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RED DATA BOOK INVERTEBRATES IN A PROTECTED AREA OF EUROPEAN RUSSIA

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Protected Areas are considered as primary efforts for biodiversity conservation worldwide. However, there is a lack of data on the biodiversity and threats for most of the federal-level Russian Protected Areas, especially for invertebrates. Intensive research on invertebrate diversity in Protected Areas is highly important to obtain comprehensive knowledge for the management of natural refugia of biodiversity. In the present paper, we studied the most vulnerable component of invertebrate diversity, i.e. the Red Data Book species, in the Mordovia State Nature Reserve (European Russia). We used both new (2007–2018) and literature (1936–2006) data to obtain information on habitat preferences, year of the first record, and spatial distribution in the Protected Area for 121 invertebrate Red Data Book species known from the Mordovia State Nature Reserve. Our study demonstrated a remarkable increase in the Red Data Book invertebrate diversity as a consequence of the research intensification in the Protected Area in the last ten years. This is also related to the fact that only 1–2 records are known for a large number of species (57.9%) within the Protected Area. The highest species richness was found close to the research stations (cordons). On one hand, this highlights their significance for biodiversity research. On the other hand, it outlines the need for performing more research in less-studied areas of the Mordovia State Nature Reserve. Finally, the species currently known for Mordovia and Russia only from this Protected Area (27 and four species, respectively) highlight the importance of the Mordovia State Nature Reserve at regional and national levels.

Key words: biodiversity, habitat preference, Mordovia State Nature Reserve, nature conservation, representativeness index

INTRODUCTION

Human impacts on nature have led to an accelerated biodiversity loss, with harmful consequences to many ecosystem processes and functions (Thuiller 2007, Butchart *et al.* 2010, Dirzo *et al.* 2014). This has lead to an increase in the number of studies on biodiversity as well as in the efforts for its conservation. A consequence of these efforts is the declaration of Protected Areas in many regions of the world (Halffter 2005, Zografou *et al.* 2014). These areas spearhead the global conservation effort (Watson *et al.* 2014). Currently, the global Protected Area Network covers about 15% of the world's terrestrial land surface (Belle *et al.* 2018). However, the designation of these protected

areas rarely considers invertebrates. For the vast majority of protected areas, only studies focusing on conspicuous groups of vertebrates and plants are available (Carignan & Villard 2002, Rodrigues *et al.* 2004, Young *et al.* 2014). The invertebrate biodiversity in Protected Areas remains largely unexplored, although these animals are key elements in the functioning of all terrestrial ecosystems. Samways (2005) and Cardoso *et al.* (2011) indicated that insects are almost four-fifths of the total of terrestrial species. However, estimations of the invertebrate diversity (e.g., Ramos *et al.* 2001) are rare due to the limited taxonomic and distribution knowledge about different taxonomic groups (Martin-López *et al.* 2007). This causes a need to investigate the effectiveness of Protected Area Networks to protect the invertebrate diversity in different regions of the world. It especially concerns biodiversity coldspots (i.e., areas with low diversity, such as the Russian Federation) of the world because the main attention of researchers is often riveted on hotspots (Kareiva & Marvier 2003).

Red Lists play an important role in generating public and policy support for species conservation (Rodrigues *et al.* 2006). Listing species according to their relative risk of extinction and comparing regularly updated Red Lists is a powerful tool in assessing the efficacy of species conservation policies (Stork *et al.* 1996, Mace *et al.* 2008). In the case of insects, and invertebrates in general, however, it has been noted that Red Lists principally reflect the state of knowledge rather than the actual status of a species' extinction risk (Cardoso *et al.* 2012).

In this study, we aimed to assess the current state of the Red Data Book insect diversity in a Protected Area in European Russia (Republic of Mordovia), the Mordovia State Nature Reserve. The Mordovia State Nature Reserve was established as a Protected Area in 1936. In this Protected Area, there was a lack of systematic investigations of the invertebrate diversity before 2007. During 2007–2018, more than 5,000 invertebrate species have first been discovered for the Nature Reserve in the framework of an intensive investigation of the Protected Area's entomological diversity (Ruchin *et al.* 2013, Makarkin & Ruchin 2014, Ruchin & Artaev 2016, Mandelshtam & Egorov 2017, Ruchin & Makarkin 2017, Ruchin & Mikhailenko 2018). Of these, 2,600 invertebrate species were firstly found for the whole Republic of Mordovia (Makarkin & Ruchin 2010, Bezina 2014, Bolshakov *et al.* 2014, Budaeva & Ruchin 2014, Semenov 2016, Ruchin & Egorov 2017*b*, Bolshakov *et al.* 2018, Chursina & Ruchin 2018*a*), including five species newly found for the Russian Federation (Mokrousov *et al.* 2013, Tomaszewska *et al.* 2018, Zemogladchuk *et al.* 2019). Results of the intensive entomological studies allowed a significant extension of the geographical ranges of some invertebrate species (Legalov *et al.* 2014, Ruchin & Artaev 2016, Anufriev 2017, Bolshakov *et al.*

2017, Egorov & Shapovalov 2017, Ruchin & Egorov 2018*b*,*d*,*e*). Concerning the Red Data Book invertebrate species, after the publication of the Red Data Book of the Republic of Mordovia (Astradamov 2005), 164 invertebrate species were recommended to be included in its second edition (Makarkin & Ruchin 2015, Mikhailenko & Ruchin 2015, Ruchin & Egorov 2015, 2017*b*, Ruchin & Nikolaeva 2015, Stoyko & Komarova 2015, Bolshakov & Ruchin 2016), while 35 invertebrate species were suggested to be excluded from the main list of the Red Data Book of the Republic of Mordovia (Egorov & Ruchin 2009, Ruchin & Nikolaeva 2015, Bolshakov & Ruchin 2016, Ruchin & Egorov 2017*b*). The first stages of systematic conservation planning should always include data collection on the location of threatened and regionally rare species in a region or its part (Margules & Pressey 2000).

The aim of this study was to analyse the current state of the diversity of the Red Data Book invertebrates of the Mordovia State Nature Reserve on the eve of the forthcoming second edition of the Red Data Book of the Republic of Mordovia.

MATERIAL AND METHODS

Study area

The Mordovia State Nature Reserve is situated in the northwest part of the Republic of Mordovia, Russian Federation (54.42–54.56 N, 43.04–43.36 E; up to 190 m a.s.l., Fig. 1). The Mordovia Reserve area is 321.62 km^2. Its flora includes 809 species from 99 families (Vargot *et al.* 2016).

Forest communities cover 89.3% of the total Mordovia Reserve area. Pine (*Pinus sylvestris* L.) is the main forest-forming wood species in the reserve. It forms pure or mixed forest communities. Birch (*Betula pendula* Roth) ranks second in areas covered by forests. It forms predominantly secondary communities at logging sites and at burned forest sites. Small-leaved linden (*Tilia cordata* Mill.) forests are present in the northern part of the Mordovia Reserve. Oak (*Quercus robur* L.) forests are distributed in the floodplain of the river Moksha in the western part of the Mordovia Reserve. Spruce (*Picea abies* L.) forests are located predominantly in floodplains of rivers and streams (Pushta, Vyaz-Pushta, Vorsklyay, Arga, etc.) and cover small areas. There are numerous oligotrophic mires dominated by *Sphagnum* or *Sphagnum – Carex* communities. Floodplain meadows are situated mainly in floodplains of the river Satis and the river Moksha in the western and northwestern parts of the Protected Area (Tereshkin & Tereshkina 2006, Vargot *et al.* 2016).

Data collection and analysis

As a target group, we selected invertebrate species included in the Red Data Book of the Republic of Mordovia, which are known from the Mordovia State Nature Reserve. Apart of them, our study considered also invertebrates suggested for inclusion for its second edition (see – Makarkin & Ruchin 2015, Mikhailenko & Ruchin 2015, Ruchin & Ego-

rov 2015, Ruchin & Nikolaeva 2015, Bolshakov & Ruchin 2016). At the same time, four species (*Argyroneta aquatica* (Clerck, 1757), *Dolomedes fimbriatus* (Clerck, 1757), *Bombus lapidarius* (Linnaeus, 1758), *Centrotus cornutus* (Linnaeus, 1758)), included in the Red Data Book of the Republic of Mordovia (Astradamov 2005), were excluded from our analysis because actually these invertebrates are common species in the region (personal data). 2007–2018 data on species diversity were collected predominantly by the first author. Previous data have been extracted from publications concerning the fauna of the Mordovia State Nature Reserve (Plavilshchikov 1964, Feoktistov 2011, Ruchin 2018, Ruchin & Grishutkin 2018). Voucher specimens collected during the study period are stored in the Collection of the Mordovia State Nature Reserve and in personal collections of the authors. Some individuals were released into nature after capture.

We estimated the increase in the number of the Red Data Book invertebrate species in the Mordovia State Nature Reserve using the first record of each species in the Protected Area, and the total number of records per each species known in the Mordovia Reserve. We assigned all known records to quarters of the Protected Area. A quarter is a square forestry unit (ca. 1×1 km) surrounded by clearings from south to north and from west to east. Hence, species distribution among quarters follows a grid system using 1 km^2 cell size.

To reveal patterns of spatial distribution of the Red Data Book invertebrates in the Mordovia State Nature Reserve, we counted the number of the Red Data Book species per quarter. These data have been used to show the biodiversity hotspots and coldspots of Red Data Book invertebrates in the Mordovia State Nature Reserve.

We analysed species confinement to different habitats by using the following habitat calssification: forests (incl. burned coniferous forest, coniferous forest, deciduous forest, mixed forest), edges of forest (incl. edge of coniferous forest, edge of deciduous forest, edge of mixed forest), forest glades (incl. glade of coniferous forest, glade of deciduous forest, glade of mixed forest), floodplain meadows, water bodies (incl. shores), man-made habitats (i.e. roadsides, arable lands, etc.), *Sphagnum* mires.

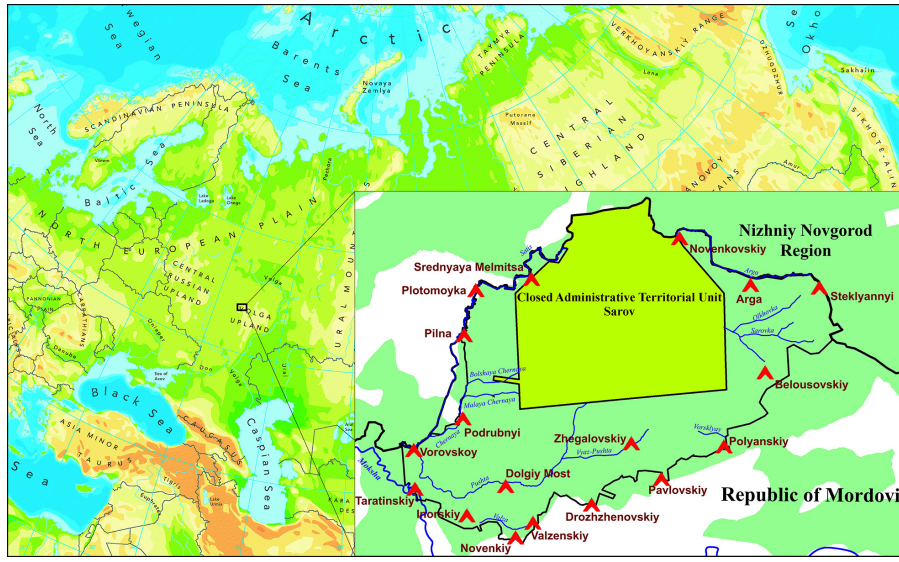

Fig. 1. Geographic location of the Mordovia State Nature Reserve in Europe. Symbols within the Mordovia State Nature Reserve indicate research stations (cordons)

To calculate a Representativeness Index (RI) of each Red Data Book invertebrate in the Mordovia State Nature Reserve, we proposed and used the following formula:

$$R = \frac{N_{PA}}{N_{TOTAL}} \times 100\%$$

where N_{PA} is the number of taxon's locations known within a Protected Area, and N_{TOTAL} is the total number of taxon's locations within a region (in this study, it is the Republic of Mordovia).

Depending on the RI values, we distinguished all Red Data Book invertebrates of the Mordovia State Nature Reserve into the following four groups using quartiles: Q1 having RI values 76–100%, Q2 – 51–75%, Q3 – 26–50%, and Q4 with the RI values from 0.1% to 25%.

To express the conservati on status of the invertebrate species involved in the study, we used the rarity category reported in the Red Data Book of the Republic of Mordovia (Astradamov 2005), as follows:

0 – *Probably extinct species*. Populations of these species have probably disappeared from the territory of the Republic of Mordovia. These species have not been recorded in the wild during the past 50 years, either in points where the species were known to be formerly present or at any other potential locations. Nevertheless, the possibility that some individuals or populations have been overlooked cannot be completely excluded.

1 – *Endangered species*. Species whose populations have reached critically small sizes and/or their habitats have changed in such a way that their survival is unlikely if the impact of threat factors persists.

2 – *Vulnerable species*. Species characterised by steadily declining populations in the region, which can quickly fall into the category of endangered species if impacts of unfavorable factors persist.

3 – *Rare species*. Species of high vulnerability because of their small population size in the region. They are distributed over a limited area or a large scale, but with a very low density.

4 – *Indeterminate species*. Species whose populations could be classified into one of the previous categories, but information about their present state is insufficient to accurately determine their status.

5 – *Recovered or recovering species*. Species whose abundance and distribution area (under the impact of natural factors or human actions aimed to recover species populations) lead to be recovered to a status for which they will not need special measures for protection and restoration.

Contour map has been created using the MapInfo 11.5 software.

RESULTS AND DISCUSSION

As a result of annual entomological investigations in the Mordovia State Nature Reserve and examination of available publications, we obtained data on 121 Red Data Book invertebrates known within the Protected Area (Table 1S). Among them, 12 species (10% of the total number) are recommended to be included in the second edition of the Red Data Book of the Russian Federation (Ilyashenko *et al.* 2018). Notably, there are 14 such species known in the whole Republic of Mordovia. Hence, 12 of 14 (86%) species of the Red Data Book of the Russian Federation (Danilov-Danilyan 2001) are known to be present in the Mordovia State Nature Reserve (the two absent species are *Aphodius bimaculatus* (Laxmann, 1770) and *Omias verruca* Boheman, 1834).

Overall, Red Data Book invertebrate species were represented by 402 locations in the Mordovia State Nature Reserve. Most of them (57.9%) have been represented by only 1–2 records in the Mordovia State Nature Reserve (Fig. 2). The number of species per class of records followed a power function with a negative exponent. Thus most of species are known by 1 or two records, and the number of speceis known for more records decreases rapidly, with remarkably few invertebrate species represented by at least nine records (e.g., *Protaetia fieberi* (Kraatz, 1880) with 18 records, *Xylocopa valga* Gerstaecker, 1872 with 15 records, *Agriades optilete* (Knoch, 1781) with 13 records). This pattern is consistent with those observed for invertebrates (e.g., Pentinsaari *et al.* 2014, Sushko 2017) and vertebrates (Silveira *et al.* 2003, Pacheco & Olmos 2005) from other contexts.

Because of the immense lack of knowledge on the conservation status of invertebrates, any intensification in the study of these animals could lead to a remarkable increase in the number of known species and their presence in Protected Areas with possible description of new taxa (Anufriev 2016, Bouchard *et al.* 2017, Mayhew 2018). Generalised data on the increase in the number of species known from the Mordovia State Nature Reserve between 1936 and 2018 shows that a plateu is far from being reached (Fig. 3). Thus the number of the Red Data Book invertebrates will be likely increase with further research.

The first record of a Red Data Book species (*Podisma pedestris* (Linnaeus, 1758)) has been reported in 1936. Plavilshchikov (1964) published the first relatively comprehensive list of insect species for the Mordovia State Nature Reserve. In the late 1960s – early 1970s, Lepidoptera and Heteroptera were mainly investigated. Between 1936 and 1986, the list of the Red Data Book invertebrates increased up to 40 species. During the next 20 years (1986–2006), there were no additions to the list of the Red Data Book invertebrates in the Mordovia State Nature Reserve due to the complete lack of entomological

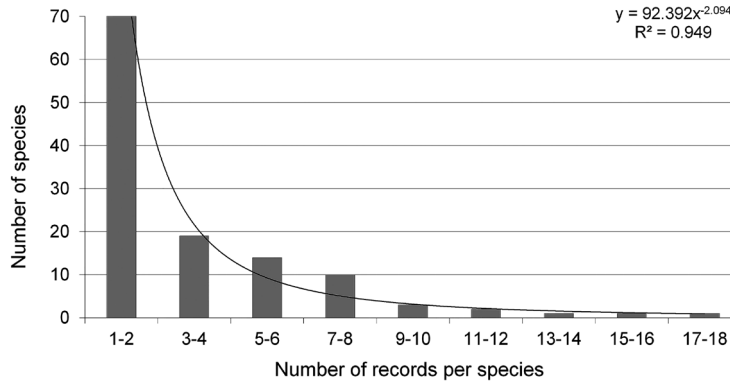

Fig. 2. Number of Red Data Book invertebrate species for different classes of records in the Mordovia State Nature Reserve

studies. A period of intensive entomological studies in the Mordovia State Nature Reserve started in 2007. Thus, between 2007 and 2018, the fauna of the Red Data Book invertebrate species has remarkably increased (by 80 species). To obtain field data we used different approaches and catch methods: pitfall traps, light traps, fermental crown traps, Malaise traps and others (e.g., see Ruchin & Egorov 2018*a*). The preparation of the first edition of the Red Data Book of the Republic of Mordovia (Astradamov 2005) was a main driving force for the study of the Red Data Book species in the region. A permanent monitoring of the Red Data Book taxa, a search for their detailed distribution, the study of their biology and ecology, and the biodiversity investigation of different invertebrate groups allowed the addition of more than 5,000 invertebrate species to the fauna of the Mordovia State Nature Reserve (Ruchin 2011, 2015*a*,*b*, 2017).

Data on the spatial distribution of the Red Data Book invertebrates in the Mordovia State Nature Reserve allowed the identification of biodiversity hotspots within the Protected Area. Figure 4 shows that the highest number of the Red Data Book invertebrate species per quarter was found in the south-west of the Mordovia State Nature Reserve. This is explained by a large diversity of landscapes and ecotones in this area. This part of the Mordovia Reserve includes floodplain meadows and deciduous forests, old-growth broad-leaved (*Quercus robur*, *Ulmus* spp., *Tilia cordata*) forests, oxbow lakes with shores, mixed forests with different-species in the second and third layers, large glades and edges of forests, and mires of different types. In general, the highest species diversity was observed around research stations of the Mordovia State Nature Reserve represented by the settlement of Pushta and cordons (a cordon is one or few inhabited or uninhabited building(s), which serve(s) as a home for forest rangers and/or as research stations), such as cordon Steklyannyi, cordon

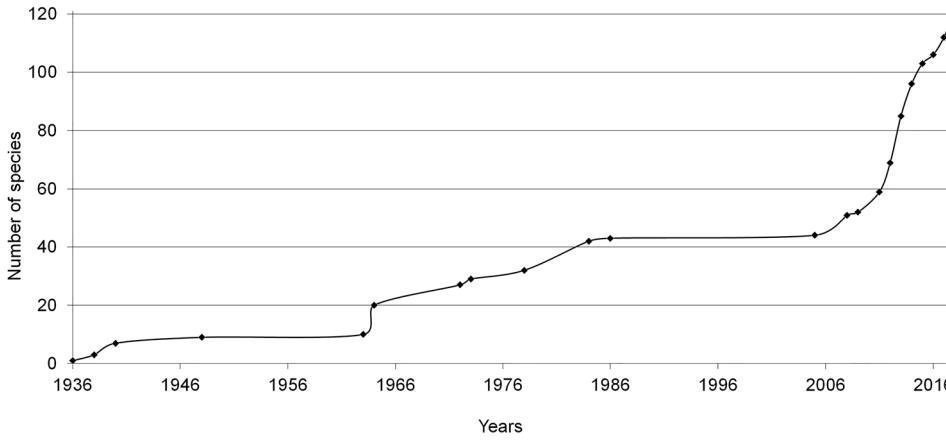

Fig. 3. Increase in the Red Data Book invertebrate species for the fauna of the Mordovia State Nature Reserve for the period 1936–2018

Srednyaya Melnitsa, cordon Pavlovskiy, cordon Vorovskoy, cordon Inorskiy, cordon Dolgiy Most, cordon Zhegalovskiy, cordon Drozhdenovskiy – see Fig. 1). Thus, it can be seen from Fig. 4 that the presence and density of research stations (settlements and cordons) positively influences the diversity and richness of known species in the various sectors of the Protected Area. The efficiency of studies can also be increased with increasing density of research stations in other environmental studies (e.g., Mishra 2013).

Low diversity of Red Data Book invertebrate species in the central and eastern parts of the Mordovia State Nature Reserve could be explained by different reasons. First, these areas are represented predominantly by pine forests with the insignificant presence of *Tilia cordata*, *Picea abies* or *Betula pendula* into the second layer and with shrub layer represented mainly by *Sorbus aucuparia* and *Frangula alnus*. Thus, the lack of broad-leaved trees possibly influences negatively the diversity of saproxylic beetles. Absence of meadows affects negatively Orthoptera and Lepidoptera. In addition, the lack of water bodies negatively influences Odonata, Lepidoptera, and Mollusca. Second, the central and eastern parts of the Mordovia State Nature Reserve have been damaged by humans, as also indicated by palaeobotanical data (see Novenko *et al.* 2017). In these parts of the Protected Areas, broad-leaved forests have been changed into pine forests, wildfires became more frequent and *Picea abies* started penetrating into the forest communities.

Analysis of habitat confinement of the Red Data Book invertebrates showed the importance of forest ecosystems as refugia for threatened species

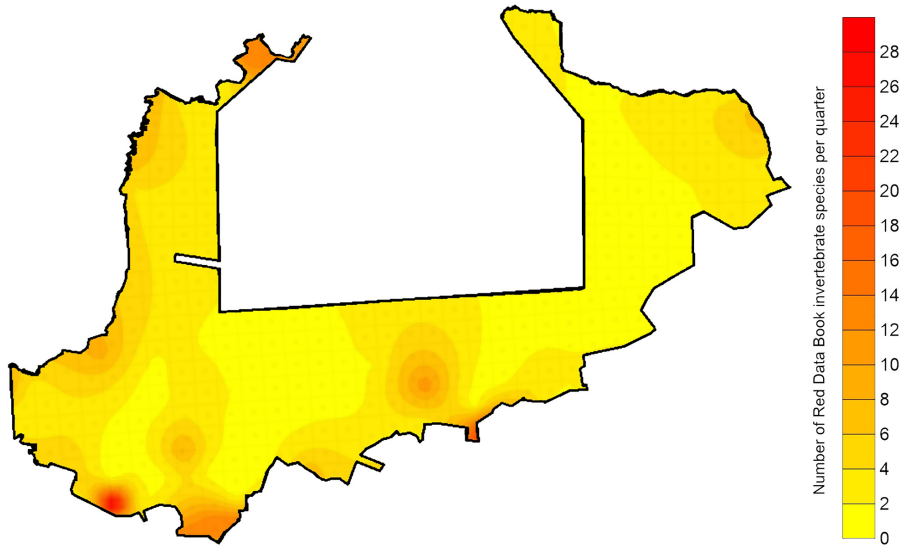

Fig. 4. Contour map showing the number of the Red Data Book invertebrate species per quarter in the Mordovia State Nature Reserve

in the Mordovia State Nature Reserve (Fig. 5) (Bengtsson *et al.* 2000, Kovac *et al.* 2018). This is clearly explained by the predominance of forest habitats (89.3% of total Protected Area) in the Mordovia State Nature Reserve. There were remarkably fewer Red Data Book invertebrate species in *Sphagnum* mires (18 records), floodplain meadows (9 records), water bodies and their shores (8 records), man-made habitats (7 records). In addition, Fig. 5 demonstrates a considerably high number of Red Data Book invertebrates within mixed forests, as well as on edges and glades of mixed forests. This is in accordance with data of other investigations (e.g., Sümegi *et al.* 2012, Novenko *et al.* 2018) that reported high species diversity in ecotone plant communities.

In the Mordovia State Nature Reserve, floodplain broad-leaved forests (linden forests and oak forests) are of special interest. This is a unique refugium for the forest fauna and flora that remained little affected by human activity for many centuries. The largest portion of such forests is located in the western, southwestern and northern parts of the Protected Area. In these areas, centuries-old *Quercus robur*, large *Tilia cordata* and *Fraxinus excelsior* L. trees still survive. There are numerous fallen and gradually decaying trunks of these trees, extremely important for the persistence of saproxylic insects. Additionally, floodplains form unique conditions for numerous saproxylic beetles and numerous species associated with broad-leaved forests and which are known only in these areas. Of special interest are some species included the current edition of the Red Data Book of the Russian Federation (Danilov-Danilyan 2001) and species recommended for inclusion in its second edition (Ilyashenko *et al.* 2018). They are: *Ceruchus chrysomelinus* (Hochenwarth, 1785), *Lucanus cervus* (Linnaeus, 1758), *Trypocopris vernalis* (Linnaeus, 1758), *Osmoderma barnabita* Motschulsky, 1845, *Protaetia speciosissima* (Scopoli, 1786), *Protaetia fieberi* (Kraatz, 1880), *Elater ferrugineus* Linnaeus, 1758 (Ruchin & Egorov 2017*b*, 2018*a*). Also, four species (*Allonyx quadrimaculatus* (Schaller, 1783), *Leptura aurulenta* Fabricius, 1793, *Nothochrysa fulviceps* (Stephens, 1836), *Catocala promissa* ([Denis et Schiffermüller], 1775)). These speceis are confined to these areas and are known only in the Mordovia State Nature Reserve in Russia (Bolshakov & Ruchin 2016, Ruchin & Egorov 2018*b*,*d*, Tomaszewska *et al.* 2018).

Meadows cover about 1% of the total Protected Area. They are located predominantly in the western and southwestern parts of the Mordovia State Nature Reserve and around cordons. For this, cordons play a very important role in biodiversity maintenance. The cordons previously served as the residence of the Mordovia Reserve officers who constantly grazed cattle or mowed grass on the nearby meadows. Typically, the number of animals grazed was quite low. Grazing and mowing brought certain benefits, counteracting the overgrowth of meadows by woody and weed-meadow plants. Exactly these conditions allowed the persistence of a *Parnassius apollo* population for a long time. However, it has gradually compromised by the decline of *Sedum maxi-*

mum (L.) Hoffm. populations, a feeding plant for *P. apollo* larvae (Ruchin & Grushutkin 2018). Within the Mordovia State Nature Reserve, populations of the following xerophilic species survive in meadow habitats: *Myrmeleotettix maculatus* (Thunberg, 1815), *Sphingonotus caerulans caerulans* (Linnaeus, 1767), *Psophus stridulus* (Linnaeus, 1758) (Orthoptera), *Parnopes grandior* (Pallas, 1771) (Hymenoptera), *Dysauxes ancilla* (Linnaeus, 1767), *Panthea coenobita* (Esper, 1785) (Lepidoptera). Due to the particular microclimatic conditions and mesophilisation processes, some meadow sites of the Mordovia State Reserve (especially in the Moksha river floodplain) are the only habitats for the lepidopterans *Phragmataecia castaneae* (Hübner, 1790), *Zygaena centaureae* Fischer von Waldheim, 1832, *Carcharodus alceae* (Esper, 1780), *Melitaea phoebe* (Goeze, 1779), *Chortobius hero* (Linnaeus, 1760), *Lycaena hippothoe* (Linnaeus, 1760).

Figure 6 presents values of the Representativeness Index (RI) for the Red Data Book invertebrate species of the Mordovia State Nature Reserve. Among all studied taxa, RI values of Neuroptera, Heteroptera, and Mollusca species were less than 50%. However, these taxa included the smallest number of the Red Data Book invertebrate species in the Mordovia State Nature Reserve. These are one Neuroptera species (*Nothochrysa fulviceps* (Stephens, 1836)), two Heteroptera species (*Cercopis vulnerata* Rossi, 1807, *Pygolampis bidentata* (Goeze, 1778)), and two Mollusca species (*Acroloxus lacustris* (Linnaeus, 1758), *Planorbis carinatus* O.F. Müller, 1774). Orthoptera have an intermediate position because they include species with both high (*Podisma pedestris* (Linnaeus, 1758), RI = 100%) and low (*Myrmeleotettix maculatus* (Thunberg, 1815), RI=23.1%; *Stenobothrus nigromaculatus* (Herrich-Schaffer, 1840), RI = 16.7%) RI

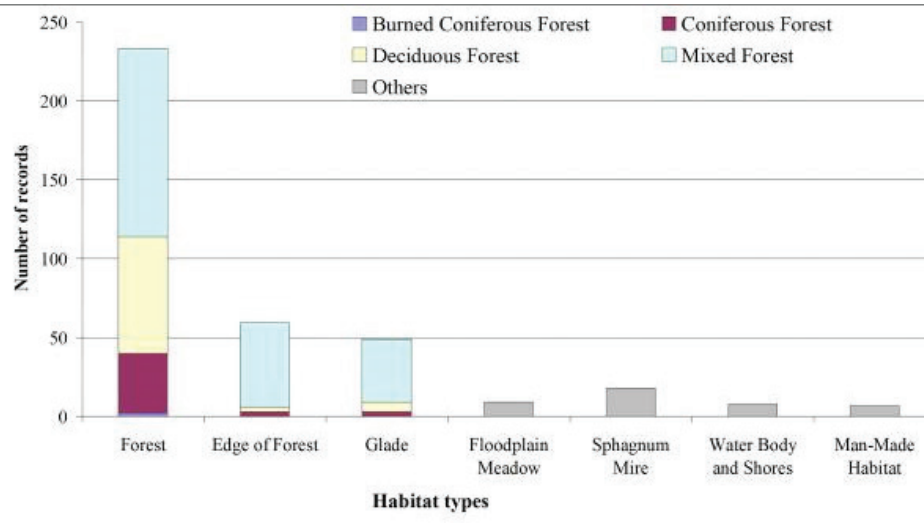

Fig. 5. Habitat preferences of Red Data Book invertebrate species in the Mordovia State Nature Reserve

values. Finally, each of the four remaining orders (Coleoptera, Lepidoptera, Hymenoptera, Diptera) contains at least 40% Red Data Book species with RI values equal to or higher than 50%. Coleoptera and Lepidoptera are the groups with the highest number (31 and 70 taxa, respectively) of the Red Data Book invertebrate species known in the Mordovia State Nature Reserve.

The conservation value of a Protected Area is obviously increased by the species that are known for only the concerned area within a region (Ruchin & Kurmaeva 2010, Mikhailenko & Ruchin 2015, Ruchin & Egorov 2015, 2017*b*, 2018*a*, Bolshakov & Ruchin 2016). On the basis of the RI values, we distinguish a group of Red Data Book invertebrate species of the region (Republic of Mordovia), which are known here only in the Mordovia State Nature Reserve (i.e., RI=100%). They are represented by one Orthoptera species (*Podisma pedestris*), six Coleoptera species (*Lebia marginata* (Geoffroy, 1785), *Sphaerites glabratus* (Fabricius, 1792), *Elater ferrugineus* Linnaeus, 1758, *Allonyx quadrimaculatus* (Schaller, 1783), *Evodinellus borealis* (Gyllenhal, 1827), *Leptura aurulenta* Fabricius, 1793), and 20 Lepidoptera species (*Eversmannia exornata* (Eversmann, 1837), *Arichanna melanaria* (Linnaeus, 1758), *Phyllodesma ilicifolia* (Linnaeus, 1758), *Smerinthus caecus* (Ménétriès, 1857), *Cerura erminea* (Esper, 1783), *Ptilodon cucullina* ([Denis et Schiffermüller], 1775), *Odontosia carmelita* (Esper, 1799), *Clostera anastomosis* (Linnaeus, 1758), *Dicallomera fascelina* (Linnaeus, 1758), *Calliteara abietis* ([Denis et Schiffermüller], 1775), *Eilema depressum* (Esper, 1787), *Lithosia quadra* (Linnaeus, 1758), *Rhyparia purpurata* (Linnaeus, 1758), *Dysauxes ancilla* (Linnaeus, 1767), *Minucia lunaris* ([Denis et Schiffermüller], 1775), *Panthea coenobita* (Esper, 1785), *Anarta myrtilli* (Linnaeus, 1760), *Boloria aquilonaris* (Stichel, 1908), *Scolitantides orion* (Pallas, 1771), *Agriades optilete* (Knoch, 1781)). Thus, the special protection regime and habitat diversity of the Mordovia State Nature Reserve is important to counteract the regional extinction of these 27 species in the Republic of Mordovia.

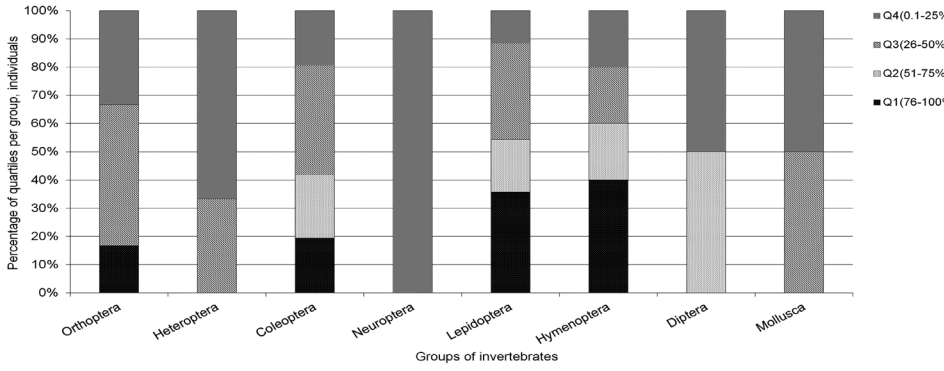

Fig. 6. Proportions of Representativeness Index values for the Red Data Book invertebrates in the Mordovia State Nature Reserve

CONCLUSIONS

The main cause for Protected Areas establishment is a need to protect threatened and rare plants and animals from extinction. However, in most cases, conservation measures are focused on the largest and most remarkable animals (Shi *et al.* 2008, Zhang *et al.* 2015, Mizin *et al.* 2018, Samson & Ramakrishnan 2018) and plants (Bauer *et al.* 2016, Wicaksono *et al.* 2016). Although conservation of these species is undoubtedly important, we should not ignore a need to study and preserve all imperiled organisms. Globally or regionally threatened invertebrate species play an important role for ecosystem functioning, yet their remain less considered in conservation programs. Protected Areas, as islands of the least destructed natural ecosystems, are main refugia of invertebrate diversity, including threatened and rare species.

In this study, we demonstrated a significant increase in the known diversity of invertebrate species with increasing research investigations in a limited area, the Mordovia State Nature Reserve. Out of the more than 6,000 invertebrate species revealed during 1936–2018, we considered 120 taxa as Red Data Book invertebrates in the Republic of Mordovia. We showed a remarkable decrease in known species diversity when moving away from research stations (e.g., cordons or settlements). This is probably because 58.3% of the Red Data Book species were found in the recent ten years and are confirmed predominantly only by 1–2 records. Hence, further surveys of areas remote from cordons could reveal a more widespread distribution of these invertebrate species. Most of the Red Data Book invertebrate species in the Mordovia State Nature Reserve are confined to forest ecosystems with many records in ecotone communities (mixed forests, glades, and edges of mixed forests). Despite the small area, oligotrophic *Sphagnum* mires and floodplain meadows were also important refugia for Red Data Book invertebrate species of the Republic of Mordovia. We found four and 27 invertebrate species known only from the Mordovia State Nature Reserve for the whole Russia and the Republic of Mordovia, respectively. However, we can expect that these species will be found outside the Mordovia Reserve during further investigations in the Republic of Mordovia and Russia as a whole. Finally, we propose to promote the knowledge of the whole invertebrate fauna of the Mordovia State Nature Reserve and the whole Republic of Mordovia to identify biodiversity hotspots and coldspots at different spatial scales.

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REFERENCES

Anufriev, G. A. (2016): Middle-summer cicadinas fauna (Hemiptera, Cicadina) of the Vitimsky Reserve (Irkutsk region). – *Nature Conservation Research* **1**(1): 65–77. https://doi.org/10.24189/ncr.2016.006 [In Russian]

Anufriev, G. A. (2017): Spittlebugs of genus *Aphrophora* Germ. (Hemiptera, Cicadinea, Aphrophoridae) in European Russia based on studies in the Mordovia State Nature Reserve. – *Proceedings of the Mordovia State Nature Reserve* **18**: 3–16. [In Russian]

Astradamov, V. I. (ed.). (2005): *Red Data Book of the Republic of Mordovia. Vol. 2: Animals*. Publisher of the Mordovia State University, Saransk, 336 pp. [In Russian]

Bauer, U., Rembold, K. & Grafe, T. U. (2016): Carnivorous Nepenthes pitcher plants are a rich food source for a diverse vertebrate community. – *Journal of Natural History* **50**(7–8): 483–495. https://doi.org/10.1080/00222933.2015.1059963

Belle, E., Kingston, N., Burgess, N., Sandwith, T., Ali, N. & MacKinnon, K. (eds.). (2018): *Protected Planet Report 2018*. UNEP-WCMC, IUCN and NGS, Cambridge UK; Gland, Switzerland; and Washington, D.C., USA, 56 pp.

Bengtsson, J., Nilsson, S. G., Franc, A. & Menozzi, P. (2000): Biodiversity, disturbances, ecosystem function and management of European forests. – *Forest Ecology and Management* **132**: 39–50.

Bezina, O. V. (2014): Terrestrial mollusks of the Mordovia State Nature Reserve. – *Proceedings of the Mordovia State Nature Reserve* **12**: 400–410. [In Russian]

Bolshakov, L. V. & Ruchin, A. B. (2016): Review of lepidopterans (Insecta: Lepidoptera) recommended for inclusion into the second edition of the Red Data Book of the Republic of Mordovia. – *Proceedings of the Mordovia State Nature Reserve* **16**: 118–268. [In Russian]

Bolshakov, L. V., Ruchin, A. B., Piskunov, V. I. & Semishin, G. B. (2014): To the fauna of Lepidoptera in the Republic of Mordovia. Addition 3. – *Eversmannia* **38**: 19–27.

Bolshakov, L. V., Ruchin, A. B., Piskunov, V. I. & Semishin, G. B. (2017): To the fauna of Lepidoptera in the Republic of Mordovia. Addition 5. – *Eversmannia* **51–52**: 40–46.

Bolshakov, L. V., Ruchin, A. B., Piskunov, V. I. & Semishin, G. B. (2018): To the fauna of Lepidoptera in the Republic of Mordovia. Addition 6. – *Eversmannia* **54**: 49–54. [In Russian]

Bouchard, P., Smith, A. B. T., Douglas, H., Gimmel, M. L., Brunke, A. J. & Kanda, K. (2017): Biodiversity of Coleoptera. Pp. 337–417. In: *Insect biodiversity: science and society. Vol. 1.* 2nd ed. – John Wiley & Sons Ltd. https://doi.org/10.1002/9781118945568.ch11

Budaeva, I. A. & Ruchin, A. B. (2014): To the fauna of blackflies (Diptera: Simuliidae) of the Republic of Mordovia (Russia). – *Caucasian Entomological Bulletin* **10**(1): 155–159. [In Russian]

Budaeva, I. A. & Ruchin, A. B. (2016): To the fauna of deer flies (Diptera: Tabanidae) of the Republic of Mordovia. – *Belgorod State University Scientific Bulletin. Natural Sciences* **35**(11): 85–93. [In Russian]

Butchart, S. H. M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P., Almond, R. E., Baillie, J. E., Bomhard, B., Brown, C., Bruno, J., Carpenter, K. E., Carr, G. M., Chanson, J., Chenery, A. M., Csirke, J., Davidson, N. C., Dentener, F., Foster, M., Galli, A., Galloway, J. N., Genovesi, P., Gregory, R. D., Hockings, M., Kapos, V., Lamarque, J. F., Leverington, F., Loh, J., McGeoch, M. A., McRae, L., Minasyan, A., Hernández Morcillo, M., Oldfield, T. E., Pauly, D., Quader, S., Revenga, C., Sauer, J. R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S. N., Symes, A., Tierney, M., Tyrrell, T. D., Vié, J. C. & Watson, R. (2010): Global biodiversity: indicators of recent declines. – *Science* **328**: 1164–1168. https://doi.org/10.1126/science.1187512

Cardoso, P., Borges, P. A. V., Triantis, K. A., Ferrández, M. A. & Martín, J. L. (2011): Adapting the IUCN Red List criteria for invertebrates. – *Biological Conservation* **144**: 2432–2440. https://doi.org/10.1016/j.biocon.2011.06.020

Cardoso, P., Borges, P. A. V., Triantis, K. A., Ferrández, M. A. & Martín, J. L. (2012): The underrepresentation and misinterpretation of invertebrates in the IUCN Red List. – *Biological Conservation* **149**: 147–148. https://doi.org/10.1016/j.biocon.2012.02.011

Carignan, V. & Villard, M. (2002): Selecting indicator species to monitor ecological integrity: a review. – *Environmental Monitoring and Assessment* **78**: 45–61.

Chikhlyaev, I. & Ruchin, A. (2014): The helminth fauna study of European common brown frog (*Rana temporaria* Linnaeus, 1758) in the Volga basin. – *Acta Parasitologica* **59**(3): 459–471. https://doi.org/10.2478/s11686-014-0268-5

Chikhlyaev, I. V., Ruchin, A. B. & Fayzulin, A. I. (2016): The helminth fauna study of European common toad in the Volga Basin. – *Nature, Environment and Pollution Technology* **15**(3): 1103–1109.

Chursina, M. A. & Ruchin, A. B. (2018a): A checklist of Bombyliidae (Diptera) from Mordovia, Russia and variation of wing shape in *Bombylius* species. – *Biodiversitas* **19**(6): 2147–2156. https://doi.org/10.13057/biodiv/d190622

Chursina, M. A. & Ruchin, A. B. (2018b): A checklist of Syrphidae (Diptera) from Mordovia, Russia. – *Halteres* **9**: 57–73. https://doi.org/10.5281/zenodo.1255874

Danilov-Danilyan, V. I. (ed.). (2001): *Red Data Book of Russian Federation. Animals*. Astrel, Moscow, 862 pp. [In Russian]

Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. B. & Collen, B. (2014): Defaunation in the Anthropocene. – *Science* **345**: 401–406.

Egorov, L. V. & Ruchin, A. B. (2009): About status of some beetle species (Insecta, Coleoptera) in the Red Data Book of the Republic of Mordovia. Pp. 21–39. *In: Rare animals of the Republic of Mordovia: materials for maintenance of the Red Data Book of the Republic of Mordovia for 2009*. – Publisher of the Mordovia State University, Saransk. [In Russian]

Egorov, L. V. & Shapovalov, A. M. (2017): On the distribution of a poorly known longicorn beetle, *Phymatodes abietinus* Plavilstshikov et Lurie, 1960 (Coleoptera, Cerambycidae: Cerambycinae). – *Entomological Review* **97**: 353–356.

Feoktistov, V. F. (2011): The list of insect species discovered for the first time in the Mordovia State Nature Reserve and in adjacent territories. – *Mordovia University Bulletin* **4**: 83–89. [In Russian]

Halffter, G. (2005): Towards a culture of biodiversity conservation. – *Acta Zoologica Mexicana* **21**(002): 133–153.

Ilyashenko, V. Yu., Shatalkin, A. I., Kuvaev, A. V., Komendatov, A. Yu, Britaev, T. A., Kosyan, A. R., Pavlov, D. S., Shilin, N. I., Ananjeva, N. B., Tuniyev, B. S., Semenov, D. V., Syroechkovskiy, E. E., Morozov, V. V., Mishchenko, A. L., Rozhnov, V. V. & Poyarkov, A. D. (2018): *Rare and endangered animals of Russia. Materials towards the Red Data Book of the Russian Federation*. KMK Scientific Press Ltd., Moscow, 112 pp. [In Russian]

Kareiva, P. & Marvier, M. (2003): Conserving biodiversity coldspots. – *American Scientist* **91**(4): 344–351.

Kornev, I. I., Aksenenko, E. V. & Ruchin, A. B. (2016): New data of the fauna and distribution of the genus Bibio Geoffroy, 1762 (Diptera: Bibionidae) of the Republic of Mordovia (Russia). – *Ukrainska Entomofaunistyka* **7**(4): 55–56. [In Russian]

Kovac, M., Hladnik, D. & Kutnar, L. (2018): Biodiversity in (the Natura 2000) forest habitats is not static: its conservation calls for an active management approach. – *Journal for Nature Conservation* **43**: 250–260. https://doi.org/10.1016/j.jnc.2017.07.004

Legalov, A. A., Egorov, L. V. & Ruchin, A. B. (2014): First record of *Mesauletobius pubescens* (Kiesenwetter, 1851) (Coleoptera, Rhynchitidae) in Russia. – *Euroasian Entomological Journal* **13**(4): 400. [In Russian]

Mace, G. M., Collar, N. J., Gaston, K. J., Hilton-Taylor, C., Akçakaya, H. R., Leader-Williams, N., Milner-Gulland, E. J. & Stuart, S. N. (2008): Quantification of extinction risk: IUCN's system for classifying threatened species. – *Conservation Biology* **22**: 1424–1442. https://doi.org/10.1111/j.1523-1739.2008.01044.x

Makarkin, V. N. & Ruchin, A. B. (2010): Materials on the green lacewing fauna of Mordovia (Neuroptera, Chrysopidae). – *Mordovia University Bulletin* **1**: 123–127. [In Russian]

Makarkin, V. N. & Ruchin, A. B. (2014): A contribution to the knowledge of Neuroptera and Raphidioptera of Mordovia (Russia). – *Caucasian Entomological Bulletin* **10**(1): 111–117. [In Russian]

Makarkin, V. N. & Ruchin, A. B. (2015): The extent of the knowledge of lacewings and snakeflies of the Republic of Mordovia, with recommendations for inclusion in the main lists of protected taxa. – *Proceedings of the Mordovia State Nature Reserve* **15**: 133–141. [In Russian]

Mandelshtam, M. Yu. & Egorov, L. V. (2017): Materials to the knowledge of bark beetles (Coleoptera, Curculionidae, Scolytinae) of the Mordovia State Nature Reserve. Report 1. – *Proceedings of the Mordovia State Nature Reserve* **18**: 274–278. [In Russian]

Margules, C. R. & Pressey, R. L. (2000): Systematic conservation planning. – *Nature* **405**: 243–253.

Martin-López, B., Montes, C. & Benayas, J. (2007): The non-economic motives behind the willingness to pay for biodiversity conservation. – *Biological Conservation* **139**: 67–82.

Mayhew, P. J. (2018): Explaining global insect species richness: lessons from a decade of macroevolutionary entomology. – *Entomologia Experimentalis et Applicata* **166**(4): 225–250. https://doi.org/10.1111/eea.12673

Mikhailenko, A. P. & Ruchin, A. B. (2015): About Orthoptera species recommended to be protected in the Republic of Mordovia. – *Proceedings of the Mordovia State Nature Reserve* **15**: 143–155. [In Russian]

Mishra, A. K. (2013): Effect of rain gauge density over the accuracy of rainfall: a case study over Bangalore, India. – *SpringerPlus* **2**(1): 311. https://doi.org/10.1186/2193-1801-2-311

Mizin, I. A., Sipko, T. P., Davydov, A. V. & Gruzdev, A. R. (2018): The wild reindeer (*Rangifer tarandus*: Cervidae, Mammalia) on the Arctic islands of Russia: a review. – *Nature Conservation Research* **3**(3): 1–14. https://doi.org/10.24189/ncr.2018.040

Mokrousov, M. V., Ruchin, A. B. & Egorov, L. V. (2013): The wasp fauna of Mordovia State Nature Reserve and adjacent territories. – *Proceedings of the Mordovia State Nature Reserve* **11**: 193–205. [In Russian]

Novenko, E. Yu., Zyuganova, I. S., Volkova, E. M. & Dyuzhova, K. V. (2018): A 7000-year pollen and plant macrofossil record from the Mid-Russian Upland, European Russia: vegetation history and human impact. – *Quaternary International*. https://doi.org/10.1016/j.quaint.2017.11.025

Novenko, E. Y., Tsyganov, A. N., Payne, R. J., Mazei, N. G., Volkova, E. M., Chernyshov, V. A., Kupriyanov, D. A. & Mazei, Y. A. (2017): Vegetation dynamics and fire history at the southern boundary of the forest vegetation zone in European Russia during the middle and late Holocene. – *Holocene* **28**(2): 308–322. https://doi.org/10.1177/0959683617721331

Pacheco, J. F. & Olmos, F. (2005): Birds of a latitudinal transect in the Tapajós-Xingu interfluvium, eastern Brazilian Amazonia. – *Revista Brasileira de Ornitologia* **13**: 29–46.

Pentinsaari, M., Hebert, P. D. N. & Mutanen, M. (2014): Barcoding Beetles: A Regional Survey of 1872 Species Reveals High Identification Success and Unusually Deep Interspecific Divergences. – *PLoS ONE* **9**(9): e108651. https://doi.org/10.1371/journal.pone.0108651

Plavilshchikov, N. N. (1964): A list of insect species found on the territory of the Mordovia State Nature Reserve. – *Proceedings of the Mordovia State Nature Reserve* **2**: 105–134. [In Russian]

Ramos, M. A., Lobo, J. M. & Esteban, M. (2001): Ten years inventorying the Iberian fauna: results and perspectives. – *Biodiversity and Conservation* **10**: 19–28.

Rodrigues, A. S. L., Andelman, S. J., Bakarr, M. I., Boitani, L., Brooks, T. M., Cowling, R. M., Fishpool, L. D. C., da Fonseca, G. A. B., Gaston, K. J., Hoffmann, M., Long, J. S., Marquet, P. A., Pilgrim, J .D., Pressey, R. L., Schipper, J., Sechrest, W., Stuart, S. N., Underhill, L. G., Waller, R. W., Watts, M. E. J. & Yan, X. (2004): Effectiveness of the global protected area network in representing species diversity. – *Nature* **428**: 640–643.

Rodrigues, A. S. L., Pilgrim, J. D., Lamoreux, J. F., Hoffmann, M. & Brooks, T. M. (2006): The value of the IUCN Red List for conservation. – *Trends in Ecology & Evolution* **21**: 71–76. https://doi.org/10.1016/j.tree.2005.10.010

Ruchin, A. B. (2011): First additional materials towards the entomofauna of the Mordovia State Nature Reserve. – *Proceedings of the Mordovia State Nature Reserve* **9**: 150–182. [In Russian]

Ruchin, A. B. (2015a): List of invertebrates (Invertebrata) of the Mordovia State Nature Reserve (ex. Insecta – Ectognatha). – *Proceedings of the Mordovia State Nature Reserve* **13**: 334–350. [In Russian]

Ruchin, A. B. (2015b): Second additional materials on the insect fauna of the Mordovia State Nature Reserve. – *Proceedings of the Mordovia State Nature Reserve* **13**: 351–398. [In Russian]

Ruchin, A. B. (2017): Third additional materials to the entomofauna of the Mordovia State Nature Reserve. – *Proceedings of the Mordovia State Nature Reserve* **19**: 161–181. [In Russian]

Ruchin, A. B. (2018): Biology and distribution of the Clouded Apollo *Parnassius mnemosyne* (Linnaeus, 1758) (Lepidoptera: Papilionidae), a rare butterfly in the Republic of Mordovia, Russia. – *Journal of Threatened Taxa* **10**(7): 11980–11983. https://doi.org/10.11609/jot.3709.10.7.11980-11983

Ruchin, A. B. & Artaev, O. N. (2016): On expansion of the distribution range of some scoliid wasps (Scoliidae, Hymenoptera, Insecta) in the Middle Volga region. – *Research Journal of Pharmaceutical, Biological and Chemical Sciences* **7**(3): 2110–2115.

Ruchin, A. B. & Egorov, L. V. (2015): Beetle species (Coleoptera) recommended to be protected in the Republic of Mordovia (main list of protected taxa). – *Proceedings of the Mordovia State Nature Reserve* **15**: 70–104. [In Russian]

Ruchin, A. B. & Egorov, L. V. (2017a): New and interesting species of Coleoptera in the Republic of Mordovia. – *Eversmannia* **51–52**: 21–26. [In Russian]

Ruchin, A. B. & Egorov, L. V. (2017b): Overview of insect species included in the Red Data Book of Russian Federation in the Mordovia State Nature Reserve. – *Nature Conservation Research* **2**(Suppl. 1): 2–9. https://doi.org/10.24189/ncr.2017.016 [In Russian]

Ruchin, A. B. & Egorov, L. V. (2018a): Beetles (Insecta, Coleoptera), collected using fermental crown trap in the Republic of Mordovia. Report 1. Mordovia State Nature Reserve. – *Scientific Proceedings of the State Nature Reserve «Prisursky»* **33**: 209–215. [In Russian]

Ruchin, A. B. & Egorov, L. V. (2018b): Discovery of *Allonyx quadrimaculatus* (Schaller, 1783) (Coleoptera Cleridae Clerinae) in Russia. – *Redia* **101**: 143–146. https://doi.org/10.19263/REDIA-101.18.19

Ruchin, A. B. & Egorov, L. V. (2018c): Fauna of longicorn beetles (Coleoptera: Cerambycidae) of Mordovia. – *Russian Entomological Journal* **27**(2): 161–177. https://doi.org/10.15298/rusentj.27.2.07

Ruchin, A. B. & Egorov, L. V. (2018d): *Leptura aurulenta* (Coleoptera, Cerambycidae), a new record of a very rare species in Russia. – *Nature Conservation Research* **3**(1): 88–91. https://doi.org/10.24189/ncr.2018.003

Ruchin, A. B. & Egorov, L. V. (2018e): On distribution of *Mimela holosericea* (Fabricius, 1787) (Insecta, Scarabaeoidea, Scarabaeidae, Rutelinae) in Russia and adjacent territories. – *Journal of Entomological and Acarological Research* **50**: 7390. https://doi.org/10.4081/jear.2018.7390

Ruchin, A. B., Egorov, L. V. & Semishin, G. B. (2018): Fauna of click beetles (Coleoptera: Elateridae) in the interfluve of Rivers Moksha and Sura, Republic of Mordovia, Russia. – *Biodiversitas* **19**(4): 1352–1365. https://doi.org/10.13057/biodiv/d190423

Ruchin, A. B. & Grishutkin, G. F. (2018): Biology and distribution of *Parnassius apollo* (Linnaeus, 1758) a rare species in Mordovia Republic, Russia. – *Biodiversitas* **19**(2): 431–436. https://doi.org/10.13057/biodiv/d190210

Ruchin, A. B. & Kurmaeva, D. K. (2010): On rare insects of Mordovia included in the Red Book of the Russian Federation. – *Entomological Review* **90**(6): 712–717. https://doi.org/10.1134/S0013873810060060

Ruchin, A. B. & Makarkin, N. V. (2017): Neuroptera and Raphidioptera in the Mordovia State Nature Reserve. – *Nature Conservation Research* **2**(2): 38–46. https://doi.org/10.24189/ncr.2017.001 [In Russian]

Ruchin, A. B. & Mikhailenko, A. P. (2018): Fauna of mantids and orthopterans (Insecta: Mantodea, Orthoptera) of the Mordovia State Nature Reserve, Russia. – *Biodiversitas* **19**(4): 1194–1206. https://doi.org/10.13057/biodiv/d190403

Ruchin, A. B. & Nikolaeva, A. M. (2015): Recommendations towards the preparation of the list of rare and monitored species of bugs (Insecta, Heteroptera) in the Republic of Mordovia. – *Proceedings of the Mordovia State Nature Reserve* **15**: 156–162. [In Russian]

Ruchin, A. B., Ryzhov, M. K., Artaev, O. N. & Khapugin, A. A. (2013): New records of *Argiope bruennichi* (Scopoli, 1772) (Aranei: Araneidae) from Mordovia and adjacent regions of Russia. – *Arthropoda Selecta* **22**(4): 361–362.

Ruchin, A. B., Chikhljaev, I. V. & Lukijanov, S. V. (2009): Analysis of helminthofauna of common spaedfoot *Pelobates fuscus* (Laurenti, 1768) and moor frog *Rana arvalis* Nilsson, 1842 (Amphibia: Anura) at their joint habitation. – *Parazitologiya* **43**(3): 240–247. [In Russian]

Samson, A. & Ramakrishnan, B. (2018): Population status, habitat selection and people's perception on *Pavo cristatus* (Aves: Phasianidae) in Sigur Plateau, the Nilgiris, Tamil Nadu, India. – *Nature Conservation Research* **3**(1): 80–87. https://doi.org/10.24189/ncr.2018.010

Samways, M. J. (2005): Insect diversity conservation. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511614163

Semenov, V. B. (2016): New data on the fauna of Staphylinidae (Coleoptera) of Mordovia. – *Proceedings of the Mordovia State Nature Reserve* **16**: 431–434. [In Russian]

Shi, H., Liu, N., Cao, L. & Barter, M. (2008): Status of the East Asian population of the Dalmatian Pelican *Pelecanus crispus*: The need for urgent conservation action. – *Bird Conservation International* **18**(2): 181–193. https://doi.org/10.1017/S0959270908000178

Silveira, L. F., Olmos, F. & Long, A. (2003): Birds in Atlantic Forest Fragments in north-east Brazil. – *Cotinga* **20**: 32–46.

Stork, N. E., Samways, M. J. & Eeley, H. A. C. (1996): Inventorying and monitoring biodiversity. – *Trends in Ecology & Evolution* **11**: 39–40.

Stoyko, T. G. & Komarova, E. V. (2015): About two terrestrial mollusks recommended to be protected in the Republic of Mordovia. – *Proceedings of the Mordovia State Nature Reserve* **15**: 224–226. [In Russian]

Sümegi, P., Persaits, G. & Gulyás, S. (2012): Woodland-grassland ecotonal shifts in environmental mosaics: lessons learnt from the environmental history of the Carpathian Basin (Central Europe) during the Holocene and the last ice age based on investigation of paleobotanical and mollusk remains. Pp. 17–57. *In*: Myster, R. (ed.): *Ecotones between forest and grassland*. – Springer, New York. https://doi.org/10.1007/978-1-4614-3797-0_2

Sushko, G. G. (2017): Diversity and species composition of beetles in the herb-shrub layer of a large isolated raised bog in Belarus. – *Mires and Peat* **19**(10): 1–14. https://doi.org/10.19189/MaP.2017.OMB.266

Tereshkin, I. S. & Tereshkina, L. V. (2006): Vegetation of the Mordovia Reserve. Successive series of the successions. – *Proceedings of the Mordovia State Nature Reserve* **7**: 186–287. [In Russian]

Thuiller, W. (2007): Biodiversity–climate change and the ecologist. – *Nature* **448**: 550–552.

Tomaszewska, W., Egorov, L. V., Ruchin, A. B. & Vlasov, D. V. (2018): First record of *Clemmus troglodytes* (Coleoptera: Coccinelloidea, Anamorphidae) for the fauna of Russia. – *Nature Conservation Research* **3**(3): 103–105. https://doi.org/10.24189/ncr.2018.016

Vargot, E. V., Khapugin, A. A., Chugunov, G. G. & Grishutkin, O. G. (2016): *Vascular plants of the Mordovia State Nature Reserve (an annotated species list)*. Commission of RAS on biodiversity conservation; IPEE RAS, Moscow, 68 pp. [In Russian]

Watson, J. E. M., Dudley, N., Segan, D. B. & Hockings, M. (2014): The performance and potential of protected areas. – *Nature* **515**: 67–73.

Wicaksono, A., Mursidawati, S., Sukamto, L. A. & Teixeira da Silva, J. A. (2016): *Rafflesia* spp.: propagation and conservation. – *Planta* **244**(2): 289–296. https://doi.org/10.1007/s00425-016-2512-8

Young, R. P., Hudson, M. A., Terry, A. M. R., Jones, C. G., Lewis, R. E., Tatayah, V., Zuël, N. & Butchart, S. H. M. (2014): Accounting for conservation: Using the IUCN Red List Index to evaluate the impact of a conservation organization. – *Biological Conservation* **180**: 84–96. https://doi.org/10.1016/j.biocon.2014.09.039

Zemoglyadchuk, A. V., Ruchin, A. B. & Egorov, L. V. (2019): The annotated list of pintail beetles (Coleoptera, Mordellidae) of the Republic of Mordovia, with short review of the family in European Russia. – *Zoologicheskii Zhurnal*. [In press]

Zhang, L., Tian, Y., Guo, Q. X., Kou, X. J., Han, X. M., Miquelle, D. G., Oliver, C. D., Xu, R. M. & Ge, J. P. (2015): Amur tigers and leopards returning to China: direct evidence and a landscape conservation plan. – *Landscape Ecology* **31**(3): 491–503.

Zografou, K., Kati, V., Grill, A., Wilson, R. J., Tzirkalli, E., Pamperis, L. N. & Halley, J. M. (2014): Signals of Climate Change in Butterfly Communities in a Mediterranean Protected Area. – *PLoS ONE* **9**(1): e87245. https://doi.org/10.1371/journal.pone.0087245

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Table S1. The list of the Red Data Book invertebrate species known in the Mordovia State Nature Reserve (European Russia). RI = Representativeness index; RC2005 = Rarity category (according to Astradamov 2005), RC2001 = Rarity category (according to Danilov-Danilyan 2001).

Species	Habitats	RI,%	RC2005	RC2001
Odonata				
Anax imperator Leach, 1815	WBS	16.7	2	3
Orthoptera				
Chorthippus pullus (Philippi, 1830)	MF	50.0	3	–
Myrmeleotettix maculatus (Thunberg, 1815)	GMH, MMH	23.1	3	–
Podisma pedestris (Linnaeus, 1758)	MF, CF, MMH, GMF	100.0	1	–
Psophus stridulus (Linnaeus, 1758)	MF	28.6	2	–
Sphingonotus caerulans caerulans (Linnaeus, 1767)	BCF, MMH	45.5	3	–
Stenobothrus nigromaculatus (H.-S., 1840)	?	16.7	4	–
Heteroptera				
Cercopis vulnerata Rossi, 1807	GMF, GDF	50.0	4	–
Cicadetta montana (Scopoli, 1772)	GMF	15.8	2	–
Pygolampis bidentata (Goeze, 1778)	GMF	12.5	2	–
Coleoptera				
Allonyx quadrimaculatus (Schaller, 1783)	DF	100.0	3	–
Aromia moschata (Linnaeus, 1758)	DF	26.7	3	–
Calosoma auropunctatum (Herbst, 1784)	MMH	9.1	2	–
Calosoma investigator (Illiger, 1798)	CF, MF	18.8	3	–
Calosoma sycophanta (Linnaeus, 1758)	EMF	10.0	3	2
Carabus aurolimbatus Dejean & Boisduval, 1829	FM	33.3	4	–
Carabus clathratus Linnaeus, 1761	DF, MF, FM	35.0	3	–
Carabus nitens Linnaeus, 1758	MF	28.6	3	–
Carabus schoenherri Fischer von Waldheim, 1820	DF	40.0	3	–
Ceruchus chrysomelinus (Hochenwarth, 1785)	MF, DF	50.0	3	2
Copris lunaris (Linnaeus, 1758)	MF	41.7	3	–
Dytiscus latissimus Linnaeus, 1758	WBS	33.3	3	2
Elater ferrugineus Linnaeus, 1758	DF, MF	100.0	1	2
Emus hirtus (Linnaeus, 1758)	EMF	16.7	3	–
Evodinellus borealis (Gyllenhal, 1827)	MF, DF	100.0	3	–
Gnorimus variabilis (Linnaeus, 1758)	MF, DF, EDF	66.7	3	–
Hololepta plana (Sulzer, 1776)	DF	20.0	3	–
Lebia marginata (Geoffroy, 1785)	EMF	100.0	3	–

Species	Habitats	RI,%	RC2005	RC2001
Leptura aurulenta Fabricius, 1793	DF	100.0	3	–
Lucanus cervus (Linnaeus, 1758)	EMF	25.0	3	2
Meloe variegatus Donovan, 1793	EMF	50.0	3	–
Necydalis major Linnaeus, 1758	MF, DF	35.7	3	–
Osmoderma barnabita Motschulsky, 1845	DF, MF	44.4	2	2
Protaetia fieberi (Kraatz, 1880)	MF, DF, EDF	66.7	3	2
Protaetia speciosissima (Scopoli, 1786)]	MF, DF	53.8	2	2
Purpuricenus kaehleri (Linnaeus, 1758)	MF, DF	62.5	1	–
Pyrochroa coccinea (Linnaeus, 1760)	CF, MF	28.6	3	–
Sphaerites glabratus (Fabricius, 1792)	CF, MF	100.0	3	–
Trypocopris vernalis (Linnaeus, 1758)	MF	75.0	3	2
Valgus hemipterus (Linnaeus, 1758)	MF, CF	56.3	4	–
Velleius dilatatus (Fabricius, 1787)	MF, EDF, DF	57.1	3	–
Neuroptera				
Nothochrysa fulviceps (Stephens, 1836)	MF	25.0	1	–
Lepidoptera				
Acossus terebrus ([Den. et Schiff.], 1775)	DF	60.0	3	–
Agriades optilete (Knoch, 1781)	SM	100.0	1	–
Anarta myrtilli (Linnaeus, 1760)	ECF	100.0	1	–
Arctia flavia (Fuessly, 1779)	MF	50.0	4	–
Argynnis laodice (Pallas, 1771)	MF	75.0	4	–
Arichanna melanaria (Linnaeus, 1758)	SM	100.0	1	–
Boloria aquilonaris (Stichel, 1908)	SM	100.0	1	–
Brenthis daphne ([Den. et Schiff.], 1775)	GMF, DF, MF, MMH, FM	55.6	3	–
Callimorpha dominula (Linnaeus, 1758)	MF	66.7	2	–
Calliteara abietis ([Den. et Schiff.], 1775)	CF	100.0	1	–
Callopistria juventina (Stoll, 1782)	CF	75.0	2	–
Carcharodus alceae (Esper, 1780)	FM	25.0	3	–
Catocala promissa ([Den. et Schiff.], 1775)	MF	16.7	3	–
Celaena haworthii (Curtis, 1829)	SM	66.7	3	–
Cerura erminea (Esper, 1783)	MF	100.0	3	–
Cerura vinula (Linnaeus, 1758)	DF	71.4	3	–
Chortobius hero (Linnaeus, 1760)	GMF, MF, EMF, FM	80.0	2	–
Clostera anastomosis (Linnaeus, 1758)	MF	100.0	4	–
Comibaena bajularia ([Den. et Schiff.], 1775)	DF	33.3	2	–

Species	Habitats	RI,%	RC2005	RC2001
Coscinia cribraria (Linnaeus, 1758)	MF	66.7	3	–
Dicallomera fascelina (Linnaeus, 1758)	MF	100.0	4	–
Dicycla oo (Linnaeus, 1758)	DF	50.0	3	–
Driopa mnemosyne (Linnaeus, 1758)	GMF, GDF, EMF	23.3	3	–
Dysauxes ancilla (Linnaeus, 1767)	DF	100.0	4	–
Eilema depressum (Esper, 1787)	MF	100.0	2	–
Epicallia villica (Linnaeus, 1758)	MF	50.0	2	–
Erebia aethiops (Esper, [1777])	EMF	66.7	3	–
Eucharia festiva (Hufnagel, 1766)	MF	66.7	1	–
Eudia pavonia (Linnaeus, 1758)	MF	50.0	2	–
Eversmannia exornata (Eversmann, 1837)	EMF	100.0	2	–
Fixsenia ilicis (Esper, [1779])	MF	40.0	3	–
Glaucopsyche alexis (Poda, 1761)	CF	22.2	2	–
Iphiclides podalirius (Linnaeus, 1758)	GMF, EMF, GCF, FM	53.8	5	–
Laothoe amurensis (Staudinger, 1892)	MF	25.0	2	–
Lasiocampa quercus (Linnaeus, 1758)	MF, DF	85.7	3	–
Lemonia dumi (Linnaeus, 1760)	MF	50.0	3	–
Lithosia quadra (Linnaeus, 1758)	ECF	100.0	1	–
Lycaena hippothoe (Linnaeus, 1760)	FM	33.3	4	–
Melitaea cinxia (Linnaeus, 1758)	EMF	68.8	3	–
Melitaea diamina (Lang, 1789)	EMF	62.5	4	–
Melitaea phoebe (Goeze, 1779)	GMF, EMF, FM	45.5	3	–
Minucia lunaris ([Den. et Schiff.], 1775)	MF	100.0	3	–
Neptis sappho (Pallas, 1771)	MF	28.6	3	–
Odontosia carmelita (Esper, 1799)	MF	100.0	2	–
Pachigastria trifolii ([Den. et Schiff.], 1775)	CF, MF, DF	100.0	4	–
Panthea coenobita (Esper, 1785)	MF	100.0	1	–
Parnassius apollo (Linnaeus, 1758)	GMF	14.3	2	3
Pelosia obtusa (Herrich-Schäffer, 1847)	WBS	33.3	4	–
Pericallia matronula (Linnaeus, 1758)	MF	33.3	4	–
Peridea anceps (Goeze, 1781)	MF	50.0	3	–
Phragmataecia castaneae (Hübner, 1790)	FM	50.0	4	–
Phyllodesma ilicifolia (Linnaeus, 1758)	MF	100.0	4	–
Phyllodesma tremulifolia (Hübner, 1809)	DF	50.0	2	–
Proserpinus proserpina (Pallas, 1772)	MF	50.0	2	–
Pseudoterpna pruinata (Hufnagel, 1767)	CF	83.3	2	–

Species	Habitats	RI,%	RC2005	RC2001
Ptilodon cucullina ([Den. et Schiff.], 1775)	MF	100.0	4	–
Pyrgus alveus (Hübner, [1803])	EMF	50.0	3	–
Rhodostrophia vibicaria (Clerck, 1759)	CF	25.0	2	–
Rhyparia purpurata (Linnaeus, 1758)	MF, DF	100.0	3	–
Sabra harpagula (Esper, 1786)	DF	33.3	4	–
Scolitantides orion (Pallas, 1771)	CF	100.0	4	–
Scotopterix moeniata (Scopoli, 1763)	CF	50.0	2	–
Scotopteryx mucronata (Scopoli, 1763)	CF	87.5	2	–
Setina irrorella (Linnaeus, 1758)	MF	50.0	4	–
Smerinthus caecus (Ménétriès, 1857)	MF	100.0	1	–
Spiris striata (Linnaeus, 1758)	MF, CF	83.3	4	–
Staurophora celsia (Linnaeus, 1758)	MF	16.7	3	–
Trichiura crataegi (Linnaeus, 1758)	MF	50.0	3	–
Watsonalla binaria (Hufnagel, 1767)	DF	50.0	3	–
Zerynthia polyxena ([Den. et Schiff.], 1775)	DF, GMF	27.3	2	–
Zygaena centaureae Fischer von Waldheim, 1832	FM	33.3	4	–
Hymenoptera				
Bombus hypnorum (Linnaeus, 1758)	EMF	85.7	3	–
Bombus terrestris (Linnaeus, 1758)	GMF	25.0	2	–
Orussus abietinus (Scopoli, 1763)	EMF, MF, CF	53.8	4	–
Parnopes grandior (Pallas, 1771)	GMF, ECF	30.8	4	3
Xylocopa valga Gerstaecker, 1872	GMF, MF, GCF, CF, GDF	78.9	2	–
Diptera				
Laphria gibbosa (Linnaeus, 1758)	CF, GMF, EMF	57.1	2	–
Mollusca				
Acroloxus lacustris (Linnaeus, 1758)	WBS	14.3	4	–
Planorbis carinatus O.F. Müller, 1774	WBS	50.0	4	–
Total			121	12

Abbreviations: BCF – Burned Coniferous Forest, CF – Coniferous Forest, DF – Deciduous Forest, MF – Mixed Forest, ECF – Edge of Coniferous Forest, EDF – Edge of Deciduous Forest, EMF – Edge of Mixed Forest, GCF – Glade of Coniferous Forest, GDF – Glade of Deciduous Forest, GMF – Glade of Mixed Forest, FM – Floodplain Meadow, WBS – Water Body and Shore, MMH – Man-Made Habitats, SM – Sphagnum Mire.