



Lessons from insect conservation in Russia

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Abstract

Insect conservation in Russia has a long history, but it has been developing partly independently from the conservation tradition of the Western world, and consequently it is characterised by certain peculiarities. While this means that in many aspects the Russian conservation system is lagging behind the accomplishments of other countries, some of its solutions could possibly serve as good examples to be followed elsewhere. We summarise the main features of the Russian conservation-oriented activities and regulations to protect insect fauna, focusing on both their achievements and failures. In particular, we consider entomological microreserves, which represent a unique type of protected areas made of small fragments of land totally excluded from human economic activity, and devoted to the conservation (often active one) of specific insect groups. We also discuss the drawbacks of the expert assessment approach to select insects for the inclusion in the national and regional Red Data Books, which in Russian legal system entails protected status of the species. Finally, we outline the rationale of sozological analysis [the analysis of conservation value], which offers a useful alternative, allowing much more objective selection of insect species of conservation concern, based on numerous basic criteria reflecting both the status of the focal species and their societal values.

Keywords Entomological reserves · Legal protection · Red Data Books · Sozological analysis · Species prioritisation

Introduction

Due to its large territory and the pristine state of many of its ecosystems, the Russian Federation is bound to play an important role in the preservation of numerous Palearctic species, including insects (Tuzov et al. 1997; Griffin 1999; Lockwood and Sergeev 2000). Nevertheless, the status of insect communities in Russia is not free from threats and many species require dedicated conservation measures. Insect conservation in Russia has a long history, but at the same time its development, especially in recent years, has

been somewhat independent from the world-wide trends in species and habitat conservation. Consequently, while the present Russian conservation-oriented activities and regulations share certain common features with those applied in the European Union member states, the United States or Canada, they are also characterized by many peculiarities. The fact that the Russian conservation system is built partially disregarding the earlier successful examples of insect conservation in the Western countries (cf. Collins and Thomas 1991; New et al. 1995; Thomas et al. 2011) may be considered a drawback, but on the other hand there is no reason to ignore the Russian own experiences in this respect. The aim of the present paper is thus to provide a summary of the past and present status of insect conservation science in Russia, as well as to outline its main characteristics. We believe that the Russian achievements and failures could serve as lessons to the outside world, respectively as good examples to follow and as mistakes to avoid while setting conservation programmes.

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Historical overview

The beginnings of insect conservation in Russia date back to the medieval times, when the laws for the protection of wild honey bees were established. For several centuries bee products such as honey (used as traditional drink or the replacement of sugar and medicines) and wax (utilised in the production of church candles among others) served as important articles of both domestic and foreign trade as well as currency to pay tributes and taxes (Klyuchnikov 2005; Sviridov 2011). Therefore it is not surprising that the “Russkaya Pravda [Russian Truth]”, one of the first collections of laws (1113 AC), included five articles devoted to the protection of the rights of wild-honey collectors. They enforced penalties not only for stealing bees, honey, honeycombs, but also for damaging trees with wild hives; moreover, during gathering honey the collector was supposed to leave about half of the comb to the bees (Pereletov 2008). While all the above regulations were designed as measures for protecting businesses, they obviously benefited wild honey bees as well.

The modern conservation era started with the Forest Charter passed in 1888, which defined the concept of protective forests with special regime of unconditional preservation of several types of forests, including those safeguarding coast or agricultural fields as well as mountain and suburban forests (Chernov 2002). Shortly afterwards came the idea of nature reserves as the fragments of lands withdrawn from any economic use, where all the elements of nature are legally protected (Moskalenko 2016). Interestingly, the first such nature reserve, “Chapli” created in 1898 near the village of Askania Nova (currently Eastern Ukraine), encompassed 545 hectares of virgin steppes, which represent one of Europe’s insect biodiversity hotspots (Tye 1991). Nevertheless, no insect species were mentioned explicitly in the legislative statutes of this or later reserves (Sviridov 2011). It was only in the 1920s that the need for the dedicated actions to protect insects (bees, butterflies, beetles), especially in urbanised areas, was clearly formulated (Kozhevnikov 1926).

Entomological microreserves

The twentieth century development of entomology in Russia brought more understanding of the role played by insects in ecosystems and of the ecosystem services provided by them. The growing appreciation of insect importance as pollinators, food resource for various animals, or natural enemies of agricultural pests led to the idea of entomological microreserves, which would serve as refuge

areas for insects (Grebennikov 1972, 1990). Their establishment became to be perceived as urgency especially in agricultural regions, where the agriculture intensification and the resulting increase in the application of chemical fertilisers as well as herbicides and insecticides seriously impacted insect communities, decimating not only the targeted pest insects but also many beneficial ones (cf. Tilman et al. 2002; Beketov et al. 2013).

In particular, the mass deaths of bumblebees was highly publicised, and it caused legitimate concerns about the fate of these important pollinators (Byvaltsev 2009a). Consequently, in 1972 the decision of the Omsk regional Executive Committee established, the country’s first entomological reserve “Shmelinnye Kholmy [Bumblebee Hills]”, encompassing 6.5 hectares of forest-steppe in the Isilkulsky district, intended primarily for the protection of this group (Kassal et al. 2016). A year later the second bumblebee-oriented microreserve was created near the settlement of Ramon (Voronezh oblast). Similar microreserves soon followed in the Novosibirsk and Irkutsk oblasts, the Stavropol Krai, and the Chuvash Autonomous Republic. It is worth noting that all these microreserves should not be perceived merely as the fragments of land set aside for bumblebees, but instead they represent areas of active conservation, where artificial holes, simulating the burrows of rodents, are made in the ground to serve as nesting sites for bumblebees (but also for some other insects), improving their breeding success and thus increasing local abundances (Chenikalova et al. 2008).

The success of the aforementioned bumblebee sanctuaries provided inspiration for establishing further microreserves intended for other insect groups, such as butterflies or orthopterans. The best example of them is the network of three microreserves set up in the neighbourhood of Pushkino (Moscow oblast), spanning a wide range of meadow, steppe and deciduous forest habitats (Kochetova et al. 1986). Furthermore, in the forest zone of Russia about 80 myrmecological microreserves were established (Zakharov 2003). They are mostly designed for the conservation of the red wood ants of the genus *Formica*. Many of them reach considerable sizes and can in fact be classified as standard nature reserves. This category includes the myrmecological reserves of the Upper Klyazma (600 ha; Solnechnogorsky district, Moscow oblast) or Gusevsky Forest (111 ha; Gus-Khrustalny district, Vladimir oblast) to name just a few. In general, however, as the name implies the entomological microreserves are relatively small in size. Although they are mostly established as a result of local initiatives (see below), and hence no comprehensive information exists about their numbers and areas across Russia, the data we managed to gather suggest that they are usually below 40 ha (Fig. 1).

The Russian entomological microreserves may superficially resemble small-scale nature reserves existing in other

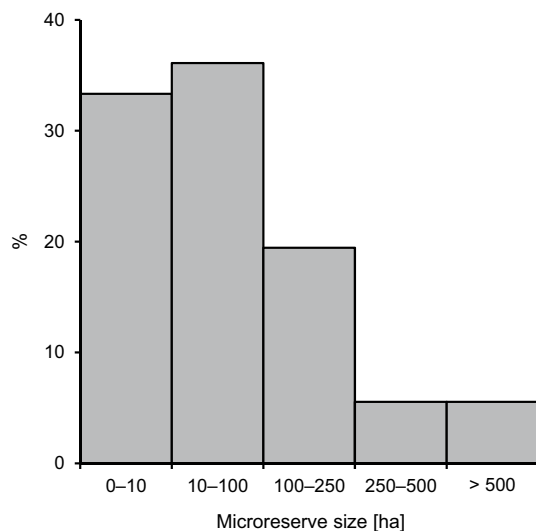


Fig. 1 Size distribution of entomological microreserves in Russia, based on a sample of 36 microreserves with detailed information available (minimum: 0.05 ha; median: 39.4 ha; maximum: 3581 ha). It should be noted that the presented distribution is strongly positively biased, because there is a huge number of apparently small microreserves, for which the size is not reported

parts of the world (Chape et al. 2008), and in particular the network of Natura 2000 sites (Gaston et al. 2008; Evans 2012), established in the European Union as one of the practical implementation steps of its Habitats Directive (European Commission 1992). Many Natura 2000 sites aimed at the preservation of insect species listed in Annexes of the Habitats Directive are indeed similarly small in size, reaching a few tens to a few hundreds hectares (European Environment Agency 2018). Nevertheless, the main difference is that the Russian entomological microreserves, unlike Natura 2000 sites, do not form a harmonised system, but rather an assemblage of small protected areas functioning completely independently from one another. They have mostly been created as a result of uncoordinated bottom-up initiatives of local authorities, state forest directorates or even schools or nature enthusiast organisations (Grebennikov 1990; Logvinovsky 1996; Chenikalova et al. 2008). A consequence of such a situation is that hardly any attention is given to spatial configuration of microreserves that could ensure their sufficient connectivity and hence allow the exchange of insect individuals (and their genes) among the microreserves. This does not necessarily imply a strong isolation of microreserves, as they are often located within large and well-connected expanses of natural or semi-natural habitats. Nevertheless, the existing network of microreserves may prove not robust enough in the case of increasing habitat fragmentation in future.

Regrettably, due to the complete lack of insect monitoring or even systematic entomological surveys in Russia, the

effectiveness of microreserves in preserving insect communities and/or viable populations of target species cannot be reliably evaluated empirically. Nevertheless, based on theoretical grounds the system of microreserves offers a highly promising solution for insect conservation. Small area of a single microreserve significantly simplifies the withdrawal of land from any economic activity. Microreserves can also be easily created in lands, which are hardly accessible due to topography (ravines, steep slopes, etc.) and have thus low economic importance, but potentially high natural values. Besides, networks of small, but close-lying sites, may be optimal for the regional persistence of insect species, many of which are known to form typical metapopulations (Thomas and Hanski 1997). As postulated in the SLOSS debate (Gilpin and Diamond 1980) microreserve networks should also be more resistant to catastrophic events and disease spreading than a single large protected area (Soule and Simberloff 1986; Shafer 2001). Specifically in the case of insects, which typically have small area requirements and narrow but diverse habitat requirements, such networks are likely to support much larger numbers of species (Baz and Garcia-Boyer 1996), especially those that prefer transition habitats or habitat edges (Fletcher et al. 2007; Nowicki et al. 2013).

On the other hand, in the light of SLOSS debate small-scale protected areas such as microreserves have inevitable drawbacks as well. First of all, they are subject to strong impacts from the surrounding countryside (Soule and Simberloff 1986; Primack 2002), which especially within agricultural landscapes are predominantly negative (e.g. pesticides, fertilisers). In addition, microreserves are prone to succession, which constitutes a major threat to precious insect communities, often associated with early successional stages of semi-natural habitats (Fenner and Palmer 1998; Bubova et al. 2015). Over a large area the succession does not take place strictly simultaneously, so the whole set of insect species is preserved thanks to the existing heterogeneity in successional stages; in turn, small sites rarely provide such an effect. Finally, environmental stochasticity, e.g. adverse weather conditions (drought, abnormally cold winter, etc.) or habitat disturbances (floods, fires) in a particular year, can make the entire microreserve temporarily unsuitable for certain species and lead to their local extinctions, even if its state of environment is favourable in the long term perspective. Nevertheless, the role of environmental stochasticity as a factor shaping insect populations should not be overestimated, since its importance in this respect has recently been questioned (León-Cortés et al. 2003; Nowicki et al. 2009, 2015; Kajzer-Bonk et al. 2013).

More generally, the microreserves share the disadvantages of any area-based passive conservation strategies. It is commonly known that the protected status of the territory does not guarantee the preservation of specialist species with

particular requirements, and there were several cases when previously quite common species completely vanished from the Russian microreserves. A good example in this respect is the Apollo butterfly *Parnassius apollo*, which went extinct in the Prioksko-Terrasny reserve (Kochetova et al. 1986). Its caterpillars have a narrow trophic niche (Nakonieczny et al. 2007), and the imminent reason for the species disappearance was ploughing of the field adjacent to the reserve, which constituted the local reservoir of the *Sedum album* host plants (ZooClub 2017). Similar cases of the Apollo butterfly suffering from habitat loss within protected areas are in fact well known also from the Western Europe (Munguira 1995; Nakonieczny et al. 2007).

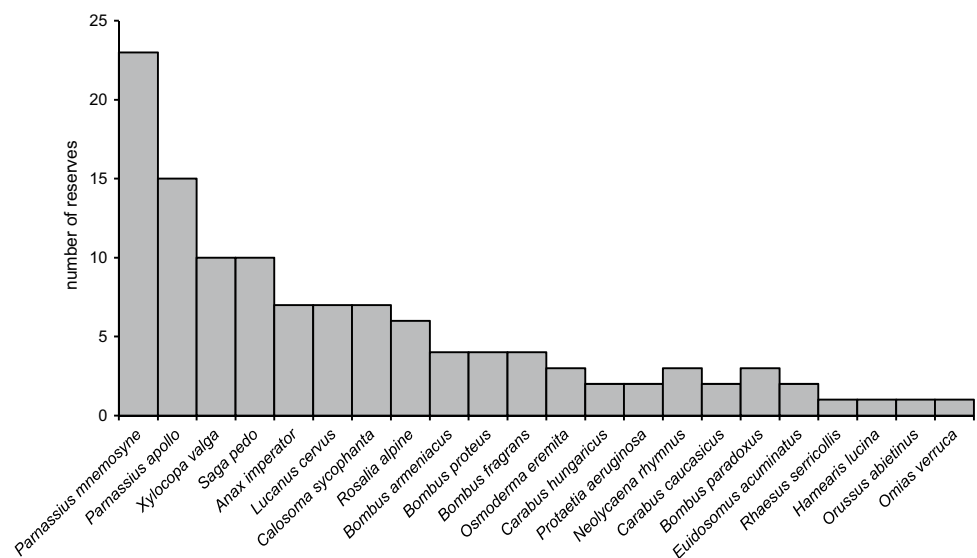
Other protected areas and their role in insect conservation

There are five ‘federal’ categories of protected areas in the Russian Federation: state nature reserves (zapovedniks; $n = 103$); national parks ($n = 48$); natural parks ($n = 64$); (4) state nature-sanctuaries ($n = 64$); and natural landmarks ($n = 8360$, including both federal and regional natural landmarks). Apart from natural landmarks, which roughly correspond in size with microreserves, the remaining categories can be classified as large-scale protected areas as typically exceeding a thousand square kilometres. In addition, the current nature conservation legislation allows the designation of further protected areas of regional and local importance, and although so far such areas have been established in only about one-third of the regions, they constitute an overwhelming majority (87%) of the Russian protected areas (Danilova et al. 2018).

Altogether, protected areas cover 11.4% per cent of the land surface of the country (Stepanitskiy 2016). Obviously, the fact that such a substantial portion of land is mostly withdrawn from economic use and devoted to the preservation of nature is highly positive for biodiversity conservation in general. Nevertheless, other than the entomological microreserves described in the previous section, the protected areas bring relatively little specific contribution to the insect conservation in Russia. It is so for several reasons.

First of all, while in theory the designation of a protected area should follow a comprehensive surveys of all the biotic and abiotic elements present within its prospective territory (Stepanitskiy and Sinitsyn 2008), in practice the decisions are typically taken on the basis of the occurrence of a few charismatic species, mostly large mammals or birds, and the generally favourable status of habitats. The information on the situation of insects of conservation concern is often disregarded in the process. It is symptomatic that among 47 state nature reserves existing in the European part of Russia only 33 (70%) officially report to include insect species listed in the Russian Red Data Book (Speranskaya and Zaitsev 2011). Moreover, in most cases no more than 1–2 species are reported and quite often they are restricted to relatively wide-spread Apollo butterfly species, namely *P. apollo* and *P. mnemosyne* (Fig. 2). While a similar quantitative assessment is not possible for the Asian state nature reserves due to the lack of comprehensive data, this fact itself indicates that the officially reported situation is even worse in this part of Russia. Obviously, this does not mean that many insect species of conservation concern are totally absent from the Russian state nature reserves since they may simply go undetected (MacKenzie et al. 2002; Kery and Schmid 2004), but rather that their status there is neglected, which is still a negative sign.

Fig. 2 The reported occurrence of Red Data Book insect species in 47 state nature reserves of the European part of Russia



Another disadvantage of Russian protected areas in respect to insect conservation is their predominant focus on the passive preservation of the current (assumably favourable) state of their ecosystems, achieved primarily through prohibiting or restricting various forms of human activity, whereas many insects would often benefit from active management of their habitats (Fenner and Palmer 1998; Thomas et al. 2011; Bubova et al. 2015). Apart from this, there is a clear imbalance between the habitat composition of protected areas and the habitats required by endangered insect species. For instance, in most regional Red Data Books insects are dominated by grassland species, but nature reserves are predominantly covered with forests and wetlands, whereas grassland habitats typically account for only a few percent of the overall protected area (Lagunov 2004; Platonova and Belova 2011).

The geographical coverage of the protected areas is also not adequately representative for the country. For instance, three insect biodiversity hotspots were identified in Russia: Caucasus, Altai-Sayan mountains, and the southern part of Primorsky Krai (Shchurov and Zamotajlov 2006; Barkalov 2007; Lelej and Storozhenko 2010), but within these regions there are hardly any protected areas in which insects are declared as the objects of conservation (Fig. 3). Similarly, there is no particular focus on faunistic studies of insects

or their monitoring in the hotspot regions. All this implies that biogeographic knowledge is not really utilised in insect conservation in Russia.

Compiling Red Data Books

Independently of the protected area-based conservation, there have been efforts to identify insect species that deserve individual protection in Russia. Already in the 1960s it was postulated that their selection should be based on objective criteria, reflecting the species vulnerability, such as extinction risk, rarity, or biogeographical relict status (Kurentsov 1964). A decade later such criteria were first formulated by Ermolenko (1973) and after slight modifications they were subsequently agreed on at the national entomological meeting (Mirzoyan 1975). According to them, the protected species should include “(i) all the useful, rare, relict and endemic insects; (ii) insects with aesthetic values; and (iii) intact communities of insects in natural biocoenoses, except of those explicitly harmful”. Such an approach represented a noticeable step away from protecting only the insects of importance for human economy, which previously used to be the case.



Fig. 3 The distribution of protected areas where insects constitute the main objects of conservation (black dots) in relation to the location of three biodiversity hotspots in Russia (hatched fragments: A=Caucasus; B=Altai-Sayan mountains, C=southern part of Primorsky Krai)

The first Red Data Book of the former Soviet Union (USSR), which appeared in 1978, contained no insects at all, and only its second edition of 1984 listed 202 insect species (Borodin et al. 1984; Nikitsky and Sviridov 1987). In turn, the Red Data Book of the Russian Soviet Republic (RSFSR) published in parallel in 1983 included 34 insect species (Eliseev 1983). Obviously, the insect fauna of RSFSR may be expected to be slightly less diverse than that of the USSR, since the former territory was about three quarters of the latter (17,125,200 vs. 22,402,200 km²), excluding the insect-rich southern regions of Central Asia, Transcaucasia, and Eastern Europe. Nevertheless, the difference should presumably be slight only, and in fact a vast majority of the insect species listed in the USSR Red Data Book occur in Russia as well. Instead, the striking discrepancy in the representation of insects in the two aforementioned Red Data Books can be mostly explained by the different methodologies adopted for species selection in both cases (Sviridov 2011). The approach used for the Russian Red Data Book was evidently more stringent and thus restrictive ('conservative'), being based on only two criteria for species inclusion, namely (i) a species being at the verge of extinction; or (ii) a species experiencing a continuous decline. With the lack of the data on species abundances, the evaluation of the latter criterion was primarily based on the reduction of distribution ranges. Nevertheless, the criterion was still highly exclusive, because the relevant information was hardly available for most insect species. The objective assessment of the extinction risk was even more problematic and hence it was arbitrarily decided that the condition of being at the verge of extinction is met only by species with at most five local populations remaining (Sviridov 2011). In contrast, the selection of species for the Soviet Union Red Data Book relied also on additional criteria, such as endemism for the state, restricted distribution or aesthetic values, thus being definitely more lenient and inclusive (Borodin et al. 1984).

Almost immediately after their publication, both the Soviet Union and Russian Red Data Books met with criticism, mostly for following the approach of the first version of the IUCN Red Data Book (1966), which in the Western world was already considered obsolete and criticised for not being based on quantitative criteria (Shchurov and Zamotajlov 2006). Soon the works on the new editions began and the guiding principles were formulated as follows (Mazin 1999):

1. A species should be listed in the Red Data Book only if it requires urgent protection; its economic, scientific, aesthetic and other values should only be treated as a secondary criterion;
2. The need for the species protection must be confirmed by objective data on the status of its populations across different parts of the distribution range;

3. Species should be selected regardless of their taxonomic position, i.e. all insect groups should equally considered;
4. For the selection of species it is desirable to take into account the interactions between different species.

With the collapse of the Soviet Union in 1991, the preparation of its Red Data Book was no longer on the agenda, and publishing its Russian version was delayed considerably. The long-awaited book eventually came out in 2001, and until now it remains the most actual edition. It comprises 95 insects species, representing five taxa: Odonata—1 species; Orthoptera—2 species; Coleoptera—36 species, Hymenoptera—23 species; and Lepidoptera—33 species (Danilov-Danilyan 2001; Tikhonov 2002). Although, the species selection has been based on much more objective criteria than in the case of the first Russian Red Data Book, it is still widely believed that listing the species does not always truly reflect their threatened conservation status. This is particularly true for some charismatic and/or wellstudied, yet relatively common Lepidoptera, such as the butterflies *Neolycaena rhymnus* or *P. mnemosyne*, and moth *Actias artemis* (Gorbunov and Murzin 2009; Poltavsky and Poltavskaya 2010). In turn, less popular species, for which even basic information on their distribution in Russia is hardly available (Fig. 4), are less likely to be included in the Red Data Book.

In general, certain taxa appear overrepresented in the Russian Red Data Book, while many others are likely to be somewhat overlooked. The former group comprises honey bees and bumblebees (*Apis* spp., *Bombus* spp.), stag beetles (Lucanidae), and swallowtail butterflies (Papilionidae), with nearly or over 10% of their species listed in Red Data Book, whereas the representation of other taxa is usually ca. 1% (Table 1). The over-inclusiveness of 'flagship' insect taxa, popular due to their charismatic appearance and/or important role in ecosystems, is obviously not only a Russian ailment, but rather a general problem of virtually all Red Data Books or Red Lists across the world (cf. Collins and Morris 1985; Henning et al. 2009; Nieto and Alexander 2010; van Swaay et al. 2010; Cardoso et al. 2011). The situation is well understandable, because in the case of popular species being subject to numerous studies it is simply easier to gather evidence that they meet the defined criteria. However, in the Russian reality such an over-inclusiveness of the Red Data Book is not merely an academic problem, because unlike the IUCN Red Data Book and most of their national editions or Red Lists, which are not legally binding documents, but only provide recommendations, in Russia listing a species automatically entails its nationwide legal protection. Moreover, the protected species status is granted regardless of the threat category, i.e. for all the species classified as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

In practice, however, such a status brings hardly any active conservation of a species, and it is limited to a ban

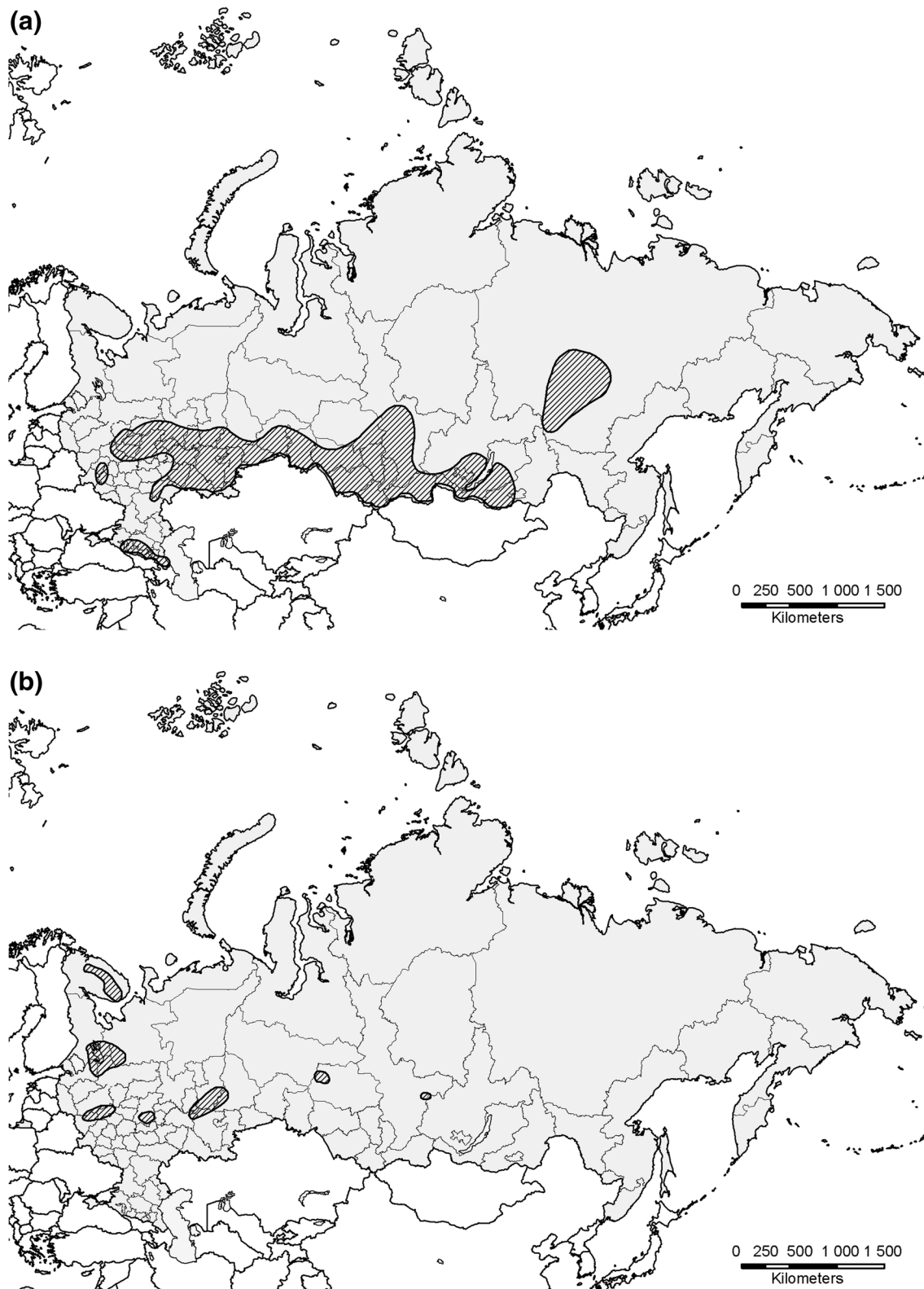


Fig. 4 The known distribution ranges (hatched areas) of selected insect species listed in the Russian Red Data Book: **a** the butterfly *Parnassius apollo*—an example of intensively studied species with

well-known distribution; **b** the sawfly *Acantholyda flaviceps*—an example of species with only fragmentarily known distribution

Table 1 Representation of insect groups in the Russian Red Data Book

Taxon	Species richness in Russia		Red Data Book species	
	<i>N</i>	Source	<i>n</i>	%
Dragonflies and damselflies (Odonata)	154	Haritonov and Eremina (2010)	1	0.65
Hymenopterans (Hymenoptera)			23	
Sawflies (Symphyta)	ca. 1100	Sundukov and Lelej (2009)	10	0.91
Bradynobaenid wasps (Bradynobaenidae)			1	
Cuckoo wasps (Chrysididae)			1	
Ants (Formicidae)	264	Belokobylsky and Lelej (2017)	1	0.38
Digger bees (Anthophorini)			1	
Honey bees (<i>Apis</i> spp.)	2	Engel et al. (2009)	1	50
Bumblebees (<i>Bombus</i> spp.)	90	Byvaltsev (2009b)	8	8.89
Butterflies and moths (Lepidoptera)	ca. 8900	Sinev (2008)	33	0.37
Skippers (Hesperiidae)	55	Klepikov (2002)	1	1.82
Nymphalids (Nymphalinae)	130	Gordeev (2016)	2	1.54
Satyrids (Satyriinae)	198	Tuzov et al. (1997)	2	1.01
Swallowtails (Papilionidae)	35	Streletsov and Gluschenko (2005)	5	14.29
Lycaenids (Lycaenidae)			8	
Metalmarks (Riodinidae)			1	
Hawk moths (Sphingidae)			2	
Owlet moths (Noctuidae)			6	
Silk moths (Bombycidae)			1	
Tiger moths (Arctiidae)			2	
Puss moths (Notodontidae)			1	
Tussock moths (Lymantriinae)			2	
Orthopterans (Orthoptera)			2	
Beetles (Coleoptera)			36	
Longhorn beetles (Cerambycidae)	583	Danilevsky (2014)	9	1.54
Weevils (Curculionidae)			5	
Ground beetles (Carabidae)	ca. 1950	Belova (2014) and Koshkin et al. (2016)	12	0.62
Scarab beetles (Scarabaeidae)	435	Kabakov (2006)	6	1.38
Stag beetles (Lucanidae)	20	Zinchenko and Ivanov (2006)	2	10
Leaf beetles (Chrysomelidae)			1	
Click beetles (Elateridae)			1	

on killing or capturing its individuals, which for insects is tantamount with the ban on collecting its specimens. Occasionally, this may in fact have an adverse effect, since the declaration of legal protection of previously little known species increases public interest in them, which also attracts illegal collecting. On the other hand, collecting is rarely (if ever) responsible for insect species declines (cf. Thomas et al. 2011). Instead, it is the destruction or deterioration of their habitats, which almost always constitutes the most serious threat (Collins and Thomas 1991). Regretfully, the legal protection of a species is not associated with the protection of its habitats in Russia, as it is now required in the European Union member states according to the Habitats Directive. For the effective conservation of insect species in Russia it would be thus highly desirable to follow the

example set by the Habitats Directive, and introduce legislative changes aimed at the preservation of insect habitats. Some of the solutions are fairly evident, e.g. prohibition of pesticide and fertiliser use at the edges of the cultivated areas and near hedge rows, or creation of uncultivated strips around large-scale agricultural fields to serve as refugia for natural enemies of pest species, whereas others may be quite specific, e.g. restriction on the use of antiparasitic drugs such as ivermectins, which are toxic for dungfeeding invertebrates (Strong and Wall 1994; Conforti et al. 2018). Besides, many insect habitats may benefit from active management, such as mowing or grazing (see Bubova et al. 2015). Hence, certain economic activities may be compatible with insect conservation and they should not only be allowed, but also encouraged within protected areas. In turn, in agricultural lands it

would be desirable to seed field margins with nectar-rich herbs such alfalfa, sainfoin or phacelia. These are known to provide vital resources for a wide range of pollinating insects, supporting their viable populations (Kovalenko 2009; Medvedsky and Medvedskaya 2010).

It has recently been postulated that assigning Red Data Book categories and thus legal protection to insect species in such vast and diverse country as Russia should optimally derive from the analyses of its regional Red Data Books (Poltavsky and Poltavskaya 2010). Nevertheless, at present this ambitious goal seems unachievable despite the wealth of regional publications. Out of 85 Russian regions, 75 have their own Red Data Books, and in many of them two or even three editions (e.g. in Karelia) have been published so far; while the early editions sometimes date back to the Soviet era, the most recent ones usually appeared in the first decade of the twenty-first century. The problem lies, however, in the inadequate reliability of the regional editions, as we elaborate below.

The entomofauna of many regions of Russia is poorly studied, so it is hardly ever possible to follow strictly the objective criteria of the IUCN due to the lack of data on species abundance and occurrence. While normally species population trends can be inferred from the changes in habitat availability, as long as basic knowledge of the species ecology and distribution is available, this is again rarely realistic in such a vast and diverse country as Russia, where comprehensive information on the state of habitats is lacking as well. All concerned, the species status evaluation is frequently done using the purely subjective ‘expert assessment’ approach (Poltavsky 2011). Consequently, more appealing insects species (those of large size, unusual shape, or interesting colours) are more likely to be listed even if they are not really at risk (Shilenkov 2010). The best example here are probably tiger moths (Arctiidae), highly represented in almost all Red Data Books of the Siberia region, in spite of the fact that they mostly live in the highlands or other remote places under no particular treat. Similarly, even within less charismatic groups such as ground beetles, large species dominate the lists and small ones are hardly ever considered (Shilenkov 2010).

Furthermore, the selection of species listed in the regional Red Data Books often depends on the interests, expertise, and the number of people and institutions involved in drafting the books, which is evident in the high variation in the numbers of the listed insect species among the books. Obviously, these numbers are affected by the richness of regional insect fauna so much variation in them should be expected, however striking differences exist even between the neighbouring regions with comparable size and fairly similar entomofauna. For instance, the Red Data Book of Karelia includes 255 insect species, while that of the adjacent Arkhangelsk oblast contains less than 50 species. Further

pair-wise comparison of neighbouring regions reveal analogous discrepancies, e.g. between the Zabaykalsky Krai and the Amur oblast (75 vs. 26 species), the Novosibirsk oblast and the Altai Krai (58 vs. 30 species) or the Chuvash Republic and the Mari El Republic (145 vs. 84 species). The above two- to five-fold differences in the listed species numbers apparently indicate the lack of concordance in the principles of species selection procedures, thus undermining any joint analyses of their outcomes.

Sozological analysis as alternative way of species prioritisation

While both the Russian and regional editions of Red Data Books have been repeatedly criticized for their subjectivity in their species listing, especially concerning insect fauna (Bol’shakov 2008), it has been postulated that the IUCN criteria should be precisely followed as they are well-designed, clearly structured, standardised, objective, and theoretically sound (Korb 2015). However, as previously explained, strict adherence to the IUCN criteria does not appear feasible in the Russian reality due to the lack of detailed quantitative data on the state and trends of most insect species. In such a situation a useful alternative seems to be offered by sozological analysis, which most recently has been increasingly used in regional Red Data Books (Lagunov 2011, 2015; Haritonov et al. 2014; Popov and Shapovalov 2014). The term “sozology” was first introduced by Goetel (1966) and it refers to the study of nature protection (from Greek “sozo” = to protect). The sozological analysis combines numerous criteria which reflect both the ecological status of focal species as well as their values for human society. Each criterion is evaluated through a simple rank-based scoring system and assigned a specific weight.

The most versatile tool applied in sozological analysis is the Saksonov–Rozenberg matrix (Saksonov and Rozenberg 2000), later adapted for insects by Lagunov (2011), who modified the weights given to particular sozological characteristics used as criteria. The matrix comprises twelve criteria with the weights ranging from 1 to 5 (Table 2). A species is scored 1 to 4 points for each of the criteria. These scores are multiplied by the criteria weights and the integrated sozological assessment of the species is subsequently derived as the sum of the points obtained (Table S1 in the Electronic Supplementary Material). Based on this summarised score the species can be classified as Critically Endangered (120–136 points), Endangered (102–119 points), Very Rare (85–101 points), Moderately Rare (68–84 points) or Non-endangered (< 68 points) (Lagunov 2013). Both categories of rare species are assumed to correspond roughly to the IUCN category of Vulnerable species. The comparison of the species lists of the regional Red Data Books and the

Table 2 Saksonov–Rozenberg matrix as applied in sozological analysis for selecting insect species of conservation importance (Lagunov 2011)

Criterion no.	Sozological characteristics of species	Weight	Score			
			1	2	3	4
1	Relative abundance (in typical habitats)	5	Dominant	Common	Rare	Very rare
2	Number of inhabited sites in the region	5	> 30	11–30	6–10	1–5
3	Trend of change in abundance	4	Increasing	Stable	Slightly decreasing	Sharply decreasing
4	Vulnerability to anthropogenic threats	4	Weak	Moderate	High	Very high
5	Ecological niche breadth	3	Broad	Moderate	Narrow	Very narrow
6	Biogeographic significance	3	Species within core area of its continuous distribution	Species within core area of its disconnected (= patchy) distribution	Species at the edge of its distribution	Species in enclave out of its standard distribution
7	Distribution range	3	Intercontinental species	Continental endemic	Regional endemic	Local endemic
8	Territorial protection (presence within protected areas)	2	Protected areas with various protection regimes	Only faunistic protected areas	Only non-specialised protected areas	None
9	Official conservation status	2	Listed in the IUCN Red Data Book	Listed in the Red Data Book of the Russian Federation	Listed in other regional Red Data Books	None
10	Scientific value	1	Insignificant	Moderate	High	Very high
11	Aesthetic value	1	Insignificant	Moderate	High	Very high
12	Economic value	1	Insignificant	Moderate	High	Very high

Table 3 The comparison of the numbers of insect species included in the regional Red Data Books and the outcomes of sozological analyses for the selected regions of Russia

Region (species group)		Udmurt Republic (butterflies)	Chelyabinsk Oblast (all insects)	Republic of Adygea (all insects)
Red Data Book categories	Critically Endangered	–	8	–
	Endangered	–	11	23
	Vulnerable	13	27	52
	Near threatened	1	49	47
	Least concern	–	–	–
	Total	14	95	122
Source		Baranova (2012)	Korytin (2005)	Zamotajlov (2012)
Sozological analysis categories	Critically Endangered	7	–	–
	Endangered	12	5	84*
	Very Rare	12	39	48
	Moderately rare	27	63	–
	Non-endangered	65	–	–
	Total	123	107	132
Source		Adakhovskiy (2017)	Lagunov (2013)	Zamotajlov et al. (2015)

Critically Endangered and Endangered species were not distinguished in the sozological analysis for the Republic of Adygea and thus the number marked with asterisk refers to both categories pooled together

outcomes of zoological analyses conducted for the same regions indicates that the latter are generally more inclusive (Table 3), which is understandable since the species on which there is only limited ecological knowledge can also be considered. Furthermore, zoological analyses typically assign more species to higher categories of conservation concern, which in the case of Red Data Books are more difficult to be granted if the information on the magnitude of species decline is lacking.

The approach adopted in zoological analyses seems a highly promising solution, combining applicability for data-deficient species (which is typically the case of insects in Russia) with objectivity and reliability of the assessment. Although developed independently and virtually unknown outside Russia and the neighbouring states formerly making Soviet Union, this simplified method of prioritising species of conservation concern is not entirely unique. Several alternatives to the standard Red List categorisation following IUCN criteria were suggested and successfully applied in the past; combining various indices of species rarity, vulnerability or taxonomic distinctiveness (e.g. Kattan 1992; Freitag and van Jaarsveld 1997; Fattorini 2010, 2011, 2014; Matenaar et al. 2015; Miličić et al. 2017). The Russian zoological analyses are generally based on similar principles (except for disregarding taxonomic distinctiveness), with the rare and more vulnerable species receiving higher scores and thus being assigned to higher categories of conservation concern. However, their peculiarity is the fact that some consideration is also given to scientific, aesthetic and economic values of evaluated insect species.

Conclusions

With its extensive territory and high diversity of natural habitats, Russia faces tremendous challenges in the efforts to conserve its entomofauna. The most obvious problem is the lack of basic information on the state and trends of the population of all insect species except for the few well-studied ones. While it can be argued that the lack of country-wide monitoring schemes is to blame for this, such a situation is in fact a reality in most other countries as well. Even in the Western world with its long tradition of strong public involvement in biodiversity monitoring, insect monitoring programmes are restricted to several popular groups (butterflies, dragonflies, selected beetles) in just a few countries (van Swaay et al. 2008; McGeoch et al. 2011; Sebek et al. 2012). This may be enough for the purpose of using insects as indicators of large-scale biodiversity trends (Feest 2013), but it does not help in the objective selection of species of conservation concern in all other insect groups.

Due to the lack of relevant data, the Russian system of drawing the lists of insects included in the national and

regional Red Data Books, and thus legally protected, has long been based on subjective expert assessments. The system has been widely criticised for both listing some charismatic species under no particular threat as well as for omitting others which deserved to be conserved but simply do not attract adequate expert attention. The recently proposed use of zoological analysis for prioritising species appears a promising solution in this respect. The clearcut quantitative criteria of the IUCN may be very well-grounded in the scientific theory, but they are often difficult to be applied in practice because of data shortage (Mace et al. 2008). In turn, zoological analysis relying on qualitative ranking system can be applied for data-deficient species, but it still remains an unbiased rule-based procedure. Moreover, it is relatively flexible and can be easily adjusted, e.g. through removing certain criteria, adding new ones, or modifying their weights, if the conservation priorities change. This may be helpful in the ongoing process of regionalisation of the lists of conservation concern species, which is indeed highly recommendable for an extensive and diverse country like Russia.

Unfortunately, declaring the status of legally protected species is often the end, and not the beginning of conservation efforts in the Russian reality. There is a strong focus on the passive protection of the species themselves, and not on the active preservation of their habitats. Such an approach may occasionally work in the conservation of some large vertebrates, for which direct extermination by humans is the main driver of decline, but it is not effective for insects, usually associated with particular habitat types, many of which require continuous management to persist (Fenner and Palmer 1998; Bubova et al. 2015). A noteworthy exception in the predominantly passive insect conservation in Russia are the entomological microreserves dedicated to some insect groups. Promoting this form of nature protection areas is not only highly recommendable for Russia, but it also seems a potentially useful solution for many other countries.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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