

## Saproxylic beetles (Insecta: Coleoptera) from forest ecosystems of the Republic of Moldova

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**Abstract.** The first inventory of saproxylic beetles collected during 2009-2022 years from 19 forest ecosystems was performed in the Republic of Moldova. A total of 103 Coleoptera species belonging to 91 genera and 36 families were identified. One genus (*Xylophilus*) and 12 species (*Aesalus scarabaeoides* (Panzer, 1794), *Calodromius spilotus* (Illiger, 1798), *Malthinus balteatus* Suffrian, 1851, *Mycetochara flavipes* (Fabricius, 1792), *Mycetophagus fulvicollis* Fabricius, 1793, *Plegaderus dissectus* Erichson, 1839, *Ptenidium formicetorum* Kraatz, 1851, *Rhizophagus bipustulatus* (Fabricius, 1792), *Siagonium humerale* Germar, 1836, *Synchita undata* Guérin-Méneville, 1844, *Tritoma bipustulata* Fabricius, 1775 and *Xylophilus testaceus* (Herbst, 1806)) are new for the fauna of the Republic of Moldova.

**Keywords:** silvicolous ecosystems, wood decompose, new species.

### Introduction

Saproxylic beetles are one of the main components of the forest fauna due to their high diversity and involvement in important ecosystem services such as dead wood decomposition and nutrient recycling (García-López et al. 2016). Just like other insect groups, they depend for part of their life cycle on dead wood, the wood of dying trees (fallen or standing), wood-dwelling fungi, or the presence of other saproxylic groups (Speight 1989). Some species feed on the wood itself, but many depend on various fungi that feed on the wood or the fine wood mold. Many species are hunters, feeding on the species that nibble the wood and fungi. Some species are saprophagous, consuming remnants of the vital activity of other species, but there are also species with a mixed diet. Moreover, the diet of the adults differs from that of the larvae.

Many of these species are used as indicator species for old-growth forests with good ecological status (Brustel 2004, Müller 2005). Studies carried out on the ecology of saproxylic coleopterans (Grove 2002a, Schmidl & Buřler 2004) and their status in managed forest ecosystems (Siitonen 2001, Grove 2002b) highlight the role of saproxylic coleopterans in dead wood recycling processes, but also the danger of biodiversity decline in managed European forests (Speight 1989, Nieto & Alexander 2010).

Until now, saproxylic coleoptera from the Republic of Moldova have been mentioned in Neculiseanu et al. 2002, Bacal & Cocirta 2015, Bacal et al. 2022, Buřmachiou & Bacal 2022. All saproxylic beetles depend on specific microhabitats (Siitonen 2001); some of them have a reduced dispersion capacity (Schiegg 2000), while others are small and cryptic (Bouget et al. 2008). Therefore, the collection methods are essential in sampling a greater diversity of species (Brustel 2004, Redolfi et al. 2014, Papis & Mokrzycki 2015, Hilszczański et al. 2015, Nakládal et al. 2017, Heijerman et al. 2018). Thus, various collection protocols were used to identify a wide spectrum of saproxylic coleopteran species from some forest ecosystems of the Republic of Moldova.

The area covered with forests in the Republic of Moldova has a surface of 377.500 ha (with an afforestation degree of 11,2%), with approximately 800 forest bodies, the area of which varies between 5 - 1500 ha, being unevenly distributed

in the country.

The central area occupies the largest share of 13.5%, the northern area 7.2%, and the southern area 6.7%. In the north part of the country, two types of forests are present: pedunculated oak (*Quercus robur*) with cherry (*Prunus avium*) and pedunculated oak with birch (*Betula alba*). The Pădurea Domnească Reserve has a special significance for the forest fund of the northern area.

In the central area, on the slopes with northern and northeastern exposure, there are sectors of beech forest (*Fagus sylvatica*). On the slopes with southern exposure, monodominant sessile oak (*Quercus petraea*) and sessile oak with hornbeam (*Carpinus betulus*) predominate. Three important reserves are in the central part of the Republic of Moldova: Cobîleni, Codrii, and Plaiul Fagului.

In the southern part of the country, there are forest communities with downy oak (*Quercus pubescens*) and pedunculated oak (*Quercus robur*). The Prutul de Jos Biosphere Reserve is particularly important for the southern area.

This work aimed to inventory the saproxylic coleopteran species from various forest ecosystems and tree species, with special emphasis on the rare and harmful species.

### Materials and methods

#### Sites of collection

The material was collected during the years 2009-2022 from the decomposed wood of fallen logs or standing trees and thick rotten branches from 19 forest ecosystems: Prutul de Jos Biosphere Reserve; Reserves: Cobîleni, Codrii, Pădurea Domnească, and Plaiul Fagului; Landscape Reserves: Codrii Țigheci, Pohrebni, Teița, Țipova, Vila Nisporeni, and Saharna; National Park Nistrul de Jos; urban park Valea Morilor; natural forest near localities: Condrîța, Rusca and Vulcănești and forest plantation near Sadaclia, Măcărești, and Troița Noua.

#### Collection methods

The materials discussed in the paper were collected using eight different collection methods. The most used one was the manual collection method, but small specimens were sucked with an exhaustor directly from the dead wood (Figure 1). Various types of traps were used to collect coleopterans: trunk trap for intercepting the flight, window trap, and Barber pitfall trap (Figure 2). Microscopic-

sized beetles were extracted from dead wood using the modified floatation method described by Buşmachi et al. 2015. Several specimens were collected directly from plants with an entomological net, shaking off the mushrooms from trees. Some rare species, included in the Red Book of Moldova, were photographed in their natural environment.

The following keys were used for species identification:



Figure 1 Stump of a tree from the Pădurea Domnească Reserve.



Figure 2 Standing dead tree with interception trap in the Plaiul Fagului Reserve.

## Results

A total of 973 individuals belonging to 36 families, 91 genera, and 103 species were collected during the study carried out in forest ecosystems located in 19 different localities. Between them, one genus (*Xylophilus* Mannerheim, 1823) and 12 species (*Aesalus scarabaeoides* (Panzer, 1794), *Calodromius spilotus* (Illiger, 1798), *Malthinus balteatus* Suffrian, 1851, *Mycetochara flavipes* (Fabricius, 1792), *Mycetophagus fulvicollis* Fabricius, 1793, *Plegaderus dissectus* Erichson, 1839, *Ptenidium formicetorum* Kraatz, 1851, *Rhizophagus bipustulatus* (Fabricius, 1792), *Siagonium humerale* Germar, 1836, *Synchita undata* Guérin-Ménéville, 1844, *Tritoma bipustulata* Fabricius, 1775 and *Xylophilus testaceus* (Herbst, 1806)) are new for the fauna of the Republic of Moldova.

The list of the Coleoptera species identified in the decomposed wood of forest ecosystems in the Republic of Moldova is presented below. Newly identified taxa are marked with an asterisk (\*).

Family Rhysodidae: *Omoglymmius germari* (Ganglbauer, 1892).

Family Carabidae: *\*Calodromius spilotus* (Illiger, 1798); *Tachyta nana* (Gyllenhal, 1810).

Family Histeridae: *Abraeus perpusillus* Marsham, 1802; *Dendrophilus punctatus* (Herbst, 1791); *Hololepta plana* (Sulzer, 1776); *Paromalus flavicornis* (Herbst, 1791); *Platylomalus complanatus* (Panzer, 1796); *Platysoma compressum* (Herbst, 1783); *\*Plegaderus dissectus* Erichson, 1839; *Teretrius fabricii* Mazur, 1972.

Family Ptiliidae: *Nossidium pilosellum* (Marsham, 1802); *\*Ptenidium formicetorum* Kraatz, 1851.

Family Leiodidae: *Amphicyllis globus* (Fabricius, 1792).

Family Silphidae: *Phosphuga atrata* (Linnaeus, 1758).

Kryzhanovskij 1965, Gidei & Popescu 2014, <http://www.ukbeetles.co.uk>, <http://www.coleonet.de>, and <http://www.cerambyx.uochb.cz>. The identification was made using Leica and Meiji Techno microscopes. The specimens were deposited in the Museum of Entomology, Institute of Zoology collection. To identify some species, the museum's etalon specimens were used as a standard.

Family Staphylinidae: *Scaphidium quadrimaculatum* Olivier, 1790; *Scaphisoma boleti* (Panzer, 1793); *Sepedophilus testaceus* (Fabricius, 1793); *\*Siagonium humerale* Germar, 1836.

Family Lucanidae: *\*Aesalus scarabaeoides* Panzer, 1794; *Dorcus parallelipedus* (Linnaeus, 1785); *Lucanus cervus* (Linnaeus, 1758); *Platycerus caraboides* (Linnaeus, 1758).

Family Buprestidae: *Dicerca aenea* (Linnaeus, 1766); *Ptosima undecimmaculata* (Herbst, 1784).

Family Elateridae: *Ampedus elegantulus* Schönherr, 1817; *Ampedus pomonae* (Stephens, 1830); *Ampedus sanguineus* (Linnaeus, 1758); *Ampedus sanguinolentus* (Schrank, 1776); *Megapenthes lugens* (Redtenbacher, 1842); *Melanotus brunniipes* (Germar, 1824); *Stenagostus rhombeus* (Olivier, 1790).

Family Eucnemidae: *\*Xylophilus testaceus* (Herbst, 1806).

Family Lycidae: *Erotides cosnardi* (Chevrolat, 1829); *Lopheros rubens* (Gyllenhal, 1817).

Family Cantharidae: *\*Malthinus balteatus* Suffrian, 1851.

Family Ptinidae: *Xestobium rufovillosum* (De Geer, 1774).

Family Trogossitidae: *Tenebroides mauritanicus* (Linnaeus, 1758).

Family Cleridae: *Thanasimus formicarius* (Linnaeus, 1758).

Family Melyridae: *Dasytes niger* (Linnaeus, 1760).

Family Erotylidae: *Dacne bipustulata* (Thunberg, 1781). *Triplax aenea* (Schaller, 1783); *\*Tritoma bipustulata* Fabricius, 1775.

Family Monotomidae: *Monotoma longicollis* (Gyllenhal, 1827); *\*Rhizophagus bipustulatus* (Fabricius, 1792).

Family Cryptophagidae: *Cryptophagus acutangulus* Gyllenhal, 1827.

Family Silvanidae: *Uleiota planata* (Linnaeus, 1761).

Family Cucujidae: *Cucujus cinnaberinus* (Scopoli, 1763); *Placonotus testaceus* (Fabricius, 1787).

Family Cerylonidae: *Cerylon deplanatum* Gyllenhal, 1827;

*Cerylon histeroides* (Fabricius, 1792).

Family Endomychidae: *Endomychus armeniacus* Motschulsky, 1835; *Symbiotes gibberosus* (Lucas, 1846).

Family Latridiidae: *Corticarina minuta* (Fabricius, 1792); *Dienerella filum* (Aubé, 1850).

Family Mycetophagidae: *Mycetophagus ater* (Reitter, 1879); *Litargus connexus* (Geoffroy, 1785); *\*Mycetophagus fulvicollis* (Fabricius, 1792); *Mycetophagus piceus* (Fabricius, 1777); *Mycetophagus quadripustulatus* (Linnaeus, 1761).

Family Melandryidae: *Abdera quadrifasciata* (Curtis, 1829); *Dircaea australis* Fairmaire, 1856.

Family Mordellidae: *Tomoxia bucephala* Costa, 1854.

Family Zopheridae: *Bitoma crenata* (Fabricius, 1775); *Colydium elongatum* (Fabricius, 1787); *\*Synchita undata* Guérin-Méneville, 1844.

Family Tenebrionidae: *Bolitophagus reticulatus* (Linnaeus, 1767); *Crypticus quisquilius* (Linnaeus, 1761); *Diaclina testudinea* (Piller & Mitterpacher, 1783); *Diaperis boleti* (Linnaeus, 1758); *Mycetochara axillaris* (Paykull, 1799); *\*Mycetochara flavipes* (Fabricius, 1792); *Nalassus dermestoides* (Illiger, 1798); *Neatus picipes* (Herbst, 1797); *Platydemus violaceum* (Fabricius, 1790); *Platydemus dejeani* Laporte de Castelnau & Brullé, 1831; *Prionychus ater* (Fabricius, 1775); *Stenomax aeneus* (Scopoli, 1763); *Scaphidema metallicum* (Fabricius, 1792); *Tenebrio opacus* Duftschmid, 1812; *Ulloma culinaris* (Linnaeus, 1758).

Family Prostomidae: *Prostomis mandibularis* (Fabricius, 1801).

Family Pyrochroidae: *Pyrochroa coccinea* (Linnaeus, 1761); *Pyrochroa serraticornis* (Scopoli, 1763).

Family Scaptiidae: *Anaspis frontalis* (Linnaeus, 1758).

Family Cerambycidae: *Aegosoma scabricorne* (Scopoli, 1763); *Cerambyx scopolii* Fuessly, 1775; *Chlorophorus sartor* (Muller, 1766); *Chlorophorus varius* (Muller, 1766); *Dinoptera collaris* (Linnaeus, 1758); *Leptura aurulenta* Fabricius, 1792; *Mesosa curculionoides* (Linnaeus, 1761); *Morimus asper funereus* Mulsant, 1862; *Prionus coriarius* (Linnaeus, 1758); *Pyrrhidium sanguineum* (Linnaeus, 1758); *Rhagium inquisitor* Linnaeus, 1758; *Rhagium sycophanta* (Schrank, 1781); *Rosalia alpina* (Linnaeus, 1758); *Rutpela maculata* (Poda, 1761).

Family Anthribidae: *Platyrhinus resinosus* (Scopoli, 1763).

Family Curculionidae: *Cossonus cylindricus* Sahlberg, 1835; *Platypus cylindrus* (Fabricius, 1792); *Xyleborus monographus* (Fabricius, 1792).

Most species belonged to the families Cerambycidae and Tenebrionidae. They were represented by 14 and 15 species each, followed by the families Histeridae (8 species), Elateridae (7 species), Mycetophagidae (5 species), Staphylinidae and Lucanidae (4 species each), Erotylidae and Zopheridae (3 species each). The other 13 families (Curculionidae, Ptiliidae, Buprestidae, Lycidae, Monotomidae, Cucujidae, Endomychidae, Latridiidae, Anthribidae, Melandryidae, Pyrochroidae, Carabidae, Cerylonidae) were represented by two species each and 14 families (Rhysodidae, Leiodidae, Silphidae, Eucnemidae, Cantharidae, Ptinidae, Trogossitidae, Cleridae, Melyridae, Cryptophagidae, Silvanidae, Mordellidae, Prostomidae, Scaptiidae) by one species each.

The largest number of coleopteran species were collected in the Plaiul Fagului Reserve (42 species), followed by the

Pădurea Domnească Reserve (36 species).

Brief ecological characteristics of the newly identified species, presented in alphabetical order, were selected from literature data and new data from the research carried out by the authors.

*Aesalus scarabaeoides* (Panzer, 1794) is a saprophagous species. The larvae develop for about three years in decaying trunks and roots of oak (*Quercus* spp.) and beech (*Fagus sylvatica*), less often on other deciduous trees. This species is not considered harmful for technical wood. The species is threatened with extinction due to the evacuation of rotten and scurvy trees and the destruction of old forest habitats (<https://www.zin.ru/animalia/coleoptera/addpages/lucanidb/lucanidb.htm>). Only one specimen of this species was collected manually from the decomposed wood of *Fagus sylvatica* from the Plaiul Fagului Reserve.

*Calodromius spilotus* (Illiger, 1798) inhabits deciduous and mixed forests. It prefers trees with smooth bark, such as beech, ash, maple, and acacia (<https://www.ukbeetles.co.uk>). One specimen of this species was collected using the flotation method from the decomposed wood of poplar from the Prutul de Jos Biosphere Reserve.

*Malthinus balteatus* Suffrian, 1851 inhabits flooded forests. Adults can be found from June to the end of August (Alexander 2003). One specimen of this species was collected using an interception trap from the decomposed wood of *Quercus* sp. from the Pădurea Domnească Reserve.

*Mycetochara flavipes* (Fabricius, 1792) is common in poplar, ash, and silverberry trees (Nakládal et al. 2017). One specimen of this species was collected manually from the decomposed poplar wood from the Nistrul de Jos National Park.

*Mycetophagus fulvicollis* Fabricius, 1793 prefers mold of deciduous and coniferous trees (<http://coleonet.de/>). In the Republic of Moldova, nine specimens of this species were collected manually from the decomposed wood of poplar from the Codrii Reserve and natural forest from Vulcănești locality.

*Plegaderus dissectus* Erichson, 1839 is a widespread species that inhabits damp and decaying stumps and logs in deciduous and mixed forests and prefers oak and beech. The species is associated with the ants of the genus *Lasius* and *Formica*. Both adults and larvae are predators of small grubs and eggs under bark or among decaying wood debris (<https://www.ukbeetles.co.uk>). One specimen was collected with an exhauster in the Plaiul Fagului Reserve from the decomposed wood of *Fagus sylvatica*.

*Ptenidium formicetorum* Kraatz, 1851 is associated with *Formica rufa* and *Lasius niger* (<http://www.coleonet.de>). One specimen was extracted using flotation methods from the decomposed wood of poplar in the Pădurea Domnească Reserve.

*Rhizophagus bipustulatus* (Fabricius, 1792) inhabits moist bark or decaying wood on fungus-infected deciduous or coniferous trees. Adults feed on mycelia, eggs, and larvae of various bark beetles (<https://www.ukbeetles.co.uk>). Many individuals (43) were collected by the exhauster in Vila Nisporeni Landscape Reserve, a natural forest from Vulcănești locality, and Codrii Reserve from the decomposed wood of *Fraxinus excelsior*.

*Synchita undata* Guérin-Méneville, 1844 is a species

widespread on deciduous trees. It is associated with the fungi that grow on maple (Heijerman et al. 2018). One specimen was collected with the exhaustor in the Codrii Reserve from the decomposed wood of *Acer* sp.

*Siagonium humerale* Germar, 1836, inhabits wet forests. It is found under the bark of recently dead and fallen trees. The species is exclusively saproxylic, fungivorous, predatory, or saprophagous in the galleries of other bark beetles (<http://www.coleonet.de>). Five specimens were collected by exhaustor in the natural forest of Vulcănești locality from the decomposed wood of *Fagus sylvatica*.

*Tritoma bipustulata* Fabricius, 1775 inhabits deciduous forests and wooded parks with mature trees in various stages of degradation. Larvae develop among debris under bark or in trunk-bodied fungi (*Polyporus* sp., *Trametes* sp., etc.) (<https://www.ukbeetles.co.uk>). One specimen was shaken off the poplar mushrooms from the Nistrul de Jos National Park.

*Xylophilus testaceus* (Herbst, 1806) was found on poplar, beech (Papis & Mokrzycki 2015), and oak (Hilszczański et al. 2015). Only two specimens were collected during our study using the interception trap method from the poplar in the Pădurea Domnească Reserve.

In addition to the newly identified species in the studied forest ecosystems, the following protected coleopteran species were recorded: *Cucujus cinnaberinus*, *Lucanus cervus*, *Morimus asper funereus*, and *Rosalia alpina*.

*Cucujus cinnaberinus* (Scopoli, 1763) is protected by Annex II of the Bern Convention and included in the Red Book of Moldova as a critically endangered (CR).

*Lucanus cervus* (Linnaeus, 1758) is protected by Natura 2000, Annexes II and IV of Directive 92/43/CEE. In the Republic of Moldova, the species is included in the Red Book of Moldova as a vulnerable (VU).

*Morimus asper funereus* Mulsant, 1863 is protected by Natura 2000, Annex II of Directive 92/43/CEE. In the Republic of Moldova, the species has the status of an endangered (EN).

*Rosalia alpina* (Linnaeus, 1758) is protected by Natura 2000, Annex II of Bern Convention, Annexes II and IV of Directive 92/43/CEE. In the Republic of Moldova, the species is included in the Red Book of Moldova as critically endangered (CR).

## Discussion

The first inventory of saproxylic beetles collected in the decomposed wood of forest ecosystems from 19 localities revealed a total of 103 Coleoptera species belonging to 91 genera and 36 families, including 12 new species for the Republic of Moldova.

Lachat et al. 2012 analyzed data on saproxylic beetles studied in the beech forests of 7 Central European countries and identified 127 indicator species. The present research in the Republic of Moldova forest ecosystems revealed 19 of them, 14 common species and 5 with priority level: *Bolitophagus reticulatus*, *Dendrophilus punctatus*, *Mycetophagus piceus*, *Plegaderus dissectus*, and *Ulloma culinaris*. Priority species were defined by Lachat et al. 2012 as species listed in the European Red List or the red list of one country included

in the study.

In Sweden, Ols et al. (2013) studied 100 stumps of *Picea abies* and *Betula* spp. located in wet and dry habitats. As a result of the study, 49 species of saproxylic beetles were found. Revealed coleopteran species include nine common species with those identified in the Republic of Moldova, but in Sweden, numerically dominant were *Dacne bipustulata*, *Bitoma crenata*, *Tomoxia bucephala*, and *Cerylon histeroides*. *Ampedus sanguineus*, *Dasydes niger*, *Sepedophilus testaceus*, *Pyrochroa coccinea*, and *Rhagium inquisitor* were cited with a small number of individuals. No protected species were identified.

The preset study revealed the presents of four rare and protected coleopteran species, *Cucujus cinnaberinus*, *Lucanus cervus*, *Morimus funereus*, and *Rosalia alpina* in the Republic of Moldova, frequently used as an indicator of forests biodiversity in the silvicolous ecosystems of European countries. These species inhabit only veteran trees of the secular forests.

In our research on the harmful species, we can mention the coleopterans of the family Curculionidae: *Platypus cylindrus* and *Xyleborus monographus*. According to Bellahirech et al. 2021 these two species carry fungi from affected trees to the weakened ones and infest them.

Another harmful coleopteran species is *Rhagium inquisitor*, which affects the weakened pine trees in the Republic of Moldova at approximately 50 years old. Most of them have been seriously affected by prolonged droughts since 2000. The first three individuals of *Rhagium inquisitor* were identified in the Republic of Moldova in 1964 in Ivancea locality. Later, in 2007 two specimens were collected from *Pinus sylvestris* in the urban park of Chișinău. The broad study of the species distribution of the wood-boring species *Rhagium inquisitor* from *Pinus nigra* and *P. sylvestris* plantations in the Republic of Moldova was analyzed in the paper of Bacal et al. 2022. The records dated 2022 on the territory of the Republic of Moldova demonstrated the wide distribution of this pest species in the coniferous plantations of the country, but the species was seldom found under the bark of dried coniferous trees.

Redolfi et al. 2014 studied the diversity of saprophagous beetles in the relict beech forest in Italy. Common numerical dominant species with the studies carried out in the Republic of Moldova are practically minimal, only *Ulloma culinaris* and another species related to cavities, wood fungi, or subcortical habitats - *Xyleborus monographus*.

The comparisons presented above prove once again that the saproxylic insect species depend on the tree species. In the Republic of Moldova, most of the natural silvicolous ecosystems are mixed on the base of oak species. There are also small patches of natural monodominant beech forests and several forest plantations.

## Conclusions

The first inventory of saproxylic coleopteran species in the Republic of Moldova revealed 103 species, 91 genera, and 36 families. The different collection methods used for the extensive study of the decomposed wood from 19 localities allowed us to identify one genus, *Xylophilus*, and 12

coleopteran species new for the fauna of the country. The study confirms the presence in the forest ecosystems of four protected species (*Cucujus cinnaberinus*, *Lucanus cervus*, *Morimus asper funereus*, *Rosalia alpina*, and 19 saproxylic indicator species, including *Bolitophagus reticulatus*, *Dendrophilus punctatus*, *Mycetophagus piceus*, *Plegaderus dissectus* and *Uloma culinaris*) with a priority level for European countries. The presence of species listed above proves that in the Republic of Moldova, there are old-growth forests with veteran trees, which ensure favorable conditions for developing rare and indicator species.

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