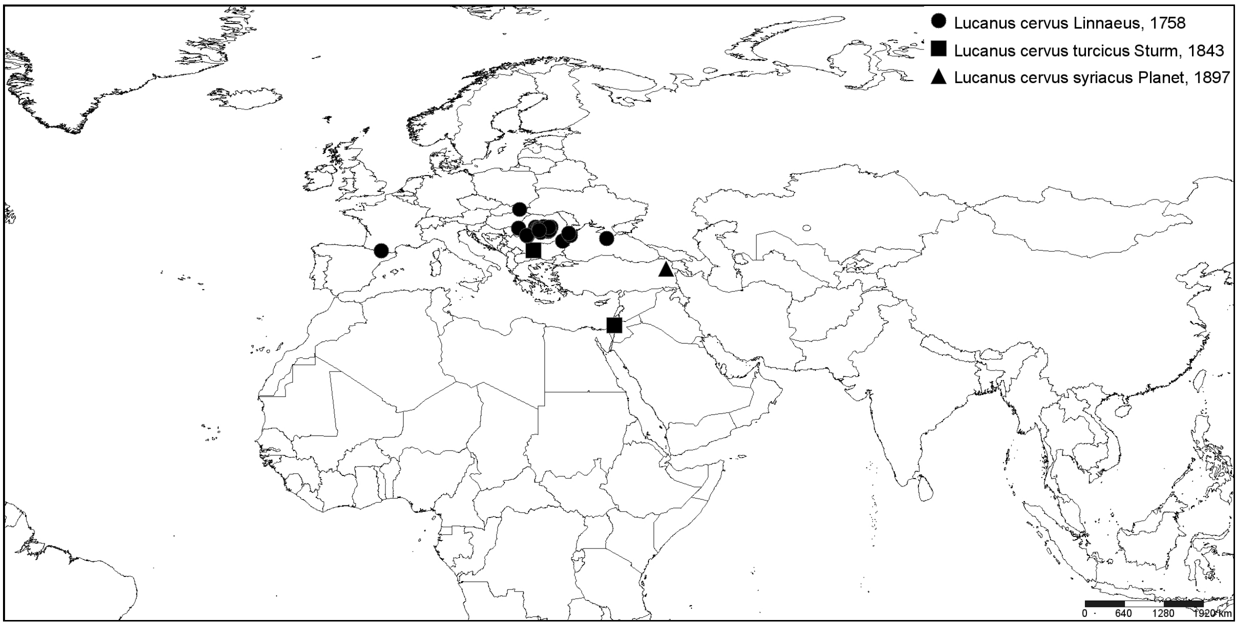


**Fig. 2.** Collection localities for the *Lucanus cervus* Linnaeus, 1758 specimens in the museum's collections

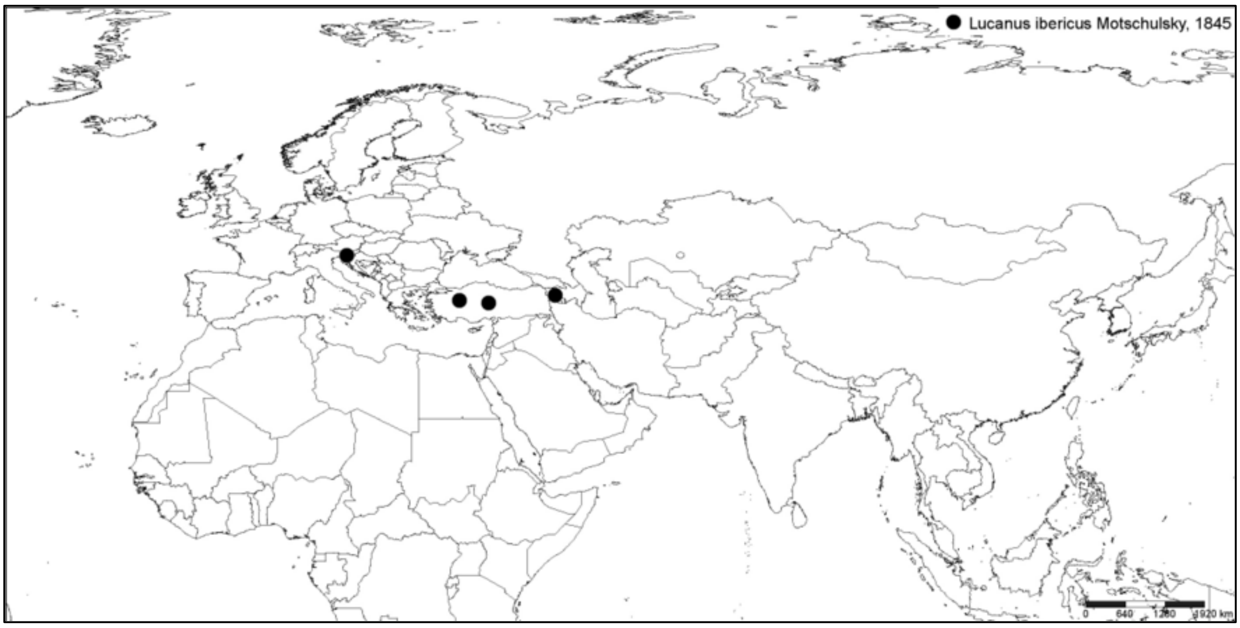


**Fig. 3.** Collection localities for the *Lucanus ibericus* Motschulsky, 1845 specimens in the museum's collections


**Fig. 4.** Collection localities for the *Lucanus tetraodon* Thunberg, 1806 specimens from the museum's collections

# COMPARATIVE ANALYSIS OF ANT ASSEMBLAGES (*HYMENOPTERA: FORMICIDAE*) OF OLD TRANSYLVANIAN DECIDUOUS FORESTS

**Ioan TĂUȘAN** *
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**Maria Ramona TRICĂ** ***

***Abstract.*** *Comparative analysis of ant assemblages from three old deciduous forests was carried out in Transylvania. Ants were collected with pitfall traps during 2011. Altogether we identified 12 species, amongst them Aphaenogaster subterranea was recently published as a new record for Transylvania. Myrmica rubra and M. ruginodis were the most abundant ant species. Community composition was characterised mainly by forest species. We tested differences between ant assemblages of the three forests using a permANOVA multivariate analysis.*
***Key words:*** *ant assemblages, deciduous forests, Transylvania*

***Rezumat.*** *Analiza comparativă a comunităților de furnici a fost studiată în trei păduri mature de foioase, în Transilvania. Furnicile au fost colectate cu capcane Barber în 2011. În total, 12 specii au fost identificate, printre care amintim specia Aphaenogaster subterranea, care a fost recent publicată ca noutate faunistică pentru Transilvania. Speciile Myrmica rubra și M. ruginodis au fost cele mai abundente specii. Compoziția comunităților a fost caracterizată de prezența speciilor tipice de pădure. Utilizând analiza multivariată permANOVA am identificat diferențe semnificative între comunitățile de furnici din pădurile investigate.*
***Cuvinte cheie:*** *comunități de furnici, păduri de foioase, Transilvania*

## Introduction

Forests represent one of the most important ecosystems of our planet. Due to their characteristics (microclimate, microhabitats) they support the greatest global biodiversity (Niemelä 1997, Battles *et al.* 2001, Lindenmayer *et al.* 2006). Deciduous forests are particularly important due to their seasonal appearance and disappearance of the canopy, gradients of soil moisture, leaf-layer and dead wood (Keddy, Drummond 1996).

Arthropods assemblages are an important component of deciduous forests. Ants are an essential part of deciduous forest ecosystems as they are generalist predators, soil engineers and pollinators (reviewed in Del Toro *et al.* 2012). Whereas in European coniferous forests, usually *Formica s. str.* species prevail (Czechowski *et al.* 1995, Vepsäläinen *et al.* 2000, Arnan *et al.* 2009, Żmihorski 2010), however in the case of temperate deciduous forests the community composition is different. *Myrmica* species (*M. ruginodis, M. rubra, M. scabrinodis*) are mainly found alongside other species belonging to *Temnothorax, Stenamma* and *Myrmecina,* but also species of *Lasius* (*L. brunneus, L. platythorax*) (Dekoninck *et al.* 2008, Markó 2008, Babik *et al.* 2009).

In Romania, studies focusing on ant communities of forests are scarce (Markó 2008, Tăușan, Markó, 2009). However, forests from southern Transylvania are of great interest, comprising a high number of Natura 2000 sites. Specifically, we published *Aphaenogaster subterranea* first record in Transylvania in a *Quercus pubescens* forest (Tăușan et *al.* 2011).

The aim of the study is to characterize and compare the ant communities of different old deciduous forests, in order to reveal a possible community structure typical for these established ecosystems. Specifically, we tested differences among old deciduous forests in terms of species composition, diversity and dynamics.

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## Material and methods

Three forest sites (> 120 years old) were investigated during 2011. One site (CJ1) was sampled near Cluj-Napoca (Cluj County), in Hoia forest, while the other two (DB1, DB2) near Dumbrăveni (Sibiu County). DB2 is a Natura 2000 site with *Quercus pubescens*.

The sites were located at an elevation of 450-550 m a.s.l. CJ1 and DB1 site have a north slopes (20 and 27 degrees) while DB2 has a southern exposition (20 degrees).

Vegetation of the three sites was recorded in three periods of time (May, July and September) in 2011. Percentage cover values for all cryptogams and vascular plant species within three 400 $m^2$ plots were visually estimated applying the Braun-Blanquet cover classes. In terms of vegetation structure, the sites are similar, thus represented by species of oak, mainly *Quercus pubescens* (DB2), *Q. petraea* and *Q.robur* (CJ1 and DB1). However the hornbeam, *Carpinus betulus* was present in all of the sites (see Table 1 for details).

Altogether 16 pitfall traps were used (4 X 4 grid), within a 225 $m^2$ plot, randomly selected, at each sampling site, during three period of time, consisting of 10 days (May, July and September) in 2011. Neighbouring traps were separated by five meters. The traps (175 ml plastic cups) were filled with killing and preserving agent (glycol: water, 2: 1 solution). Trapping period consisted of 10 days and the identification of ant species was carried out on the basis of several available identification keys (Seifert 2007, Czechowski *et al.* 2012). The specimens are preserved in the personal collections of Ioan Tăușan.

The pitfall trap data were pooled for every period in the case of each habitat for Shannon-Wiener general entropy values (log2) diversity analysis. Dynamics of the species number and individuals was also assessed.

Differences in terms of species composition were tested using a permANOVA (5000 permutations, Poisson distribution) based on pitfall trap data. Two NMDS (Nonmetric multidimensional scaling) analysis were used for revealing similarities between sites (Bray-Curtis similarity index). In the first case only species a treshold of 0.1 individuals /trap was considered for each species. A second analysis was performed for all data set.

## Results

Altogether we identified 12 ant species belonging to two subfamilies (Table 2). Pitfall trapping yielded mainly forest ants, mainly oligotopic, preferring deciduous forests (*Aphaenogaster subterranea, Myrmecina graminicola, Stenamma debile, Temnothorax crassispinus, Lasius brunneus* and *L. fuliginosus*). Moreover, we sampled *Myrmica ruginodis* and *L. platythorax* which are polytopic forest species (Czechowski *et al.* 2012).

However, we sampled open land species like *Tetramorium* cf. *caespitum* and ubiquist species such as *Myrmica rubra* and *Lasius alienus*.

Regarding the humidity requirements of ant species spectrum covered a narrow range, almost all of the species being mesohygrophile. Two species require high humidity level (*Myrmica rubra* and *M. ruginodis*) while two species occure at dry habitats (*Camponotus vagus* and *Tetramorium* cf. *caespitum*). As for the thermal tolerance, most of the species require mesothermo-thermophile conditions.

Concerning species richness, two sites (CJ1 and DB1) are represented by four ant species. The Natura 2000 site (DB2) is represented by 10 species, including sub-Mediterranean species, *Aphaenogaster subterranea* (Table 2).

Shannon-Wiener diversity index decreases towards September, in both Dumbrăveni sites (DB1 and DB2) (Fig. 1) while in the case of CJ1 the peak is recorded in summer, followed by a decrease.

Analysing the seasonal changes in species and individual numbers we observed that in all of sites the number of individuals caught by pitfall traps reaches a maximum in summer (July campaign) (Fig. 2). However, the number of species showed different trend in each site. We observed adecrease in species number in DB1 (Fig. 2), while in DB2 the species number was constant (Fig. 2). In CJ1 the variation of species number was similar to the number of individuals (Fig. 2).

Significant differences, in terms of species composition, were recorded amongst sites (permANOVA, 5000 permutations, $p<0.005$, $F = 48.13$, $Df = 91$). Moreover, NMDS analysis revealed that in spite of differences in exposition amongst the Dumbrăveni sites, a higher similarity between DB1 and DB2 where species like *Myrmica ruginodis, Stennama debile* and *Lasius* *platythorax* are present (Fig. 3). The CJ1 site is different due to the presence and abundance of *Myrmica rubra* which is absent in the Dumbrăveni sites (Fig. 4).

**Discussions**

Our results revealed an impoverished system with barely 12 ant species. Considering the fact that an exhaustive study based on the ant fauna of Sibiu County yielded 75 species (Tăuşan *et al.* 2012) the real number of species could be higher. However, the low number of species may also indicate high conservational value, due to the presence of climax species (e.g. *Myrmica ruginodis, Aphaenogaster subterranea*).

DB2 recorded the highest species richness (10 species). This could be explained by the management of the site, where dead wood, thick leaf layer and other microhabitats are often present (suitable habitats for species such as *Camponotus vagus* and *Aphaenogaster subterranea*).

In a similar study Markó (2008) identified 13 species from a mixed oak forest from Foieni (Maramureș County). The species composition was similar, thus some thermophilic ant species were in addition identified: *Dolichoderus quadripunctatus*, *Liometopum microcephalum* and *Camponotus truncatus* (Markó 2008).

In a study of a *Querco robori–Carpinetum* Soó et Pócs (1931) forest from Sibiu, Tăuşan, Markó (2009) identified eight ant species. The results were similar with the present study, as disturbance-tolerant species were found (*Formica cinerea, Lasius paralienus*).

Moreover, in a recent study, Német *et al.* (2012) identified seven species from a mixed deciduous forest from Cefa Nature Park (NW of Romania). The species spectrum was similar to our findings.

Further analysis of more deciduous forests (from different regions of Romania) could enhance the species number and particularly, thermophilic forests could provide additional data regarding community composition.

**Acknowledgements**

The authors are grateful for the comments of Dr. Klara Benedek and Dr. Robert Gallé, who improved the first version of the manuscript. We are in debt to the Forestry Agencies (RomSilva Dumbrăveni and RomSilva Cluj-Napoca), for their help in providing useful data about the study sites. We owe thanks to Aurelia Ştefu, Adriana Cravă and Laurenţiu Anghel for the help during field campaigns.

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAȚIILOR

**Tab. 1.** Average coverage (%) of the most abundant plant species from the study sites (DB1: 120 years old site in Dumbrăveni, DB2: 120 years old, Natura 2000 site in Dumbrăveni; CJ1: 120 years old site in Cluj-Napoca)

| Species / Sites | CJ1 | DB1 | DB2 |
|---|---|---|---|
| *Quercus pubescens* | - | - | 62.91 |
| *Quercus petraea* | 21.27 | 38.5 | - |
| *Quercus robur* | 3.17 | - | - |
| *Carpinus betulus* | 45 | 26.5 | 16.33 |
| *Fagus sylvatica* | - | 5.83 | - |
| *Acer campestre* | - | - | 8.92 |
| *Corylus avellana* | - | - | 7.83 |
| *Galium odoratum* | - | 6.11 | - |

**Tab. 2.** List of species collected in the present study [DB1: 120 years old site in Dumbrăveni, DB2: 120 years old, Natura 2000 site in Dumbrăveni; CJ1: 120 years old site in Cluj-Napoca; number of individuals, average/per pitfall trap (± SD)] with reference to their ecological preference in terms of temperature and humity: E – eurytopic, P –polytopic, O – oligotopic; mes – mesohygrophile, hyg-mes – hygro-mesohygropile, mes-xer – mesohygro-xerophile, mte – mesothermophile, oli-mte – oligo-mesothermophile, mte-ter – mesothermo-thermophile (based on Czechowski *et al.* 2012)

| Species | CJ1 | DB1 | DB2 | Ecological elements | Humidity tolerance | Thermal tolerance |
|---|---|---|---|---|---|---|
| **Subfam. Myrmicinae Lepeletier, 1836** | | | | | | |
| *Aphaenogaster subterranea* Latreille 1798 | - | - | **9**, 0.21 ±0.78 | O | Mes | Mte |
| *Myrmica rubra* Linnaeus, 1758 | **40**, 1 ±1.38 | - | - | E | hyg-mes | oli-mte |
| *Myrmica ruginodis* Nylander, 1846 | **4**, 0.1 ±0.38 | **152**, 3.45 ±3.41 | **140**, 3.33 ±4.37 | P | hyg-mes | oli-mte |
| *Myrmecina graminicola* Latreille, 1802 | - | - | **4**, 0.1 ±0.30 | O | Mes | mte-ter |
| *Stenamma debile* Förster, 1850 | **1**, 0.025 ±0.16 | **5**, 0.11 ±0.39 | **4**, 0.1 ±0.30 | O | Mes | Mte |
| *Tetramorium* cf. *caespitum* | **1**, 0.025 ±0.16 | - | - | P | mes-xer | mte-ter |
| *Temnothorax crassispinus* Karavaiev, 1926 | - | **1**, 0.02 ±0.15 | **1**, 0.02 ±0.15 | O | Mes | mte-ter |
| **Subfam. Formicinae Lepeletier, 1836** | | | | | | |
| *Camponotus vagus* Scopoli, 1763 | - | - | **1**, 0.02 ±0.15 | O | mes-xer | mte-ter |
| *Lasius alienus* Förster, 1850 | - | - | **1**, 0.02 ±0.15 | O | Mes | Mte |
| *Lasius brunneus* Latreille, 1798 | - | - | **58**, 1.38 ±8.48 | O | Mes | mte-ter |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Lasius fuliginosus* Latreille, 1798 | - | - | **1**, 0.02 ±0.15 | O | Mes | Mte |
| *Lasius platythorax* Seifert, 1991 | - | **6**, 0.14 ±0.39 | **8**, 0.19 ±0.59 | P | Mes | oli-mte |
| **Total of species** | **4** | **4** | **10** | | | |

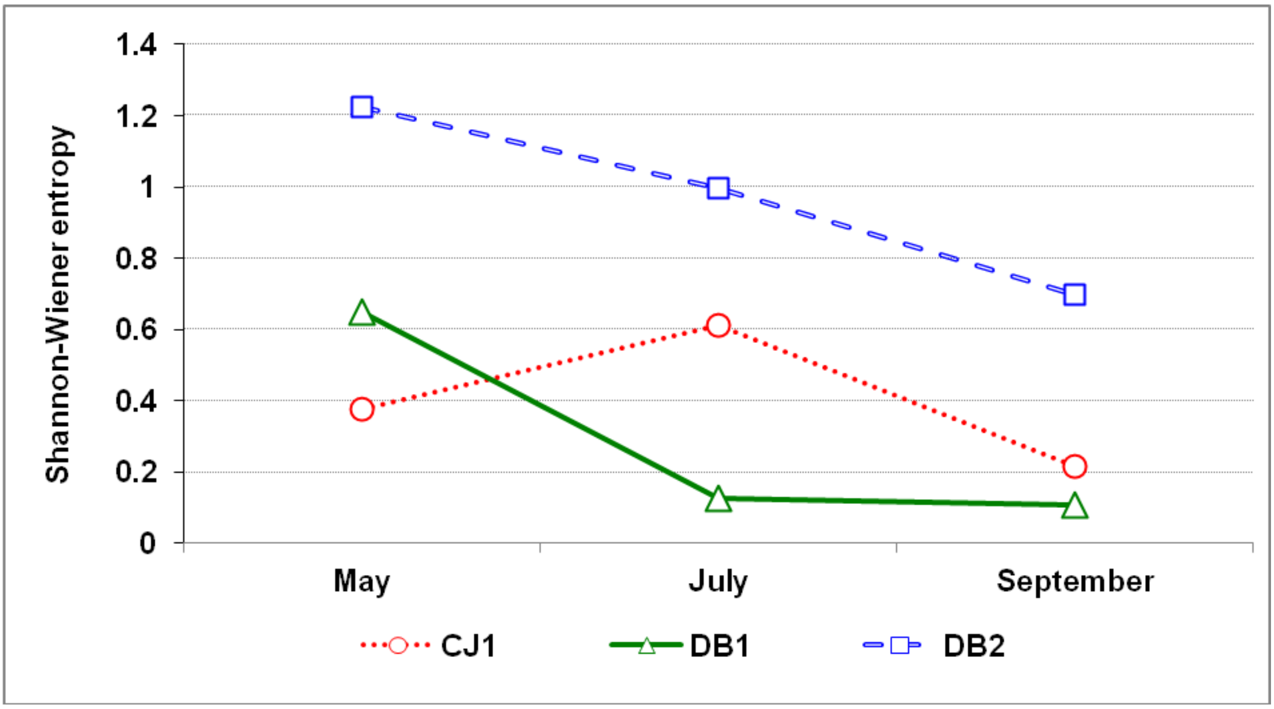


**Fig. 1.** Changes in the diversity (Shannon-Wiener general entropy, log2) of the ant communities of deciduous forests (CJ1, DB1, DB2 – forest sites)

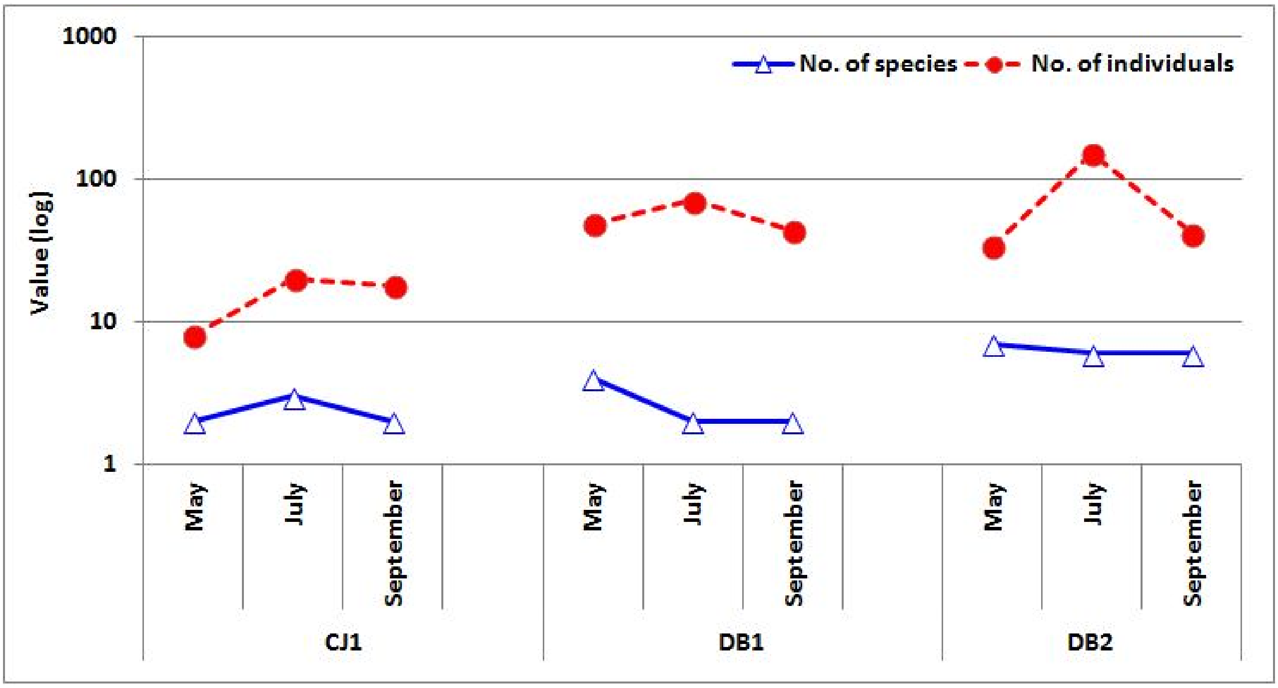


**Fig. 2.** Dynamics of species number and individuals of the ant communities of deciduous forests (CJ1, DB1, DB2 – forest sites)

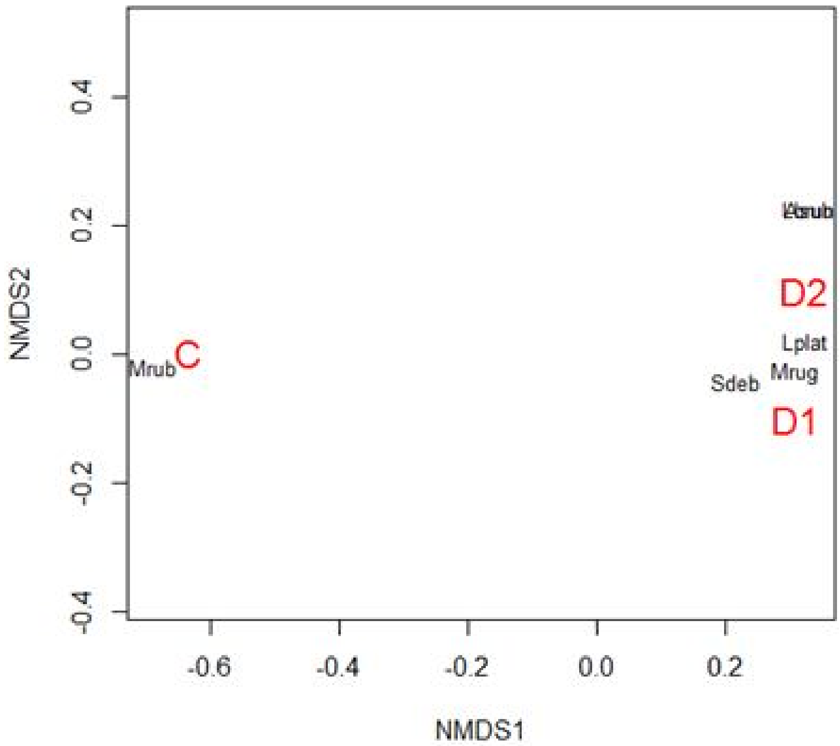


**Fig. 3.** Non-metric multidimensional scaling ant communities of deciduous forests based on the presence of the most abundant species (Bray-Curtis index of similarity, Stress=0, Mrub – *Myrmica rubra*, Mrug – *M. ruginodis,* Lplat – *Lasius platythorax,* Lbrun – *L. brunneus,* Asub – *Aphaenogaster subterranea,* C – CJ1, D1-DB1, D2-DB2)

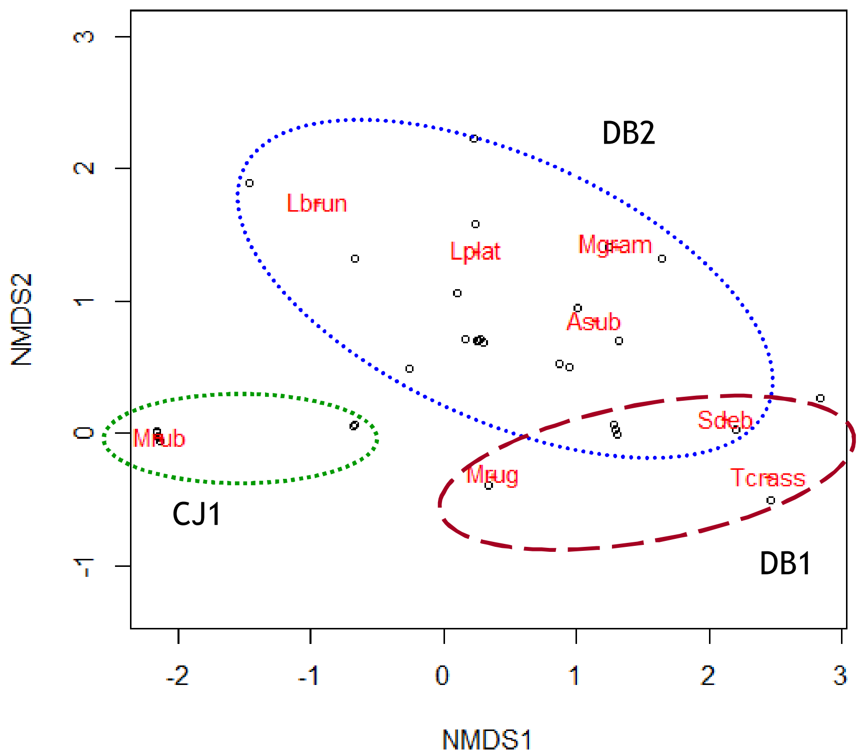


**Fig. 4.** Non-metric multidimensional scaling ant communities based on all pitfall trap data (Bray-Curtis index of similarity, Stress=0.058, Mrub – *Myrmica rubra*, Mrug – *M.ruginodis,* Lplat – *Lasius platythorax,* Lbrun – *L. brunneus,* Asub – *Aphaenogaster subterranea,* Sdeb – *Stenamma debile,* Mgram – *Myrmecina graminicola,* Tcrass – *Temnothorax crassispinus,* empty dots – pitfall traps, CJ1, DB1, DB2 – forest sites)

# THE CATALOGUE OF THE KIMAKOWICZ MALACOLOGICAL COLLECTION FROM THE NATURAL HISTORY MUSEUM IN SIBIU (PART I)

**Ana-Maria PĂPUREANU***

***Abstract.*** *The catalogue presents 113 species belonging to 11 families and 64 genuses from the Kimakowicz Malacological Collection, part of the Natural History Museum in Sibiu (Brukenthal National Museum). The list follows the order of the inventory numbers. The specimens have been studied taxonomically confirming or infirming the original identifications done by Moritz and Richard von Kimakowicz. This paper is the first catalogue of the Kimakowicz collection including exotic marine species.*
***Keywords****: Kimakowicz Malacological collections, catalogue, Natural History Museum Sibiu*

***Rezumat.*** *Catalogul include 113 specii aparţinând la 11 familii şi respectiv 64 genuri. Specimenele fac parte din colecţia malacologică Kimakowicz, inclusă în patrimoniul malacologic al Muzeului de Istorie Naturală din Sibiu, department al Muzeului Naţional Brukenthal. Piesele sunt catalogate urmând ordinea numerelor de inventar. Ele au fost studiate din punct de vedere taxonomic, confirmând sau infirmând identificările iniţiale ale lui Moritz şi Richard von Kimakowicz. Această lucrare este primul catalog al colecţiei Kimakowicz incluzând specii exotice marine.*
***Cuvinte cheie****: colecţia malacologică Kimakowicz, catalog, Muzeul de Istorie Naturală Sibiu*

## Introduction

Two exceptional malacologists formed the Kimakowicz Malacological Collection: Mauritius Hieronymus von Kimakowicz – Winnicki (1849 – 1921), known also as Moritz von Kimakowicz, and his son Richard Emanuel (1876 – 1973).

Moritz von Kimakwicz joined the Transylvanian Society for Natural Sciences – *Siebenbürgischer Verein für Naturwissenschaften zu Hermannstadt* in 1880. In 1886, he became the custodian of the Society Zoological Collection. One year later, he started the Kimakowicz Malacological Collection.

As a passionate researcher and collector, Moritz von Kimakowicz did not dedicate all of his time and efforts towards Malacology, concurring to the development of the Society Entomology, Vertebrata, Paleontology and Mineralogy – Petrography Collections. The permanent headquarter of the Society and storage area for the collections was inaugurated in May 1895, a building that functioned also as a museum, today's Natural History Museum in Sibiu, department of the Brukenthal National Museum.

At the inauguration of the building, Moritz von Kimakowicz, as museum director, handed the key of the museum to Eduard Albert Bielz, president of the Society.

In 1911, Moritz von Kimakowicz was the custodian of the Brukenthal Archeology Collection. He remained as member of the Transylvanian Society but he focused his research towards archeology and cultural history.

Moritz von Kimakowicz died in 1921, at the age of 72. At the time of his death, he was the director of the *Siebenbürgischer Verein für Naturwissenschaften zu Hermannstadt* and the custodian of the Brukenthal Archeology Collection.

The research of Moritz von Kimakowicz in field of malacology, completely overlapped with his son's interests, as they both devoted, almost all of their studies, to the genus *Clausilia* Draparnaud, 1805 (Coan *et al.* 2011, 4). Richard von Kimakowicz donated to the Museum of Natural History in Sibiu the Kimakowicz Malacological collection in October 1967 (Corocleanu, 1969, 145). The donation consisted of 305.431 specimens belonging to different species of mollusks. The Kimakowicz donation exceeded in size the existing Malacological Society Collection present in the

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museum at that time. The collection was legally included in the museum's heritage in 1973.

The Kimakowicz Malacological collection can be divided into the General Collection (115.279 specimens, from which 2.211 are fossils), the *Clausilia* Collection (73.321 specimens, from which 37.190 are doubles) and the General Doubles Collection (116.831 specimens).

The historical information within the collection is vast and it covers localities from Romania but also from all over the world. The massive geographical range was achieved by exchanging with other professional conchologists from Europe (Fig. 4 a), like César Marie Félix Ancey (1860 – 1906), with fellow researchers and members of the Transylvanian Society, especially Eduard Albert Bielz (1827 – 1898) and Carl Friedrich Jickeli (1850 – 1925) or by donations from Dr. Arthur Soterius von Sachsenheim (1852 – 1913). Kimakowicz also bought some specimens (Fig. 4 b).

According to the initial inventories from 1973, the Kimakowicz Malacological Collection comprises 7000 species and subspecies, from which 80 are hollotypes (Corocleanu, 1987, 275 – 295). According to today's taxonomy and recent researches in the field the collection is not documented so we do not know how many species it really contains.

An updated catalogue of the collection is necessary, as the collections old catalogues were written between 1973 and 1983 following the original labels, hand written by Moritz von Kimakowicz (Fig. 2). The collection does not include card index archives. The collecting sites are originally given (both in labels and publications) in German or Hungarian, seldom in Romanian, thus, besides the systematical revision, the person studying the collection has to identify the present-day geographic names of the collecting areas.

Until today, partial information related to 3.151 inventory numbers representing 17.239 specimens has been included in an Excel spreadsheet as demanded by the Romanian Cultural Ministry Methodological Norms of museum collections evidence, curatorial and inventory processes from 2000. The inventory presents for each old and new inventory number the original data from the label and the number of specimens found at that inventory number.

A part of the information included in the spreadsheets is presented in this catalogue:

- New inventory number and written in brackets the old inventory number,
- Current scientific name,
- The scientific name of the specie as it is written on the original label,
- The number of specimens found under that inventory number,
- Collecting point.

The species were identified with the help of the internet databases (Rosenberg, 2009; Appeltans *et al.*, 2012; Hardy, 2013), confirming also the old scientific names considered today as synonyms. The taxonomic classification follows the World Register of Marine Species (Appeltans *et al.*, 2012).

The catalogue lists 113 species belonging to 11 families and 64 genuses (Tab. 1) according to the taxonomic group to which they belong starting with inventory number 1 and finishing with inventory number 621, following the order of the inventory numbers. The final spreadsheets and the published reviewed catalogues will help in developing a more efficient and up-to-date database of the Kimakowicz Collection.

## Material and results

Class CEPHALOPODA

Order Octopoda
Superfamily Argonautoidea
**Family Argonautidae**

Genus *Argonauta* Linnaeus, 1758:
1 (3259) *Argonauta argo* Linnaeus, 1758 – shell, 1 specimen, Adriatic Sea;
2 (3258) *Argonauta hians* Lightfoot, 1786 – shell, label *Argonauta tuberculosa* Lamarck, 1822, 1 specimen, Maluku Islands archipelago, Pacific Ocean.

Infraclass Decapodiformes
Order Sepiida
**Family Sepiidae**

Genus *Sepia* Linnaeus, 1758:
3 (5941) *Sepia hedleyi* Berry, 1918 – cuttlebone, label *Sepia jacksonensis*, 2 specimens, Pacific Ocean, Port Jackson, New South Wales, Australia;
4 (10.566) *Sepia elegans* de Blainville, 1827 – cuttlebone, label *Sepia* sp., 1 specimen, Ostend Beach, Belgium, North Sea;

7 (5939) *Sepia officinalis* Linnaeus, 1758 – cuttlebone, 1 specimen, North Sea, North Frisian Islanda;
8 (5938) *Sepia officinalis* Linnaeus, 1758 – cuttlebone, 1 specimen, Adriatic Sea, Split, Republic of Croatia.

Infraclass Decapodiformes
Order Spirulida
**Family Spirulidae**

Genus *Spirula* Lamarck, 1799:
5 (3251) *Spirula spirula* (Linnaeus, 1758), label *Spirula peroni*, 1 specimen, Antilles Islands.

Infraclass Decapodiformes
Order Myopsida
**Family Loliginidae**

Genus *Loligo* Lamarck, 1798:
6 (5940) *Loligo vulgaris* Lamarck, 1798 – pens (internal shell), 1 specimen, Adriatic Sea.

Class GASTROPODA

Subclass Heterobranchia
Infraclass Opisthobranchia
Order Thecosomata
Suborder Euthecosomata

Superfamily Cavolinioidea
**Family Cavoliniidae**

Genus *Cavolinia* Abildgaard, 1791:
9 (6076) *Cavolinia globulosa* (Gray, 1850), label *Hyalaea globosa* Rang., 1 specimen, Red Sea;
15 (3254) *Cavolinia tridentata* (Niebuhr, 1775), label *Hyalaea tridentata* Ford., 1 specimen, Mediterranean Sea .

Genus *Diacavolinia* van der Spoel, 1987:
13 (6075) *Diacavolinia longirostris* (De Blainville, 1821), label *Hyalaea longirostris* Less., 5 specimens, Red Sea, Dahlak Arhipelago;
14 (3250) *Diacavolinia longirostris* (De Blainville, 1821), label *Hyalaea longirostris* Less., 15 specimens, Red Sea, Dahlak Arhipelago.

Superfamily Cavolinioidea
**Family Cliidae**

Genus *Clio* Linnaeus, 1767:
12 (3256) *Clio pyramidata* Linnaeus, 1767, label *Cleodora pyramidata*, 1 specimen, Mediterranean Sea, Sicily.

Superfamily Limacinoidea
Family Creseidae

Genus *Styliola* Gray, 1847:
11 (1400) *Styliola subula* (Quoy and Gaimard, 1827), label *Creseis spinifera* Rang., 4 specimens, Mediterranean Sea, Alger.

Superfamily Limacinoidea
**Family Limacinidae**

Genus *Limacina* Bosc, 1817:
10 (3255) *Limacina retroversa* (Fleming, 1823), label *Spiralis flemingi* Forb., 1 specimen, England.

Subclass Caenogastropoda
Order [unassigned] Caenogastropoda
Superfamily Epitonioidea
**Family Janthinidae**

Genus *Janthina* Röding, 1798:
16 (3276) *Janthina janthina* (Linnaeus, 1758), label *Janthina communis* Lamarck, 1799, 1 specimen, Jamaica;
17 (3277) *Janthina janthina* (Linnaeus, 1758), label *Janthina fragilis* Lamarck, 1799, 1 specimen, People's Republic of China;
18 (3278) *Janthina globosa* Swainson, 1822, 1 specimen, Massawa, Eritrea, northern Red Sea;
19 (3309) *Janthina globosa* Swainson, 1822, 2 juveniles specimens, Red Sea, Dahlak Arhipelago.

Order Littorinimorpha
Superfamily Pterotracheoidea
**Family Carinariidae**

Genus *Carinaria* Lamarck, 1801:
20 (3257) *Carinaria lamarckii* Blainville, 1817, label *Carinaria sp.*, 1829, 1 specimen, Austral Ocean or Southern Ocean, Antarctica (Fig. 4).

Order Neogastropoda
Superfamily Muricoidea
**Family Muricidae**
Subfamily Muricinae

Genus *Murex* Linnaeus, 1758:
21 (3260) *Murex (Murex) scolopax* Dillwyn, 1817, label *Murex (Tribulus) scolopax* Dillw., 1 specimen, Red Sea, Dahlak Arhipelago;
22 (3261) *Murex (Murex) scolopax* Dillwyn, 1818, 2 specimens, Massawa, Eritrea, northern Red Sea;
23 (3260) *Murex (Murex) tribulus* Linnaeus, 1760, label *Murex (Tribulus) tribulus L. crassispina Lam.*, 1 specimen, East Indian Ocean;

24 (4028) *Murex (Murex) tribulus* Linnaeus, 1758, label *Murex (Tribulus) tribulus* L., 2 specimens, Republic of Singapore;
25 (3267) *Murex pecten pecten* Lightfoot, 1786, label *Murex (Tribulus) tenuispina Lam.*, 1 specimen, East African seacoast;
26 (4029) *Murex (Murex) trapa* Röding, 1798, label *Murex (Tribulus Kobl.) rarispina Sow.*, 1 specimen, East Indian Ocean;
27 (3262) *Murex (Murex) occa* G. B. Sowerby II, 1834, label *Murex (Tribulus) occa Sow.*, 2 specimens, People's Republic of China;
28 (3265) *Murex brevispina* Lamarck, 1822, label *Murex (Tribulus) brevispina Lam.*, 1 specimen, Zanzibar, East African seacoast;
91 (3301) *Murex sp.* Linnaeus, 1758, 1 specimen, California, U.S.A;
109 (5954) *Murex sp.* Linnaeus, 1758, 1 specimen, Pacific Ocean, Australia;
110 (9101) *Murex sp.* Linnaeus, 1759, 2 specimens, Pacific Ocean, Australia.

Genus *Siratus* Jousseaume, 1880:
29 (3264) *Siratus kugleri* (Clench & Perez Farfante, 1945), label *Murex (Tribulus) similis Sow.*, 2 specimens, Saint Thomas Island, Caribbean Sea.

Genus *Bolinus* Pusch, 1837:
31 (10567) *Bolinus brandaris* (Linnaeus, 1758), label *Murex (Tribulus) brandaris L.*, 2 specimens, Mediterranean Sea;
32 (3274) *Bolinus brandaris* (Linnaeus, 1758), label *Murex (Tribulus) brandaris L. var. nodosa*, 1 specimen, Adriatic Sea, Zadar, Republic of Croatia;
33 (3273) *Bolinus brandaris* (Linnaeus, 1758), label *Murex (Tribulus) brandaris* L., 1 specimen, Adriatic Sea, Ragusa today south region Republic of Croatia;
34 (3271) *Bolinus brandaris* (Linnaeus, 1758), label *Murex (Tribulus) brandaris* L., 1 specimen, Adriatic Sea, Zadar, Republic of Croatia;
35 (3272) *Bolinus brandaris* (Linnaeus, 1758), label *Murex (Tribulus) brandaris* L., 2 specimens, Adriatic Sea, Split, Republic of Croatia;
36 (3270) *Bolinus brandaris* (Linnaeus, 1758), label *Murex (Tribulus) brandaris* L., 3 specimens, Adriatic Sea, Rijeka, Republic of Croatia;
37 (10,568) *Bolinus brandaris* (Linnaeus, 1758), *Murex (Tribulus) brandaris* L., 10 specimens, Mediterranean Sea.

Genus *Haustellum* Schumacher, 1817:
38 (3269) *Haustellum haustellum* (Linnaeus, 1758), label *Murex (Tribulus) haustellum* L., 2 specimens, Massawa, Eritrea, northern Red Sea;
39 (3268) *Haustellum haustellum* (Linnaeus, 1758), label *Murex (Tribulus) haustellum* L., 1 specimen, Republic of the Philippines.

Genus *Chicoreus* Montfort, 1810:
40 (5167) *Chicoreus ramosus* (Linnaeus, 1758), label *Murex (Chicareus) inflatus* Lamarck, 1822, 2 specimens, New Britain Island, Bismarck Archipelago, Papua New Guinea;
41 (3239) *Chicoreus ramosus* (Linnaeus, 1758), label *Murex (Chicareus) inflat*us Lamarck, 1822, 3 specimens, Red Sea, Dahlak Arhipelago;
42 (3239) *Chicoreus ramosus* (Linnaeus, 1758), label *Murex (Chicareus) inflatus* Lamarck, 1822, 2 specimens, Red Sea, Dahlak Arhipelago;
43 (3240) *Chicoreus ramosus* (Linnaeus, 1758), label *Murex (Chicareus) inflatus* Lamarck, 1822, 1 specimen, Indian Ocean;
44 (3238) *Chicoreus ramosus* (Linnaeus, 1758), label *Murex (Chicoreus) tuberosus* Dillwyn, 1817, 1 specimen, Red Sea, Dahlak Arhipelago;
45 (5609) *Chicoreus ramosus* (Linnaeus, 1758), label *Murex (Chicoreus) sp.* Montfort, 1810, 2 juveniles specimens, Massawa, Eritrea, northern Red Sea;
46 (3243) *Chicoreus asianus* Kuroda, 1942, label *Murex (Chicoreus) sinensis* Reeve, 1845, 1 specimen, China Sea;
47 (5169) *Chicoreus brunneus* (Link, 1807), label *Murex (Chicoreus) adustus* Lamarck, 1822, 2 specimens, New Britain Island, Bismarck Arhipelago, Papua New Guinea;
48 (3244) *Chicoreus microphyllus* (Lamarck, 1816), label *Murex (Chicoreus) microphyllus* Lamarck, 1816, 1 specimen, the Brazilian coast;
49 (3279) *Chicoreus capucinus* (Lamarck, 1822), label *Murex (Chicoreus) capucinus* Lamarck 1822, 2 specimens, Republic of India;
50 (3249) *Chicoreus corrugatus* G.B. Sowerby II, 1841, label *Murex (Chicoreus) corrugatus* Sowerby, 1841, 2 specimens, Red Sea, Suez;
51 (3275) *Chicoreus sp.* Montfort, 1810, label *Murex (Chicoreus) massanensis*, 1 specimen, Massawa, Eritrea, northern Red Sea;
52 (5608) *Chicoreus strigatus* (Reeve, 1849), label *Murex (Chicoreus) penchinati* Crosse, 1861, 1 specimen, Cochinchina, southern Socialist Republic of Vietnam;
53 (5168) *Chicoreus axicornis* (Lamarck, 1822), label *Murex (Chicoreus) axicornis* Lamarck, 1822, 2 specimens, Ambon Island, part of the Maluku Islands archipelago, Pacific Ocean;
56 (3232) *Chicoreus virgineus* (Röding, 1798), label *Murex (Chicoreus) anguliferus* Lamarck, 1822, 1 specimen, former Senegambia Confederation, Atlantic Ocean;

57 (5171) *Chicoreus brevifrons* (Lamarck, 1822), label *Murex (Chicoreus) brevifrons* Lamarck, 1822, 2 specimens, Puerto Rico.

Genus *Phyllonotus* Swainson, 1833:
58 (5170) *Phyllonotus pomum* (Gmelin, 1791), label *Murex (Chicoreus) pomum* Gmelin, 1791, 2 specimens, Republic of Cuba.

Genus *Hexaplex* Perry, 1810:
54 (3230) *Hexaplex erythrostomus* (Swainson, 1831), label *Murex (Chicoreus) erythraeus* Fisch., 2 specimens, Massawa, Eritrea, northern Red Sea;
55 (3229) *Hexaplex erythrostomus* (Swainson, 1831), label *Murex (Chicoreus) erythraeus* Fisch., 1 specimen, Dahlak Arhipelago;
59 (3245) *Hexaplex trunculus* (Linnaeus, 1758), label *Murex (Phyllonotus) trunculus* Linnaeus, 1758, 2 specimens, Adriatic Sea, Zadar, Republic of Croatia;
60 (3248) *Hexaplex trunculus* (Linnaeus, 1758), label *Murex (Phyllonotus) trunculus* Linnaeus, 1758, 8 specimens, Adriatic Sea, Split, Republic of Croatia;
61 (10569) *Hexaplex trunculus* (Linnaeus, 1758), label *Murex tru*nculus Linnaeus, 1758, 4 specimens, Adriatic Sea, Lovran, Republic of Croatia;
62 (3246) *Hexaplex trunculus* (Linnaeus, 1758), label *Murex tru*nculus Linnaeus, 1758, 1 specimen, Adriatic Sea, Rijeka, Republic of Croatia;
63 (3247) *Hexaplex trunculus* (Linnaeus, 1758), label *Murex tru*nculus Linnaeus, 1758, 2 specimens, Adriatic Sea, Dubrovnik, Republic of Croatia;
64 (10570) *Hexaplex trunculus* (Linnaeus, 1758), label *Murex tru*nculus Linnaeus, 1758, 4 specimens, Adriatic Sea, Lovran, Republic of Croatia;
65 (3237) *Hexaplex erythrostomus* (Swainson, 1831), label *Murex bicolor* Valenciennes, 1832, 1 specimen, the Republic of Panama;
66 (3283) *Hexaplex erythrostomus* (Swainson, 1831), label Murex regius Schubert & Wagner, 1829, 2 specimens, the Republic of Panama;
67 (3234) *Hexaplex radix* (Gmelin, 1791), label *Murex radix* Gmelin, 1791, 1 specimen, Indian Ocean;
68 (3241) *Hexaplex cichoreum* (Gmelin, 1791), label *Murex endivia* Lamarck, 1822, 1 specimen, eastern Indian Ocean.

Genus *Pterynotus* Swainson, 1822:
72 (3280) *Pterynotus alatus* (Röding, 1798), label *Murex pinnatus* Swainson, 1822, 1 specimen, People's Republic of China.

Genus *Pterymarchia* Houart, 1995 alternative representation Genus *Pterynotus* Swainson, 1833:
73 (4030) *Pterymarchia triptera* (Born, 1778), label *Murex tripterus* Born, 1778, 1 specimen, the Republic of the Philippines.

Genus *Purpurellus* Jousseaume, 1880:
79 (3290) *Purpurellus pinniger* (Broderip, 1833), label *Murex cristatus* Wood, 1828, 1 specimen, Adriatic Sea, Zadar (Repubic of Croatia);
80 (3291) *Purpurellus pinniger* (Broderip, 1833), label *Murex cristatus* Wood, 1828, 2 specimens, Adriatic Sea, Zadar (Repubic of Croatia);
81 (3293) *Purpurellus pinniger* (Broderip, 1833), label *Murex cristatus* Wood, 1828, 2 specimens, Adriatic Sea, Dubrovnik (Republic of Croatia);
87 (6080) *Purpurellus pinniger* (Broderip, 1833), label *Murex cristatus* Wood, 1828, 15 specimens, Adriatic Sea, Spalato today Split (Republic of Croatia);
88 (6080) *Purpurellus pinniger* (Broderip, 1833), label *Murex cristatus* Wood, 1828, 6 specimens, Adriatic Sea, Spalato today Split (Republic of Croatia);
89 (3294) *Purpurellus pinniger* (Broderip, 1833), label *Murex cristatus* Wood, 1828, 4 specimens, Adriatic Sea, Dubrovnik (Republic of Croatia).

**Family Muricidae**
Subfamily Muricopsinae

Genus *Homalocantha* Mörch, 1852:
69 (3284) *Homalocantha anatomica* (Perry, 1811), label *Murex rota* Mawe, 1823, 4 specimens, Red Sea;
70 (10571) *Homalocantha anatomica* (Perry, 1811), label *Murex rota* Mawe, 1823, 6 specimens, Massawa, Eritrea, northern Red Sea;
71 (3286) *Homalocantha anatomica* (Perry, 1811), label *Murex rota* Mawe, 1823, 7 specimens, Red Sea;
84 (3285) *Homalocantha anatomica* (Perry, 1811), label *Murex rota* Mawe, 1823, 5 specimens, Red Sea;
85 (6078) *Homalocantha anatomica* (Perry, 1811), label *Murex rota* Mawe, 1823, 2 specimens, Red Sea;
86 (3287) *Homalocantha digitata* (G. B. Sowerby II, 1841), label *Murex digitatus* G. B. Sowerby II, 1841, 5 specimens, Massawa, Eritrea, northern Red Sea.

Genus *Favartia* Jousseaume, 1880:
104 (3288) *Favartia cyclostoma* (G. B. Sowerby II, 1841), label *Murex cyclostoma* G. B. Sowerby II, 1841, 15 specimens, Red Sea;

105 (3288) *Favartia cyclostoma* (G. B. Sowerby II, 1841), label *Murex cyclostoma* G. B. Sowerby II, 1841, 12 specimens, Red Sea;
106 (3288) *Favartia cyclostoma* (G. B. Sowerby II, 1841), label *Murex cyclostoma* G. B. Sowerby II, 1841, 1 specimen, Red Sea;
107 (3289) *Favartia cyclostoma* (G. B. Sowerby II, 1841), label *Murex cyclostoma* G. B. Sowerby II, 1841, 12 specimens, Red Sea.
108 (5166) *Favartia (Favartia) tetragona* (Broderip, 1833), label *Murex tetragonus* Broderip, 1833, 2 specimens, Mauritius Island (Republic of Mauritius).

**Family Muricidae**
Subfamily Ocenebrinae

Genus *Pteropurpura* Jousseaume, 1880:
74 (3281) *Pteropurpura (Pteropurpura) festiva* (Hinds, 1844), label *Murex festivus* Hinds, 1844, 1 specimen, California, U.S.A.

Genus *Ceratostoma* Herrmannsen, 1846:
75 (3282) *Ceratostoma nuttalli* Conrad, 1837, label *Murex nuttalli* Conrad, 1837, 1 specimen, California, U.S.A.

Genus *Ocinebrina* Jousseaume, 1880:
76 (5610) *Ocinebrina aciculata* (Lamarck, 1822), label *Murex aciculatus* Lamarck, 1822, 2 specimens, Adriatic Sea;
77 (1402) *Ocinebrina aciculata* (Lamarck, 1822), label *Murex aciculatus* Lamarck, 1822, 1 specimen, Mediterranean Sea;
78 (6079) *Ocinebrina aciculata* (Lamarck, 1822), label *Murex aciculatus* Lamarck, 1822, 1 specimen, Adriatic Sea, Spalato today Split (Republic of Croatia);
82 (3292) *Ocinebrina* Jousseaume, 1880, label *Murex sp.* Linnaeus, 1758, 1 specimen, Adriatic Sea, Dubrovnik (Republic of Croatia);
83 (10572) *Ocinebrina* Jousseaume, 1880, label *Murex sp.* Linnaeus, 1758, 1 specimen, Adriatic Sea, Lovran (Republic of Croatia);
99 (1401) *Ocinebrina edwardsii* (Payraudeau, 1826), label *Murex edwardsii* (Payraudeau, 1826), 5 specimens, Mediterranean Sea, Provence.

Genus *Vaughtia* Houart, 1995:
90 (3536) *Vaughtia dunkeri* (Krauss, 1848), label *Murex dunkeri* Krauss, 1848, 1 specimen, South Africa;
183 (3544) *Vaughtia scrobiculata* (Dunker, 1846), label *Fusus scrobiculatus* Dunker in Philippi, 1846, 5 specimens, South Africa.

Genus *Ocenebra* Gray, 1847:
92 (2263) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 4 specimens, Brit, South Africa;
93 (3487) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 2 specimens, Bantry Bay, Southwest Ireland;
94 (3295) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 4 specimens, Adriatic Sea;
95 (3296) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 2 specimens, Adriatic Sea, Dubrovnik (Republic of Croatia);
96 (10573) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 3 specimens, Adriatic Sea, Lovran (Republic of Croatia);
97 (6081) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 4 specimens, Adriatic Sea, Spalato today Split (Republic of Croatia);
98 (3298) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 1 specimen, Adriatic Sea, Zadar (Republic of Croatia);
100 (3299) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 1 specimen, Adriatic Sea, Zadar (Republic of Croatia);
101 (3297) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 1 specimen, Adriatic Sea, Dalmatia;
102 (9102) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 1 specimen, Red Sea;
103 (4026) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 4 specimens, Adriatic Sea, Dubrovnik (Republic of Croatia);
111 (3300) *Ocenebra erinaceus* (Linnaeus, 1758), label *Murex erinaceus* Linnaeus, 1758, 1 specimen, Adriatic Sea, Zadar (Republic of Croatia).

Genus *Hadriania* Bucquoy & Dautzenberg, 1882:
116 (5612) *Hadriania craticulata* Bucquoy, Dautzenberg & Dollfus, 1882, label *Hadriania craticuloides* (Vokes, 1964), 2 specimens, Mediterranean Sea.

Genus *Crassilabrum* Jousseaume, 1880:
115 (3303) *Crassilabrum crassilabrum* (G. B. Sowerby II, 1834), label *Traphon crassilabrum*, 1 specimen, Valparaiso (Chile).

Genus *Urosalpinx* Stimpson, 1865:
117 (6083) *Urosalpinx cinerea* (Say, 1822), 1 specimen, West India;

118 (3488) *Urosalpinx cinerea* (Say, 1822), 2 specimens, North America, Harwich Port.

Genus *Nucella* Röding, 1798:
523 (2260) *Nucella lapillus* (Linnaeus, 1758), label *Purpura (Polytropa) lapillus* (Linnaeus, 1758), 6 specimens, Devon, southwestern England;
524 (2261) *Nucella lapillus* (Linnaeus, 1758), label *Purpura (Polytropa) lapillus* (Linnaeus, 1758), 7 specimens, Montrose, Angus, Scotland;
525 (12241) *Nucella lapillus* (Linnaeus, 1758), label *Purpura (Polytropa) lapillus* (Linnaeus, 1758) (Linnaeus, 1758), 9 specimens, Katwijk, South Holland;
545 (2262) *Nucella lapillus* (Linnaeus, 1758), label *Purpura (Polytropa) lapillus* (Linnaeus, 1758), 6 specimens, Wales, England;
526 (6259) *Nucella lapillus* (Linnaeus, 1758), label *Purpura (Polytropa) lapillus* Lamarck, 1822, 10 specimens, Spitsbergen Island (Svalbard Archipelago in Norway), Lyngen (Troms county, Norway);
527 (6258) *Nucella lamellosa* (Gmelin, 1791), label *Purpura (Polytropa) crispata* Chemnitz, 2 specimens, Gulf of California;
528 (6260) *Nucella freycinetii* (Deshayes, 1839), label *Purpura (Polytropa) saxicola* Valenciennes, 1846, 1 specimen, Gulf of California.

Genus *Trochia* Swainson, 1840:
543 (6264) *Trochia cingulata* (Linnaeus, 1771), label *Purpura cingulata* Linnaeus, 1771, 1 specimen, the Cape of Good Hope (South Africa);
544 (3546) *Trochia cingulata* (Linnaeus, 1771), label *Purpura cingulata* Linnaeus, 1771, 2 specimens, South Africa.

Genus *Mexacanthina* Marko & Vermeij, 1999:
597 (6298) *Mexacanthina lugubris* (Sowerby, 1821), label *Monoceros cymatum* Sowerby, 1835, 1 specimen, Gulf of California;
609 (6297) *Mexacanthina lugubris* (Sowerby, 1821), label *Monoceros lugubris* G. B. Sowerby I, 1821, 1 specimen, California (S.U.A.).

Genus *Acanthina* Fischer von Waldheim, 1807:
598 (6299) *Acanthina* Fischer von Waldheim, 1807, label *Monoceros cappilloides*, 1 specimen, Gulf of California;
610 (5194) *Acanthina unicornis* (Bruguière, 1789), label *Monoceros crassilabrum* Lamarck, 1816, 2 specimens, Valparaiso (Chile).

**Family Muricidae**
Subfamily Typhinae
Genus *Siphonochelus* Jousseaume, 1880:
112 (3302) *Siphonochelus arcuatus* (Hinds, 1843), label *Typhis duplicatus* Sowerby, 1870, 1 specimen, Adriatic Sea, Spalato today Split (Republic of Croatia).

**Family Muricidae**
Subfamily Trophoninae

Genus *Boreotrophon* P. Fischer, 1884:
113 (4027) *Boreotrophon truncatus* (Strøm, 1768), label *Trophon truncatus* (Strøm, 1768), 1 specimen, North Sea.

Genus *Scabrotrophon* McLean, 1996:
114 (3304) *Scabrotrophon fabricii* (Møller, 1842), label *Trophon craticulatum* Fabricius, 1780, 1 specimen, Greenland.

**Family Muricidae**
Subfamily Rapaninae

Genus *Nassa* Röding, 1798:
153 (4083) *Nassa francolina* (Bruguière, 1789), label *Pisania francolina*, 2 specimens, Indian Ocean;
546 (6261) *Nassa serta* (Bruguière, 1789), label *Purpura (Polytropa) sertum*, 2 specimens, East Indian Ocean;
547 (6262) *Nassa serta* (Bruguière, 1789), label *Purpura (Iopas) serta*, 7 specimens, Massawa, Eritrea, northern Red Sea;
466 (6207) *Nassa hepatica* Montagu, 6 specimens, Massawa, Eritrea, northern Red Sea.

Genus *Purpura* Bruguière, 1789:
503 (5191) *Purpura patula* (Linnaeus, 1758), 4 specimens, Republic of Cuba;
504 (6236) *Purpura persica* (Linnaeus, 1758), label *Purpura rudolphi* Lamarck, 1822, 1 specimen, Republic of the Philippines;
510 (6242) *Purpura* Bruguière, 1789, 1 specimen, Suez Canal, Red Sea;
512 (6243) *Purpura* Bruguière, 1789, *Purpura (Thelassa) trupa*, 1 specimen, Republic of Cuba;
536 (5192) *Purpura (Polytropa) cataracta*, 2 specimens, Island Saint Thomas, Caribbean Sea;
538 (6255) *Purpura* Bruguière, 1789, 3 specimens, Pacific Ocean, Port Jackson, Australia;
539 (6250) *Purpura bufo* Lamarck, 1822, label *Purpura (Stramonita) bufo*, 1 specimen, Manila (Philippines);

540 (10579) *Purpura* Bruguière, 1789, 2 specimens, juveniles, Pacific Ocean, Port Jackson, Australia.

Genus *Stramonita* Schumacher, 1817 :
519 (6246) *Stramonita haemastoma* (Linnaeus, 1767), label *Purpura (Stramonita) haemastoma* (Linnaeus, 1767), 3 specimens, West Africa;
541 (6252) *Stramonita biserialis* (Blainville, 1832), label *Purpura biserialis* Blainville, 1832, juvenile, 1 specimen, Atlantic Ocean.

Genus *Mancinella* Link, 1807:
506 (5188) *Mancinella armigera* Link, 1807, label *Purpura (Thalessa) armigera*, 2 specimens, Mauritius Island (Republic of Mauritius);
513 (6245) *Mancinella alouina* (Röding, 1798), label *Purpura (Thelassa) mancinella*, 1 specimen, Philippines Islands today the Republic of the Philippines, Southeast Asia.

Genus *Thalessa* H. Adams & A. Adams, 1853:
508 (6241) *Thalessa savignyi* (Deshayes, 1844), label *Purpura (Thelassa) saviguyi*, 6 specimens, Massawa, Eritrea, northern Red Sea;
515 (12265) *Thalessa savignyi* (Deshayes, 1844), label *Purpura (Thelassa) saviguyi*, 3 specimens, Massawa, Eritrea, northern Red Sea;

Genus *Reishia* Kuroda & Habe, 1971:
521 (6247) *Reishia bitubercularis* (Lamarck, 1822), label *Purpura (Stramonita) undata*, 1 specimen, Republic of Cuba;
534 (6254) *Reishia bitubercularis* (Lamarck, 1822), label *Purpura (Stramonita) untada*, 1 specimen, Manila (Philippines);
535 (5949) *Reishia bitubercularis* (Lamarck, 1822), label *Purpura (Stramonita) untada*, 2 specimens, Pacific Ocean, Port Jackson, Australia;
542 (10580) *Reishia bitubercularis* (Lamarck, 1822), label *Purpura undata* Lamarck, 1822, 1 specimen, Red Sea, Dahlak Arhipelago;

Genus *Vasula* Mörch, 1860:
514 (6244) *Vasula melones* (Duclos, 1832), label *Purpura (Thelassa) melones*, 1 specimen, Ecuador;
522 (5190) *Vasula deltoidea* (Lamarck, 1822), label Purpura (Stramonita) deltoida, 2 specimens, Saint Thomas Island, U.S. Virgin Islands, the Caribbean Sea.

Genus *Thais* Röding, 1798:
30 (3266) *Thais (Thalessa) virgata* (Dillwyn, 1817), label *Murex (Tribulus) plicatus Sow.*, 1 specimen, Mazatlán, American Northwest coast;
516 (6237) *Thais (Thalessa) virgata* (Dillwyn, 1817), label *Purpura (Thelassa) hippocastanum*, 1 specimen, East Indian Ocean;
517 (6238) *Thais (Thalessa) virgata* (Dillwyn, 1817), label *Purpura (Thelassa) hippocastanum*, 1 specimen, East Indian Ocean.

Genus *Thaisella* Clench, 1947:
505 (6235) *Thaisella chocolata* (Duclos, 1832), label *Purpura chocolata* Duclos, 1832, 1 specimen, Mazatlán, Mexico;
518 (5189) *Thaisella forbesii* (Dunker, 1853), label *Purpura (Stramonita) forbesi*, 3 specimens, Saint Thomas Island, U.S. Virgin Islands, the Caribbean Sea;
537 (6251) *Thaisella coronata* (Lamarck, 1816), label *Purpura coronata* Lamarck, 1816, 1 specimen, Republic of Senegal.

Genus *Dicathais* Iredale, 1936:
529 (6256) *Dicathais orbita* (Gmelin, 1791), label *Purpura (Plytropa) textilosa*, 2 specimens, Australia;
530 (5948) *Dicathais orbita* (Gmelin, 1791), label *Purpura (Plytropa) textilosa*, 3 specimens, Pacific Ocean, Port Jackson, Australia;
531 (6257) *Dicathais orbita* (Gmelin, 1791), label *Purpura (Polytropa) succincta*, 1 specimen, New Zeeland;
532 (5987) *Dicathais orbita* (Gmelin, 1791), label *Purpura (Polytropa) succincta*, 1 specimen, Pacific Ocean, Port Jackson, Australia.

Genus *Semiricinula* Martens, 1904:
533 (6249) *Semiricinula muricina* (Blainville, 1832), label *Purpura (Stramonita) muricina*, 1 specimen, Île Bourbon today Réunion Island (France), Indian Ocean, east of Madagascar, south west of Mauritius Island.

Genus *Neothais* Iredale, 1912:
577 (6280) *Neothais marginatra* (Blainville, 1832), label *Ricinula (Sistrum) marginallum*, 1 specimen, Antilles Islands;
578 (6253) *Neothais marginatra* (Blainville, 1832), label *Ricinula marginata*, 1 specimen, Île Bourbon today Réunion Island (France), Indian Ocean, east of Madagascar, southwest of Mauritius Island.

Genus *Vexilla* Swainson, 1840:
548 (6263) *Vexilla vexillum* (Gmelin, 1791), label *Purpura (Vexilla) vexillum*, 1 specimen, Île Bourbon today Réunion Island (France), Indian Ocean, east of Madagascar, Southwest of Mauritius Island.

Genus *Drupa* Röding, 1798:
550 (6269) *Drupa ricinus* (Linnaeus, 1758), label *Ricinula ricinus* (Linnaeus, 1758), 1 specimen, Djedda today Jeddah (Makkah Province, Saudi Arabia), Red Sea;
551 (6270) *Drupa ricinus* (Linnaeus, 1758), label *Ricinula ricinus* (Linnaeus, 1758), 1 specimen, Massawa, Eritrea, northern Red Sea;
552 (6271) *Drupa ricinus* (Linnaeus, 1758), label *Ricinula ricinus* (Linnaeus, 1758), 1 specimen, Red Sea;
553 (6266) *Drupa clathrata* (Lamarck, 1816), label *Ricinula clathrata* Lamarck, 1816, 1 specimen, Île Bourbon today Réunion Island (France), Indian Ocean, east of Madagascar, south west of Mauritius Island;
554 (6265) *Drupa morum* Röding, 1798, label *Ricinula horrida* Lamarck, 1816, 1 specimen, Pacific Ocean;
555 (6268) *Drupa ricinus* (Linnaeus, 1758), label *Ricinula arachnoides* Lamarck, 1816, 1 specimen, Republic of Philippine.

Genus *Drupina* Dall, 1923:
557 (6273) *Drupina grossularia* (Röding, 1798), label *Ricinula digitata* Lamarck, 1816, 1 specimen, Tahiti Island;
558 (6272) *Drupina grossularia* (Röding, 1798), label *Ricinula digitata* ver. *Lobata*, label Ricinula lobata, 1 specimen, Massawa, Eritrea, northern Red Sea;
559 (9557) *Drupina grossularia* (Röding, 1798), label *Ricinula digitata ver. Lobata*, label Ricinula lobata, 1 specimen, Dahlak Arhipelago, Red Sea.

Genus *Ricinula* Lamarck, 1816:
591 (6284) *Ricinula nodus* Lamarck, 1816, label *Ricinula (Sistrum) nodosulum*, 1 specimen, Massawa, Eritrea, northern Red Sea;
595 (10581) *Ricinula* Lamarck, 1816, 4 specimens, Pacific Ocean, Port Jackson, Australia;
596 (10582) *Ricinula* Lamarck, 1816, 3 specimens, Pacific Ocean, Port Jackson, Australia.

Genus *Concholepas* Lamarck, 1801:
599 (6300) *Concholepas concholepas* (Bruguière, 1789), label *Concholepas peruviana* Lamarck, 1801, 1 specimen, Republic of Peru.

Genus *Rapana* Schumacher, 1817:
608 (6301) *Rapana bezoar* (Linnaeus, 1767), 1 specimen, People’s Republic of China;
611 (6302) *Rapana rapiformis* (Born, 1778), label *Rapana bulbosa* (Dillwyn, 1817), 1 specimen, East Indian Ocean;
612 (6303) *Rapana rapiformis* (Born, 1778), label *Rapana bulbosa* (Dillwyn, 1817), 3 specimens, Dahlak Arhipelago, Red Sea;
613 (6304) *Rapana rapiformis* (Born, 1778), label *Rapana bulbosa* (Dillwyn, 1817), 1 specimen, Massawa, Eritrea, northern Red Sea.

**Family Muricidae**
Subfamily Ergalataxinae

Genus *Cronia* H. Adams & A. Adams, 1853:
520 (6248) *Cronia (Usilla) avenacea* (Lesson, 1842), label *Purpura (Stramonita) leucostoma*, 2 specimens, Nagasaki (Japan);
579 (3621) *Cronia (Usilla) avenacea* (Lesson, 1842), label *Ricinula leucostoma*, 1 specimen, Île Bourbon today Réunion Island (France), Indian Ocean, east of Madagascar, Southwest of Mauritius Island.

Genus *Morula* Schumacher, 1817
Subgenus *Morula (Morula)* Schumacher, 1817:
556 (6267) *Morula (Morula) uva* (Röding, 1798), label *Ricinula alba* Mörch, 1852, 1 specimen, Tahiti Island, Pacific Ocean;
560 (5193) *Morula (Morula) uva* (Röding, 1798), label *Ricinula (Sistrum) morus*, 3 specimens, the Independent State of Samoa;
573 (6275) *Morula (Morula) anaxares* (Kiener, 1836), label *Ricinula (Sistrum) anaxares*, 7 specimens, Massawa, Eritrea, northern Red Sea ;
574 (6275) *Morula (Morula) anaxares* (Kiener, 1836), label *Ricinula (Sistrum) anaxares*, 4 specimens, Massawa, Eritrea, northern Red Sea;
575 (6276) *Morula (Morula) anaxares* (Kiener, 1836), label *Ricinula (Sistrum) anaxares*, 5 specimens, Dahlak Arhipelago, Red Sea;
576 (6277) *Morula (Morula) anaxares* (Kiener, 1836), label *Ricinula (Sistrum) anaxares*, 1 specimen, Snakui, Red Sea.

Genus *Morula* Schumacher, 1817
Subgenus *Morula (Habromorula)* Houart, 1995:
564 (6295) *Morula (Habromorula) bicatenata* (Reeve, 1846), label *Ricinula (Sistrum) bicatenata*, 1 specimen, Dahlak Arhipelago, Red Sea;
580 (6294) *Morula (Habromorula) bicatenata* (Reeve, 1846), label *Ricinula (Sistrum) bicatenata*, 6 specimens, Massawa, Eritrea, northern Red Sea;
581 (6294) *Morula (Habromorula) bicatenata* (Reeve, 1846), label *Ricinula bicatenata* Reeve, 1846, 3 specimens, Massawa, Eritrea, northern Red Sea;
582 (6294) *Morula (Habromorula) bicatenata* (Reeve, 1846), label *Ricinula bicatenata* Reeve,

1846, 7 specimens, Massawa, Eritrea, northern Red Sea.

Genus *Tenguella* Arakawa, 1965:
561 (6274) *Tenguella granulata* (Duclos, 1832), label *Ricinula (Sistrum) granulata*, 1 specimen, the Port of Natal, Potengi River, Brazil;
562 (6278) *Tenguella granulata* (Duclos, 1832), label *Ricinula (Sistrum) tuberculatum*, 1 specimen, Massawa, Eritrea, northern Red Sea;
572 (6951) *Tenguella granulata* (Duclos, 1832), label *Ricinula (Sistrum) granulata*, 7 specimens, Pacific Ocean, Port Jackson, Australia;

Genus *Drupella* Thiele, 1925:
563 (6279) *Drupella rugosa* (Born, 1778), label *Ricinula (Sistrum) cocatenata*, 2 specimens, Island D. Trau.;
587 (6288) *Drupella margariticola* (Broderip, in Broderip & Sowerby, 1833), label *Ricinula (Sistrum) undata*, 8 specimens, Mumbai (India), Indian Ocean;
589 (6281) *Drupella cornus* (Röding, 1798), label *Ricinula (Sistrum) spectrum*, 8 specimens, Massawa, Eritrea, northern Red Sea;
590 (6282) *Drupella cornus* (Röding, 1798), label *Ricinula (Sistrum) spectrum*, 8 specimens, Dahlak Arhipelago, Red Sea;
592 (6283) *Drupella cornus* (Röding, 1798), label *Ricinula (Sistrum) spectrum*, 1 specimen, Snakui, Red Sea;
593 (6285) *Drupella cornus* (Röding, 1798), label *Ricinula (Sistrum) spectrum*, 2 specimens, Massawa, Eritrea, northern Red Sea;
594 (6284) *Drupella cornus* (Röding, 1798), label *Ricinula (Sistrum) spectrum*, 1 specimen, Djedda today Jeddah (Makkah Province, Saudi Arabia), Red Sea.

Genus *Muricodrupa* Iredale, 1918:
565 (6287) *Muricodrupa fiscella* (Gmelin, 1791), label *Ricinula (Sistrum) fiscellum*, 2 specimens, Dahlak Arhipelago, Red Sea;
585 (6289) *Muricodrupa fiscella* (Gmelin, 1791), label *Ricinula (Sistrum) fiscellum*, 13 specimens, Massawa, Eritrea, northern Red Sea;
586 (6290) *Muricodrupa fiscella* (Gmelin, 1791), label *Ricinula (Sistrum) fiscellum*, 7 specimens, Dahlak Arhipelago, Red Sea;
566 (9558) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 6 specimens, Massawa, Eritrea, northern Red Sea;
567 (9559) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 6 specimens, Massawa, Eritrea, northern Red Sea;
568 (9560) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 6 specimens, Massawa, Eritrea, northern Red Sea;
569 (9561) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 6 specimens, Massawa, Eritrea, northern Red Sea;
570 (9558) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 8 specimens, Massawa, Eritrea, northern Red Sea;
583 (6293) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 6 specimens, Dahlak Arhipelago, Red Sea;
584 (6293) *Muricodrupa fenestrata* (Blainville, 1832), label *Ricinula (Sistrum) cariosa*, 6 specimens, Dahlak Arhipelago, Red Sea.

Genus *Pascula* Dall, 1908:
571 (6292) *Pascula ochrostoma* (Blainville, 1832), label *Ricinula (Sistrum) ochrostoma*, 12 specimens, Dahlak Arhipelago, Red Sea;
588 (6291) *Pascula ochrostoma* (Blainville, 1832), label Ricinula (Sistrum) ochrostoma, 27 specimens, Massawa, Eritrea, northern Red Sea.

**Family Muricidae**
Subfamily Coralliophilinae

Genus *Coralliophila* H. Adams & A. Adams, 1853:
600 (6308) *Coralliophila violacea* (Kiener, 1836), label *Coralliophila neritoidea* (Gmelin, 1791), 2 specimens, Australia;
601 (6309) *Coralliophila violacea* (Kiener, 1836), label *Coralliophila neritoidea* (Gmelin, 1791), 2 specimens, 1 specimen, Massawa, Eritrea, northern Red Sea;
602 (6310) *Coralliophila violacea* (Kiener, 1836), label *Coralliophila neritoidea* (Gmelin, 1791), 2 specimens, Snakui, Red Sea;
603 (6311) *Coralliophila monodonta* (Blainville, 1832), label *Coralliophila madreporina*, 1 specimen, Djedda today Jeddah (Makkah Province, Saudi Arabia), Red Sea;
604 (6312) *Coralliophila monodonta* (Blainville, 1832), label *Coralliophila madreporina*, 4 specimens, Sankui, Red Sea;
605 (6307) *Coralliophila brevis* (Blainville, 1832), label *Pseudomurex brevis*, 1 specimen, Adriatic Sea;
606 (6306) *Coralliophila meyendorffii* (Calcara, 1845), label *Pseudomurex meyendorffii* Calcara, 1845, 3 specimens, Adriatic Sea, Spalato today Split (Republic of Croatia);
607 (6305) *Coralliophila meyendorffii* (Calcara, 1845), label *Pseudomurex meyendorffii* Calcara, 1845, 1 specimen, Adriatic Sea, Spalato today Split (Republic of Croatia);

620 (5196) *Coralliophila robillardi* (Liénard, 1870), label *Leptoconchus robillardi* Liénard, 1870, 2 specimens, Republic of Mauritius.

Genus *Magilus* Montfort, 1810:
614 (5198) *Magilus antiquus* Montfort, 1810, 1 specimen compoused of 2 pieces, Republic of Mauritius.

Genus *Leptoconchus* Rüppell, 1834:
615 (12266) *Leptoconchus* Rüppell, 1834, 1 specimen, New Zeeland;
616 (6314) *Leptoconchus peronii* (Lamarck, 1818), label *Leptoconchus striatus* Rüppell, 1835, 1 specimen, Massawa, Eritrea, northern Red Sea;
617 (6313) *Leptoconchus peronii* (Lamarck, 1818), label *Leptoconchus striatus* Rüppell, 1835, 3 specimens, Dahlak Arhipelago, Red Sea;
618 (6313) *Leptoconchus peronii* (Lamarck, 1818), label *Leptoconchus striatus* Rüppell, 1835, 1 specimen, Dahlak Arhipelago, Red Sea;
619 (5195) *Leptoconchus peronii* (Lamarck, 1818), label *Leptoconchus striatus* Rüppell, 1835, 2 specimens, Republic of Mauritius;
621 (5197) *Leptoconchus lamarckii* Deshayes, 1863, 2 specimens, Republic of Mauritius.

## Conclusions

In a natural history collection, elements are automatically placed in categories when they are identified, process called today cross-cataloging. The storage location of a specimen is selected by its identification and the existing taxonomic arrangement of the collection. This is also the case of the Kimakowicz Malacological Collection. According to the identifications done by Moritz and Richard von Kimakowicz, following the taxonomic information available at that time, the specimens were cross-catalogued correctly. According to today's taxonomy, the specimens could be placed in different categories, the inventory numbers do not follow one after the other, and species are hard to find without a complete database. This catalogue and the others to follow are the first step towards an efficient management system of the collection.

The majority of the species catalogued in this paper belong to the superfamily Muricoidea, family Muricidae. The specimens were mainly collected from the Red Sea area and the Adriatic Sea, between 1880 and 1894, bought or obtained as donation/exchange.

Durring the inventories were answered a series of questions. Firstly, the year written on the original labels is the collecting year and not the year when the specimen was included in the Kimakowicz Collection. For instance, the Mediterranean Sea species were obtained from César Marie Félix Ancey (1860 – 1906). On the labels is written the year 1884, which must refer to the year when the specimens were collected as the Kimakowicz collection was initiated only in 1887.

Secondly, the name of the collector is not included on all the original labels but considering the collecting area, period and from the museum archives, we can narrow down the list of possible collectors. Eduard Albert Bielz and Carl Friedrich Jickeli are mentioned the most on the original labels. C. F. Jickeli collected the majority of specimens from the Red Sea during his expedition to the region between 1870 and 1871. The inventory number 8 (5938) was collected by Sachsenheim from the Adriatic Sea, Split, Republic of Croatia in 1884. On February 28, 1883, Sachsenheim became a ship doctor for the Austro-Hungarian Lloyd Steamship Company. Between 1883 and 1884, he visited coastal towns and islands of Dalmatia, Greece, the European part of Turkey, Asia – minor, Syria, Egypt, Italy, Spain and Portugal. He went twice to Brazil. Then he visited the coastal countries of the Red Sea, the western part of India, the islands of Ceylon and Sumatra, the eastern part of India and China. During his trips, he would gather ethnographic objects. Sachsenheim donated to the Transylvanian Society Ethnographic Collection over 100 objects that Kimakowicz, as Society member and custodian of the collections, received. The proof that mollusk specimens collected by Sachsenheim during his trips were included in the Kimakowicz Collection are also the inventory numbers 4 (10.566) and 141 (6082). He collected the species during his expedition in 1895 organized by Wilhelm Bade, to the North Sea and the Southern Ocean, Antarctica (Kimakowicz, 1896, 67-81).

## Acknowledgements

The author is grateful to the museum curator Gabriela Cuzepan (Natural History Museum, Sibiu, Romania) for photographing the specimens, to Henk Dekker PhD, Naturalis Biodiversity Center, The Netherlands, for identifying the specimens belonging to the inventory number 45 (5609) and to the anonymous reviewers for their constructive comments.

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## LIST OF ILLUSTRATIONS

**Fig. 1.** Hand written label by Moritz von Kimakowicz (photo by Gabriela Cuzepan).

**Fig. 2.** The first inventory number (according to the present inventory books), from the Kimakowicz collection, 1 (3259) *Argonauta argo* Linnaeus, 1758, 1 specimen, Adriatic Sea, obtained from Bielz in 1884 (photo bx Gabriela Cuzepan).

**Fig. 3 a, b.** Hand written list by Moritz von Kimakowicz of the aquired specimens from the Red Sea and Northeast Africa (Archive – Natural History Museum in Sibiu)

**Tab. 1** List of the families, genuses and species catalogued in the paper.

## LISTA ILUSTRAŢIILOR

**Fig. 1.** Etichete scrise de către Moritz von Kimakowicz (foto Gabriela Cuzepan).

**Fig. 2.** Primul număr de inventar (după registrele de inventar actuale) din colecţia Kimakowicz, 1 (3259) *Argonauta argo* Linnaeus, 1758, 1 specimen, Marea Adriatică, sursa Bielz, anul 1884 (foto Gabriela Cuzepan).

**Fig. 3 a, b.** Listele scrise de Moritz von Kimakowicz incluzând specimene din zona Mării Roşii şi NE Africii, achizitionate/primate sub formă de donaţi (Arhivă – Muzeul de Istorie Naturală din Sibiu).

**Tab. 1** Lista familiilor, genurilor şi specilor enumerate în această lucrare.

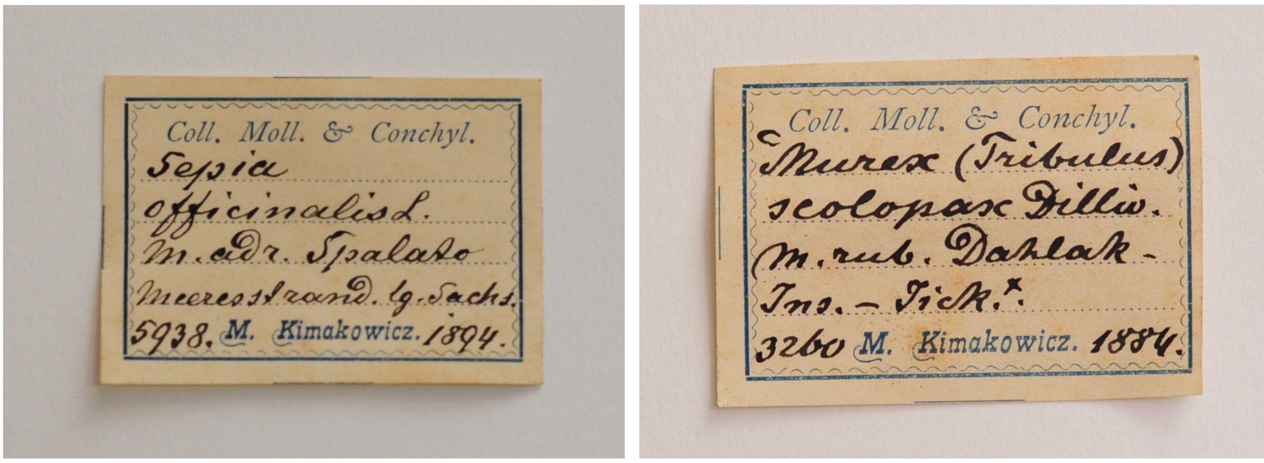



**Fig. 1.** Hand written labels by Moritz von Kimakowicz (photo by Gabriela Cuzepan).

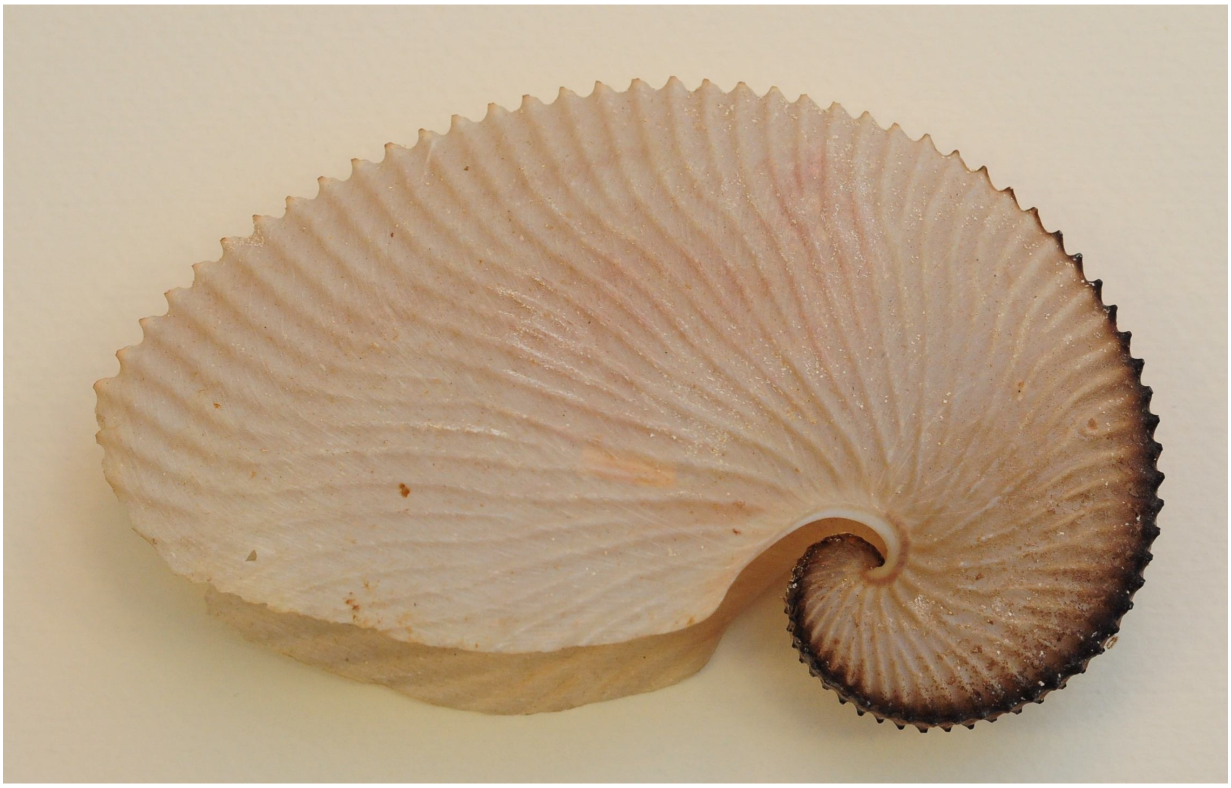
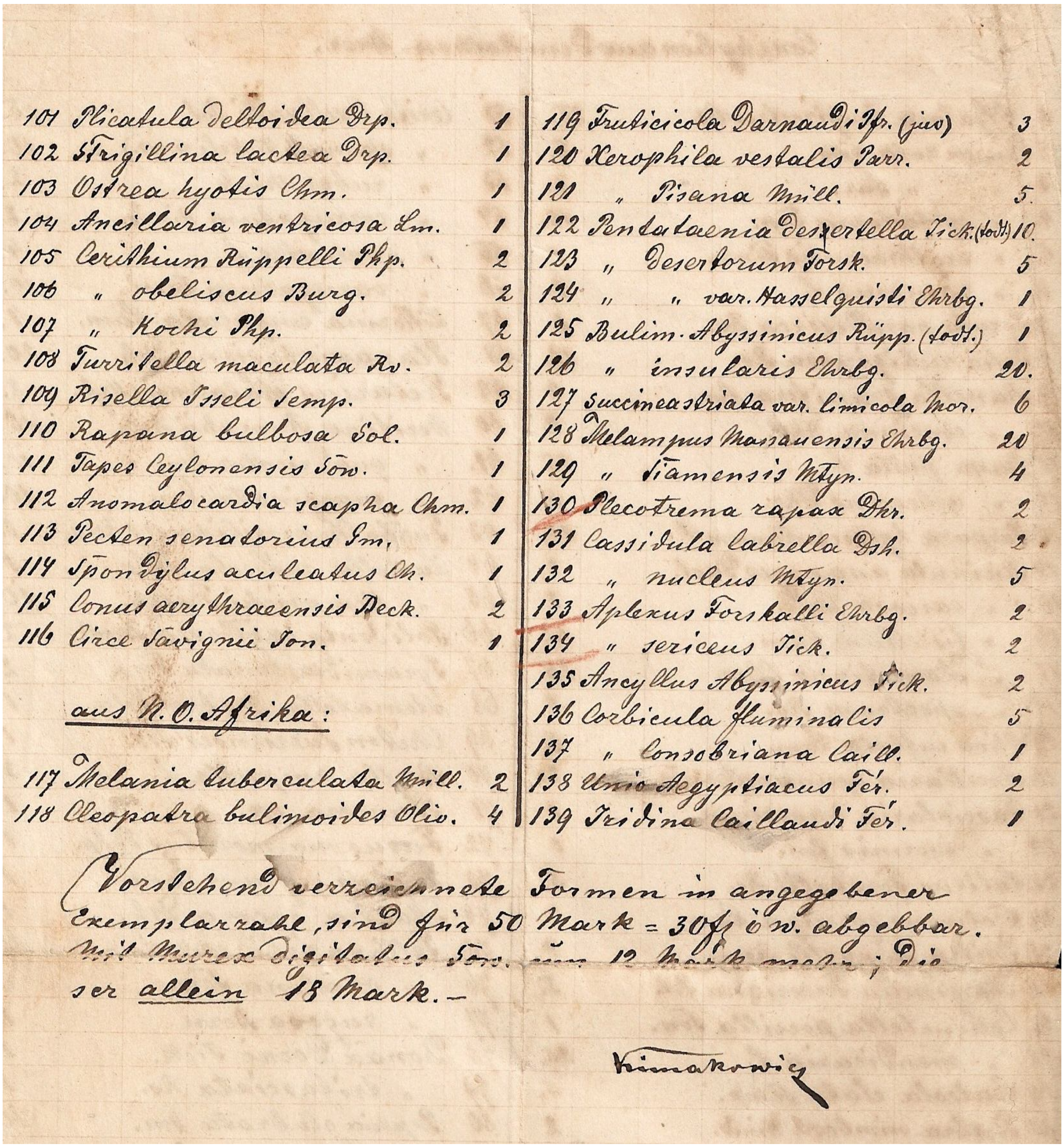


**Fig. 2.** The first inventory number (according to the present inventory books) from the Kimakowicz collection, 1 (3259) *Argonauta argo* Linnaeus, 1758, 1 specimen, Adriatic Sea, obtained from Bielz in 1884 (photo by Gabriela Cuzepan)

Conchylien aus dem Rothen-Meer. 114

| | | | | | |
|---|---|---|---|---|---|
| 1. | Hyalaea longirostris Les. | 25. | 51 | Cerith. Caillaudi Pot. | 25. |
| 2 | Murex rota Sow. | 5. | 52 | " sp. (nach Jickeli n. sp.) | 10. |
| 3 | " " var. | 1. | 53 | " ruber Hinds | 2. |
| 4. | " cyclostoma Tap. | 10. | 54 | " corrugatum Hinds. | 2. |
| 5. | " erythraeensis Fisch. | 1 | 55 | " palustre L. | 4. |
| 6. | " ramosus L. | 1 | 56 | " variegatum Quoi. | 10. |
| 7 | Pyrula paradisiaca Rv. | 1 | 57 | Littorina angulata Lam. | 4. |
| 8. | Polia rubiginosa Rv. | 10. | 58 | Planaxis Savignii Dsh. | 20. |
| 9. | Ranella granifera Lm. | 6 | 59 | Tectarius Natalensis Krss. | 8. |
| 10. | " concinna Dkr. | 2 | 60 | Neritina Rumphii Recl. | 15 |
| 11 | Nassa pulla L. | 15 | 61. | " quadricolor Gm. | 10. |
| 12 | " albescens Dkr. | 5. | 62 | " marginata Gm. | 10. |
| 13 | Purpura hippocastanum L. | 10. | 63 | Turbo Chemnitzianus Reev. | 1. |
| 14 | Ricinula anaxares Ducl. | 2. | 64 | Lunella modesta Phlp. | 1 |
| 15 | " cariosa Wood. | 2 | 65 | " Hemprichi Trosch. | 10 |
| 16 | " fiscellum Chm. | 15. | 66 | Polidonta erythraea Broch. | 2 |
| 17 | " Mauritiana Chm. | 25 | 67 | Pyramidea dentata Fors. | 2. |
| 18 | " spectrum Rv. | 2. | 68 | Stomatella scabra Phlp. | 1 |
| 19 | Oliva inflata Lam. | 5. | 69 | Chiton Sueziensis Iss. | 1 |
| 20. | Ancillaria acuminata Sow. | 2 | 70 | Bulla ampulla L. | 3 |
| 21. | Fasciolaria trapecium | 1 | 71 | Pterocera sp. | 1 |
| 22 | " inermis Jon. | 1 | 72 | Fusus marmoratus Phlp. | 1 |
| 23. | Latirus Forskalli Rv. | 5. | 73 | Triton pyrum Lam. | 1 |
| 24. | Scolimus corniger Lam. | 2. | 74 | Mactra decora Dsh. | 1 |
| 25. | Mitra Rüppelli Reev. | 2. | 75 | Tellina foliacea L. | 3 |
| 26. | Marginella Terveriana Pet. | 5. | 76 | " opalina Sow. | 6 |
| 27. | Columbella poecilla Sow. | 1 | 77 | " rugosa Born | 1 |
| 28 | " mendicaria L. | 25. | 78 | Donax Dorni Jick. | 1 |
| 29 | Scaleola elata Semp. | 5. | 79 | " trifasciata Rv. | 1 |
| 30. | Terebra nimbosa Hinds. | 2 | 80 | Paphia glabrata Gm. | 10 |
| 31. | Conus arenatus Brug. | 2 | 81 | Ervilia scaliola Iss. | 15 |
| 32 | " " var. minor Brug. | 5. | 82 | Tivela damaoides Gray. (juv) | 10 |
| 33 | " classiarius Brug. | 6 | 83 | Lioconcha Arabica Chm. | 6 |
| 34 | " " var. | 4 | 84 | Chione flammea Lam. | 6 |
| 35 | " acuminatus Brug. | 4 | 85 | Dosina alba Dunc. | 6 |
| 36 | " " var. grossa | 2 | 86 | " cretacea Rv. | 4 |
| 37 | Strombus tricornis Lam. | 3 | 87 | Lucina exasperata Rv. | 1 |
| 38 | " fasciatus Born. | 6 | 88 | " Fischeriana | 10 |
| 39 | " gibberulus var. rhodostoma Mrt. | 3 | 89 | Diplodonta Savignii Vaill. | 4 |
| 40 | Rostellaria curvirostris Lam. | 2 | 90 | Mytilus decussatus Lm. | 2 |
| 41 | Cypraea caurica L. | 3 | 91 | " variabilis Krss. | 2 |
| 42 | " camelopardalis Perry. | 2 | 92 | Modiola auriculata Krss. | 2 |
| 43 | " Arabica L. | 3 | 93 | Lithodomus Hanleyanus Dkr. | 5 |
| 44 | " pantherina Sold. | 5 | 94 | Malleus regula Fors. | 3 |
| 45 | " turdus Lam. | 15 | 95 | Barbatia Helblingi Dkr. | 4 |
| 46 | " carniola L. | 1. | 96 | " lacerata L. | [illegible] |
| 47 | Cerithyum erythraeense Lam. | 1. | 97 | " nivea L. | 5 |

**a.**



| | | |
|---|---|---|
| 101 | Plicatula deltoidea Drp. | 1 |
| 102 | Strigillina lactea Drp. | 1 |
| 103 | Ostrea hyotis Chm. | 1 |
| 104 | Ancillaria ventricosa Lm. | 1 |
| 105 | Cerithium Rüppelli Php. | 2 |
| 106 | " obeliscus Burg. | 2 |
| 107 | " Kochi Php. | 2 |
| 108 | Turritella maculata Rv. | 2 |
| 109 | Risella Isseli Semp. | 3 |
| 110 | Rapana bulbosa Sol. | 1 |
| 111 | Tapes Ceylonensis Sow. | 1 |
| 112 | Anomalocardia scapha Chm. | 1 |
| 113 | Pecten senatorius Gm. | 1 |
| 114 | Spondylus aculeatus Ch. | 1 |
| 115 | Conus aerythraeensis Beck. | 2 |
| 116 | Circe Savignii Jon. | 1 |

aus N.O. Afrika:

| | | |
|---|---|---|
| 117 | Melania tuberculata Müll. | 2 |
| 118 | Cleopatra bulimoides Oliv. | 4 |
| 119 | Fruticicola Darnaudi Pfr. (juv) | 3 |
| 120 | Xerophila vestalis Parr. | 2 |
| 121 | " Pisana Müll. | 5 |
| 122 | Pentataenia Desertella Jick. (todt) | 10 |
| 123 | " Desertorum Forsk. | 5 |
| 124 | " " var. Hasselquisti Ehrbg. | 1 |
| 125 | Bulim. Abyssinicus Rüpp. (todt) | 1 |
| 126 | " insularis Ehrbg. | 20 |
| 127 | Succinea striata var. limicola Mor. | 6 |
| 128 | Melampus Massauensis Ehrbg. | 20 |
| 129 | " Siamensis Mtyn. | 4 |
| 130 | Plecotrema rapax Dhr. | 2 |
| 131 | Cassidula labrella Dsh. | 2 |
| 132 | " nucleus Mtyn. | 5 |
| 133 | Aplexus Forskalli Ehrbg. | 2 |
| 134 | " sericeus Jick. | 2 |
| 135 | Ancyllus Abyssinicus Jick. | 2 |
| 136 | Corbicula fluminalis | 5 |
| 137 | " Consobriana Caill. | 1 |
| 138 | Unio Aegyptiacus Fér. | 2 |
| 139 | Iridina Caillaudi Fér. | 1 |

(Vorstehend verzeichnete Formen in angegebener Exemplarzahl, sind für 50 Mark = 30 fl ö. W. abgebbar. Mit Murex digitatus Sow. um 12 Mark mehr; dieser allein 18 Mark.–

Kimakowicz

**b.**

**Fig. 4 a,b.** Hand written list by Moritz von Kimakowicz of the aquired specimens from the Red Sea and Northeast Africa (Archive – Natural History Museum in Sibiu)

**Tab. 1.** List of the families, genuses and species catalogued in the paper

| Family/Subfamily | Genus | Species |
|---|---|---|
| Argonautidae | *Argonauta* Linnaeus, 1758 | *Argonauta argo* Linnaeus, 1758 |
| | | *Argonauta hians* Lightfoot, 1786 |
| Sepiidae | *Sepia* Linnaeus, 1758 | *Sepia hedleyi* Berry, 1918 |
| | | *Sepia elegans* de Blainville, 1827 |
| | | *Sepia officinalis* Linnaeus, 1758 |
| Spirulidae | *Spirula* Lamarck, 1799 | *Spirula spirula* (Linnaeus, 1758) |
| Loliginidae | *Loligo* Lamarck, 1798 | *Loligo vulgaris* Lamarck, 1798 |
| Cavoliniidae | *Cavolinia* Abildgaard, 1791 | *Cavolinia globulosa* (Gray, 1850) |
| | | *Cavolinia tridentata* (Niebuhr, 1775) |
| | *Diacavolinia* van der Spoel, 1987 | *Diacavolinia longirostris* (De Blainville, 1821) |
| Cliidae | *Clio* Linnaeus, 1767 | *Clio pyramidata* Linnaeus, 1767 |
| Creseidae | *Styliola* Gray, 1847 | *Styliola subula* (Quoy and Gaimard, 1827) |
| Limacinidae | *Limacina* Bosc, 1817 | *Limacina retroversa* (Fleming, 1823) |
| Janthinidae | *Janthina* Röding, 1798 | *Janthina janthina* (Linnaeus, 1758) |
| | | *Janthina umbilicata* d'Orbigny, 1840 |
| Carinariidae | *Carinaria* Lamarck, 1801 | *Carinaria lamarckii* Blainville, 1817 |
| Muricidae | | |
| *Subfamily Muricinae* | *Murex* Linnaeus, 1758 | *Murex (Murex) scolopax* Dillwyn, 1817 |
| | | *Murex (Murex) tribulus* Linnaeus, 1758 |
| | | *Murex pecten pecten* Lightfoot, 1786 |
| | | *Murex (Murex) trapa* Röding, 1798 |
| | | *Murex (Murex) occa* G. B. Sowerby II |
| | | *Murex brevispina* Lamarck, 1822 |
| | *Siratus* Jousseaume, 1880 | *Siratus kugleri* (Clench & Perez Farfante, 1945) |
| | *Bolinus* Pusch, 1837 | *Bolinus brandaris* (Linnaeus, 1758) |
| | *Haustellum* Schumacher, 1817 | *Haustellum haustellum* (Linnaeus, 1758) |
| | *Chicoreus* Montfort, 1810 | *Chicoreus ramosus* (Linnaeus, 1758) |
| | | *Chicoreus asianus* Kuroda, 1942 |
| | | *Chicoreus brunneus* (Link, 1807) |
| | | *Chicoreus microphyllus* (Lamarck, 1816) |
| | | *Chicoreus capucinus* (Lamarck, 1822) |
| | | *Chicoreus strigatus* (Reeve, 1849) |
| | | *Chicoreus axicornis* (Lamarck, 1822) |
| | | *Chicoreus virgineus* (Röding, 1798) |
| | | *Chicoreus brevifrons* (Lamarck, 1822) |
| | *Phyllonotus* Swainson, 1833 | *Phyllonotus pomum* (Gmelin, 1791) |
| | *Hexaplex* Perry, 1810 | *Hexaplex erythrostomus* (Swainson, 1831) |
| | | *Hexaplex trunculus* (Linnaeus, 1758) |
| | | *Hexaplex cichoreum* (Gmelin, 1791) |
| | *Pterynotus* Swainson, 1822 | *Pterynotus alatus* (Röding, 1798) |
| | *Pterymarchia* Houart, 1995 alternative representation Genus | *Pterymarchia triptera* (Born, 1778) |

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|---|---|---|
| | *Pterynotus* Swainson, 1833 | |
| | *Purpurellus* Jousseaume, 1880 | *Purpurellus pinniger* (Broderip, 1833) |
| *Subfamily Muricopsinae* | *Homalocantha* Mörch, 1852 | *Homalocantha anatomica* (Perry, 1811) |
| | | *Homalocantha digitata* (G. B. Sowerby II, 1841) |
| | *Favartia* Jousseaume, 1880 | *Favartia cyclostoma* (G. B. Sowerby II, 1841) |
| | | *Favartia (Favartia) tetragona* (Broderip, 1833) |
| *Subfamily Ocenebrinae* | *Pteropurpura* Jousseaume, 1880 | *Pteropurpura (Pteropurpura) festiva* (Hinds, 1844) |
| | *Ceratostoma* Herrmannsen, 1846 | *Ceratostoma nuttalli* Conrad, 1837 |
| | *Ocinebrina* Jousseaume, 1880 | *Ocinebrina aciculata* (Lamarck, 1822) |
| | | *Ocinebrina edwardsii* (Payraudeau, 1826) |
| | *Vaughtia* Houart, 1995 | *Vaughtia dunkeri* (Krauss, 1848) |
| | | *Vaughtia scrobiculata* (Dunker, 1846) |
| | *Ocenebra* Gray, 1847 | *Ocenebra erinaceus* (Linnaeus, 1758) |
| | *Crassilabrum* Jousseaume, 1880 | *Crassilabrum crassilabrum* (G. B. Sowerby II, 1834) |
| | *Urosalpinx* Stimpson, 1865 | *Urosalpinx cinerea* (Say, 1822) |
| | *Nucella* Röding, 1798 | *Nucella lapillus* (Linnaeus, 1758) |
| | | *Nucella lamellosa* (Gmelin, 1791) |
| | | *Nucella freycinetii* (Deshayes, 1839) |
| | *Trochia* Swainson, 1840 | *Trochia cingulata* (Linnaeus, 1771) |
| | *Mexacanthina* Marko & Vermeij, 1999 | *Mexacanthina lugubris* (Sowerby, 1821) |
| | *Acanthina* Fischer von Waldheim, 1807 | *Acanthina unicornis* (Bruguière, 1789) |
| *Subfamily Typhinae* | *Siphonochelus* Jousseaume, 1880 | *Siphonochelus arcuatus* (Hinds, 1843) |
| *Subfamily Trophoninae* | *Boreotrophon* P. Fischer, 1884 | *Boreotrophon truncatus* (Strøm, 1768) |
| | *Scabrotrophon* McLean, 1996 | *Scabrotrophon fabricii* (Møller, 1842) |
| *Subfamily Rapaninae* | *Nassa* Röding, 1798 | *Nassa francolina* (Bruguière, 1789) |
| | | *Nassa serta* (Bruguière, 1789) |
| | | *Nassa hepatica* Montagu ? |
| | *Purpura* Bruguière, 1789 | *Purpura patula* (Linnaeus, 1758) |
| | | *Purpura persica* (Linnaeus, 1758) |
| | | *Purpura bufo* Lamarck, 1822 |
| | *Stramonita* Schumacher, 1817 | *Stramonita haemastoma* (Linnaeus, 1767) |
| | | *Stramonita biserialis* (Blainville, 1832) |
| | *Mancinella* Link, 1807 | *Mancinella armigera* Link, 1807 |
| | | *Mancinella alouina* (Röding, 1798) |
| | *Thalessa* H. Adams & A. Adams, 1853 | *Thalessa savignyi* (Deshayes, 1844) |
| | *Reishia* Kuroda & Habe, 1971 | *Reishia bitubercularis* (Lamarck, 1822) |

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|---|---|---|
| | *Vasula* Mörch, 1860 | *Vasula melones* (Duclos, 1832) |
| | | *Vasula deltoidea* (Lamarck, 1822) |
| | *Thais* Röding, 1798 | *Thais (Thalessa) virgata* (Dillwyn, 1817) |
| | *Thaisella* Clench, 1947 | *Thaisella chocolata* (Duclos, 1832) |
| | | *Thaisella forbesii* (Dunker, 1853) |
| | | *Thaisella coronata* (Lamarck, 1816) |
| | *Dicathais* Iredale, 1936 | *Dicathais orbita* (Gmelin, 1791) |
| | *Semiricinula* Martens, 1904 | *Semiricinula muricina* (Blainville, 1832) |
| | | |
| | *Neothais* Iredale, 1912 | *Neothais marginatra* (Blainville, 1832) |
| | *Vexilla* Swainson, 1840 | *Vexilla vexillum* (Gmelin, 1791) |
| | *Drupa* Röding, 1798 | *Drupa ricinus* (Linnaeus, 1758) |
| | | *Drupa clathrata* (Lamarck, 1816) |
| | | *Drupa morum* Röding, 1798 |
| | *Drupina* Dall, 1923 | *Drupina grossularia* (Röding, 1798) |
| | *Ricinula* Lamarck, 1816 | *Ricinula nodus* Lamarck, 1816 |
| | *Concholepas* Lamarck, 1801 | *Concholepas concholepas* (Bruguière, 1789) |
| | *Rapana* Schumacher, 1817 | *Rapana bezoar* (Linnaeus, 1767) |
| | | *Rapana rapiformis* (Born, 1778) |
| *Subfamily Ergalataxinae* | *Cronia* H. Adams & A. Adams, 1853 | *Cronia (Usilla) avenacea* (Lesson, 1842) |
| | *Morula* Schumacher, 1817 | *Morula (Morula) uva* (Röding, 1798) |
| | | *Morula (Morula) anaxares* (Kiener, 1836) |
| | | *Morula (Habromorula) bicatenata* (Reeve, 1846) |
| | *Tenguella* Arakawa, 1965 | *Tenguella granulata* (Duclos, 1832) |
| | *Drupella* Thiele, 1925 | *Drupella rugosa* (Born, 1778) |
| | | *Drupella margariticola* (Broderip, in Broderip & Sowerby, 1833) |
| | | *Drupella cornus* (Röding, 1798) |
| | *Muricodrupa* Iredale, 1918 | *Muricodrupa fiscella* (Gmelin, 1791) |
| | | *Muricodrupa fenestrata* (Blainville, 1832) |
| | *Pascula* Dall, 1908 | *Pascula ochrostoma* (Blainville, 1832) |
| *Subfamily Coralliophilinae* | *Coralliophila* H. Adams & A. Adams, 1853 | *Coralliophila violacea* (Kiener, 1836) |
| | | *Coralliophila monodonta* (Blainville, 1832) |
| | | *Coralliophila brevis* (Blainville, 1832) |
| | | *Coralliophila meyendorffii* (Calcara, 1845) |
| | | *Coralliophila robillardi* (Liénard, 1870) |
| | *Magilus* Montfort, 1810 | *Magilus antiquus* Montfort, 1810 |
| | *Leptoconchus* Rüppell, 1834 | *Leptoconchus peronii* (Lamarck, 1818) |
| | | *Leptoconchus lamarckii* Deshayes, 1863 |

**BENTHIC MACROINVERTEBRATE COMMUNITIES FROM THE WESTERN PART OF THE APUSENI NATURE PARK (CRIŞUL NEGRU UPPER RIVER BASIN, ROMANIA)**

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***Abstract.*** *The benthic macroinvertbrate communities from the western part of Apuseni Nature Park were researched in August-September 2005. Samples were collected from 21 stations established along five tributaries of Crişul Negru River. The structure of benthic communities was characterized in terms of mean density and relative abundance of the invertebrate taxa. The investigated rivers shelter benthic communities which are characteristic to small mountain creeks, with rocky substratum, clear water, and low human impact, numerically dominated by Ephemeroptera and Chironomidae.*
***Key words:*** *community structure, Ephemeroptera, spatial dynamics, human impact*

***Rezumat.*** *Comunităţile de macronevertebrate bentonice din partea vestică a Parcului Natural Apuseni au fost studiate în august-septembrie 2005. Au fost colectate probe din 21 staţii de prelevare stabilite de-a lungul a cinci afluenţi ai Crişului Negru. Structura comunităţilor bentonice a fost caracterizată în termeni de densitate medie şi abundenţă relativă a grupelor de nevertebrate. Râurile investigate adăpostesc comunităţi bentonice caracteristice pentru pâraie montane, cu substrat stâncos, apă curată şi impact antropic redus, dominate numeric de Ephemeroptera şi Chironomidae.*
***Cuvinte cheie:*** *structură de comunităţi, Ephemeroptera, dinamică spaţială, impact antropic*

## Introduction

According to their ecological demands living organisms can be used as indicators of different environment characteristics. In case of freshwaters, and especially rivers, the benthic macroinvertebrates are frequently used for monitoring the water quality and other habitat traits, as a measure of the human impact. Although there are differences among the species within the superior taxa concerning their ecological demands, several benthic systematic groups can be used as indicators. Most Ephemeroptera, Trichoptera, and especially Plecoptera, are characteristic for the upper sectors of rivers, with high oxygen concentration, low temperatures and organic load, and hard substratum (Csia, Sárkány-Kiss 1997; Buzan, Sárkány-Kiss 1997; Ujvárosi 1997). Mollusca, represented in these waters by the freshwater limpet, *Ancylus fluviatilis* O.F. Müller, 1774, are even more exacting, being found only in habitats where these conditions are extreme (Sárkány-Kiss 1986). In contrast, Oligochaeta is the most tolerant taxon to heavy organic pollution, presenting the highest abundance in polluted waters downstream large localities (Sárkány-Kiss *et al.* 1999; Szitó, Mózes 1997), indicating low oxygen concentration, high temperatures and organic load. Thus, some of the benthic macroinvertebrates, identified to order or other higher taxon level, are used as bioindicators of the water quality and environmental conditions of the aquatic ecosystems, by calculating a series of indices, like the EPT index (Lenat 1988) or the percent Oligochaeta (Kiah *et al.* 2007).

In contrast, Oligochaeta is the most tolerant taxon to heavy organic pollution, presenting the highest abundance in polluted waters downstream large localities (Sárkány-Kiss *et al.* 1999; Szitó, Mózes 1997), indicating low oxygen concentration, high temperatures and organic load. Thus, some of the benthic macroinvertebrates, identified to order or other higher taxon level, are used as bioindicators of the water quality and environmental conditions of the aquatic ecosystems, by calculating a series

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of indices, like the EPT index (Lenat 1988) or the percent Oligochaeta (Kiah *et al*. 2007).

**Study area and Methods**

The Apuseni Nature Park is situated in Western Romania, in the central-north-western side of the Apuseni Mountains, comprising a part of Bihor and Vlădeasa massifs. The hydrological network of the park is part of three river basins: Someşul Mic, Crişul Negru, and Arieşul Mare. The present paper is based on samples collected from Crişul Negru River basin in August-September 2005.

Crişul Negru River is situated between Crişul Repede (in north) and Crişul Alb (in south) river basins. It has 144 km and covers a surface of 4476 km$^2$ (Ujvári, 1972). Crişul Negru springs from Bihorului Mountains, from the northern slope of Cucurbăta Peak, at 1460 m elevation, from the vicinity of Arieş River spring. The researched tributaries are right side affluents. Crişul Băiţa has 21 km and its basin covers 96 km$^2$. In its upper part it is characterized by a karst landscape, with over 36 caves carved in triasic-jurasic limestones (idem). Sighiştel, the main right side tributary of Crişul Băiţa, also crosses an important karst area in its upper sector, with several active caves. Along Crăiasa (Chişcău) Valley, the next tributary of Crişul Negru, there are also a series of caves, among them, the best known is Bears' Cave (Peştera Urşilor). The main tributary of Crişul Negru is Crişul Pietros, formed of two rivers strongly influenced by the karst waters from the Bihorului Mountains: Galbena, with a 10 km lenght and its basin covering 36 km$^2$, and Bulz, only 7 km long, but with a much larger basin, covering 58 km$^2$ (Ujvári, 1972). Bulz River is formed by the confluence of Boga and Valea Plaiului, and has numerous tributaries (Valea Rea, Oşelu, Bulbuci), most of them draining probably the underground waters from Padiş Plateau.

Within the borders of Apuseni Nature Park we established 21 sampling stations along some of the tributaries of Crişul Negru, namely (from north to south) Boga, Valea Plaiului, Galbena and Bulz (at their confluence), Crăiasa, Sighiştel, and Crişul Băiţa (Figure 1). Sampling sites were chosen along the mentioned rivers, from the source area downstream to the confluence, according to the characteristics of water flow, habitat heterogeneity and the sources of human impact. From each station were collected 3 samples, usually in cross-section, from different types of substrata, depth, and waterflow velocity zones.

Samples were collected using a 625 cm$^2$ functional surface Surber benthometer and fixed in 4% formaldehide solution. Benthic invertebrates were sorted out using a stereobinocular and conserved in 70% ethanol. The results are expressed in terms of mean density (ind/m$^2$) and relative abundance (%).

**Results and Discussions**

The structure of the benthic communities in the three sampling stations along Boga, expressed in terms of densities, is illustrated in Figure 2. In the upper station, upstream the river capture (S 11), Boga has a typical mountain stream aspect, with rugged boulders and fragments of rocks fixed in the river bed, 5-10 cm deep, 5-7 m wide. The benthic community is poor, represented by only 7 taxa, with low densities. Ephemeroptera is prevailing with 500 ind./m$^2$, followed at a great distance by Chironomidae (158 ind/m$^2$) and Amphipoda (105 ind/m$^2$). Lowest densities were calculated for Coleoptera and Hydracarina. At Perla Boghii (S 12) the dilution flow is very low, most of the water being captured upstream. In the river bed there are very well fixed flat boulders. The benthic community is richer, both in terms of taxa and density. Characteristic for the upper sectors, amphipods are present only upstream, being replaced at Perla Boghii by Oligochaeta, Collembola, and other Diptera. All the taxa have significantly higher densities compared to the previous station. Ephemeroptera remains the dominant group, with 1053 ind/m$^2$, followed at great distance by Oligochaeta (273 ind/m$^2$) and Chironomidae (210 ind/m$^2$). In the lowest sampling station, at the confluence with Galbena River (S 13), the riverbed is stony, with large boulders, rounded stones and fragments of rocks. The benthic community is richer, as two new taxa with low densities (Plathelminthes and Mollusca) appear, replacing Collembola. Thus, the number of taxa reaches 10. Compared to Perla Boghii, there is an increase in density for all the groups. The highest differences were recorded for Plecoptera, from 89 to 732 ind/m$^2$, but also for Oligochaeta, from 273 to 905 ind/m$^2$. The most abundant taxon remains Ephemeroptera (1674 ind/m$^2$).

The structure of benthic communities along Boga River is relatively constant considering the main macroinvertebrate taxa. There is a slight decrease in the ratio of Chironomidae, compensated by the increase of Oligochaeta, characteristic for lower sectors. The EPT (Ephemeroptera, Plecoptera, Trichoptera) group, used as benthic indicator of good quality waters (Lenat 1988), has a constant relative abundance along the river, but within the group, there is a shift between Ephemeroptera, the dominant taxon, and Plecoptera, with a higher ratio in the last station.

Valea Plaiului is a small tributary of Boga river, with clear water and a substratum represented by reddish gravel. The sampling station was situated at the confluence with Boga (S 14). The benthic community is typical for small mountain rivulets, with Ephemeroptera and Chironomida co-dominant, having similar densities (592.5 ind./$m^2$ and 568 ind./$m^2$). Among the other six taxa, Plecoptera and Trichoptera have higher abundances (Figure 3).

On Galbena River the first station was established in Galbenei Gorges (S 21). In the narrows, the riverbed is covered with large rocks detached from the walls and fixed boulders, with only isolated stripes of gravel on a bed of sand. The depth of the water is very variable, from a few cm to over 1 m in whirlpools. There are numerous fast flowing areas, with a torrential aspect. As an effect of the fast flowing waters, the benthic community is poor, only 5 taxa were identified, the lowest number of benthic groups recorded for this area. The highest density was calculated for Ephemeroptera (263 ind/$m^2$) (Figure 4). Downstream the gorges (S 22), the river's morphology is different. The water flow is calmer, flat boulders with rounded edges are deeply burrowed in the substratum of reddish sand. The change in environmental conditions induces a significant change in the benthic community structure. The diversity increases, a few new taxa are present: Hydracarina, Amphipoda, Oligochaeta, Plathelminthes, and other Diptera. Densities increase for Ephemeroptera, Plecoptera, and especially Chironomidae, the most abundant group in this station (1616 ind/$m^2$). The lowest value (5 ind/$m^2$) was calculated for Trichoptera, Coleoptera, and other Diptera. In the lowest station, at the confluence with Bulz (S 23), the river enters a new sector of karst gorges. Here the substratum is more homogenous, with large limestone boulders. Some of the groups present in the previous station, namely Plathelminthes, Amphipoda, and Hydracarina, disappear. Concerning the abundance of benthic groups, no general pattern can be observed, Trichoptera and other Diptera record a significant increase, Plecoptera, Oligochaeta, and Chironomidae a decrease, while Coleoptera and Ephemeroptera have similar densities, the last one regaining its dominance, with 1090 ind/$m^2$.

The structure of benthic communities along Galbena River is not influenced by the distance from the spring, but the presence of the two sectors of karst gorges. These have very similar community structures, clearly dominated by Ephemeroptera, representing between 70.7 and 86.7% of the invertebrates. The increase in relative abundance of Ephemeroptera is compensated by the decrease in Plecoptera, from 16.9 to 5%, thus the ratio of EPT group is similar in the two narrows sectors. Oligochaeta is absent from the first station and has a negligible ratio (0.4%) in the last one. Considering the similarity of the benthic community structures from the two stations, we can define a community characteristic for the karst gorges of this river, formed of Chironomidae, Plecoptera, Trichoptera, Coleoptera, and dominated by Ephemeroptera. However, this structure is completely different from that mentioned in other narrow sectors, like the Cibin Gorges (Curtean-Bănăduc, 2005) or the Ordâncuşa Gorges (Sîrbu *et al.*, 2013), where dominant are Trichoptera (32.7%) and respectively Chironomida (49.9%), while Ephemeroptera is significantly less abundant (9.4% and 20.3%). The benthic community has a completely different structure downstream Galbena Gorges, where the prevailing taxa is Chironomidae (46.5%) and Ephemeroptera drops to 27.7%.

Along Crăiasa River 5 sampling stations were chosen. The first station was established on Valea Fagului (S 31), a rivulet considered the spring of Crăiasa. It is 2-3 m wide and 5-20 cm deep. The riverbed is covered with large rugged boulders, a little rolled material, and no sediments. In the benthic community 8 taxa were identified, the highest densities being calculated for Ephemeroptera (1400 ind/$m^2$) and Plecoptera (958 ind/$m^2$) (Figure 5). Downstream the confluence with Sighiştel (S 32), all along its course, the river is affected by hydrotechnical works, mainly concrete rapids and embankments. In the second station, the environmental conditions are strongly modified, the riverbed being covered in several sectors by concrete rapids. The river width varies between 3 and 6 m and the depth between 10 and 30 cm. Fragments of rocks detached from the slopes, rounded boulders, a lot of rolled material, and few stripes of sand and gravel form the riverbed. The artificial conditions do not affect the presence of benthic taxa, but their abundance is significantly different. The most important changes occur in case of Ephemeroptera, which undergoes a significant decrease in density, to 642 ind/$m^2$, and Chironomidae, which increase from 273 to 763 ind/m$^2$. Upstream Giuleşti (S 33), the slope is steeper and the waterflow faster. The riverbed is covered with rounded boulders and a lot of rolled material. Upstream the sampling station there are two waste dumps from abandoned mines, the sterile reaching the river. Collembola are replaced by Mollusca and other Diptera. Considering the densities, the most significant change is the increase of Ephemeroptera, which reach 4687 ind/m$^2$, the highest density among the sampling stations from Crăiasa. Upstream Chişcău (S 34), the river is 5-7 m wide, up to 30 cm deep, with clear water, and the riverbed covered by flat stones with rounded edges, occasionally boulders. The number of taxa decreases, as well as the density of the remaining groups. Coleoptera, Hydracarina, and Mollusca are absent in this sector, although they will reappear downstream. Plathelminthes is a new group, present only in this station. Ephemeroptera remains the dominant taxon, but its density is significantly lower (363 ind/m$^2$). In the lowest sector, upstream the confluence with Crişul Negru (S 35), Crăiasa River is 5-7 m wide and 30-40 cm deep and flows through deeper sediments, having high banks covered with dense vegetation, shrubs, and willow thickets. The riverbed maintains its mountain characteristics, with rapid waterflow, gravel, flat stones, and isolated stripes of sand. The benthic community records an important increase in diversity, due to 5 new groups. Among them Amphipoda was found only in this station. Some of the taxa (Trichoptera, Chironomidae, and especially Oligochaeta) have higher densities compared to the previous station, other decreased in abundance (Ephemeroptera, Trichoptera).

Considering the spatial dynamics of macrozoobenthic communities' structure along Crăiasa River, four sectors can be distinguished based on the presence or absence of certain taxa, as well as on their change in density, caused by different environmental conditions. The community structure in the upper station, Valea Fagului, is characteristic for mountain streams, dominated by Ephemeroptera (47.2%) and Plecoptera (32.2%). The changes occurred in the second station, and especially the shift in dominance between Ephemeroptera (28.4%) and Chironomidae (33.8%) are caused by the hydrotechnical works. Despite the presence of waste dumps from the deserted mines, in the next sector Ephemeroptera records an important increase in density and relative abundance, reaching its highest ratio (72.9%) along this river, in disfavour of Chironomidae (10%) and also Plecoptera (8.8%). This structure is maintained to upstream Chişcău (with a decrease of Ephemeroptera), an important change taking place in the lowest sector, upstream the confluence. Here, the substratum heterogeneity causes an increase in the diversity of the benthic community, both in terms of taxa number and their evenness. Characteristic for lower sectors, Oligochaeta present an increase in relative abundance, as well as some of the low abundance goups, namely Amphipoda (found only in this station), Coleoptera, Mollusca, and Hydracarina.

In the first sampling station from Sighiştel, situated in the narrow sector, at the confluence with the creek flowing out of Coliboaia Cave (S 41), the river is shallow; the water depth does not exceed 10 cm. The substratum is formed of large boulders and a lot of material from the slopes, with little rolled stones, covered in moss. The benthic community is clearly dominated by Ephemeroptera (Figure 6) having one of the highest densities among all the sampling sites (4734 ind./m$^2$), but typical krenon and rhitron taxa are also very well represented: Amphipoda, with 421 ind./m$^2$ and Plathelminthes, reaching its highest density, of 194 ind./m$^2$. In the second station, situated downstream in the same gorges sector, at the entrance of Pişolca Cave (S 43), the river has similar characteristics, being slightly broader, with large fragments of rocks encastrated in the riverbed, and some whirlpools. The benthic community is represented by the maximum number of taxa (11), but its abundance is lower due to the drop in the density of Ephemeroptera, to less than a quarter (1158 ind./m$^2$) compared to the previous site. Still, this taxa prevails in the community, followed by Plecoptera (505 ind./m$^2$). Downstream the gorges (S 45), the riverbed is covered with relatively rounded stones and boulders on a bed of red gravel and in some places stripes of reddish sand. The surface of boulders is clean. The water is deeper, up to 30 cm. The benthic community has a peculiar structure, with a very high density of Trichoptera (2944 ind./m$^2$), which clearly outnumber Ephemeroptera (1506 ind./m$^2$). The typical stream taxa are absent (Plathelminthes) or very scarce (Amphipoda – 5 ind./m$^2$). Downstream Sighiştel (S 47), like in most sectors downstream localities, there are waste deposits in the riverbed. The substratum is formed of large and rounded boulders on a bed of fine sand. The water is 20-30 cm deep. The benthic community is characteristic for middle sectors of mountain rivers, with a very high density of Chironomidae (4108 ind./m$^2$), but a low abundance of Oligochaeta (205 ind./m$^2$), which indicate the absence of an important organic pollution as a result of household wastewater discharges from the village.

The upper sector of Sighiştel river, a characteristic narrow sector, between the entrances of Coliboaia and Pişolca caves, presents a homogenous structure of the benthic community, dominated by Ephemeroptera, decreasing from 69.8% to 46.1% of the sampled specimens. Characteristic for small streams with rocky substratum, in this sector Amphipoda is well represented (up to 10.3%), but becomes scarce downstream. The dominance of Ephemeroptera, followed at a great distance by Plecoptera and Chironomidae appears to be a characteristic for the narrow sectors in this area (a common feature for Sighiştel and Galbena rivers) but this community structure, as it was mentioned before, is different compared to gorges in other areas from Apuseni Mountains (Sîrbu *et al*., 2013) or elsewhere (Curtean- Bănăduc, 2005). Thus, although it appears that the narrow sectors of a river crossing a karst area shelter similar benthic communities and their structure may be shared by different rivers, no model for the benthic communities from river gorges in general can be detected. In the next sector an important change occurs in the community structure. Within the EPT group Trichoptera takes over the dominance (53.7% downstream the gorges) in disfavour of Ephemeroptera (27.4%) and Plecoptera (from 20.1% to 4.4%). Down to this point Chironomidae maintain a constant ratio (around 9%), but record a significant increase in the lowest sector, reaching 61% downstream Sighiştel. This increase is associated with the drop in the density and ratio of Trichoptera, the other taxa having constant relative abundances.

Among the three researched tributaries of Sighiştel river, the first two, namely Coliboaia (S 42) and Pişolca creeks (S 44), exiting the caves with the same name, have very similar benthic communities, characteristic for small rivulets in karstic areas, dominated by Ephemeroptera, with densities up to 5008 ind./m$^2$ in Coliboaia Creek and abundant populations of amphipods, up to 1311 ind./m$^2$ in the same rivulet (Figure 7), the highest density among all the researched stations. The third creek (S 46) however, has a completely different structure of the benthic community. Its total abundance is very high (16113 ind./m$^2$), the prevailing taxon being Chironomidae (11660 ind./m$^2$). Besides this group, Oligochaeta (2370 ind./m$^2$) and Mollusca (1042 ind./m$^2$) also reach their highest density among the investigated sites. These features of the benthic community can be explained by the habitat peculiarities. The creek is the outflow from an artificial basin at the cave's entrance, used as water catchment for Sighiştel village. Thus, it has an important load of detritus and is rich in sediments, allowing the development of abundant populations of Chironomidae, Oligochaeta, and Mollusca, but generating unsuitable conditions for other taxa, especially Plecoptera, Plathelminthes, and Acarina, which are absent.

Crişul Băiţa is a contrasting example of intensively polluted and degraded river, atypical for Apuseni Mountains Nature Park. The effects of mining exploitations from the upper sector are drastic and obvious. Their impact is evidentiated upstream Nucet (S 51) by the grey water colour and the anorganic sediments that cover the whole substratum. Many large-sized elements of the benthic community (Mollusca, Amphipoda) are absent, and those that are present are very likely part of the drift coming from tributaries and the upper sectors. The diversity and density of taxa are very low, the only group with more than 100 ind./m$^2$ is Chironomidae (584 ind./m$^2$) (Figure 8), indicating its significantly higher resistance to anorganic pollution. Downstream Nucet (S 52) the river shows tendencies of water and sediments natural self-cleaning, indicated by a better representation of Ephemeroptera (505 ind./m$^2$), as well as Plecoptera (200 ind./m$^2$) and Trichoptera (100 ind./m$^2$), while Chironomidae records a slight decrease (442 ind./m$^2$). However, even here, the impact of mining activities from upstream are well marked, and aggravated by the hydrotehnical works and the usual household waste deposits, which are more numerous than in other valleys, being placed both on the banks and in the riverbed.

The total density of the benthic communities varies significantly among the investigated stations (Figure 9), the calculated values ranging between 372 (in Galbena Gorges) and 16113 ind/m$^2$ (in the carstic creek tributary to Sighiştel). These densities are similar to those found in our previuos study from Arieş River Basin (Sîrbu *et al.* 2013). In both areas the highest density was recorded in a karstic creek, the prevailing taxa being Chironomidae, with more than 10000 ind/m$^2$. Although the lowest density from Galbena Gorges is associated with the lowest number of taxonomic groups (5), there is no correlation between the total density and the number of taxa.

The researched rivers are typical mountain watercourses. Considering the entire research area, the benthic communities are numerically dominated by Ephemeroptera, representing 39.5% of the collected specimens, followed by Chironomidae, with 31.0%. Considered together the EPT group represents 55%. Oligochaeta, on the other hand, is poorly represented, with only 5.8% of the specimens. Among the other taxa the most important is Amphipoda (3.5%) (Figure 10). Some literature data enable the comparison of these results with the structure of other rivers from the Crişul Negru Upper River Basin. Nimăieş Valley River, a right side tributary of Crişul Negru, shelters a benthic community clearly dominated by Trichoptera and Ephemeroptera species, which reach their maximum density during the summer month, while the abundance of the poorly represented Oligochaeta is decreasing from spring to autumn (Cupşa, Vaida 2005). The benthic community from Ormanului Valley, a left side tributary of Crişul Negru, is dominated by Ephemeroptera, Amphipoda, and Plathelminthes, while no Oligochaeta was identified (Cupşa, Marian 2012).

Compared to our previous study from Apuseni Mountains Nature Park, based on samples from Arieş River Basin (Sîrbu *et al*., 2013), these results indicate a different benthic community structure, more characteristic to small mountain creeks, with rocky substratum, clear water, and low human impact.

Considering their densities in the sampling stations, the benthic taxa with a low frequency and abundance (Coleoptera, Plathelminthes, Heteroptera, Collembola, Diptera - other than Chironomidae, and Acarina) form a compact group at a small distance (Figure 11), joined at relatively equal distances by Mollusca, Amphipoda, Plecoptera, Oligochaeta, and Trichoptera. The most distant taxa are Ephemeroptera, and especially Chironomidae.

Densities of benthic taxa are often correlated. Considering the mean densities in the sampling sites, significant ($p < 0.05$) positive correlations were found for 15 pairs of taxa. Compared to the results from Arieş River Basin (Sîrbu *et al.* 2013) these correlations are much weaker. Only within the group formed of Chironomidae, Oligochaeta, and Mollusca the relations are strong ($r > 0.9$). The correlations between the other groups are either not significant, or weak, the highest coefficient was calculated for Diptera - Heteroptera ($r = 0.799$) and Collembola - Amphipoda ($r = 0.769$), due to their high density in the upper stations from Sighiştel.

In contrast with the situation from Arieş River Basin, where a strong negative correlation (reaching $r = -0.947$ if considering only the stations along Arieş River) was found between the ratio of EPT group and Oligochaeta (and some other taxa), in the Criş River Basin none of the negative correlations between the benthic taxa was found to be significant, probably due to a higher homogeneity among the stations characteristic for upstream sectors, with low densities of Oligochaeta.

Considering the structure of the benthic macroinvertebrate communities (in terms of relative abundance), three major groups of stations can be distinguished (Figure 12). The first group is formed by the stations situated in the upper sector, next to the spring area, or in karst gorges (S23 to S31). Here the habitat is represented by narrow riverbeds, hard substratum formed of large boulders or fragments of rocks, steep slopes, rapid and turbulent water flow, few sediments, and a low human impact. The benthic communities are dominated by the EPT group, with the highest ratio of Ephemeroptera. Some taxa characteristic for krenon and rhitron, like Plathelminthes and Amphipoda are also well represented. The second group joins the stations from the lower sector (S35 to S22), where the habitats are characterized by broader riverbeds, slower and laminar waterflow, well represented sediments, and a mild human impact, in form of hydrotechnical works, water catchment, and a slight organic pollution. Here Ephemeroptera and Chironomidae are codominant in the benthic community. The station S45 (Sighiştel river downstream the gorges) joins alone the first two groups at a relatively great distance. Its characteristic is represented by a very high ratio of Trichoptera, significantly greater than in any other station from the research area. The most distant group consists of stations where the human impact is most acute, either as anorganic pollution from mining activities (on Crişul Băiţa) or water catchment and organic pollution from households wastewater discharges (on the lower sector of Sighiştel), and Chironomidae are clearly prevailing.

## Conclusions

The benthic macroinvertebrate communities from the Crişul Negru upper river basin is numerically dominated by Ephemeroptera, representing 39.5% of the collected specimens, followed by Chironomidae, with 31.0%. Compared to our previous study from Apuseni Mountains Nature Park, based on samples from Arieş River Basin, these results indicate a different benthic community structure, more characteristic to small mountain creeks, with rocky substratum, clear water, and low human impact. The habitat characteristics, the lack of a proper lower river sectors, of larger localities, and thus of an important organic pollution, do not favour the development of Oligochaeta populations, which have low abundances in most stations. The longitudinal pattern in the dynamics of benthic communities density along the river, well expressed along Arieş and some of its tributaries, is absent in the research area. The benthic communities are grouped not on geographic criteria, but based on habitat features, even slight differences are reflected in the community structure. For some taxa, in the station of maximum abundance, the density is significantly higher than in the other stations (up to 25 times in case of Mollusca). In some cases this outlier maximum is reached by different taxa in the same station (in the karst creek from Sighiştel by Mollusca, Oligochaeta, and Chironomidae, in Coliboaia stream by Amphipoda, Collembola, and Ephemeroptera). Between the abundance of these taxa there is a significant and positive correlation. No correlation was found between the number of taxa and the total density.

## Acknowledgements

The present study was accomplished in the frame of the PHARE CBC RO 2003 / 005-702.01 “Romanian-Hungarian Corridor for Biodiversity Conservation” coordinated by the Oradea Forestry Directorate. Special gratitude for those who lead this project and scientific research, namely Dr. Alin Moş, Director of Apuseni Natural Park and Dr. Milca Petrovici.

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

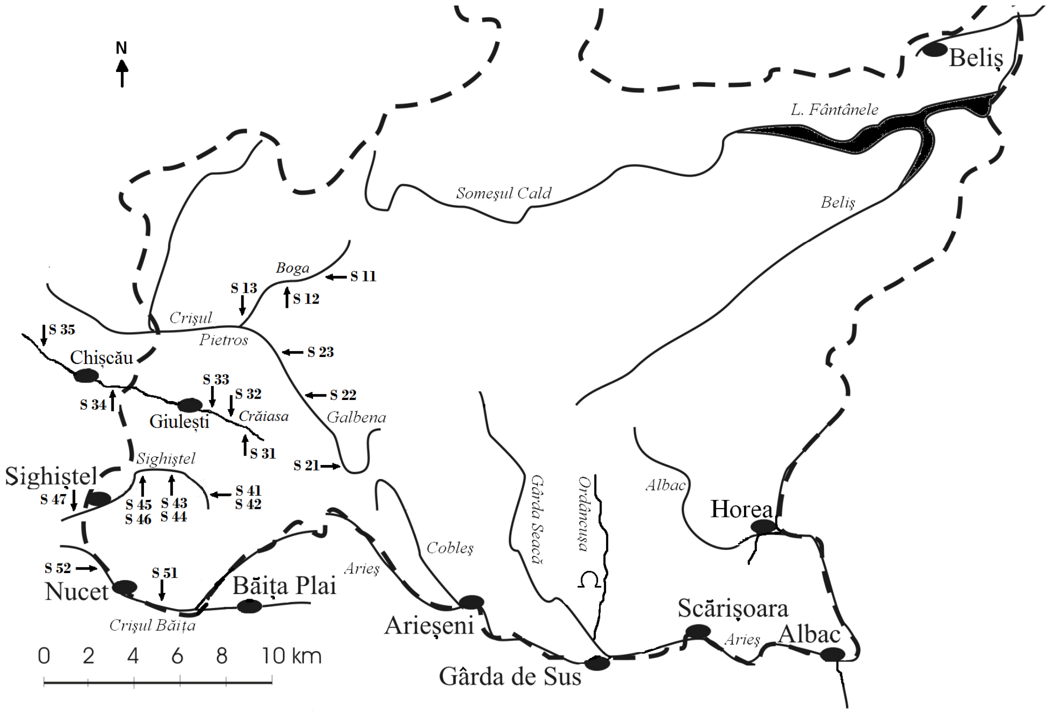


**Fig. 1**. Map and codes of the sampling stations from the Arieş River Basin on the territory of Apuseni Nature Park (the station codes will be used further; the first digit of the code indicates the river: 1 – Boga, 2 – Galbena, 3 – Crăiasa, 4 – Sighiştel, 5 – Crişul Băiţa)


**Fig. 2.** Benthic community structure in terms of mean density (ind/$m^2$, logarithmic scale) in the sampling stations along Boga River

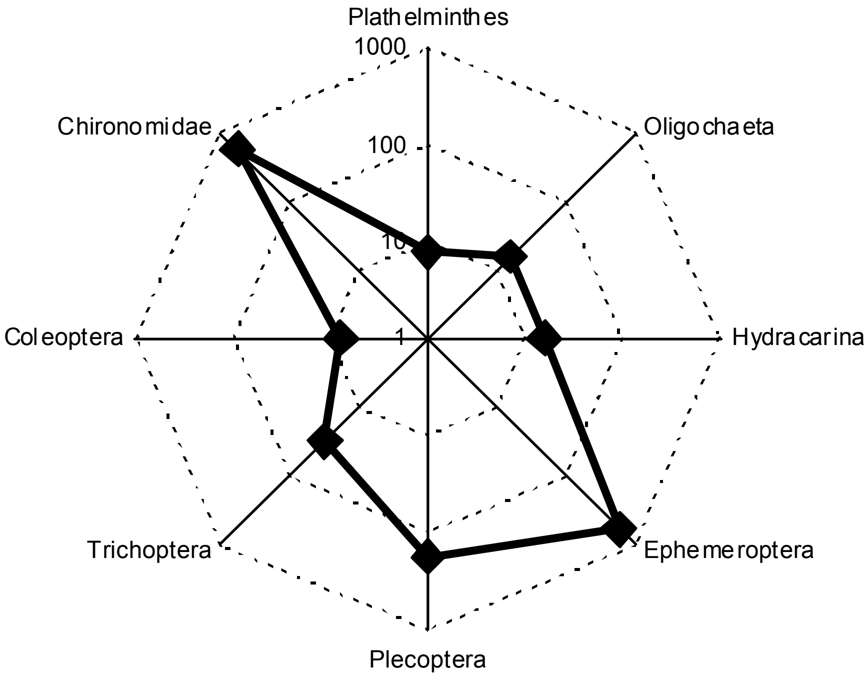


**Fig. 3.** Benthic community structure in terms of mean density (ind/ m$^2$, logarithmic scale) in the sampling station from Valea Plaiului

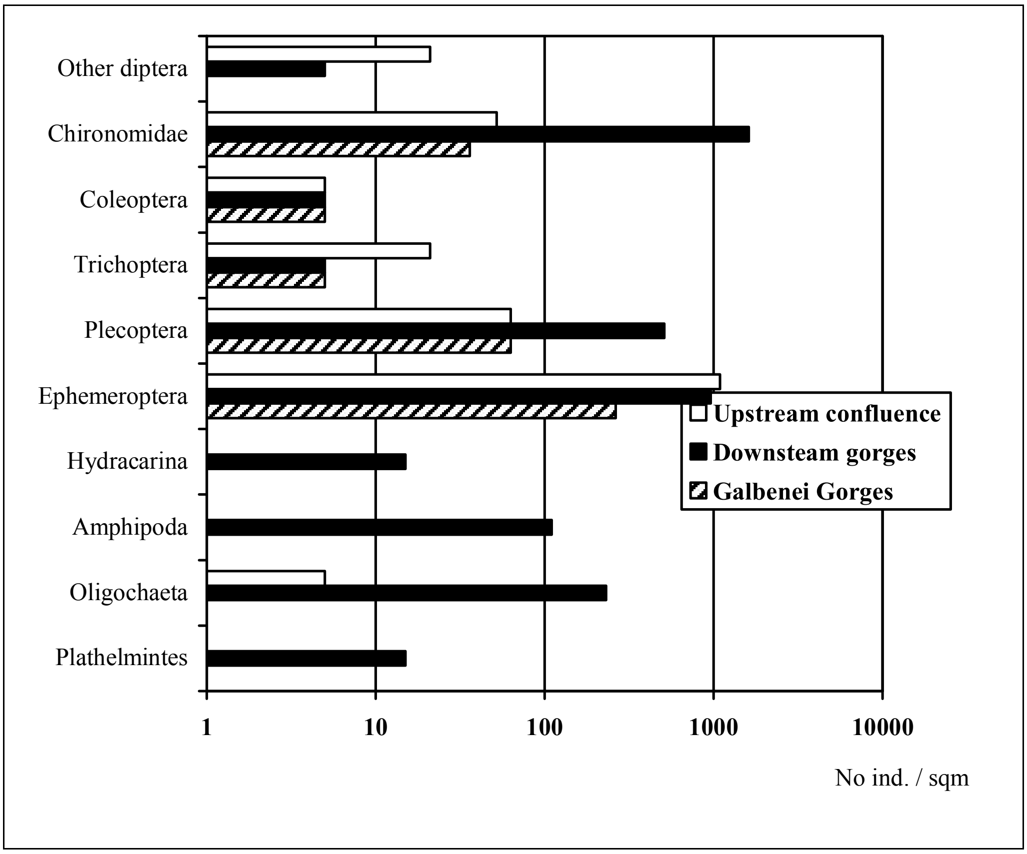


**Fig. 4.** Benthic community structure in terms of mean density (ind/m$^2$, logarithmic scale) in the sampling stations along Galbena River

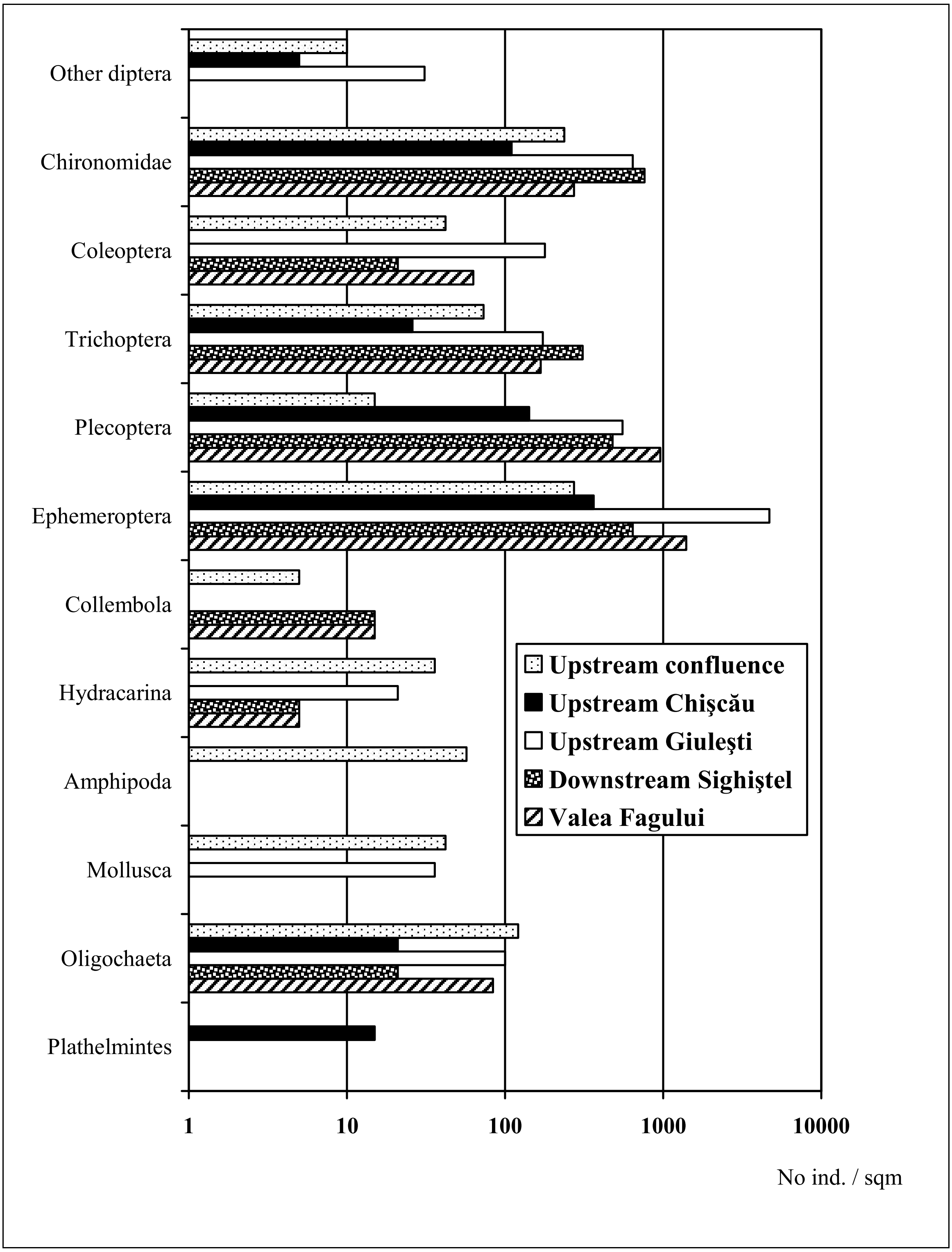


**Fig. 5.** Benthic community structure in terms of mean density (ind/$m^2$, logarithmic scale) in the sampling stations along Crăiasa River

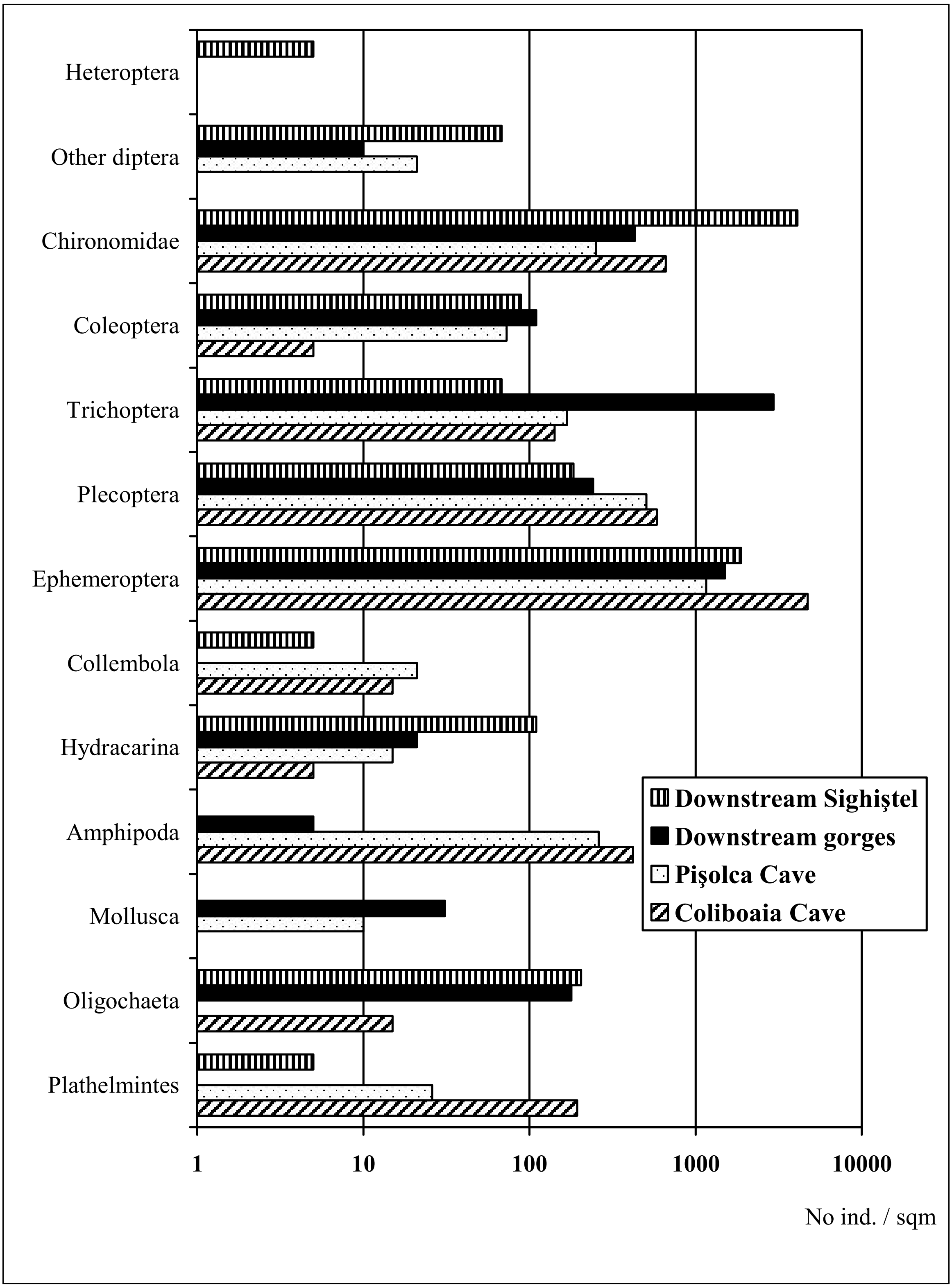


**Fig. 6.** Benthic community structure in terms of mean density (ind/m$^2$, logarithmic scale) in the sampling stations along Sighiştel River

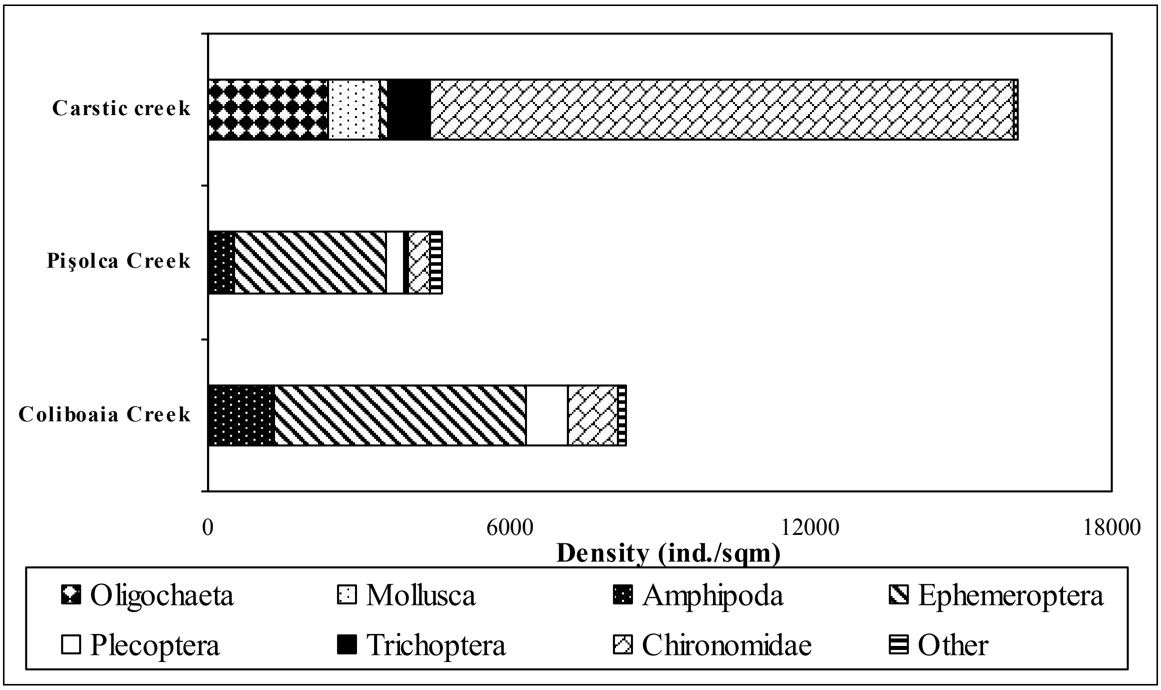


**Fig. 7.** Benthic community structure in terms of mean density (ind/m$^2$, logarithmic scale) in the tributaries of Sighiştel river

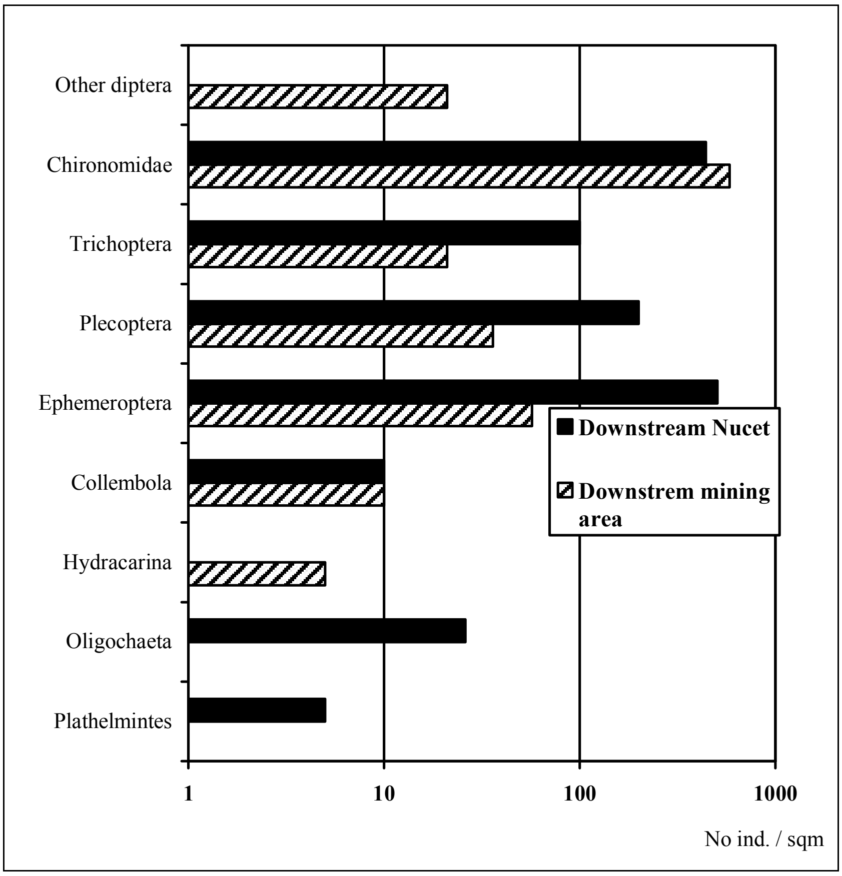


**Fig. 8.** Benthic community structure in terms of mean density (ind/m$^2$, logarithmic scale) in the two sampling stations from Crişul Băiţa River

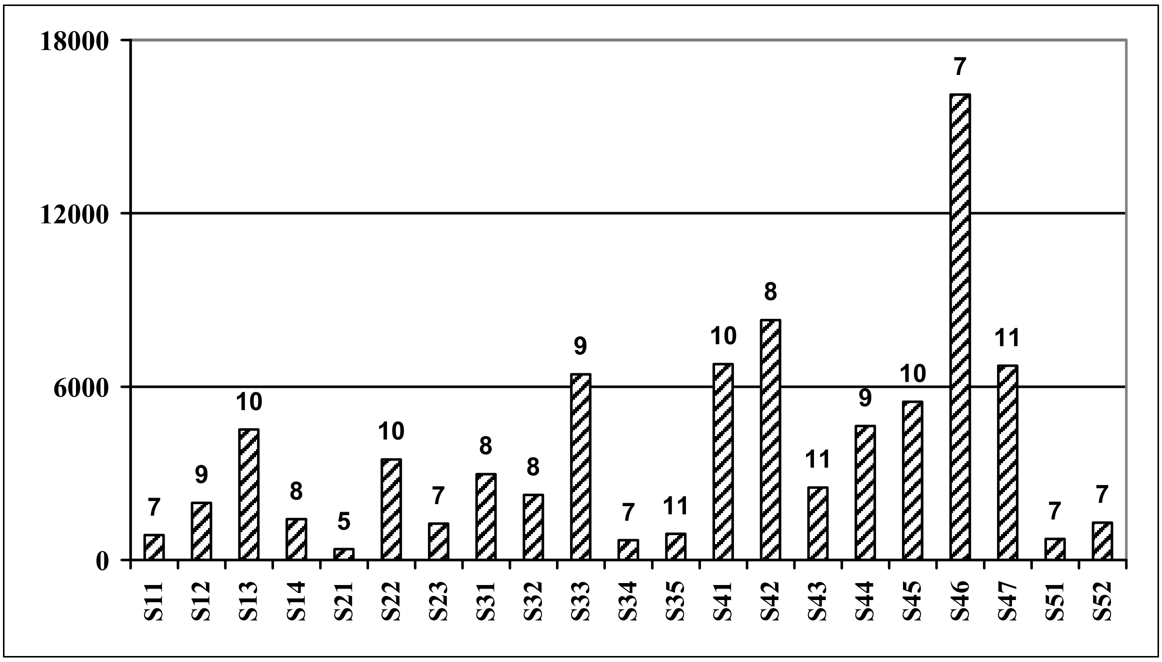


**Fig. 9.** Total density of benthic macroinvertebrate communities (mean no. individuals /m$^2$) and number of taxa in the investigated stations (the codes of the stations are given in the text)

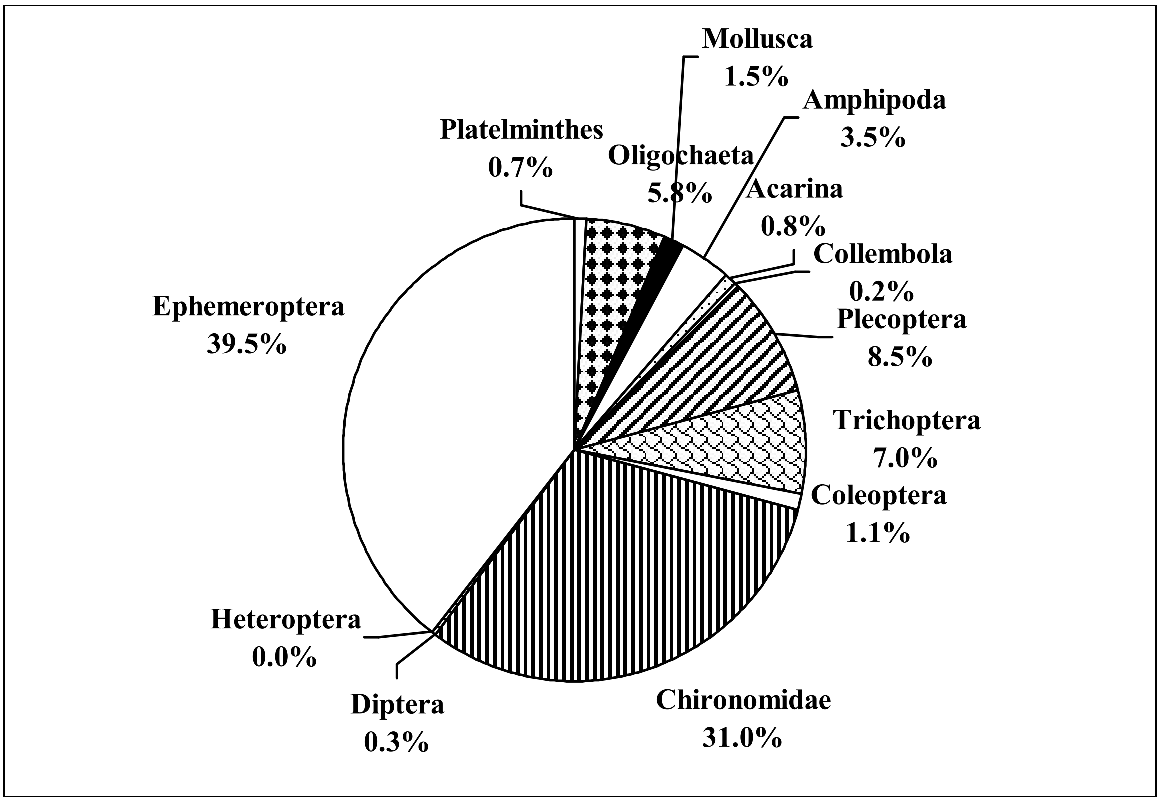


**Fig. 10.** The structure of benthic macroinvertebrates communities in the whole investigated area (abundance proportion %)

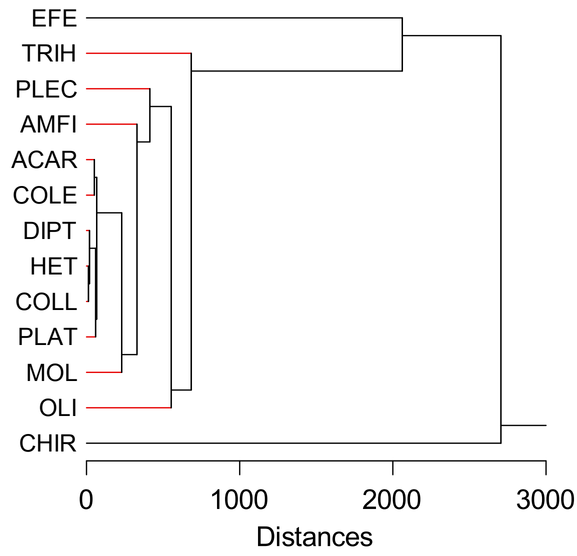


**Fig. 11.** Hierarchical clustering of benthic taxa based on mean densities (euclidean distances, average linkage method). The codes are: PLAT – Plathelminthes, OLI – Oligochaeta, MOL – Mollusca, AMFI – Amphipoda, ACAR - Acarina, COLL – Collembola, EFE – Ephemeroptera, PLEC – Plecoptera, TRIH – Trichoptera, COLE – Coleoptera, CHIR – Chironomidae, DIPT –Diptera other than Chironomidae, HET – Heteroptera)

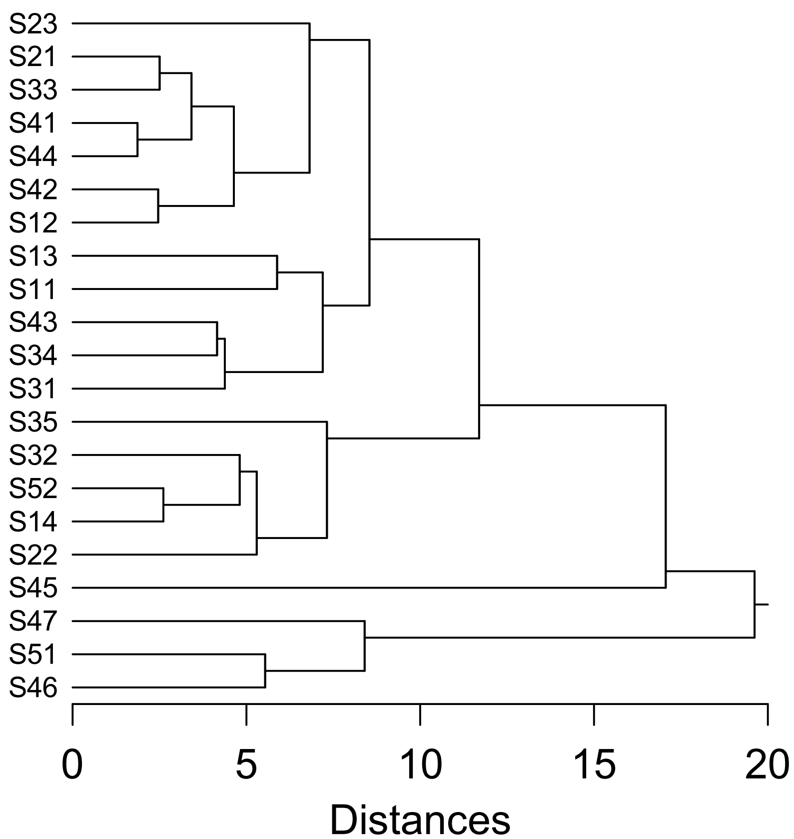


**Fig. 12.** Classification of sampling stations based on the ratio (%) of benthic macroinvertebrates taxa (Euclidean distances, average linkage method) – the station codes are given in the text

**DATA COMPATIBILITY IN A LONG-TERM STUDY ON BIRD FAUNA OF CÂMPENEȘTI ANTHROPOGENIC WETLANDS (NW ROMANIA)**

**Liviu Răzvan PRIPON**[*]
**Alexandru Nicolae STERMIN**[**]

***Abstract.*** *Since 1988 until 2012 there are 25 years of collecting data about Câmpenești bird fauna, during which 161 bird species had been reported. We present in this work unpublished bird records and we compare the results obtained over time, arguing some conceptual issues. We found an incompatibility between data sets derived from different collectors and from different time periods, so we concluded that their assemblage in a historic fauna may be considered artificial; comparison between past and present fauna is also difficult to assess.*
***Key words:*** *qualitative data set, human impact, fishpond, sampling.*

***Rezumat.*** *Între 1988 și 2012, pe durata a 25 de ani de studiu a avifaunei de la Câmpenești, au fost identificate 161 de specii de păsări. În această lucrare prezentăm semnalări nepublicate și comparăm rezultatele obținute de-a lungul timpului, argumentând unele aspecte conceptuale. Am găsit o incompatibilitate a seturilor de date provenite din perioade diferite și de la colectori diferiți. Astfel am concluzionat că asamblarea acestora într-o fauna istorică poate fi considerată artificială, comparația dintre trecut și prezent fiind de asemenea dificil de evaluat.*
***Cuvinte cheie:*** *set de date calitative, impact antropic, heleșteu, prelevare de probe.*

## Introduction

Data on historical bird fauna of the anthropogenic habitats from Câmpenești, Cluj County is presented in this paper; focusing on cumulative spectrum of species but also on variation in qualitative composition of bird species after the strong anthropogenic impact started around 2000 and continuously increasing over time.

Regarding bird fauna, Câmpenești fishponds and surrounding areas have the advantage of a long-term study, conducted by several researchers, for more than 25 years and almost 10 years of personal investigations. In this time there has been continuous field sampling on the entire bird fauna with the result of three bird fauna publications (e.g. Munteanu *et al.* 2004, Moga 2004, Munteanu Munteanu 2005). Certain species studies have been conducted in the region, focusing on reproductive biology of Little Bittern (e.g. David *et al.* 2005), Great Crested Grebe (e.g. Stermin *et al.* 2009) or on Little Crake' ethology (e.g. Stermin, Pripon 2010).

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We bring here personal and unpublished data, collected at Câmpenești between 2003 and 2004 as well from 2009 until 2012. This data complete the results gathered by other researchers from 1988 until 2004 and cover the period between 2004 until 2012, when no information was availible.

Our aim is to integrate the data obteined by us in the, already established, species list of the region. The purpose is to show the potential of anthropogenic habitats concerning bird species richennes and implicite the importance of this type of wetlands in conservation. Asking ourselfs how we can relate the data collected by us, some wich reflects the present but some whic reflects the past, to the existing information, we realize that we have to evaluate it, both from a temporal perspective and a methodological one. In other words, can we put together both species' lists obtatined in the past with the ones obtained more recently? Can we put together species' lists from one researcher with the ones of another? What is the objectivity of those lists taking into acount the subjectivity of the observers?

One of the most important goals of interpreting bird monitoring data is the separation of human-caused environmental changes from "natural" changes (Koskimies 1989). On the other hand we need to focus on analysis that can make us capable to notice and/or anticipate changes in bird communities (Radovic, Tepic 2009) whether is anthropogenic or natural but more often a combination of those two. The development of Câmpenești is a very good context in which we can analyse some aspects related to bird fauna variation.

Beside bird fauna's dynamic, bird fauna studies provide lists which include all species recorded during long periods of observations (e.g. Kokl 1983; Stănescu 1983; Munteanu 1983; Munteanu, Munteanu 2005; Gache 2010).

Thus we can distinguish two major types of pursued aims in long-term bird fauna research:

First type of aims in fauna long-term studies is to reveal directed variances due to a disturbing factor, mainly anthropogenic. Those types of studies will generally present the loss of certain species and also discuss the cause of their local extinction by means of habitat alteration. In the same time there will be presented new species observed in those new conditions. These are interpretative studies.

Second type of aims is to gather all data and to generate a historical fauna as an assembly of species observed over a long period of time. These are descriptive aims and are less scientific unless they do not answer one specific question. Question is: does that assemblage reflect equivalence between species predictability and therefore a natural situation?

If one study will conclude with a fauna prediction, answering to the question above, than it will generally satisfy the scientific goals. Those will be predictability aims.

Trying to evaluate the degree of historical artificiality it meant to establish both types of aims. First we had to bring data from all sources together and, before put it in the same list, to see if there is a species variance in time which could have been a result of a disruptive moment in the fauna continuity.

As a consequence, the next few questions followed. If there is a species variance is that a taxa decrease, increase or a dynamic in both directions? Which of these directions predominates and what categories of species are most affected by the local dynamics? If we compose an historical fauna can we put together all the data from every period or do different data sets signify different fauna episodes? How do these episodes relate to each other? What caused these episodes to be different?

## Study area

Câmpenești fishponds are situated in Feiurdeni Valley (NW Romania), on the limit of two geographical unities: Transylvanian Plane and Someșan Plateau (Pop 2001). The valley is crossed by an affluent of Someșul Mic (Pop 2001). Damming and embankment on this watercourse formed a series of 8 main fishponds and 4 smaller ones, modifying the original landscape into an anthropogenic wetland.

Fishing related activities are certified at Câmpenești from 1984. At that time, the complex consisted of a lake, 5 main fishponds and 4 small ponds used for raising juvenile fish, with a total area of 120 ha of water surface (Munteanu *et al.* 2004).

## Methods

Even though studies argue on some sort of non-equivalence between methodologies, both of aims' directions discussed in the introduction, overlook in most of cases, an actual evaluation of data sets compatibility. Some analyses divide the long-term studies in different periods, but on a subjective basis such as research history where the fauna dynamic is descriptive presented and just intuitive evaluated (e.g. Petrescu *et al.* 2009). Other studies try to evaluate the variation in both qualitative and quantitative bird fauna in order to reveal variation caused by artificial wetlands formation (e.g. Munteanu, Mătieș 1983). Still their evaluation is not scientifically rigorous.

When a statistical low compatibility between data sets is detected it will show the lack of correspondence in spatial and temporal dimensions taken into account by the study, as well as it will reveal the data subjectivity from the point of view of the observer personal detectability.

Spatial dimension is given by the methodology as the transect or fixed point method can be applied as they should but the length, the trajectory and the number of transect and points are at researcher free will and depends on the local space conformation.

From a temporal perspective of time fauna is not a homogenous and continuous phenomenon. We can state that because of the natural succession of every habitat, the variable anthropogenic impact and climate change that influence the avian range (Hockey, Midgley 2009). Climate change has been implicated or demonstrated as the causal agent of changes in phenology, migratory behaviour, and/or distributions of plants and animals and reductions in range and/or abundance (Hockey, Midgley 2009). In this context we may have distinct fauna episodes, well defined in what concerns the presence probability of bird species.

Cumulating data can be taken as artificial, as those distinct fauna episodes can have a distinct predictable future. If a certain fishpond establishment is to remain as it is by same management politics, we can predict that its bird fauna have a certain course. This may have less in common with its past if a major anthropogenic impact is involved (Pripon, Stermin 2012), whatever its ecological succession may be. This predictability dichotomy is the major scientific argument of artificiality in putting together data from different time periods.

In this context we consider appropriate to define some fauna concepts:

By temporal "joint" of information, we consider three types of fauna: past fauna, present fauna and historical fauna. Past and present fauna are to be considered equivalent data sets, in terms of spatial dimension, first sampled in the past time and second most recently collected. The time interval of sampling for one episode should vary from three to seven years. On the other hand the historical fauna consists in cumulative data from each episode, past as well as present, which reflects all species found in the study area, during all studies.

There is another distinction to be made, in terms of data sampling and data assembling, which separate two types of fauna: the natural and the artificial fauna. The natural fauna is the data set which has comparative segments. Artificial fauna is a "sum" of data sets that are not compatible. This compatibility refers to the presence of species over a longer period of time of more than 3 years. If they are missing from the observations conducted in this time, their presence probability is significant different from the periods they are reported. This incompatibility is reflected by a low similarity between checklists corresponding to certain fauna episode and other statistic differences that state the qualitative data sets cannot be compared.

It has been revealed that simple qualitative analysis had the strength to reveal the difference between communities (Radovic, Tepic 2009) therefore in the context of methodological limitations (Igl, Johnson 2005) we didn't use quantitative data. Also we analyse if Câmpenești historical fauna is natural and if not to emphasize the major cause which determine its artificiality.

There was no equivalent method used by researchers but all samplers had collected data in every season as well as on all fishponds and surrounding. They used transect method (Bibby 1992) and point observation (Korodi-Gal 1969) without following the same track or the same spots for fix observations.

Between 2002 and 2004, at Câmpenești, there have been three simultaneous studies by different research groups. From each contribution were selected records corresponding to a specific time period. Species mentioned in Munteanu's work (Muntenau, Munteanu 2005) without any particular year of observation were considered to have constant presence in the region throughout his study. We considered that the author observed them in all period from 1988 till 2004 because all other species have mentioned the year when they were observed. Besides that, all those species are generally considered common for Romanian fauna. These are: *Podiceps cristatus, Ardea cinerea, Botaurus stellaris, Ixobrychus minutus, Ciconia ciconia, Anas platyrhynchos, Anas penelope, Anas querquedula, Anas crecca, Buteo buteo, Accipiter nisus, Circus aeruginosus, Falco tinnunculus, Coturnix coturnix, Phasianus colchicus, Crex crex, Gallinula chloropus, Fulica atra, Vanellus vanellus, Charadrius dubius, Calidris alpina, Calidris temminckii, Gallinago gallinago, Actitis hypoleucos, Tringa totanus, Philomachus pugnax, Chroicocephalus ridibundus, Chlidonias niger, Cuculus canorus, Athene noctua, Alauda arvensis, Hirundo rustica, Anthus trivialis, Motacilla alba, Motacilla flava, Lanius collurio, Sturnus vulgaris, Pica pica, Corvus monedula, Corvus frugilegus, Corvus cornix, Corvus corax, Acrocephalus schoenobaenus, Acrocephalus palustris, Acrocephalus scirpaceus, Acrocephalus arundinaceus, Sylvia communis, Sylvia curruca, Oenanthe oenanthe, Saxicola torquatus, Saxicola rubetra, Turdus pilaris, Parus major, Passer domesticus, Passer montanus, Carduelis carduelis, Carduelis cannabina, Emberiza calandra, Emberiza schoeniclus, Emberiza citrinella*. We have no intention to consider these species common in general but only for Muntenau's study from 1988 till 2004 in order to complete the matrix in Table 1 by assign them to a certain time period.

We were able to generate six data sets (A, B, C, D, E, F) corresponding to three samplers and four intervals of time (1988-2002, 2002-2003, 2003-2004 and 2009-2012 (Table 1)). That was possible by checking three contributions as mentioned before (Moga 2004, Munteanu *et al.* 2004, Munteanu, Munteanu 2005) from which we had extracted the species mentioned in a certain time period by the author and have compiled information with data collected by us, between 2003 and 2004 and 2009 until 2012.

Data belonging to each sampler, utilized in our study, overlaps partially but there is a certain time period between 2002 and 2004 when simultaneous sampling took place in more than two cases.

The consistency of field methodology and effort among years is critical in maintaining the compatibility of any survey (Ralph *et al.* 1995; Igl, Johnson 2005). Given that methodology is vaguely described in our sources, the possibility of comparing data of different samplers, but collected in the same period could give us the chance to evaluate their pairing on a larger scale.

For time related comparison we use three data sets. First one corresponds to the already established historical fauna which covers the period of 14 years from 1988 until 2002. Second one it's a past fauna episode which corresponds to the period of 3 years when the anthropic impact started, lasting from 2002-2004. The third one corresponds to the present fauna episode, lasting 4 years, from 2009 until 2012. These data sets were extracted from Munteanu's two articles (Munteanu *et al.* 2004; Munteanu, Munteanu 2005) and Moga's work (Moga *et al.* 2004), compiled with our data. We took into account for comparison at least 3 years interval because we considered sufficient to capture the presence of the occasional species which we do not want to leave out from this study where they do have importance.

For author related comparison we constructed four data sets. Two lists consist of information belonging to the period from 2002 until 2003, data which was collected concomitant by Munteanu and Moga. Other two data sets corresponding to reports from 2003 until 2004 belong to Munteanu and Pripon who had overlapped observations.

The comparisons of these data sets have the importance of detecting the compatibility between fauna episodes. The distinction between data sets measures the possibility of combining the lists of species as they do or do not complete each other.

If time related data sets of the same or equivalent researchers are too distinct than there is a incompatibility in putting together the lists because they do not complete each other but they reflect two different episodes, with distinct ecological context and distinct predictability.

If the author related data sets from the same period of time are very different those lists can be put together as the information complete each other. The distinction between data sets corresponds to species omission by the one or more authors taken into account. If we want to compare the past and present fauna each belonging to different sources that have revealed such incompatibility at some point we won't be able to estimate the fauna dynamic but to notice non-equivalence in methodology that researchers applied in their subjectivity.

These two aspects have to be taken together. If there is a resemblance in both time related and author related data sets we can precisely put together species lists and construct the historical fauna which can be considered natural. In this case mostly occasional species should have been detected over time.

On the other hand if there is a low resemblance in both time related and author related data sets we find our self in a confusing situation as we cannot estimate the distinction between past and present to be a real fauna dynamic or to reflect collectors' subjectivity; nor can we decide if the historical fauna is artificial or natural. If we notice succession of relevant species than we can state that historical fauna is artificial.

If time related data sets significantly differ between them but the author related data sets are similar or the same author did the survey in the past as well in the present we can certain admit that the historical fauna is artificial.

Similar time related data sets but distinct author related data sets is the case of systematic investigation of both authors which overcome their subjectivity in species detectability but had available long periods of time, capturing the whole spectrum of species. In this situation the historical fauna is considered natural.

For comparing similarity between data sets we used Jaccard cluster analysis and to evaluate the differences we applied Generalized Linear Model with binomial distribution in JMP®.

For taxonomic classification and species nomenclature we follow the one adopted by Collins 2$^{nd}$ Edition (Svensson 2010).

**Results and Discussions**

Between 2003 and 2004 we found a number of 85 species from which 7 are unfound in the past or in the later observations from 2009 – 2012. These are: *Netta rufina, Aquila chrysaetos, Falco peregrinus, Perdix perdix, Recurvirostra avosetta, Streptopelia turtur, Remiz pendulinus* (Table 1). Between 2009 and 2012 we found a number of 95 species from which 6 are new reports for the region: *Falco subbuteo, Rallus aquaticus, Porzana porzana, Porzana parva, Locustella fluviatilis, Phoenicurus ochruros* (Table 1).

Compiling the information between 1988 and 2012, from all sources we found being identified a number of 161 bird species belonging to 17 orders and 39 families (Table 1). Relatively to the 380 bird species found in Romania (Munteanu, 1999), Câmpenești hosted almost a half (42%). Only 146 bird species had been found in the Fizeș Basin (David, 2008), one of the most complex and larger wetland in Transylvania Plane and the closest to our study area. This proves the importance of Câmpenești, concerning bird fauna.

The highest number of species (135 species) seems to appear in the period between 2002 and 2004 (Fig. 1) but this doesn't necessarily reflect an objective reality. This result may be an intense and simultaneous sampling by more persons.

There is a number of common species (80 species) that had been observed in all periods but a higher number of species (66 species) not found between 2009 and 2012 (Table 2). This means that only a half of all recorded species are constant (50%) and almost a half (40%) have not been observed in the latest observation (Table 2). There is also a considerable number of species (40 species – 25%) that are observed after 2000, the point when anthropogenic impact started (Table 2).

There is a difference concerning the similarity of the periods divided by the presence of anthropogenic impact, showing a distinction between the so called present fauna and the past one, that is measured not only in a decrease of number of species but also in considerable change in bird species composition (Fig. 1). This is shown by the high percentage of new species and unfound species in the period after the anthropogenic impact initialisation (Table 2).

The GLM whole model test shows a possible complete separation of the data ($p = 0.9245$), reasoning that data sets must be considered compatible with caution, concerning their comparison and their fitting into an ensemble.

The statistical analysis reveal a human influenced dynamics of bird fauna but the low similarity between past and present data doesn't necessarily reflect the true value of the variation. We consider this because of the following reasons:

1. The period before the anthropogenic impact in which data was collected is longer from the one after, therefore more occasional species could be detected in the first case;
2. There were no systematic (equivalent) methods in collecting data by all samplers which can conduct to species omission;
3. The subjectivity of the sampler is an important factor for different results as its experience can grow or diminish the detectability of species;

Concerning the subjectivity of sampling this is proved in our case by a higher Jaccard similarity (0.72) (Fig. 2) between the results of the same sampler, from different time periods compared to the ones of different samplers obtained in the same period of time (0.5) (Fig. 2). In other words, one and the same thing is seen more different by different observers than one of the observers sees two different things. Therefore data sets of different sampler provenience are not always compatible, and are certainly incompatible, in our case, for bird fauna dynamics evaluation, as it can reflect an artificial variation. On the other hand the data is compatible for compilation because this situation reveals species omission by different observers and their data joint will complete missing records. This is the reason why we took in our evaluation on time related data sets the episode form 2002 until 2004 compiled from all sources.

If we take the cumulative data from 2002 until 2004 compared with the present observations we can see a decrease in number of species. Because the incompatibility of different provenience data for variance evaluation, we compare only our observations from 2003 until 2004 with the ones from 2009 until 2012. In this situation we could observe an increase of the number of bird species. For this reason is difficult to decide if we had an increase, decrease or some sort of stable situation.

Even though the fauna artificiality or variance is hard to evaluate we can discuss some particular species to see what we should decide concerning this matter. If we take into account the disappearance of some species like *Crex crex, Coturnix coturnix, Cyrcus cyaneus, Lanius minor* or *Sylvia* species we see the influence of the urban development on the regions in the proximity of the ponds where the habitats have been undertaken. Looking at some species like *Oriolus oriolus*, *Sitta europae*, *Aegithalos caudatos*, *Columba palumbus* or woodpeckers we can relate their missing reports to the land modification that lead to removal of the orchard by cutting down the last relatively old trees.

In some other cases there are some birds succession that can be observed. This cases show the differentiation between past and present fauna beyond any statistical analysis. The couple *Streptopelia turtur* and *Streptopelia decaocto* is a classic example. First species is replaced by the more competitive and anthropogenic second one. We could also notice the absent *Motacila flava*, a typical species for reed beds, where now only *Motacilla alba* is abundant in the present. Other example is *Phoenicurus ochruros* that haven't been observed until 2009 and who is an anthropic species for this region. This species replaced other muscicapid, *Saxicola torquatus* where its habitat has been replaced by houses, gardens and other human settlements. Also *Saxicola torquatus* that shares, in some areas, where no human settlements exist, the same habitat with *Saxicola rubetra* is the only present species in the developed parts of the region.

All this examples of species suggest the anthropogenic impact and as a result, the modification of fauna. The most affected are land birds, as we seen in the examples before. There are also some sensitive waterfowl, reed bed or marsh inhabitants that are affected. *Charadrius hiaticula* who was a frequent species in the past, haven't been seen in the present.

## Conclusions

Cumulating data on Câmpenești bird fauna, from 1988 until 2012, we found a high number of 161 bird species, representing 42% from all reported in Romania and one of the highest in Transylvania.

The results of analysis are two separated fauna episodes, one starting with the ponds constructions in 1984 and lasting until 2003-2005. The second episode started after the first one ended without a precise moment and it can be observed in present days.

This historical fauna composed of the 161 species is considered artificial because the significant distinction between fauna episodes as a result of the anthropogenic impact shown by the lack in compatibility between time related data sets but also questionable because the author related data sets. The artificiality could be established because of some particular species interpretation.

Even though we did systematic sampling in the field, we notice a decrease in number of species, revealing that present community consists of only 58% from all species identified so far (Table 2).

There is not only a simple decrease over time, but also a modification in bird species composition (Fig. 1), a lot of species being new records and others unfound in the present (Table 2).

Nevertheless we can observe that more species are unfound than the ones that are new records (Table 2). These appearances are important but not necessarily from a good point of view as most of them are anthropic species that suggest a developing of negative biodiversity.

In this context the difference, characterized by a Jaccard similarity of only 0.5, between present and past data (Fig. 1) can be considerable, but not necessarily a measurement for a true variation caused by human impact. The human impact splits the bird fauna of Câmpenești in two distinct episodes but the value of variation can't be taken from the comparison of those episodes because of the incompatibility of author related data sets.

More important is the cumulative data, revealing the importance of this region in many species dispersion, which can find there suitable habitats, even if of anthropogenic origin, for feeding, nesting or migration stops.

On the other hand the compiled results show that a longer period of collecting data brings new species records for a region, even after 25 years of continuous observations.

Following our aims we reach to a theoretical aspect of our analysis, which probably has a greater importance than the descriptive result of the bird fauna on long-term. This importance is referring to the delimitation of some fauna episodes of the same potential habitats but expose to different ecological and anthropogenic pressures, connected to species dispersal variation, distinguished in so much degree as the fauna cannot be considered homogenous, continuous and cumulative even outside the typical succession.

Our results have importance in conservation by splitting between past and present species presence predictability. Given the actual anthropogenic pressures or other ecological influences we can consider some past species no longer persistent in the new conditions. Therefore the management plan and priority species list has to adapt, being unsuitable in the present as it was in the past.

Another practical importance of our study is the bird fauna atlases construction. The fauna episodes can be presented distinctive and present species encountering can be related to the most actual episode.

Another important conclusion derived from our study is that methods applied in data sampling are not enough standardized, resulting important subjectivity in results obtained. The differences between researchers involved in Câmpenești bird fauna studies are too high to permit evaluation of data sampled by different person.

There are events that may lead to some dramatic changes in ecosystems, cases when deriving new habitats have nothing to do with old ones, nor do they reversible transform by natural causes, therefore the two corresponding fauna episodes are just artificial put together. The same situation happened with the embanking and damming on small hillside rivers. In this process some new aquatic habitats emerge, being very different from the temporary flooded valleys and terrestrial ecosystem found before.

One perspective is that transformation and reestablishment of natural wetlands for fisheries are one reason for declining bird populations (Weller 1999). More recent studies show an overtime increase in species, pointed in some modified wetlands (Stermin, David 2012). Other studies revealed new records of waterfowl, even after massive human development of wetlands, by building settlements, but an insignificant change in water bird species qualitative aspect (Pripon, Stermin 2012). On the other hand fisheries as Câmpenești Complex can be considered stepping stones in species dispersion.

Beyond any perspective we have to see the given fact that the majority of wetlands are human impact affected areas, a reality almost impossible to annihilate nowadays. Still this impact can be managed by sustaining key elements of habitats that can support "urbanisation" but which, at their turn are sustaining bird populations. .

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAȚIILOR

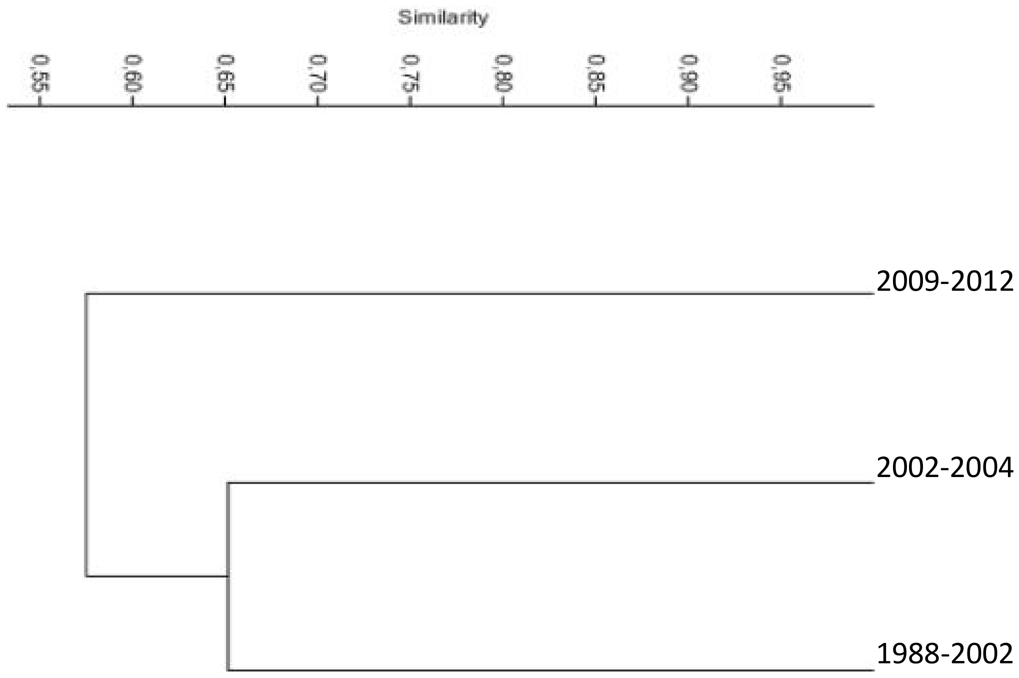


**Fig. 1.** Jaccard similarity between data sets sampled before (1988 - 2002), at the beginning (2002 - 2004) and after (2009 - 2012) the initialization of anthropogenic impact.

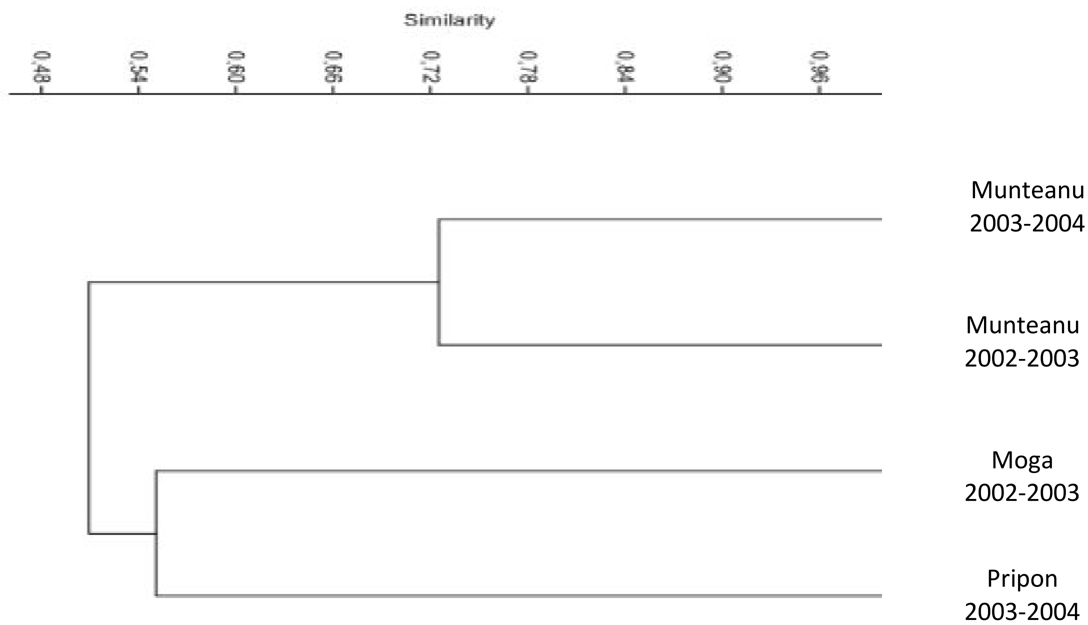


**Fig. 2.** Jaccard similarity between data sets sampled during 2002 - 2004.

**Tab. 1.** Species spectrum in different periods sampling between 1988 and 2012 (**A** – extracted from Munteanu, Munteanu 2005 and Munteantu *et al.* 2004, **B** – extracted from Munteanu, Munteanu 2005 and Munteantu *et al.* 2004, **C** – extracted from Moga *et al.* 2004, **D**- extracted from Munteanu, Munteanu 2005 and Munteantu *et al.* 2004, **E** – personal, unpublished data, **F** – personal, unpublished data).

| | **Species** | **Observation period** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1988-2002 A** | **2002-2003 B** | **2002-2003 C** | **2003-2004 D** | **2003-2004 E** | **2009-2012 F** |
| **1.** | *Gavia arctica* | * | | | | | |
| **2.** | *Podiceps cristatus* | * | * | * | * | * | * |
| **3.** | *Podiceps grisegena* | * | | * | | * | * |
| **4.** | *Podiceps nigricollis* | * | * | * | | * | * |
| **5.** | *Tachybaptus ruficollis* | * | | * | | * | * |
| **6.** | *Phalacrocorax carbo* | * | | * | | | |
| **7.** | *Egretta garzetta* | * | * | * | | | * |
| **8.** | *Casmerodius albus* | * | * | * | | * | * |
| **9.** | *Ardea cinerea* | * | * | * | * | * | * |
| **10.** | *Ardea purpurea* | * | * | | | | * |
| **11.** | *Botaurus stellaris* | * | * | * | * | * | * |
| **12.** | *Ixobrychus minutus* | * | * | * | * | * | * |
| **13.** | *Nycticorax nycticorax* | * | | | | | * |
| **14.** | *Ardeola ralloides* | * | | | | | |
| **15.** | *Ciconia ciconia* | * | * | * | * | * | * |
| **16.** | *Ciconia nigra* | * | | | | | * |
| **17.** | *Cygnus olor* | * | | | | | |
| **18.** | *Anser anser* | | * | | | | |
| **19.** | *Anser albifrons* | | * | | | | |
| **20.** | *Anser fabalis* | * | | * | | | |
| **21.** | *Anas platyrhynchos* | * | * | * | * | * | * |
| **22.** | *Anas strepera* | * | * | * | | | * |
| **23.** | *Anas acuta* | * | * | * | | | |
| **24.** | *Anas penelope* | * | * | * | * | * | * |
| **25.** | *Anas crecca* | * | * | * | * | * | * |
| **26.** | *Anas querquedula* | * | * | * | * | * | * |
| **27.** | *Anas clypeata* | * | * | * | | * | |
| **28.** | *Netta rufina* | | | | | * | |
| **29.** | *Aythya ferina* | * | * | * | * | * | * |
| **30.** | *Aythya fuligula* | * | * | * | * | * | * |
| **31.** | *Aythya marila* | * | | | | | |
| **32.** | *Aythya nyroca* | * | * | * | * | * | * |
| **33.** | *Bucephala clangula* | * | * | * | | | * |
| **34.** | *Tadorna tadorna* | * | | * | | | |
| **35.** | *Mergus serrator* | | | * | | | |
| **36.** | *Mergus merganser* | | * | | | | |
| **37.** | *Aquila chrysaetos* | | | | | * | |
| **38.** | *Circaetus gallicus* | | | | * | | |
| **39.** | *Buteo buteo* | * | * | * | * | * | * |
| **40.** | *Buteo lagopus* | * | | * | | | |
| **41.** | *Accipiter nisus* | * | * | * | * | | * |
| **42.** | *Accipiter gentilis* | | | * | | * | * |
| **43.** | *Circus aeruginosus* | * | * | | * | * | * |
| **44.** | *Circus cyaneus* | * | | * | | * | |
| **45.** | *Falco peregrinus* | | | | | * | |
| **46.** | *Falco subbuteo* | | | | | | * |
| **47.** | *Falco tinnunculus* | * | * | * | * | | * |

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|---|---|---|---|---|---|---|---|
| **48.** | *Falco vespertinus* | * | | | | | * |
| **49.** | *Pandion haliaetus* | | * | * | | | |
| **50.** | *Coturnix coturnix* | * | * | | * | | |
| **51.** | *Perdix perdix* | | | | | * | * |
| **52.** | *Phasianus colchicus* | * | * | * | * | * | * |
| **53.** | *Grus grus* | * | | | | | * |
| **54.** | *Crex crex* | * | * | | * | | |
| **55.** | *Rallus aquaticus* | | | | | | * |
| **56.** | *Porzana porzana* | | | | | | * |
| **57.** | *Porzana parva* | | | | | | * |
| **58.** | *Gallinula chloropus* | * | * | * | * | * | * |
| **59.** | *Fulica atra* | * | * | * | * | * | * |
| **60.** | *Vanellus vanellus* | * | * | * | * | * | * |
| **61.** | *Charadrius hiaticula* | * | | | * | * | |
| **62.** | *Charadrius dubius* | * | * | * | * | * | * |
| **63.** | *Pluvialis squatarola* | * | * | | * | * | |
| **64.** | *Pluvialis apricaria* | * | | * | | | |
| **65.** | *Arenaria interpres* | * | | | | | |
| **66.** | *Calidris ferruginea* | * | | * | | | |
| **67.** | *Calidris alpina* | * | * | * | * | | * |
| **68.** | *Calidris alba* | * | | | * | | |
| **69.** | *Calidris minuta* | * | | | | | |
| **70.** | *Calidris temminckii* | * | * | | * | | |
| **71.** | *Calidris canutus* | * | | | | | |
| **72.** | *Gallinago gallinago* | * | * | * | * | * | * |
| **73.** | *Numenius arquata* | | | * | | | |
| **74.** | *Limosa limosa* | * | | * | | * | * |
| **75.** | *Limosa lapponica* | * | | | | | |
| **76.** | *Actitis hypoleucos* | * | * | * | * | | * |
| **77.** | *Tringa ochropus* | * | * | | | | * |
| **78.** | *Tringa glareola* | * | * | | * | | * |
| **79.** | *Tringa nebularia* | * | * | * | | * | * |
| **80.** | *Tringa stagnatilis* | * | | | | | * |
| **81.** | *Tringa totanus* | * | * | * | * | * | * |
| **82.** | *Tringa erythropus* | * | | | | | * |
| **83.** | *Philomachus pugnax* | * | * | * | * | * | * |
| **84.** | *Recurvirostra avosetta* | | | | | * | |
| **85.** | *Larus cachinnans* | * | | * | | | * |
| **86.** | *Larus canus* | * | * | | | | |
| **87.** | *Larus fuscus* | * | * | | | * | * |
| **88.** | *Larus melanocephalus* | | | | * | | |
| **89.** | *Chroicocephalus ridibundus* | * | * | * | * | * | * |
| **90.** | *Hydrocoloeus minutus* | * | | * | | | * |
| **91.** | *Rissa tridactyla* | * | * | * | | | |
| **92.** | *Chlidonias niger* | * | * | * | * | * | * |
| **93.** | *Chlidonias leucopterus* | * | | * | | * | |
| **94.** | *Chlidonias hybrida* | * | * | * | | * | |
| **95.** | *Hydroprogne caspia* | | * | | | | |
| **96.** | *Sterna hirundo* | * | | * | | | * |
| **97.** | *Columba palumbus* | | | * | | | |
| **98.** | *Streptopelia decaocto* | | | * | | * | * |
| **99.** | *Streptopelia turtur* | | | | | * | |
| **100.** | *Cuculus canorus* | * | * | * | * | * | * |
| **101.** | *Athene noctua* | * | * | * | * | * | * |

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|---|---|---|---|---|---|---|---|
| **102.** | *Asio otus* | | | * | | * | |
| **103.** | *Alcedo atthis* | | | * | | * | * |
| **104.** | *Upupa epops* | * | | * | | * | |
| **105.** | *Picus canus* | * | | | | | |
| **106.** | *Alauda arvensis* | * | * | * | * | * | * |
| **107.** | *Galerida cristata* | * | * | | * | * | |
| **108.** | *Riparia riparia* | * | | | | * | * |
| **109.** | *Hirundo rustica* | * | * | * | * | * | * |
| **110.** | *Delichon urbicum* | | | * | | * | * |
| **111.** | *Anthus trivialis* | * | * | | * | | |
| **112.** | *Anthus pratensis* | * | | | | | |
| **113.** | *Anthus campestris* | * | | * | | | |
| **114.** | *Motacilla alba* | * | * | * | * | * | * |
| **115.** | *Motacilla flava* | * | * | * | * | * | |
| **116.** | *Motacilla cinerea* | | | * | | | |
| **117.** | *Lanius collurio* | * | * | * | * | | * |
| **118.** | *Lanius minor* | * | | | | | |
| **119.** | *Lanius excubitor* | * | | * | | * | * |
| **120.** | *Oriolus oriolus* | | | * | | * | |
| **121.** | *Sturnus vulgaris* | * | * | * | * | * | * |
| **122.** | *Garrulus glandarius* | | | * | | * | * |
| **123.** | *Pica pica* | * | * | * | * | * | * |
| **124.** | *Corvus monedula* | * | * | | * | * | * |
| **125.** | *Corvus frugilegus* | * | * | * | * | * | * |
| **126.** | *Corvus cornix* | * | * | * | * | * | * |
| **127.** | *Corvus corax* | * | * | | * | * | |
| **128.** | *Locustella fluviatilis* | | | | | | * |
| **129.** | *Locustella luscinioides* | * | | | | | |
| **130.** | *Acrocephalus schoenobaenus* | * | * | | * | * | * |
| **131.** | *Acrocephalus palustris* | * | * | | * | | * |
| **132.** | *Acrocephalus scirpaceus* | * | * | * | * | * | * |
| **133.** | *Acrocephalus arundinaceus* | * | * | * | * | * | * |
| **134.** | *Sylvia communis* | * | * | | * | * | |
| **135.** | *Sylvia curruca* | * | * | * | * | | |
| **136.** | *Sylvia nisoria* | | | * | | | |
| **137.** | *Phylloscopus collybita* | | * | * | | | |
| **138.** | *Oenanthe oenanthe* | * | * | | * | * | * |
| **139.** | *Saxicola rubetra* | * | * | | * | * | * |
| **140.** | *Saxicola torquatus* | * | * | * | * | * | * |
| **141.** | *Phoenicurus ochruros* | | | | | | * |
| **142.** | *Erithacus rubecula* | | | * | | | * |
| **143.** | *Turdus merula* | | | * | | | |
| **144.** | *Turdus torquatus* | | * | | | | |
| **145.** | *Turdus pilaris* | * | * | * | * | * | * |
| **146.** | *Parus major* | * | * | * | * | * | * |
| **147.** | *Cyanistes caeruleus* | * | | | | * | * |
| **148.** | *Aegithalos caudatus* | | | * | | | |
| **149.** | *Panurus biarmicus* | | | | | * | * |
| **150.** | *Remiz pendulinus* | | | | | * | |
| **151.** | *Sitta europaea* | | | * | | | |
| **152.** | *Passer domesticus* | * | * | * | * | * | * |
| **153.** | *Passer montanus* | * | * | * | * | * | * |
| **154.** | *Fringilla coelebs* | | | * | | | |

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|---|---|---|---|---|---|---|---|
| **155.** | *Carduelis carduelis* | * | * | * | * | * | * |
| **156.** | *Carduelis cannabina* | * | * | * | * | * | * |
| **157.** | *Carduelis spinus* | * | | | | | |
| **158.** | *Carduelis flammea* | * | | | | | |
| **159.** | *Emberiza calandra* | * | * | * | * | * | * |
| **160.** | *Emberiza schoeniclus* | * | * | * | * | * | * |
| **161.** | *Emberiza citrinella* | * | * | * | * | * | * |

**Tab. 2**. The percentage of species found in different periods of time and of their persistence.

| | **1988-2012** | **1988-2002** | **2002-2004** | **2009-2012** | **Common species 1988-2012** | **New species 2002-2012** | **Unfound species 2009-2012** |
|---|---|---|---|---|---|---|---|
| **Species number** | 161 | 121 | 135 | 94 | 80 | 40 | 66 |
| **Percentage** | | 74% | 83% | 58% | 49% | 24% | 40% |

## CONTRIBUTION TO THE KNOWLEDGE OF THE VERTEBRATE AND INVERTEBRATE FAUNA OF SOVATA AREA

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**Cristian DOMŞA[****]**

***Abstract.*** *This paper presents a faunistic survey of the „Lacul Ursu şi Arboretele de pe Sărături" Scientific Reserve and its surroundings. The invertebrate animal species were inventoried in 2008 and 2009, and data on vertebrates were collected from 1990 to 2009. There were identified in total 301 species of animals (118 invertebrates and 184 vertebrates species). Of these, 68 animal species are protected under law.*
***Key words:*** *„Lacul Ursu şi Arboretele de pe Sărături" Scientific Reserve, invertebrates and vertebrates species*

***Rezumat.*** *Lucrarea de faţă prezintă un studiu taxonomic despre fauna Rezervaţiei Ştiinţifice "Lacul Ursu şi Arboretele de pe Sărături" şi împrejurimile sale. Speciile de nevertebrate au fost inventariate în 2008 şi 2009, iar datele referitoare la fauna vertebrate au fost colectate între anii 1990 - 2009. Au fost identificate în total 301 de specii de animale (118 nevertebrate şi 184 specii de vertebrate). Dintre acestea 68 de specii sunt protejate de lege.*
***Cuvinte cheie:*** *Rezervaţia Ştiinţifică "Lacul Ursu şi Arboretele de pe Sărături", specii de animale nevertebrate şi vertebrate.*

### Introduction

Nearly 20% of Romania's territory is protected area, as a result of a recently finished process of protected area designation (Iojă *et al.* 2010). Although most of these areas have special protection statuses (Gaston *et al.* 2007), the scientific and conservation importance of these highlight the general biodiversity value of Romania (Cogălniceanu, Cogălniceanu 2010). For conservation and management purposes, knowing the exact or estimated spatial distribution of the study object is one of the key information pieces one requires in order to understand a species' potential: its current status as well as the ecological factors contributing to the species' dynamics and future perspective in case of changing environment (Strange *et al*. 2011; Fischer *et al*. 2011). To do so, one requires information collected at local to regional level (Schmeller *et al.* 2008). As most protected areas in the country are fairly new most have only base-line surveys performed, lacking proper studies necessary for management planning (Curtean-Bănăduc 2006). Hereby we would like to present a thorough faunistic survey of a small scientific reserve („Lacul Ursu şi Arboretele de pe Sărături" Scientific Reserve, Sovata) and its surroundings.

Zoological research targeting Sovata is very poor and most papers report on the biota of its salt lakes. Thus, Trică (1983) studied the biota of some saline lakes from Sovata (Roşu, Verde, Mierlei, Aluniş, Negru lake). Zooplankton is dominated by protozoa, rotiferans, crustaceans, among insects, larvae of *Ephydra riparia* and *Chironomus thumni* are mentioned. All these organisms contribute to the therapeutic mud of the lake bottom. Their dead bodies form, through bacterial decomposition, sapropelic mud with active mineral components, which gives it a remarkable therapeutic value (Alexe *et al*. 2006).

In 1998, Ionescu and collaborators published a review about the biota of salt lakes in Romania, which includes Mierlei, Ursu, and Nergru lakes (Ionescu *et al.* 1998). Compared to Trică's work

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(1983) about the fauna of these lakes, only a few new insect species are mentioned in addition.

Up to our knowledge there is no systematic review of the fauna of the region, while, there are a few notes in zoological papers dealing with specific groups. Paraschivescu (1972) mentioned three ant species from Muntele de Sare, while Szél *et al.* (2007) lists *Carabus hampei hampei* (Coleoptera, Carabidae) from Sovata.

In an ethnozoological book detailing the fauna of Sărăţeni area, a nearby village situated in the upper valley of Târnava Mică, Gub (1996) specifies Sovata as a habitat of some animal species, listing annelids (7 species), molluscs (4), arthropods (35), fishes (9), amphibians (5), reptiles (4), birds (27) and mammals (10 species).

The aim of this paper is to inventory the animal species characteristic of the different habitats from Sovata area, and to identify the rare and protected species on the basis of national and international legislation.

**Material and methods**

This study refers to the souroundings of Ursu, Aluniş, Paraschiva, Roşu, Verde, Şerpilor, Mierlei lakes, Salt Mount, Sărat creek („Lacul Ursu şi Arboretele de pe Sărături” Scientific Reserve), the upper and middle part of Răchitiş creek, respectively the mixed broadleaves forest of this whole area, which neighbours the protected area of the Lake Ursu Nature Reserve. This area is characterised by different habitats: aquatic, littoral and palustral habitats, hygrophilous tall-herb fringe communities, mesic grasslands, wet meadows, inland saline habitats, mixed broadleaves forest, dominated by beech (*Fagus sylvatica*), and small conifere stands, with both Scotts Pine (*Pinus sylvestris*) and Norway Spruce (*Picea abies*). A detailed characterisation of vegetation from the studied area along with a map detailing study locations are given in Frink *et al.* (2013).

The field surveys were performed in 2008 and 2009 (May, July, September). However, data on vertebrates were collected from 1990 to 2009. All vertebrates and most invertebrate species were identified on the ground, only in cases where this was not possible they were collected and identified in the laboratory. The invertebrate species were collected using tweezers, blow-type aspirator, leaf-litter sieve, sweep net, and butterfly net. The species were identified using the identification keys of Motzfeld-Müller (2004), Móczár (1984), Heimer and Nentwig (1991), Tolman and Lewington (2001).

Identification larger of mammals (Carnivora, Artiodactyla, Lagomorpha) was implemented primarily by tracks, while visual observations were recorded for a number of different species, with the occasion of bird surveys. Bats and small mammals were incidentally recorded, mainly as roadkills, prey remains of predatory birds and bycatches of ornithological mist netting. Bird records are the results of systematic survey of breeding birds in the region using point count surveys, territory mapping and standardised mist netting (targeting migratory species) (Sándor A. in prep). A number of rarer species were recorded as incidental observations while doing the systematic surveys. All reptile and amphibian records represent incidental observations.

**Results and discussion**

The study area is characterized by a diverse fauna, due to variability of vegetation, relief, topoclimate, geological substrate and soil.

In the studied area were identified a total of 301 species of animals: 118 invertebrate and 184 vertebrate species. Of these, 68 species are protected under national law (according to OUG27/2007). The complete list of taxa recorded is given in Table 1. From the identified invertebrate species 112 species belong to the phylum Arthropoda, several of these are strictly protected/rare species (*Cerambyx cerdo, Lucanus cervus, Morimus funereus, Rosalia alpina)*. Three species belong to the phylum Mollusca, and 3 to the phylum Annelida. We found a number of two fish, 8 reptile, 9 amphibian, 129 bird and 38 mammal species present in the protected area.

Only 9 species of amphibians out of the 19 species occurring nationally were recorded in the area. This is primarily the result of the wide-spread presence of saltwater habitats, unsuitable for amphibians. Most amphibian species are forest specialists, and they use for reproduction the small temporary ponds and the stream sections present in the area. The only freshwater habitat in the region is the Paraschiva Lake, which contains a small population of *Rana ridibunda*. Boreal forests are mostly poor in reptile species, thus most reptiles present in the area are either using man-made habitats (*Podarcis muralis*) or occur preferentially in clearings and small meadows. Both fish species are common species and were introduced purposefully to Lake Paraschiva by local anglers.

There is a large number of bird species observed, which in part are the result of the long survey period, using of several different methods and partly a result of the diverse mosaics of habitats in the study area. Moreover, bird surveys were performed in all seasons, thus cover not only the breeding, but postbreeding, migratory and wintering periods. Among birds, the most diverse group is represented by Passeriformes, typical for forested areas, but the group of woodpeckers (Piciformes) has also high species numbers. The regular observation of large predatory birds (*Aquila pomarina, Bubo bubo, Pernis apivorus*) typically reflects the presence of nearby undisturbed forests.

Mammals observed in the region are common inhabitants of the boreal ecoregion and mainly species living in forested habitats. The composition of mammal fauna is rich and is dominated by small mammals (bats, rodents), with the regular presence of large carnivores and herbivores. As forest cover is continuous along the northern and western part of the reserve, the populations of mammals are not fragmented by the reserve border.

Detailed faunistical surveys with the data provided followed by rigorous monitoring are the basic needs for any protected area management decision. This is especially important for small and faunistically rich areas, where anthropic pressure is high. The „Lacul Ursu şi Arboretele de pe Sărături" Scientific Reserve is a small area, in close vicinity and with organic links to one of the largest Site of Community Interest of Romania, laying in the alpine bioregion, the ROSCI0019 Călimani-Gurghiu. This particular situation favours the exchange of faunal elements and enables the area to be visited by large carnivores (wolf, bear) or other species which require more extensive forest cover, like predatory birds.

However, for the maintenance of such a rich fauna, any management decision in the reserve has to be carefully planned and should be based on sound scientific arguments. We consider that our survey created the foundation for such an approach and this baseline survey managed to identify most species present in the reserve, providing all the necessary tools for a good start of this process.

## Acknowledgements

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

**Tab. 1.** List of animals species recorded in Sovata area. *Abbreviation*: IUCN Categories: LR - Lower Risc, LC - Least Concern, Vu – Vulnerable, CD - Conservation Dependent, NT - Near Threatened, En – Endangered, NE - Non Evaluated, CR- Critically Endangered; BD – Birds Directive, HD – Habitats Directive; An3 – Annex nr. 3, An4A – Annex nr. 4A, An4B – Annex nr. 4B, An5 – Annex nr. 5 of the OUG 57/2007 /

| | ***IUCN category*** | ***Legislation*** | ***Aquatic habitats*** | ***Littoral and palustral habitats*** | ***Hygrophilous tall-herb fringe communities*** | ***Wet meadows*** | ***Mesic grasslands*** | ***Inland saline habitats*** | ***Mixed broadleaves forest*** |
|---|---|---|---|---|---|---|---|---|---|
| **REGNUM ANIMALIA** | | | | | | | | | |
| **1.1. Phylum: Mollusca** | | | | | | | | | |
| *Bielzia coerulans* | | | | | | | | | x |
| *Clausilia* sp. | | | | | x | | | | x |
| *Helix pomatia* | | | | x | x | x | x | x | x |
| **1.2. Phylum: Annelida** | | | | | | | | | |
| *Eisenia andrei* | | | | | | | | | x |
| *Lumbricus terrestris* | | | | | x | | | | x |
| *Haemopis sanguisuga* | | | $x_F$ | x | | | | | |
| **1.3. Phylum: Arthropoda** | | | | | | | | | |
| **1.3.1. Subphylum: Myriapoda** | | | | | | | | | |
| **1.3.1.1. Clasa: Chilopoda** | | | | | | | | | |
| *Geophilus* sp. | | | | | x | | | | x |
| *Lithobius forficatus* | | | | | x | x | | | x |
| *Lithobius muticus* | | | | | x | x | | | x |
| **1.3.1.2. Clasa: Diplopoda** | | | | | | | | | |
| *Cilindroiulus* sp. | | | | | x | | | | x |
| *Julus terrestris* | | | | | | | | | x |
| **1.3.2. Subphylum: Chelicerata** | | | | | | | | | |
| **1.3.2.1. Clasa: Arachnida** | | | | | | | | | |
| *Araneus diadematus* | | | | | x | | | | x |
| *Araniella cucurbitina* | | | | | x | | | | x |
| *Argiope bruennichi* | | | | | x | x | x | | x |
| *Phalangium opilio* | | | | | | x | x | | x |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Tetragnatha extensa* | | | | x | | x | | | x |
| **1.3.2.2. Clasa: Acarina** | | | | | | | | | |
| *Ixodes ricinus* | | | | | | | | | x |
| **1.3.3. Subphylum: Crustacea** | | | | | | | | | |
| *Artemia salina* | | | $x_S$ | | | | | | |
| *Armadillidium vulgare* | | | | | | | | | x |
| *Porcellio scaber* | | | | | x | x | | | x |
| **1.3.4. Subphylum: Hexapoda** | | | | | | | | | |
| **1.3.4.1. Clasa: Insecta** | | | | | | | | | |
| **1.3.4.1.1. Ordo: Odonata** | | | | | | | | | |
| *Aeshna cyanea* | | | $x_F$ | x | | | | | |
| *Calopteryx virgo* | | | $x_F$ | | | | | | |
| *Coenagrion puella* | | | $x_F$ | | | | | | |
| *Ischnura elegans* | | | $x_F$ | | | | | | |
| *Libellula depressa* | | | $x_F$ | | | | | | |
| *Platycnemis pennipes* | | | $x_F$ | | | | | | |
| *Sympetrum vulgatum* | | | $x_F$ | | | | | | |
| **1.3.4.1.2. Ordo: Dermaptera** | | | | | | | | | |
| *Forficula auricularia* | | | | | x | x | x | | x |
| **1.3.4.1.3. Ordo: Orthoptera** | | | | | | | | | |
| *Chorthippus parallelus* | | | | | | x | x | | |
| *Gryllus campestris* | | | | | | x | x | x | |
| *Leptophyes punctatissima* | | | | | x | x | x | | |
| *Pholidoptera griseoaptera* | | | | | x | | | | x |
| *Stenobothrus lineatus* | | | | | x | x | x | | |
| **1.3.4.1.4. Ordo: Heteroptera** | | | | | | | | | |
| *Gerris paludum* | | | $x_F$ | | | | | | |
| *Notonecta glauca* | | | $x_F$ | | | | | | |
| *Palomena prasina* | | | | | x | x | x | | x |
| *Pentatoma rufipes* | | | | | x | | | | x |
| *Pyrrhocoris apterus* | | | | | x | | | | x |
| **1.3.4.1.5. Ordo: Homoptera** | | | | | | | | | |
| *Cicadella viridis* | | | | | x | x | | | |
| *Cercopis vulnerata* | | | | | x | x | x | | |
| **1.3.4.1.6. Ordo: Coleoptera** | | | | | | | | | |
| *Abax parallelepipedus* | | | | | x | x | | | x |
| *Abax parallelus* | | | | | x | x | | | x |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Abax schueppeli* | | | | | | | | | x |
| *Adalia bipunctata* | | | | x | x | x | x | | x |
| *Agriotes sputator* | | | | | x | x | x | | |
| *Amara montivaga* | | | | | x | x | x | | |
| *Bembidion lampros* | | | | | | | | | x |
| *Calathus fuscipes* | | | | | x | x | x | | |
| *Calathus melanocephalus* | | | | | x | x | x | | |
| *Calosoma sycophanta* | | | | | | | | | x |
| *Cantharis rustica* | | | | | x | x | x | | x |
| *Carabus cancellatus* | | | | | | | x | | x |
| *Carabus coriaceus* | | | | | x | | | | x |
| *Carabus ullrichi* | | | | | | | | | |
| *Carabus violaceus* | | | | | x | x | x | | x |
| *Cerambyx cerdo* | Vu | An3, An4A | | | | | | | x |
| *Cerambyx scopolii* | | | | | | | | | x |
| *Cetonia aurata* | | | | | x | x | x | | |
| *Cicindela sp.* | | | | | | | | x | |
| *Coccinella septempunctata* | | | | x | x | x | x | | x |
| *Cychrus caraboides* | | | | | | | | | x |
| *Dorcus parallelipipedus* | | | | | | | | | x |
| *Dytiscus marginalis* | | | $x_F$ | | | | | | |
| *Gastrophysa viridula* | | | | x | | | | | |
| *Geotrupes stercorosus* | | | | | x | x | x | | x |
| *Harpalus latus* | | | | | x | x | x | | |
| *Harpalus rufipes* | | | | | x | x | x | | x |
| *Hydrophilus* sp. | | | $x_F$ | | | | | | |
| *Liparus glabrirostris* | | | | | x | x | x | | x |
| *Lucanus cervus* | LR | An3, An4A | | | | | | | x |
| *Lytta vesicatoria* | | | | | | | | | x |
| *Molops piceus* | | | | | x | | | | x |
| *Morimus funereus* | Vu | An3, An4A | | | | | | | x |
| *Plateumaris sericea* | | | | x | | | | | |
| *Poecilus lepidus* | | | | | x | x | x | | x |
| *Pterostichus niger* | | | | | x | x | x | | x |
| *Pterostichus oblongopunctatus* | | | | | x | | | | x |
| *Rosalia alpina* | Vu | An3, An4A | | | | | | | x |
| *Rutpela maculata* | | | | | x | x | x | | |
| *Stenurella bifasciata* | | | | | x | x | x | | |
| *Trichodes apiarius* | | | | | | x | x | | |
| *Vadonia livida* | | | | | x | x | x | | |
| **1.3.4.1.7. Ordo: Neuroptera** | | | | | | | | | |
| *Chrysoperla carnea* | | | | x | x | | | | x |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.3.4.1.8. Ordo: Hymenoptera** | | | | | | | | | |
| *Bombus terrestris* | | | | | x | x | x | | x |
| *Cynips quercusfolii* | | | | | | | | | x |
| *Formica rufa* | | | | | | | | | x |
| *Lasioglossum malachurum* | | | | | | | | x | |
| **1.3.4.1.9. Ordo: Lepidoptera** | | | | | | | | | |
| *Acherontia atropos* | | | | | | | | | x |
| *Aglais urticae* | | | | | x | x | x | | |
| *Apatura iris* | | | | | | | | | x |
| *Argynnis paphia* | | | | | | x | x | | x |
| *Cupido minimus* | | | | | | | | | x |
| *Erebia aethiops* | | | | | x | x | x | | x |
| *Gonepteryx rhamni* | | | | | x | x | x | | x |
| *Aglais (Inachis) io* | | | | | x | x | x | | x |
| *Limenitis populi* | | | | | | | | | x |
| *Lycaena virgaureae* | | | | | x | x | x | | x |
| *Maniola jurtina* | | | | | x | x | x | | |
| *Melanargia galathea* | | | | | x | x | x | | x |
| *Minois dryas* | | | | | | | | | x |
| *Nymphalis antiopa* | | | | | | | | | x |
| *Nymphalis polychloros* | | | | | x | | | | x |
| *Ochlodes* sp. | | | | | x | x | x | | |
| *Papilio machaon* | | | | | x | x | x | | |
| *Polyommatus* sp. | | | | | x | x | x | | x |
| *Saturnia pyri* | | | | | | | | | x |
| *Vanessa atalanta* | | | | | x | x | x | | |
| *Zygaena filipendulae* | | | | | x | x | x | | |
| **1.3.4.1.10. Ordo: Mecoptera** | | | | | | | | | |
| *Panorpa communis* | | | | x | x | x | | | x |
| **1.3.4.1.11. Ordo: Diptera** | | | | | | | | | |
| *Aedes vexans* | | | $x_F$ | x | x | | | | x |
| *Chrysotoxum festivum* | | | | x | x | | | | x |
| *Culex pipiens* | | | $x_F$ | x | x | x | | | |
| *Ephydra riparia* | | | $x_S$ | | | | | | |
| *Episyrphus balteatus* | | | | x | x | x | x | | x |
| *Eristalis tenax* | | | | | x | x | x | | |
| *Mikiola fagi* | | | | | | | | | x |
| *Syrphus ribesii* | | | | | x | x | x | | |
| *Tipula oleracea* | | | | x | x | x | | | |
| | | | | | | | | | |
| **1.4. Phylum: Vertebrata** | | | | | | | | | |
| **1.4.1. Actinopterygii** | | | | | | | | | |
| *Carassius carassius* | | | $x_F$ | | | | | | |
| *Cyprinus carpio* | | | $x_F$ | | | | | | |
| | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| **1.4.2. Clasa: Amphibia** | | | | | | | | | |
| *Bombina variegata* | LC | An3, An4A | $x_F$ | x | x | x | x | | x |
| *Bufo bufo* | LC | An4A , An4B | $x_F$ | | x | x | | | x |
| *Rana dalmatina* | LC | An4A | $x_F$ | x | x | x | x | | x |
| *Rana temporaria* | | | $x_F$ | x | x | x | x | | x |
| *Rana ridibunda* | LC | | $x_F$ | | | | | | |
| *Salamandra salamandra* | | | | | | | x | | x |
| *Triturus alpestris* | | | $x_F$ | x | x | x | x | | x |
| *Triturus cristatus* | LC | An4A | $x_F$ | x | x | | x | | x |
| *Triturus vulgaris* | | | $x_F$ | x | x | | x | | x |
| **1.4.3. Clasa: Reptilia** | | | | | | | | | |
| *Natrix natrix* | | | $x_F$ | x | x | x | x | x | x |
| *Coronella austriaca* | – | An4A | | x | x | x | x | | |
| *Elaphe longissima* | – | An4A | | | | x | x | | x |
| *Vipera berus* | | | | | | | x | | |
| *Anguis fragilis* | | | | x | x | x | x | | |
| *Lacerta agilis* | – | An4A | | x | | | x | x | |
| *Lacerta vivipara* | LR/LC | An4A | | x | | x | x | | |
| *Podarcis muralis* | LC | An4A | | x | | | | x | |
| **1.4.4. Clasa: Aves** | | | | | | | | | |
| *Accipiter gentilis* | | | | | | | | | x |
| *Accipiter nisus* | | | | | | | | | x |
| *Acrocephalus arundinaceus* | | | | x | | x | | | |
| *Acrocephalus palustris* | | | | | | x | x | | |
| *Acrocephalus schoenobaenus* | | | | x | | x | x | | |
| *Acrocephalus scirpaceus* | | | | x | | x | | | |
| *Actitis hypoleucos* | | | | x | | | | | |
| *Aegithalos caudatus* | | | | | x | x | x | | x |
| *Alauda arvensis* | | | | | | | x | | |
| *Alcedo atthis* | | | | | | | | | |
| *Anas platyrhynchos* | | | $x_F$, $x_S$ | | | | | | |
| *Anthus pratensis* | LC | An5 | | | | x | x | | |
| *Anthus spinoletta* | | | | x | x | | | x | |
| *Anthus trivialis* | | | | | x | x | x | | x |
| *Aquila pomarina* | LC | An3, BD | | | | x | x | | |
| *Asio otus* | | | | | | x | x | | x |
| *Athene noctua* | | | | | | | | | x |
| *Aythya ferina* | | | $x_S$ | | | | | | |
| *Bombycilla garrulus* | | | | | | | | | x |
| *Bubo bubo* | LC | An3, BD | | | | | | | x |
| *Buteo buteo* | | | | | | x | x | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Buteo lagopus* | | | | | | | x | | |
| *Caprimulgus europaeus* | | | | x | | | | | |
| *Carduelis cannabina* | LC | An4B | | | | x | x | x | |
| *Carduelis carduelis* | LC | An4B | | x | x | x | x | x | x |
| *Carduelis chloris* | LC | An4B | | | x | x | x | x | x |
| *Carduelis flammea* | LC | An4B | | | | x | x | | |
| *Carduelis spinus* | LC | An4B | | | x | x | x | | x |
| *Carpodacus erythrinus* | LC | An4B | | | | x | | | |
| *Certhia brachydactyla* | | | | | | | | | x |
| *Certhia familiaris* | | | | | | | | | x |
| *Ciconia ciconia* | LC | An3, BD | | | | x | | | |
| *Circus aeruginosus* | | | | | | x | x | | |
| *Circus cyaneus* | | | | | | x | x | | |
| *Coccothraustes coccothraustes* | LC | An4B | | | x | x | | | x |
| *Columba livia domestica* | | | | | | | | | x |
| *Columba oenas* | | | | | | | | | x |
| *Columba palumbus* | | | | | | | | | x |
| *Corvus corax* | | | | | | x | x | x | x |
| *Corvus cornix* | | | | | | x | x | x | x |
| *Corvus frugilegus* | | | | | | x | x | | |
| *Corvus monedula* | | | | | | x | x | | |
| *Coturnix coturnix* | | | | | | x | | | |
| *Crex crex* | LC | An3, BD | | | | x | | | |
| *Cuculus canorus* | | | | | | x | x | | x |
| *Delichon urbica* | | | $x_S$ | x | | x | x | x | x |
| *Dendrocopos leucotos* | LC | An3, BD | | | | | | | x |
| *Dendrocopos major* | | | | | | | | | x |
| *Dendrocopos medius* | LC | An3, BD | | | | | | | x |
| *Dendrocopos minor* | | | | | | | | | x |
| *Dendrocopos syriacus* | LC | An3, BD | | | | x | | | x |
| *Dryocopus martius* | LC | An3, BD | | | | | | | x |
| *Emberiza calandra* | | | | | | | x | | |
| *Emberiza citrinella* | | | | | x | x | x | x | x |
| *Emberiza schoeniclus* | | | | | | x | x | | |
| *Erithacus rubecula* | LC | An4B | | x | x | x | x | x | x |
| *Falco columbarius* | LC | BD | | | | x | x | | |
| *Falco subbuteo* | LC | An4B | | | | x | x | | x |
| *Falco tinnunculus* | LC | An4B | | | | x | x | | |
| *Ficedula albicollis* | LC | An3, BD | | | | | | | x |
| *Ficedula hypoleuca* | | | | | | | | | x |
| *Ficedula parva* | LC | An3 | | | | | | | x |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Fringilla coelebs* | | | | x | x | x | x | x | x |
| *Fringilla montifringilla* | | | | | | | x | | x |
| *Gallinago gallinago* | | | | x | | | | | |
| *Gallinula chloropus* | | | $x_F$, $x_S$ | x | | | | | |
| *Garrulus glandarius* | | | | x | x | x | x | x | x |
| *Hippolais icterina* | | | | | | x | x | | x |
| *Hirundo rustica* | | | | x | | x | x | x | x |
| *Jynx torquilla* | LC | An4B | | | | | | | x |
| *Lanius collurio* | LC | An3 | | | x | x | x | | |
| *Lanius excubitor* | | | | | | | x | | |
| *Locustella fluviatilis* | LC | An4B | | | | x | x | | |
| *Loxia curvirostra* | | | | | | | | | x |
| *Lullula arborea* | | | | | x | x | x | | x |
| *Luscinia luscinia* | | | | | | x | x | | |
| *Merops apiaster* | LC | An4B | | | | | x | | |
| *Motacilla alba* | LC | An4B | | x | x | x | | x | |
| *Motacilla cinerea* | LC | An4B | | x | x | | | x | |
| *Motacilla flava* | LC | An4B | | | | x | x | | |
| *Muscicapa striata* | LC | An4B | | x | | | | x | x |
| *Nucifraga caryocatactes* | LC | An4B | | | | x | x | | x |
| *Oenanthe oenanthe* | | | | | | x | x | | |
| *Oriolus oriolus* | LC | An4B | | | | x | x | | x |
| *Parus ater* | | | | | | | | | x |
| *Parus caeruleus* | | | | | x | x | x | | x |
| *Parus major* | | | | x | x | x | x | | x |
| *Parus montana* | | | | | | | | | x |
| *Parus palustris* | | | | | x | x | x | | x |
| *Passer domesticus* | | | | x | x | | | x | |
| *Passer montanus* | | | | x | x | x | x | x | x |
| *Perdix perdix* | | | | | | x | | | |
| *Pernis apivorus* | | | | | | x | x | | |
| *Phasianus colchicus* | | | | | | x | x | | |
| *Phoenicurus ochruros* | LC | An4B | | x | | | | x | |
| *Phoenicurus phoenicurus* | LC | An4B | | | x | | | | x |
| *Phylloscopus collybita* | LC | An4B | | | x | x | x | | x |
| *Phylloscopus sibilatrix* | LC | An4B | | | x | x | x | | x |
| *Phylloscopus trochilus* | LC | An4B | | | x | x | x | | x |
| *Pica pica* | | | | x | x | x | x | x | |
| *Picus canus* | LC | An3, BD | | | | | | | x |
| *Picus viridis* | LC | An4B | | | | | | | x |
| *Prunella modularis* | LC | An4B | | x | x | | | | x |
| *Pyrrhula pyrrhula* | | | | x | x | x | x | x | x |
| *Rallus aquaticus* | | | $x_F$ | x | | | | | |
| *Regulus ignicapilla* | LC | An4B | | | x | | | | x |
| *Regulus regulus* | LC | An4B | | | | | | | x |
| *Saxicola rubetra* | | | | | | x | x | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Saxicola torquata* | | | | | | x | x | | |
| *Serinus serinus* | LC | An4B | | | x | x | | | x |
| *Sitta europaea* | | | | | | | | | x |
| *Streptopelia decaocto* | | | | x | | | | | x |
| *Streptopelia turtur* | | | | | | x | | | |
| *Strix aluco* | | | | | | | | | x |
| *Strix uralensis* | LC | BD | | | | | | | x |
| *Sturnus vulgaris* | | | | x | | x | x | | x |
| *Sylvia atricapilla* | | | | x | x | x | x | | x |
| *Sylvia borin* | | | | | | x | x | | |
| *Sylvia communis* | | | | | | | x | | x |
| *Sylvia curruca* | | | | | x | x | x | | x |
| *Sylvia nisoria* | | | | | | x | | | |
| *Troglodytes troglodytes* | | | | x | x | | | | x |
| *Turdus iliacus* | | | | | | | x | | x |
| *Turdus merula* | | | | | x | x | x | | x |
| *Turdus philomelos* | | | | x | x | x | x | | x |
| *Turdus pilaris* | | | | | | x | x | | |
| *Turdus viscivorus* | | | | x | | | | | x |
| *Upupa epops* | LC | An4B | | | | x | | | x |
| *Vanellus vanellus* | | | | | | x | x | | |
| **1.4.5. Clasa: Mammalia** | | | | | | | | | |
| **1.4.5.1. Ordo: Insectivora** | | | | | | | | | |
| *Crocidura leucodon* | LC | | | | x | x | x | x | x |
| *Crocidura suaveolens* | LC | | | | x | x | x | | |
| *Erinaceus roumanicus* | LC | | | x | x | x | x | x | x |
| *Neomys fodiens* | LC | | $x_F$ | | | x | x | | x |
| *Sorex araneus* | LC | | | x | x | x | x | x | x |
| *Sorex minutus* | LC | | | x | | x | | x | x |
| *Talpa europaea* | LC | | | x | x | x | x | x | x |
| **1.4.5.2. Ordo: Chiroptera** | | | | | | | | | |
| *Myotis daubentonii* | LR/LC | HD | $x_F$, $x_S$ | x | x | x | x | x | x |
| *Myotis myotis* | LR/NT | | $x_F$, $x_S$ | x | | x | | | x |
| *Myotis mystacinus* | | HD | $x_F$, $x_S$ | x | x | x | x | x | x |
| *Nyctalus noctula* | LR/LC | HD | | x | x | x | x | x | x |
| *Pipistrellus pipistrellus* | LR/LC | HD | $x_F$, $x_S$ | x | | | | | x |
| *Pipistrellus pygmaeus* | LC | HD | $x_F$, $x_S$ | x | | | | | x |
| *Rhinolophus ferrumequinum* | LR/NT | An3, HD | | x | | x | x | x | |
| *Rhinolophus hipposideros* | LC | An3, HD | | x | | x | x | x | x |
| | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.4.5.3. Ordo: Carnivora** | | | | | | | | | |
| *Canis lupus* | LC | An3, HD | | | | x | x | | x |
| *Vulpes vulpes* | LC | | | | x | x | x | x | x |
| *Felis silvestris* | LC | HD | | | | | x | | x |
| *Martes foina* | LC | | | x | x | x | | | x |
| *Martes martes* | LC | | | | | x | x | | x |
| *Mustela erminea* | LR/LC | | | x | x | x | | | |
| *Mustela nivalis* | LC | | | x | x | x | x | x | x |
| *Ursus arctos* | LR/LC | An3, HD | | | | x | x | | x |
| **1.4.5.4. Ordo: Artiodactyla** | | | | | | | | | |
| *Sus scrofa* | LC | | | x | x | x | x | x | x |
| *Cervus elaphus* | LR/LC | | | | x | x | x | | x |
| *Capreolus capreolus* | LR/LC | | | | x | x | x | | x |
| **1.4.5.5. Ordo: Rodentia** | | | | | | | | | |
| *Apodemus agrarius* | LC | | | | x | x | x | | x |
| *Apodemus flavicollis* | LC | | | | | x | | | x |
| *Apodemus sylvaticus* | LC | | | | x | x | x | | x |
| *Clethrionomys glareolus* | LC | | | | | | | | x |
| *Microtus arvalis* | LC | | | | | | x | | x |
| *Mus musculus* | LC | | | x | x | | | | |
| *Muscardinus avellanarius* | LC | | | | x | | x | | x |
| *Myoxus glis* | LC | | | | | | | | x |
| *Pitymys subterraneus* | LC | | | | x | x | x | | x |
| *Rattus norvegicus* | LC | | | x | x | x | x | x | x |
| *Sciurus vulgaris* | LC | | | | | | | | x |
| **1.4.5.6. Ordo: Lagomorpha** | | | | | | | | | |
| *Lepus europaeus* | LC | | | | x | x | x | | |

$x_F$ – fresh water; $x_S$ – saline water

# FLORISTIC SURVEYS IN THE LAKE URSU NATURE RESERVE AND ADJACENT AREAS (SOVATA, TRANSYLVANIA, ROMANIA)

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***Abstract.*** *The paper is dealing with the vascular flora inventory in the surrounding area of the lakes in Sovata. The study territory overlies to the protected area of national interest Lake Ursu Nature Reserve. The aim of the study is to provide an up-to-date systematic checklist of the vascular plant taxa growing in the area. Field surveys were carried out in 2008-2009. The field inventory list was completed with plant taxa from the existing and consulted bibliographic sources. As a result of the study, 330 vascular plant taxa are listed, belonging to 66 families. From de total number of taxa, 275 are original data, representing specimens identified by the authors in the field, and 55 are cited from bibliographic sources. The study area is an important conservation area from botanical point of view, hosting taxa listed in the Habitats Directive, as well as taxa listed in national red lists.*
***Key words:*** *vascular plant taxa, deciduous forests, halophytes, saline lakes, freshwater lakes, Lake Ursu Nature Reserve, Sovata*

***Rezumat.*** *Lucrarea conţine inventarul florei vasculare din împrejurimile lacurilor de la Sovata. Teritoriul cercetat se suprapune ariei protejate de interes naţional Rezervaţia Naturală Lacul Ursu şi arboretele de pe sărături – LUas. Scopul cercetărilor a fost întocmirea unei liste actualizate şi cât mai complete asupra plantelor vasculare din acest teritoriu. Inventarierile în teren au avut loc în perioada 2008-2009. Lista taxonilor identificaţi în teren a fost completată cu date din literatură, pe baza consultării surselor bibliografice existente. Ca rezultat al cercetărilor, sunt listaţi 330 taxoni de plante vasculare aparţinând la 66 familii. Din acest total, 275 taxoni reprezintă date originale, specimene identificate de autori în teren, iar 55 taxoni sunt citaţi din surse bibliografice. Teritoriul cercetat este important din punct de vedere al conservării plantelor, adăpostind taxoni incluşi în Directiva Habitate, cât şi taxoni listaţi pe diferite liste roşii naţionale.*
***Cuvinte cheie:*** *plante vasculare, păduri caducifoliate, halofite, lacuri sărate, lacuri cu apă dulce, Rezervaţia Naturală Lacul Ursu şi arboretele de pe sărături, Sovata.*

## Introduction

Sovata is a famous Romanian spa and climatic health resort located in the eastern part of the Transylvanian Basin (Fig. 1), in the so-called Salt-Region (Mureş county, Transylvania) at approx. 530 m asl. More exactly, it is situated in the Praid-Sovata Basin, a sub-mountainous depression developed at the western foot of Gurghiului Mountains (Eastern Carpathians).

Characteristic to the area is an impressive salt massive, which was formed approximately 20-22 million years ago during the Miocene, as a result of gradual disappearance of the Pannonian Sea and salt sedimentation (Alexe *et al*. 2006; Alexe, 2007). The diapir wrinkle from Praid is 1600 m long and 500 m wide, ending on the Salt Mount (Ro: Muntele de Sare) in Sovata. The highest points of the Salt Mount are Zoltán Peak (555 m asl) and Sarea Peak (533 m asl).

Another important geomorphologic and landscape feature of the area is the presence of lakes. Majority of them naturally resulted by the dissolution on the salt massive (Alexe *et al.* 2006; Şerban, Alexe 2006; Alexe 2007). Today, there are 10 major lakes in Sovata area: 6 saline lakes (Negru, Ursu, Aluniş, Roşu, Verde, Mierlei), 3 freshwater lakes (Paraschiva, Tivoli – the former

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Tineretului, Dulce) and one saline lake turned into swamp (Şerpilor). Furthermore, there are some ponds affected by siltation or totally silted and transformed into marshes (Şerban, Alexe 2006). The Tineretului Lake, arranged and maintained in the past for recreational purposes and fishing, was drained in 1997 because of increasing infiltration of freshwater to the salt lakes system (Alexe 2007). It was rearranged recently, in 2009-2010 and now is named Tivoli Lake.

The area is situated in the low mountain vegetation belt characterised by the dominance of deciduous forests (beech, oak, hornbeam). Salty habitats and halophytes are patchily distributed in this area due to the presence of salty lakes and the appearance of salt on the soil surface. Also, aquatic and paludal habitats are linked to the presence of freshwater lakes in the area. As a result of anthropogenic activities, there are secondary semi-natural grasslands which alternate with forests.

The entire area of the lakes, the Salt Mount and the surrounding forests are included in the Lake Ursu Nature Reserve (Ro: *Rezervaţia Naturală Lacul Ursu şi arboretele de pe sărături - LUas,* Fig. 2), which was established in 1970. The protected area is defined as a nature reserve of national interest, corresponding to category IV IUCN (L 5/2000; OUG 57/2007; L 49/2011). It covers 79 ha, of which 73.3 ha are forests and 5.7 ha are water bodies. Its main purpose is to protect the Lakes Ursu, Aluniş, Roşu, Verde, Mierlei and Paraschiva, respectively to conserve the surrounding forest with role in the maintenance of the hydrogeological features of these lakes. The area is included in the larger Natura 2000 site ROSCI0019 Călimani-Gurghiu (OM 2387/2011).

The first systematic botanical researches in the area were carried out by Nyárády E. I., at the middle of the 20th century. Firstly, he published some observations and explanations regarding the presence and development of woody vegetation on the salt belt (Nyárády 1944, 1950), without providing a list of plants. However, in this period he made a complex floristic survey of the area, collected specimens and prepared a comprehensive study describing in details the surroundings of the lakes from geological, geomorphologic and botanical point of view, also including a list of species (Nyárády 1959 mscr.). This monographic work was never published; it was lost in different private libraries in Cluj-Napoca and unfortunately we could not consult this manuscript.

Observations on a special ecotype of pedunculate oak growing on the salt massive and adapted to special soil conditions were published by Ştefănescu (1961). This author also mentions some woody and herbaceous species growing in the forest surrounding Lake Ursu. Some botanical data can also be found in the study of Bulgăreanu *et al.* (1978), which mainly concerns the hydrology and hydrogeology of the Lake Ursu, but includes a list of several vascular plant species present around the lake, identified by dead vegetative parts or fruits present on the water surface and/or in the sediments of the lake.

More recent publications refer to a larger area, the Praid-Sovata Basin, from phytosociologic point of view (Pop, Buz 1994; Buz 1999) and ethnobotanical point of view (Gub 1996), containing data on the vascular flora of the surrounding area of Lake Ursu. The newest floristic data can be found in the studies of Pop (2006) and Sămărghiţan, Pop (2006). However, all the above mentioned publications contain poor and scattered botanical data, excepting Nyárády's manuscript, but which was elaborated more than half a century ago. Thus, taking into account on the one hand the poor and scattered data, and on the other hand the socio-economic and habitat changes of the last decades in the area, an updated vascular plant list became necessary. Its importance resides also from the protected status of the area: a comprehensive and up-to-date database regarding the presence and distribution of vascular plant species in the protected area can help to elaborate recommendations and/or to take good management decisions from a biodiversity conservation perspective.

The aim of this paper is to provide an up-to-date systematic checklist of the vascular plant taxa growing in the surrounding area of the lakes in Sovata, based on field surveys and bibliographic documentation.

## Material and Methods

*Study area*

The study area completely overlies to the Lake Ursu Nature Reserve, exceeding its limits in the northwest and west, and includes the following territories (Fig. 2): the surroundings of Lakes Ursu, Roşu, Verde, Aluniş, Mierlei, Şerpilor and Paraschiva, the Salt Mount, the Pârâul Sărat and "*Pusta Nămoloasă*" areas, as well as the upper and middle course of Răchitiş rivulet, locally named

"*Jánosmező*" and "*Rakottyás*". Short characterization of these objectives is given in the followings.

***Lake Ursu*** (Eng: Bear Lake; Hu: Medve-tó) is the largest karsto-saline lake in the Transylvanian Basin, with heliothermic properties. Its surface is 4.12 ha, the average depth is 6.36 m, at certain points reaching 18.2 m (Alexe 2007). The average salt concentration of its water is 250 g/l (Alexe *et al*. 2006). The lake was formed in 1875-1880 due to natural geological, meteorological and hydrological events: a gradual dissolution of the salt massive, followed by landslides and water accumulation after a cloudburst (Alexe 2007). The name was given by locals who have seen its shape resembled a large bearskin. At present, one part of the lake is exploited for its therapeutic properties, the other part is protected.

***Lake Roşu*** (Eng: Red Lake; Hu: Vörös-tó) and ***Lake Verde*** (Eng: Green Lake; Hu: Zöld-tó) are located near to Lake Ursu, in its northwestern part (Fig. 2). These are two small lakes: Verde Lake (291 $m^2$) is smaller than Roşu Lake (1406 $m^2$). Their water comes from a salt spring and their surplus water runs into Lake Ursu, constituting the main salt water source of the latter one (Alexe, 2007).

***Lake Aluniş*** (Eng: Hazelnut Lake; Hu: Mogyorós-tó) is situated 60 m west of Lake Ursu (Fig. 2). Its origin is closely linked to that of the Lake Ursu: the less salty surplus water from Ursu Lake flooded a salt doline, which collapsed in the late 1870's, giving rise to Aluniş Lake (Alexe *et al*., 2006; Alexe, 2007). The lake's surface is 3731 $m^2$ and its maximum depth is 6.4 m (Alexe 2007). The temperature and salinity of its water is lower than that of Lake Ursu. It is exploited therapeutically. Its name comes from the hazel bushes, which are frequent in the surrounding forest. The surplus water form Aluniş Lake overflows and gives rise to the Valea Frumoasei stream (Nyárády 1950; Fig. 2).

***Lake Mierlei*** (Eng: Blackbird Lake; Hu: Rigó-tó) is the youngest lake formed in the early 1950's in a salt-doline (Alexe *et al.* 2006). It is located in the middle of the forest; it has a surface area of 1462 $m^2$ and an average depth of 1.85 m (Alexe 2007). In its surroundings there are some salt springs which feed the lake. Its name refers to the blackbird, which is very frequent in the surrounding forest.

***Lake Şerpilor*** (Eng: Snake's Lake; Hu: Kígyó-tó) is situated in the forest, above the Mierlei Lake (Fig. 2). It was a saline lake, but in the last decades it turned into a swamp, due to sediments accumulation.

***Lake Paraschiva*** (Hu: Piroska-tó) is situated north of Ursu Lake (Fig. 2). It is a freshwater lake formed in a salt doline by accumulation of precipitations in the spring of 1980. Sediments on the lake bed are very thick, so the water did not reach the salt layer. It was arranged for recreational purposes and fishing, being populated with fish. It has a surface of 0.23 ha (Alexe *et al*. 2006; Alexe 2007).

***Muntele de Sare*** (Eng: Salt Mount; Hu: Só-hegy) is located near the Roşu Lake and between the Verde and Ursu Lake (Fig. 2). Following water infiltration and heavy rains, landslides have occurred on its surface, leading to the appearance of salt blocks on the surface of the slopes.

***Pârâul Sărat*** (Eng: Saline stream; Hu: Sós-árok). Surplus water from Şerpilor and Mierlei Lake is drained by Ţifra stream (Nyárády 1950). This flows into Valea Frumoasei, which drains excess water from Lake Aluniş (Fig. 2). After the confluence, the waterflow is called Pârâul Sărat; this is the left tributary of the Sovata rivulet. Along Pârâul Sărat there are several salt springs, some of them being captured for therapeutic purposes. This flat place with gleyed soil, due to the springs and the stream flow, is called *"Pusta Nămoloasă"* (Nyárády 1950; Fig. 2). Here, a very narrow salt layer appears on the soil surface.

***"Jánosmező" and "Rakottyás" areas.*** The Răchitiş rivulet springs on the southern, southwestern slope of Cireşului Peak (956 m asl) and crosses large meadows which along the upper course are called "*Jánosmező*", and along the middle course are named "*Rakottyás*" (Fig. 2). Finally, the brook flows into Sovata rivulet. In these areas there are large grasslands (Fig. 2), which according to the microrelief, exposure, soil moisture and floristic composition are mesic meadows (on slopes and slightly inclined terrains) or wet meadows (on flat areas).

In the study area, *the soils* are moderately deep, superficial in some places with salt on the surface. The salt massive is protected by a thin layer of soil mixed with clay and sandstone (Alexe *et al*. 2006; Alexe 2007).

*The climate* is temperate continental-moderate, relatively cool and wet, with average annual temperatures of 8.6°C and rainfall of more than 820 mm/year. The warmest month is August (average temperature is 18.7°C) and the coldest is January (average temperature is 3.4°C). Annual amount of rainfall is 755 mm, the driest month is September with 32.3 mm. Because of the mountains surrounding the depression covered by large forests, there are just a few days per year with wind. Occasional winds are from the northeast (Şerban, Alexe 2006; Sămărghiţan, Pop 2006; Alexe 2007).

*Working methods*

The field surveys were conducted in 2008-2009, between June and September.

The identification of vascular plant taxa was done in the field, using Simon (2002) and Ciocârlan (2009). In cases when field identification was difficult (particularly for polymorphic, taxonomically difficult and doubtful taxa), the plant material was collected and determined in the laboratory, using comprehensive monographic works (Săvulescu, 1956-1976; Jávorka, Csapody, 1991). A few collected specimens (only 5 herbarium vouchers) are deposited in the Herbarium of the Babeş-Bolyai University, Cluj-Napoca (CL, acronym according to *Index Herbariorum*), under inventory numbers 659865, 659866, 659867, 659868, 659869.

The bibliographic documentation consisted in reviewing the previous floristic and/or vegetation studies related to the area. Only those taxa have been extracted and added to the final floristic checklist, which location within the study area was accurately given in the bibliographic sources.

The nomenclature of plant taxa follows Flora Europaea (Tutin *et al.* 1964-1980), being actualized with the electronic online version (*http://rbg-web2.rbge.org.uk/FE/fe.html*).

In the floristic checklist, the vascular plants (cormophytes) are presented by families, in systematic order. The family names and the assignment of species and subspecies into the families are given according Flora Europaea (Tutin *et al.* 1964-1980), while the higher systematic ranks used (classis, subphylum and phylum) follow Ciocârlan (2009). Within the families, the taxa are presented in alphabetical order. The list of original data was completed with data from bibliographic sources. For taxa from bibliography, the sources are given.

For each taxa, the following features are indicated: the bibliographic sources, if it is not an original data; the habitat type in which it occurs; the place of the occurrences according to the local toponymy (ex. around Lake Paraschiva, Muntele de Sare, etc.); distribution in the area of occurrence (indicated with rare, sporadic, frequent or common); conservation status (according to the Bern Convention; Habitats Directive; L 13/1993; OUG 57/2007; L 49/2011) and/or presence on national red lists (according to Boşcaiu *et al.* 1994; Oltean *et al.* 1994; Negrean 2001), in certain cases.

## Results

*Floristic checklist*

PTERIDOPHYTA – horsetails and ferns
Equisetaceae
1. *Equisetum sylvaticum* L.: (Sămărghiţan, Pop, 2006).
2. *Equisetum telmateia* Ehrh.: hygrophilous tall-herb fringe communities; around Lakes Paraschiva, Şerpilor, Mierlei, Aluniş; sporadic.
Dryopteridaceae
3. *Dryopteris filix-mas* (L.) Schott: deciduous forest; around Lakes Mierlei and Aluniş; frequent.
Thelypteridaceae
4. *Thelypteris palustris* Schott: littoral and palustral habitats; Şerpilor Lake; rare.
Woodsiaceae
5. *Athyrium filix-femina* (L.) Roth: deciduous forest; around Mierlei Lake; sporadic.

SPERMATOPHYTA – flowering plants
PINOPHYTINA (*Gymnospermae*) – conifers
Pinaceae
6. *Abies alba* Mill.: deciduous forest; rare; planted.
7. *Larix decidua* Mill.: deciduous forest; rare; planted.
8. *Picea abies* (L.) H. Karst.: deciduous forest; rare; planted.
9. *Pinus nigra* J.F.Arnold subsp. *nigra*: deciduous forest; rare; planted.
10. *Pinus sylvestris* L.: deciduous forest; rare; planted.

MAGNOLIOPHYTINA (*Angiospermae*) – angiosperms
MAGNOLIOPSIDA (*Dicotyledonatae*)
Aristolochiaceae
11. *Asarum europaeum* L.: deciduous forest; frequent.

Ranunculaceae
12. *Aconitum lycoctonum* L. subsp. *moldavicum* (Hacq.) Jalas: deciduous forest; around Aluniş Lake; rare; Carpathian endemic taxa.
13. *Aconitum vulparia* Rchb. ex. Spreng. subsp. *vulparia*: (Pop, Buz, 1994; Buz, 1999).
14. *Aconitum variegatum* L. subsp. *paniculatum* (Arcang.) Greuter & Burdet: (Pop, Buz, 1994; Buz, 1999).
15. *Actaea spicata* L.: deciduous forest; around Aluniş Lake; sporadic.
16. *Anemone nemorosa* L.: deciduous forest; frequent.
17. *Anemone ranunculoides* L.: deciduous forest; frequent.
18. *Caltha palustris* L.: littoral and palustral habitats; around Ursu Lake; littoral and palustral habitats, hygrophilous tall-herb fringe communities and wet meadows around Paraschiva Lake; hygrophilous tall-herb fringe communities along Pârâul Sărat; frequent.
19. *Clematis vitalba* L.: deciduous forest; sporadic.
20. *Helleborus purpurascens* Waldst. & Kit.: deciduous forest; around Lakes Mierlei and Aluniş; sporadic.
21. *Hepatica nobilis* Schreb.: deciduous forest; common.
22. *Isopyrum thalictroides* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş; frequent.
23. *Ranunculus auricomus* L.: deciduous forest; frequent.
24. *Ranunculus cassubicus* L.: (Pop, Buz, 1994; Buz, 1999).
25. *Ranunculus polyanthemos* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
26. *Ranunculus repens* L.: wet meadows around Paraschiva Lake; mesic grasslands, wet meadows in "*Jánosmező*" and "*Rakottyás*"; common.
27. *Thalictrum aquilegiifolium* L.: (Pop, Buz, 1994; Buz, 1999).
28. *Thalictrum lucidum* L.: wet meadows in "*Jánosmező*" and "*Rakottyás*"; rare.
29. *Trollius europaeus* L. subsp. *europaeus*: wet meadows; "*Jánosmező*" and "*Rakottyás*"; rare; national red list taxa.
Ulmaceae
30. *Ulmus glabra* Huds.: deciduous forest; around Lakes Roşu, Verde and Aluniş; frequent.
31. *Ulmus minor* Mill.: deciduous forest; sporadic.
Urticaceae
32. *Urtica dioica* L.: hygrophilous tall-herb fringe communities; around Lakes Ursu, Paraschiva and Aluniş; common.
Fagaceae
33. *Fagus sylvatica* L.: deciduous forest; common.
34. *Quercus petraea* (Matt.) Liebl.: deciduous forest; frequent.
35. *Quercus robur* L.: deciduous forest; frequent.
Betulaceae
36. *Alnus glutinosa* (L.) Gaertn.: around Lakes Ursu, Paraschiva, Şerpilor, along Pârâul Sărat, in "*Jánosmező*" and "*Rakottyás*"; frequent.
37. *Alnus incana* (L.) Moench: around Lakes Ursu, Paraschiva, Şerpilor and along Pârâul Sărat; frequent.
Corylaceae
38. *Carpinus betulus* L.: deciduous forest; common.
39. *Corylus avellana* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş; frequent.
Caryophyllaceae
40. *Dianthus armeria* L. subsp. *armeriastrum* (Wolfner) Velen.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; rare.
41. *Dianthus carthusianorum* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
42. *Lychnis flos-cuculi* L.: wet meadows; around Paraschiva Lake, "*Jánosmező*" and "*Rakottyás*"; sporadic.
43. *Silene latifolia* Poir. subsp. *alba* (Mill.) Greuter & Burdet: hygrophilous tall-herb fringe communities, mesic grasslands; around Lakes Ursu and Aluniş; "*Jánosmező*" and "*Rakottyás*"; frequent.
44. *Silene vulgaris* (Moench) Garcke: mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; forest edge on Muntele de Sare; sporadic.
45. *Stellaria graminea* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; common.
46. *Stellaria holostea* L. (Sămărghiţan, Pop, 2006).
47. *Stellaria media* (L.) Vill.: deciduous forest; mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; common.
48. *Stellaria nemorum* L. (Sămărghiţan, Pop, 2006).
Chenopodiaceae
49. *Atriplex prostrata* (Boucher) ex DC.: inland saline habitats; around Lakes Roşu and Verde, Muntele de Sare, along Pârâul Sărat and *"Pusta Nămoloasă"* area; sporadic.
50. *Salicornia europaea* L.: inland saline habitats; around Lakes Ursu, Roşu and Verde, Muntele de Sare, along Pârâul Sărat and *"Pusta Nămoloasă"* area; frequent.
Polygonaceae
51. *Polygonum amphibium* L.: wet meadows, hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
52. *Polygonum bistorta* L.: wet meadows; around Paraschiva Lake, in "*Jánosmező*" and "*Rakottyás*"; sporadic.
53. *Rumex acetosa* L.: mesic grasslands; in "*Jánosmező*" and "*Rakottyás*"; sporadic.

54. *Rumex conglomeratus* Murray: hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
55. *Rumex crispus* L.: hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
56. *Rumex hydrolapathum* Huds.: hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
57. *Rumex obtusifolius* L.: hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
Crassulaceae
58. *Sedum telephium* L. subsp. *maximum* (L.) Krock: Muntele de Sare, around Aluniş Lake; rare.
Grossulariaceae
59. *Ribes uva-crispa* L. (Sămărghiţan et Pop, 2006).
Rosaceae
60. *Agrimonia eupatoria* L.: mesic grasslands; Pârâul Sărat and *"Pusta Nămoloasă"* area; "*Jánosmező*" and "*Rakottyás*"; frequent.
61. *Crataegus monogyna* Jacq.: deciduous forest; frequent.
62. *Crataegus nigra* Waldst. & Kit.: deciduous forest; rare; national red list taxa.
63. *Filipendula ulmaria* (L.) Maxim.: hygrophilous tall-herb fringe communities, wet meadows; around Lakes Ursu, Paraschiva, Şerpilor, along Pârâul Sărat and *"Pusta Nămoloasă"* area; frequent.
64. *Filipendula vulgaris* Moench: mesic grasslands; in "*Jánosmező*" and "*Rakottyás*"; frequent.
65. *Fragaria vesca* L.: deciduous forest; common.
66. *Fragaria viridis* Duchesne: (Pop, Buz, 1994; Buz, 1999).
67. *Geum urbanum* L.: deciduous forest; frequent.
68. *Malus sylvestris* Mill.: deciduous forest; sporadic.
69. *Prunus avium* L.: deciduous forest; sporadic.
70. *Rosa canina* L.: deciduous forest; around Aluniş Lake; sporadic.
71. *Rosa pimpinellifolia* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; rare.
72. *Rubus caesius* L.: hygrophilous tall-herb fringe communities; around Lakes Ursu, Paraschiva, Aluniş; frequent.
73. *Rubus hirtus* Waldst. & Kit.: deciduous forest; frequent.
74. *Rubus idaeus* L.: hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
75. *Sorbus aucuparia* L.: deciduous forest; frequent.
76. *Sorbus torminalis* (L.) Crantz: deciduous forest; around Lakes Mierlei and Aluniş; sporadic.
Leguminosae (Fabaceae)
77. *Astragalus glycyphyllos* L.: hygrophilous tall-herb fringe communities around Paraschiva Lake; mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; sporadic.
78. *Coronilla varia* L.: mesic grasslands; along Pârâul Sărat, in "*Jánosmező*" and "*Rakottyás*" zone, forest edge on Muntele de Sare; frequent.
79. *Dorycnium pentaphyllum* Scop. subsp. *herbaceum* (Vill.) Rouy: mesic grasslands; along Pârâul Sărat, in "*Jánosmező*" and "*Rakottyás*"; sporadic.
80. *Genista tinctoria* L.: mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; deciduous forest around Aluniş Lake, Muntele de Sare; frequent.
81. *Lathyrus hallersteinii* Baumg.: (Sămărghiţan, Pop, 2006).
82. *Lathyrus niger* (L.) Bernh.: (Pop, Buz, 1994; Buz, 1999); deciduous forest; sporadic.
83. *Lathyrus vernus* (L.) Bernh.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş; frequent.
84. *Lembotropis nigricans* (L.) Griseb.: (Pop, Buz, 1994; Buz, 1999).
85. *Lotus corniculatus* L.: wet meadows, mesic grasslands; around Paraschiva Lake, in "*Jánosmező*" and "*Rakottyás*"; frequent.
86. *Lotus tenuis* Waldst. & Kit. ex Willd.: hygrophilous tall-herb fringe communities; around Ursu Lake; rare.
87. *Medicago lupulina* L.: mesic grasslands; in "*Jánosmező*" and "*Rakottyás*"; frequent.
88. *Melilotus alba* Medik.: hygrophilous tall-herb fringe communities; around Ursu Lake; rare.
89. *Melilotus officinalis* (L.) Pall.: hygrophilous tall-herb fringe communities around Lakes Ursu, Paraschiva, Aluniş; hygrophilous tall-herb fringe communities and mesic grasslands along the Pârâul Sărat and *"Pusta Nămoloasă"* area; common.
90. *Ononis spinosa* L.: mesic grasslands along the Pârâul Sărat; in "*Jánosmező*" and "*Rakottyás*"; sporadic.
91. *Robinia pseudacacia* L.: deciduous forest; around Aluniş Lake; sporadic; invasive, North American taxa; planted.
92. *Trifolium medium* L.: (Pop, Buz, 1994; Buz, 1999).
93. *Trifolium montanum* L.: mesic grasslands; along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; sporadic.
94. *Trifolium pannonicum* Jacq.: mesic grasslands; in "*Jánosmező*" and "*Rakottyás*"; forest edge on Muntele de Sare; rare.
95. *Trifolium pratense* L.: mesic grasslands; along Pârâul Sărat and *"Pusta Nămoloasă"* area; "*Jánosmező*" and "*Rakottyás*"; frequent.
96. *Vicia cracca* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.

97. *Vicia sepium* L.: mesic grasslands; along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; sporadic.
98. *Vicia sylvatica* L.: deciduous forest; around Lakes Mierlei and Aluniş; frequent.
Lythraceae
99. *Lythrum salicaria* L.: hygrophilous tall-herb fringe communities, wet meadows; around Lakes Ursu and Paraschiva, "*Jánosmező*" and "*Rakottyás*"; frequent.
Onagraceae
100. *Circaea lutetiana* L.: (Sămărghiţan, Pop, 2006).
101. *Epilobium angustifolium* L.: (Pop, Buz, 1994; Buz, 1999).
102. *Epilobium montanum* L. (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006).
Elaeagnaceae
103. *Hippophäe rhamnoides* L.: deciduous forest; around Paraschiva Lake; rare; planted.
Thymelaeaceae
104. *Daphne mezereum* L.: deciduous forest; around Lakes Mierlei and Aluniş; sporadic.
Cornaceae
105. *Cornus mas* L.: deciduous forest; sporadic.
106. *Cornus sanguinea* L.: deciduous forest; frequent.
Celastraceae
107. *Euonymus verrucosus* Scop.: deciduous forests; around Mierlei Lake; sporadic.
Euphorbiaceae
108. *Euphorbia amygdaloides* L.: deciduous forest; frequent.
109. *Euphorbia angulata* Jacq.: deciduous forest; sporadic.
110. *Euphorbia carniolica* Jacq. (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006).
111. *Euphorbia cyparissias* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; common.
112. *Mercurialis perennis* L.: deciduous forest; around Lakes Roşu, Verde and Aluniş; frequent.
Rhamnaceae
113. *Frangula alnus* Mill.: deciduous forest; around Aluniş Lake; sporadic.
114. *Rhamnus catharticus* L.: (Pop, Buz, 1994; Buz, 1999).
Vitaceae
115. *Parthenocissus quinquefolia* (L.) Planch.: hygrophilous tall-herb fringe communities; around Ursu Lake; ornamental invasive taxa originated from North America; rare.
Aceraceae
116. *Acer campestre* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş; frequent.
117. *Acer platanoides* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş; frequent.
118. *Acer pseudoplatanus* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş; frequent.
Oxalidaceae
119. *Oxalis acetosella* L.: deciduous forest; sporadic.
Geraniaceae
120. *Geranium pratense* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
121. *Geranium palustre* L.: hygrophilous tall-herb fringe communities; around Paraschiva Lake; sporadic.
122. *Geranium phaeum* L.: deciduous forest; sporadic.
123. *Geranium robertianum* L.: deciduous forest; frequent.
124. *Geranium sylvaticum* L.: deciduous forest; around Aluniş Lake; sporadic.
Balsaminaceae
125. *Impatiens noli-tangere* L.: hygrophilous tall-herb fringe communities; around Lakes Paraschiva, Roşu, Verde and Aluniş; frequent.
126. *Impatiens parviflora* DC.: (Pop, Buz, 1994; Buz, 1999); invasive taxa originated from Asia.
Araliaceae
127. *Hedera helix* L.: deciduous forest; around Aluniş Lake; sporadic.
Umbelliferae (Apiaceae)
128. *Aegopodium podagraria* L: hygrophilous tall-herb fringe communities, deciduous forest; around Lakes Ursu, Paraschiva, Roşu, Verde, Şerpilor, Aluniş, along Pârâul Sărat and *"Pusta Nămoloasă"* area; common.
129. *Angelica sylvestris* L.: hygrophilous tall-herb fringe communities, wet meadows; around Lakes Ursu, Paraschiva, along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*" zone; sporadic.
130. *Anthriscus sylvestris* (L.) Hoffm.: deciduous forest; frequent.
131. *Astrantia major* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; mesic grasslands in "*Jánosmező*" and "*Rakottyás*" zone; common.
132. *Chaerophyllum aromaticum* L.: hygrophilous tall-herb fringe communities; around Lakes Paraschiva and Aluniş; sporadic.
133. *Chaerophyllum aureum* L. (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006).
134. *Chaerophyllum hirsutum* L.: hygrophilous tall-herb fringe communities; around Lakes Ursu and Paraschiva; sporadic.
135. *Daucus carota* L. subsp. *carota*: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
136. *Heracleum sphondylium* L.: hygrophilous tall-herb fringe communities around Lakes Ursu,

Paraschiva, Roşu, Verde, Şerpilor, Aluniş, along Pârâul Sărat and *"Pusta Nămoloasă"* area; mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; frequent.
137. *Laser trilobum* (L.) Borkh. (Sămărghiţan, Pop, 2006).
138. *Peucedanum oreoselinum* (L.) Moench: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
139. *Sanicula europaea* L.: deciduous forest around Lakes Ursu, Paraschiva, Roşu, Verde, Mierlei and Aluniş; mesic grasslands along Pârâul Sărat; common.
Hypericaceae (Guttiferae)
140. *Hypericum hirsutum* L.: deciduous forest, mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
141. *Hypericum maculatum* Crantz: (Pop, Buz, 1994; Buz, 1999).
142. *Hypericum perforatum* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
Violaceae
143. *Viola mirabilis* L.: (Pop, Buz, 1994; Buz, 1999).
144. *Viola reichenbachiana* Jord. ex Boreau: deciduous forest; frequent.
145. *Viola riviniana* Rchb.: (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006).
Tiliaceae
146. *Tilia cordata* Mill.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; sporadic.
147. *Tilia platyphyllos* Scop.: deciduous forest; around Aluniş Lake; sporadic.
Cruciferae (Brassicaceae)
148. *Alliaria petiolata* (M. Bieb.) Cavara & Grande: deciduous forest; frequent.
149. *Cardamine bulbifera* (L.) Crantz: deciduous forest; common.
150. *Cardamine glanduligera* O. Schwarz: (Sămărghiţan, Pop, 2006); Carpathian subendemic taxa.
Salicaceae
151. *Populus alba* L.: around Aluniş Lake; rare; planted.
152. *Populus tremula* L.: deciduous forest; around Lakes Paraschiva, Mierlei and Aluniş; sporadic.
153. *Salix alba* L.: around Ursu Lake; rare.
154. *Salix caprea* L.: around Lakes Paraschiva and Şerpilor, along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; frequent.
155. *Salix cinerea* L.: around Lakes Ursu, Paraschiva, Şerpilor, along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; frequent.
156. *Salix purpurea* L.: around Paraschiva Lake; rare.
157. *Salix triandra* L.: around Paraschiva Lake; rare.
Primulaceae
158. *Lysimachia nummularia* L.: hygrophilous tall-herb fringe communities around Ursu Lake; hygrophilous tall-herb fringe communities, wet meadows around Paraschiva Lake, in "*Jánosmező*" and "*Rakottyás*" zone; frequent.
159. *Lysimachia vulgaris* L.: hygrophilous tall-herb fringe communities, wet meadows; around Lakes Ursu and Paraschiva, along Pârâul Sărat, in "*Jánosmező*" and "*Rakottyás*" zone; frequent.
160. *Primula elatior* (L.) Hill: (Sămărghiţan, Pop, 2006).
161. *Primula veris* L.: mesic grasslands; along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; sporadic.
Gentianaceae
162. *Centaurium erythraea* Rafn: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
163. *Gentiana asclepiadea* L.: deciduous forest; around Aluniş Lake; rare.
164. *Gentiana cruciata* L.: (Pop, Buz, 1994; Buz, 1999).
165. *Gentiana pneumonanthe* L.: wet meadows; "*Jánosmező*" and "*Rakottyás*"; rare; national red list taxa.
Oleaceae
166. *Fraxinus excelsior* L.: deciduous forest; around Aluniş Lake; sporadic.
167. *Ligustrum vulgare* L.: deciduous forest; around Lakes Roşu, Verde and Mierlei; frequent.
Convolvulaceae
168. *Calystegia sepium* (L.) R. Br.: littoral and palustral habitats, hygrophilous tall-herb fringe communities; around Lakes Ursu and Paraschiva; sporadic.
169. *Convolvulus arvensis* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
Boraginaceae
170. *Echium vulgare* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
171. *Myosotis scorpioides* L.: hygrophilous tall-herb fringe communities, wet meadows; around Paraschiva Lake; sporadic.
172. *Pulmonaria mollis* Wulfen ex Hornem. subsp. *mollissima* (A.Kern.) Nyman: (Pop, Buz, 1994; Buz, 1999).
173. *Pulmonaria obscura* Dumort.: deciduous forest; around Aluniş Lake; sporadic.
174. *Pulmonaria officinalis* L.: deciduous forest; around Aluniş Lake; sporadic.
175. *Pulmonaria rubra* Schott: (Sămărghiţan, Pop, 2006).

176. *Symphytum officinale* L.: hygrophilous tall-herb fringe communities around Ursu Lake, wet meadows around Paraschiva Lake; frequent.
177. *Symphytum tuberosum* L.: deciduous forest; around Lakes Paraschiva, Roşu, Verde, Mierlei and Aluniş; frequent.
Labiatae (Lamiaceae)
178. *Ajuga genevensis* L.: deciduous forest; common.
179. *Ajuga reptans* L.: deciduous forest; common.
180. *Clinopodium vulgare* L.: deciduous forest; common.
181. *Galeopsis tetrahit* L.: deciduous forest; common.
182. *Glechoma hederacea* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; common.
183. *Glechoma hirsuta* Waldst. & Kit.: deciduous forest; common.
184. *Lamiastrum galeobdolon* (L.) Ehrend. & Polatschek: deciduous forest; around Lakes Roşu, Verde and Aluniş; frequent.
185. *Lamium purpureum* L.: hygrophilous tall-herb fringe communities; around Ursu Lake; sporadic.
186. *Melittis melissophyllum* L.: (Pop, Buz, 1994; Buz, 1999).
187. *Origanum vulgare* L.: forest edge around Aluniş Lake; mesic grasslands along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; frequent.
188. *Prunella vulgaris* L.: mesic grasslands; along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*" zone; frequent.
189. *Salvia glutinosa* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; frequent.
190. *Salvia nemorosa* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
191. *Salvia verticillata* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
192. *Stachys annua* (L.) L.: hygrophilous tall-herb fringe communities around Ursu Lake; mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; frequent.
193. *Stachys officinalis* (L.) Trevis.: wet meadows, mesic grasslands; around Paraschiva Lake, along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; frequent.
194. *Stachys sylvatica* L.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; frequent.
195. *Thymus pannonicus* All. s.l.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
Plantaginaceae
196. *Plantago cornuti* Gouan: inland saline habitats; along Pârâul Sărat and *"Pusta Nămoloasă"* area; frequent; national red list taxa.
197. *Plantago lanceolata* L.: mesic grasslands; around Paraschiva Lake, along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; common.
198. *Plantago maritima* L.: inland saline habitats; along Pârâul Sărat and *"Pusta Nămoloasă"* area; frequent.
199. *Plantago media* L.: mesic grasslands; along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; common.
Scrophulariaceae
200. *Digitalis grandiflora* Mill.: deciduous forest; around Lakes Roşu, Verde, Mierlei, Aluniş, Muntele de Sare; sporadic.
201. *Lathraea squamaria* L.: (Sămărghiţan, Pop, 2006).
202. *Melampyrum bihariense* A. Kern.: deciduous forest; around Aluniş Lake; sporadic.
203. *Melampyrum nemorosum* L.: deciduous forest; around Lakes Paraschiva, Roşu, Verde, Mierlei and Aluniş; frequent; national red list taxa.
204. *Rhinanthus angustifolius* C.C. Gmel.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
205. *Scrophularia nodosa* L.: deciduous forest; around Aluniş Lake; sporadic.
206. *Verbascum phlomoides* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
207. *Veronica austriaca* L. subsp. *teucrium* (L.) D.A.Webb: (Sămărghiţan, Pop, 2006).
208. *Veronica officinalis* L.: (Pop, Buz, 1994; Buz, 1999).
Solanaceae
209. *Atropa bella-donna* L.: hygrophilous tall-herb fringe communities; around Ursu Lake; rare.
210. *Solanum dulcamara* L.: hygrophilous tall-herb fringe communities; around Lakes Ursu, Paraschiva, Şerpilor; sporadic.
Campanulaceae
211. *Campanula glomerata* L.: (Pop, Buz, 1994; Buz, 1999).
212. *Campanula patula* L. subsp. *patula:* mesic grasslands; along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; frequent.
213. *Campanula persicifolia* L.: deciduous forest; around Lakes Roşu, Verde and Aluniş, Muntele de Sare; mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; frequent.
214. *Campanula rapunculoides* L.: deciduous forest; around Lakes Paraschiva, Roşu, Verde, Mierlei and Aluniş; frequent.
215. *Campanula rapunculus* L.: deciduous forest; around Lakes Paraschiva, Roşu, Verde, Mierlei and Aluniş; frequent.
216. *Campanula trachelium* L.: deciduous forest; around Lakes Mierlei and Aluniş; sporadic.
Rubiaceae

217. *Cruciata glabra* (L.) Ehrend.: (Pop, Buz, 1994; Buz, 1999).
218. *Cruciata laevipes* Opiz: (Sămărghiţan, Pop, 2006).
219. *Galium album* Mill.: hygrophilous tall-herb fringe communities around Lakes Ursu, Paraschiva and Aluniş, Muntele de Sare; mesic grasslands in "*Jánosmező*" and "*Rakottyás*"; frequent.
220. *Galium odoratum* (L.) Scop.: deciduous forest; frequent.
221. *Galium schultesii* Vest: deciduous forest; around Aluniş Lake; sporadic.
222. *Galium verum* L.: mesic grasslands; along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; frequent.
Caprifoliaceae
223. *Lonicera xylosteum* L.: (Pop, Buz, 1994; Buz, 1999).
224. *Sambucus nigra* L.: deciduous forest; sporadic.
225. *Viburnum lantana* L.: deciduous forest; sporadic.
226. *Viburnum opulus* L.: deciduous forest; around Aluniş Lake; sporadic.
Valerianaceae
227. *Valeriana officinalis* L.: wet meadows around Paraschiva Lake; mesic grasslands along Pârâul Sărat; sporadic.
Dipsacaceae
228. *Knautia arvensis* (L.) Coult.: mesic grasslands; along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; frequent.
229. *Succisa pratensis* Moench: wet meadows; "*Jánosmező*" and "*Rakottyás*"; sporadic.
Compositae (Asteraceae)
230. *Achillea millefolium* L.: mesic grasslands; along Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*" zone; frequent.
231. *Achillea ptarmica* L.: wet meadows; "*Jánosmező*" and "*Rakottyás*"; sporadic; national red list taxa.
232. *Artemisia vulgaris* L.: hygrophilous tall-herb fringe communities; around Ursu Lake; sporadic.
233. *Aster tripolium* L.: inland saline habitats, hygrophilous tall-herb fringe communities; around Lakes Ursu, Roşu, Verde and Mierlei, Muntele de Sare, along the Pârâul Sărat and *"Pusta Nămoloasă"*; frequent.
234. *Bellis perennis* L.: mesic grasslands; around Paraschiva Lake; frequent.
235. *Carlina acaulis* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; rare.
236. *Centaurea jacea* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
237. *Cichorium intybus* L.: mesic grasslands; along the Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; frequent.
238. *Cirsium canum* (L.) All.: hygrophilous tall-herb fringe communities, wet meadows; around Paraschiva Lake, "*Jánosmező*" and "*Rakottyás*"; sporadic.
239. *Cirsium oleraceum* (L.) Scop.: hygrophilous tall-herb fringe communities; around Lakes Ursu and Paraschiva, along the Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; sporadic.
240. *Cirsium palustre* (L.) Scop: hygrophilous tall-herb fringe communities; around Lakes Ursu and Paraschiva; rare.
241. *Cirsium rivulare* (Jacq.) All.: wet meadows; around Paraschiva Lake; sporadic.
242. *Cirsium vulgare* (Savi) Ten.: hygrophilous tall-herb fringe communities; around Ursu Lake; sporadic.
243. *Crepis paludosa* (L.) Moench: hygrophilous tall-herb fringe communities; around Ursu Lake; sporadic.
244. *Erigeron annuus* (L.) Pers.: hygrophilous tall-herb fringe communities, mesic grasslands; around Paraschiva Lake, along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; invasive taxa originated from North America; frequent.
245. *Eupatorium cannabinum* L.: hygrophilous tall-herb fringe communities; around Lakes Ursu, Paraschiva, Mierlei and Aluniş; frequent.
246. *Galinsoga parviflora* Cav.: hygrophilous tall-herb fringe communities; around Ursu Lake; invasive taxa originated from South America; sporadic.
247. *Hieracium murorum* L. agg.: deciduous forest; frequent.
248. *Hieracium racemosum* Waldst. & Kit. ex Willd.: (Sămărghiţan et Pop, 2006).
249. *Hieracium umbellatum* L.: deciduous forest; sporadic.
250. *Inula britannica* L.: inland saline habitats; along the Pârâul Sărat and *"Pusta Nămoloasă"* area; sporadic.
251. *Inula salicina* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
252. *Lapsana communis* L.: (Pop, Buz, 1994; Buz, 1999).
253. *Leucanthemum vulgare* Lam.: mesic grasslands; along the Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; frequent.
254. *Mycelis muralis* (L.) Dumort.: deciduous forest; common.
255. *Rudbeckia laciniata* L.: hygrophilous tall-herb fringe communities; around Paraschiva Lake, Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*"; ornamental and invasive, North American taxa; frequent.

256. *Senecio doria* subsp. *umbrosus* (Waldst. & Kit.) Soó: hygrophilous tall-herb fringe communities; around Ursu Lake, along Pârâul Sărat and *"Pusta Nămoloasă"* area; sporadic.
257. *Senecio nemorensis* L.: mesic grasslands; along Pârâul Sărat and *"Pusta Nămoloasă"* area; rare.
258. *Senecio papposus* (Rchb.) Less.: (Pop, Buz, 1994; Buz, 1999).
259. *Solidago virgaurea* L.: deciduous forest; sporadic.
260. *Tanacetum corymbosum* (L.) Sch. Bip.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş, Muntele de Sare; frequent.
261. *Tanacetum vulgare* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; sporadic.
262. *Telekia speciosa* (Schreb.) Baumg.: hygrophilous tall-herb fringe communities; around Lakes Paraschiva, Mierlei and Aluniş, along Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*" zone; sporadic.
263. *Tussilago farfara* L.: hygrophilous tall-herb fringe communities; around Lakes Ursu, Paraschiva, Şerpilor; frequent.
LILIOPSIDA (*Monocotyledonatae*)
Alismataceae
264. *Alisma plantago-aquatica* L.: littoral and palustral habitats; Paraschiva Lake; rare.
Juncaginaceae
265. *Triglochin maritima* L.: inland saline habitats; along the Pârâul Sărat and *"Pusta Nămoloasă"* area; rare.
Potamogetonaceae
266. *Potamogeton natans* L.: aquatic habitats; Paraschiva Lake; sporadic.
267. *Potamogeton pectinatus* L.: aquatic habitats; Paraschiva Lake; sporadic.
Liliaceae
268. *Allium vineale* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; rare.
269. *Erythronium dens-canis* L.: (Sămărghiţan, Pop, 2006).
270. *Lilium martagon* L.: (Pop, Buz, 1994; Buz, 1999); deciduous forest; rare.
271. *Maianthemum bifolium* (L.) F.W.Schmidt: deciduous forest; around Mierlei Lake; sporadic.
272. *Paris quadrifolia* L.: deciduous forest; around Aluniş Lake; rare.
273. *Polygonatum latifolium* (Jacq.) Desf.: deciduous forest around Lakes Mierlei and Aluniş; mesic grasslands along the Pârâul Sărat; frequent.
274. *Polygonatum multiflorum* (L.) All.: (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006); deciduous forest; common.
275. *Polygonatum odoratum* (Mill.) Druce: deciduous forest; around Lakes Mierlei and Aluniş; frequent.
276. *Polygonatum verticillatum* (L.) All.: (Pop, Buz, 1994; Buz, 1999, Sămărghiţan, Pop, 2006); deciduous forest; sporadic.
277. *Veratrum album* L.: wet meadows, hygrophilous tall-herb fringe communities; "*Jánosmező*" and "*Rakottyás*"; sporadic.
Amaryllidaceae
278. *Galanthus nivalis* L.: deciduous forest; sporadic; protected according to Habitats Directive, 92/43/EEC; OUG 57/2007; L 49/2011.
279. *Narcissus poëticus* L. subsp. *radiiflorus* (Salisb.) Baker: wet meadows; "*Jánosmező*" and "*Rakottyás*"; rare; national red list species.
Iridaceae
280. *Crocus banaticus* J. Gay: deciduous forest; Carpathian subendemic taxa; sporadic.
Orchidaceae
281. *Cephalanthera damasonium* (Mill.) Druce: (Sămărghiţan, Pop, 2006).
282. *Cephalanthera longifolia* (L.) Fritsch: (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006); deciduous forest; rare.
283. *Corallorhiza trifida* Châtel.: (Sămărghiţan, Pop, 2006).
284. *Cypripedium calceolus* L.: deciduous forest; around Aluniş Lake; rare; community interest species, protected according to Bern Convention, 82/72/EEC; Habitats Directive, 92/43/EEC; L 13/1993; OUG 57/2007; L 49/2011; national red list species.
285. *Epipactis atrorubens* (Hoffm.) Besser: (Pop, Buz, 1994; Buz, 1999); deciduous forest; rare.
286. *Epipactis helleborine* (L.) Crantz: deciduous forest; around Lakes Mierlei and Aluniş; mesic grasslands along the Pârâul Sărat; sporadic.
287. *Gymnadenia conopsea* (L.) R. Br.: mesic grasslands, wet meadows; along the Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; sporadic.
288. *Listera ovata* (L.) R. Br.: deciduous forest; around Mierlei Lake; sporadic.
289. *Neottia nidus-avis* (L.) Rich.: deciduous forest; frequent.
290. *Orchis ustulata* L.: mesic grasslands, wet meadows; "*Jánosmező*" and "*Rakottyás*"; rare; national red list taxa.
291. *Platanthera bifolia* (L.) Rich.: deciduous forest; sporadic.
Juncaceae
292. *Juncus conglomeratus* L.: littoral and palustral habitats, wet meadows around Paraschiva Lake; hygrophilous tall-herb fringe communities along Pârâul Sărat and *"Pusta Nămoloasă"* area;

wet meadows in "*Jánosmező*" and "*Rakottyás*"; frequent.
293. *Juncus effusus* L.: littoral and palustral habitats, hygrophilous tall-herb fringe communities; around Lakes Paraschiva and Şerpilor; frequent.
294. *Juncus inflexus* L.: littoral and palustral habitats, wet meadows; around Paraschiva Lake; frequent.
295. *Luzula luzuloides* (Lam.) Dandy & Wilmott: deciduous forest; frequent.
296. *Luzula sylvatica* (Huds.) Gaudin: deciduous forest; around Aluniş Lake; sporadic.
Cyperaceae
297. *Carex digitata* L.: (Pop, Buz, 1994; Buz, 1999).
298. *Carex divulsa* Stokes: (Pop, Buz, 1994; Buz, 1999).
299. *Carex nigra* (L.) Reichard: littoral and palustral habitats around Paraschiva Lake; inland saline habitats along the Pârâul Sărat and *"Pusta Nămoloasă"* area; sporadic.
300. *Carex pilosa* Scop. (Sămărghiţan, Pop, 2006).
301. *Carex remota* L.: hygrophilous tall-herb fringe communities; around Şerpilor Lake; sporadic.
302. *Carex sylvatica* Huds.: deciduous forest; frequent.
303. *Carex vulpina* L.: littoral and palustral habitats; around Paraschiva Lake; sporadic.
304. *Scirpus sylvaticus* L.: littoral and palustral habitats, hygrophilous tall-herb fringe communities; around Lakes Ursu and Paraschiva; frequent.
Gramineae (Poaceae)
305. *Agrostis capillaris* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; common.
306. *Agrostis stolonifera* L.: inland saline habitats; along Pârâul Sărat and *"Pusta Nămoloasă"* area; frequent.
307. *Anthoxanthum odoratum* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; common.
308. *Brachypodium sylvaticum* (Huds.) P. Beauv.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; frequent.
309. *Briza media* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
310. *Bromus benekenii* (Lange) Trimen: (Pop, Buz, 1994; Buz, 1999).
311. *Cynosurus cristatus* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
312. *Dactylis glomerata* L.: mesic grasslands; along the Pârâul Sărat, "*Jánosmező*" and "*Rakottyás*"; frequent.
313. *Dactylis glomerata* L. subsp. *aschersoniana* (Graebn.) Thell.: deciduous forest; around Lakes Roşu, Verde, Mierlei and Aluniş; sporadic.
314. *Deschampsia cespitosa* (L.) P.Beauv: wet meadows; around Paraschiva Lake, "*Jánosmező*" and "*Rakottyás*"; frequent.
315. *Festuca drymeja* Mert. & W.D.J.Koch: deciduous forest; frequent.
316. *Festuca gigantea* (L.) Vill.: (Pop, Buz, 1994; Buz, 1999; Sămărghiţan, Pop, 2006).
317. *Festuca heterophylla* Lam.: (Sămărghiţan et Pop, 2006).
318. *Festuca pratensis* Huds.: wet meadows, mesic grasslands; around Paraschiva Lake, in "*Jánosmező*" and "*Rakottyás*"; frequent.
319. *Festuca rubra* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
320. *Glyceria arundinacea* Kunth: littoral and palustral habitats, hygrophilous tall-herb fringe communities; around Lakes Ursu and Paraschiva; sporadic.
321. *Holcus lanatus* L.: mesic grasslands, wet meadows; "*Jánosmező*" and "*Rakottyás*"; sporadic.
322. *Melica uniflora* Retz.: (Pop, Buz, 1994; Buz, 1999).
323. *Molinia caerulea* (L.) Moench: wet meadows; "*Jánosmező*" and "*Rakottyás*"; sporadic.
324. *Phleum pratense* L.: mesic grasslands; "*Jánosmező*" and "*Rakottyás*"; frequent.
325. *Phragmites australis* (Cav.) Trin. ex Steud.: littoral and palustral habitats, hygrophilous tall-herb fringe communities around Lakes Ursu, Paraschiva, Şerpilor and Mierlei; hygrophilous tall-herb fringe communities along the Pârâul Sărat and *"Pusta Nămoloasă"* area, "*Jánosmező*" and "*Rakottyás*", Muntele de Sare; frequent.
326. *Poa nemoralis* L.: deciduous forest; frequent.
327. *Puccinellia distans* (L.) Parl. subsp. *distans*: inland saline habitats; around Lakes Roşu and Verde, along the Pârâul Sărat and *"Pusta Nămoloasă"* area; frequent.
328. *Puccinellia distans* (L.) Parl. subsp. *limosa* (Schur) Jáv.: inland saline habitats; along the Pârâul Sărat and *"Pusta Nămoloasă"* area; sporadic.
Typhaceae
329. *Typha latifolia* L.: littoral and palustral habitats, hygrophilous tall-herb fringe communities around Lakes Paraschiva and Şerpilor; sporadic.
Lemnaceae
330. *Spirodela polyrhiza* (L.) Schleid.: aquatic habitats; Lakes Paraschiva and Şerpilor; frequent.

## Discussion

Up to the present, 330 vascular plant taxa have been identified, belonging to 66 families. From the total number of taxa, 275 are original data, representing plants identified in the field, and 55 are cited from bibliographic sources.

The most abundant families (>5 %) are: Compositae (Asteraceae) – 10.30%; Gramineae (Poaceae) – 7.27%; Leguminosae (Fabaceae) – 6.66%; Labiatae (Lamiaceae) – 5.45% and Rosaceae with 5.15%.

The highest level of particularity of the flora from phytogeographic point of view is given by its Carpathians endemic (*Aconitum lycoctonum* subsp. *moldavicum*) and subendemic (*Cardamine glanduligera, Crocus banaticus*) elements (Hurdu *et al.* 2012). Other taxa indicate the floristic links with the mountainous (*Pulmonaria rubra, Telekia speciosa*) and sub-mountainous (*Lathyrus hallersteinii, Geranium sylvaticum, Melampyrum bihariense*) areas of the Carpathians and the Balkan Mountains.

The salty soils are populated by halophytes: some species are obligatory halophytes (*Aster tripolium, Plantago cornuti, P. maritima, Puccinellia distans* subsp. *distans, Puccinellia distans* subsp. *limosa, Salicornia europaea, Triglochin maritima*), which form patches of characteristic vegetation.

Two protected species are present: *Cypripedium calceolus* (Bern Convention, 82/72/EEC; Habitats Directive, 92/43/EEC; L 13/1993; OUG 57/2007; L 49/2011) and *Galanthus nivalis* (Habitats Directive, 92/43/EEC; OUG 57/2007; L 49/2011). Seven taxa are included in national red lists (Boşcaiu *et al*. 1994; Oltean *et al*. 1994; Negrean 2001): *Achillea ptarmica, Crataegus nigra, Gentiana pneumonanthe, Melampyrum nemorosum, Narcissus poëticus* subsp. *radiiflorus, Orchis ustulata, Trollius europaeus* subsp. *europaeus*). Out of these, only *Cypripedium calceolus, Galanthus nivalis* and *Narcissus poëticus* subsp. *radiiflorus* are included in the European Red List of Vascular Plants (Bilz *et al.* 2011).

It is worth mentioning the presence of 6 invasive neophytes (Anastasiu, Negrean 2009): *Erigeron annuus*, *Galinsoga parviflora, Impatiens parviflora, Parthenocissus quinquefolia, Robinia pseudacacia* and *Rudbeckia laciniata.* These taxa require special attention from a biodiversity conservation perspective.

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

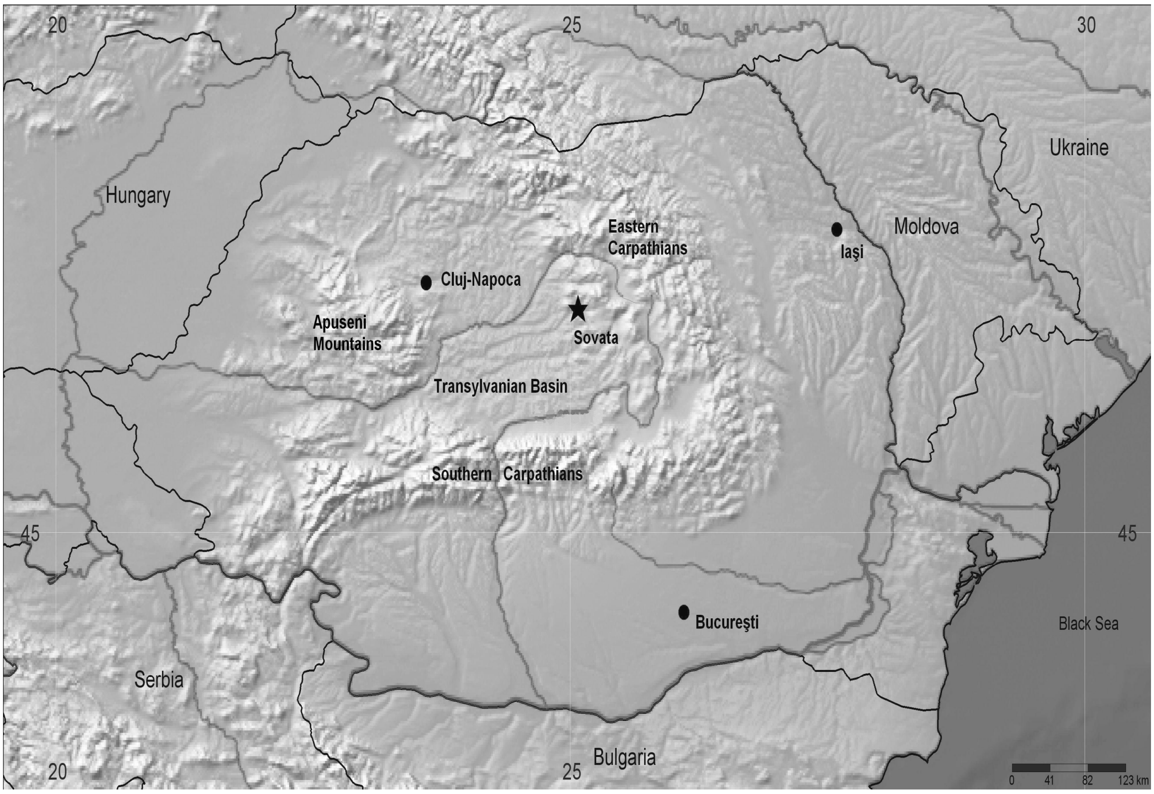


**Fig. 1.** Position of Sovata on Romania's territory, in relation with the main geographic units.

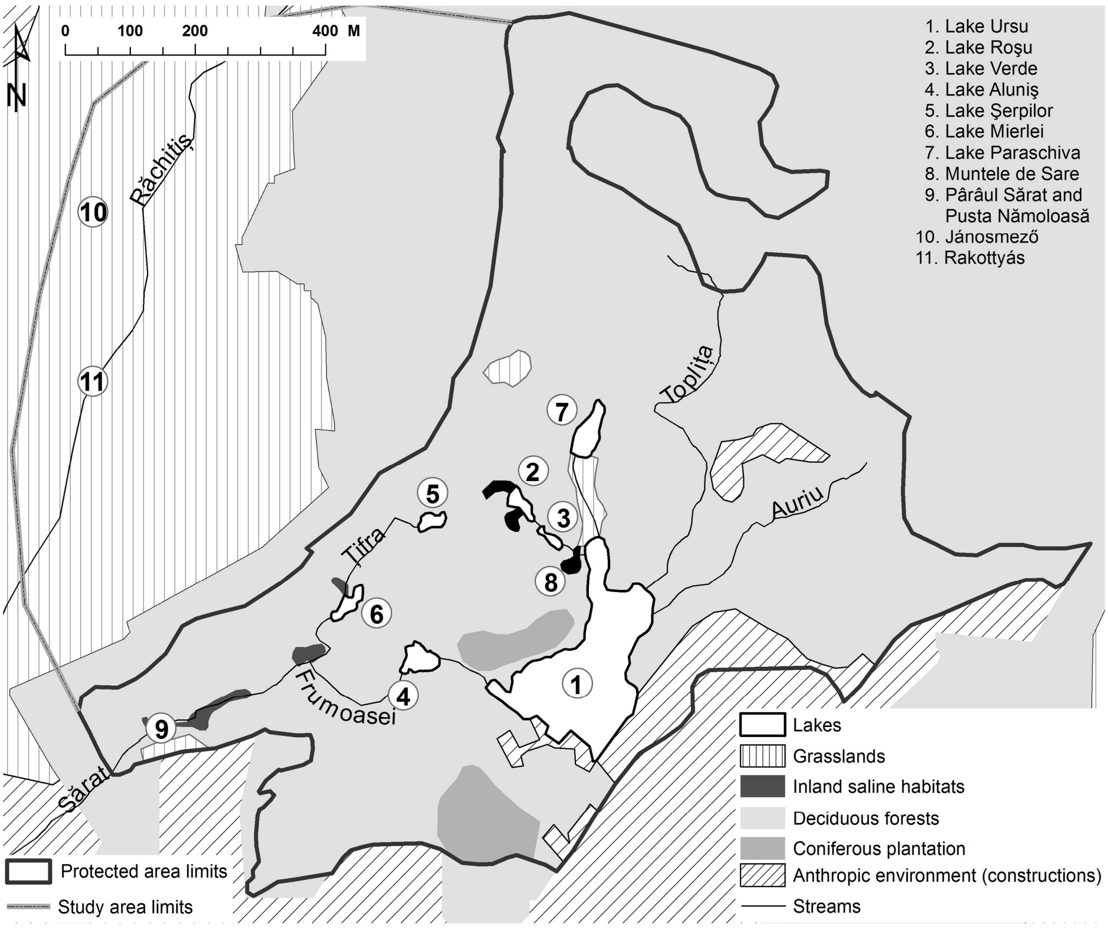


**Fig. 2.** The Lake Ursu Nature Reserve and the study area.

**THE VEGETATION OF THE BREITE WOOD-PASTURE (SIGHIŞOARA, ROMANIA) – HISTORY, CURRENT STATUS AND PROSPECTS**

**Kinga ÖLLERER***

***Abstract.*** *The Breite Ancient Oaks Tree Reserve near to Sighişoara (Schäßburg, Romania) is probably one of the best preserved wood-pastures in Central-East Europe. Although it is renowned mostly for its veteran oaks, the herbaceous vegetation is also of conservation interest, increasing the biodiversity of the site. The paper aims to describe the current ground vegetation patterns of the Breite also in the context of its historical development, and to discuss its future prospects and some conservation management issues.*
***Key words:*** *ground vegetation, historical ecology, ethnoecosystems, traditional management practices, biodiversity conservation, Romania.*

***Rezumat.*** *Rezervaţia Stejarii seculari de la Breite (Sighişoara, România***)** *lângă Sighişoara este probabil una din cele mai bine menţinute pajişti cu stejari seculari din Europa Centrală şi de Est. Deşi rezervaţia este cunoscută mai ales datorită prezenţei stejarilor seculari, vegetaţia ierboasă prezintă de asemenea interes conservativ, contribuind la creşterea biodiversităţii în ansamblu a zonei. Lucrarea prezintă situaţia actuală a covorului vegetal de pe platoul Breite, având totodată şi o abordare istorică, fiind discutate şi perspectivele de viitor, respectiv aspecte privind managementul conservării.*
***Cuvinte cheie:*** *vegetaţie ierboasă, ecologie istorică, etnoecosisteme, practici tradiţionale, conservarea biodiversităţii, România.*

## Introduction

Ethnoecosystems are a particular type of secondary ecosystems that are shaped, regulated and maintained in time by human activities in the form of traditional practices embedded in the cultural identity of a certain human community (Cristea, Rákosy 2011). Silvopastoral systems, the deliberate combination of forestry and pasturing represent one example of ethnoecosystems, which also include wood-pastures, characterized by a more-or-less open woodland structure, with trees scattered in a grazing area.

Land-use legacies are highly important for conservation and planning activities related to ethnecosystems. The history of disturbance shapes the structure, composition and functions of ecosystems; recognizing this can increase the effectiveness of management interventions, while ignoring historical legacies might result in setting up a wrong direction of conservation and management schemes (Foster *et al*. 2003). Major habitat modifications, as a result of different management interventions, such as abandonment of grazing, increasing its intensity or changing the grazing periods, drainage *etc*. are historical phenomena that cause modification of the original vegetation pattern and community structures. In several cases, the outcomes of such modifications might be mistaken for the original natural vegetation, unless the history of the area is taken into consideration (Mueller-Dombois, Ellenberg 1974). The aim of historical (landscape) ecology is to fill this gap of knowledge, therefore strengthening the arguments that support or speak against one management practice over another. Knowledge, and, when possible, the understanding of historical events / processes that led to the present state is indispensable for building up models and making predictions regarding the possible direction of habitat modifications and outcome of management practices.

Both natural conditions and cultural history are reflected in the present-day state of wood-pasture habitats, and addressing spatio-temporal variations is of great importance in their research. Therefore, a comprehensive study in such areas has to address (i) the landscape context, (ii) the present and former management practices, (iii) the components, conservation value and metrics of biodiversity, all

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which have to be considered when evaluating the findings and elaborating recommendations regarding biodiversity management. Gathering the necessary data in order to cover these aspects requires a comprehensive documentation phase. This, besides the evaluation of the current situation should rely also on historical documents (legal, administrative files deposited in libraries and archives, ordnance surveys, topographical maps), old monographs, toponyms (place names bearing valuable information on former uses), series of aerial photographs, including the use of more recent technological advances, such the Geographical Information System, and on anecdotal evidence.

Wood-pasturing dates back in Southern Transylvania to at least the 13th century, when the Transylvanian Saxons settled in the area and were allowed free use of the forests, which in those times included also grazing with pigs and cattle (Dorner 1910). Most villages had at least one wood-pasture in their vicinity that was common land for all inhabitants and its use was regulated by the communal authorities (Dorner 1910). Wood-pastures were important mainly from the perspective of livestock, especially pannage for Pigs, the trees being grown and maintained exactly for this purpose, while the extraction of wood was less important.

These forests consisted almost exclusively of oaks (*Quercus robur* and *Quercus petraea*), occasionally with few beech *Fagus sylvatica* and hornbeam *Carpinus betulus*, with trees kept at a distance that allowed the formation of a large canopy, providing food (acorn and nuts) and shelter for the grazing livestock. Other species, especially lime *Tilia*, wild pear *Pyrus*, apple *Malus* and cherry *Prunus avium,* were also often left to grow scattered. Pigs were fattenened especially on acorns ("Eichelmast"), and sometimes on beechnuts and wild apple, pear and cherry, which were known under the collective name "mast" (Siegmund 1948; Vera 2000). Ground vegetation was periodically cleared of shrubs in order to allow free movement for grazing animals.

The existence of German and Hungarian names for this kind of habitat in historical documents dating back to the 17th century (Szabó T.A. 1982, 2005) also support the idea of long-term existence of this management practice in this part of Transylvania. These include the German terms "Hutewald", "Hudewald", "Hutung", related to the cattle herder ("der Hüter"), "Weidewälder" is translated as pasture-forest. The Hungarian term "fáslegelő" is translated as pasture with trees, "legelőerdő" as pasture-forest and "makkos erdő" as acorn forest.

In Central and Eastern Europe wood-pasturing was a widespread and determinant land-use practice till the 19th-mid-20th century, when it was stopped as a result of agrarian reforms and changes in forestry and pasturing regulations that followed the increasing demand for timber and crop production (Saláta *et al.* 2009; Bergmeier *et al.* 2010). Modifications in the number of grazing animals (decrease in the number of cattle and increase in the number of sheep; National Institute of Statistics), collectivisation and nationalization of communal and private land, and the demand for increased productivity led to the abandonment of traditional practices and degradation of several wood-pastures during the Communist regime in Romania. Abandonment triggered the appearance of weeds and scrub, and the development of secondary woodland in many wood-pastures and their transformation into close canopy woodland, while other sites were affected by overgrazing. Short reports (Akeroyd 2003) and preliminary results (Mihai Eminescu Trust 2007) show that intensification of grazing, and later its abandonment, the cessation of regular mowing, and care for the establishment of younger oak generations, together with more recent improper interventions, *i.e.* dessiccation, uncontrolled tourism *etc.* have led to the degradation and overall loss in biodiversity value of the Breite wood-pasture, caused by decreased soil quality, lack of oak regeneration, ruderalisation *etc.*

The aim of the conducted research was to investigate the diversity, structure, physiognomy and floristic richness of plant communities encountered in the Breite wood-pasture. This was completed with literature study regarding the history of the area and traditional land-use practices relevant from the perspective of wood-pasture habitats in general. The information obtained from the field studies combined with the historical data was used to formulate recommendations for conservation management.

## Study area and methods

*Description of the study area*

The Breite wood-pasture is located in the middle section of the Târnava Mare River, part of the Transylvanian Tableland. It covers about 133 ha and is situated on the plateau bearing the same name and reflecting very well the open character of this habitat (Breite means „wideness" in German) nearby Sighişoara, Romania; center point coordinates: lat. 46.2011, lon. 24.7606; average elevation about 510 m a.s.l. The open area, with over 630 scattered or locally grouped mature oaks (*Quercus robur* and *Q. petraea*), out of which around 400 are several centuries old, is surrounded by a mixed deciduous Sessile Oak *Quercus petraea* and Hornbeam *Carpinus betulus* with Beech *Fagus sylvatica* forest (Mihai Eminescu Trust 2007; Fig. 1, 2). The wood-pasture was formed partially from the opening of this forest, protection of regrowth and plantings, trees being pollarded, promoting a larger and denser canopy (Siegmund 1948; Akeroyd 2003); all these were the characteristic land-use practices maintaining these habitats throughout Europe and also in Transylvania since the Middle Ages (Vera 2000; Rackham 2003; Oroszi 2004).

The soil types on the plateau are brown forest soils, podsols and clayey-illuvial and alluvial, with marshy character and gleying at the surface in the open area and transformation into pseudogley levigated stagnosol, which is an outcome of opening the original forest and the impermeability of the clay (Siegmund 1948). The limiting factor for the productivity of these soils are the fine texture, the lack of structure and aeration (reduced permeability) and the large difference of permeability between the illuvial horizon B and the upper horizon (Siegmund 1948). Siegmund even concludes that due to these harsh conditions, the oaks on the Breite are a special "ecotype", Akeroyd (2003) and Oroian (2009) mentioning *Quercus pedunculiflora*. Soil pH values measured in 2009–2011 varied between 5.2 and 6.5, decreasing with the distance from the main forestry road which is also a pathway for the grazing animals, therefore affected by cattle and sheep urine deposition.

The hydrology of the plateau is severely influenced by a drainage system built in the 1970s (Deppner 1995; Mihai Eminescu Trust 2007). Besides, the character of the vegetation on the Breite is strongly influenced by the 72 temporary ponds and several archeological ditches. The ponds have an average area of 57.8 $m^2$ (SD: 112.3 $m^2$), average depth of 17.76 cm (SD: 10.34 cm), are filled with water after snowmelt and abundant rainfall, desiccate several times per year and dry out completely in summer (Mihai Eminescu Trust 2007). The environmental characteristics, including pedology and climate, were presented in detail in the paper describing the flora of the Breite (Öllerer 2012).

*Vegetation history reconstruction*

The biodiversity of wood-pastures cannot be studied through ecological means alone. In order to clearly understand the present structures and features of a habitat and formulate sound recommendations for its further management it is necessary to find out its management history. Unfortunately, no written records were found regarding the former management of the Breite precisely, except some indications by Siegmund (1948). The reconstruction of the vegetation history is based therefore on his work and on the old maps and literature data that refer to the historical use of (wood)-pastures (*e.g.* Schuller 1895; Zsarolyáni 1897; Crofts, Jefferson 1999; Vera 2000; Rackham 2003; Bergmeier *et al.* 2010), but also on anecdotal evidence – oral history data from personal communication of locals. The following historical maps were used: 1st Ordnance Survey of the Habsburg Empire, also known as the Josephinian land register (1769–1773, scale 1: 28800); the 3rd Ordnance Survey of the Habsburg Empire (1869–1873, scale 1: 25000) and the topographical map realized by R.V. Gerzabek (Umgebungskarte von Schäßburg des SKV – Der Siebenbürgische Karpatenverein, early 20th c., 1: 25000). The present aspect of the area, in terms of openness and amount of woody vegetation is well shown by the Google Earth imagery.

*Phytosociological study*

The field research was conducted in the 2005–2011 period during the vegetation season. Relevé sampling was performed according to the recommendations for phytosociological studies of the school from Cluj, which is based on the methodology of the Central-European Phytosociological School and adapted for Romania (Braun-Blanquet 1964; Cristea *et al.* 2004). While choosing representative phytocoenoses, the number and size of relevés was adapted to the local conditions, therefore only homogenous areas were sampled and sometimes relevés were smaller than 25 × 25 m, the recommended size for grasslands (Cristea *et al.* 2004), since such large patches were only rarely encountered, neighbouring plant communities forming a diverse mosaic.

Plant species were identified in the field or based on collected material with the help of illustrated guides in use for the Romanian flora (Săvulescu

1952-1976, Ciocârlan 2009). Species nomenclature follows Flora Europaea (2001). The names of the associations are in accordance with the International Code of Phytosociological Nomenclature, 3rd edition (Weber *et al.* 2000). Syntaxonomic identification was based on Csűrös, Kovács (1962), Sanda *et al.* (1976, 2008), Doniţă (2005) and Oroian (2009). Data regarding bioforms and geoelements were obtained from Ciocârlan (2009); ecological parameters (UTR values) were obtained from Sanda *et al.* (2003); data regarding ploidy level was obtained from Oroian (2009) and the BiolFlor database on biological and ecological traits http://www2.ufz.de/biolflor/index.jsp (Klotz *et al.* 2002). Abundance-Dominance (AD) was estimated visually according to the Braun-Blanquet scale, modified and completed by Tüxen and Ellenberg, using the scores r, +, 1, 2, 3, 4, 5; constancy (K) was estimated visually according to the Braun-Blanquet system, using the scores I-V (Cristea 2004).

**Results and discussion**

*The vegetation history*

Although no records were found regarding the exact period when the Breite wood-pasture was created, several forestry registers cited by Siegmund (1948) and the historical maps, including suggestive toponyms (Fig. 1) offer valuable information regarding the history of its use. In the following, these are presented in chronological order:

- „Conditiones der Hirten und Hüter“ from 1721 mentions grazing with cattle and horses on the Breite in that period (Siegmund 1948);
- on the 1st Ordnance Survey (1769-1773) there is less open area than on the later representations and the present situation. There is only one toponym: “Kalte” (Fig. 1);
- according to a regulation from 1838 (Gub. Verordnung 1838/1009) forest grazing is banned, being allowed only on “kahlen Breite” and only for public herds (Siegmund 1948);
- in his work on the flora of Sighişoara, Fronius (1858) uses the toponym “Kahlen Breite”;
- the 3rd Ordnance Survey (1869-1873), on which scattered trees are clearly visible, mentions three toponyms besides “Breite”, referring to the northern part of the plateau: “Kulter B.” (Kulterberg on the later maps, Fig 1, left, zone B), “Aaker Breite” (the forest on the western side of the plateau) and “Wiesen B.” (the southern area, Fig 1, left, zone F). The map also provides information regarding the land-use: “H” (the German terms “Hutweide”, “Heide”, “Hutung” were used in the Ordnance Survey for the denomination of areas where livestock were taken out to graze). The forestry road is also clearly visible and the open area is larger than its actual state, and much larger than on the previous map, the open wood-pasture being considerably increased in length towards south (Fig. 1);
- an open grazing area is established on “kahle Breite” while the remaining part of the forest is placed entirely under grazing ban according to the 1879 Hungarian Forestry Act (Siegmund 1948);
- the topographical map realized by R.V. Gerzabek (Umgebungskarte von Schäßburg des SKV, early 20th c) mentions the toponyms “Kahle (Scobaten) Breite”, “Akersch-Breite” (at the western edge of the plateau, but in the forest) and “Grosser Garten” (south-western side of the plateau, again, in the forest);

The terms “Kalte” (1st OS), “Kahle” (Gerzabek) and “Kahlen” (Fronius) are denominating the same, northern area. The differences are probably the result of misspelling. The maps show an open area, while the German term “Kahle” means “bald”. Based on these representations, and on the existence of the well-developed veteran trees, with large canopies, most probably because they are open-growths, it can be presumed that the northern area of the Breite was an open wood-pasture since at least the mid-18th century. Today this area is indeed the “baldest”, lacking trees on a few hundred square meters (Fig 1, left, zone A). The terms “Aaker” (3rd OS) and “Akersch-Breite” (Gerzabek) are related to the medieval term “acker” that was used for places where pigs were taken out to feed on the mast (Vera 2000; Teşculă, Goţa 2007). “Aaker” means beechmast according to the Saxon dialect. The term “Wiesen B.” (3rd OS), denominating the southern open area of the plateau is probably referring to its character (“Die Wiese” stands for grassland, meadow in German). Today this is the most valuable area from the perspective of the ground vegetation (see the next section for details). The term “Scobaten” mentioned on the map realized by Gerzabek is most probably a misspelling of the latin term “scopa” (broom, branches tied together) and referring to the area where the spring celebration Skopationfest was organized (Teşculă, Goţa 2007). “Grosser Garten” (great garden in translation) might refer to the high number of wild fruit trees, especially pear in that part of the plateau (Teşculă, Goţa 2007).

Until the expropriations from 1924, the "kahle Breite" was used as a moderately grazed "Weidewald" (wood-pasture), since then it was managed as common land (Siegmund 1948). The evidence regarding the utilization of the grassland on the Breite in the 1914-1946 period is incomplete, however it is known that the area was alternately grazed or mowed, several plots being parceled out to the city (Siegmund 1948). Starting with the 1950s, the history of the Breite was one of degradation, the area being proposed as location for an airport, ploughed with the intention to transform it into a crop field, several veteran trees being cut and even dynamited and then pulled out to the edge of the open area (Teşculă, Goţa 2007). In the 1970s, Eckhard Hügel (1908-1977), a naturalist from Sighişoara, made several efforts to protect the Breite. Despite this, the detrimental intensive livestock farming was introduced (Schneider 2001), while the special character of the Breite has been further threatened by the construction of a drainage system (15 drainage ditches) in the 1970s. At the beginning of the 1980s an ammunition depot belonging to the Romanian Army was built on the Breite, while in 2001 the plateau was proposed as a location for the Dracula Park project, but following a strong international lobby based on local initiative, the project of the amusement park was dropped (Teşculă, Goţa 2007). On this occasion, several articles in protest were published highlighting the importance of this unique historical and cultural landscape (*e.g.* articles in *Schäßburger Nachrichten*, no. 16 in 2001).

As recognition of its biodiversity values, the Breite became gradually protected and designated as nature reserve ("Stejarii seculari de la Breite" – "The Breite ancient oak tree reserve") in 2000. In 2006, the Mihai Eminescu Trust and the Local Council of Sighişoara undertook the custody of the reserve, compiling also a management plan (Mihai Eminescu Trust 2007). In 2007, the entire plateau was included in the Natura 2000 network of protected areas, in the Sighişoara-Târnava Mare SCI and the larger Podişul Hârtibaciului SPA sites, and the legal custody of the reserve was transferred in 2010 to the administrator of these sites, the Association Progresul Silvic from Sibiu.

The connection between the Breite and the town of Sighişoara is therefore a historical one, the plateau being used as grazing area for pigs and cattle, supplying timber for buildings but also beautiful scenery for outdoor recreation and socio-cultural events, especially the Skopationfest, dating probably from Medieval times and organized almost every spring until 1939 (Siegmund 1948; Schneider 2001; Teşculă, Goţa 2007).

Although there are no historical records regarding the exact period when the Breite wood-pasture was created, the mentioned documents and the name of the area itself ("Breite" means wideness in German) show that grazing was practiced for several centuries on the Breite.The cited sources show that the Breite was used as a grazing area since at least 1721, however there is indirect evidence dating back to the 16$^{th}$ century, when grazing in woodlands became legally regulated (Oroszi 2004; Teşculă, Goţa 2007).

The differences regarding the size of the open area depicted on the 1$^{st}$ and 3$^{rd}$ Ordnance Survey, show that the Breite gained its current open character somewhere in between the second half of the 18$^{th}$ and second half of the 19$^{th}$ century. The most probable explanation for the increase of the open wood-pasture is the enforcement of the 1853 law proclaimed by Franz Joseph I that required the separation of forest and pasture areas between the squire and villains. As a result, several forests were opened and transformed into pastoral parkland areas suitable for larger scale grazing (Saláta *et al.* 2009). The fact that the area was more forested before the realisation of the 3$^{rd}$ Ordnance Survey is proved also by a tree auctioning organized in 1872 regarding oak and beech trees from the "Kahlen Breite" (Teşculă, Goţa 2007).

The maintenance of several hundred old-growth broad-canopy trees following the opening of the forest is determinant for the overall diversity and the present state of the ground vegetation in particular, these veteran trees providing a characteristic microclimate with a great variety of light and humidity conditions, and increased soil nutrient values (Bergmeier *et al.* 2010).

*The current status of the vegetation and correspondence to Natura 2000 habitat types*

According to the classification of Bergmeier *et al.* (2010), the Breite is a wood-pasture habitat type *5*, with the characteristic species: *Fagus sylvatica*, *Quercus petraea*, *Q. robur* and *Carpinus betulus* with traditional land-uses include pollarding, lopping and shredding, while the representative animals are: cattle, pigs, sheep, horses and deer.

Although not recognised on the whole as a habitat according to the Natura 2000 classification, Bergmeier *et al.* (2010) highlighting several inconsistencies of this system from the perspective of wood-pastures, the following habitats have been identified on the Breite plateau: 6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) in the open area (Fig. 3, left) and 9170 Galio-Carpinetum oak-hornbean forests, surrounding the actual wood-pasture (Fig. 3, right). In the Romanian classification, the habitat 6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) corresponds to R3716 – Danubian-pontic grasslands with *Poa pratensis*, *Festuca pratensis* and *Alopecurus pratensis* and R3802 – Daco-getic *Arrhenatherum elatius* grasslands (Doniţă *et al.* 2005). 9170 Galio-Carpinetum oak-hornbean forests, corresponds in the Romanian classification (Doniţă *et al.* 2005) to R4123 Dacic sessile oak (*Quercus petraea*), beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*) forests with *Carex pilosa*.

Following the field studies conducted in 2005-2011, 17 plant associations have been identified on the Breite. The syntaxonomic checklist of these associations was compiled according to Sanda *et al.* (2008) and Oroian (2009):

LEMNETEA O. de Bolós et Masclans 1955
LEMNETALIA MINORIS O. de Bolós et Masclans 1955
Lemnion minoris O. de Bolós et Masclans 1955
1. *Lemnetum minoris* Oberdorfer ex T. Müller et Görs 1960
PHRAGMITETEA AUSTRALIS R. Tüxen et Preising 1942
MAGNOCARICETALIA Pignatti 1953
Magnocaricion elatae Koch 1926
Caricenion gracilis (Neuhäusl 1959) Oberdorfer et al. 1967
2. *Caricetum acutiformis* Eggler 1933 (Syn.: Caricetum acutiformis-ripariae Soó 1947)
3. *Caricetum vesicariae* Chouard 1924
BIDENTETEA TRIPARTITI
BIDENTETALIA TRIPARTITI Br. ‑ Bl. et R. Tüxen ex Klika et Hadač 1944
Bidention tripartiti Nordhagen 1940 em. R. Tüxen in Poli et J. Tüxen 1960
4. *Bidenti-Polygonetum hydropiperis* Lohmeyer in R. Tüxen 1950
MOLINIO-ARRHENATHERETEA R. Tüxen 1937
MOLINIETALIA CAERULEAE Koch 1926
Calthion R. Tüxen 1937 em. Balátová-Tuláčková 1978
Calthenion (R. Tüxen 1937) Balátová-Tuláčková 1978
5. *Scirpetum sylvatici* Ralski 1931
Agrostion stoloniferae Soó (1933) 1971
6. *Agrostetum stoloniferae* (Ujvárosi 1941) Burduja et al. 1956 1958 (Syn.: *Rorippo sylvestris-Agrostietum stoloniferae* (Moor 1958) Oberdorfer et Th. Müller 1961)
7. *Cirsio cani-Festucetum pratensis* Májovsky ex Ružičková (Syn.: *Festucetum pratensis* Soó 1938)
ARRHENATHERETALIA R. Tüxen 1931
Arrhenatherion Koch 1926
8. *Arrhenatheretum elatioris* Br.-Bl. Ex Scherrer 1926
9. *Anthoxantho-Agrostietum capillaris* Sillinger 1933
POTENTILLO ‑ POLYGONETALIA R. Tüxen 1947
Potentillion anserinae R. Tüxen 1937
10. *Ranunculetum repentis* Knapp ex. Oberdorfer 1957
Juncenenion effusi Westhoff et van Leeuwen ex Hejný et al. 1979
11. *Juncetum effusi* Soó (1931) 1949 (Syn.: *Epilobio palustri-Juncetum effusi* Oberd. (1953) 1957)
12. *Junco inflexi-Menthetum longifoliae* Lohmeyer 1953
DESCHAMPSIETALIA CAESPITOSAE Horvatić 1956
Deschampsion caespitosae Horvatić 1930
13. *Agrostio-Deschampsietum caespitosae* (Soó 1928) Ujvárosi 1947 (Syn.: *Deschampsietum caespitosae* Hayek et Horvatič 1930)
PLANTAGINETEA MAJORIS R. Tüxen et Preising 1950
PLANTAGINETALIA MAJORIS R. Tüxen et Preising in R. Tüxen 1950
Lolio-Plantaginion R. Tüxen 1947
14. *Juncetum tenuis* Schwik 1944 (Syn.: *Juncetum macri* (Diemont et al. 1940) R. Tüxen 1950)
ARTEMISIETEA VULGARIS Lohmeyer et al. in R. Tüxen 1950
ONOPORDETALIA ACANTHII Br. ‑ Bl. et R. Tüxen ex Klika et Hadač 1944
Arction lappae R. Tüxen 1937
15. *Tanaceto-Artemisietum* Sissingh 1950
GALIO-URTICETEA Passarge 1967 em. Kopecký 1969
LAMIO ALBI-CHENOPODIETALIA BONI-HENRICI Kopecký 1969
Aegopodion podagrariae R. Tüxen 1967
16. *Urtico-Aegopodietum* R. Tüxen ex Görs 1963 (Syn.: *Urtico dioicae ‑ Aegopodietum podagrariae* R. Tüxen ex Görs 1963)

ALNETEA GLUTINOSAE Br. - Bl. et R. Tüxen ex Westhoff et al. 1946
SALICETALIA AURITAE Doing ex Westhoff et Den Held 1969
Salicion cinereae Th. Müller et Görs ex Passarge 1958
17. *Calamagrostio-Salicetum cinereae* Soó et Zólyomi in Soó 1955

1. *Lemnetum minoris* Oberdorfer ex T. Müller et Görs 1960, frequent in the water bodies from oak and beech forests, was identified in the southern part of the Breite, close to the forest edge (zone F). It presents only a small number of species, besides the characteristic *Lemna minor* (AD: 4, 4-5) only *Alisma plantago-aquatica, Epilobium palustre* and *Glyceria fluitans* were recorded. Nr. of relevés: 2, sampling area: 4 m$^2$, vegetation cover: 60-70 %, total nr. of species: 4.

2. *Caricetum acutiformis* Eggler 1933 was identified at the edge and the area nearby two drainage ditches in zone D. Besides *Carex acutiformis* (AD: 5), the most abundant species were *Agrostis solonifera, Deschampsia caespitosa, Lysimachia vulgaris, Lythrum salicaria* and *Juncus conglomeratus.* Nr. of relevés: 2, sampling area: 20 and 25 m$^2$, vegetation cover: 90 and 100 %, total nr. of species: 26.

3. *Caricetum vesicariae* Chouard 1924 (Fig. 4, left) was identified in one large wet area in the southern part of the Breite (zone D). Besides the dominant *Carex vesicaria* (AD: 5) several other species were found, but in considerably smaller number, and mainly at the edge of the relevé, including: *Agrostis stolonifera*, *Carex cespitosa*, *C. elata*, *C. vulpina*, *Deschampsia caespitosa*, *Epilobium palustre*, *Juncus effusus*, *Lysimachia vulgaris*, *Polygonum hydropiper*, *Ranunculus acris*, *Scirpus sylvaticus*, *Scutellaria galericulata*. Nr. of relevés: 2, sampling area: 25 m$^2$, vegetation cover: 100 %, total nr. of species: 23.

4. *Bidenti-Polygonetum hydropiperis* Lohmeyer in R. Tüxen 1950 was identified in the shallow parts of some drainage ditches and on the dirt road from the southern part of the area (zones E and F). These habitats are filled up with water in spring after snowmelt, but dry out at the end of summer and autumn. The characteristic species *Bidens tripartita* (AD: +) and *Polygonum hydropiper* (AD: 3) are seconded by *Juncus effusus, Lycopus europaeus*, *Lysimachia nummularia*, *Poa palustris*, *Ranunculus repens*, *Urtica dioica* etc. Nr. of relevés: 3, sampling area: 8, 10 and 10 m$^2$, vegetation cover: 60-80 %, total nr. of species: 24.

5. *Scirpetum sylvatici* Ralski 1931 was identified forming short strips in the partially shaded zones close to the clear-cut area and on the dirt road from the southern part of the area, where the soils have excessive humidity almost all the year (zones E and F). The dominance of *Scirpus sylvaticus* (AD: 3-4–4) and the elongated shape of the stands allows the presence of only a small number of other species, most of which appeared from the surrounding communities, including *Agrostis stolonifera, Epilobium palustre*, *Festuca rubra*, *F. pratensis*, *Filipendula ulmaria*, *Juncus articulatus*, *Galium uliginosum*, *Lysimachia nummularia*, *Lythrum salicaria, Polygonum hydropiper.* Nr. of relevés: 3, sampling area: 10 and 12 m$^2$, vegetation cover: 65-70 %, total nr. of species: 21.

6. *Agrostetum stoloniferae* (Ujvárosi 1941) Burduja et al.1956 1958 (Syn.: *Rorippo sylvestris-Agrostietum stoloniferae* (Moor 1958) Oberdorfer et Th. Müller 1961) was identified in zones D and E. Besides the dominant *Agrostis stolonifera* (AD: 4-5), other recorded species include *Achillea millefolium*, *Alopecurus pratensis*, *Deschampsia caespitosa*, *Festuca pratensis*, *Lychnis flos-cuculi*, *Poa pratensis*, *Ranunculus repens*, *Stellaria graminea*, *Trifolium pratense* etc. Nr. of relevés: 4, sampling area: 25 m$^2$, vegetation cover: 80-90 %, total nr. of species: 56.

7. *Cirsio cani-Festucetum pratensis* Májovsky ex Ružičková (Syn.: *Festucetum pratensis* Soó 1938) was identified in zones C and D. *Festuca pratensis* (AD: 3), *Agrostis stolonifera* (AD: 1), *Alopecurus pratensis* (AD: 1) and *Cirsium canum* (AD: +) form the superior vegetation layer, with heights up to 100-120 cm. Other species present include *Holcus lanatus, Lotus corniculatus*, *Lysimachia nummularia, Ranunculus acris*, *Rumex acetosa, Trifolium repens* etc. Nr. of relevés: 3, sampling area: 20 and 25 m$^2$, vegetation cover: 80 and 90 %, total number of species: 51.

8. *Arrhenatheretum elatioris* Br.-Bl. Ex Scherrer 1926 was identified in zones D and F. This is one of the most vulnerable communities from the area, being negatively influenced by grazing. It includes most of the vulnerable or rare species from the Breite, namely: *Achillea ptarmica*, *Gentiana pneumonanthe*, *Gymnadenia conopsea* and *Sanguisorba officinalis* (Öllerer 2012). Besides *Arrhenatherum elatius* (AD: 2-3), the following characteristic species have been encountered:

*Achillea millefolium, Agrostis capillaris*, *Briza media, Campanula patula* ssp. *patula*, *Knautia arvensis*, *Stellaria graminea* etc. Nr. of relevés: 3, sampling area: 25 $m^2$, vegetation cover: 70 and 100 %, total nr. of species: 57.

9. *Anthoxantho-Agrostietum capillaris* Sillinger 1933 was identified in zones D, E and F. The dominant species *Agrostis capillaris* (AD: 3), *Anthoxanthum odoratum* (AD: 2-3), together with *Campanula patula* ssp. *patula, Dactylis glomerata* and *Leucanthemum vulgare* form the superior vegetation level, shorter species including *Trifolium repens* and *Veronica chamaedrys*. Nr. of relevés: 4, sampling area: 25 $m^2$, vegetation cover: 90 and 100 %, total nr. of species: 54.

10. *Ranunculetum repentis* Knapp ex. Oberdorfer 1957 was identified in zones D, E and F, in areas of excessive humidity close to the drainage ditches and in shallow soaks that dry out completely in the summer. The floristic composition is quite species-poor due to the dominant *Ranunculus repens* (AD: 3-4–4) which develops fast and covers significant areas by the means of its stolons. Other species encountered: *Agrostis stolonifera*, *Polygonum aviculare*, *Potentilla reptans, Trifolium repens* etc. Nr. of relevés: 3, sampling area: 6, 8 and 10 $m^2$, vegetation cover: 70-85 %, total nr. of species: 17.

11. *Juncetum effusi* Soó (1931) 1949 (Syn.: *Epilobio palustri-Juncetum effusi* Oberd. (1953) 1957) (Fig. 4 right) was identified all around the area, due to the influence of cattle grazing, but its most representative stands were encountered in the drainage ditches from zones D, E and F. Besides *Juncus effusus* (AD: 3-4) other species recorded include *Agrostis capillaris, Deschampsia caespitosa, Lysimachia nummularia, L. vulgaris, Lythrum salicaria, Potentilla anserina*. Nr. of relevés: 4, sampling area: 10, 25 and 25 $m^2$, vegetation cover: 70-80 %, total nr. of species: 36.

12. *Junco inflexi-Menthetum longifoliae* Lohmeyer 1953 was identified in zones D and E in places disturbed and trampled by grazing cattle and sheep. The dominance of *Juncus inflexus* (AD: 4) allows the presence of only a few other species, including: *Agrostis stolonifera, Lysimachia nummularia*, *Potentilla reptans Ranunculus repens* and *Trifolium repens*. Nr. of relevés: 3, sampling area: 10, 16 and 20 $m^2$, vegetation cover: 70-85 %, total nr. of species: 26.

13. *Agrostio-Deschampsietum caespitosae* (Soó 1928) Ujvárosi 1947 (Syn.: *Deschampsietum caespitosae* Hayek et Horvatič 1930) is the most widespread, and thus the characteristic association of the Breite wood-pasture. Its most representative stands were encountered in zones A, D and F. *Deschampsia caespitosa* is monodominant in several patches during summer drought (Fig. 5). The association usually develops on flat or slightly inclined areas from the hilly region, on humic gley soils that are humid or wet throughout the year (Csűrös *et al*. 1985). The spectrum of bioforms (Fig. 6, left) based on the studied relevés, with the dominance of hemicriptophytes (75 %), that of the geoelements (Fig. 6, right), with the dominance of Eurasian floristic elements (51.56 %) and that of the ecological categories (Fig. 7), with the large number of mesophilous-mesohygrophilous ($U_4$ = 29.67 %), micro-mesothermal ($T_3$ = 54.69 %) and amfitolerant and acid-neutrophilous ($R_0$ = 57.81 % and $R_3$ = 21.88 %) species corresponds to the analysis of Csűrös *et al*. (1985) regarding this association, to the analysis of Öllerer (2012) regarding the flora of the Breite and also to the analysis of Oroian (2009) regarding the flora of the wider region. Nr. of relevés: 5, sampling area: 25 $m^2$, vegetation cover: 80-100 %, total nr. of species: 64 (Table 1).

14. *Juncetum tenuis* Schwik 1944 (Syn.: *Juncetum macri* (Diemont et al. 1940) R. Tüxen 1950) is the most frequently encountered anthropic association from the Breite, covering relatively large areas in zones A, E and F. It is present in the shape of narrow strips on the pathways and along the forestry road, forming several patches nearby football field and the sites around, especially in the semi-shaded areas with some excess of humidity. The recorded species include *Bellis perennis, Juncus tenuis* (AD: 3-4), *Poa annua, Plantago major, Prunella vulgaris Ranunculus repens, Taraxacum officinale* and *Trifolium repens.* Nr. of relevés: 3, sampling area: 4-6 $m^2$, vegetation cover: 65-80 %, total nr. of species: 19.

15. *Tanaceto-Artemisietum* Sissingh 1950 was recorded in zone A, however the most recent anthropic influences (widened forestry road, excavations *etc*.) seem to favour the spread of this association. The stands are dominated by *Artemisia vulgaris* (AD: 3-4), other species include *Achillea millefolium, Aegopodium podagraria, Cichorium intybus, Convolvulus arvensis, Tanacetum vulgare*. Nr. of relevés: 2, sampling area: 12 and 8 $m^2$, vegetation cover: 65-70 %, total nr. of species: 20.

16. *Urtico-Aegopodietum* R. Tüxen ex Görs 1963 (Syn.: *Urtico dioicae-Aegopodietum podagrariae*

R. Tüxen ex Görs 1963) was recorded in zones A and B in the most disturbed areas of the Breite. Besides *Urtica dioica* (AD: 4-5) and *Aegopodium podagraria* (AD: 3-4), also *Chaerophyllum aromaticum*, *Galium aparine*¸ *Glechoma hederacea* and *Lamium album* have been recorded. Nr. of relevés: 3, sampling area: 6, 10 and 10 $m^2$, vegetation cover: 70-80 %, total nr. of species: 23.

17. *Calamagrostio-Salicetum cinereae* Soó et Zólyomi in Soó 195 was recorded in zones E and F. *Salix cinerea* (AD: 3-4) dominates the stands, other species include: *Angelica sylvestris, Calamagrostis canescens, Deschampsia caespitosa, Frangula alnus, Galium aparine*, *Lycopus europaeus* and *Polygonum bistorta*. Nr. of relevés: 3, sampling area: 25 $m^2$, vegetation cover: 80-90 %, total nr. of species: 20.

The vegetation of the Breite has an overall mesophilous and mesohygrophilous character, determined by the marshy character of the soil, still maintained in the southern area despite the desiccation interventions, and by the slightly low pH. This character is shown by the fact that over 50% of the flora consists of mesophilous and mesohygrophilous species (Öllerer 2012), and that 9 out of the 17 identified associations belong to the Class *Molinio-Arrhenatheretea*. The class can be encountered on gleysoils that are mesic during most of the vegetation period and its characteristic and dominant grass species include *Alopecurus pratensis, Deschampsia caespitosa, Festuca arundinacea, F. pratensis, Poa pratensis etc*. These mesotrophic grasslands from the hilly areas are usually used as pastures or hay meadows, therefore their species composition and character is strongly influenced by human activity (Sanda *et al*. 2008). This finding and the occurrence of species like *Gentiana pneumonanthe*, *Succisa pratensis*, *Inula britannica etc.*, indicating good quality pastures and the great variety of species (Öllerer 2012) shows that the ground vegetation of the Breite is also valuable, and its state could be improved by continuing the traditional extensive grazing in combination with mowing.

In the absence of permanent water source, besides the climatic factors (amount of precipitation), the temporary ponds, drainage and archaeological ditches have a decisive role in the hydrology of the Breite plateau, with an important impact on the ground vegetation. Most of the (meso) hygrophilous species are nowadays limited to these increasingly rare temporary aquatic habitats, or the areas nearby, despite the fact that the Breite was more humid in the past, prior to the construction of the drainage system (Siegmund 1948; Deppner 1995). Sedges (*Carex* sp.) are the characteristic and almost monodominant species of the temporary ponds (e.g. *Caricetum acutiformis* and *Caricetum vesicariae* in zone D and *Carex brizoides* in zone F, close to the forest), while rushes (*Juncus* sp.) are present mainly in the ditches, contributing to the overall mosaic-like character of the vegetation. The number of associations is further increased by the presence of anthropic communities and those reflecting the abandonment of the traditional shrub clearing activities that define wood-pasture use.

*Traditional mananagement practices in the past and at present time*

After a gradual decrease of pannaging on the Breite, justified with the bad acorn production, pigs were taken out to feed on acorns only till the first decades of the 20th century, after which this historical practice determinant for wood-pastures was completely abandoned due to changes in agricultural practices (Siegmund 1948).

Although sheep were not widespread in the traditional Saxon grazing practice, the inhabitants preferring cattle, horses and pigs (Schuller 1895; Dorner 1910), Eckhard Hügel noted in the 1970s that *Gentiana pneumonanthe* was disappearing as a result of sheep grazing pressure, while in 1972 Hedwig Deppner pointed out the risks of nitrogen fertilization on the specific flora of the Breite (Deppner 1995; Schneider 2001). Besides, the grazing periods also changed, becoming longer. Grazing was traditionally done only in certain periods, delimited by celebrations of different saints, but adapted yearly to the particular weather conditions, which is again a proof that the spiritual and cultural aspects of life were embedded in the landscape management practices. For example, sheep grazing was not recommended during the dry season when the animals pull out the plants (Zsarolyáni 1897), therefore grazing with sheep was allowed around Sighişoara only before St. George's Day (24th April) and from the end of August, but often only after St. Michael's Day (29th September), or even St. Martin's Day (11th November). The period in between the areas were mowed or grazed with cattle and horses, allowing the vegetation time to regenerate (Schuller 1895, Dorner 1910). The Breite was characteristically maintained by extensive grazing, however, this practice was completely stopped for management reasons in 2006, after a short period of almost complete reduction (2004–2006), because it became detrimental after about three decades of intensive grazing. This triggered a fast process of shrub encroachment, mainly with hornbeam saplings invading from the surrounding forest, and the expansion of willows. Secondary woodland development – the fast regeneration of hornbeam – is one of the main threats for the open character of the Breite and other wood-pastures in the region. Extensive grazing with cattle was reintroduced in 2008, while grazing with sheep and goats was reintroduced in 2009, as part of the biodiversity conservation strategy (Mihai Eminescu Trust 2007). It is important to stress out that sheep had only a small role in the traditional Saxon farming practice, while goats had even less, being often banned to graze in open areas or their keeping was completely prohibited (Dorner 1910). Oak saplings die back as a result of biomass removal caused by close grazing with sheep and goats (Dorner 1910, Vera 2000).

Despite the fact that regular mowing on the Breite was practiced even in the first decades of the 20th century (Siegmund 1948), it was later applied only occasionally. During its custody (2006–2010), the Mihai Eminescu Trust carried out experimental mowing, but the short time and lack of periodicity did not have any particular effect.

Modifications in the traditional management regime (changes in stock rates – intensification of grazing in certain periods, grazing species – favouring sheep and goats instead of cattle and horses, temporary abandonment of grazing and mowing, uncontrolled tourism *etc.*) can produce significant changes in the ground vegetation within a very short time, as shown by the experience of the last years on the Breite. Therefore, consideration of knowledge regarding traditional practices, their maintenance, reintroduction or inconsideration and abandonment will shape the ground vegetation of the Breite in the future.

*Prospects*

When discussing the prospects of the future management of the Breite, and other similar wood-pastures, during the setup of a (conservation) management strategy two main targets can be distinguished, both beneficial for biodiversity conservation, but from obviously different perspectives: (i) allowing spontaneous secondary woodland development, contributing as such to the increase in the cover of deciduous forests at the expense of losing several open landscape species, and (ii) maintenance of the open wood-pasture, in accordance with the increasing interest for traditional cultural landscapes. Both directions would be beneficial for ecological and economical reasons, but with very different outcomes from the perspective of the ground vegetation, the veteran trees and all associated flora and fauna that can be now encountered on the Breite.

Secondary woodland development, without any intervention for the maintenance of veteran trees and ensuring renewal – the potentially large and old trees for the future, would result in the loss of the old-growth value and the habitat heterogeneity and species diversity connected with it. Oaks cannot regenerate well under closed canopy, the development of saplings being facilitated by low intensity grazing with cattle and pigs (traditional livestock in the Saxon society), mowing, by establishment in brushwood and thorny scrub or artificially, by protecting them with fences (Vera 2000, Johnson *et al*. 2009). For this reason, the lack of any intervention is not recommended considering the fact that the loss of such old organisms represents a potential threat to ecosystem integrity, since the unique ecological roles played by veteran trees cannot be provided by younger, smaller trees (Lindenmayer *et al*. 2012). Besides, European landscapes have been shaped by human communities for millennia, leading to the development of a specific biodiversity, for which the interference of man is crucial (Plieninger 2007). Therefore, the transformation into a closed forest where natural forest dynamic processes are combined with the protection of individual old trees and the facilitation of permanent old-growth represents one viable further management direction.

The second major direction is built up on the present heterogenous state of the wood-pasture, with a predominantly open character, allowing the presence of mesophilous grassland vegetation with scattered or locally grouped large old trees. This would maintain also the historical character of the area, namely a grazing site, since forest grazing cannot be seen as a potential way further, considering that it is legally forbidden and allowed only in exceptional cases (Romanian Law No. 46/2008 – the Forestry Code, article 53, § 1-2). In this way, the continuation of a disappearing traditional practice would be also ensured. However, in order to achieve this, the required maintenance practices should be applied regularly, including reintroduction of the extensive grazing with cattle, horses, (pigs?) and much less sheep and goats, periodical pasture clearings and reintroduction of mowing (Akeroyd 2003; Mihai Eminescu Trust 2007; Öllerer 2012). Besides, the open wood-pasture scenario would be beneficial also from the perspective of ecological education and well-planned ecotourism, helping to restore the historical link between local communities and visitors and nature, as already seen in the last years (www.rezervatia-breite.ro). The scattered distribution of the large (veteran) trees makes their observation much easier than in closed forest conditions. These characteristics and the closeness to villages and towns, being usually easily accessible by foot or cycling, make wood-pastures ideal locations for outdoor education and recreation. Their need for constant management, including grazing, mowing, removal of tall-grown shrubs, protection of saplings through fencing and sometimes even plantings *etc*., provide various opportunities for children to learn about nature conservation by active participation. Most of the management practices and interventions that would ensure the maintenance of the present state of the Breite, including the reduction of the threatening factors were included in the Management Plan (Mihai Eminescu Trust 2007).

## Conclusions

Wood-pastures are a historical landscape element, and as such, the issue of their conservation must have a strong historical approach, supported by information gathered from a great variety of sources, including old written documents, maps, photographs and even the memories of the users, bearers of the traditional knowledge that formed the basis of the applied land-use practices.

The (vegetation) history of the Breite has been determined by the interaction of different socio-economic driving forces acting at the global (*e.g.* increased need for timber) to the local scale (traditional practices and ownership) in close connection with the local and landscape environmental attributes. The present mesophilous vegetation and the character (in terms of openness) of the Breite as a whole dates back only to the end of the 19$^{th}$ century. The accelerated changes in the last less than 150 years, including the extension of the wood-pasture at the end of the 19$^{th}$ century, the different management interventions starting with the second half of the 20$^{th}$ century (ploughing, desiccation, intensive grazing *etc.*) or lack of these (abandonment of grazing and mowing) resulted in a flora and vegetation comprising species with very diverse ecological requirements. *Agrostio-Deschampsietum caespitosae* (Soó 1928) Ujvárosi 1947 can be considered the characteristic association of the Breite wood-pasture at a large scale (Csergő 2007), however a more detailed study revealed the presence of several other associations. The present paper showed that despite the fact that the Breite is renowned for its veteran oaks, the herbaceous vegetation is also relatively diverse, though not rich in endangered species (Öllerer 2012) or rare communities. Conservation efforts usually focus on rare and / or threatened species and communities, however the importance of common species is increasingly acknowledged, on the basis that these are the organisms to shape the structure and functioning of communities (Gaston 2010). From this perspective, the importance of the heterogenous ground vegetation in its contribution to the biodiversity value of the entire wood-pasture and the wider region is even more apparent.

Considering these findings, the rapid shift in socio-economic conditions, the different potential directions of further management, and the obvious scenario of ruderalisation and secondary woodland development in only a few decades with the lack of any intervention, conservation management should try to follow and adapt to these dynamics. Its main objective should thereby remain the maintenance of ecological, socio-cultural and socio-economical values of this historical landscape.

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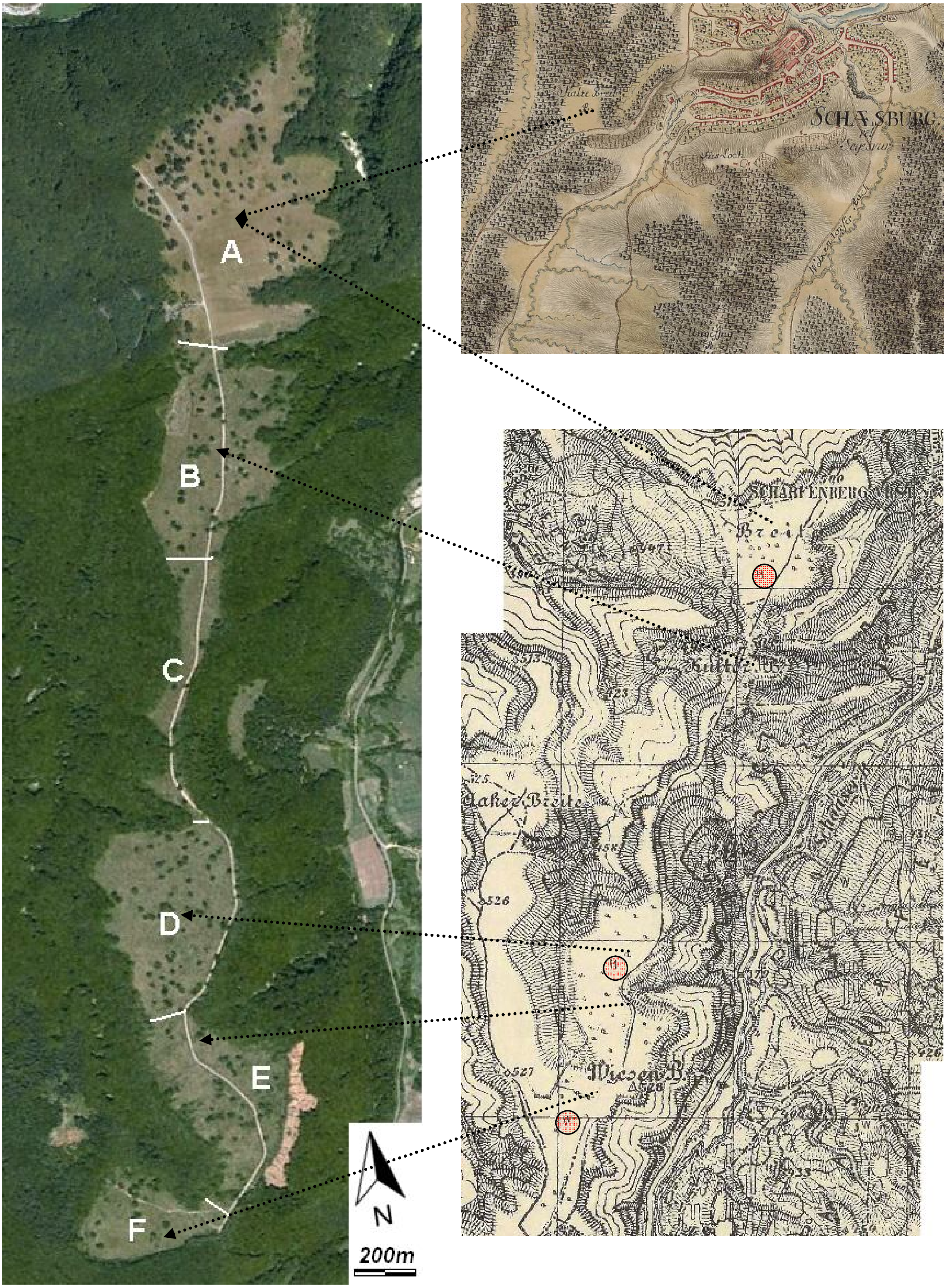


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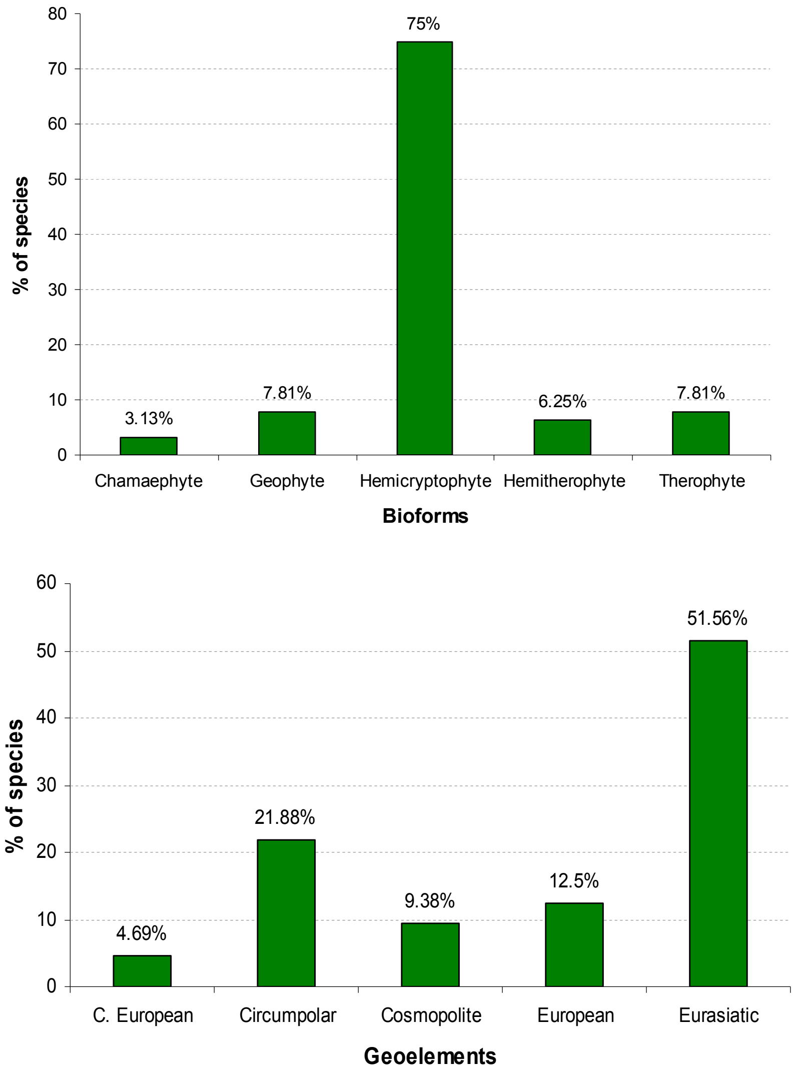


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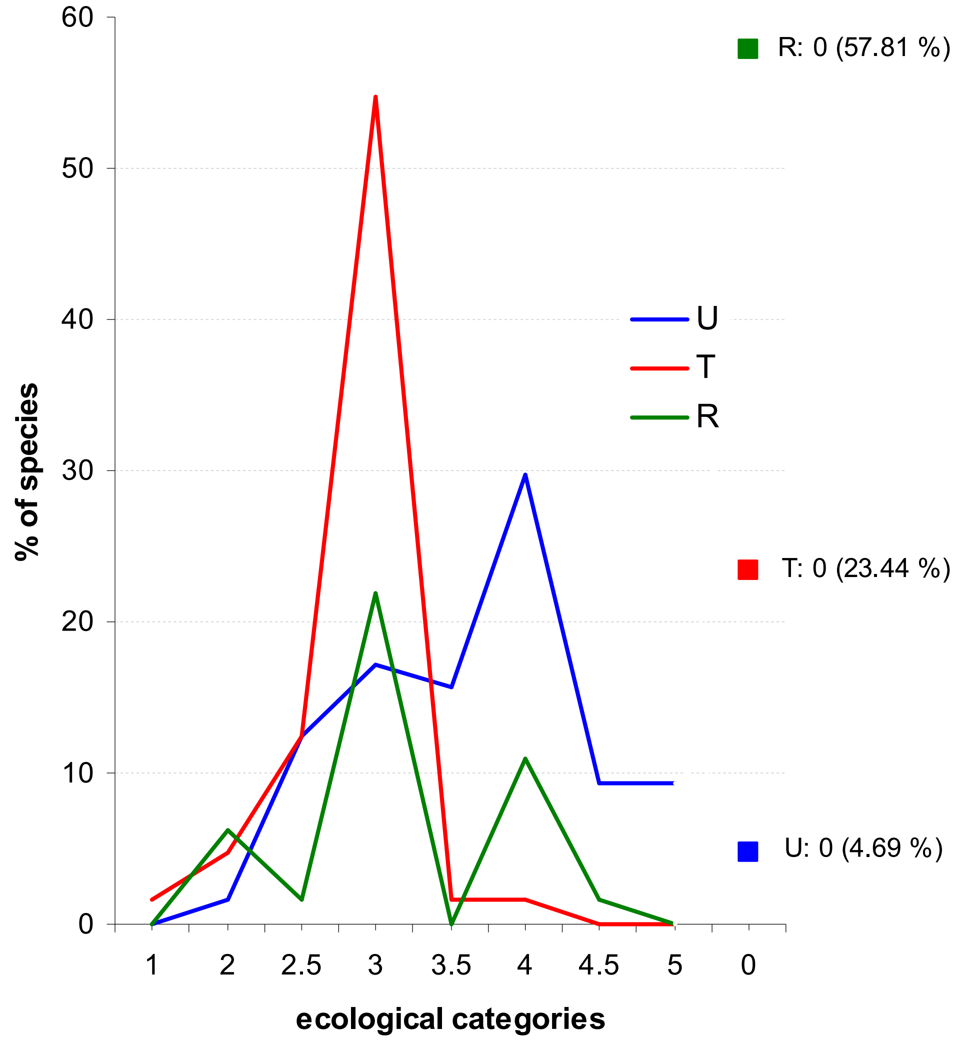


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**Tab. 1.** *Agrostio-Deschampsietum caespitosae* (Soó, 1928) Ujvárosi 1947 (Syn.: *Deschampsietum caespitosae* Hayek et Horvatič 1930)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Relevé number** | **1*** | **2** | **3** | **4** | **5** | |
| | | | | | | **Vegetation cover (%)** | **100** | **100** | **95** | **90** | **100** | |
| | | | | | | **Sampling area ($m^2$)** | **25** | **25** | **25** | **25** | **25** | |
| Bioforms | Geoelements | U | T | R | 2n | Species | | | | | | K |
| H | Cosm | 4 | 0 | 0 | D | *Deschampsia caespitosa* | 5 | 5 | 4-5 | 5 | 4 | V |
| H | Circ | 4 | 0 | 0 | P | *Agrostis stolonifera* | 1 | + | + | + | . | IV |
| H | Euras | 3 | 0 | 0 | P | *Achillea millefolium* | . | . | + | . | + | II |
| H | Euras | 2.5 | 3 | 4 | P | *Agrimonia eupatoria* | + | + | . | . | + | III |
| H | Circ | 0 | 0 | 0 | P | *Agrostis capillaris* | . | . | + | . | . | I |
| H | Eur | 3.5 | 2.5 | 0 | P | *Ajuga reptans* | + | . | + | + | . | III |
| H | Euras | 4 | 3 | 0 | P | *Alopecurus pratensis* | + | . | . | . | . | I |
| Ht-H | Euras | 4 | 3 | 3 | D | *Angelica sylvestris* | . | + | + | . | + | III |
| H | Euras | 0 | 3 | 0 | D | *Briza media* | . | . | + | + | + | III |
| Ht | Eur | 3 | 2.5 | 3 | D | *Campanula patula* ssp. *patula* | . | + | 1 | . | . | II |
| G | Circ | 0 | 3 | 0 | P | *Carex hirta* | 1 | + | . | + | . | III |
| G | Circ | 4 | 3 | 2 | P | *Carex nigra* | . | + | + | . | + | III |
| H | Circ | 4 | 2.5 | 3 | P | *Carex ovalis* | + | + | + | . | . | III |
| H | Eur | 3 | 2.5 | 3 | P | *Centaurea phrygia* | + | + | + | . | + | IV |
| G | Euras | 4.5 | 3 | 4.5 | D | *Cirsium canum* | . | . | + | . | + | II |
| Ht | Euras | 4.5 | 3 | 2.5 | D | *Cirsium palustre* | + | + | . | . | . | II |
| H | C. Eur | 4 | 3.5 | 0 | D | *Cirsium rivulare* | . | . | + | . | . | I |
| H | C. Eur | 2.5 | 3 | 3 | P | *Dactylis glomerata* | . | . | . | + | + | II |
| H | Circ | 5 | 0 | 2 | P | *Epilobium palustre* | . | + | + | . | . | II |
| H | Eur | 4 | 3 | 4 | P | *Festuca arundinacea* | . | . | + | . | + | II |
| H | Euras | 4 | 2 | 0 | D | *Filipendula ulmaria* | . | . | . | . | + | I |
| T | Euras | 3 | 0 | 0 | P | *Galeopsis bifida* | + | . | . | + | . | II |
| H | Eur | 2.5 | 2.5 | 3 | P | *Galium album* ssp. *album* | . | . | + | + | . | II |
| H | Circ | 5 | 3 | 0 | D-P | *Galium palustre* | . | + | + | . | . | II |
| Ch | Eur | 2.5 | 3 | 2 | P | *Genista tinctoria* ssp. *tinctoria* | . | + | + | . | + | III |
| H | Euras | 4 | 3 | 0 | D | *Gentiana pneumonanthe* | . | . | + | . | . | I |
| H | Euras | 2 | 3 | 4 | P | *Hieracium cymosum* | . | . | . | . | + | I |
| H | Eur | 3 | 3 | 3 | P | *Hieracium murorum* | . | + | + | . | . | II |
| H | Cosm | 3.5 | 3 | 0 | D | *Holcus lanatus* | . | + | + | . | . | II |
| Ht | Euras | 3 | 3 | 0 | P | *Inula Britannica* | . | . | + | . | . | I |
| H | Circ | 4.5 | 3 | 3 | P | *Juncus conglomeratus* | + | + | 1 | . | . | III |
| H | Cosm | 4.5 | 3 | 3 | P | *Juncus effuses* | 1 | + | . | + | + | IV |
| H | Euras | 3 | 0 | 0 | D | *Leucanthemum vulgare* | . | + | + | . | . | II |
| H | Euras | 2.5 | 0 | 0 | P | *Lotus corniculatus* | . | . | + | + | . | II |
| H | Euras | 3.5 | 2.5 | 0 | D | *Lychnis flos-cuculi* | + | + | + | . | . | III |
| H (Hh) | Euras | 5 | 3 | 0 | D | *Lycopus europaeus* | + | + | . | . | . | II |
| Ch | Euras | 4 | 3 | 3 | P | *Lysimachia nummularia* | + | + | + | . | . | III |
| H | Euras | 5 | 2 | 0 | P | *Lysimachia vulgaris* | + | + | + | . | . | III |
| H | Circ | 4 | 2.5 | 0 | P | *Lythrum salicaria* | . | + | + | . | + | III |
| H (G) | Circ | 3 | 3 | 0 | P | *Mentha arvensis* | + | . | + | . | . | II |
| H | Euras | 4.5 | 3 | 4 | P | *Mentha longifolia* | . | . | . | + | . | I |
| H | Euras | 5 | 3 | 0 | P | *Myosotis scorpioides* | + | + | . | . | . | II |
| H | Euras | 3,5 | 0 | 0 | P | *Phleum pratense* | + | . | . | + | + | III |
| H | Euras | 3 | 0 | 0 | D | *Plantago major* ssp. *major* | . | . | + | + | . | II |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-H | Cosm | 3.5 | 0 | 0 | P | *Poa annua* | . | . | . | + | + | II |
| G | Euras | 4 | 2.5 | 3 | P | *Polygonum bistorta* | + | + | . | . | . | II |
| T | Circ | 5 | 3 | 4 | D | *Polygonum hydropiper* | + | . | . | . | . | I |
| H | Cosm | 4 | 3 | 4 | P | *Potentilla anserina* | . | . | + | . | . | I |
| H | Euras | 4 | 1 | 0 | P | *Potentilla erecta* | + | + | + | . | . | III |
| H | Cosm | 3 | 3 | 0 | P | *Prunella vulgaris* | + | . | + | + | . | III |
| H | C. Eur | 3.5 | 0 | 0 | D | *Ranunculus acris* | + | + | + | . | . | III |
| H | Euras | 4 | 0 | 0 | P | *Ranunculus repens* | + | + | + | + | . | IV |
| H | Circ | 4 | 4 | 4 | D | *Rumex conglomeratus* | + | + | . | . | + | III |
| H | Circ | 3.5 | 3 | 0 | P | *Sanguisorba officinalis* | + | 1 | . | . | . | II |
| G | Circ | 4.5 | 3 | 0 | P | *Scirpus sylvaticus* | . | . | . | . | + | I |
| H | Euras | 3.5 | 3 | 3 | P | *Selinum carvifolia* | + | + | + | . | . | III |
| H | Euras | 3 | 3 | 0 | D | *Stachys officinalis* | . | + | + | . | . | II |
| H | Euras | 2.5 | 2 | 3 | D | *Stellaria graminea* | + | + | . | + | . | III |
| H | Euras | 4 | 2.5 | 0 | D | *Succisa pratensis* | + | . | 1 | . | . | II |
| H | Euras | 4 | 3 | 0 | P | *Symphytum officinale* | . | . | . | . | + | I |
| T-Ht | Eur | 2.5 | 3 | 0 | D | *Trifolium aureum* | . | + | + | . | . | II |
| H | Euras | 3.5 | 0 | 0 | P | *Trifolium repens* | + | . | . | . | + | II |
| T | Euras | 3.5 | 3 | 3 | D | *Vicia tetrasperma* | + | . | . | . | + | II |
| H | Euras | 2.5 | 0 | 2 | P | *Viola canina* ssp. *canina* | . | + | . | + | + | III |
| | | | | | | **Number of species (total = 64)** | **32** | **35** | **40** | **18** | **23** | |

*relevés 1-2 were recorded together with Anna-Mária Csergő in August 2006, relevés 3-5 were recorded by K.Ö. in July 2009

# TAXONOMIC REVISION OF SOME TAXA OF *JACEA-LEPTERANTHUS* GROUP (*CENTAUREA* GENUS) BASED ON MORPHOMETRIC ANALYSIS

**Ghizela VONICA***
**József Pál FRINK****
**Maria CANTOR*****

***Abstract.*** *Variation, morphological differenties and geographic distribution of the taxa of Jacea-Lepteranthus group were investigated in field samples and in herbarium vouchers of the Natural History Museum Sibiu. Multivariate morphometric analysis revealed significant differentiation between species and some hybrids in several morphological characters (fimbria length, length of appendages on middle involucral bracts, length of the involucre and ratio between length and width of appendage of middle bracts). Two hybrids can not be morphologically distinguished, namely Centaurea x prodanii Wagn. and Centaurea x devensis Nyár. In conclusion, the morphometric analysis and their geographical distribution shows that both hybrids must be treated as C. x prodanii Wagn. which is a hybrid between C. phrygia (2n=4x) and C. indurata Janka (2n=4x). The herbarium vouchers were revised in this sense.*
***Key words:*** *Lepteranthus sect., hybrids, C. x prodanii, C. x devensis, geographic distribution, multivariate morphometric analysis.*

***Rezumat.*** *Variaţia, diferenţa morfologică şi distribuţia geografică a specimenelor din grupul Jacea-Lepteranthus au fost studiate pe speciile colectate din flora spontană dar şi pe cele din colecţia de herbarii a Muzeului de Istorie Naturală din Sibiu. Analiza multivariată arată o diferenţă semnificativă între specii, dar şi între hibrizi la câteva caractere morfologice (lungimea fimbriei, lungimea apendicilor foliolelor involucrale mijlocii, lungimea involucrului şi raportul dintre lungimea şi lăţimea apendicilor foliolelor bracteale mijlocii). Din întregul gup de taxoni analizaţi doar doi hibrizi nu se pot diferenţia morfologic, şi anume C. x prodanii Wagn şi C. x devensis Nyár. Analizele morfologice şi distribuţia geografică au arătat că cei doi hibrizi ar trebui trataţi ca C. x prodanii care este un hibrid între C. phrygia (2n=4x) şi C. indurata (2n=4x). Materialul de herbar al Muzeului de Istorie Naturală din Sibiu a fost revizuit în urma acestor analize.*
***Cuvinte cheie:*** *Secţia Lepteranthus, hibrizi, C. x prodanii, C. x devensis, distribuţia geografică, analiza morfometrică multivariată.*

## Introduction

The hybridisation and polyploidy within the *Centaurea* genus are significant sources of diversity (Kouteký 2007, 2008, Susanna, Garcia-Jacas 2009, Kouteký *et al.* 2011, 2012). In Europe, detailed studies of the morphological differentiation were made on the polymorphic groups especially in the *Jacea* and *Lepteranthus* groups (Garcia-Jacas *et al.* 2001, Vanderhoeven *et al.* 2002, Kouteký *et al*. 2011, 2012).

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However, the taxonomic treatment of hybrids at specific or infra-specific levels is still controversial. In the Romanian flora, many infra-specific taxa, hybrids or cytotypes are treated as autonomous taxa of various ranks, up to species. If these taxa are isolated entities from morphological, ecological and/or geographical point of view, it is reasonable to treat them as autonomous taxa (Soltis *et al.* 2007, Mráz *et al*. 2011 and Kouteký *et al.* 2012). In general, morphology of the *Centaurea* specimens are an important criterion to delimited the differences between some species, which is a good identification key for many practical researches (agriculture science, vegetation science). Some morphological characters can be easily evaluated directly in the field, other, can be evaluated only the statistical results, after many observation.

In comparasion to the generic level, in *Lepteranthus* group there are many difficulties at the specific and lower ranks. In Europe, the *C. phrygia* section comprises 15-20 taxa (Linnaeus 1753, Dostál 1976, Greuter 2006-2009), with numerous local and poorly resolved taxa, especially in Romania (Schur 1866, Wagner 1910, Prodan 1930, Prodan, Nyárády 1964, Soó 1970, Ciocârlan 2009).

In Romania up to 6 taxa are recognized by the majority of the authors, namely *C. phrygia* L., *C. pseudophrygia* C. A. May, *C. stenolepis* A. Kern, *C. indurata* Janka, *C. melanocalathia* Borbás, *C. carpatica* (Porcius) Porcius (Dostál 1976, Ciocârlan 2009). Some of these taxa are treated as subspecies of *C. phrygia* L or part of them as subspecies of *C. stenolepis* A. Kern or *C. pseudophrygia* C. A. May (Ciocârlan 2009). A recent revision indicates that these taxa are usually uniform in terms of chromosome number, excepting *C. phrygia* L. (Garcia-Jacas *et al*. 2001, Kouteký 2007, 2008). Recent investigation show that *C. phrygia* has 2 cytotypes (diploids and tetraploids) (Kouteký *et al*. 2012) and *C. melanocalathia* Borbás is a hybrid between tertraploid cytotype of *C. phrygia* L. (namely *C. erdneri* Wagn.) and *C. jacea* L. In the majority of the distribution area of *C. phrygia*, only the diploid cytotype is known (Koutecký 2008, Koutecký *et al*. 2012, Koutecký, Vonica unpublished).

The hybridization between individuals of *Jacea* and *Lepteranthus* groups is very frequent but at different ploidy levels it is unusual and the resulted triploids are sterile (Koutecký *et al*. 2011). Thus, we have doubts that the cited hybrids from the Romanian flora does exist (Wagner 1910); if they really exists, they have numerous inaccuracies in distinguishing them (Prodan 1930, Prodan, Nyárády 1964, Soó 1970, Vonica, Cantor 2010).

Therefore, we conducted the present detailed study, asking the following questions. Are the hybrids from *Lepteranthus* section morphologically differentiated and their morphological characters clear? What is the geographical distribution of the cytotypes and hybrids of *C. phrygia* group in Transylvania (Romania)?

## Materials and methods

This study focuses on 5 species of *Centaurea* genus and 5 hybrids included in the *Phrygia* section or between *Jacea* and *Leteranthus* sections, very difficult to recognize and identify. Morphological observations were made on specimens of *Jacea* and *Lepteranthus* groups collected in the field by the first author, as well as on specimens deposited in the plant collection of Natural History Museum of Sibiu (SIB). Totally, 347 specimens were analyzed.

*Voucher specimens*

Morphometric analyses were made on dried sample specimens, part of E. I. Nyárády's collection (187 herbarium specimens), deposited at the Natural History Museum Sibiu (SIB). The individuals analysed belongs to the following taxa: *C. phrygia* L, *C.* x *erdneri* Wagn. (*C. phrygia* x *C. pseudophrygia*), *C. stenolepis* A. Kern., *C. pseudophrygia* C.A. May, *C. indurata* Janka, *C.* x *devensis* Wagn. (*C. phrygia* x *C. stenolepis*), *C.* x *prodani* Wagn. (*C. phrygia* x *C. indurata*), *C.* x *alexandrii-borzae* Prod. (*C. indurata* x *C. nigrescens*) and *C. melanocalathia* Borbás. The taxons names are those originally used by Nyárády on herbarium labels, meaning of some names can be different from how they are used nowadays (e.g. *C. erdneri, C. x melanocalathia*). All herbarium vouchers were reviewed, determined or/and revised using the classical method of determination based on morphological characters (Annex 2). For the identification, the following publications were used: Prodan (1930), Prodan, Nyárády (1964), Soó (1970), Meusel, Jäger (1992), Ciocârlan (2009) and Koutecký *et al.* (2012). Some voucher specimens were morphologically compared with the field samples which were previously analyzed with flow cytometry by Koutecký Petr from University of South Bohemia, Czech Republic (Koutecký, Vonica unpublished).

*Field sampling*

From different regions of Transylvania (Romania), 160 individuals (belonging to 7 populations) were collected. These individuals belongs to *C. erdneri* Wagn., *C. stenolepis* A. Kern, *C. indurata* Janka and hybrids between *C. jacea* L. and specimens of the *Lepteranthus* section. The plants were collected during 2010-2012 within the field work for the Ph.D Thesis of the first author. The specimens collected were used for comparison with the herbarium samples.

The majority of the individuals from the *Lepteranthus* section grow in lax clusters, each cluster corresponding to one genet. Therefore, only one stem from a cluster was sampled. If achenes were present on the main steam of cluster, these were collected from capitula with just ripe achenes. From each population 15-30 individuals were sampled and for each individual 3-5 achene was collected. Vouchers are deposited in the Herbarium of South Bohemia University-České Budějovice (CBFS) and the Natural History Museum Sibiu (SIB).

*Morphometric analysis*

The final data matrix includes 17 quantitative characters and 5 ratios (Table 1). Morphological characters were measured on dried plants to avoid the possible differences between herbarium vouchers and specimens collected from the field. The majority of the characters were recorded on the inflorescence (including the bracts) and three quantitative characters were recorded on achenes. It was not possible to collect all the samples, therefore, achenes were not available for all individuals studied and all analyses were computed twice, with the achene characters either included or omitted.

Reducing the data from analysis, for each population collected from the field an average value of morphological characters was calculated and in some analyses, populations were used as the operational taxonomic units (OTUs). At the population level, the achene characters were not considered if there were data for less than 5 individuals per population (4 populations was excluded from the dataset, 3 of them collected from Porumbacu de Sus Valley- PSV1, PSV2, PSV3, and one from Petrilaca, Viilor Hill- PDV (see the Annex 1).

Basic statistical measures (mean, median, maximum and minimum values, quartiles, 5 and 95 percentiles and standard deviation) were computed for each population. The normality of the distribution of each character within sets of data was tested using Shapiro-Wilk statistics. Values of all characters (excepted BL and SL) which markedly deviated from a normal distribution were log-transformed (Tab. 1). For analysis of hybrids between *C. phrygia*, *C. indurata* and *C. stenolepis* which are very similar from morphological point of view, were not log-transformated SL, BW, BL, BLW and FL characters (Tab. 1). Pearson's correlation coefficients were calculated for pairs of characters for the whole data set to study relationships between the characters. *Prior* to principal component analyses (PCA), the data were standardized to have zero mean and unit standard deviation.

PCA based on a correlation matrix using both populations as OTUs and herbarium individuals was run to obtain a first insight into the structure of the group studied. Linear discriminant analysis (LDA; also named canonical discriminant analysis), which attempts to maximize differences between *a priori* defined groups, was employed to test the discriminating power of individual characters. Forward selection (FS summary) procedure was used to detect the minimal subset of characters without significant loss of the discrimination power. Although LDA assumes a multivariate normal distribution of the characters, it is to a large extent robust to violations of this assumption, except for significance tests (Hammer *et al*. 2001, Lepš, Šmilauer 2003).

Therefore, Monte Carlo permutation tests were used instead of parametric tests. Classificatory discriminant analysis based on probabilities using individuals of *C. phrygia*, *C. stenolepis*, *C. indurata* and their hybrids (*C.* x *prodani*, *C.* x *devensis*), which are very closed from morphological point of view, was run to quantify separation of the individuals and the *a priory* probabilities of classification. The discriminant power was determined by adjusting the discriminanting variables provided by the within-group standard deviation. Because it is a difference between individuals and hierarchical design, we used an individual as the leave-out unit in the cross validation procedure. Besides the parametric method, a non-parametric k-nearest neighbour algorithm with similar design of cross validation was performed.

*Geographical distribution*

Distributions of the *Phrygia* group's individuals were estimated based on our field observations and on the data extraction of herbarium specimens. For the distribution map, the specimens of uncertain determination are not considered.

*Software*

The statistical analyses were run with PAST-Paleontological Statistics 2.15 (Hammer 1999-2012) and CANOCO for Windows 4.5 (Terr Braak, Šmilauer 2002). Basic statistical measures, normal distribution, log-transformation and classifications were computed with PAST and the ordinations including the adjusting of the variabiles were run with CANOCO for Windows 4.5.

The distribution maps were made with SimpleMappr-online tool (Shorthouse 2010).

**Results and discussions**

*Morphometric analysis*

The parametric test of correlations (Pearson's correlation) has no given correlation between all pairs of matrix (in the lower triangle). Algorithm follow Hammer *et al*. (2001) and Press *et al*. (1992), where the significance's coefficient is $r \geq |0.95|$ (the significance is computed using a two-tailed t test with n-2 degrees of freedom). No highly correlated characters were found and all characters were used in the multivariate analyses.

The taxa from *C. phrygia* section (*C. phrygia*, *C. pseudophrygia*, *C. indurata*, *C. stenolepis, C. erdneri*) are very well differentiated. PCA revealed that there is morphological differentiation between the taxa, especially between *C. stenolepis*, *C. pseudophrygia*, *C. phrygia* and the hybrid *C x alexandrii-borzae* (Fig. 1). The two cytotypes of *C. phrygia* (2x and 4x) can be distinguished by combination of several morphological characters and geographic distribution. LDA of *Phrygia* group as OTUs and individuals confirmed some overlap of the cytotypes (*C. phrygia* and *C. erdneri*) and hybrids, excepting two hybrids (*C.* x *prodani* and *C.* x *devensis*). The hybrids *C* x *prodanii* and *C.* x *devensis* can not be morphologically distinguished. Also, their geographic distribution overlaps and confirmes this (Fig. 4).

When these hybrids were analysed together with their parents, using the discriminant analysis based on probabilities, was able to classify correctly almost 88% of individuals and a moderate separation can be observed between parents and hybrids (Fig. 2). For the majority of individuals the classification was highly successful (90–100%), there were numerous miss classifications at individuals of these hybrids (Annex 2). Canonical score shows that two hybrids are the same from morphological point of view (Fig. 3)

Characters that contributed significantly to the separation of the hybrids and their parents (*C. phrygia*, *C. stenolepis* and *C. indurata*) are listed in Table 3. However, the majority of the discrimination power was associated with one character, appendage length/width ratio (MLW - Tab. 2; Tab. 3).

The hybrid *C.* x *prodanii* (*C. indurata* x *C. phrygia*), has parents with different ploidy levels (*C. phrygia* – 2x and *C. indurata* - 4x) wich is almost impossiblenot probable. Koutecký (2007) and Koutecký *et al*. (2012) have studied the hybridization between different levels of ploidity and it seems that *C. phrygia* (2x) can hybridize with *C. stenolepis* (2x) in our case, or *C. indurata* (4x) can hybridize with *C. erdneri* (4x). Probably *C.* x *prodanii* is a hybrid between *C. indurata* and *C. erdneri,* but morphological analysis show that there are no difference between *C.* x *prodanii* and *C.* x *devensis*. Both hybrids have a brunched steam with numerous inflorescences, leaves are ruffy, the margins are never entire, but with irregular teeth and the appendices of middle bracts has always triangle shape with appendage length shorter than in *C. indurata*, and the pappus is absent or, if it is present, it is irregular and very short.

The complete overlap of canonical scores of these two hybrids was observed. Five significant characters (when all individuals were analysed) were identified by forward selection procedure at the level of individuals (with decreasing discriminant power), namely: fimbria length (FL), length of appendages on middle involucral bracts (ML), length of the involucre (IL) and the ratio ML/MW. When achene characters were included, 4 significant characters were found: length of appendages on middle involucral bracts (ML), width of appendages on middle involucral bracts (MW), ratio ML/MW and width of the middle involucral bracts (BW) (Tab. 2). However, the characters SB and MLW differ slowly but these are not discriminant and the *C.* x *prodanii* and *C.* x *devensis* can not distinguish very clearly. K-means clustering and discriminant score classify those two hybrids in the same group (Fig. 3).

For inflorescence number (IN) and inflorescence width (IW), there is complete overlap of the variation ranges across the two hybrids and the means and the quartiles (not shown) are only slightly shifted (Tab. 4).

Box plotting of the hybrids characters comparing with their parents' shows no major differences and the best characters (MLW) of the hybrids is between *C. phrygia* and *C. indurata* (Fig. 4).

In conclusion, the morphological differentiation between *C.* x *prodanii* and *C.* x *devensis*is is very weak and it is necessary to treat these hybrids as the same taxon: *C.* x *prodanii* Wagn. (*C. indurata* x *C. erdneri*). Probably this hybrid is the same with the hybrid between *C. oxylepis* and *C. erdneri,* which is known from the north-east of the Czech Republic, southern Poland and margins of the Western Carpathians in Slovakia (Koutecký *et al*. 2012).

*Geographical distribution*

The analysis of herbarium material and field material confirmed that *C. erdneri* grows in the south of Transilvania (Southern Romanian Carpathians) and *C. phrygia* in the east of Transilvania (Eastern Romanian Carpathians). The 2 cytotypes of *C. phrygia* and their distributions are quite new for the Transylvanian flora because they are geographical separated (Fig. 5). This hypothesis is confirmed by Koutecký *et al.* (2012), which showed that the diploid and tetraploid cytotypes of *C. phrygia* are also widespreaded in the Eastern Romanian Carpathians (Fig. 5). *C. stenolepis* has a continuous distribution on the highlands and *C. indurata* can be found on the degradated grasslands sourrounding the localities.

Remarkably, the hybrids *C.* x *prodanii* and *C.* x *devensis* are not geographically separated in their distribution range, but they have the same distribution with *C. erdneri*. Both hybrids occur in the Carpathian Basin, especially in highlands where they have a more or less continuous distribution. The distribitution is not connected with the lowlands of Transylvania (Fig.5).

*Taxonomic classification and nomenclature*

Our preliminary researches on the herbarium material show that *C. erdneri* was missidentified with *C. phrygia* (2x) or treated as a hybrid (*C. phrygia* x *C. pseudophrygia*, *C. phrygia* x *C. jacea* and *C. phrygia* x *C. stenolepis*). We have observed that *C. erdneri* (4x) differs from *C. phrygia* (2x) in having shorter pappus and irregular, slightly larger capitula; the basal appendage is triangular, dark - brown and the upper parts of appendage is recurved. The Hungarian botanist János Wagner described *C.* x *erdneri* as a putative hybrid *C. phrygia* × *C. pseudophrygia* (Wagner 1910). *C. erdneri* is morphologically "intermediate" between *C. phrygia* and *C. pseudophrygia*. Koutecký *et al*. (2012) shows that the name *C. erdneri* was really intended to mark these "intermediate" plants.

Concerning *C. pseudophrygia* from herbarium material, this taxon it was missidentified as *C.* x *devensis* (*C. phrygia* x *C. stenolepis*).

Under the name *C. stenolepis* we found *C. pseudophrygia* and *C. phrygia*. The hybrid *C.* x *alexandrii-borzae* (*C. indurata* x *C. nigrescens*) which is very clearly morphologically separated, and it was misidentificated as *C. indurata* or a hybrid between *C. jacea* and *C. phrygia* complex.

The hybrids *C.* x *prodanii* and *C.* x *devensis* were identified under a wider complex of names, namely *C. erdneri* x *C. indurata*, *C. phrygia* x *C. stenolepis*, *C. phrygia* x *C. pseudophrygia*, *C. jacea* x *C. phrygia*, *C. phrygia*, *C. indurata*.

Our results regarding morphological differences between *C.* x *prodanii* and *C.* x *devensis* are congruent and are supporting the treatment of this hybrids as one morphotype. Wagner (1910) described this hybrid (*C.*x *prodanii*) as a higer plant (almost 1 m) with a branched steam in upper part, "*intens pupureo - bruneus*" and slowly "*arachnoideo – tomentosa*". The appendages are narrowly lanceolate, fimbriate and the basis is dilatate. *Centaurea* x *devensis* Wagner was described by the author as less tomentose plant, slowly "*arachnoideo – tomentos*", with irregular denticulate leaves and ovate capitula. Appendage base is slowly dilatate and apex is filiform recurbate. Prodan (1930) has observed that *C.* x *prodanii* and *C.* x *devensis* can not be morphologically distinguished. He mentionated that *C. x devensis* has slowly arachnoideo-tomentose leaves and steam in the upper part; the basal part of appendage is dilatate. They don't have distinct geographical distributions and they are in contact zone with their parents.

In conclusion, according with the International Code of Nomenclature (Melbourne Code) adopted by the 19$^{th}$ International Botanical Congress (McNeill *et al*. 2012), we propose to treat *C.* x *prodanii* Wagn. and *C.* x *devensis* Wagn. as *C. erdneri* x *C. indurata* (*C.* x *prodanii*).

A determination key for *C. phrygia* group in the Transylvanian Basin is presented below, based on Koutecký (2007, 2008), Koutecký *et al.* (2012) and the results of the present paper (Annex 3). The values represent 5% and 95% quantiles. "*Appendages*" refer to the longest appendages on the middle involucral bracts. The recurved tips of the appendages on the involucral bracts are not included in the measurement of the width of an involucre and the lateral teeth/fimbriae are not included in the width of an appendage.

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## LIST OF ILLUSTRATIONS

**Fig. 1.** PCA of 347 individuals of *C.phrygia* group using all 22 characters, including achenes. Analysed taxa are: *C. erdneri* (erd)- empty diamond, *C. indurata* (ind)- empty circle, *C. phrygia* (phryg)- full diamond, *C. pseudophrygia* (pseud)-cross, *C. x prodani* (prod)- full square, *C. x devenis* (dev)- empty square, *C. x alexandrii-borzae* (alex-bor)- full up triangle, *C. x melanocalathia* (melan)- full down triangle, hybrids between *C. phrygia* and *C. pseudophrygia* (phryg x)- full star, *C. stenolepis* (sten)- full circle, hibrids of *C. jacea* (x jacea)- points. The first and the second ordination axis are depicted, which explain 52.6% and 24.7% of the variation, respectively.

**Fig. 2.** LDA of 111 individuals of *C. phrygia* group using 19 characters, excluding achenes. Analysed taxa are: *C. indurata* (ind)- cross, *C. phrygia* (phryg)- empty square, *C. x devensis* (dev)- circle, *C. x prodani* (prod)-diamonds, *C. stenolepis* (sten)- fill square. The first and the second ordination axis are depicted, which explain 50.51% and 25.27% of the variation, respectively.

**Fig. 3.** Histogram of canonical scores of linear discriminant analysis of individuals of *C.* x *prodanii* and *C.* x *devensis* (n =42). All characters were used. The canonical correlation coefficient equals 0.39. Percent correctly classified is 88.1%.

**Fig. 4.** Box- plotting of the best morphological characters which differentiated hybrids by their parents.

**Fig. 5.** Geographical distribution of *C.* x *devensis* and *C.* x *prodanii* and their parents (*C. stenolepis*, *C. indurata* and *C. phrygia* - diploid and tetraploid). Note that *C. phrygia* (2x) has larger distribution in Eastern Romanian Carpathians in mountain grasslands and *C. erdneri* (4x) has larger distribution in south (Southern Romanian Carpathians). *C.* x *prodanii* and *C.* x *devensis* have the same area of distribution, along the parent's distribution. *C. stenolepis* grows in mountain grasslands and *C. indurata* grows in the whole Carpathian Basin, in degradated grasslands.

**Tab. 1.** List of morphological characters studied. All characters were measured on specimens with a fully developed and undamaged terminal capitulum. The accuracy of the measurements is two decimal place.

**Tab. 2.** Linear discriminant analyses of all individuals with forward selection of the characters. Characters with a significant conditional effect (i.e. the effect of the variable in addition to other variables already included in the model) are listed. The significance was tested using a Monte Carlo permutation test (999 permutations). The analysis was run twice with achene characters either included or not. λ = eigenvalue, i.e. discriminant force of the particular character, P = significance level (conditional effect), corr. = correlation coefficient with the canonical axis (when achenes are included, the majority have negative canonical scores), marg. = characters with significant marginal effects (i.e., the effect of the variable when alone in the model) but insignificant conditional effects

**Tab. 3**. Linear discriminant analyses of the *C.* x *devensis*, *C.* x *prodanii* and their parents (*C. phrygia*, *C. indurata*, *C. stenolepis* and *C. erdneri*) with forward selection of the characters. Characters with a significant conditional effect are listed. The significance was tested using a Monte Carlo permutation test (999 permutations). The analysis was run without achene characters. λ = eigenvalue, i.e. discriminant force of the particular character, P = significance level (conditional effect), corr. = correlation coefficient with the canonical axis, marg. = characters with significant marginal effects but insignificant conditional effects.

**Tab. 4.** Variation of the best discriminating characters for the hybrids *C.*x *prodanii* and *C.* x *devensis*. N = number of individuals analyzed, SD = standard deviation, min = minimum, max = maximum, 5% and 95% indicate the respective quantiles.

**Annex 1** *Centaurea* populations sampled within this research. All localities are from Transylvania. The name of each population is indicated after the local toponymy.

**Annex 2** Table with herbarium vouchers (SIB- E. I. Nyárády collection) revised according to the results of this study.

**Annex 3** *Centaurea* species from *Lepteranthus* section identification key.

## LISTA ILUSTRAŢIILOR

**Fig. 1.** Analiza PCA pentru 347 de indivizi din grupul *C. phrygia* folosind 22 de caractere morfologice, inclusiv şi caracterele achenelor. Taxonii analizaţi sunt: *C. erdneri* (erd)- romb gol, *C. indurata* (ind)- cerc gol, *C. phrygia* (phryg)- romb plin, *C. pseudophrygia* (pseud)-cruciuliţă, *C. x prodani* (prod)- pătrat plin, *C. x devenis* (dev)- pătrat gol, *C. x alexandrii-borzae* (alex-bor)- triunghi cu vf. în sus plin, *C. x melanocalathia* (melan)- triunghi plin cu vf. in jos, hibrizi între *C. phrygia* şi *C. pseudophrygia* (phryg x)- stea plină, *C. stenolepis* (sten)- cerc plin, hibrizi cu *C. jacea* (x jacea)- puncte. Prima şi a doua axă sunt reprezentate ceea ce explică 52,6% respectiv 24,7% din variaţia totală.

**Fig. 2.** Analiza LDA calculată pentru 111 indivizi din *C. phrygia* group folosind 19 caracteres, fără achene. Specimenele analizate sunt: *C. indurata* (ind)- cruciuliţă, *C. phrygia* (phryg)- pătrat gol, *C. x devensis* (dev)- cerc, *C. x prodani* (prod)-romb, *C. stenolepis* (sten)- pătrat plin. Sunt reprezentate prima şi a doua axă de ordinaţie, care explică 50,51% respectiv 25,27% din variaţia totală.

**Fig. 3.** Histograma scorului canonic a analizei liniare discriminante calculate pentru indivizii de *C.* x *prodanii* şi *C.* x *devensis* (n =42). Toate caracterele au fost folosite. Coeficientul canonic de corelaţie este 0,39. Procentul de clasificare corectă este 88,1%.

**Fig. 4.** Reprezentarea grafică a celor mai bune caractere morfologice care diferenţiază hibrizii de părinţi.

**Fig. 5.** Distribuţia geografică a hibrizilor *C.* x *devensis* şi *C.* x *prodanii* şi a părinţilor (*C. stenolepis*, *C. indurata* şi *C. phrygia* - diploid şi tetraploid). *C. phrygia* (2x) este întâlnită mai frecvent în Carpaţii Orientali în pajişti montane, lipsind în Carpaţii Meridionali, în timp ce *C.* x *erdneri* (4x) populează în special arealul Carpaţiilor Meridionali dar şi alte zone. *C.* x *prodanii* şi *C.* x *devensis* au aceiaşi suprafaţă de distribuţie cu cea a părinţilor, excluzând diploidul speciei *C. phrygia*. *C. stenolepis* creşte mai mult în pajişti montane şi *C. indurata* creşte în întregul Bazin Carpatic, în pajişti degradate.

**Tab. 1.** Lista caracterelor morfologice studiate. Toate caracterele au fost măsurate pe specimenele aflate la maturitate şi nedeteriorate. Acurateţea măsurătorilor s-a făcut cu 2 decimale.

**Tab. 2.** Analiza linear discriminantă calculată pentru toate specimenele pe baza tuturor caracterelor. Caracterele cu un semnificativ effect conditional sunt listate în tabel. Semnificaţia a fost testată cu testul Monte Carlo (999 de permutări). Analizele au fost realizate de două ori, cu achene şi fără achene. λ = valoarea unică, ex. forţa discriminantă a fiecărui caracter, P = nivelul de semnificaţie (efect condiţional), corr. = coeficientul de corelaţie cu axele canonice (când achenele au fost incluse, majoritatea au scor canonic negativ), marg. = caractere cu effect de margine semnificativ (efectul variabilei când este luat separat în analiză) dar cu efect condiţional nesemnificativ.

**Tab. 3**. Analiza linear discriminantă calculată pentru hibrizii *C.* x *devensis*, *C.* x *prodanii* şi părinţii lor (*C. phrygia*, *C. indurata*, *C. stenolepis* and *C. erdneri*) prin selectarea caracterelor. Caracterele cu efect condiţional semnificativ sunt prezentate în tabel. Semnificaţia a fost testată cu testul Monte Carlo (999 de permutări). Analiza a fost efectuată pentru toate caracterele excuzând caracterele achenelor. λ = valoarea unică, P = nivelul de semnificaţie, corr. = coeficientul de corelaţie cu axele canonice, marg. = caracterele cu efect marginal semnificativ.

**Tab. 4.** Variaţia celor mai bune caractere discriminante calculate pentru hibrizii *C.*x *prodanii* şi *C.* x *devensis*. N = numărul de indivizi analizaţi, SD = deviaţia standard, min = minima, max = maxima, 5% şi 95% indică cuartilele.

**Anexa 1.** Populaţiile de *Centaurea* studiate în acestă cercetare. Numele populaţiilor sunt date după toponimia locului.

**Anexa 2.** Tabelul cu specimenele de ierbar (SIB- colecţia E. I. Nyárády) revizuite pe baza rezultatelor obţinute.

**Anexa 3.** Cheia de determinare a speciilor de *Centaurea* din secţia *Lepteranthus*.

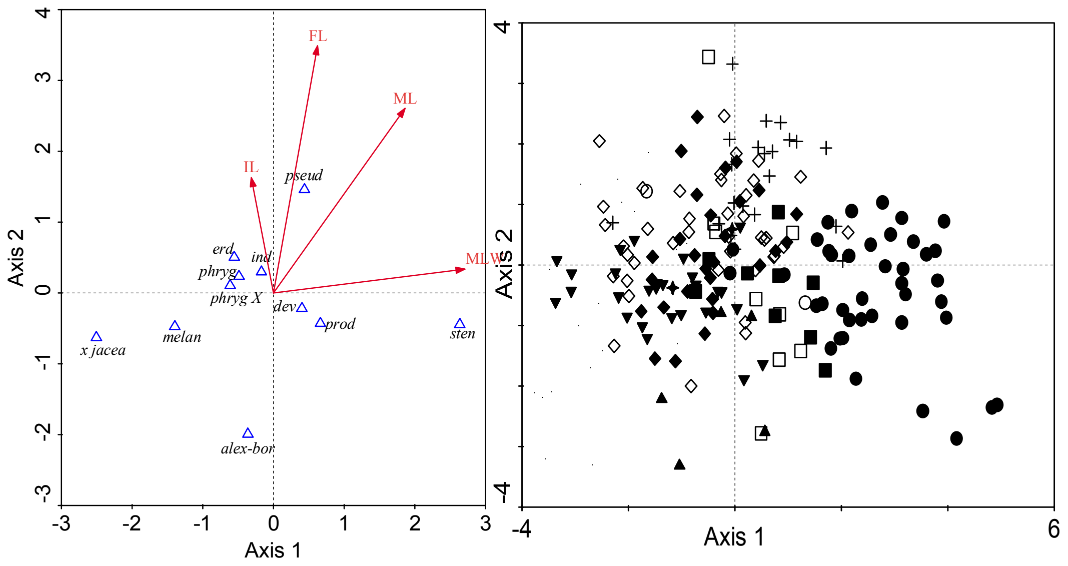


**Fig.1**. PCA of 347 individuals of *C.phrygia* group using all 22 characters, including achenes. Analysed taxa are: *C. erdneri* (erd)- empty diamond, *C. indurata* (ind)- empty circle, *C. phrygia* (phryg)- full diamond, *C. pseudophrygia* (pseud)-cross, *C. x prodani* (prod)- full square, *C. x devenis* (dev)- empty square, *C. x alexandrii-borzae* (alex-bor)- full up triangle, *C. x melanocalathia* (melan)- full down triangle, hybrids between *C. phrygia* and *C. pseudophrygia* (phryg x)- full star, *C. stenolepis* (sten)- full circle, hibrids of *C. jacea* (x jacea)- points. The first and the second ordination axis are depicted, which explain 52.6% and 24.7% of the variation, respectively.

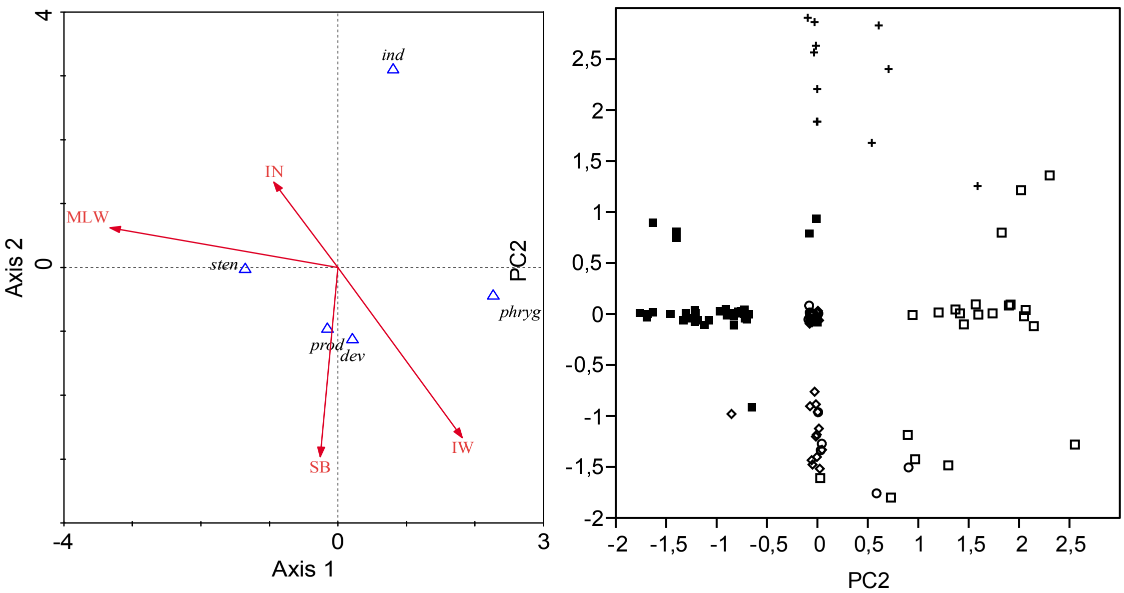


**Fig. 2.** LDA of 111 individuals of *C. phrygia* group using 19 characters, excluding achenes. Analysed taxa are: *C. indurata* (ind)- cross, *C. phrygia* (phryg)- empty square, *C. x devensis* (dev)- circle, *C. x prodani* (prod)-diamonds, *C. stenolepis* (sten)- fill square. The first and the second ordination axis are depicted, which explain 50.51% and 25.27% of the variation, respectively.

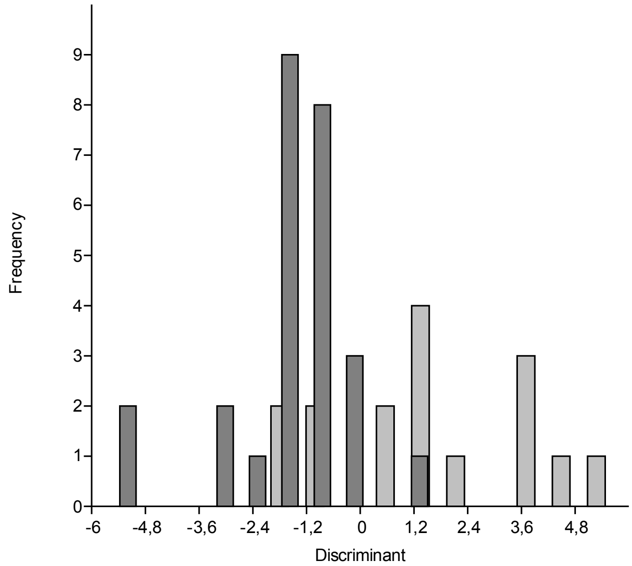


**Fig. 3.** Histogram of canonical scores of linear discriminant analysis of individuals of *C*. x *prodanii* and *C*. x *devensis* (n =42). All characters were used. The canonical correlation coefficient equals 0.39. Percent correctly classified is 88.1%.

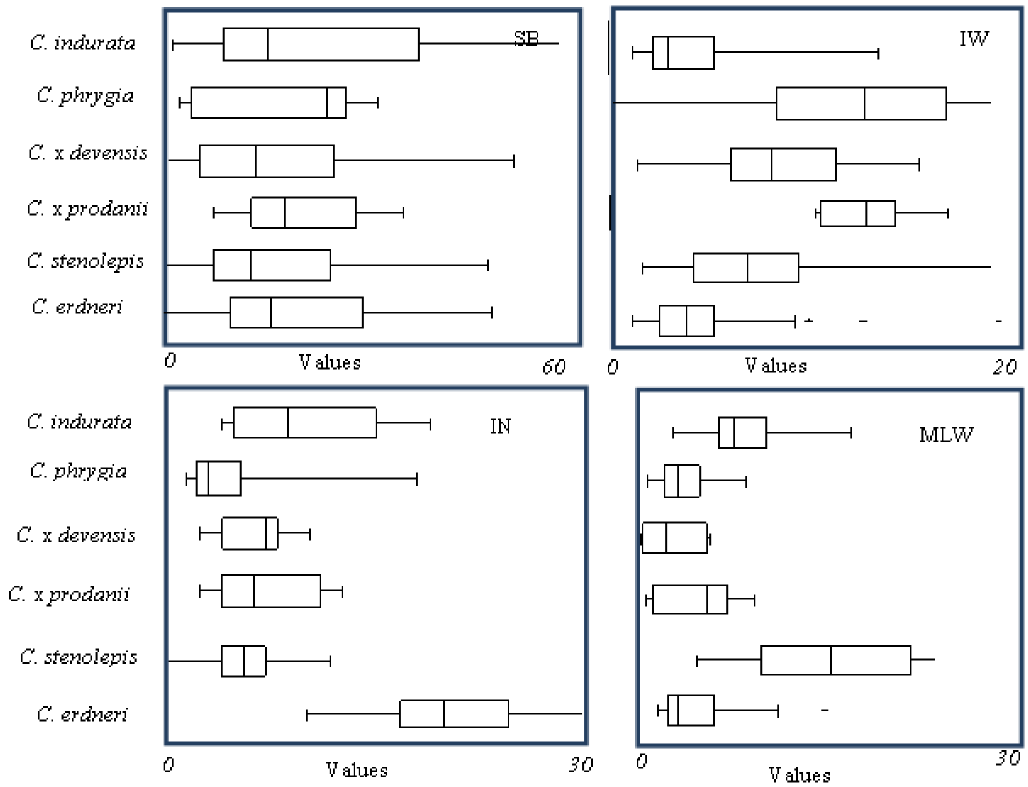


**Fig.4.** Box- plotting of the best morphological characters which differentiated hybrids by their parents.

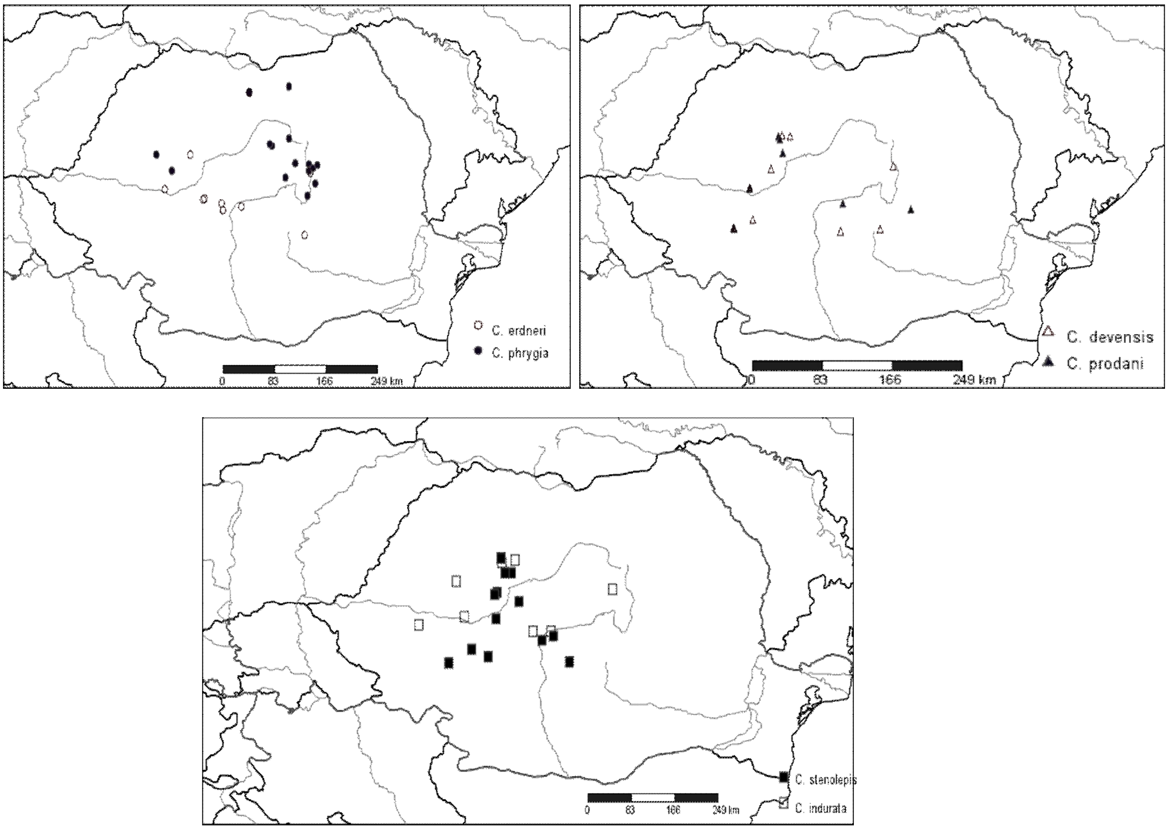


**Fig. 5.** Geographical distribution of *C*. x *devensis* and *C*. x *prodanii* and their parents (*C. stenolepis*, *C. indurata* and *C. phrygia* - diploid and tetraploid). Note that *C. phrygia* (2x) has larger distribution in Eastern Romanian Carpathians in mountain grasslands and *C. erdneri* (4x) has larger distribution in south (Southern Romanian Carpathians). *C*. x *prodanii* and *C*. x *devensis* have the same area of distribution, along the parent's distribution. *C. stenolepis* grows in mountain grasslands and *C. indurata* grows in the whole Carpathian Basin, in degradated grasslands.

**Tab. 1** List of morphological characters studied. All characters were measured on specimens with a fully developed and undamaged terminal capitulum. The accuracy of the measurements is two decimal place.

| **Quantitative characters** | | |
|---|---|---|
| SL | total stem height | cm |
| SB | height of the flowering part of the stem, i.e. height from the lowest flowering branch to the first inflorescence; short (a few cm) thin branches with reduced capitula that sometimes develop in the lower leaf axils were not considered | cm |
| SN | number of stem branch | |
| LL | lamina length of a middle stem leaf | cm |
| LW | lamina width of a middle stem leaf, including lateral teeth / lobes | cm |
| IL | height of the involucre of the terminal capitulum, i.e. from the base of the involucre to the top of appendages on the innermost involucral bracts | cm |
| IW | width of the involucre of the terminal capitulum; the distance between outer surfaces of involucral bracts is measured, recurved parts of involucral bracts were not included | cm |
| IN | inflorescence number / stem | |
| BL | length of the middle involucral bracts of the terminal capitulum, whithout appendage | mm |
| BW | width of the middle involucral bracts of the terminal capitulum | mm |
| ML | length of the longest appendage on middle involucral bracts of the terminal capitulum, including the terminal seta on the appendage | mm |
| MW | maximal width of the lower widened part of the longest appendage on middle involucral bracts of the terminal capitulum; lateral teeth / fimbriae were not included | mm |
| FN | number of lateral fimbriae on one side of the longest appendage on middle involucral bracts of the terminal capitulum | |
| FL | length of the longest lateral fimbriae of the appendage on middle involucral bracts of the terminal capitulum | |
| AL | achene length, excluding the pappus (average of 3 achenes) | mm |
| AW | achene width (average of 3 achenes) | mm |
| PL | length of the longest setae on the pappus (average of 3 achenes) | mm |

| **Ratios** | |
|---|---|
| SBL | proportion of the height of the flowering part of the stem (SF/ST) |
| LLW | length / width of the lamina of a middle stem leaf (LL/LW) |
| ILW | length / width of the involucre of the terminal capitulum (IL/IW) |
| BLW | length / width of the middle involucral bracts of the terminal capitulum (BL/BW) |
| MLW | length / width of the longest appendage on middle involucral bracts of the terminal capitulum (ML/MW) |

**Tab. 2** Linear discriminant analyses of all individuals with forward selection of the characters. Characters with a significant conditional effect (i.e. the effect of the variable in addition to other variables already included in the model) are listed. The significance was tested using a Monte Carlo permutation test (999 permutations). The analysis was run twice with achene characters either included or not. $\lambda$ = eigenvalue, i.e. discriminant force of the particular character, P = significance level (conditional effect), corr. = correlation coefficient with the canonical axis (when achenes are included, the majority have negative canonical scores), marg. = characters with significant marginal effects (i.e., the effect of the variable when alone in the model) but insignificant conditional effects.

| **Achenes excluded (n=347)** | | | | **Achenes included (n=138)** | | | |
|---|---|---|---|---|---|---|---|
| Character | Λ | P | corr | Character | λ | P | F |
| MLW | 0.70 | 0.001 | 0.98 | MLW | 0.75 | 0.001 | 0.90 |
| FL | 0.28 | 0.001 | 0.15 | MW | 0.44 | 0.001 | -0.17 |
| IL | 0.19 | 0.001 | -0.06 | FN | 0.25 | 0.011 | -0.02 |
| ML | 0.17 | 0.001 | 0.51 | BW | 0.47 | 0.018 | -0.20 |
| marg.: MW,BW, BLW, IW, BL, IN, SL. | | | | marg.: BLW, ML, BL, IW, LLW, AW, FL, AL, LW. | | | |

**Tab. 3** Linear discriminant analyses of the *C.* x *devensis*, *C.* x *prodanii* and their parents (*C. phrygia*, *C. indurata*, *C. stenolepis* and *C. erdneri*) with forward selection of the characters. Characters with a significant conditional effect are listed. The significance was tested using a Monte Carlo permutation test (999 permutations). The analysis was run without achene characters. λ = eigenvalue, i.e. discriminant force of the particular character, P = significance level (conditional effect), corr. = correlation coefficient with the canonical axis, marg. = characters with significant marginal effects but insignificant conditional effects.

| **Achenes excluded (n=111)** | | | |
|---|---|---|---|
| Character | λ | P | corr. |
| MLW | 0.51 | 0.001 | -0.70 |
| SB | 0.40 | 0.001 | -0.53 |
| IW | 0.28 | 0.001 | 0.42 |
| IN | 0.13 | 0.001 | -0.25 |
| marg.: MW, LW, ML, BLW, IL, BW, BL | | | |

**Tab. 4** Variation of the best discriminating characters for the hybrids *C.*x *prodanii* and *C.* x *devensis*. N = number of individuals analyzed, SD = standard deviation, min = minimum, max = maximum, 5% and 95% indicate the respective quantiles. Variaţia celor mai bune caractere discriminante calculate pentru hibrizii *C.*x *prodanii* şi *C.* x *devensis*. N = numărul de indivizi analizaţi, SD = deviaţia standard, min = minima, max = maxima, 5% şi 95% indică cuartilele.

| Character | Species | N | Unit | Mean | SD | (min-)5%-95%(-max) |
|---|---|---|---|---|---|---|
| SB | dev | 16 | cm | 21.48 | 11.98 | (6.68-) 9.85- 33.65 (-40) |
| | prod | 26 | cm | 17.16 | 9.35 | (0.5-) 11.95- 24.06 (-34.51) |
| IN | dev | 16 | | 7.56 | 3.53 | (3-) 4.5- 9.75 (-15) |
| | prod | 26 | | 6.61 | 3.62 | (2-) 4- 8.25 (-15) |
| IW | dev | 16 | mm | 12.45 | 3.37 | (8.34)9.34- 14.42 (-18.78) |
| | prod | 26 | mm | 14.26 | 2.92 | (8.9-) 12.35- 15.76 (-20.72) |
| MLW | dev | 16 | mm | 7.70 | 3.02 | (5.91-) 5.91- 8.13 (-15.05) |
| | prod | 26 | mm | 11.87 | 5.03 | (5.48-) 7.81- 14.18 (-24.8) |

**Annex 1** *Centaurea* populations sampled within this research. All localities are from Transylvania. The name of each population is indicated after the local toponymy.

| No of the label | Location | Lat. | Long. | Taxa |
|---|---|---|---|---|
| *MIN* | Natural History Museum's Garden, Sibiu | 45°47'40.88"N | 24° 9'15.61"E | *C. erdneri* x *C. jacea* |
| *PDV* | Petrilaca, Viilor Hill- Mureş County | 46°24'47.45"N | 24° 8'7.48"E | *C. jacea* x *C. phrygia* (4n) |
| *PSB1* | Poiana Sibiului, School Valley | 45°48'20.59"N | 23°43'54.12"E | *C. erdneri* |
| *PSV1* | Porumbacului Valley - on way to Negoi Peak | 45°41'58.84"N | 24°29'26.78"E | *C. erdneri* |
| *PSV3* | Porumbacului Valley - on way to Negoi Peak | 45°42'18.68"N | 24°29'41.66"E | *C. stenolepis* |
| *SDV2* | Sadului Valley- on way to "Gâtul Berbecului" | 45°38'41.16"N | 24° 7'28.61"E | *C. erdneri* x *C. jacea* |
| *SDV3* | Sadului Valley- on way to "Gâtul Berbecului" | 45°38'40.86"N | 24° 8'26.98"E | *C. erdneri* x *C. jacea* |

| | | | | |
|---|---|---|---|---|
| *PSV2* | Valea Porumbacului- on way to Negoi Peak | 45°41'58.84"N | 24°29'26.78"E | *C. indurata* |
| *SDV1* | Sadului Valley - on way to “Gâtul Berbecului” | 45°39'33.38"N | 24° 9'52.79"E | *C. erdneri* |
| *TPA1* | Tehno-Park Astra, Sibiu | 45°45'10.18"N | 24° 6'45.59"E | *C. erdneri* |
| *TPA2* | Tehno-Park Astra, Sibiu | 45°45'11.89"N | 45°45'11.89"N | *C. erdneri* x *C. jacea* |

**Annex 2** Table with herbarium vouchers (SIB- E. I. Nyárády collection) revised according to the results of this study.

| Revised taxa | Voucher registration no. and original labeling |
|---|---|
| *C. erdneri* Wagn. | *C. phrygia L.*, inv. no. 115.116, Cluj County, Turda Town, near Arieşul Mic River, 19.07.1912, leg. E.I. Nyárády. |
| *C. erdneri* Wagn. | *C. phrygia L.*, inv. no. 115.117, Harghita County, Odorhei Town, in mountain medow near Homorod Bath, alt. 700 m, 13.07.1927 leg. A. Borza, rev. I Prodan |
| *C. erdneri* Wagn. | *C. phrygia L.*, inv. no. 115.120, Harghita County, Homorod Baths, on the meadow slope near the forest, alt. 740 m, 8.08.1949, leg. E.I. Nyárády. |
| *C. erdneri* Wagn. | *C. phrygia L.* , inv. no. 115.124, Mureş County, Sovata Bath, near Manci villa, alt. 472 m, 25.07.1943, leg. E.I. Nyárády. |
| *C.* x *melanocalathia* Borb. | *C. phrygia L.* , inv. no. 115.125; 115.127, Crăciunel Mt., above Valea Vinului Bath, skeletic soil, alt. 900-1300 m, 22.07.1923, leg. E.I. Nyárády. |
| *C. indurata* Janka | *C. phrygia L*, inv. no.. 115.128, Mureş County, Sovata Bath, alt. 530 m, 22.07.1943, leg. E.I. Nyárády. |
| *C. erdneri* Wagn. | *C. phrygia L.*, inv. no. 115.132, Mureş County: Sovata Bath, near Lia and Gloria Lakes, alt. 520 m, 21.07.1943, leg. E.I. Nyárády. |
| *C. erdneri* Wagn. | *C. phrygia L.*, inv. no. 115.133, Alba County, Vulcan Mt., near Abrud, 9.09.1910, leg. Bányai János |
| *C. jacea* x *C. phrygia* | *C. phrygia L*, inv. no. 115.136, Mureş County, Sovata Bath, alt. 502 m, 3.09.1943, leg. E.I. Nyárády. |
| *C. x erdneri* Wagn. | *C. phrygia L*, inv. no. 115.139; 115.140, Covasna County, Întorsura Buzăului, on Glicoş Hill, alt. 720 m, 30.07.1963, leg. E.I. Nyárády. |
| *C.* x *melanocalathia* Borb. | *C. phrygia L*, inv. no. 115.141, Braşov County, between Perşani and Brădet, near the railway, 11.08.1955, leg. E.I. Nyárády. |
| *C. x erdneri* Wagn. | *C. phrygia L*, inv. no. 115.142, Cluj County, Malom (Morii) Valley, near Feleac Village, 5.08.1933, leg. E.I. Nyárády. |
| *C. jacea* x *C. pseudophrygia* | *C. phrygia L*, inv. no. 115.143, Bistriţa Năsăud County, Sângiorz Bath, alt. 490 m, 15.08.1958, leg. E.I. Nyárády. |
| *C.* x *melanocalathia* Borb. | *C. phrygia L.*, inv. no. 115.145, Cluj County, near Căpuşu Mic Village, alt. 500 m, 1.09.1961, leg. E.I. Nyárády. |
| *C. phrygia* subsp. *indurata* (Janka) Dostál | *C. phrygia L*, inv. no. 115.147, Cluj County, at Runcu in hayfield, 29.07.1959, leg. A. Nyárády |

| | |
|---|---|
| *C.* x *prodanii* Wagn. | *C. x devensis,* inv. no. 115.368; 115.367, Hunedoara County, Nucşoara Valley, near Fagi Village, humic soil, alt. 800-999 m, 23.08.1933, leg. E.I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. x devensis*, inv. no. 115.366, near Herculane Bath, alt. 165-170 m, 07.1950, leg. E.I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. x devensis*, inv. no. 115.365, Hunedoara County, between Clopotina and Grădişte, alt. 520 m, 14.08.1950,leg. E.I. Nyárády. |
| *C. phrygia x C. pseudophrygia* | *C. x erdneri*, inv. no. 115.371, Harghita County, Giurgeni place in the medows and cultivated place, near Lăzarea, alt. 720-735 m, 15.07.1948, leg. E.I. Nyárády. |
| *C. phrygia* L. | *C. x erdneri*, inv. no. 115.378, Harghita County, near Gheorgheni, alt. 750 m, 8.08.1941, leg. E.I. Nyárády. |
| *C. phrygia* L. | *C. x erdneri*, inv. no. 115.380, Harghita County, Gheorgheni, in the mountain meadows near Mureş river spring, alt. 800 m, 1.07.1924, leg. E.I. Nyárády. |
| *C.* x *melanocalathia* Borb. | *C. x erdneri*, inv. no. 115.381, Slovacia, Tatra Mts., near Bansko, Liptó region, alt. 950 m, 30.07.1907, leg. E. I. Nyárády. |
| *C. phrygia* L. | *C. x erdneri*, inv. no. 115.387, Alba County, in mountain meadows near Poşaga de Sus, alt. 450 m, 26.07.1920, leg. A. Borza, det. I. Prodan |
| *C.* x *melanocalathia* Borb. | *C. x erdneri*, inv. no. 115.390, Mureş County, in the meadows and on roky slopes near Mureş river, Deda and Răstolniţa localities, alt. 495 m, 3.07.1921, leg. E.I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. x erdneri*, inv. no. 115.393, Hunedoara County, in the meadow's Culmea Mt., above Serel locality, alt. 800 m, 31.07.1929, leg. E.I. Nyárády. |
| *C.* x *melanocalathia* | *C. x erdneri*, inv. no. 115.394, Harghita County, in the fir forest, alt. 900-1200 m, 10.07.1928, leg. E.I. Nyárády |
| *C. phrygia* L. | *C. x erdneri,* inv. no. 115.398, Braşov County, Zărneşti Gorges, alt. 700-1000 m, 17.07.1950, leg. E.I.Nyárády. |
| *C.* x *prodanii* Wagn. | *C. x erdneri*, inv. no. 115.401, Prahova County, Sinaia on the Peleş Valley, alt. 800-900 m, 19.07.1953, leg. E.I.Nyárády. |
| *C.* x *prodanii* Wagn. | *C. x erdneri*, inv. no. 115.405, Harghita County at Uzonka Bath, alt. 750 m, 11.07.1956, leg. E.I.Nyárády. |
| *C. phrygia x C. pseudophrygia* | *C. x erdneri*, inv. no. 115.408 B, Rodnei Mts. on the Anieş Valley, alt. 530-600 m, 30.07.1948, leg. A. Nyárády and E. I. Nyárády. |
| *C. erdneri Wagn.* | *C. atrodevensis*, inv. no. 115.068, Retezat Mts., Nucşoara Valley, in Fagi region, humic soil, alt. 800-1000 m, 23.08.1933, leg. A. Nyárády and E. I. Nyárády. |
| *C. phrygia* L. | *C. prodanii* Wagn. , inv. no. 115.808, Alba County, Gârda de Sus Village, near Scărişoara ice cave, alt. 900 m, 25.08.1946, leg. M. Ghiuta. |
| *C. phrygia* L. | *C. prodanii* Wagn. , inv. no. 115.811, Harghita County, Homorod Bath, in the forest, alt. 730 m, 8.08.1949, leg. E. I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. pseudophrygia* C.A.May, inv. no. 115.823, Tatra Mts. on Krizsna Peak, above Revuca place, alt. 1575 m, 8.08.1924, leg. E. I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. stenolepis* Kern. , inv. no. 116.110, Flora Exssicata Austro-Hungarica 3425, Tirolia Australis, Val di Ledro locality, alt. 400-800 m, leg. E. I. Nyárády. |

| | |
|---|---|
| *C.* x *prodanii* Wagn. | *C. stenolepis* Kern. , inv. no. 116.117, without locality, 08.1903, leg. J. Wagner |
| *C.* x *prodanii* Wagn. | *C. stenolepis* Kern. , inv. no. 116.127, Arad County, on the slope of the Highiş Mt, above Draut Lake, alt. 600 m, 5.08.1951, leg. E. I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. stenolepis* Kern. , inv. no. 116.128, Alba County on the Piatra Cetii Mt., above Galda de Sus Village, alt. 1230 m, 21.07.1938, leg. E. Ghişa and E. I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. stenolepis* Kern., inv. no. 116.130; 116.132, Govora Bath, in forest clearing, 4.09.1957, leg. E. I. Nyárády. |
| *C.* x *prodanii* Wagn. | *C. stenolepis* Kern., inv. no. 116.134, Retezat Mts. on Nucşoara Valley, near Fagi place, alt. 800-1000 m, 28.08.1933, leg. E. I. Nyárády |
| *C.* x *prodanii* Wagn. | *C. stenolepis Kern* , inv. no. 116.137, Hungaria, near Budapest, sept. 1903, leg. E. I. Nyárády. |

## Annex 3

### *Centaurea* species from *Lepteranthus* section identification key

**1a**. Margin of the leaves has irregular teeth; the shape of the appendages is relatively short and rounded, wider then 2 mm (basal part), in outline with long marginal teeth irregularly fused into groups. The appendages are lax adpressed by involucre and only the fimbriaes are recurved; pappus absent or shorter then 0.3 mm............................................................................................................... hybrids with ***C. jacea*** L.
**1b.** Appendages regularly fimbriate on the margin, the fimbriae not fused; the basal part of the appendage is thinner then 2 mm; linear - lanceolate and strong recurved on the apex; pappus present or absent................. **2**
**2a.** Stem is sparingly branched; leaves broadly lanceolate, irregular dentate, acute, atenuate into winged petiole; involucre ovoidal-cylindrical 8–10.1 / 12.3–14.3 mm, often with 3 capitula grouped; central undivided part of appendages narrowly triangular, attenuated into a subulate-filiform, recurved terminal acumen; the fimbriae length 3 mm; pappus absent or very short; 2n=44...............................***C. indurata*** Janka
**2b.** Leaves lanceolate to ovate; involucre ovoid to globose; central undivided part of appendages blackish, linear to ovate, attenuated into a long laterally fimbriate acumen (rounded in section); pappus present…...... **3**
**3a**. Stem branched in the upper 1/3, branches short, forming dense corymb of capitula, if the stem branched in lower parts and with longer branches, then several capitula in corymbs at the end of branches; size of cauline leaves usually gradually decreasing towards the top of the stem and the leaf margin is entire; involucre ovoid or cylindrical; central undivided part of appendages linear, 0.4–0.9 mm wide, distal part of appendages light brown or ochre; 2n=22 ..........................................................................***C. stenolepis*** Kern.
**3b.** Stem branched from the middle, long branches, not forming dense corymb of capitula; size of cauline leaves only slightly decreasing towards the top of the stem; involucre ovoid or globose; central undivided part of appendages linear - lanceolate to ovate, 1.35–2.4 mm wide, distal part of appendages brown or blackish........................................................................................................................................... **4**
**4a.** Involucre ovoid or cylindrical, 12.35 / 15.75 mm, appendage have 6.8-9.5 mm length, the basal part is narrowly triangular, 0.57-0.91 mm wide; pappus irregular or absent...............................***C.*x *prodanii*** Wagner
**4b.** Involucre globose or ovoid, 11- 20 mm long and 13-19 mm wide; the appendage 5.4-16.9 mm long, basal part of appendage is narrowly triangular or lanceolate/oval; pappus always present and regular........................................................................................................................................... **5**
**5a.** Appendages 9.4-14.5 mm long, forming dense "sheath" around the involucre; the basal part of appandage narrowly lanceolate, 0.6-1.2 mm length gradually attenuated into terminal fimbriate acumen; distal part of appendages brown; appendages of inner involucral bracts not exserted, covered by appendages of the middle involucral bracts; pappus 0.7-1.5 mm length; steam corymbosely branched from the middle upper part, 2n=22 ..............................................................................................***C. pseudophrygia*** C. A. May
**5b.** Appendages 6.32-12.1 mm length forming a lax "sheath" around the involucre, rounded at the base, intern appendage exert over appendage of midlle bracts; involucre 15-19.59 mm length and 13.-19.21 mm width ........................................................................................................................................... **6**
**6a.** Involucre broadly ovoid to globose, 14–19 /18–21 mm; central undivided part of appendages ovate or triangular, 0.8–2.4 mm wide, abruptly attenuated into terminal fimbriate acumen; appendages of inner involucral bracts, exceeding appendages of the middle involucral bracts; pappus 0.5–1.4 mm long; 2n=22........................................................................................................................... ***C. phrygia*** L.
**6b.** Appendages 6.8-12.1 mm long, the basal part is triangular, black or braun, the distal part is black, strongly recurved; pappus short, between 0.1-1 mm; 2n=44................................................***C. erdneri*** Wagner.

# OBSERVATIONS ON THE GORNOVIŢA LEVELING SURFACE IN THE AREA OF POIANA SIBIULUI – JINA REGARDING LAND DEGRADATION THROUGH HYDRIC EROSION

**Marioara COSTEA***

***Abstract.*** *The Carpathian leveling surfaces are the most conclusive morphogenetic forms, created in geological time, that suggest the rythmicity of orogenetic cycles and the collaboration of internal factors (tectonic movements) and external ones (modeling in climatic conditions of different geological periods) in finalizing the current configuration of the relief. These are relict forms that dominate the landscape of the Cindrel Mountains and beyond through expansion in surface and flatness (horizontality). The leveling surfaces are evidence of an evolution in successive stages of the mountain unit, an evolution integrated in the regional ensemble of the Parâng and Carpaţi groups. Within these, current modeling has also created and is still creating new detailed forms. Active external agents (climate and man through his activities) currently shape this geomorphological matrix, and the aggressiveness of their action can lead to land degradation. A representative example of this is „Mărginimea Platform" in the area between Poiana Sibiului and Jina, where current modeling under conditions of rainfall aggresion and intensive use of this space has led to land degradation by surface erosion, rill erosion and ravines.*
***Key words:*** *leveling surfaces, erosion levels, hydric erosion, land degradation, suprafaţa Gornoviţa Gornoviţa surface, Cindrel Mountains.*

***Rezumat.*** *Suprafeţele de nivelare din Carpaţi constituie cele mai concludente forme morfogenetice, create în timp geologic, care sugerează ritmicitatea ciclurilor orogenetice şi conlucrarea factorilor interni (mişcările tectonice) şi externi (modelarea în condiţiile climatice ale diferitelor perioade geologice) în definitivarea configuraţiei actuale a reliefului. Acestea reprezintă forme relicte care prin extindere în suprafaţă şi prin planitate (orizontalitate) domină peisajul Munţilor Cindrelului, şi nu numai. Suprafeţele de nivelare sunt dovezi ale unei evoluţii pe etape succesive ale unităţii montane, evoluţie integrată în ansamblul regional al grupei Parângului şi al Carpaţilor Meridionali. Modelarea actuală a creat şi crează în cadrul lor noi forme, de detaliu. Agenţii externi activi (climatul şi omul prin activităţile sale) modelează în prezent această matrice geomorfologică, iar agresivitatea acţiunii acestora poate conduce la degradarea terenurilor. Un exemplu reprezentativ în acest sens este „Platforma Mărginimii" în arealul cuprins între localităţile Poiana Sibiului şi Jina, unde modelarea actuală în condiţiile agresivităţii pluviale şi de utilizare intensivă a spaţiului a condus la degradarea terenurilor prin eroziune în suprafaţă, şiroire şi ravenare.*
***Cuvinte cheie:*** *suprafeţe de nivelare, nivele de eroziune, eroziune hidrică, degradarea terenurilor, suprafaţa Gornoviţa, Munţii Cindrelului.*

## About leveling surfaces

The unfolding of leveling surfaces in the mountainous region is the result of a continuous evolution of the Carpathian orogen and constitutes an undeniable testimony of the succession of orogenetic phases followed by modeling. The erosion exerted by the external agents, helped by repeated epirogenetic movements, made the polycyclic modeling and the sculpting of leveling surfaces possible (Mihăilescu, 1963).

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Characteristic to the area is an impressive saltmassive, which was formed approximately 20-22.

The specialty literature on Romania's relief (Martonne de 1907, Mihăilescu 1963, Posea *et al.* 1974, Posea 2002, Geografia României 1983, 1987) and recent records from doctoral theses on the Cindrel Mountains (Buza 2000, Costea 2005, Giuşcă 2006) emphasize the existence of the three leveling surfaces, known generically as Borăscu, Râu Şes and Gornoviţa. These belong to the three modeling cycles: Paleogene, Miocene and Pliocene and cannot be reduced to just three clearly defined morphological surfaces. Within the three big cycles several phases succeeded, making the forming of several secondary levels possible. These are sometimes presented under local names, thus emphasizing their broad development on the respective summits: Cindrel, Păltinei and Guga (Mihăilescu 1963) or Săliște and Poiana for the two levels of the Pliocene surface (Posea 1969, Posea 2002).

**Landscape aspects of the Gornoviţa area in the Poiana Sibiului – Jina region**

The settlements Poiana Sibiului and Jina are located in the Cindrel Mountains on the lowest leveling surface in the Carpathian area named Gornoviţa Platform or „Carpathian border area" (Posea 1969, 2002). This extends as a polycyclic complex on the heights that descend to the north of the Cindrel Mountains and on the Carpathian valley corridors, at altitudes of 1100 – 800 m (Platforma Mărginimii, Buza 2000). This sculptural complex was modeled under conditions of a Mediterranean climate in the Pliocene, through processes of abrasion, fluvial erosion and pedimentation (Posea *et al.* 1974, Velcea, Savu 1982, Geografia României 1983) and presents two levels (Fig.1).

The upper level is located at altitudes of 960 – 1150 m and is predominantly shaped by abrasion in the Pontian (modeling starts right at the end of the Sarmatian, being guided by the base level of the Transylvanian Basin) and continues upstream with the valley shoulders level located at ± 1200 m in the Sebeş, Cibin, Sadu and its affluents' valleys. The extension of this level of the Gornoviţa platform is at its maximum point south of Poiana Sibiului – Jina on the interfluve between the Dobra and Săliște basins: Năvrâp (1039 m), Dl. Popii (1029 m), Culmea Căptanului (de la 1000 m la 1229 m at Căptan Peak), South of Poiana Sibiului in the Măgura hills (1000 m) and in Petriceana (1063 m) and in the Dobra basin in the Hurdubeu and Dosu Dobrii peaks. The interfluves have an almost flat configuration, are slightly undulated and give the relief the aspect of a plateau and not of medium mountains (Geografia României1983, 1987). The most appopiate local name would be the Jina level, coming from the remarkable extension this level has throughout the boundaries of this area.

The lower level is located at ± 800 m and is called the Poiana level (Posea 1969), denomination that we use as well. It frequently rises at 900 m, sometimes at 950 m, making the connection with the upper level of the Gornoviţa surface, and descends at altitudes of 760 m, extending through the interfluves of the submountainous hills, in the form of extended ridges with a south-north direction. This interfluvial peripheral level can be connected with the valley shoulders level, being the result of predominantly fluvial modelling and of pedimentation exercised in the Dacian – Romanian. The separation of the two levels is achieved through relatively inclined connecting surfaces (slopes up to 15 – 25$^{o}$), resulting from raising movements from the Rhodan phase. This level is very well represented north of Jina on the Fruntea Neagră plateau (± 900 m) which extends northward to Dl. Nedeiu (800 – 885 m) between the valley with the same name and its left affluents - Dumbrăviţa and Cucuruzului Valley. The Jina Plateau continues north to the spring area of Gârbova and Valea Chipeşii in the Rădăcina, Bujorul, Răcoarele and Cosoarele hills. It also has a considerable extent on the territory of Poiana Sibiului and north of this in the Delniţa, Piţigaia and Dumbrava hills.

The flatness of the interfluves, the minor relief energy in the lower leveling surface (25 – 50 – 80 m/km$^2$) and the suitability of the climate (average annual temperature of 6 – 7$^{o}$C, approx. 150 – 200 days with frost, the position above the thermal inversion layer, precipitations of 700 – 900 mm/year etc.) facilitated the development of permanent settlements at such heights: Jina and Poiana Sibiului and their spatial evolution on peaks in the form of groves (Costea 2008a). The smoothness of this border surface (3-10$^{o}$ slopes) contrasts with the strongly inclined slopes of the valleys.

The morphometry of the relief influences the bio–pedo-climatic conditions and introduces differences in the vegetation coverage and land use. Unlike the southern mountain area which is well forested, the Gornoviţa plateau near the border settlements is characterized by the maximum extension of grasslands. This element is also signaled by toponymy through names like Poiana Sibiului, Poiana Pietrei, Delniţă etc. These are secondary grasslands resulting from forest exploitation and deforestation carried out more than a century ago (1870) in the Dobrei, Nedeiului basins and at the springs of the Gârbova valley, Poiana and Săliște. The pasture lands and hayfields have extended also as a result of grazing and farming, which are the main occupations of the inhabitants. Small patches of land are used for crop production (corn, rye) or in horticulture.

Compared with pastures, forests have a lower extension. Decidiuous forests (beech, oak, birch, oak-hornbeam) are found dispersed at interfluve levels, and mixed forests (beech and fir) or just conifers are better represented the valleys. The pedo-climaic conditions specific to intracarpathian valley corridors with a relief energy of 400 – 500 m/km$^2$ determine vegetation inversions. When referring to these differences between interfluvial areas and valleys belonging to Carpathian border area, Buza (2000) signaled an inversion regarding the land use generated especially by the features of the landscape. The deforested area overlap to a favorable exposure, today being represented by land covered with meadows and by those cultivated, located at 900 m, so in full mountainous area, while at altitudes of 700 - 900 m on the valley slopes predominates forest use.

The high density of stables and sheepfolds indicates a mountainous economy based on pastoral activities. Permanent households and those with seasonal character are connected by a dense network of local roads, paths and animal trails. It is a landscape where one can notice a high frequency of land degradation through rill erosion, ravines and torrentiality. The possibility of abstraction appears imminent; Secaşul Mare through Gârbova, Valea Poienii and Rod exerts pressure through regressive erosion on affluents of Cibin (Săliştea). This phenomenon is possible due to the brittleness of foothills deposits and the lower base level of the Mureşului River in Alba Iulia then the Oltului River in Turnu Roşu (Costea 2008b).

**Current modeling and land degradation condition**

The analyzed area has a perimeter of 22.3 km and a surface of 4.0 km$^2$ and is located on both sides of the road connecting the two settlements in the northern extremity of the Cindrel Mountains (Fig. 2).

Mesometamorphic crystalline schists (micaschists, paragnaise, ocular gneisses) of the Sebeş-Lotru series and the epimetamorphic ones (quartz schists, sericite and chlorite schists), which are partially covered with a sedimentary layer composed of sand and gravel with a thickness of 8 – 10 m (Harta Geologică 1968) are also part of the geological composition. The reduced granulometry of these deposits (fine sand up to coarse gravel of 10 – 15 cm diameter favored accelerated erosion and the formation of strongly ravined torrential catchments at the springs of Nedeiu, Câlnic, Gârbova and Dosului Valley (right affluent of Gârbova in the upper sector) and of Poiana Valley (Costea, Ciobanu 2012).

The relief consists of flat and slightly rounded interfluves, which belong to the lower level of the Gornoviţa area (800 – 1000 m) and shallow valleys in this level (maximum relief energy of 100 – 150 m). Slopes vary from 6$^{o}$ to 10$^{o}$ at interfluve level and rise on hillsides and valleys up to 15 – 20 – 25$^{o}$. In the climatic conditions specific to the lower mountain level, the rock and the morphometric conditions favor surface erosion, runoffs and gullying.

Surface erosion is a dominant process on surfaces slightly inclined and lacking vegetation or with a grassy carpet degraded from the repeated passing of animal herds and on secondary roads between households. It can also constitute a secondary process associated with superficial landslides or ravines, contributing to greater forms of degradation. The convex character of the surfaces and the poor cohesiveness of ground aggregates (due to the high content of sand and coarse material) are factors that favor pluvial denudation. This occurs both through the impact of raindrops and especially through nappe water leaking, and laminar erosion. These processes are particularly active in late spring – early summer, during heavy rains.

Runoff also has a high frequency in the studied area, being a dominant process on animal trails, paths and secondary roads, as well as a subsidiary process on the banks of ravines and furrows lacking vegetation. Runoff channels develop through linear erosion mostly in the spring, summer and fall, and are shaped by the concentrated flow of water from melting snow or rain. Their sizes are generally modest (20 to 25 cm depth) and are mostly ephemeral due to their refilling with sediment. On more inclined surfaces, devoid of vegetation and on beaten paths there still is a risk of increase in size (lenght of tens of meters, depth of 50 – 60 cm) and their ramification, through collecting drainage from nearby surfaces.

Gullying is the most representative linear erosion process in this area. The genesis and evolution of gullies are influenced by characteristics of altered bark and of soils, but especially by regional climatic conditions (precipitations) and by the land use, which exercises a particular control on modeling slopes. The most common and advanced forms are spring ravines which form catchments of affluents of Gârbova, Valea Poienii, Sălişte şi Nedeiu. The development of spring ravines is at its highest on the slopes in north, north-east and east, benefiting from the high degree of moisture of the slopes' deposits.

In the spring basin of the Dosului Valley ravines have developed regressively in the lower valleys and have created a complex configuration, ie a system of ravines. This consists of an axial sinuous ravine with depths of 4 – 8 m and branches with lenghts of 200 – 500 m developed on tributaries. Evolution by ramification offers the system a barred (connection is done at an angle of approx. $90^o$) or a dendritic form (connection is done at an acute angle) (Fig.3).

The complex character of the ravines' form is also present in the case of Gârbova spring. Ravines are continuous and the configuration is also the result of the composition of the barred and dendritic forms. Unlike the first case, this ravined spring is much more stable as a result of fixation with forest vegetation on almost the entire network (Fig.4).

The spring of Poienii Valley also presents a ravined character (Fig. 5). Runoff and gullying south of Poiana Sibiului have led to complex degradation of the slope. Ravines have lengths exceeding 500 m, are composed like in the other cases, but are less branched, indicating some stability in the process. A particular aspect is the possibility that under human pressure through habitat and pastoral use and due to the increased traffic on roads connecting the settlements and under the conditions of pluvial aggressiveness accentuation, the western spring of the Poienii Valley might be collected through regressive erosion by the Dosului Valley (affluent of Gârbovei), where erosion is manifested more intensely.

The permeability of superficial deposits and the impermeability of the crystalline substrate favored the emergence and development of ground-water table and streams at the contact of the two types of geological formations (Buza 2000). Being supplied by rain and snowmelt (the average amount of precipitation at this altitude is approx. 750 – 800 mm/year) and functioning permanently, these maintain the evolution phenomenon of erosion forms and of ravine deepening in the lower part, especially during the warm season of the year. In cross section the erosion forms present the aspect of the letter „V" with a smaller or greater opening depending on the erosion resistance to deposits. In all cases there is a tendency of widening the cross profile by associating concentrated leakage with surface washing, runoff and superficial landslides.

Another important factor in the formation and evolution of ravines and furrows in the Poiana Sibiului – Jina area is the land use and the space dynamics of the two settlements. The expanding of the human habitat and the pastoral activity of inhabitants since the earliest times has led to modification in the structure of the land fund. The presence of acidic soils from the cambisoil class and the dominance of the districambosoils indicate the past existence of beech *(Fagus sylvatica)* and oak forests (*Quercus petraea*). Today the extension of these forests is reduced in size as a result of deforestation. Coniferous forests that occupy varying areas were introduced artificially to reduce erosion. As plant formations specific to this area from the lower mountain level we fiind mountainous pastures formed of associations of *Agrostis tenuis, Festuca rubra* as well as *Asperula odorata*, *Oxalis acetosella*, *Athyrium filix femina, Dryopteris filix mas*. As a result of deforestation a series of secondary mesophilic pastures with gramineae (*Poa pratensis, Triestum flavescens)*, legumes, various species of clover (*Trifolium pratense, Trifolium repens*), composites and other herbaceous formations were formed, which are used mainly for grazing.

The large share of pastures, meadows and forests has led to an increase in human pressure through pastoral and forestry use. Tabel 1 presents the land fund situation at a administrative territorial unit level in 2010. Of the total land of the city Poiana Sibiului 59 % are pastures and meadows and 34 % are forests. In Jina the forests' share is higher (74 %), and that of pastures lower (23 %).

Pastures and hayfields have always supported an intense pastoral activity, which resulted in land degradation through erosion on animal paths. Moreover, field observations and maps of the distribution of degraded areas through gullying show that the representative land degradations occur in pastures. Statistics show that between the two settlements there still are significant differences both in terms of size and land structure. This affects the size of anthropic pressure indicators at administrative territorial level (Tab. 2) (Costea 2013).

Note that the administrative boundaries of the commune Jina extend further south to the main peak of the Cindrel Mountains and exceed the analyzed area. It should also be mentioned that the commune Poiana Sibiului has the smallest surface of all the settlements from Mărginime, which has led to a very high anthropic pressure. The share of degraded and unproductive areas is very low (Table 1 and 2). In addition to these there is also agricultural land (pastures, meadows) degraded by surface erosion process, runoffs and ravines.

**Conclusions**

The morphogenesis of relief units and the familiarization with the peculiarities of the polycyclic relief (the leveling surfaces) have primarily a scientific importance by providing very important information about the genesis and evolution in geological time of the relief, about stages and phases of modeling in neighboring units, useful information for delimitation and geomorphological regionalization and for the correlation of landforms. On the other hand, leveling surfaces, through their morphometric characteristics (altitude, reduced slopes, large surface extension, low relief energy), have a great practical importance through their favourable conditions for habitat and through its capacity of ensuring the development of a complementary mountain economy. The natural landscape has undergone transformations through the use of landforms for the location of human settlements or through the carrying out of mountain specific human activities, in this case shepherding. The high anthropic pressure through habitat, deforestations and pastoral use and the aggresiveness of the mountain climate are factors that associated in the studied area and generated imbalances in the geomorphological system. Maintaining the stability of landforms and landscapes requires a rational exploitation of land, protection and degraded surface reduction measures through pluviodenudation, runoff and gullying processes.

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

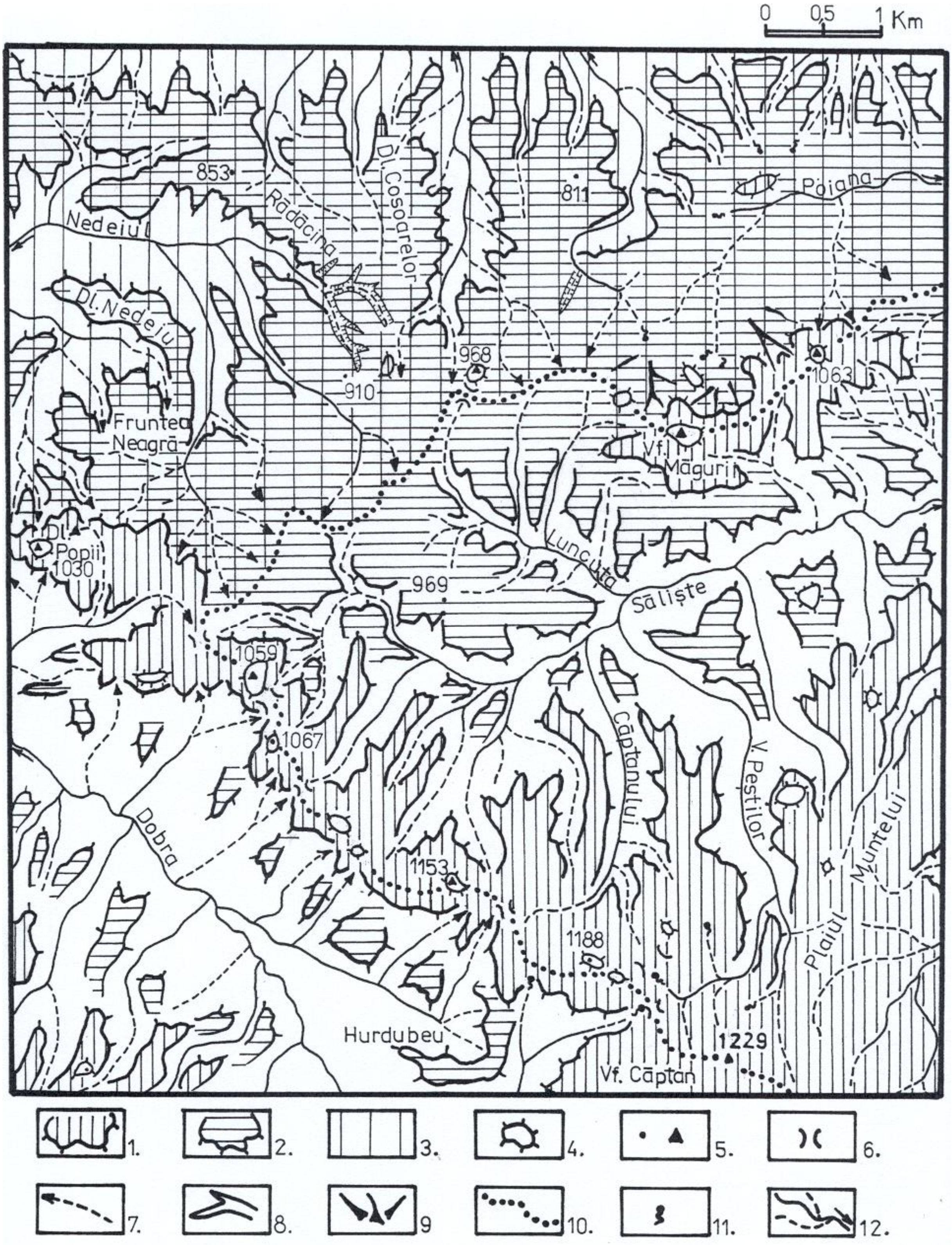


**Fig.1.** Gornoviţa leveling surface in Dobra - Jina – Poiana Sibiului sector (Costea, 2009)
1. Superior level (950 – 1200 m); 2. Inferior level (750 – 950 m); 3. Jina Piedmont;
1. Erosion outlier; 5. Peaks; 6. Saddles; 7. Regressive erosion; 8. Ravines; 9. Gullies;
10. Watershed between Olt and Mureş river basin; 11. Springs; 12. Hydrographical network.

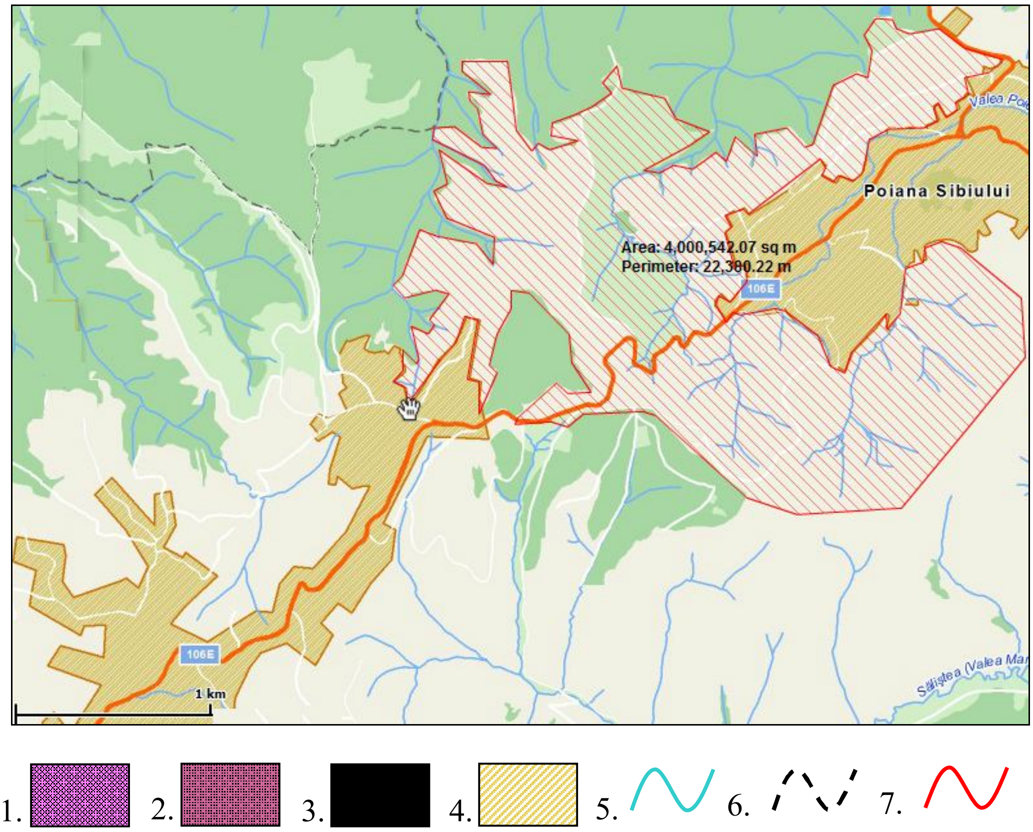


**Fig. 2**. Degraded areas in the vicinity of Poiana Sibiului and Jina (processing on the ANCPI land cover map)
1. Forests; 2. Pastures; 3. Other land uses; 4.Settlements; 5. Hydrographical network; 6. Administrative limit; 7. Contour of degraded areas by erosion processes.

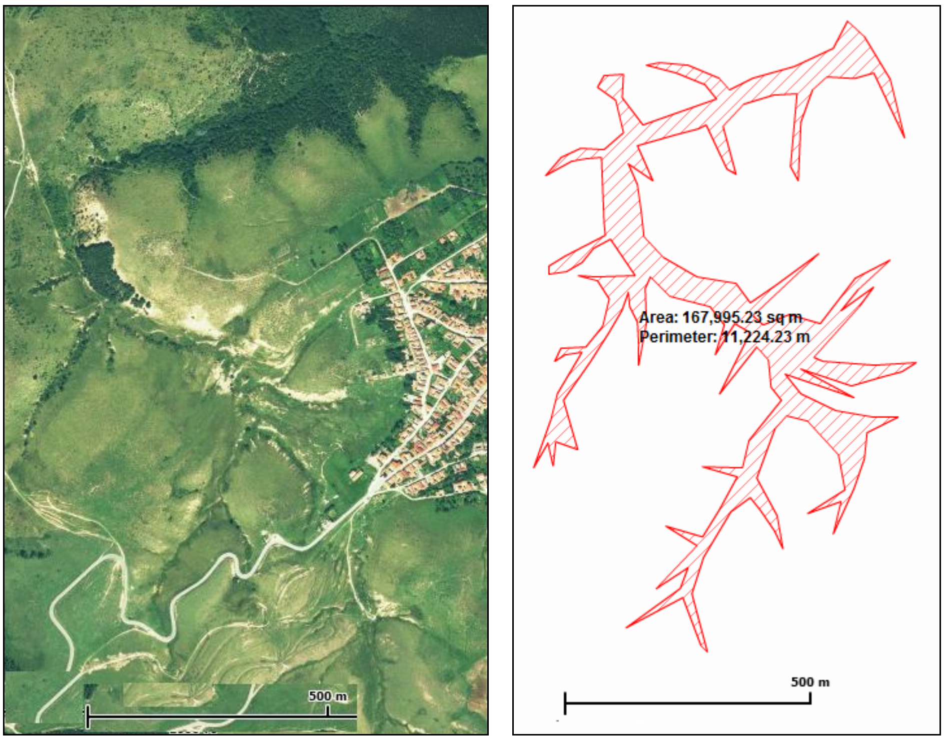


**Fig. 3.** The plan configuration of ravine system in the source area of Dosului Valley to west of Poiana Sibiului (processing on orthophotomap ANCPI 2009)

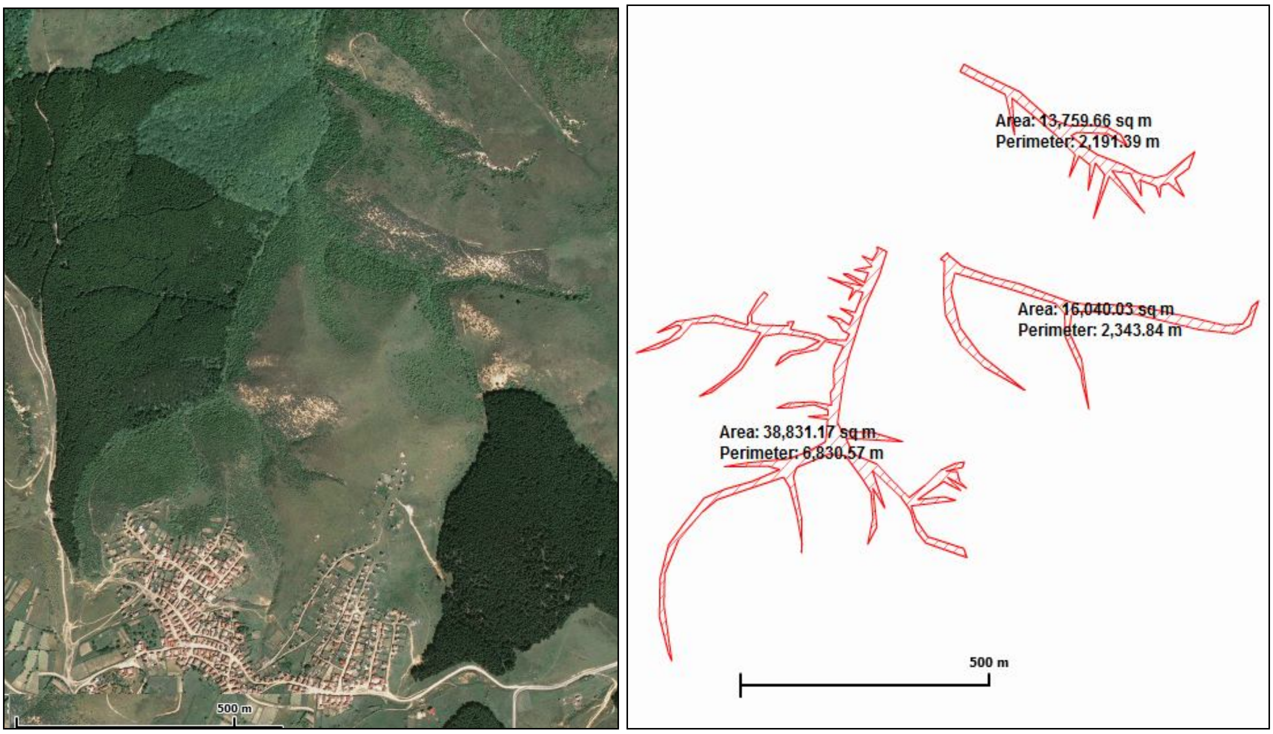


**Fig. 4.** Configuration in plan of Gârbova Valley source at Jina
(processing on orthophotomap ANCPI 2009)

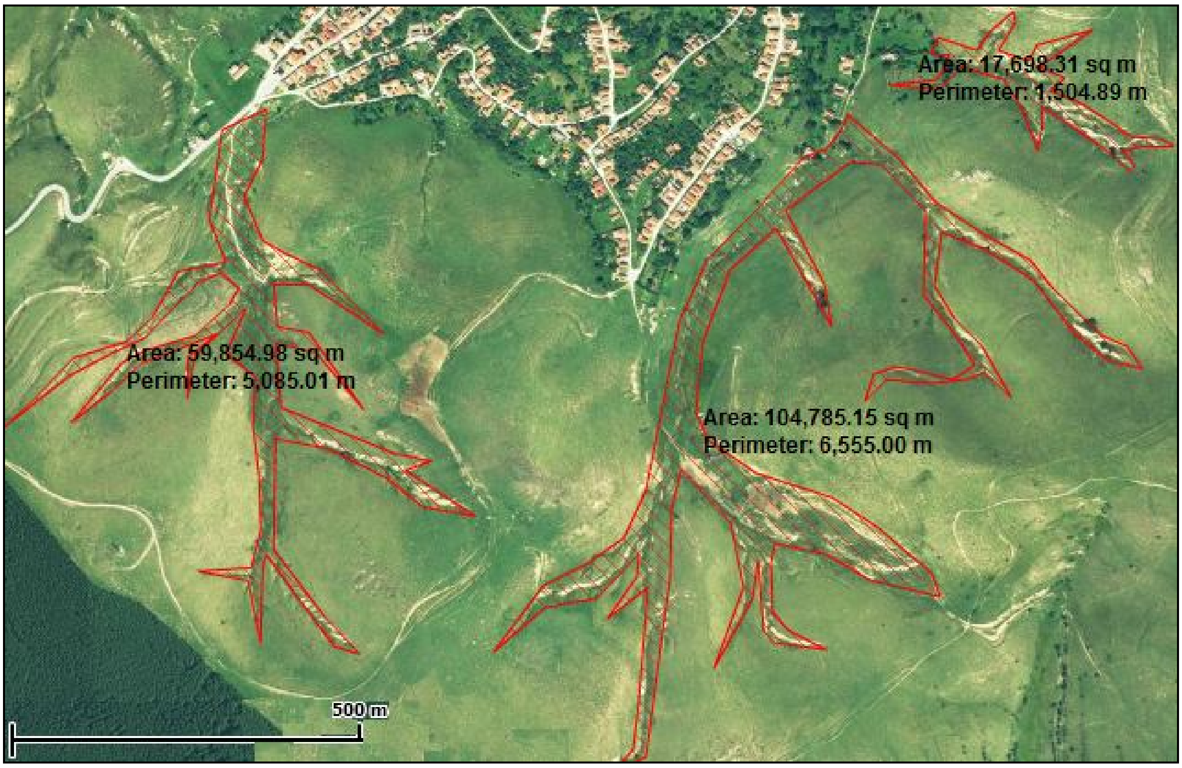


**Fig. 5.** Configuration in plan of Poiana Valley source at Poiana Sibiului
(processing on orthophotomap ANCPI 2009)

**Tab.1** Land fund surface in 2010 on land use type

| | Surfaces in 2010 (ha) | |
|---|---|---|
| | **Jina** | **Poiana Sibiului** |
| **Total** | **32351** | **2347** |
| **Agricultural** | **7988** | **1429** |
| Arable | 232 | 23 |
| Pastures | 2105 | 860 |
| Hayfields | 5651 | 546 |
| **Non-agricultural land** | **24363** | **918** |
| Forests and forests vegetation | 24032 | 808 |
| Waters | 93 | 11 |
| Buildings | 88 | 43 |
| Communications network | 108 | 45 |
| Degraded and unproductive land | 42 | 11 |

Source: INSSE

**Tab. 2** Indicators of anthropogenic pressures on space on administrative units for 2010

| **U.A.T.** | **I n** | **Ite** | **Id** | **Index of human presure through land use (Ipu)** | | | |
|---|---|---|---|---|---|---|---|
| | | | | **agricultural** | **arable** | **pastoral** | **forestry** |
| **Jina** | 74,29 | 162,18 | 0,13 | 1,95 | 0,06 | 1,89 | 5,87 |
| **Poiana Sibiului** | 34,43 | 25,16 | 0,47 | 0,55 | 0,01 | 0,54 | 0,31 |

Source: Processing data after the INSSE raw data (2010) (Costea, 2013)
UAT = administrative territorial unit
In = naturality index
Ite = environmental transformation index
Id = degradation index
Ipu = index of human presure through land use

# OBSERVATIONS ON LAND DEGRADATION THROUGH EROSION IN GÂRBOVA RIVER BASIN (TRANSYLVANIAN DEPRESSION)

**Marioara COSTEA***

***Abstract.*** *The main purpose of this paper is to highlight the role of water erosion processes in land degradation. The analysis is based on the interpretation of the relationships between geological substrate, geomorphologic parameters, land use and morphodynamic in a small basin located at the contact between the Southern Carpathians and the Transylvanian Depression. Land degradation through erosion is the result of a combination of natural and anthropogenic factors. The intensity of degradation and the density of landforms are directly related to the type of substrate, soil type, morphometric characteristics, the type of land cover and land use. Mechanical stress induced by overgrazing, inappropriate agricultural techniques with typology of soils, disruption of agriculture and anthropogenic pressure (sometimes manifested by uncontrolled interventions, contribute to the increase of the imbalances caused by water erosion. It can also consider that the natural parameters did not show significant changes.*
***Key words:*** *erosion, land use, land degradation, Gârbova river basin, Transylvanian Depression.*

***Rezumat.*** *Prin lucrarea de faţă urmărim evidenţierea rolului proceselor de eroziune hidrică în degradarea terenurilor. Analiza se bazează pe interpretarea relaţiilor dintre substratul geologic – parametri geomorfologici – utilizarea terenurilor – morfodinamică într-un bazin hidrografic de mici dimensiuni situat la contactul dintre Carpaţii Meridionali şi Depresiunea Transilvaniei. Degradarea terenurilor prin eroziune este rezultatul asocierii factorilor naturali şi antropici. Intensitatea degradării şi densitatea formelori sunt corelate direct cu tipul de substrat, tipul de sol, caracteristicile morfometrice, tipul şi gradul de acoperire cu vegetaţie şi modul de utilizare a terenurilor. Stressul mecanic indus de păşunatul excesiv, de tehnicile agricole neadecvate tipologiei terenurilor, dezorganizarea agriculturii şi presiunea antropică manifestată uneori prin intervenţii necontrolate concură la creşterea dezechilibrelor generate de eroziunea hidrică, şi nu numai, în condiţiile în care parametri naturali nu au înregistrat schimbări substanţiale.*
***Cuvinte cheie:*** *eroziune, utilizarea terenurilor, degradarea terenurilor, bazinul Gârbovei, Depresiunea Transilvaniei.*

## Introduction

Land degradation are imbalances of relief - soil system commonly found in a favorable geological conditions, to which the hydro-climatic stress and the anthropogenic pressure by intensive or incorrect land use are added (Knijff *et al.* 2000, Costea 2012).

The most important factors of morphodynamic in the Gârbova river basin, and also the most active, are the hydroclimatic condition and human activities. As passive factors, are considered the rocks constitution (sandstone, gravel, marl, clay, sand Badenian, Sarmatian and Panonian) and geomorphological characteristics. These factors work together and in the presence of weak vegetation cover, predominantly grassy, give to the slopes a high morphodynamic potential (Posea 1987, Sandu 1998, Costea 2005).

Gârbova Basin is a inferior order basin of the Secaşul Mare river basin, developed in the contact area between the Transylvanian Depression and Cindrel Mountains, on a difference of 678 m. The maximum altitude, of 968 m, is reached in the source area located in the inferior mountain level at Jina and the minimum altitude of 290 m which is recorded in the Apold Depression, at the confluence of Gârbova with Secaşul Mare River.

As a consequence of its position in a morphological and structural contact area (Sandu, 1998) the Gârbova river basin is characterized by a wide variety of erosion processes, with variable intensity, shapes and sizes. The degradation forms are in various stages of development and reflect the combination of natural and anthropogenic factors. Relief transformations through agricultural

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activities and other human activities and the changes in land use allowed the transition to new morphodynamic equilibrium conditions (Goudie 2006). After 1990 the abandonment of land works is noted. Humidity and lack of planning works (land returned to their former owners, vineyards and orchards have been abandoned and are in state of decay) lead to the reactivation of degraded land by splash erosion, rill erosion, gullying and even by torrentiality.

**Research methodology**

To highlight the typology and the predominance of erosion processes on slopes various methods as, the direct observation, inventory of erosion forms and recording of phenomena on maps were used. Also, based on the detailed topographic map (scale 1: 25000), using GIS techniques, the thematic maps were made (Mitasova *et al*. 1997, Knijff *et al*. 2000, Stanchi *et al.* 2003). This methodology was used to study the land degradation through current geomorphological processes in Curvature Subcarpathians (Bălteanu 1983), in Moldavian Plateau (Rădoane *et al.* 1999), especially the landslides (Surdeanu 1998, Constantin 2006, Rădoane, Rădoane 2007 etc.), in Hârtibaciului Plateau (Grecu 1996, Grecu, Sandu 2000). All of these stood at the basis of mapping of processes distribution and dynamics studies of the slopes in these areas.

Research in the field of land degradation by erosion in Gârbova river basin had as a target the identification of processes, inventory of forms and localization of degraded areas affected by erosion processes (like splash erosion, runoff, gullying) and also the identification of local conditions at the time of observation and marking of these areas on the map.

The studied areas are numbered in the inventory order from 1 to 7. Details of each area were marked with lower case letters a, b, c,...n. Collected data from the field are summarized in the Tables 1 and 2. In this small basin 7 areas degraded by erosion has been identified, as totaling 16.13 $km^2$ (data summarized in Table 1, 2, Figure 1, 2), which represents 24.96% of the basin total surface.

Direct observations and thematic maps were used to develop a detailed analysis regarding the relationship between cause (factor) and effect (shape and intensity of degradation). Degraded areas are shown in the distribution map of land degradation by erosion (Figure 6), on severity levels.

**Results and discutions**

***Data analysis and interpretation***

The data presented in Tables 1 and 2 show for the Gârbova basin the following aspects:

***Combined and simultaneous action of processes in slope morphogenetic systems***

Erosion processes occurs not singular, they are associated with each other forming the morphogenetic systems (Ielenicz 2000, Costea 2009). One or two processes are dominant and other are auxiliary processes. Also, in all observed areas the erosion processes are associated with the gravitational processes (landslides). In some areas (Figure 2: 1, 2b, 2c, 2e, 2f, 4, 6, 7) superficial landslides are secondary processes, most commonly in the form of solifluxion and are caused by local hydro-climatic conditions and pastoral use. In other areas (Figure 2: 2a, 2d, 3, 5) erosion processes acting on the old or recent landslides These have displaced the slope deposits, have interrupted the vegetation cover and by head scarp of detachment and chaotically waves of mass-movement, provide the surfaces devoid of vegetation for pluvial denudation and runoff.

In all analyzed areas, the erosion processes are active or reactivated by torrential rains (falling mainly in the spring-summer period from April to July, and also in autumn, October), on hillsides with slopes greater than 8-10$^{o}$, occupied by pastures on glacises or deluvial sliding deposits. There are extinguished or stabilized forms, mostly ravines, totally or partially fixed by shrub vegetation. Even though are moderate, the slope conditions, the geological substrate features and intensive land use by grazing create the prerequisites of reactivation of these forms/processes through regressive erosion and of degraded areas expansion.

***Development and acceleration of the processes on the fine and very fine grain deposits and compact rocks***

Distribution of degraded areas through erosion by types of superficial deposits (Table 1, 3) indicates the development and extent of processes on the fine and very fine grain deposits with high content of clay. Clayay-loamy deposits prevailing in 85%

of cases on the surface affected by degradation due to rill erosion, along with loams (57%), clayey loams (71%), sandy clays (71%), sandy loams (42%). These deposits are part of the geological substrate and forming the parental material on which preluvisols, regosols, moderate and strong eroded luvisols are developed.

Clayey component found in the substrate of the most areas confers impermeability to these deposits and favors the runoff and development of linear erosion forms: streams channels, gullies, ravines (Ciobanu 2002). At the same time, clayey and loamy deposits are passive factors in landslides, favoring a higher rate of production of surface erosion (splash erosion), rill erosion and ravening (Costea, Ciobanu 2012).

In the case of 1, 2f, 2e areas (Figure 2) the presence of alteration crusts rich in skeleton promotes a better infiltration (Carnicelli 1999) of water from rainfall, but its small thickness and the impermeability of metamorphic substrate from submountainous hills and lower mountain level are factors that contribute to the increase of the runoff, ravening and torrential flow, under conditions of a higher rainfall aggressiveness compared to the lower basin.

***Density of forms and intensity of erosion processes depend on morphometric indicators, the shape and exposure of slopes***

Among the most significant morphometric indicators in slopes erosion on analyzed areas, to be mentioned are the relief fragmentation, the declivity and slopes exposure. Most of the analyzed areas and erosion forms are grouped in class of fragmentation density between 1-2 km/km$^2$ (Figure 2: areas 1, 3, 4, 5, with a total surface of 5.19 km$^2$). However, the largest degraded surfaces by runoff and ravening and the most representative in size forms (Figure 2: areas 1, 2, 7) are grouped in classes of fragmentation density between 2-3 and 3-4 km/km$^2$. Statistical processing of the areas affected by erosion depending on the fragmentation density values indicate a direct and significant correlation expressed mathematically by the following exponential equation (1):

$$\mathbf{y} = 0{,}2961e^{0{,}6273x} \qquad (1)$$

where: **y** is the area affected by the linear erosion processes, and **x** is the density of fragmentation.

Regarding the relief energy of surfaces degraded by erosion, it was grouped into classes of values as follows: 40-80 m/km$^2$, 80-120 m/km$^2$ and over 120 m/km$^2$. In relief energy class of 40-80 m/km$^2$ enter the areas 3, 4, 5, totaling a surface of 3.19 km$^2$, and in class of 80-120 m/km$^2$ fall the most part of areas 1, 7 and the entire areas 2 and 6, totaling a surface of about 12 km$^2$. The distribution of degraded areas by classes of relief energy is achieved after a second-degree polynomial equation (2):

$$y = -9{,}94x^2 + 38{,}64x + 25{,}52 \qquad (2)$$

where: **x** is the relief energy and **y** is the area degraded by erosion.

Distribution of erosion forms is closely related to the slopes declivity, which is also an indicator of differentiation of the types of processes. Pluvial denudation processes and weak to moderate diffuse runoff occur on inclined surfaces in the range of 2 - 10° of declivity. They are specific to interfluvial summits, very slightly inclined slopes, glacises, bridges of terraces and can be easily identified in areas 1, 2, 3, 4, 5 and 7. Alongside these processes the weak gravitational processes such solifluxions are also encountered.

Slopes in the range of 10 - 20° are favorable to accentuated ablation and to moderate linear erosion, encountered in areas 2, 6 and 7. Associated with these, small scale landslides appear. Intense linear erosion with large developing of gullies and ravines encounters on the slopes which are the ranging between 20° and 35°. The areas affected by these processes decrease with increase of the angle of slope, the erosion processes leaving the place to landslides or collapses. Statistical processing of the areas affected by erosion depending on the slope angle values indicate a significant inverse correlation expressed mathematically by the following exponential equation (3):

$$\mathbf{y} = 5{,}1207x^{-0{,}4496} \qquad (3)$$

where: **x** is the declivity and y is the area degraded by erosion.

In analyzing the distribution of processes on slopes with different declivity we must take into account the altitudinal strip in which they operate and the slope exposure. In the Gârbova river basin the most degraded areas by erosion are found on the slopes of the right side of the valleys Gârbova, Chipeşa, Reciu with northwest exposure (Figure 2:

areas 1, 2, 7), northern (Figure 2: areas 1, 7) and also on their left side, on slopes with eastern exposure (Figure 2: 2b, 5, 6), northeastern (Figure 2: 2c) or even southern (area 4) (Figures 3, 4).

Regarding the typology of processes, the slopes are divided in altitudinal strips (Bianchi *et al.* 2001). In lower half or in the inferior middle third of the slope predominant are the linear erosion forms, heavy deepened. In the upper half or in the superior third part of slopes predominant are the splash erosion, surface erosion and runoff.

***The distribution and intensity of degradation by erosion depend on the land use and the type of land cover***

Land use is diversified and depends directly on the altitude, slope exposure and declivity and soil type. Forestry use is specific to upper basin, on steep slopes which make the connection between the mountain and submountainous hills (Figure 5). The forests are distributed between 550-600 m and 850-900 m altitude. These are composed of deciduous species (beech, hornbeam, oak) distributed as massive forest areas in the south - southeast of the basin (Bărcu Divlei – Dumbrava - Piţigaia 16.5 $km^2$) and in the Southwestern part (Chipeşu – 4 $km^2$, Bărcu Laţului – 2.5 $km^2$ from which 1 $km^2$ in Gârbova basin) and in the western part of basin on the interfluves between Câlnic and Reciu rivers, at the Garbova basin boundary (Hebedeu - Dâlma - Albele over 8 $km^2$). Also, the forest has a scattered distribution on top of interfluves (Gârbova of 0.65 $km^2$, Dobârca to east of 0.70 $km^2$). They have an important role in protecting downstream land against erosion through rain interception and consumption of groundwater resources. However, the forest surfaces are also susceptible to linear erosion, especially in upper small basin by accumulation and the concentration of the flow from pastures upstream situated. Some forest areas of spruce, pine and birch which are located on the bottom of the valleys (Chipeşa Valley downstream Cărpiniş) or on slopes (north of the connecting road Poiana Sibiului – Jina), indicate the anthropogenic intervention through reforestation. These have the role of protection and erosion mitigation. The erosion processes, particularly violent, were installed in these areas after deforestations practiced in the late XIX$^{th}$ and early XX$^{th}$ century.

The direct observations made in the field reveals that the areas most affected by degradation through erosion are pastures and hayfields, followed by orchards, vineyards and fields used in crop production. Grasslands degradation by surface erosion processes and reactivation of ravening is favored by intensive grazing and sheepfolds installation on the slopes. These phenomena are particularly active on the paths of animals and trodden areas near sheepfolds and stables of animals. The vegetation is totally destroyed and where there are the pastures the herbaceous layer are enriched in less productive allochthonous species or even invasive, which lead to their degradation.

Orchards and vineyards are also subject to degradation by erosion. Created even to protect land against landslides, most of them are in an advanced state of aging and neglected, due to the erosion processes and gravitational mass-movement reinstalled. Moreover, the agricultural work along the slope practiced on small plots and land fragmentation are factors that activate and accelerate the erosion and lead to expansion of degraded areas.

Arable land occupies the versants with smaller slopes, the surfaces of interfluves and the bridges of terraces. However, they are also subject to pluvial denudation through rill and interrill erosion, especially because the agricultural activities made along the slope, the service roads of the parcels or too deep plowing, create channels and gullies that attract and concentrate the flow.

**Intensity of degradation by erosion**

The direct observations from the field, the inventory of geomorphological processes and degraded areas have made possible the hierarchy or gradation of degradation phenomena (Grecu 1996, Surdeanu 1998). This operation was achieved by applying a qualitative method of evaluation and ranking, known in the literature as the method Champenoise (Irimuş *et al.* 2006). Through this method we have achieved a hierarchy of land degradation phenomenon and a spatial distribution of degraded areas by qualitative state of microforms and geomorphological processes observed and inventoried in the field, and correlated with morphological and hydrological factors analysis previously performed (Figure 6).

The following three categories of degraded areas with different intensities depending on the weight and active or potential character of geomorphological processes (Sidorchuk 1999) are distinguished. For mapping purpose the quality fund method (colors) was used.

The weakly degraded areas characterize the surfaces by high degree of stability, where the geomorphological slope processes or channel erosion with risk character lacking or have very rare frequency in time and space.

The medium or moderately degraded area overlap of areas affected by old geomorphological processes and stabilized forms but with a potential instability, i.e. potential for reactivation. This category includes the areas moderately affected by pluvial denudation (splash erosion, gullying, torrentiality) or fluvial processes (erosion, accumulation) and with a low weight of stability factors (fixation by forest, pastoral use, operation slopes materials or bed etc.); are often frequent associations with gravitational processes;

The highly degraded areas overlap on areas affected by erosion in the past, with or without landslides, to currently active areas during the time of observation and to those which showing obvious signs of reactivation or recurrence processes.

## Conclusions

As a result of field observations, analysis and interpretation of them, we can conclude that the geology of the region, relief morphometry and soil characteristics in the Gârbova basin are passive factors which influence the land degradation through erosion and give to this space a great vulnerability to these processes. In recent decades, climate variability and stress conditions imposed by the alternation of dry and rainy periods, rainfall concentration for short periods of time, thermal variations which prepare the crust for complex processes action, lead to increasing of erosion processes and to an active dynamic of landforms.

In these circumstances anthropogenic pressure, due to intensive use of space and inadequate techniques to relief morphology and the characteristics of the land, has serious consequences on these lands through the acceleration of the evolution of processes and generate imbalances in the geomorphological system, difficult to impede. These actions are transmitted on the landscape components and also on the economy.

Geomorphological research conducted at national and international level, and our experience on this topic of degradation processes and geomorphologic risk reveal that the areas which have been affected in the past by geomorphological processes have a high potential of reactivation and therefore high vulnerability, even if during the analysis the processes are no longer active or low active.

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR



**Fig. 1.** Ravening processes (left) and splash and surface erosion (right) in Gârbova submountain hills

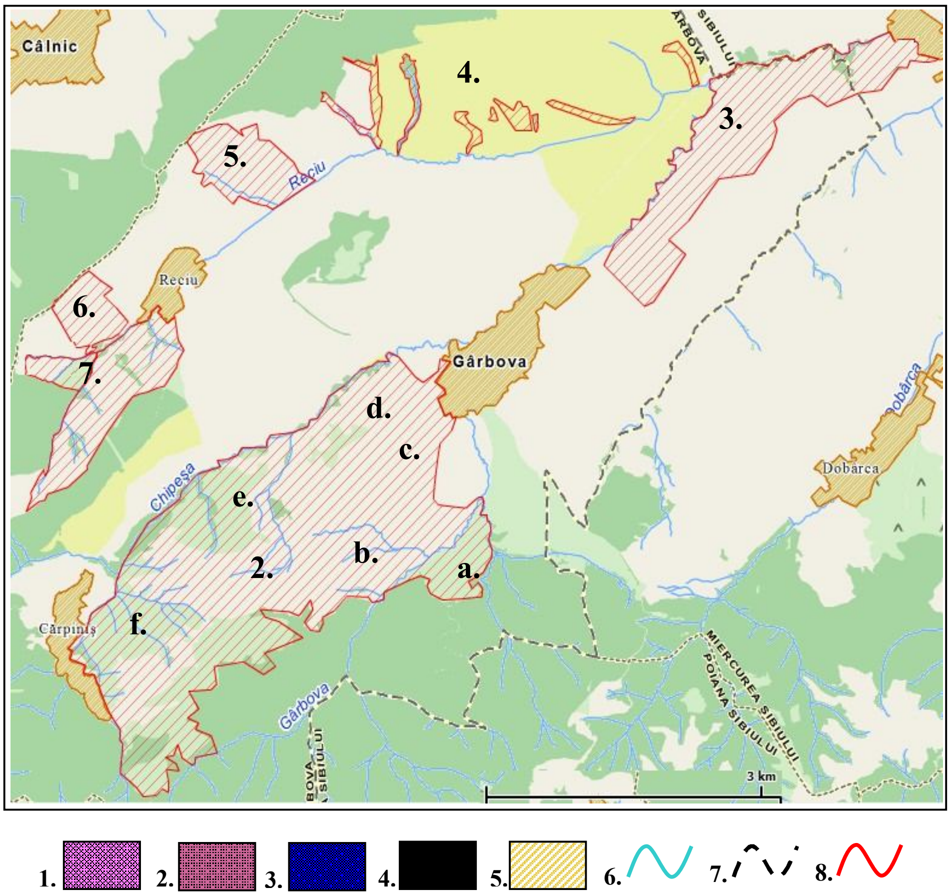


**Fig. 2**. Degraded areas through erosion in the Gârbova river basin (processing on the ANCPI land cover map) 1. Forests; 2. Pastures; 3. Arable land; 4. Other land uses; 5.Settlements; 6. Hydrographical network; 7. Administrative limit; 8. Contour of degraded areas by erosion processes.

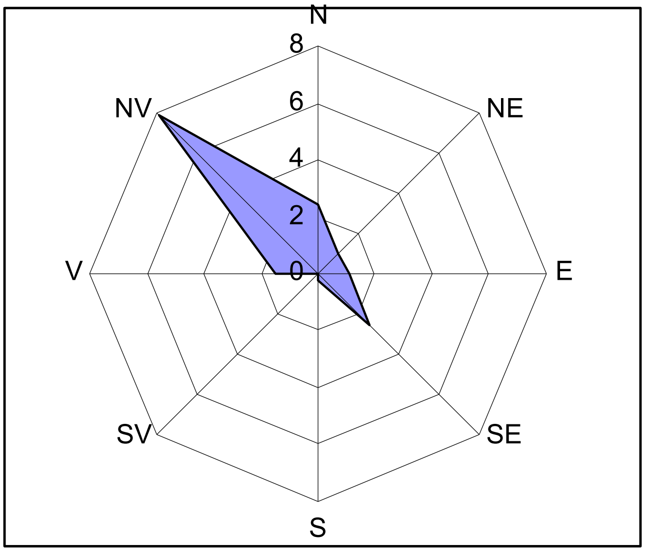


**Fig. 3**. Distribution of degraded surfaces depending on slope exposure (km$^2$)

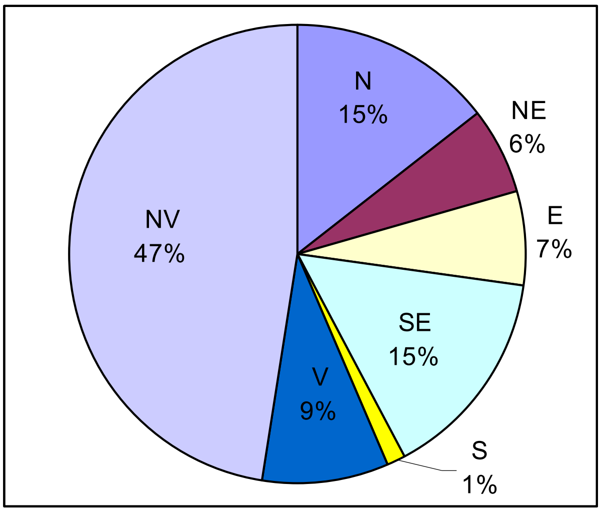


**Fig. 4.** Weight of degraded surfaces (%) depending on slope exposure in the Gârbova river basin

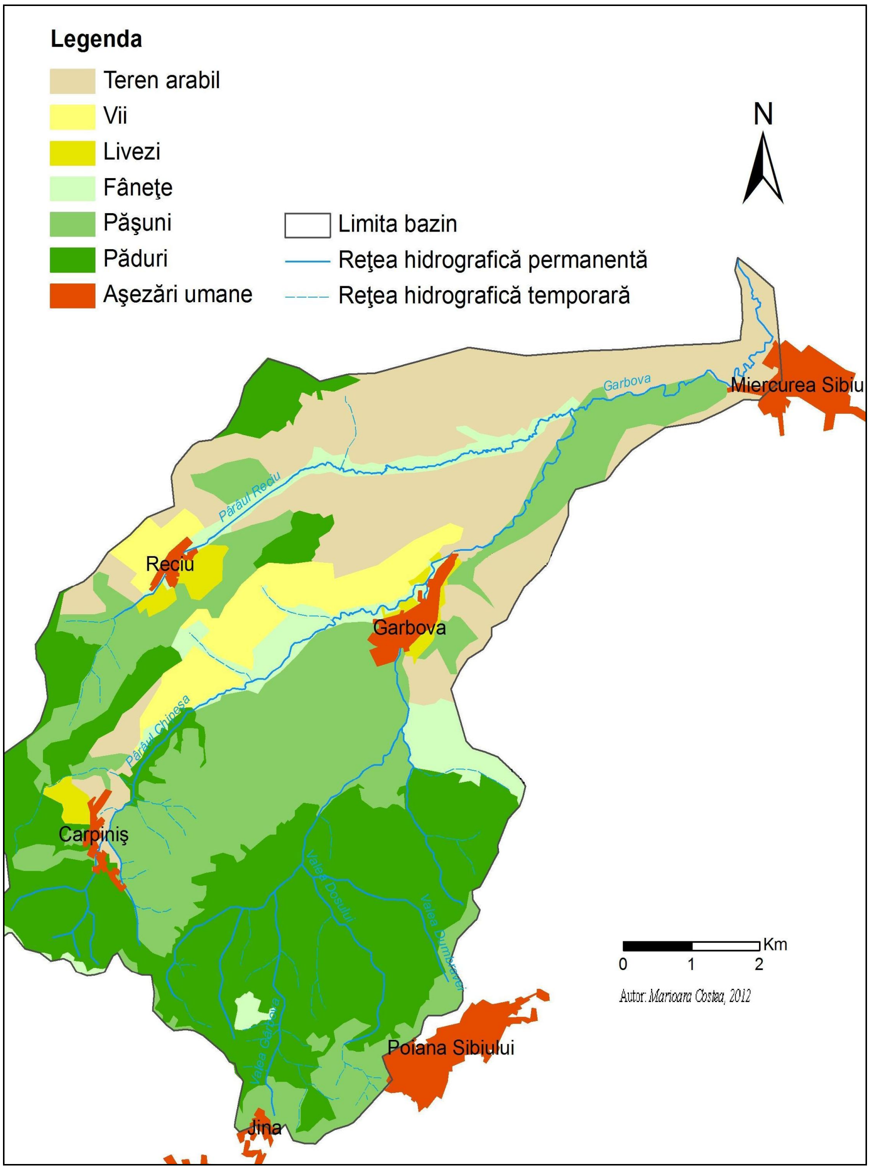


**Fig. 5.** Land use map in the Gârbova river basin

**Tab. 1** Synthetic data on the degraded areas in the Gârbova river basin

| No. area | Location | Perim (km)/ Area ($km^2$) | Geological substrate and litology of superficial deposits | Morphometry | | Soils | Land use |
|---|---|---|---|---|---|---|---|
| | | | | Lenght slope (m), exposure | Fragmentation density ($km/km^2$) Relief energy (m) Medium slope (°) | | |
| 1. | On the summit, to north of Jina and Poiana Sibiului, in the Cindrel Mountains | 12.2/ 2.0 | Metamorphic rocks and piedmont deposits of sands and gravels | Short slopes, 100 – 250 m, exposure N, NE, NW | 0.8 – 3.5<br><br>80–100–130<br><br>2° – 8° – 10° | Mostly Districambosoils, Luvisols and skeletal soils<br>LN, N, Pt | Pasture and hayfield, woods and valleys on the edge of the area |
| 2. | South of Gârbova Garbova-Chipeşa interfluves, in the submontainous hills | 21.21/ 9.13 | Metamorphic rocks in the southern part, sedimentary rocks, deposits of Mio-Pliocene on valley, hills and glacis (sand, clay, marl clays) and crystalline nuclei | Complex slopes with lenght of 250 – 500 – 1000 m, different exposure: N, E, SE, NW, W | 1.5 – 2.7 - 3.6<br><br>80 – 120<br><br>2 – 5° on summits<br>15 – 35 °on slopes | Predominant Luvisols and Lithosoils, complex of Luvisols and Preluvisols, moderately and strongly eroded RegosolsP<br>LN, AL, L, LA,AN, LP | Highly degraded pastures and meadows, old orchards of plum and apple, isolated pine plantation, oak and beech forest at the southern limit of the area |
| 3. | Right side of the Gârbova valley, upstream to Miercurea Sibiului, on foreheads of superior terraces of Secas Mare river | 12.11/ 2.21 | Pleistocene sedimentary deposits of terrace, (small gravel, sand, clay, marl clays) and colluvial deposits | Convex and mixed slopes, 750 – 1000 m, exposure NW | 1.2 – 1.4<br><br>60 – 75 m<br><br>3 - 10 ° with most prominent sectors 20 - 30 ° | Mostly Preluvisols, complex of Regosol and Preluvosoil moderately eroded<br>AL, L, NA, LN, LA, AN | Grassland areas degraded by overgrazing, pasture with shrubs and isolated trees |
| 4. | Left versant of Reciu river under the Albele Hill, dispersed forms on the foreheads of upper and middle terraces of Secaşul Mare river | 6.85/ 0.23 | Pleistocene sedimentary deposits of terrace, (small gravel, sand, clay, marl clays) and colluvial deposits | Long slope, 1000 m, predominantly convex, exposure S | 1.5 – 2<br><br>45 – 80<br><br>2 - 10 ° | Preluvosoils moderately eroded, calcareous Regosols<br>LA, AL, AN, AM | Agricultural use, predominant arable land, cereals crops |
| 5. | Left versant of Reciu river, downstream of Reciu settlement, on valley glacis | 4.09/ 0.75 | Sarmatian and Pontian deposits of little gravels and sands, with clay and gray marls, carbonate deposits and deluvial deposits depoz. deluviale | Long slope, 1000 m, predominantly concave, exposure SE | 1 – 1.3<br><br>60 – 75<br><br>3 - 7° | Preluvosoils moderately and strongly eroded, complex of Regosols and Preluvosoils, Phaeozems<br>AN, AL, LNA, L | Degraded agricultural land, covered by shrubs and bushes |
| 6. | Left versant of Reciu river, upstream of Reciu settlement, in the sub-mountainous hills | 2.56/ 0.38 | Sarmatian and Pontian deposits of gravels, loamy-clayay and carbonate deposits | Medium lenght slope, 750 m, convex, exposure SE | 0.25 – 0.5<br><br>100<br><br>10 - 17 ° | Calcaric skeletal Regosols, erodosoils and complex of regosol and preluvosoil LA, AL, AN, | Grassland with shrubs and isolated trees |
| 7. | Source area of | 8.67/ | Clayey deposits | Complex | 2.5 – 3.5 | Luvisols moderately | Pasture, pasture |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Reciu river, in the sub-mountainous hills | 1.43 | (clayey loam, loamy clay) and carbonate deposits | slopes, predominantly concave, 500 – 1000 m, exposure .N, NV, V | 75 – 100 – 125<br><br>5 – 8° and 15 - 20 | eroded, complex of Luvisols and Preluvosoil moderately - highly eroded AL, LA, L, | with shrubs, overgrazing |

LN – sandy loam; N – sand; Pt –gravel; AL – loamy clay; L – loam; LA – clayey loam; AN – sandy clay; LP – silty loam; NA – clayey sand; AM – medium clay; LNA – sandy clayey loam;

**Tab. 2** Data on the types of processes and their state in the degraded areas

| No. area | Location | Dominant processes | Associated processes | State | Tendency |
|---|---|---|---|---|---|
| **1.** | On the summit, to north of Jina and Poiana Sibiului, in the Cindrel Mountains | Ravening | Sheet erosion<br>Rill erosion<br>Superficial landslides | Active processes | Regressive erosion and ramification of forms on animal paths and roads |
| **2.** | South of Gârbova Garbova-Chipeşa interfluves, in the submontainous hills | **a.** Superficial and medium depth landslides | Ravening,<br>Rill erosion, sheet erosion,<br>Alteration - nitrites, nitrates | **a**. Active processes on the right of Gârbova valley, chaotically located on medium depth landslides (20-50 m long, 0.5 - 1.5 m depth). | **a.** Instability due to the presence of springs and overgrazing |
| | | **b.** Ravening | **b.** Sheet erosion,<br>Rill erosion,<br>Solifluxions,<br>Alteration - nitrites, nitrates,<br>River banks erosion | **b.** Fixed with bush vegetation in the lower part of slope but active to the upper part of slope (250 - 500 - 1000 m length and 3-5 m depth). | **b.** Capture and union trends through regressive erosion on gullies and ravines favoured by grazing. |
| | | **c.** Ravening | **c.** Rill erosion<br>Sheet erosion,<br>Stabilized landslides,<br>Solifluxions | **c.** Active gullies (1 – 2 m depth) and ravines (6 – 8 m depth), without vegetation, with length of 250 – 750 m and superficial stabilized landslides | **c.** Deepening, ramification and combination trend through regressive erosion |
| | | **d.** Superficial landslides | **d**. Sheet erosion and rill erosion | **d**. Active processes of splash erosion, sheet erosion and rill erosion against a background of superficial landslides in the lower half of the slope. | **d**. Instability, extending towards the upper part the slope, intensification of processes due to the slope (25 - 30°) and the presence of springs which maintain sliding. |
| | | **e.** Ravening | **e**. Sheet erosion,<br>Landslides, River bank erosion,<br>Alteration - nitrites, nitrates | **e**. Active ravines with depths of 1 – 3 m and length of 100 – 250 – 750 m, ravening of river courses with active bank erosion, very active surface erosion processes | **e.** Intensification of processes in the upper half of the slopes by associating of processes on steep slopes (25 - 35°) with intensive grazing. |
| | | **f.** Ravening | **f.** Sheet erosion | **f**. Active ravines (50 -250 – 600 m length) and gullies (6 – 10 m length) at the basis of slopes, partially fixed in the inferior part, active to the edge, with depths of 2,5 – 3 m, surface erosion and rill erosion in the middle third of slopes. | **f.** Regressive erosion favoured by using as pasture of the medium third of the slope, stabilizing trend by the expanding of spontaneous birch forest. |
| **3.** | Right side of the Gârbova valley, upstream to Miercurea Sibiului | Landslides<br>Sheet erosion | Rill erosion<br>Ravening<br>River bank erosion | Surface erosion and runoff against a background of active landslides with head scarp of 2 – 6 m. | Expanding of surface erosion areas caused by interruption of vegetation cover, the presence of springs and grazing. |
| **4.** | Left versant of | Ravening | Rill erosion | Ravines of different size (10 – | Trend of increase of |

| | | | | | |
|---|---|---|---|---|---|
| | Reciu river under the Albele Hill, dispersed forms | | Sheet erosion | 20 – 50 m şi 50 – 750-1000 m length, 3 – 5 m deep), stabilized with shrubs.<br>Active surface erosion processes. | surface erosion even under relatively good land management and agricultural practices appropriate to the slope characteristics. |
| **5.** | Left versant of Reciu river, downstream of Reciu settlement | Superficial landslides | Ravening<br>Sheet erosion | Processes partially stabilized by fixing with shrubs; associated surface erosion (splash and sheet erosion) occurs | Laterally extending trend through sliding and increased of surface erosion by vegetation cover disruption. |
| **6.** | Left versant of Reciu river, upstream of Reciu settlement | Sheet erosion | Suffosion,<br>Rill erosion,<br>Solifluxions | Active processes on the whole surface, caused by slope and grassy vegetation disruption | Expansion and accentuation trend of processes favoured by sandy-clayey and sandy loamy deposits. |
| **7.** | Source area of Reciu river | Ravening<br>Sheet erosion<br>Rill erosion | Superficial landslides | Active processes (ravines of 2-4 m deep and 400-500 m long, gullies of 1 - 1,5 m deep and 10-20 m long) maintained by a high degree of moisture of the substrate (springs at the periphery of the forest) | Extension and accentuation trend of forms following the intensive grazing and runoff on animal paths. |

**Tab. 3** Distribution of degraded areas by erosion by type of superficial deposits

| **Granulometry** | **Areas** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| LN – sandy loam; | x | x | x | | | | |
| N – sand, | x | | | | | | |
| Pt –gravel; | x | | | | | | |
| AL – loamy clay, | | x | x | x | x | x | x |
| L – loam, | | x | x | | x | | x |
| LA – clayey loam; | | x | x | x | | x | x |
| AN – sandy clay; | | x | x | x | x | x | |
| LP – silty loam; | | x | | | | | |
| NA – clayey sand; | | | x | | | | |
| AM – medium clay; | | | | x | | | |
| LNA – sandy clayey loam | | | | | x | | |

# SAMUEL VON BRUKENTHAL MINERAL COLLECTION. CONSERVATION LEVEL

**Rodica CIOBANU**[*]
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***Abstract.*** *Samuel von Brukenthal's activity as collector of paintings, coins, medals and furniture is well known. However, his interest in collecting valuable mineral samples is less known. Further on, we will address the baron's mineral collection, in order to analyse the conservation level of the items in this collection. The process of setting up the collection was very much connected to everything else that was happening at that time, especially in the baron's society and to the geological knowledge of the collector. It is our belief that the history of a collection is particularly important for properly understanding the conservation level of that particular collection. Most of the items have maintained their integrity and remained unchanged over the past 200 years (since the collection was started). But there are a couple of items which have been affected by several processes of chemical and physical alteration, which could be either stopped or slowed down in vacuum conditions - which is nevertheless not the case.*
***Key words:*** *Samuel von Brukenthal, minerals, conservation, Sibiu.*

***Rezumat.*** *Activitatea de colecţionar de tablouri, monede, medalii, mobilier a lui Samuel von Brukenthal este bine cunoscută. În schimb, mai puţin cunoscut este interesul baronului pentru adunarea unor mostre valoroase de minerale. Asupra colecţiei de minerale a baronului ne vom îndrepta atenţia în cele ce urmează şi vom analiza starea de conservare a eşantioanelor ce alcătuiesc colecţia. Alcătuirea colecţiei a fost legată de ceea ce se petrecea în epocă, în societatea în care a trăit şi de cunoştinţele geologice ale colecţionarului. Istoricul constituirii unei colecţii, considerăm noi, este important pentru a înţelege starea de conservare a unei colecţii. Marea majoritatea a pieselor şi-au păstrat integritatea şi sunt neschimbate de aproape 200 de ani (vechimea colecţiei). Sunt însă un număr de piese afectate de procese de alterare chimică şi fizică care, posibil, s-ar stopa sau încetini în condiţii de vid ceea ce nu este posibil.*
***Cuvinte cheie:*** *Samuel von Brukenthal, minerale, conservare, Sibiu.*

## Introduction

Samuel von Brukenthal's activity as collector of paintings, coins, medals and furniture is well known. However, his interest in collecting valuable mineral samples is less known. Further on, we will address the baron's mineral collection, in order to analyse the conservation level of the items in this collection. The process of setting up the collection was very much connected to everything else that was happening at that time, especially in the baron's society and to the geological knowledge of the collector. It is our belief that the history of a collection is particularly important for properly understanding the conservation level of that particular collection.

After 1690, Transylvania fell under the domination of The Habsburg Empire, and thus constituted a fertile ground for the principles of the Enlightenment, that developed and stimulated research in natural sciences as well. The research of minerals was also influenced favourably by economic interests aiming to exploit the mineral resources of Transylvania. Thus, in the eighteenth century, new directions for the studying and forming of mineralogical collections were outlined. Eighteenth-century Transylvanian naturalist literature consists mainly of monographic works about the minerals of the Principality.

After having studied at Halle, Jena and Vienna, baron Brukenthal, as an imperial official, attended to the finance issues of the state, also taking into consideration the invaluable source of income which the Transylvanian mineral resources constituted for the Viennese Court and for private owners.

As Chairman of the Chancery Court, Brukenthal issued a report about the economic situation of the Grand Principality of Transylvania and mentioned

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the noble metals that could be extracted from the mines of Transylvania as new sources of income. (Göllner 1977, p.15). In 1765, Brukenthal was appointed chairman of the Chancery Court. The report referred to in the text was drafted in January 1767.

In 1764, in order to intensify mining, Brukenthal brings forward the idea of creating a University in Transylvania. Although this did not imply the existence of a natural science department, the proposal of a department of "economy and state revenues" took into account that mines were rich sources of revenue for the imperial treasury (Göllner 1977, p.15).

After having returned from Vienna, Brukenthal owned shares in mines from Săcărâmb, Zlatna, Topliţa, Boiţa, and Bucium. These days, the areas from where most of the minerals were collected, are located in the auriferous quadrilateral of Transylvania. His archive documents show that the acquisition of shares was less about income and more about encouraging the capitalization of Transylvania's riches. Thus, in 1775, Brukenthal owned eight shares in the Barbara gallery in Zlatna, and in 1781, eight shares in the St. Clement gallery in Săcărâmb. In 1782 he also bought eight shares in Topliţa Bucium Boiţa (Schuller 1969, p.285).

As governor and shareholder in mining, Brukenthal was able to acquire valuable mineralogical samples (Ittu, 2008).

The increased interest for mineral resources led to a true fashion of creating mineral collections. At the Viennese Court, Emperor Francis I was a zealous collector. He was the founder of the "cabinets" where various collections were created. A "cabinet of natural sciences" also existed at the Court. Such cabinets were present at "courts" of Austro-Hungarian nobles and in all Western Europe. It seems that these Viennese collections, with the power of their example, influenced Brukenthal's work as a collector (Schuller 1969, p. 283, 284). Furthermore, at the University in Halle, a true „school" of future representatives of enlightenment, Brukenthal perceived the importance of personal example, political pragmatism, and philosophical openness, the custom of building an artistic and literary setting.

His efforts to better capitalize the land's riches for the state's budget and the impulses he received from the Viennese collections gave his interests for minerals a scientific direction. The complexity of the collection and the mineralogy books from the library reveal that Samuel von Brukenthal appreciated not only arts and literature, but that he also had extensive knowledge and interest for the natural sciences, especially for mineralogy. A recognition of his interest for mineralogical sciences and his role as their protector was the title of honorary member, that the "Mineralogical Society of Jena" (Jenaische mineralogische Sozietät) granted to him in 1798. The society's director called him, in a letter which accompanied the diploma, an "expert and protector of the mineralogical sciences" (Göllner 1977, p.15).

After his dismissal from his post as governor, Brukenthal had more time for his collections and scientific interest within the circle of enlighteners that created itself around him, in Sibiu.

The exact time when Brukenthal began his collection cannot be appreciated. In 1778 he did not have a private collection. We deduce this from Fichtel's specification in 1780 (quoted by Neugeboren, 1866, p. 377), who in his paper *Beitrag zur Mineralgeschichte von Siebenbürgen"* („A contribution to the history of minerals in Transylvania"/„Contribuţie la istoria mineralelor din Transilvania") regretted the absence of mineral collections in Transylvania. Therefore we can assume that Brukenthal started compiling his collection after 1780, exactly during the time when the wave of scientific research in natural history left Sweden and was taking over the rest of Europe. We can consider that the collection that was also enrichened in the last years of his life was completed after the mid 90s and that a new stage in the evolution of the Brukenthal mineral collection followed – cataloguing. In conclusion, he created most if his collection between 1778 and 1787. Brukenthal made some purchases shortly before his death, namely in 1799 and 1800, when he bought gold samples.

**Results**

In order to capitalize and maintain these cultural treasures, he had by his side knowledgeable experts in the field, who were also collectors, such as Johann Fichtel, Johann Michael von Rosenfeld, Carl Eder etc. The principal of the Normal School in Sibiu, Carl Eder (1760-1810), stood by Brukenthal "with advice and actions". As curator of the collection, not only does he organize it according to the most advanced scientific criteria of the age, but he also creates the first catalogue. The catalogue - manuscript, "Verzeichnis

Siebenbürgischer Mineralien, die sich in dem Cabinette des Freiherrn von Brukenthal befinden“ has 353 pages and is now at Brukenthal’s Library.

Carl Eder stressed in the catalogue that “so much pure gold” had never been found in any other European country as it has been in Transylvania, and the collection of Baron Samuel von Brukenthal reflected this reality. The catalogue has a particularly important historical value for the notes relating to position and time of collection of the pieces, the status of their research and exploitation attempts (Schuller 1969, p.286).

The one who is in line for the post of curator of the collection with the same success was Neugeboren Johann Ludwig (1806-1887), one of the most prominent forerunners of palaeontology in Transylvania. His work *Notizen über Sammlungen siebenbürgischer Mineralien*, published in 1866, and proved that Neugeboren knew most of the Transylvanian mineral collectors and their collections of the eighteenth and nineteenth centuries. This knowledge offered him the possibility of comparing Brukenthal’s contemporary collection with those contemporary to it and the ones that followed it. Neugeboren believes that one collection risen to its level in terms of samples of gold, copper, silver and nagyagit, that of Karl Knöpfer (Neugeboren 1866, p. 391).

Baron Samuel von Brukenthal’s mineral collection counted 2018 items, most of them of Transylvanian origin, in the time that Carl Eder was custodian. The collection grew over the years, but the most valuable acquisition was the collection of the thesaurus councillor Johann Michael von Rosenfeld (1771-1837). L.J. Neugeboren said in his work published in 1866, when referring to the Rosenfeld collection, that is was a great fortune for the research of Transylvanian minerals that this collection was added to the baron's collection, and that this way all Transylvanian deposits will be represented.

As custodian, Neugeboren organized the baron’s collection and drafted the second catalogue of the collection. The catalogue-manuscript, in three volumes, is now at Brukenthal’s Library and is titled *Brukenthalisches Hausarchiv, Verzeichnis der Mineraliensammlung*. The catalogue was working with the space to be filled later. Foil sheets were used to catalogue of Herbarium reused the watermark and you can see traces of dried plants. Neugeboren, the famous paleontologist, and has served his apprenticeship in studying mineral collection from this collection.

Around 1774, Fichtel noticed, when referring to the mineralogical collections of Transylvania, that most collectors of the time, although animated, at the beginning, by the desire of collecting local minerals, would give in to the scientific incentives by enriching their collections with items from abroad. This makes baron Samuel von Brukenthal’s collection even more special, as it contains only 50 items that come from outside of Transylvania (from Austria, Hungary, Bohemia, Sweden).

The location and ownership of the collection experienced changes over time. According to the will of baron Samuel von Brukenthal, after the death of the last male offspring od the family – Hermann von Brukenthal – in 1872, the collections automatically went in the possession of the Evangelical Church. (Ittu, 2007) Originally united with the other collections, the collection of minerals was handed over in 1923, by the management of Brukenthal Museum of the time – maintaining property rights – to the „Transylvanian Society of Natural Sciences” („Societatea Ardeleană de Ştiinţele Naturii”), for its museum, the Museum of Natural History (Binder 1958). Therefore, the collection was moved to the Museum of Natural History.

Subsequently, in accordance with Decree 176 of August 3rd 1948, because of the properties of churches, congregations, communities or individuals passing to state property, the patrimony of the Brukenthal Museum went into the administration of the Ministry of Arts and Information (Ittu 2008). This way, the baron’s mineral collection ended up again in 1957 at the „mother” scripted but factually it remained in the museum’s storage. Currently the collection in in the process of restitution (Decision no. 614 of November 21st 2005), together with the entire patrimony of the Brukenthal Museum to the Evangelical Church, the rightful owner of the heritage of the Brukenthal foundation, which was enrichened in time by three barons.

Currently the mineral collection of baron Brukenthal is at the Museum of Natural History in Sibiu and includes 3.622 samples. It is actually the baron’s collection, to which the mineral collection of Rosenfeld was added. The catalogue of the Rosenfeld collection was compiled and systematically arranged by Neugeboren. The catalogue of Rosenfeld's collection has been signed by Neugeboren on June 15th 1838.[1]

The Brukenthal mineral collection being in process of restitution has also been studied and analyzed in terms of preservation because the current legislation does not allow restitution of a patrimony without it being classed. In 2007, when the collection management was taken over by a new manager a high state of deterioration of the 112 samples was found. As a result of the measures taken by the Ministry of Culture they were discarded. Unfortunately, the causes that led to their deterioration have caused and still cause poor conservation for other samples as well. We will further analyze the causes of past and ongoing degradation.

The parts to be discarded and those that will be proposed for disposal were and still are in a very advanced physical and chemical state of degradation due to the presence of some iron sulphides in the form of single minerals, mineral associations or in the composition of minerals that are unstable.

The instability is either caused by the lower crystallization system and its changing tendency towards a higher one, or it is related to the deposit conditions, to the forming process of the mineral.

In this category are also samples of marcasite (rhombic $FeS_2$), pyrite (cubic $FeS_2$), which are present not only singular but also in combination with other minerals in most of the samples submitted for disposal (calcite, quartz, pirargirit, sphalerite, tetrahedrite, burnonit etc.), which are crystallographically unstable and thus also chemically and physically (Fig. 1, 2).

Antimonite (rhombic $Sb_2S_3$), which usually crystallizes in fine and friable acicular forms, is perishable, turning, under the presence of water vapours in the atmosphere (in undetectable quantities), in valentinite ($Sb_2O_3$), and cervantite ($Sb_2O_4$), which leads to the disintegration of the samples (Fig.3).

In the case of argentite (cubic $Ag_2S_3$), which is sensitive to exogenous environmental conditions, namely the changes in temperature and humidity, especially when in association with pyrite and marcasite, it decomposes and pulverizes in the same manner as the minerals with which it is associated (Fig.4).

Galena (cubic PbS) and sphalerite (cubic ZnS) deteriorate due to improper storage conditions, where any increase or decrease in temperature and moisture triggers intrinsic physical and chemical reactions within the crystal net of these minerals that lead to the development of new minerals with different chemical compositions (Fig. 5, 6).

Chalcopyrite (tetragonal $CuFeS_2$) selfdegradation when subjected to variations in temperature and moisture, transforming into earthy and sandy masses. Perishability, the ferro-sulphitese composition of pyrite ($FeS_2$-cubic), leads to the self-destruction of the mineral (Fig.7).

The presence of iron sulphides and some mineral associations, generally of physically and chemically stable ones like: rhodocrosite, cerussite, barite, calcite, with some easily perishable ones have also led to their destruction.

Halite or rock salt has numerous cracks that relate to the evolution of the deposits of which it is composed and to the history of these museum items. The fragmentation of the samples occurs along these cracks, and in fluctuating temperature and humidity conditions, dissolution and recrystallization occurs on cracks, which leads to fragmentation

## Conclusions

In conclusion, the processes that have led and will lead to the degradation of mineral samples are of **physical-mechanical** nature (disintegration, fragmentation, cracking), of **chemical** nature (changes in other minerals with different chemical formulas) and of **mineralogical** nature (paragenesis with chemically instable minerals; the tendency to move to superior crystallographic systems etc.). These deterioration processes cannot be stopped and many of them are related to the outcrop conditions, i.e. the deposit from where they were extracted. The collection which includes these minerals are 200 years old and have been moved to different storage spaces, most of them improper – excessive moisture, until being stored in the museum's current deposits. Unstable iron from these minerals in combination with water in the air and temperature variations have led either to the acceleration of the already started alteration in deposits or to initiation of these processes, that

[1] State Archives Sibiu, fondul Brukenthal, $CD_{1-51}$, no.131.

have finally led to the **destruction** of the mineralogical items.

The chemical processes of decomposition, namely of transformation of some chemical, respectively mineral substances in others is irreversible and unstoppable. Conservation measures that can be taken are those of isolation of the sample from the others. The chemicals resulting from the decomposition processes can contribute to the onset of some chemical processes in other samples and can weaken the deposits' material. As for any collection, storage conditions such as constant and normal temperature and humidity are essential.

Today, the baron's mineral collection, extended after the founder's death, has a great scientific, historical and museum-related importance. It is the tangible proof of the concerns and knowledge for and about nature, the generosity of this precursor of systematic knowledge of the environment as a premise of protecting it. If Sibiu „becomes at the end of the eighteenth century the scientific centre of the Transylvanian naturalist movement" (Pop 1970), gaining an international reputation as a cultural and scientific center, this was due, first of all, to the patron of arts and sciences that was Samuel von Brukenthal.

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## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

**Fig. 1.** Altered Pyrite due to ferro-sulphides composition in the hygroscopic environment

**Fig. 2.** Tetrahedrite in marcasite heavily altered physically and chemically

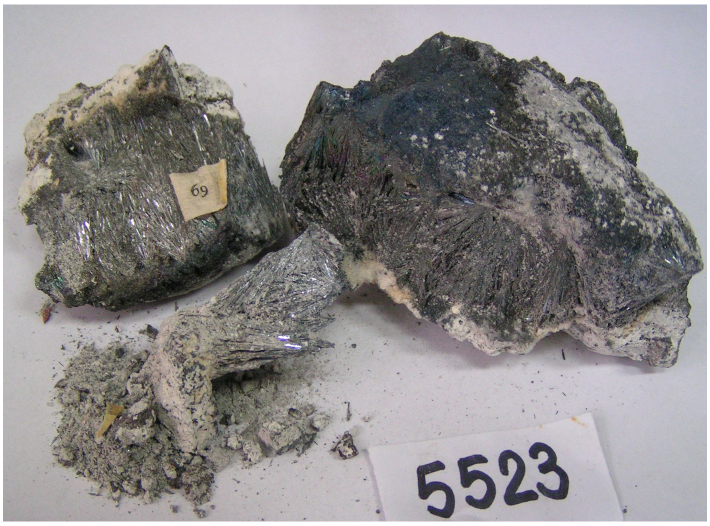


**Fig. 3.** Altered finely crystallized antimonite - turned into valentinite and cervantite


**Fig. 4.** Altered argentite due to pyrite and marcasite paragenesis

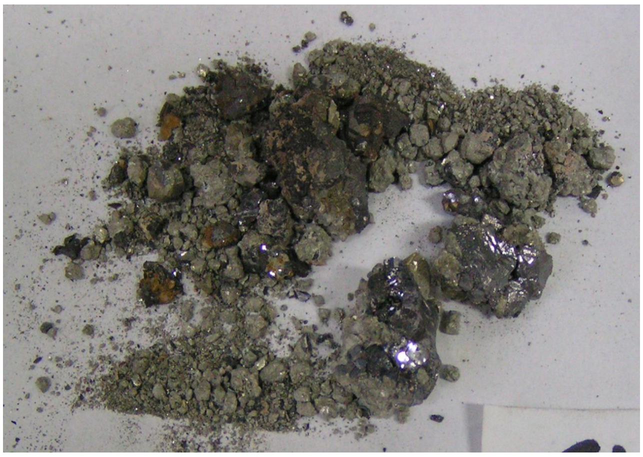

**Fig. 5.** Galena – physically and chemically altered

**Fig. 6.** Altered sphalerite due to pyrite and marcasite paragenesis

**Fig. 7.** Physically and chemically altered chalcopyrite

# LABRIDAE (OSTEICHTHYES) FROM „TURNU ROŞU (ROMANIA) EOCENE LIMESTONE" RESERVE

**Rodica CIOBANU** *

***Abstract.*** *The present study is focused on fossil teeth of the Labroidae family. The teeth studied belong to the paleontological collections - Richard Breckner's Collections - of the Natural History Museum from Sibiu, from the Turnu Roşu (Sibiu) limestone. The Eocene fossil fauna from Turnu Roşu (Sibiu) drew the researchers attention since the late 18th century. The members of the Transylvanian Society of Natural Sciences, founded in 1849 in Sibiu, were the most active in studying the fossil area Turnu Roşu (Porceşti). They pointed out the importance of this habitat not only through the variety of the palaeofauna, but also for palaeogeographical reconstructions of the Eocene stratigrapghy of the southern Transylvanian Basin. The first observations on the presence of fossil fish remains (teeth) belonging to the Labridae family, in the limestone in Turnu Roşu (the teeth studied in this paper belong to the same outcrop) were made by Dica (2003) and assigned to the Lachnolaimus multidens. The Eocene pharyngeal teeth were illustrated and described by Şuraru et al. (1980) as within the Limestone from Cluj, as belonging to Nummopalatus cf. multidens (Munster). In this study we illustrate and describe Lachnolaimus pharyngeal teeth plate from Turnu Rosu. Six pharyngeal dental apparatus studied in this paper are referable to Lachnolaimus multidens (Munster, 1883) ?Lachnolaimus sp. and Labridae gen. et sp. indet.*
***Key words:*** *teeth, Labridae, Late Eocene, Turnu Roşu, Romania*.

***Rezumat.*** *Lucrarea este axată pe studiul dinţilor fosili din familia Labridae. Dinţii studiaţi aparţin colecţiilor paleontologice – Colectia Richard Brekner – din Muzeul de Istorie Naturală din Sibiu, din calcarele de Turnu Roşu. Fauna fosilă eocenă de la Turnu Roşu a atras atenţia cercetătorilor încă de la mijlocul secolului al XVIII-lea. Membrii Societăţii Ardelene de Ştiinţele Naturii, fondată în 1849 în Sibiu, au fost cei mai activi în studiul faunei fosile de la Turnu Roşu (Porceşti). Ei au scos în evidenţă acest habitat nu numai prin varietatea paleofaunei, dar şi pentru reconstrucţii paleogeografice în ceea ce priveşte stratigrafia Eocenului în sudul Bazinului Transilvaniei. Primele observaţii asupra prezenţei resturilor de peşti fosili (dinţi) ce aparţin familiei Labridae, din calcarul de Turnu Roşu (dinţii studiaţi în această lucrare aparţin aceluiaşi aflorimentt) au fost făcute de Dica (2003) şi determinaţi ca Lachnolaimus multidens. Dinţii faringieni eoceni au fost ilustraţi şi descrişi de Şuraru et al. (1980) din Calcarul de Cluj, ca aparţinând Nummopalatus cf. multidens (Munster). În acest studiu sunt ilustraţi şi descrişi dinţi faringieni Lachnolaimus de la Turnu Roşu. Şase aparate dentale faringiene sunt studiate în lucrare şi diagnosticate ca Lachnolaimus multidens (Munster, 1883) ?Lachnolaimus sp. și Labridae gen. et sp. indet.*
***Cuvinte cheie:*** *dinţi, Labridae, Eocen superior, Turnu Roşu, Romania.*

## Introduction

A point of interest in the scientific research since the 1800's, especially for the researchers in the 1849 Transylvanian Society for Natural Sciences in Sibiu, the Eocene fossil area from Turnu Roşu (Porceşti) was particularly regarded for the re-structuring of the Eocene stratigraphy in the southern part of the Transylvanian Basin, as well as for the re-structuring of the palaeogeographic constructions and the notable diversity of the palaeofauna. To this point, mention should be made that the first scientific paper about sharks in Romania was published by Ludwig Johann Neugeboren in 1850.

He was also a member of the above mentioned Society. The work presents the descriptive characteristics of the fossil shark teeth – and it was not only a first structured, systematic scientific attempt for Neugeboren on this topic, but also a première in the country in dealing with this subject. Actually, one could argue that the research of fossil fauna in this area could be positioned at European level during the 19th century. This was accomplished only thanks to the work that the members of the Transylvanian Society for Natural

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Sciences carried out. As a result, a diverse patrimony was left behind, currently administered by the Natural History Museum in Sibiu. The Society owned the majority of this patrimony until November 3rd, 1951.

Louis Agassiz's "Recherches sur les poisons fossiles" published in 1834 – 1844 had laid the foundations for the research of palaeo ichtyol fauna, as well as for the modern study of fossil fish. The significant role of the Swede's work is highlighted and recognized as such even by Neugeboren himself, who gives credit to his fellow researcher for laying the grounds for the topic he dealt with in his own study.

If in the 19th century fossil fauna research in Turn Roşu was at and European level and not only, it is due to the members of the Transylvanian Society of Natural Sciences; Neugeboren was also a member. The majority of the patrimony of the Natural History Museum belonged until November 3, 1951 to the Society.

The current paper also deals with a number of seven teeth from the Richard Breckner collection, which plays a particularly significant role in the ichtyol - palaeontology research in our country. He was also a member of the Transylvanian Society for Natural Sciences and as such, in charge with the palaeontology collection for a while. Breckner (1900-1979) was actually not only a researcher, but also activated as journalist and critic of art, writer and literary secretary for the theatre (*"The Lexicon of Transylvanian Saxon personalities",* 1998). He worked as self-employed researcher for a while (1933- 1938) and supported himself by writing scientific papers about the Transylvanian fossil collection. Unfortunately there is no record of the results of his research in this period, or an indication of where his writings on the collections were published. Nevertheless, the "Vereinsnachrichten" section in the Transylvanian Society magazine acknowledges his activity in reviewing the determination of the shark teeth in the collections, and generally in recording and cataloguing the entries, especially the palaeontological items, in several posts between 1937–1946. His achievements and skills in studying the shark teeth in the Porceşti area are formally recognized and appreciated even by the president of the Society, Richard Binder, in 1938. (Ciobanu 2007, 2011).

The Breckner collection above mentioned, which includes some of the items we would analyse in this paper, also contains several other fossils (molluscs) from Lăpugiu de Sus, as well as 5,000 fish teeth from Turnu Roşu/Porceşti (shark teeth mostly). The museum purchased this collection from Heinrich Breckner in 1954, which worked as printer in Sibiu and was also a relative of Richard Breckner.

## Material and methods

The paper describes 6 teeth collected from the palaeontological reserve "Calcarele eocene de la Turnu Roşu (Porceşti)". The richness of the Eocene fauna recovered in Turnu Roşu deposits, from which the fish teeth were also collected, attracted the scientists' attention as early at the beginning of the 19th century, when several valuable systematic research studies were conducted. The majority of the palaeontological studies referring to this peculiar area were conducted by the members of the Society.

These limestone rich in fauna are part of the Eocene shallow marine sequences lying north of the Făgăraş Mountains, belonging to the southern border of the Transylvanian Basin. Around Turnu Roşu, the Eocene formations emerge like a limestone "patch" area on the north-western ending of the Făgăraş Crystalline (Ciobanu, Trif 2012).

The latest concept regarding the stratigraphy of the limestone of Turnu Roşu belongs to Mészároş (1996) who defined the Turnu Roşu Group, including Valea Nişului and Valea Muntelui formations (Mészáros 1996, Ciobanu 2010, 2011, 2012). The faunal analysis underlined the existence of almost all Eocene groups and up to recently they represent the largest deposits bearing isolated fish teeth. Environment reconstructions based on correlation between fossil fauna and recent representatives of the species, are indicating warm tropical-subtropical waters, rich in oxygen and fauna (Mészáros, Ianoliu 1972, 1973, Bucur, Ianoliu 1987, Ciobanu 2006).

The natural reserve the fish teeth are from refers to Valea Nişului and Valea Caselor. Unfortunately, neither Neugeboren, nor other collectors – in our case Breckner – ever mentioned the exact location where they collected the fossils from. The sample of fish teeth collected in the last few decades is very small compared to the old collections.

Regarding the place of collection of fish fossil remains, we believe that it is Valea Nişului and Valea Caselor, for which there are written references. Unfortunately, neither Neugeboren, nor other collectors – in our case Breckner – ever mentioned the exact location where they collected the fossils from. The sample of fish teeth collected in the last few decades is very small compared to the old collections.

The first observations on the presence of fish remains (teeth) and description, belonging to the Labridae family, in the limestone in Turnu Roşu area were made by Dica (2003) and assigned to the *Lachnolaimus multidens*. In 1997 Codrea *et al.* reported in a list of Eocene fossil fish the presence of labroids *Nummopalatus* cf. *multidens* in the Cluj Limestone. The Eocene pharyngeal teeth were illustrated and described by Şuraru *et al.* (1980) as within the Limestone from Cluj, belonging to *Nummopalatus* cf. *multidens* (Munster). For the same outcrop, Dica (2003) indicated the *Lachnolaimus multidens* taxon.

**Systematic Palaeontology**

**Subclasa** *Teleostei* Müller, 1846

**Order** *Perciformes* Bleeker, 1859

**Family** *Labridae* Cuvier, 1817

**Genus** *Lachnolaimus* (Cuvier, 1829)

*Lachnolaimus multidens* (Munster, 1846)

Observations on the presence of the *Labridae* family's representatives for Romania.

1980 *Nummopalatus cf. multidens* (Munster, 1846), in Şuraru, Strusievici & Laszlo, p.178, Pl. 1, fig. 2-3.
2003 *Lachnolaimus multidens* (Munster, 1846), in Dica, p.41-43, Pl.1, fig.3, 4
2005 *Lachnolaimus multidens* (Munster, 1846), in Dica, p., Pl.IV, fig.10.

***Material:*** 6 pharyngeal teeth plates, fragments from Breckner`collection.

***Origin**:* Eocene limestone from Turnu Roşu (Porceşti).

***Description***

*Lachnolaimus multidens* (Munster, 1846)
(Figs.1, 2, 3, 4)

The material presented in these images is fragments of pharyngeal plates paved with molariform blut teeth. In Figs. 1 and 2 dental plates paved with elongated teeth (3-4), bigger than the rest, are presented. They decrease in width from the centre towards the edges. Larger teeth are located in the anterior and are surrounded by small flattened, round to sub-conical teeth. The teeth are arranged in rows parallel to the boundary between small and elongated teeth. In section the pharyngeal plate has the shape of an isosceles triangle, the limit between teeth of different dimensions being its apex. The teeth grow from below and are compacted together on the occlusal surface to form a relatively solid and continuous flat grinding surface. In fig. 3 the number of larger and elongated teeth from the anterior is greater than the dental plates from fig. 1-2. On this plate the development point of the peduncle located in anterior position is visible. On the dental plate fragment in Fig. 6 three large elongated teeth with posterior position have been preserved.

**?** *Lachnolaimus* sp.

(Figs. 5 and 6)

The fragment of dental pharyngeal teeth plates from this figs. show only flattened, round to sub-conical teeth.

**Diagnosis and discussions**

The identification of the family Labroidae species even at the genus level posed difficulties since the studied fossil remains are rather than part of dental apparatus. The main criteria for diagnosis were the morphology of the teeth and the stratigraphical age of rock horizons where the teeth were found.

The jaw mechanism in Labridae is composed by upper jaw with maxillary and premaxilary, lower jaw formed of dentary, articular, angular and sesamoid articular and lower and upper pharyngeal bones. The material available for study is composed only from pharyngeal teeth plates lower and upper. But Long (1992) stated “that pharyngeal plates in wrasses do not have morphologic characters that are taxonomically distinct, thus genus and species identification cannot be assigned”. Pharyngeal plates are of little use in lower taxonomic identification in wrasses because of lack of diagnostic characters.

Sauvage (1875) presented the characteristics of the *Nummopalatus multidens* = *Lachnolaimus multidens* species and finds as a distinction from other present species the presence, on the posterior side, of 3 large elongated teeth, followed by much smaller teeth. In the front 3-4 rounded teeth are present, which are smaller than the posterior ones but larger than the others. The rest of the plates are covered with small teeth.

Rocabert (1934) for the type species from the Miocene Viena Basin presents it as having three relatively large teeth forming a row of four completely welded teeth. In the front they are surrounded by completely rounded teeth.

Bauzá, Plans (1973) gave the diagnosis for the teeth on the upper and lower plates. The teeth placed on pharyngeal plates are overlapped over each other, occupying the occlusal surface. Teeth with posterior position are larger the ones in front. The pharyngeal plates of the Miocene species "*multidens*" have the appearance of an isosceles triangle, whereby the front apex extends very much. On the pharyngeal lower plate, teeth from the central portion with posterior position present two teeth, centrally located, larger than the others. There are five more frontal-posterior elongated teeth and the remaining teeth and rounded and decrease gradually lateral-frontally. On the posterior pharyngeal plate is a large surrounded tooth starting from the internal frontal edge of six rounded teeth. These rounded teeth decrease in size towards the posterior side behind the plate. Because the occlusal surface shows great variations during growth, determination is difficult.

The pharyngeal plate teeth have molariform blunt teeth on the surface, disposed in several rows, decreasing in width toward the edges. This arrangement is a morphological diagnostic feature of *Lachnolaimus*, stipulates Dica (2003).

The nomenclature of fossil species and genera is disputed, and the diagnostic criteria are not clear. Differentiations between species and genera are not major and can be done only when the fossil material is very rich numerically and varied as species and also diverse regarding the place of collection. The nomenclature of current species is not clarified as well and there are many synonymies.

Thus, Jordan (1981) proposed that the subfamily Harpinae, which forms a group of the Labridae family which includes 7 genera, should also include *Lachnolaimus* without motivating his option too clearly.

Kaufman, Liem (1982) consider four groups within the labroidei can be defined as monophyletic assemblages on the basis of morphological characters: Promacentridae, Cichlidae, Embiotocidae and Labridae. Labridae family include the *Lachnolaimus* genus and about 1.470 species-some 5-10 percent of living fishes.

Gomon (1997) considers that three tribes are existing into the Labridae: Cheilinini, Hypsegenyini and Julidini. The *Lachnolaimus* genus, positioned in the Hypsegenyini tribe, seems to have the most primitive characters among labrids. And the labrids include actually about 500-600 species inside 60 genera, and represent the most prominent and diverse coral reef fishes throughout the world.

Bauzá & Plans (1973) include the species "*multidens*" to the *Labrodon* genus. Gervais 1857 considered it synonymous with *Nummopalatus* Rosvault and *Pharyngodopilus* Cocchi. Dica (2003) considered that labrodon genus is an artefact and that it includes all unknown forms, which theoretically could belong to labridae.

Dica (2005) recognize only few fossil genera: *Labrus, Julis, Labrodon, Pharingodophilus* and *Nummopalatus* (for some authors synonym with Labrodon). From these genera the only *Labrus* and *Julis* have actual representatives. The same author stated that Upper Eocene represent an extinction limit for *Lachnolaimus* genus without motivating this statement.

**Conclusions**

Given the above described I can say that *Labrodon multidens* should be replaced by *Lachnolaimus multidens* – in the same Labridae family, for the Eocene from Romania.

The species holotype is the actual *Lachnolaimus maximus* Walbaun, 1792 from Miocene of Vienna Basin. Thus genus contains a single species, a large, showy fish of tropical seas (Jordan 1887). The hogfish (*Lachnolaimus maximus*) is a member of the wrasse family-Labridae and the only member of the genus *Laichonolaimus*. The hogfish is one of the larger species of wrasses family. The hogfish is currently listed as "vulnerable" with the International Union for Conservation of Nature (IUNC 2012).

In regards to the living environment, recent *Lachnolaimus* are marine and stenohaline in slightly deeper waters. The labrids feed on invertebrates such echinoderms, molluscs and crustaceans (Leis 1984), food and environment that has been reconstructed for the coastal area of the Eocene sea in Turnu Roşu as well (Ciobanu 2006). In terms of biogeographical characteristics, the fish fauna from Turnu Roşu and throughout Transylvania presents tropical indo-pacific features (Ciobanu 2006).

The majority of labroids occur within one general type of environment: warm, slow-moving water. Tropical marine reefs are densely populated by labrids. Wrasses have a cosmopolitan distribution, with about 400 species living in tropical, sub-tropical and temperate shallow coastal marine environments. Prefer rocky subtidal habitats, and frequently live in kelp, algae and sea grass beds in temperate areas (Long 1992).

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## LIST OF ILLUSTRATIONS

**Fig. 1-4**. *Lachnolaimus multidens* (Munster, 1846)

**Fig. 5-6**. **?** *Lachnolaimus* sp.

Scara imaginilor ▬▬ 1 cm

## LISTA ILUSTRAŢIILOR

**Fig. 1-4**. *Lachnolaimus multidens* (Munster, 1846)

**Fig. 5-6**. **?** *Lachnolaimus* sp.

Scale og figs. ▬▬ 1 cm

**Fig. 1**. *Lachnolaimus multidens* (Munster, 1846)

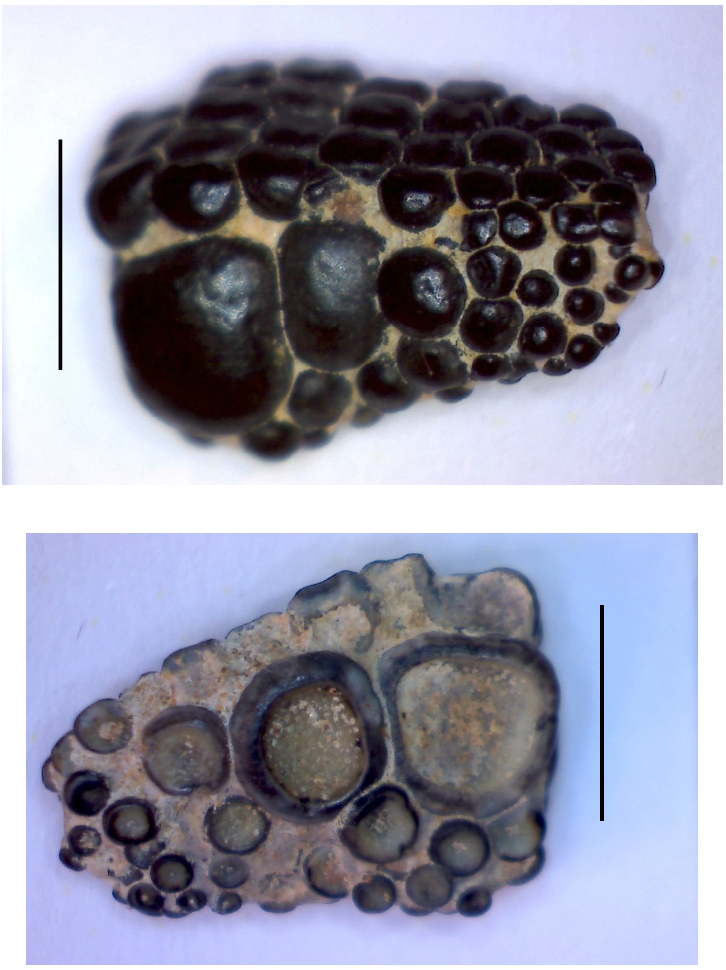

**Fig. 2**. *Lachnolaimus multidens* (Munster, 1846)

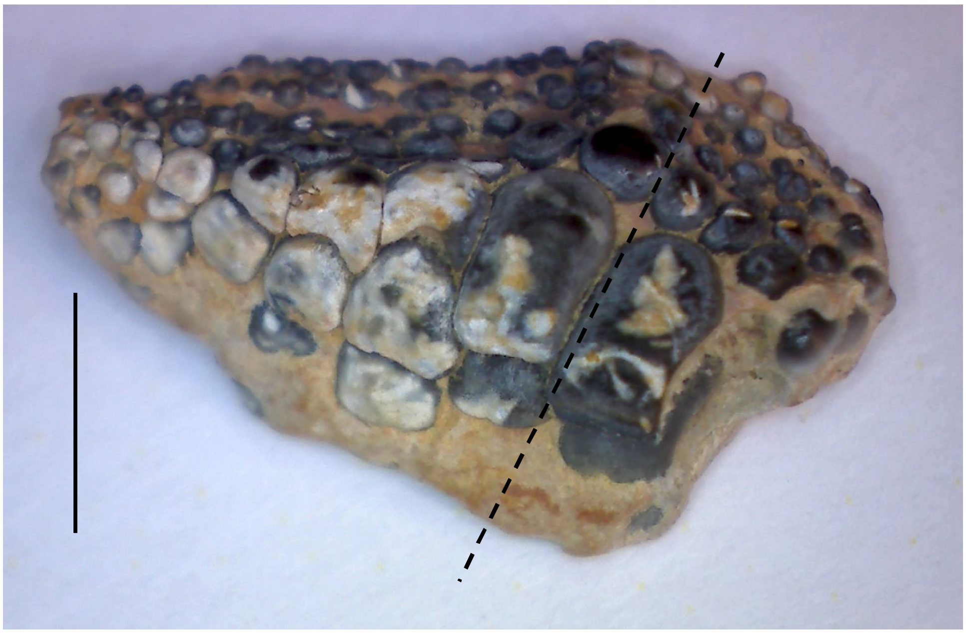

**Fig. 3**. *Lachnolaimus multidens* (Munster, 1846)

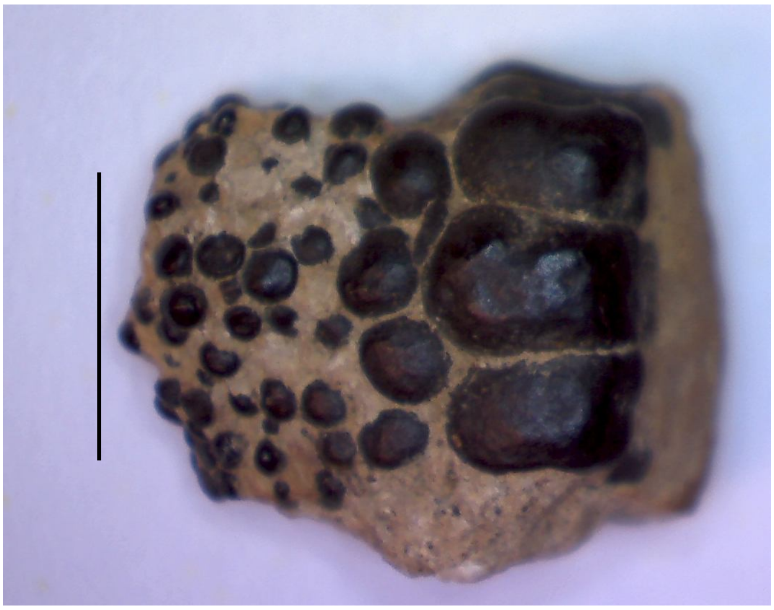

**Fig. 4**. *Lachnolaimus multidens* (Munster, 1846)

**Fig. 5**. ? *Lachnolaimus sp.*

**Fig. 6**. ? *Lachnolaimus sp.*

## GIS APPROACH ON USING LIDAR DATA TO ESTIMATE THE NUMBER OF THE TREES

**Roxana GIUŞCĂ** *

***Abstract.*** *This paper presents a different use of LIDAR data recognized by their accuracy in the vertical and less horizontal, in estimating the number of trees along the power lines of utilities in Ohio, USA. The northern part of the U.S. has been invaded in the past 12 years by an insect called the Emerald Ash Borer (EAB) from Asia and decimating the Ash Trees. Treatment works and spraying was ineffective because these insects are very small (less than 8.5 mm) and have easily dug tunnels under the bark of trees. The only proactive measures to prevent the ash fall from current lines, which would affect tens of thousands of electricity consumers in the area of reference, was cutting these trees and replanting of trees of other species. To realize this project it was necessary to estimate the number of ash trees in general and in particular over each current main zones of 15 and 35 ft. The first distance (15 ft) is the right of way to intervene in the proximity of utilities feeders and had chosen an extra distance of 20 ft (total 35 ft) to prevent the failing of the affected ash trees over other trees, which as in a game of dominoes. The total buffer distance on both sides of the electrical lines was chosen as 70 ft (35 ft in each side). This was so prevalent that led to this decision. For these calculations and estimates we were using GIS technology (ArcGIS10.0) and LIDAR data. LIDAR technology contains data for canopies, seen as sections and not as full tree. This required algorithms to group their various distances that final data to represent trees and helped to accomplish the requirements for the to budget estimates, relocation, human resources allocated etc.*
***Key words:*** *GIS, LiDAR, emerald ash borer, canopies, trees, ash trees.*

***Rezumat.*** *Lucrarea prezintă o utilizare diferită a datelor LiDAR, recunoscute prin acurateţea lor verticală şi mai puţin prin cea orizontală, în estimarea numărului de arbori de-a lungul liniilor electrice unei companii de utilităţi din Ohio, SUA. Zona Nordică a SUA a fost invadată în ultimii 12 ani de o insectă, numită Agrilus planipennis, venită din Asia şi care decimează frasinii. Lucrările de tratare şi stropire au fost neeficiente din cauza faptului că aceste insecte sunt de dimensiuni foarte mici (sub 8.5 mm) şi şi-au săpat cu uşurintă tunele sub scoarţa copacilor. Singura măsură proactivă de preîntampinare a căderii frasinilor pe liniile de curent, ceea ce ar afecta zeci de mii de consumatori de energie electrică din zona de referinţă, a fost tăierea acestor arbori şi replantarea de arbori din alte specii. Pentru a realiza acest proiect a fost necesară estimarea numărului de arbori în general şi de frasini în special, de-a lungul fiecarei magistrale de curent pe zone de 15, respective 35 ft. Prima distanţă (15 ft) reprezintă zona de drept a firmei de utilităţi de a interveni în proximitatea magistralelor şi a fost aleasă o extra distanţă de 20 ft (in total 35 ft) pentru a preveni căderea unor frasini afectaţi peste alti copaci, ca într-un joc de domino. De-o parte şi de alta a liniilor de curent, această distanţă a atins 70 ft diametru. Acest fapt a fost atât de frecvent, încât a dus spre această decizie. Pentru aceste calcule şi estimări s-a folosit tehnologie GIS (ArcGIS10.0) şi date LiDAR. Tehnologia LiDAR conţine date referitoare la coroana copacilor, văzută ca secţiuni (asemănătoare unor mănunchiuri sau buchete) şi nu ca şi copac integral. Acest fapt a necesitat algoritmi de grupare a acestora pe diferite distanţe încât datele finale să reprezinte copaci şi să ajute la estimările necesare pentru buget, replantări, resurse umane alocate etc.*
***Cuvinte cheie:*** *GIS, LiDAR, Agrilus planipennis, coronamente, arbori, frasini.*

### Introduction

This paper presents an approach of using GIS in order to estimate the number of the trees for an area where we didn't have vegetation data within the GIS database (Geodatabase). This required a search for public data available to be used, eventually free data and ready to be used as soon as possible. The project started as a consequence of Emerald Ash Borer (*Agrilus planipennis* Fairmaire 1888; Coleoptera: *Buprestidae*) (insects) invasion in north of United States and which affected the Ash Trees. These insects came from Asia and they are moving virtually undetected until Ash Trees (*Fraxinus* ssp.) are almost at the point of death. In

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2003 was for the first time identified in Ohio, in Toledo area (migrating from Michigan where it was for the first time identified two years earlier. For a while, the foresters and vegetation managers within the electric utilities have tried different treatments but all of them were unsuccessfully.

According with the Ohio Department for Agriculture the State of Ohio has over 3.8 billion ash trees, which were in good part affected by this little insect (smaller than 8.5 mm) in the past decade. The ash trees located very close by the electric lines and affected by these insects failed over the electric wires, causing power outages, affecting sometimes thousands of consumers. Therefore the damages were substantial and it was required a quick intervention in removing these trees and the ones located on their proximity too. The reason for which the project has included the proximity ash trees by the ones already affected, was the quick speed with which these insects spread from one tree to another one and they failed on other trees situated closer by the lines, causing power outages.

The lack of tree data represented a challenge because there were needs for an estimation of the expenses involved in this process and to get an idea about the size of damages.

**Technology and procedures**

A quick search revealed some free LiDAR data available for free from the State of Ohio. The data was in *.las format stored as tiles or by counties. The area of interest covered 11 counties and, considering the amount of the data, we have downloaded it by county. The size of LiDAR data was extremely high (over 20 GB for one county). There were also some other disadvantages which demanded a strategy to overcome them. For instance, LiDAR data is known for its high vertical accuracy, but not the best for horizontal accuracy. To double check the data, we have overlaid the LiDAR points on top of Bing Maps. LiDAR data for trees is actually showing the canopies and not the trees (for one tree can be more than one canopy). We came up with an idea of an algorithm to group the canopies as trees and to count them after that. The good part is that we only needed the estimation, so a lower accuracy was accepted.

ESRI defines **LiDAR** (**L**ight **D**etection **A**nd **R**anging) data as: ”*an optical remote-sensing technique that uses laser light to densely sample the surface of the Earth, producing highly accurate x, y, z measurements […] LiDAR produces mass point cloud datasets that can be managed, visualized, analyzed, and shared using ArcGIS* (*Source: http://resources.arcgis.com*).

The technology consisted in ArcGIS 10.0 software, including the 3D Analyst extension. As we have already mentioned the data used was LiDAR and raster images from Bing Maps. The structure of the LiDAR data is quite complex and it contains different returns for all the field features that have a height: vegetation (low and high), buildings, transportation infrastructure (bridges), electric poles, electric transmission lines etc.

ArcGIS allows us to convert the LiDAR points to an accepted ESRI shapefile format, known as multipoints. During this import it was possible to filter the data based on different classes and number of returns. It is well known a chart of different categories of LiDAR classes, based on intensity, elevation, number of returns etc. The technicians, who preprocessed the data before it was published, have assigned some codes as attributes to each category. For high vegetation, which was the feature we were interested in, the class number is five (see Figure 2).

Using ArcGIS 3D Analyst we have plotted the LiDAR data to the map, county by county, inserting this filter for the code #5. After this step was done, we have faced another challenge. We only needed the trees within a 70 feet buffer around the electric lines. So, we have run a selection only for the points which were intersected by this buffer, which was also created in ArcGIS. This selection limited the initial huge amounts of data to an easier maneuverable data volume.

The analysis was realized by electric feeders, so we have zoomed-in for most of the areas and took closer look to the data. It was obvious that even we have query the data based on code#5, there were some errors such as electric poles which showed on the map as canopies. They were only few on each feeder, but the manual cleaning of the data helped a lot to increase the accuracy of the data.

The zoom-in allowed us also to compare the views of the data for forest areas with a high density of the tree canopies.

We choose different study areas where we have measured the distances between the canopies if on the background from Bing maps we could see one tree, and the LiDAR data contained multiple canopies.

These were usually areas where the trees were isolated and clear as image on the backgrounds. So, we came up with an average distance between the canopies which will form a tree. In most of cases it was between 7 and 10 feet for each feeder. Using the aggregate tool we have grouped all the points within this distance (see Figure 8 and Figure 9).

The result was a new layer, with one point instead of multiple ones for a tree. Also, for the singular canopies we got nothing on the new layer. The solution was to append the ones left and which were for isolated trees/canopies to the grouped points.

In this case, we have generated polygons for the grouped points and all the points which intersected the polygons were eliminated. The polygons were converted to a single point each. These single points resulted from the polygons that were added to the singular (untouched) points before grouping. The results were again compared with the backgrounds from Bing Maps were the image was the most clear and we were able to differentiate the trees. The results were very close, and for and good enough for an estimation.

As it can be seen in the images of above (Figure 9), after grouping the points from the first image based on 7 feet distance resulted the trees from the second image. They are within the buffer, so a selection by location query can be run to obtain the count of all the trees (points) which have the centroid within the buffer (polygon).

**Conclusion**

The project was first created for an electric feeder and after that automated using the ArcGIS Model Builder and Python scripts.

We have ignored in this study the height of the canopies, but it could be used, for instance, to see which of these trees have a height close by the electric line and which are located closer than 15 feet by the electric lines.

The Vegetation Manager came with estimation, based on field area, of the number of the ash trees out of the total number of trees by feeder (percentage). The estimation proved to be very closed by the real data and started to be used successfully for budgeting, work management and estimating resources needed it for this project.

This project was original by the fact that we didn't use the LiDAR data to estimate the height or density of the canopies as it is used most of the times. The LiDAR data was used this time only for counting the total number of the trees within buffers.

## REFERENCES

ArcGIS 10.0

Help Tool

Source of LiDAR Data

ArcGIS 3D Analyst Tutorial

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www.emeraldashborer.info

http://gis3.oit.ohio.gov/geodata

http://downloads2.esri.com/ESRIpress/images/144/GISTutorial_samplechapter.pdf

http://www.agri.ohio.gov/divs/plant/eab/eab-index.aspx

## LIST OF ILLUSTRATIONS



## LISTA ILUSTRAŢIILOR

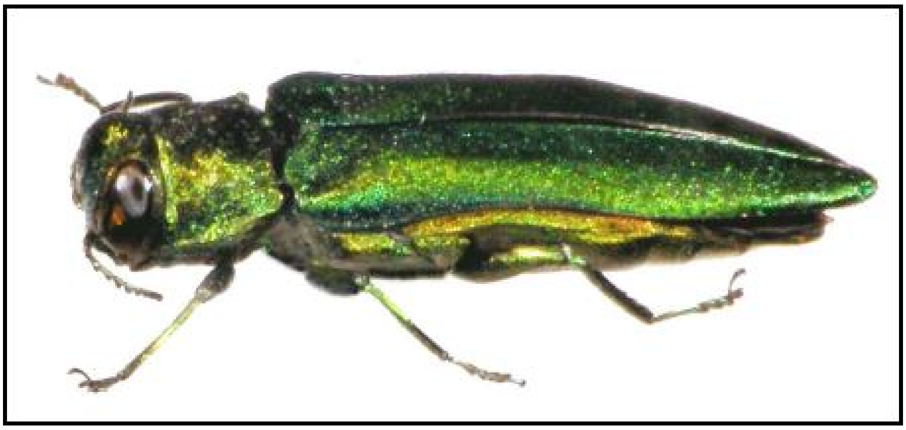

**Fig. 1.** Emerald Ash Borer present in Ohio**.** (Source: www.emeraldashborer.info)

| Class code | Classification type |
|---|---|
| 0 | Created, never classified |
| 1 | Unclassified |
| 2 | Ground |
| 3 | Low vegetation |
| 4 | Medium vegetation |
| 5 | High vegetation |
| 6 | Building |
| 7 | Low points (noise) |
| 8 | Model key |
| 9 | Water |

**Fig. 2.** Classification codes for field items (Source: ESRI Help tool)

**Fig. 3.** LiDAR data prior of being filtered

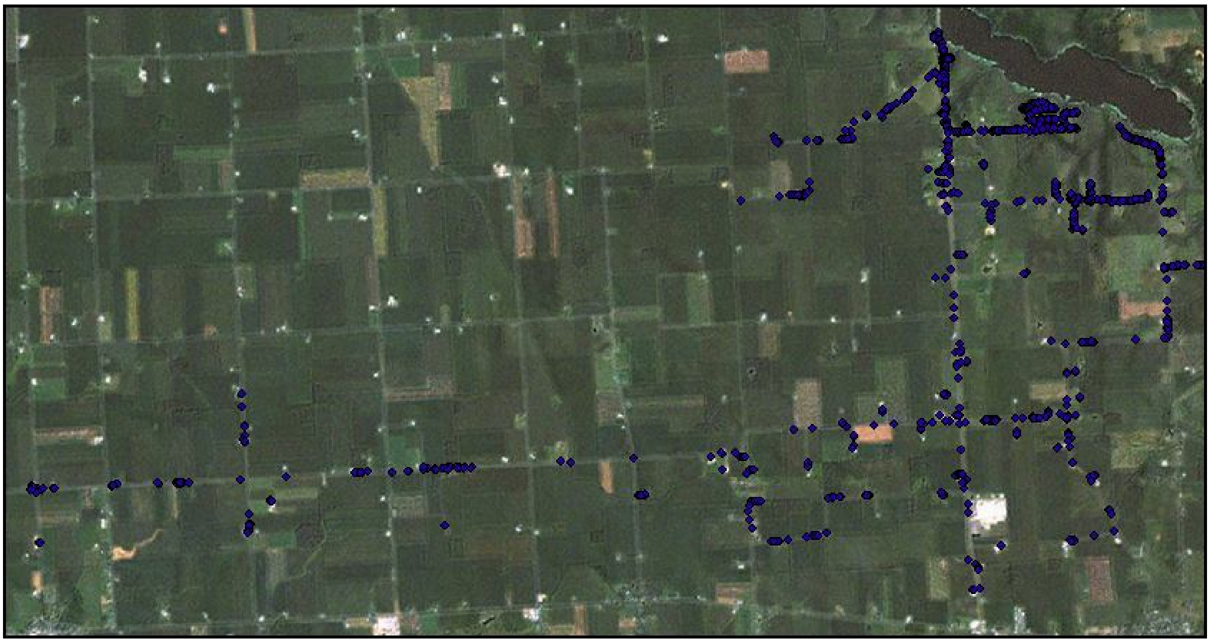

**Fig. 4**. LiDAR data for the same area as in Figure 3, but filtered by 70 feet buffer only for the area of interest (around electric lines)

**Fig. 5**. LiDAR points representing electric poles wrong displayed as tree canopies. These points were removed manually

**Fig. 6.** LiDAR canopies for a forest area overlaid on Bing Maps background

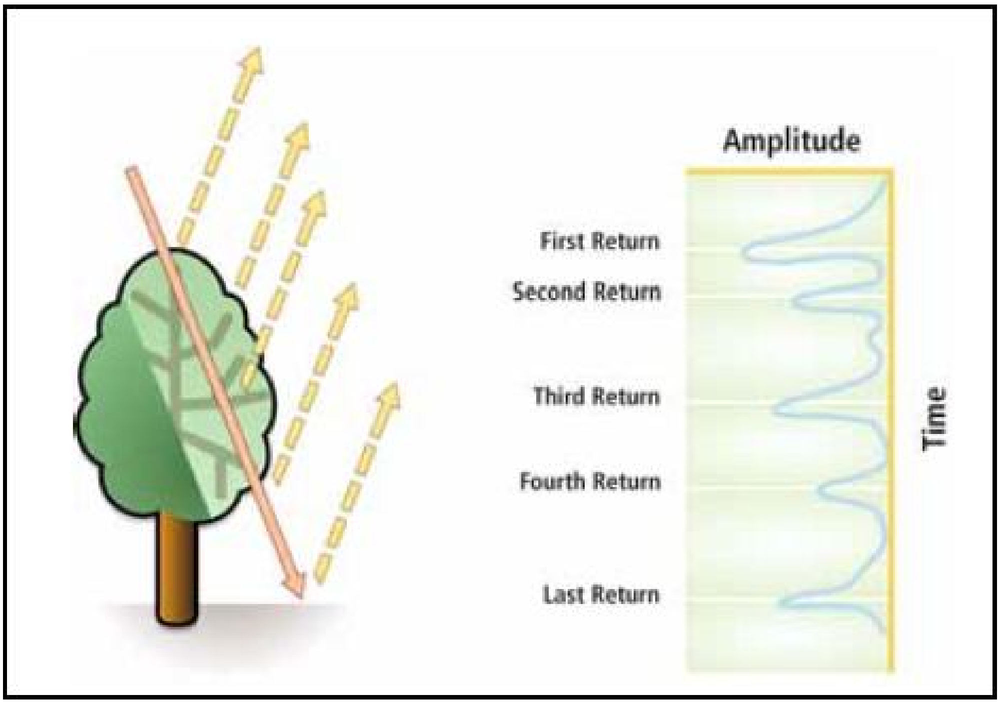


**Fig. 7.** Multiple returns of LiDAR data to/from tree canopies (Source: *ArcGIS 10. 0 Help Tool:* www.help.arcgis.com)

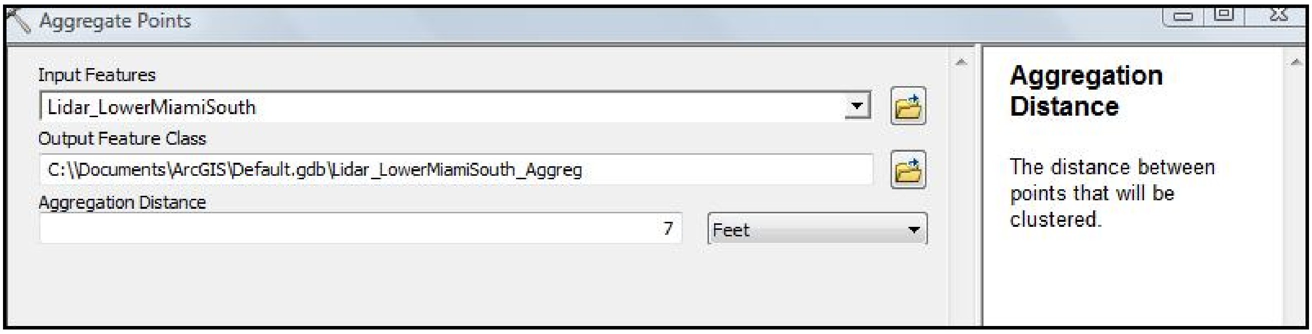


**Fig. 8.** Tree canopies (on the left) and trees resulted by grouping canopies (on the right)

**Fig. 9.** Aggregate Points Tool

**Marioara COSTEA, *Land degradation by water erosion. Methodological Guide,*** Edited by Lucian Blaga" University Sibiu Publishing House, Sibiu, 2012, 231 p., 79, fig., 5 appendices.

**Rodica CIOBANU***

Land degradation in recent decades is a problem facing society and the economy through the effects it generates in terms of living space and one assigned to agriculture. Significant increase at a pace that human society has ever known makes the living space and food for growing plants important to make the "earth" to be increasingly valuable.

Geomorphological processes and soil are considered responsible for land degradation and erosion ranks first among them. Events hydrological, meteorological took place across the globe and we have shown that erosion by the water of precipitation are major risk factors influencing human life.

In the context of these realities writes about land degradation and erosion is a commendable approach. But difficult as the author recognizes, without the support of theoretical and applied scientists involved in basic research and experimental.

Mrs. Marioara Costea having remarkable results both in theoretical and applied geomorphology, has achieved successfully, a summary and an overview of the state of theoretical research in the field. Synthesis was based on the theories, principles, laws and targets, calculation methods, etc.. Notice and only reading content systemic approach, transdisciplinary and interdisciplinary homework used in this study. The sheer volume of material bibliography (200 references that cited in the paper) show professionalism in tackling land degradation through erosion hidrică. But not only bibliographic study led to the writing, the author has extensive practical experience in the field of geomorphology. This work is the fruit of bibliographic documentation and activity under "Postdoctoral School for Livestock Biodiversity and Food Biotechnology and Bio-based Economy necessary Ecosanogenezei"

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Guideline aims of this paper some important aspects namely: the importance of land degradation and erosion, factors involved in land degradation, water erosion mechanisms and their role in triggering slope imbalances, the role of human

activity in harnessing the resources of soil, rehabilitation of quality of land, and how to quantify and experience at national and international researchers in the assessment and mitigation of these phenomena.

The first chapter on land degradation, grounded theory approach and examples of chapters. In this chapter general, factors, human influence on the land degradation process causes fluid. The fact that production, every 2-3 years for a torrential rain event with intense lead to the loss of about 20-40 t / ha of soil demonstrates once again the importance and usefulness of the topic addressed in this work. In this chapter the author points out that the loss of soil quality endanger the ecosystems, human health and economy, food security. In Romania the situation is no better arable land per year are lost through erosion by 126 million tons of soil. The author documented, arguing each statement presents not only the level of land degradation at national level but also efforts to combat erosion.

State of research at the second chapter the author outlines efforts at European level objectives that are to be traced back to the decade of the 70's last century of inventory, monitoring and reducing the risk of soil erosion. In Romania, there was a tradition in research on degraded lands since the mid-nineteenth century. The author presents in this chapter not only researchers and work on this area but make judgments on developments made.

Chapter three *Research Methodology* is a welcome chapter in a guide especially because erosion has pursued research on certain aspects. Note subsections bibliographic documentation - synthesis, evaluation and forecasting methods etc. - Field research, case studies, information systems, etc..

A proper management of land involves a complex knowledge environment, balances and internal imbalances. In this respect Chapters 4, 5 and 6: geomorphological conditions of erosion, alteration crust and slope deposits, soil erosion role just prior to proper management of the land. A key factor is the relief erosion. The morphogenetic and morphometric characteristics of this dynamic condition degradation processes. These chapters the author treats problems such as morphometric parameters, types of deposits participating in these processes analyzed in complexity.

Water erosion is a widespread phenomenon in the world and very diverse, depending on the agent model and of regional and local environmental conditions. Water erosion of the slopes (7th chapter) is just one of the forms of erosion. Called pluviodenudare within this complex author treats conditions of production, mechanisms of action and forms. In Chapters 8 and 9 are still present in the same format, erosion, surface and linear.

Chapter 10 the author presents erosion assessment models is a welcome and useful chapter on territorial planning, taking action for sustainable development and land reclamation. The author presents each model analyzed in terms of usefulness and limitations. RUSLANT model is that the author presents in detail. Choosing this presentation is the fact that it is an improved model to the other and that is adapted to the study watersheds.

Chapter 12 Italian experience in assessing erosion was developed as the author confesses documentation from a stage at the University of Florence. Are presented with the claim that the subject was exhausted, studies aimed at quantifying erosion, land erosion vulnerability assessment, identification and mapping of areas with different degrees of risk to these phenomena.

One of the most important factors that contribute to increasing human pressure on land degradation and erosion is a result of land use and changes in land structure. In this chapter the author has developed 13 - Dynamics of the land and the role of land use in erosion.

Agriculture is the most affected by erosion and with it the natural environment. Deception and land protection is a priority and interdisciplinary. Thus, in Chapter 14, Technology and strategies to land erosion. The author in closing this chapter recommends steps that should be followed in the strategies erosion.

Loss of soil fertility, destruction of household economic losses of life, the social dimension associated (poverty, unemployment, etc.) Are negative phenomena associated erosion. In Chapter 15, Perception dangerous phenomena and land degradation by erosion.

An important step in assessing land degradation, namely the development of projects, activities related legislation includes the internal and external knowledge in the field. In this paper, which is a chapter guide land degradation and soil and European law is useful. The author records the spirit of professionalism and ethics in legislative limitations and the large distance between the law and its application.

As documented, carefully, professionally and teaching skills developed Annexes author (5) at the end of the work. The author proposes several types of records that can be filled so degraded land assessor and community members where geomorphological phenomenon occurs.

It's impressive bibliography and cited in the paper. Work, only so far with the subject fills a void and will be useful to those who have the land affected by erosion concerns.

*IN MEMORIAM*
## AUGUST SPIEß VON BRACCIOFORTE ZU PORTNER UND HÖFLEIN

On the 4th of April 1953, 60 years ago, August von Spieß died in Sibiu. He gave a new meaning to the word hunter, using his knowledge and efforts to protect Transylvanian fauna.

He was born in Przemysl/Galicia (Eastern Europe), where his father was stationed as an Austrian officer. The latter was a great marksman, who early introduced his son to hunting and who sparked in him a love of nature. So it is no wonder that the son turned out to be an expert in hunting; he wrote about hunting and, owing to his skills and knowledge, became the Royal Romanian Hunting Director for many years.

In 1875, August Roland von Spieß embarked on the career typical for a member of an officer's family. When he was 11 years old, he first went to the lower secondary military school in St. Pölten, and then continued at the upper secondary military school in Mährisch-Weißkirchen (Hranice) and at the Theresian military academy in Wiener Neustadt. In the latter institution, one of his school mates was a young Székely from Transylvania, Arpád Bora de Szemerija, who depicted his native land in such bright colours and so alluringly that Lieutenant von Spieß asked to be transferred to a Transylvanian rifle battalion or infantry regiment.

In autumn 1893, after several years as a lieutenant and senior lieutenant in Broos (Orăştie) and Mühlbach (Sebeş), he was appointed to the infantry cadet school in Hermannstadt (Sibiu) as a teacher to instruct students in geography, war history, French, and the drill book. He was promoted to captain and honoured for his seven years of teaching.

In Hermannstadt (Sibiu), he married Auguste Herberth, the granddaughter of the founder of the Hermannstädter Allgemeine Sparkasse; she was said to be the most beautiful girl in Hermannstadt. The couple had four daughters, the eldest Silvia Stein-von Spieß, an ornithologist instructed by her father, became known for her work on bird migration in the Danube Delta and on birds of prey.

The military career of August von Spieß took place mainly in Hermannstadt (Sibiu), where he was promoted to commandant of the cadet school, after he had been awarded the rank of field officer in Vienna in 1911.

During the First World War, he took command of various infantry regiments in Galicia and Italy. Before the end of the war, he returned, injured by an Italian grenade. After several short episodes in other places, he finished his military career as a colonel in Szeged and returned to Hermannstadt (Sibiu).

On 1 July 1921, he was appointed as Royal Hunting Director (Hofjagddirektor S.M.) of King Ferdinand of Romania. His task was to set up the Royal Hunting Office and to organise all royal hunting grounds, whether owned or leased, donated land, and crown domains in line with Austro-Hungarian and German hunting principles.

He successfully devoted himself to this task for a full 17 years, so that the game population improved considerably, both in terms of quality and quantity. He laid down his experiences in the report "17 Jahre im kgl rumänischen Hofjagddienst" (17 years in the Royal Romanian Hunting Service).

In this context, he was soon appointed member of the selected commission for conservation and national parks, and he was made honorary hunting inspector of the country (Landesjagdinspektor). Moreover, he was an honorary member of various national and international hunting associations.

In 1934, he went on a hunting trip to Sweden. Two years later, he travelled for the first time to equatorial Africa, to the Kilimanjaro and Meru regions, and a second time in 1938, when he visited central Tanganyika (modern-day Tanzania), especially, the Wami River and Lake Manyara. Immediately after his return, his travel report was published in Romanian – "Din Ardeal la Kilimandjaro"; a first German version is due to be published soon by Neumann-Neudamm. At that time, he quit his post at the Royal Hunting Office and retired, having assumed the title of Royal Hunting Master.

As a pensioner, he revised his 39 war diaries, which had been painstakingly kept and which are now in the Vienna War Archive. These do not just contain war experiences but also observations on nature, forests, game, and hunting, especially about his 8-day stay in the tsar's forest of Bialowieza.

August von Spieß was a sportsman of many talents: mainly a big-game hunter and alpinist, and, undoubtedly, one of the most successful bear hunters in the Southern Carpathians. His trophy collection with its many national and international awards and also his collection of weapons bear eloquent witness to the quality and richness of the Transylvanian mountains. The Hunting Museum "August von Spieß", which is located in his former home and maintained by the Natural History department of the Brukenthal Museum in Hermannstadt, is – and will always remain – an attraction for hunters from far and wide.

Since he had the gift to tell of his experiences with the skill of a writer, people read with pleasure the work of this hunting author even today. In addition to his over 300 articles in the various hunting magazines of his time, he wrote books such as "Karpatenhirsche" (Carpathian stags), "Im Zauber der Karpaten" (Experiencing the magic of the Carpathians), and the monographs of the royal hunting territories – "Die Wildkammern des Retezatmassivs" (The gamebasket of the Retezat Massif) and "Gurghiu – Görgeny Szt. Imre", among others. Some of these books appeared in a second edition, revised by von Spieß himself. On the occasion of his 150th anniversary, his work will be re-edited, including some manuscripts that have hitherto remained unpublished, such as "Aus den Tagebuchblättern eines alten Jägers" – From the diary sheets of an old hunter (Nov. 2013).

In the last years of his life, August von Spieß also published in many Rumanian hunting magazines. Because today many Romanians would like to benefit from his knowledge, we decided to render several of his articles into Romanian. Thus, in 2005, the Retezat book was published under the title of "Caprele negre din Masivul Retezat". The translation was readily tackled by Walter Frank, senior forester from Rusca Montana. Furthermore, a selection of hunting reports on the most important exhibits of the hunting museum is to be published as a book, which will bring life to the exhibition. A language rich in images and the detailed observation of the behaviour of game under different conditions of terrain, wind, and weather reveal that August von Spieß was not only a hunter but also a writer and profound observer as well as an expert in animal behaviour.

*Dr. Helga STEIN, granddaughter of August von Spieß*