LADYBIRDS DIVERSITY (INSECTA: COCCINELLIDAE) FROM THE MUSEUM OF ENTOMOLOGY, INSTITUTE OF ZOOLOGY, REPUBLIC OF MOLDOVA

CREȚU Irina, BURDUJA Daniela, BUȘMACHIU Galina

Abstract. The insect collection of the Museum of Entomology is one of the most complete the Republic of Moldova, with about 15 thousand insect species. Research on ladybirds in the Republic of Moldova started at the beginning of the 20th century. The inventory of the collection of Coccinellidae housed in the Museum of Entomology allowed to reveal 1037 specimens belonging to 36 species. The specimens were collected between 1949 and 2005, from the forest and agricultural fields of the Republic of Moldova, as well as from 7 other countries: Australia, Cuba, North Korea, Kyrgyzstan, Ukraine and Russia. The paper includes the list of species, localities, countries, and some ecology of ladybirds.

Keywords: Museum of Entomology, collection, Coccinellidae, ecosystem, distribution.

Rezumat. Diversitatea buburuzelor (Insecta: Coccinellidae) din colecția Muzeului de Entomologie al Institutului de Zoologie, Republica Moldova. Colecția de insecte a Muzeului de Entomologie este una dintre cele mai vaste din țară, aici sunt depozitate circa 15 mii de specii de insecte. Cercetările coccinelidelor de pe teritoriul Republicii Moldova au debutat la începutul secolului al XX-lea, iar în urma inventarierii colecției din Muzeul de Entomologie au fost identificate 1037 exemplare, care fac parte din 36 de specii. Majoritatea exemplarelor au fost colectate în perioada anilor 1949–2005, din fâșii forestiere și culturi agricole din Republica Moldova, precum și din alte 7 țări: Australia, Cuba, Korea de Nord, Kyrgyzstan, Kazakhstan, Ucraina și Rusia. Lucrarea include lista speciilor, localitatea, țara de colectare, unele aspecte din ecologia lor.

Cuvinte cheie: Muzeul de Entomologie, colecție, Coccinellidae, ecosistem, distribuție.

INTRODUCTION

Systematically, ladybirds belong to the family Coccinellidae, superfamily Cucujoidea, order Coleoptera, class Insecta. The Coccinellidae family worldwide numbers about 6 000 species belonging to 370 genera, 30 tribes and 2 subfamilies. Ladybirds are small beetles, being in size about 0.8–2.8 mm, ranging in color from yellow, orange to light red with small white or black spots on the upper side, sometimes with bands or lines. The feeding habits of ladybirds are diverse, although most are predatory, some species are mycophagous, others phytophagous (feeding on leaves and pollen). Some species have a mixed food ration, for example *Bulaea lichatschovi* consumes both pollen and leaves and aphids, species of the Coccinellini tribe are predatory, consuming mainly aphids and coccids. Identifying ladybird species is essential for assessing their impact on agricultural pest control and overall ecosystem health. Ladybirds are known for their role in controlling such pests as aphids and others that can damage agricultural crops, and are thus considered allies of farmers and gardeners.

The research of ladybugs on the current territory of the Republic of Moldova started at the beginning of the 20th century. The first species of this group were cited for Bessarabia in 1917 by MILLER & ZUBOWSKY, in 1933 by RUSCINSKY, and in 1957 by MEDVEDEV & SHAPIRO. In 1983 in the „Animal World of Moldavia. Insects" OSTAFICIUC cited the number of 32 species of ladybugs, without any name of the species.

In the Catalogue of the Zubowsky Entomological Collection published by DERJANSCHI et al. (2016), 25 species of ladybird are cited. In 2021 BACAL et al. published the first work dedicated to ladybirds housed in the Museum of Entomology, Institute of Zoology, USM, collected from the Republic of Moldova.

According to updated data, 50 species of ladybirds have been identified and published in the Republic of Moldova (BUȘMACHIU et al., 2022; BURDUJA & BUȘMACHIU, 2023a, b; GROZDEVA et al., 2023).

The aim of this work is a continuation of the inventory of the collection of *coccinellidae* in the Museum of Entomology in order to complete the existing data.

This work represents an important step in understanding the diversity and distribution of ladybird species. To inventory and identify the species component of the existing insect collections in the Museum of Entomology, researchers can obtain a valuable information about these beneficial insects and their current status within the ecosystem. By complementing existing data and updating information on ladybird species, this work can contribute to the development of more effective strategies for biodiversity conservation and natural habitat management, ensuring the protection and conservation of these valuable insects for ecological balance.

MATERIALS AND METHODS

The entomological material revealed in this study is stored in the Museum of Entomology and includes 13 boxes with specimens collected in the period 1953-2005 years from several localities in the Republic of Moldova and other countries (Australia, Cuba, North Korea, Kyrgyzstan, Kazakhstan, Ukraine and Russia). The specimens of Coccinellidae were collected manually, using the entomological net and the Barber trap methods from natural ecosystems such as

forests, herbaceous plants, riparian habitats and different agrocenoses: apple, cherry and peach orchards; alfalfa, wheat, peas and corn fields etc.

The Meiji Techno and MBS-10 stereomicroscopes were used to identified the specimens. The statistical method was used to process and analyse the data of Coccinellidae specimens in the collection, and the graphic method was used to highlight the dominant species in the analysed collection.

RESULTS AND DISCUSSIONS

In 2020, Bacal et al. published the first work dedicated to the 18 coccinellid species housed in the Museum of Entomology, Institute of Zoology collected from the territory of the Republic of Moldova. After a further inventory of collections, 13 other boxes with specimens of Coccinellidae from the Republic of Moldova and other 7 countries: Kyrgyzstan (80 specimens), Russia (11), Ukraine (11), North Korea (10), Kazakhstan (6), Cuba (5) and Australia (3) collected by dr. Chiriac I. during international expeditions from 1949, 1956, 1957, 1973-1976, 1986-1989 were identified.

A total of 1037 ladybird specimens belonging to 36 species (905 from the Republic of Moldova, 132 from other countries or unlabelled) were included in the database.

Most of the specimens were collected during 1987-1989 years (Table 1). Additionally, 21 undetermined specimens were found in the collection: from the Republic of Moldova (9 specimens), Cuba (6), Russia (1), Australia (1) and 4 specimens without a label. The identified specimens were collected and determined by Chiriac I., Plugaru S., Șandra M., Zubowsky N. and Vereșceaghin B., who contributed considerably to the creation of the collection.

As a result of investigations, 3 species of Coccinellidae are cited for the first time in the Republic of Moldova: *Cynegetis impunctata*, *Scymnus ater* and *Scymnus impexus*. Only 2 species of genus *Scymnus* (*Scymnus frontalis* and *Scymnus rubromaculatus*) were mentioned in the first list published by BACAL et al., 2021.

The species cited for the first time for the fauna of the Republic of Moldova are marked with an asterisk (*) in Table 1.

Table 1. List of Coccinellidae species in the collection of the Museum of Entomology (foreign countries are marked in bold in the table).

Nr.	Species	Nr. of spec.	Country*	Locality	Habitats	Years
1	*Adalia bipunctata* (Linnaeus, 1758)	114	Moldova	Băcioi, Bahmut, Bozieni, Chișinău, Cojușna, Colibași, Cișmichioi, Giurgiulești, Grătiești, Hâncești, Iabloana, Ivancea, Joltai, Lozova, Nisporeni, Parcova, Păulești, Puhoi, Răzeni, Rusca, Trebujeni, Țipala, Sireți, Slobozia Mare, Stăuceni.	Apple, cherry, forest, fir, forest edge, grassy vegetation, maple, oak, orchard, pea, pine, plum, quince, vineyard, wheat, wild.	1957-2002
			Kyrgyzstan	Bishkek, Chaek	Grassy vegetation	1989
			Ukraine	Ujgorod, Zabolotivca	Cherry	1973
			Kazakhstan	-	-	1957
2	*Adalia decempunctata* (Linnaeus, 1758)	23	Moldova	Bahmut, Chișinău, Cișmichioi, Congaz, Durlești, Grătiești, Hâncești, Ivancea, Parcova, Trebujeni.	Cherry, forest, forest strip, oak, vineyard, wheat.	1958-1989
			Ukraine	Zabolotivca	Cherry	1973
3	*Anisosticta novemdecimpunctata* (Linnaeus, 1758)	2	Moldova	Durlești, Tomai.	Grass, oak.	1961, 1989
4	*Anatis ocellata* (Linnaeus, 1758)	1	Moldova	Rusca	Forest	1989
5	*Bulaea lichatschovi* (Hummel, 1827)	2	Moldova	Ivancea, Vatici.	-	1954-1964
6	*Calvia quatuordecimguttata* (Linnaeus, 1758)	10	Moldova	Bahmut, Brânzeni, Chișinău, Ivancea, Rusca, Trușeni.	Forest, on oak.	1959-2005
7	*Chilocorus bipustulatus* (Linnaeus, 1758)	8	Moldova	Chișinău, Ialoveni, Ivancea.	Forest, apple orchard, oak, forest strip.	1958-1989
			Ukraine	Crimeea	-	1956
8	*Coccinella quinquepunctata* (Linnaeus, 1758)	1	Moldova	Ivancea	-	1955
9	*Coccinella septempunctata* (Linnaeus, 1758)	105	Moldova	Băcioi, Bălți, Brăila, Boșcana, Bușeni, Brânzeni, Cantemir, Chișinău, Cișmichioi, Ciumai, Durlești, Etulia,	Apple orchard, cherry orchard, corn, dry forest, field, forest edge, forest strip, garden, grass,	1954-2004

				Giurgiulești, Grătiești, Hâncești, Iabloana, Ivancea, Lozova, Mereni, Mileștii Mici, Palanca, Păulești, Rădeni, Răzeni, Sadâc, Scoreni, Stăuceni, Tvardița, Țipala, Volodeni, Vulcănești, Zâmbreni.	hornbeam, oak forest, pea, *Robinia pseudoacacia*, maple, sainfoin, sunflower, vineyard, walnut, wheat.	
			Ukraine	Ujgorod	-	1973
			Kyrgyzstan	Naryn, Min-Kush	Naryn river bank	1989
			Russia	Voronej	Steppe	1949
			Kazakhstan	-	-	1949
10	*Coccinella transversalis* (Fabricus, 1781)	3	**Australia**	Victoria Sale	Eucalypt forest	1976
11	*Coccinula quatuordecimpustulata* (Linnaeus, 1758)	12	Moldova	Cantemir, Cimișeni, Etulia, Ivancea, Lăpușna, Mașcăuți, Țipala, Tvardița, Vatici, Vinogradovca, Vulcănești.	Bushes, field, forest strip, maize, peas, vineyard, wheat.	1953-1989
12	*Coleomegilla maculata* (De Geer, 1775)	1	**Cuba**	Havana	-	1986
13	**Cynegetis impunctata* (Linnaeus, 1758)	4	Moldova	Chișinău, Lozova, Tvardița.	Apple orchard, forest strip.	1972, 1989,1992, 1994
14	*Exochomus quadripustulatus* (Linnaeus, 1758)	42	Moldova	Bahmut, Calfa, Chișinău, Durlești, Ivancea, Mileștii Mici, Rădeni, Trebisăuți, Trebujeni.	Forest, forest strip, apple, oak, orchard, willow.	1954-1989
15	*Halyzia sedecimguttata* (Linnaeus, 1758)	9	Moldova	Bahmut, Brânzeni, Cantemir, Chișinău, Codreanca, Hâncești, Lozova.	Alfalfa, oak forest.	1960-2003
16	*Harmonia axyridis* (Pallas, 1773)	9	**Russia**	Ussuriisk, Vladivostok.	-	1975
			North Korea	Pyongyang	-	1987
17	*Harmonia quadripunctata* (Pontoppidan, 1763)	6	Moldova,	Băcioi, Chișinău, Ivancea, Trușeni, Stăuceni, Vatici.	Forest strip, pine, rowan.	1953-1989
18	*Hippodamia tredecimpunctata* (Linnaeus, 1758)	47	Moldova	Chișinău, Cișmichioi, Bălți, Bozieni, Etulia, Grătiești, Ivancea, Palanca, Sucleia, Vatici, Zâmbreni.	Alfalfa, beet, grass on the banks of river Dniester, garden, hornbeam, orchard, maple, pine, wheat.	1954-1989
			Kyrgyzstan	Naryn	-	1989
			Cuba	Havana	-	1989
19	*Hippodamia variegata* (Goeze, 1777)	112	Moldova	Anenii Noi, Băcioi, Bălți, Boșcana, Bozieni, Cantemir, Chetrosu, Chișinău, Cimișlia, Durlești, Etulia, Furceni, Gangura, Giurgiulești, Grătiești, Ivancea, Joltai, Mereni, Mileștii Mici, Nisporeni, Palanca, Tomai, Trușeni, Stăuceni, Sucleia, Suvorova, Zâmbreni.	Alfalfa, apple, forest edge, fodder beet, forest strip, grass, hawthorn, nettle, forest, maple, rape, peach orchard, pine, sainfoin, sorrel, sunflower, tobacco, walnut, wheat, willow.	1955-2004
			Kyrgyzstan	Bishkek, Chaek, Min-cush, Naryn.	Bank Naryn River, mown grass.	1989
20	*Hyperaspis campestris* (Herbst, 1783)	4	Moldova	Goteşti, Flămânda Reserve, Larga, Mileștii Mici.	Forest strip, forest edge, grass.	1988-1991
21	*Oenopia conglobata* (Linnaeus, 1758)	24	Moldova	Bahmut, Bozieni, Chetrosu, Chișinău, Fundul Galbenei, Mereșeni, Nisporeni, Păulești, Șirești, Trebujeni.	Forest, meadow, oak, orchard, bush, willow, meadow.	1957-2004
22	*Propylea quatuordecimpunctata* (Linnaeus, 1758)	227	Moldova	Băcioi, Bahmut, Balabanu, Bardar, Bălți, Berezlogi, Beşalma, Boșcana, Bozieni, Calfa, Chișinău, Cimișlia, Ciucur-Mingir, Ciumai, Cojușna, Cornești, Dubăsari, Durlești, Etulia, Fundul Galbenei, Furceni, Ghidighici, Grătiești, Hâncești, Holercani, Iabloana, Ivancea, Lăpușna, Lozova, Mileștii Mici, Nisporeni, Palanca, Răzeni, Sadâc, Sireți, Tomai, Trebujeni, Trușeni, Tvardița, Țaul, Țipala, Vinogradovca, Vulcănești.	Alfalfa, apple orchard, apricot, horn, field, forest strip, grass, forest, garden, vineyard, cherry orchard, pea, Dniester bank, mountain vegetation, peach orchard, forest, on oak, thorns, sunflower, walnut, willow, wheat.	1958-1997
			Ukraine	Kolomyia	Mountains	1974
			North Korea	Sariwon	-	1987
			Kyrgyzstan	Bishkek	Mountains	1989
23	*Psyllobora vigintiduopunctata* (Linnaeus, 1758)	159	Moldova	Anenii Noi, Bahmut Boșcana, Buțeni, Băcioi, Bălăbănești, Bălțata, Bălți, Berezlogi, Cantemir, Căpriana, Chișinău,	Wheat, oak woodland, forest, pine, vineyard, grass, sunflower, alfalfa,	1954-2004

				Ceadâr Lunga, Ciumai, Cojușna, Cornești, Durlești, Etulia, Gangura, Ghidighici, Horești, Iabloana, Ivancea, Lăpușna, Mereni, Mileștii Mici, Nisporeni, Palanca, Păulești, Pervomaisc, Răzeni, Rusca, Sucleia, Trușeni, Țipala, Țaul, Vinogradovca.	cherry orchard, pasture, forest strip, oak, willow, corn, shrubs.	
			Kyrgyzstan	Min-Cush	Grass	1989
24	*Scymnus apetzi* (Mulsant, 1846)	5	Moldova	Bahmut, Lozova, Țipala .	Wheat, grass, forest strip, sainfoin, forest edge.	1988,1993
25	**Scymnus ater* (Kugelann, 1794)	1	Moldova	Peliniei (Flămânda Reserve)	Oak forest.	1991
26	*Scymnus auritus* (Thunberg, 1795)	3	Moldova	Etulia, Slobozia Mare, Vinogradovca.	Grass, corn, alfalfa.	1989, 1991
27	*Scymnus (Nephus) bipunctatus* (Kugelann, 1794)	1	Moldova	Bahmut	Wheat	1993
28	*Scymnus frontalis* (Fabricius, 1787)	1	Moldova	Rădeni	-	1957
29	*Scymnus haemorrhoi-dalis* (Herbst, 1797)	1	Moldova	Codru	Vineyard	1989
30	**Scymnus impexus* (Mulsant, 1850)	1	Moldova	Pelinia (Flămânda Reserve)	Oak forest	1991
31	*Scymnus (Nephus) quadrimaculatus* (Herbst, 1783)	3	Moldova	Mileşti, Merețeni, Palanca.	Wild cherry, forest, grass on the banks of Dniester River.	1984,1988
32	*Scymnus rubromaculatus* (Goeze, 1777)	2	Moldova	Boșcana, Merețeni.	Oak forest, apple orchard.	1984, 1988
33	*Stethorus punctillum* (Weise, 1891)	5	Moldova	Boșcana, Bahmut, Goteşti, Larga.	Apple orchard, wheat, forest edge, vineyard.	1989-1993
34	*Subcoccinella 24-punctata* (Linnaeus, 1758)	32	Moldova	Bahmut, Căpriana, Chișinău, Codreanca, Colibaș, Doina, Etulia, Goreşti, Lozova, Tvardița.	Meadows, orchard, forest edge, forest, on oak, pea, forest strip, field, alfalfa.	1961-2005
35	*Tytthaspis sedecimpunctata* (Linnaeus, 1758)	8	Moldova	Etulia, Ivancea, Mereni, Palanca, Vatici, Vinogradovca, Strășeni,	Grass, wild grain, peach orchard, field.	1954-1993
36	*Vibidia 12-guttata* (Poda, 1761)	7	Moldova	Bahmut, Fundul Galbenei Hâncești.	Forest, on oak, walnut, shrubs.	1960-1989
			Russia	Vladivostok	-	1975

A special interest is raised by the species collected in other countries, which are not present in the fauna of the Republic of Moldova. One of such species is *Coccinella transversalis*, collected in Australia (Fig. 1), but which is found quite abundantly in Asia (SIDAURUK et al., 2023). Another species is *Coleomegilla maculata*, collected in Cuba (Fig. 2), which is one of the most prolific predators found throughout North, Central, and South America, from California to Mexico and their range stretches to Cuba (BRUST et al., 2018).

Figure 1. *Coccinella transversalis* (photo Burduja).

Figure 2. *Coleomegilla maculata* (photo Burduja).

The collection also includes specimens of *Harmonia axyridis* collected in North Korea and Russia, but which are now widely distributed in all types of habitats in the Republic of Moldova, becoming an invasive species.

The research shows that about 23% (Figure 3) of the inventoried specimens belong to the species *Propylea quatuordecimpunctata* (227 specs.), most of which were collected in the central part of the Republic of Moldova, including 12 specimens from Ukraine, North Korea and Kyrgyzstan. PERVEZ & OMKAR (2011) characterize this species as one that

reproduces faster than other large ladybird species. The species is quite common in natural and agricultural ecosystems (BURDUJA & BUȘMACHIU, 2023a, b).

The species *Psyllobora vigintiduopunctata*, which is also known for its potential in the biological control of powdery mildew (KARATARAKI et al., 2017), constituted 16% or 159 specimens of the total number of housed specimens (Fig. 1), most of them collected within the country, including 2 collected in Kyrgyzstan. The third, according to the number of specimens in the collection, is *Adalia bipunctata* (12%), which is a zoophagous species, mainly consuming aphids. This ladybird is useful for agriculture, as it provides natural biological pest control, contributing to reducing the need for the pesticides. Nowadays, *Adalia bipunctata* is quite rare compared to the last century, which can be explained by various natural and anthropogenic changes and the expanding the range of the Asian species, *Harmonia axyridis* quite common today in all European countries. A study by KENIS et al. (2020) found that the invasion of *Harmonia axyridis* is causing a considerable decline in the population of *Adalia bipunctata*.

The species *Hippodamia variegata* constituted about 11% of the Coccinellidae specimens in the collection, but this species is now practically dominant in most agricultural ecosystems. Although this species is not yet used as a natural method of aphid control in the Republic of Moldova, it is a dominant predator in other countries, that is widely used in aphid control for cotton production (JIANG et. al., 2023) and on tomatoes and potatoes (SARKAR et al., 2022). In the collection, specimens of *Coccinella septempunctata* constitute 11% of the total number of housed specimens, but this is currently a very common species in the most diverse types of habitats.

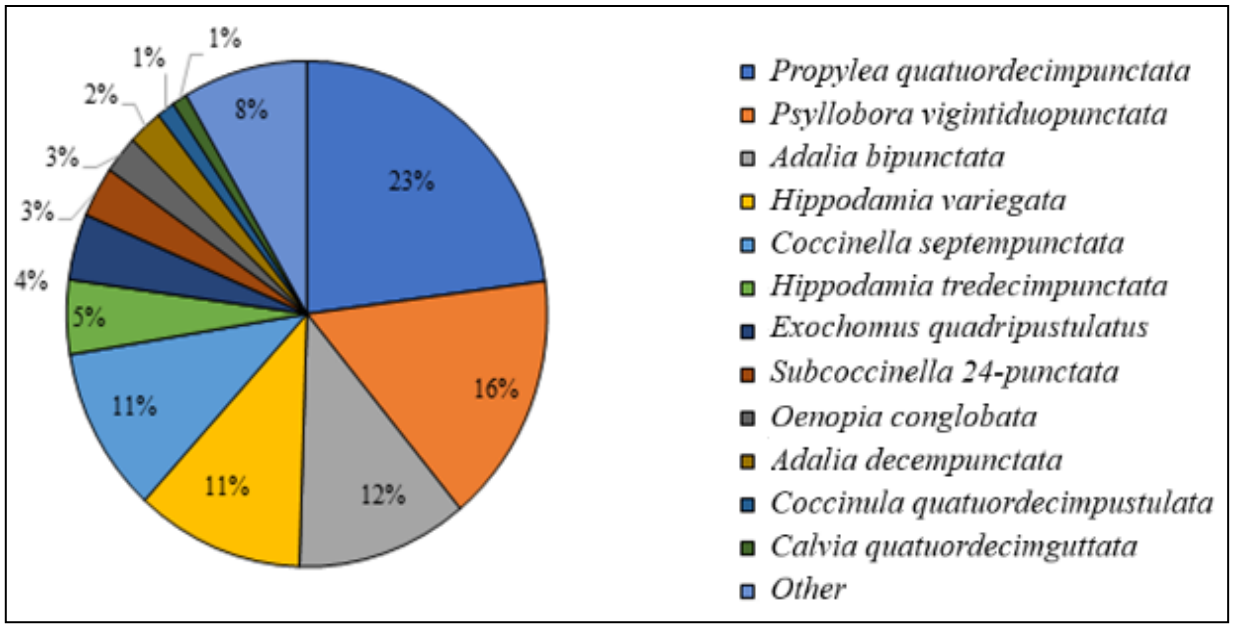

Figure 3. Coccinellidae species (%) in the collection of the Museum of Entomology, Institute of Zoology, MSU.

Exochomus quadripustulatus constitutes 4% of the number of specimens in the collection, being eurytopic, dendrobiont, aphidophagous and coccidophagous species, but currently one of the rare species in the Republic of Moldova (BACAL et al., 2021).

The species *Subcoccinella 24-punctata* with a total number of 32 specimens (5%) is also called the alfalfa ladybirds. Lucerne is attacked by both adults and larvae of this species, which gnaw the lower epidermis and leaf parenchyma, thus leaving the upper epidermis intact. The attacked leaves twist and wither, with significant damage being recorded in the first part of the growing season (BURDUJA & BUȘMACHIU, 2023a).

Three species from genus *Scymnus* (*Scymnus ater*, *S. haemorrhoidalis*, *S. impexus*), as well as two other species *Anatis ocellata* and *Nephus bipunctatus* are unique in the collection. Nevertheless, in the analysed collection, the specimens of the genus *Scymnus* are quite few, unlike in our research where *S. frontalis* is one of the dominant species in the Plaiul Fagului Reserve, often found in large numbers of individuals (BURDUJA & BUȘMACHIU, 2023b).

Comparing Coccinellidae species from museum and recently obtained data we can certainly state that the diversity of ladybirds has changed substantially during the 20th and 21st centuries. In the analysed collection, the species *Propylea quatuordecimpunctata* and *Psyllobora vigintiduopunctata* predominate, whereas, nowadays, the most common species are *Coccinella septempunctata*, *Hippodamia variegata* and *Tytthaspis sedecimpunctata* (BACAL et al., 2021).

Until now, after inventorying of all species from museum collection and published works, we summarize a total of 53 species of Coccinellidae which have been cited or collected in the Republic of Moldova.

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CONCLUSIONS

The collection of insects from the Museum of Entomology of the Institute of Zoology is one of the most complete, collected over 100 years and include an important diversity of species. The study of entomological collections allows us to better understand changes in the structure of insect populations, identify extinct, rare, common and invasive species.

The inventory of coccinellids from the collection allowed to identify three new species *Cynegetis impunctata*, *Scymnus ater* and *Scymnus impexus* for the Republic of Moldova, which, like 2 other species, *Anatis ocellata* and *Bulaea lichatschovi*, have not been attested in the last 3 decades, being present only in the museum. This underlines the importance of scientific collections in the conservation of biodiversity, it represents a valuable resource for researchers and for understanding the evolution and distribution of these insects in our country.

The most numerous in the collection are three species *Propylea quatuordecimpunctata, Psyllobora vigintiduopunctata* and *Adalia bipunctata*, whereas nowadays, the most common species are *Coccinella septempunctata*, *Hippodamia variegata* and *Tytthaspis sedecimpunctata*.

Changes in the dominance structure of today's species, compared to those identified in the last century, suggest that, currently, other species find favourable conditions for development, possibly caused by climate change. The preservation of existing collections is essential for monitoring and documenting changes in coccinellids biodiversity, which can be influenced by natural factors, but also by anthropogenic factors such as loss of natural habitats.

The inventory of the collection allowed the identification of 3 new species of Coccinellidae in the fauna of the Republic of Moldova, the list of which currently consists of 53 species.

The results of this study highlight the crucial role of biological diversity in ensuring the healthy functioning of ecosystems and supporting sustainable agricultural practices, underlining the need to protect and conserve these species as well as their natural habitats.

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Creţu Irina, Burduja Daniela, Bușmachiu Galina
Institute of Zoology, State University of Moldova.
Email: danavirlan3@gmail.com

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