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Review Article

Assessment of efficiency of pitfall trap method for enumeration of phytophagous beetles

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Abstract

The article presents an analysis of the results of using a large number of pitfall trap lines to record the species composition of the two largest groups of phytophagous beetles (Coleoptera: Chrysomelidae and Curculionoidea) on the example of the territory of one region of the European part of Russia (the Republic of Mordovia). A series of collections were conducted between April and October 2022-2023, encompassing a diverse array of habitats (forest, steppe, near-water, wasteland) across various parts of the region. A total of 126 species from four families (approximately 18% of the fauna of the Republic of Mordovia) were recorded. These included 84 species of Curculionidae (22.9% of species), 42 species of Chrysomelidae (22.9%), 3 species of Brentidae, and 1 species of Anthribidae. Fourteen species are presented for the first time in the regional fauna. The collections are dominated by species whose adults are actively moving on soil or litter, particularly those belonging to the Alticini (Chrysomelidae) (33 species; 38.4% of the fauna composition) and the subfamily Entiminae (Curculionidae) (32 species; 45.1%). The collections represent a wide range of landscape-biotopic groups (meadow, ruderal, forest, near-water, and steppe species). Extensive materials obtained in pine forests and their pyrogenic successions in the Mordovia State Nature Reserve were also analyzed. The maximum species richness (30 species) was observed on fresh pyrogenic wastelands (1–2 years after fires). This is due to the association of many species of leafhoppers and weevils with habitats with sparse ruderal vegetation and coenophobic plants. A minimum of 10 species was observed on plots of old burned areas (13 years) where the primary vegetation is degraded and a full-fledged pine forest complex has not yet formed. The maximum abundance of two ecologically plastic species (*Strophosoma capitatum* and *Hylobius abietis*) associated with young undergrowth of pine and deciduous trees was recorded in this area.

Keyword: pitfall traps, species composition, abundance, trap efficiency.

Introduction

Two of the most diverse groups of phytophages in the order Coleoptera are the weevils (Curculionoidea) and the leaf beetles (Chrysomelidae). The most significant biological trait of leaf beetles and weevils is their high degree of trophic specialization to specific taxa and plant organs and tissues (Bieńkowski, 2011; Konstantinov et al., 2009; Dedyukhin, 2016, 2022, 2023; Daccordi et al., 2020; Korotyaev, 2023; Schütte et al., 2023). The principal methods employed to study these insects comprise a combination of entomological net mowing in a wide range of biotopes and targeted collections from forage plants (Bieńkowski, 2011; Dedyukhin, 2011). In addition to the aforementioned methods, other methods have been employed (Pérez et al., 2021; Egorov et al., 2022; Ruchin et al., 2023). The use of different variants of pitfall traps is the most common method of studying actively moving herpetobiont insects, with a particular focus on the Carabidae and Formicidae, as well as soil Aranei (Curtis, 1980; Woodcock, 2005). In the study of weevils and leaf beetles, this method is either not employed or is utilized as an additional method. In its most basic form, it is typically employed to account for pests at all stages of their life cycle, whether in soil or roots (Raffa, Hunt, 1988; Hurej et al., 2013).

In a comprehensive study of arthropods using pitfall traps, these groups are typically enumerated only quantitatively, without determining the species composition. Their proportion in collections typically ranges from 2 to 5%, although in some biocenoses it can occasionally reach 30–40% of all hard-winged species (Khabibullin, 2010; Kozminykh, 2013, 2014). For instance, in pitfall trap collections within the natural complex "Ergach" (Russia), the total proportion of Curculionidae was 4%, while the proportion of Chrysomelidae was 3%. Conversely, on calcareous slopes, the proportion of weevils from the total number of beetle specimens was 41% (Kozminykh, 2014). A paucity of publications exists that analyze the species composition of phytophagous beetles caught in pitfall traps (Nazarenko, Kobzar, 2013). In the aforementioned publication (Nazarenko, Kobzar, 2013), a total of 74 specimens belonging to 14 species of weevils were counted on stationary plots over a two-year period (2012–2013). Concurrently, a meticulous and systematic approach, encompassing a vast array of landscapes and biotopes within a specific region, can prove to be an efficient method. This phenomenon is attributable to the regular or episodic movement of numerous species of leaf beetles and, in particular, weevils through the soil. This is due to several factors, including egg-laying in roots and soil, the emergence of adults from pupae developing in the soil or on plant roots, and the search for shelters in unfavourable weather and seasonal conditions. This method is particularly efficient for enumerating non-flying species that are cryptic and remain on plants for a brief duration, often in the absence of light. Such species are inadequately accounted for by entomological net mowing and are often considered rare. The objective of this research was to assess the efficiency of the pitfall trap method for regional faunistic research (Republic of Mordovia in Central Russia), including an inventory of fauna in protected areas.

Materials and methods

Samples were collected in 2022–2023 in the Republic of Mordovia (Central Russia). Mordovia is situated in the center of the Russian Plain, between 42°11' and 46°45' E and 53°38' and 55°11'. The majority of the territory is situated in the northwestern portion of the Volga Upland, which, in the west of the republic, transitions into the Ox-Don Lowland. Zonally, it is situated in the transitional zone between the natural zones of coniferous-broadleaved forests and forest steppe (Yamashkin, 1998). The samples were collected using pitfall traps. For this purpose, 0.5-litre plastic cups were filled to a depth of 0.25 m with 4% formalin. The pitfall traps were installed in a line of 10 pieces, with the distance between traps varying from 1.5 to 3 meters. Such lines were established in a variety of forest types, including those found in forest belts, along the banks of water bodies, and on steppe areas.

A series of mass collections were conducted on the territory of the Mordovia State Nature Reserve (MSNR), specifically in pine forests and post-fire restoration successions on eight model plots. These plots reflected four successional stages of forest ecosystems: pyrogenic wastelands, in place of 2021 fires; edges of 2021 burned areas near forested areas; young forest overgrowth of old 2010 burned areas; and old-growth forests (complex grass pine forests) and their edges not affected by fires. Stationary collections of specimens were conducted in the National Park "Smolny" (NPS) and the MSNR. A total of 1611 specimens from 89 samples were collected in the MSNR, while 906 specimens from 59 samples were collected in the NPS. Furthermore, collections were made on seven additional plots outside the protected areas within a single season or less. The total volume of collected material was 2,748 specimens in 33,200 trap-days. The species were identified through the use of published works, including Dieckmann (1972, 1980, 1983), Warchałowski (2003), Bieńkowski (2004), Isaev (2007), and Zabaluev (2024). The composition and extent of families, as well as species nomenclature and general range data were adopted from the following publications: Löbl & Smetana (2010) and Alonso-Zarazaga et al. (2024).

Results and discussion

A total of 126 species from four families of phytophagous beetles (17.3% of the known species composition of leaf beetles and weevils in the fauna of the region) were recorded by pitfall traps over two years (Tables 1 and 2). The high degree of novelty of the data obtained is noteworthy. Fourteen species are registered for the first time in the fauna of the region, and nine species are indicated for the MSNR fauna for the first time.

Table 1. Taxonomic and species composition of the Chrysomelidae and Curculionoidea collected by pitfall traps on the territory of the Republic of Mordovia (in comparison with the taxonomic structure of the fauna of the region)

Taxa	Pitfall traps	Fauna of the region	Proportion of collected species in the fauna of the region
Zeugophoridae	–	3	0
Orsodacnidae	–	2	0
Chrysomelidae	42	282	15.4
Donaciinae	–	19	0
Criocerinae	–	10	0
Cryptocephalinae (tribe Clytrini)	1	12	8.3
Cryptocephalinae (tribe Cryptocephalini)	–	44	0
Eumolpinae	–	4	0
Chrysomelinae	4	52	7.7
Galerucinae	36	105	34.6
Galerucinae (without a tribe Alticini)	3	18	16.7
Galerucinae (tribe Alticini)	33	87	38.4
Hispinae	–	1	0
Cassidinae	–	23	0
Bruchinae	–	7	0
Nemonychidae	–	2	0
Anthribidae	1	8	12.5
Attelabidae	–	16	0
Brentidae	3	83	3.6
Curculionidae	79	344	22.9
Dryophthorinae	–	2	0
Erirhininae	4	9	44.4
Molytinae	7	22	31.8
Cryptorhynchinae	–	1	0
Cossoninae	1	3	33.3
Lixinae	6	26	23.1
Cleonini	4	7	57.1
Lixini	2	19	10.5
Conoderinae	14	90	15.6
Conoderinae (without a tribe Ceutorhynchini)	1	7	14.3
Conoderinae (tribe Ceutorhynchini)	13	81	16.0
Orobitidinae	1	1	0
Curculioninae	7	97	7.2
Bagoinae	2	8	25.0
Hyperinae	6	13	46.2
Cyclominae	–	1	0
Entiminae	32	71	45.1
Total	**126**	**734**	**17.2**

Table 2. Species composition and number of specimens of the families Chrysomelidae and Curculionoidea collected in pitfall traps on the territory of the Republic of Mordovia during the period 2022-2023.

Taxon	Mordovia State Nature Reserve	National park Smolny"	Other collecting grounds	Total
Chrysomelidae				
Clytra quadripunctata (Linnaeus, 1758)		1		1
Chrysolina sanguinolenta (Linnaeus, 1758)	1			1
Chrysolina limbata russiella Bienkowski et Orlova-Bienkowskaja, 2011	2			2
Chrysolina pseudolurida (Roubal, 1917)**			1	1
Chrysolina sturmi (Westhoff, 1882)		1	3	4
Gonioctena quinquepunctata (Fabricius, 1787)		2		2
Galeruca tanaceti (Linnaeus, 1758)	19	7	58	84
Galerucella lineola (Fabricius, 1781)		1	2	3
Phyllobrotica quadrimaculata (Linnaeus, 1758)		2		2
Derocrepis rufipes (Linnaeus, 1758)		1		1
Crepidodera nitidula (Linnaeus, 1758)		1		1
Mantura chrysanthemi (Koch, 1803)	15			15
Altica engstroemi J. Sahlberg, 1893			1	1
Altica oleracea (Linnaeus, 1758)	33	1		34
Altica aenescens (Weise, 1888)**	7	2		9
Lythraria salicariae (Paykull, 1800)		6		6
Phyllotreta undulata Kutschera, 1860			1	1
Phyllotreta vittula (L. Redtenbacher, 1849)		4	8	12
Phyllotreta ochripes (Curtis, 1837)		1		1
Phyllotreta cruciferae (Goeze, 1777)*,**		6		6
Phyllotreta atra (Fabricius, 1775)	1			1
Aphthona lutescens (Gyllenhal, 1813)		3		3
Aphthona pallida (Bach, 1856)		2		2
Aphthona abdominalis (Duftschmid, 1825)**		1		1
Aphthona pygmaea Kutschera, 1861**			1	1
Aphthona euphorbiae (Schrank, 1781)**		7	1	8
Longitarsus echii (Koch, 1803)*	1			1
Longitarsus tabidus (Fabricius, 1775)	3			3
Longitarsus exsoletus (Linnaeus, 1758)		7		7
Longitarsus luridus (Scopoli, 1763)*	9	1		10

Longitarsus holsaticus (Linnaeus, 1758)		3		3
Longitarsus melanocephalus (De Geer, 1775)		1		1
Longitarsus rubiginosus (Foudras, 1860)**		3	1	4
Longitarsus lycopi (Foudras,1860)**		1		1
Chaetocnema concinna (Marsham, 1802)		94		94
Chaetocnema obesa (Boieldieu, 1859)**		2		2
Chaetocnema hortensis (Geoffroy, 1785)		2		2
Chaetocnema aridula (Gyllenhal, 1827)		1		1
Chaetocnema mannerheimii (Gyllenhal, 1827)		29		29
Psylliodes brisouti Bedel, 1898**		1		1
Psylliodes chalcomerus (Illiger, 1807)		1		1
Psylliodes dulcamarae (Koch, 1803)		1		1
Anthribidae				
Dissoleucas niveirostris (Fabricius, 1798)			1	1
Brentidae				
Protapion fulvipes (Geoffroy, 1785)		1		1
Protapion apricans (Herbst, 1797)		1		1
Apion haematodes Kirby, 1808		1		1
Curculionidae				
Sphenophorus striatopunctatus (Goeze, 1777)	3			3
Notaris acridulus (Linnaeus, 1758)		6		6
Thryogenes festucae (Herbst, 1795)			1	1
Grypus equiseti (Fabricius, 1775)	5	2		7
Hylobius abietis (Linnaeus, 1758)	321	118		439
Hylobius pinastri (Gyllenhal, 1813)	15			15
Hylobius transversovittatus (Goeze, 1777)			1	1
Pissodes castaneus (De Geer, 1775)	1			1
Magdalis duplicata Germar, 1819	1			1
Trachodes hispidus (Linnaeus 1758)		1		1
Acalles echinatus (Germar, 1823)			2	2
Rhyncolus ater (Linnaeus, 1758)	3	1		4
Stephanocleonus microgrammus (Gyllenhal, 1834)			1	1
Cleonis pigra (Scopoli, 1763)	5	1		6
Coniocleonus turbatus (Fåhraeus, 1842) (= *C. hollbergi* auct.)	38			38
Bothynoderes affinis (Schrank, 1781)	6			6
Lixus albomarginatus Boheman, 1843**	1			1
Lixus subtilis Boheman, 1835*,**	1			1
Limnobaris dolorosa (Goeze, 1777)		1	1	2
Pelenomus waltoni (Boheman, 1843)		1		1
Pelenomus quadrituberculatus (Fabricius, 1787)		1		1

Rhinoncus pericarpius (Linnaeus, 1758)	11	10		21
Rhinoncus leucostigma (Marsham, 1802)		3		3
Rhinoncus inconspectus (Herbst, 1795)		1		1
Tapinotus sellatus (Fabricius, 1794)		1		1
Ceutorhynchus obstrictus Marsham, 1802**			1	1
Ceutorhynchus erysimi (Fabricius, 1787)		1		1
Calosirus apicalis (Gyllenhal, 1827)		1		1
Glocianus distinctus (C.N.F. Brisout de Barneville, 1870)	3			3
Nedyus quadrimaculatus (Linnaeus, 1758)		5		5
Thamiocolus viduatus (Gyllenhal, 1813)		1		1
Phrydiuchus topiarius (Germar, 1823)**		1		1
Orobitis cyanea (Linnaeus, 1758)				1
Anthonomus phyllocola (Herbst, 1795)	2			2
Curculio nucum Linnaeus, 1758			2	2
Curculio venosus (Gravenhorst, 1807)	1			1
Curculio rubidus (Gyllenhal, 1836)			2	2
Tychius stephensi Schoenherr, 1835		2		2
Sibinia viscariae (Linnaeus, 1760)			1	1
Orchestes rusci (Herbst, 1795)		1		1
Bagous binodulus (Herbst, 1795)		1		1
Bagous lutulentus (Gyllenhal, 1813)**		1		1
Hypera conmaculata (Herbst, 1795)		1	4	5
Hypera arator (Linnaeus, 1758)	9		1	10
Hypera meles (Fabricius, 1792)	1			1
Hypera miles (Paykull, 1792)		1		1
Hypera nigrirostris (Fabricius, 1775)		1		1
Hypera transsilvanica (Petri, 1901)	1		2	3
Otiorhynchus raucus (Fabricius, 1777)		17	24	41
Otiorhynchus ovatus (Linnaeus, 1758)	235	99	51	385
Otiorhynchus tristis (Scopoli, 1763)	5	3		8
Otiorhynchus ligustici (Linnaeus, 1758)	25	11	5	41
Otiorhynchus fullo (Schrank, 1781)		6		6
Centricnemus leucogrammus (Germar, 1823)**			1	1
Attactagenus albinus (Boheman, 1833)	3			3
Romualdius scaber (Linnaeus, 1758)			1	1
Cathormiocerus aristatus (Gyllenhal, 1827)		2	1	3
Phyllobius brevis Gyllenhal, 1834			2	2
Phyllobius pyri (Linnaeus, 1758)	3			3
Phyllobius pomaceus Gyllenhal, 1834		1	1	2
Phyllobius maculicornis Germar, 1823			1	1

Phyllobius argentatus (Linnaeus, 1758)		31	5	36
Polydrusus flavipes (De Geer, 1775)		2		2
Polydrusus pilosus Gredler, 1866		2		2
Polydrusus cervinus (Linnaeus, 1758)		1		1
Polydrusus confluens Stephens, 1831	5			5
Polydrusus tereticollis (De Geer, 1775)		2	1	3
Polydrusus mollis (Strøm, 1768)		1		1
Sciaphilus asperatus (Bonsdorff, 1785)		8	12	20
Brachysomus echinatus (Bonsdorff, 1785)		133	6	139
Strophosoma capitatum (De Geer, 1775)	754	219	6	979
Brachyderes incanus (Linnaeus, 1758)	31			31
Tanymecus palliatus (Fabricius, 1787)		1	6	7
Sitona hispidulus (Fabricius, 1777)	7		2	9
Sitona macularius (Marsham, 1802)	2		1	3
Sitona languidus Gyllenhal, 1834	1			1
Sitona striatellus Gyllenhal, 1834	15			15
Sitona inops Schoenherr, 1832	2	3	2	7
Sitona sulcifrons (Thunberg, 1798)	2		3	5
Sitona lineatus (Linnaeus, 1758)	1	1	3	5
Total species	**44**	**79**	**32**	**126**
Total specimens	**1611**	**906**	**231**	**2748**

Notes: * – a species is first recorded in the MSNR, ** – a species is first listed on the territory of the Republic of Mordovia.

A number of species that are difficult to account for by entomological net mowing are also present (often in significant numbers) in samples from pitfall traps. These include *Acalles echinatus* (Linnaeus 1758), *Trachodes hispidus* (Germar, 1823), *Coniocleonus turbatus* (Fåhraeus, 1842), *Stephanocleonus microgrammus* (Gyllenhal, 1834), *Phrydiuchus topiarius* (Germar, 1823), *Otiorhynchus raucus* (Fabricius, 1777), and *Brachyderes incanus* (Linnaeus, 1758). In terms of species richness and abundance, the Curculionidae family exhibited the greatest diversity, with 84 species and 2,380 specimens. The Chrysomelidae family, in contrast, exhibited a significantly lower diversity, with 42 species and 364 specimens. Considering that 282 species of Chrysomelidae (Bardin and Timraleev, 2007; Bieńkowski, Orlova-Bienkowskaja, 2009; Timraleev et al., 2007) and 345 species of Curculionidae (Lugovaya, 1970, 1972; Dmitrieva, 2005; Timraleev et al., 2007; Egorov, Ruchin, 2010; Egorov et al., 2020) (the ratio of species richness of these families is 1:1.22) are known in the fauna of the region, taking into account our data, then the efficiency of the pitfall trap method is clearly higher in the study of Curculionoidea. The quantitative ratio of these groups in collections is even more disparate

(1:6.54). Other families of Curculionoidea are either absent in collections by pitfall traps (Attelabidae, Nemonychidae) or consist of a single species (Brentidae – 3 species, 3 specimens; Anthribidae – 1 species, 1 specimen).

The distribution of subfamilies that are dominant in collections is indicative. Among the Curculionidae, only the Entiminae (32 species) and the Conoderinae (14 species) are relatively well represented. Of these, the former have soil larvae, and numerous species in the second subfamily develop in the roots and root necks of herbaceous plants (Dieckmann 1972, 1983; Konstantinov et al., 2004; Wacławik et al., 2021). The subfamily Lixinae is relatively small, with only six species. These large flightless weevils of the tribe Cleonini develop in roots and are regularly caught in pitfall traps. A total of four species of the latter were recorded, which is due to the location of the region in the northern forest-steppe zone (only seven species are known in the region) and the majority of material collection plots being in forest habitats. In contrast, the tribe Cleonini is observed to exhibit high species diversity in steppe and desert biocenoses (Ter-Minasyan, 1967, 1988; Karpiński et al., 2023; Korotyaev, 2023). The selective nature of the method is even more evident with respect to the main groups of leaf beetles. The majority of species (36 spesies; 86%) belong to a single subfamily, Galerucinae. The tribe Alticini is the most prevalent within this group, comprising 33 species.

It is notable that species-rich subfamilies of leaf beetles, such as Chrysomelinae (4 species), Cryptocephalinae (1 species), Donaciinae, Eumolpinae, Cassidinae, Bruchinae (species of the last four subfamilies were not recorded), Curculioninae (7 species), Bagoinae (2 species), and Cossoninae (1 species), are relatively scarce or absent in pitfall traps. The overwhelming majority of these organisms are typical inhabitants of plants, not characteristic of the soil tier at the adult stage. However, representatives of the systematically rich subfamily Cryptocephalinae, which are larvae of species that develop in soil, are almost absent in the sample. This phenomenon is likely attributable to the fact that adults of this subfamily lay eggs in larval cases without descending to the ground cover (either by attaching them to plants or dispersing them from plants). In contrast to the majority of species belonging to the tribe Alticini, which are commonly encountered in collections, a significant proportion of these insects lay eggs directly in the soil at the roots of forage plants. Furthermore, numerous species at the adult stage are capable of overwintering in litter, a phenomenon that is not observed in Cryptocephalinae (Medvedev, Roginskaya, 1988; Dubeshko, Medvedev, 1989).

A comparison of pitfall trap collections with the overall fauna composition of the region reveals similar patterns. The proportion of recorded species of leaf beetles (15.4% of the fauna composition) is considerably lower than the proportion of recorded species in the family Curculionidae (22.9%). At the subfamily level, this method is most effective for inventorying the fauna of the subfamily Galerucinae (34.6%), with particular efficiency in the tribe Alticini (38.4%). Among weevils, this method is effective for the tribe Cleonini (57.1%), the subfamilies Hyperinae (46.2%) and Entiminae (45.1%). Adults of all the aforementioned groups are known to move actively on the soil surface. It is noteworthy that only local Hyperinae species develop on above-ground parts of plants (Dieckmann, 1980, 1983). The proportion of the tribe Ceutorhynchini represented in pitfall trap collections is relatively low (15.9%), with only two species (10.5%) belonging to the tribe Lixini.

The analysis of the mass (greater than 10%) and common (greater than 1%) species in the collections is also indicative. The former category includes a mere three species of weevils: the most prevalent forest species, *Strophosoma capitatum* (De Geer, 1775) (979 specimens; 35.6% of the total number of phytophagous beetles collected), *Hylobius abietis* (Linnaeus, 1758) (439 specimens; 16.0%), and the eurybiont *Otiorhynchus ovatus* (Linnaeus, 1758) (385 specimens; 15.7%). It is noteworthy that all these are non-flying forms actively moving on the soil surface (Dieckmann, 1980, 1983; Izhevsky et al., 2005; Dedyukhin, 2012). A total of ten species are commonly found in the collections. Two species of leaf beetles are near-water inhabitants: *Chaetocnema concinna* (Marsham, 1802) (94 specimens) and *Ch. mannerheimii* (Gyllenhal, 1827) (29 specimens). Additionally, two species are eurybionts, with 84 specimens of *Galeruca tanaceti* (Linnaeus, 1758) and 34 specimens of *Altica oleracea* (Linnaeus, 1758). Six weevil species are also commonly encountered, including *Brachysomus echinatus* (Bonsdorff, 1785) (125 specimens), *Otiorhynchus raucus* (Fabricius, 1777), *O. ligustici* (Linnaeus, 1758) (41 specimens each), *Phyllobius argentatus* (Linnaeus, 1758) (36 specimens), *Coniocleonus turbatus* (Fåhraeus, 1842) (38 specimens), and *Brachyderes incanus* (Linnaeus, 1758) (31 specimens). All of these species develop in soil or on plant roots. Some of them reach high abundance only in certain biotopes, while others are eurybiont (Dieckmann, 1980, 1983). Consequently, numerous species, including *Coniocleonus turbatus* (Fåhraeus, 1842) and *Brachyderes incanus* (Linnaeus, 1758), are characteristic of pine forest edges on sand, as evidenced by specimens in the collections on the territory of the MSNR.

The ratio of ecological groups among phytophagous beetle species is indicative. A mere 18 species (14.4%) of the total number of species spend the majority of their life cycle on plants. Furthermore, all of these species are either scarce or sporadic in collections. In contrast, 77 species (61.1%) have soil or root larvae. A further 35 species from the genera *Galeruca*, Chrysolina, *Chaetocnema*, *Psylliodes*, *Pelenomus*, *Rhinoncus*, *Ceutorhynchus*, and *Hypera* develop on above-ground plant parts and overwinter in soil at the adult stage. In addition, beetles actively move along the soil surface. Based on the relationship between adults and plant life forms, 29 species counted by pitfall traps are dendrobionts (22.8%), the rest are chortobionts (92 species; 72.4%) or litter forms (5 species; 3.9%). It is notable that in the fauna of phytophagous beetles of the Republic of Mordovia, the proportion of dendrobionts is significantly higher – 27.2%.

The distribution of species collected in pitfall traps was as follows, according to landscape-biotopic preference: inhabitants of open mesophytic biotopes (meadow and ruderal) (57 species), characteristic forest or forest edge species (33), representatives of the near-water complex inhabiting the vegetation of the banks of water bodies and marshes (16), predominantly steppe species (14), eurybionts characteristic of both open and forest ecosystems (5). The use of pitfall traps along the banks of water bodies and marshes allowed to take into account a number of near-water hygrophilous species, including *Phyllobrotica quadrimaculata* (Linnaeus, 1758), *Longitarsus holsaticus* (Linnaeus, 1758), *Chaetocnema mannerheimii* (Gyllenhal, 1827), *Sphenophorus striatopunctatus* (Goeze, 1777), *Notaris acridulus* (Linnaeus, 1758), *Grypus equiseti* (Fabricius, 1775), *Hylobius transversovittatus* (Goeze, 1777), *Bagous lutulentus* (Gyllenhal, 1813), and *Bagous binodulus* (Herbst, 1795). The typical steppe species such as *Chrysolina pseudolurida* (Roubal, 1917), *Psylliodes brisouti Bedel*, 1898, *Ceutorhynchus obstrictus* Marsham, 1802, *Stephanocleonus microgrammus* (Gyllenhal, 1834), *Phrydiuchus topiarius* (Germar, 1823) were discovered on steppe plots. Another species of the steppe complex were recorded on well-warmed sandy wastelands formed as a result of recent forest fires. The following species were recorded: *Chrysolina limbata russiella* Bienkowski, Orlova-Bienkowskaja, 2011, *Longitarsus echii* (Koch, 1803), *Atractagenus albinus* (Boheman, 1833), *Lixus albomarginatus* Boheman, 1843, and *L. subtilis* Boheman, 1835.

In addition to the use of traps to enumerate fauna, this method appears to be a promising approach for stationary ecological studies of phytophagous beetles, including the investigation of pyrogenic succession in forest ecosystems. Similar studies were conducted throughout the 2023 growing season in the MSNR, located at the southern edge of the forested natural area, where 89.3% of the area is forested communities (Ruchin, 2024). A total of 45 species (10 species of Chrysomelidae and 35 species of Curculionidae) were recorded during these studies (Table 3). Of these, only 11 can be categorized as forest forms. Firstly, this is a group of species associated with *Pinus silvestris* L. (*Hylobius abietis*, *H. pinastri*, *Pissodes castaneus*, *Magdalis duplicata*, *Anthonomus phyllocola*), as well as hardwood undergrowth (*Strophosoma capitatum*, three species of the genus *Phyllobius*). A further nine species are characteristic of natural psammophytic meadows and the edges of pine forests. These are *Mantura chrysanthemi* (Koch, 1803), *Coniocleonus turbatus* (Fåhraeus, 1842) (both species develop on *Rumex acetosella* L.), *Attactagenus albinus* (Boheman, 1833), *Polydrusus confluens* Stephens, 1831, *Sitona striatellus* Gyllenhal, 1834 (all three species live mainly on *Chamaecytisus ruthenicus* (Fisch. ex

Woloszcz.) Klásk.), *Brachyderes incanus* (Linnaeus, 1758) (on young pines). The majority of species are characteristic of disturbed open habitats with sparse cover (ruderal species complex), comprising 24 species.

Table 3. Species composition and number of phytophagous beetle specimens collected in pitfall traps in 2023 in pine forests and pyrogenic succession plots in the Mordovia State Nature Reserve

Taxon	Burned areas 2021	Fringes of burned areas 2021	Overgrown burned areas 2010	Unburned forests and edges	Total
Chrysomelidae					
Chrysolina sanguinolenta (Linnaeus, 1758)	1				1
Chrysolina limbata russiella Bienkowski et Orlova-Bienkowskaja, 2011	2				2
Galeruca tanaceti (Linnaeus, 1758)	8	10		1	19
Mantura chrysanthemi (Koch, 1803)	13	1		1	15
Altica oleracea (Linnaeus, 1758)	1	3	8	21	33
Altica aenescens (Weise, 1888)	4		1	2	7
Phyllotreta atra (Fabricius, 1775)	1				1
Longitarsus echii (Koch, 1803)		1			1
Longitarsus tabidus (Fabricius, 1775)	2			1	3
Longitarsus luridus (Scopoli, 1763)	8	1			9
Curculionidae					
Sphenophorus striatopunctatus (Goeze, 1777)	1			2	3
Grypus equiseti (Fabricius, 1775)		1	2	2	5
Hylobius abietis (Linnaeus, 1758)	1	119	199	2	321
Hylobius pinastri (Gyllenhal, 1813)		8	7		15
Pissodes castaneus (De Geer, 1775)		1			1
Magdalis duplicata Germar, 1819	1				1
Rhyncolus ater (Linnaeus, 1758)	1		2		3
Cleonis pigra (Scopoli, 1763)			1	4	5
Coniocleonus turbatus (Fåhraeus, 1842)	17	1		20	38
Bothynoderes affinis (Schrank, 1781)	5			1	6
Lixus albomarginatus Boheman, 1843	1				1
Lixus subtilis Boheman, 1835		1			1
Rhinoncus pericarpius (Linnaeus, 1758)	4	4		3	11
Glocianus distinctus (C.N.F. Brisout de Barneville, 1870)	2	1			3
Anthonomus phyllocola (Herbst, 1795)		2			2
Orobitis cyanea (Linnaeus, 1758)					
Curculio venosus (Gravenhorst, 1807)				1	1
Hypera arator (Linnaeus, 1758)	6			3	9
Hypera meles (Fabricius, 1792)				1	1
Hypera transsilvanica (Petri, 1901)				1	1
Otiorhynchus ovatus (Linnaeus, 1758)	159	45	2	29	235

Otiorhynchus tristis (Scopoli, 1763)	2	3			5
Otiorhynchus ligustici (Linnaeus, 1758)	20	3	2		25
Attactagenus albinus (Boheman, 1833)	1	1		1	3
Phyllobius pyri (Linnaeus, 1758)	3				3
Polydrusus confluens Stephens, 1831		1		4	5
Strophosoma capitatum (De Geer, 1775)	53	256	355	90	754
Brachyderes incanus (Linnaeus, 1758)	10	17		4	31
Sitona hispidulus (Fabricius, 1777)	5			2	7
Sitona macularius (Marsham, 1802)	1			1	2
Sitona languidus Gyllenhal, 1834	1				1
Sitona striatellus Gyllenhal, 1834	8	7			15
Sitona inops Schoenherr, 1832		1		1	2
Sitona sulcifrons (Thunberg, 1798)		1		1	2
Sitona lineatus (Linnaeus, 1758)	1			1	
Total species	**30**	**26**	**10**	**25**	**45**
Total specimens	**342**	**492**	**579**	**199**	**1611**

The ratio of species richness of phytophagous beetles on pyrogenic succession plots is worthy of further investigation. As Table 4 illustrates, the greatest number of species (30) was observed in burned areas that had burned completely 1.5 years prior to the collection of material. The species richness was slightly lower along the edges of 2021 burned areas (26 species) and in fire-intact forest areas (25 species). The lowest level of species richness (10 species) was observed in the 2010 young forest overgrowth burned areas.

Table 4. Ratio of ecological groups of phytophagous beetles collected in pitfall traps in 2023 in pine forests and pyrogenic succession plots in the Mordovia State Nature Reserve

Ecological group	Burned areas 2021	Fringes of burned areas 2021	Overgrown burned areas 2010	Unburned forests and edges	Total
Forest	5	5	5	4	11
Meadow and edge	8	8	-	6	10
Ruderal and eurybiont	17	11	4	15	24
Total species	30	26	9	25	45
Total specimens	342	491	579	199	1611

The following is our proposed explanation for the observed results. As previously observed by various authors (Konstantinov et al., 2009; Bieńkowski, 2011; Dedyukhin, 2016), leaf beetles and weevils exhibit a high level of species richness in disturbed habitats, which is attributed to the relationships of numerous species in these groups with coenophobic plants. It is these species that serve as the foundation for the communities that emerge on pyrogenic wastelands during the initial phase of recovery. A number of species characteristic of pioneer stages of succession in steppe landscapes, including *Longitarsus echii* (Koch, 1803), *Lixus subtilis* Boheman, 1835, and *Lixus albomarginatus* Boheman, 1843, are also found on litter-free and well-warmed areas.

It is noteworthy that the number of forest species observed in areas that have not been affected by fires is relatively limited (only four species), yet the complex of forest edge forms is represented to a considerable extent (seven species). The chortophilous species of open biotopes are the most prevalent (12 species). This phenomenon is likely attributable to the generally lightened character of pine forests with a developed herbaceous understory, as well as the location of one of the two lines near the forest edge. The number of species observed in old, overgrown burned areas was unexpectedly low. However, this is a phenomenon that is quite natural. Over more than ten years, the consolidation of sand and the displacement of coenophobic plants by grasses (principally *Calamagrostis epigeios* (L.) Roth) from herbaceous areas have been observed on such plots. It can be observed that these areas lack the requisite conditions for open biocenosis species at the primary stages of succession, as well as for the majority of forest and forest edge forms. The maximum abundance of two ecologically plastic species, *Strophosoma capitatum* (De Geer, 1775) and *Hylobius abietis* (Linnaeus, 1758), is observed here (Table 3). The first species of adult is found in young deciduous undergrowth, primarily birch. The second species of adult is known to damage young pine shoots. A change in the structure of phytophagous beetle communities is observed during pyrogenic succession, both in terms of qualitative and quantitative aspects.

Conclusion

The results of the conducted studies have demonstrated that the systematic use of pitfall traps is an effective method for the research of Chrysomelidae and Curculionidae. A total of 126 species from four families (representing approximately 18% of the regional fauna) were documented over two years. This method proved highly effective in recording the species composition of weevil beetles (Curculionidae) (84 species; 22.9% of the fauna). However, the proportion of recorded species of leaf beetles (Chrysomelidae) (relative to the composition of the regional fauna of this family) was notably lower (42 species; 22.9%). Furthermore, single species were recorded in the families Brentidae and Anthribidae. A comparison of the known composition of the fauna of these groups in the Republic of Mordovia has demonstrated that this method has a high degree of selectivity. While it does not reflect the actual ratio of species in communities, it allows for the supplementation of faunistic lists with new findings and the generation of formalized quantitative data that can be correctly utilized in comparative analysis. This method is most effective for the enumeration of species whose adult forms actively move through the soil, both in search of shelter and for the purposes of reproduction. Furthermore, pitfall trap collections enabled us to elucidate the composition and participation in communities of species that were inadequately accounted for by traditional methods and, as a consequence, often unjustifiably considered rare. A research conducted in the MSNR revealed that the maximum species richness of phytophagous beetles (30 species) was observed in the most transformed biotopes following recent fires, characterised by sparse pioneer vegetation. In contrast, the minimum number of species (10) was observed on plots of old burned areas (13 years), where pioneer vegetation had been degraded and a full-fledged complex of pine forests and their psammophytic edges had not yet formed. In general, the method of pitfall traps, while not replacing traditional approaches and methods of studying phytophagous beetles, can be recommended as an additional method that increases the efficiency of ecological and faunistic studies of plant-eating hardwings, especially the family Curculionidae.

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