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Conservation of orthopteran biological diversity relative to landscape change in temperate Eurasia

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This paper discusses orthopteran conservation in temperate and subtropical Eurasia. Distribution patterns of the orthopteran centres of diversity and endemism are described. Eleven main areas of diversity and endemism are identified. The majority of rare taxa are associated with these areas. The distribution of protected areas is discussed in relation to orthopteran conservation. Some proposals for inclusion or exclusion of certain orthopteran species on the IUCN and national Red Lists are debated. Emphasis is given to landscape heterogeneity and ecosystem mosaics for orthopteran biodiversity conservation.

Keywords: Orthoptera; grasshoppers; katydids; populations; communities.

Introduction

Orthopteran insects are a major taxonomic group in natural and disturbed ecosystems of temperate and subtropical Eurasia. These insects are abundant and colonize natural (particularly grasslands) and anthropogenic landscapes (meadows, agricultural fields, lawns, buildings, etc.). Among them are many potential pests. Therefore, we recognize many orthopteran insects as keystone species. However, this order also includes many rare species. Generally, the ranges of these rare species are small and abundance is low. Indeed, orthopteran conservation is highly important in meadow, cropland, desert and mountain landscapes of temperate and subtropical Eurasia. The main aim here is to discuss the essential Orthoptera conservation issues in Palaearctic Eurasia. These issues include (1) distribution patterns of centres of diversity and endemism relative to the distribution of protected areas, (2) the orthopteran Red Lists and (3) changes of orthopteran distribution, populations and communities as a result of human activities.

Centres of diversity and endemism

The distribution of the centres of diversity and endemism relates to the general distribution of Orthoptera. The main centres are in 11 areas of temperate and subtropical Eurasia (Fig. 1):

(1) The west Mediterranean region (many endemic pamphagids and katydids, e.g. *Amphiestres* Fieber, *Pterolepis* Rambur, *Thyreonotus* Audinet Serville, *Ephippigerida* I. Bolivar, *Acinipe* Rambur, *Cophopodisma* Dovnar-Zapolskij and others).

(2) The mountains of the eastern Mediterranean, the Caucasus including (*Ancistura* Uvarov, *Poecilimonella* Uvarov, *Bucephaloptera* Ebner, *Paranocarodes* I. Bolivar, *Oropodisma* Uvarov and others).

(3) The mountains of the Arabian Peninsula (*Dhofaria* Popov, *Rashidia* Uvarov, *Fitzgeraldia* Uvarov and others).

(4) The mountains of West Iran (*Dinaria* Popov, *Wiltshirella* Popov, *Grigorija* L. Mistshenko and others).

(5) The Turan Deserts (*Grylliscus* Serg. Tarbinsky, *Ammoxenulus* Bei-Bienko, *Bufonacridella* Adelung and others).

(6) The mountains of Tien Shan, Pamiro-Allay and the Hindu-Kush in Afghanistan (*Ferganusa* Uvarov, *Squaminana* Zeuner, *Pravdiniana* Sergeev et Pokivajlov, *Melanotmethis* Uvarov, *Mizonocara* Uvarov and others).

(7) The mountains of the West Himalayas and south-western Tibet (*Hyphinomos* Uvarov, *Paedomastax* C. Bolivar, *Dicranophyma* Uvarov and others).

(8) The mountains of south-eastern Tibet and adjoining slopes of the Himalayas (*Kingdonella* Uvarov, *Ptygonotus* Serg. Tarbinsky, *Dysanema* Uvarov, *Orinchippus* Uvarov and others).

(9) The arid region of Mongolia and China (*Bieukoxenus* Čejchan, *Eulithoxenus* Bei-Bienko, *Pseudotmethis* Bei-Bienko, *Sinotmethis* Bei-Bienko and others).

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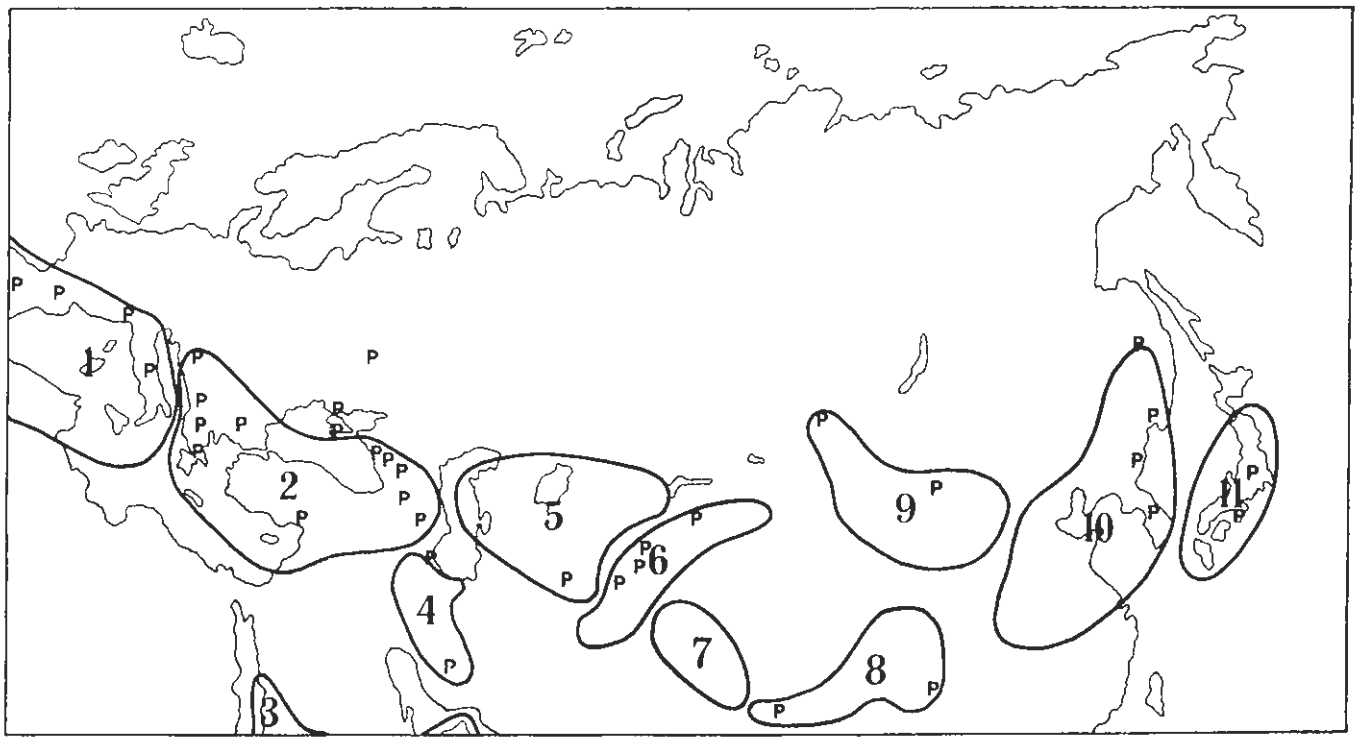

Figure 1. Distribution of main areas of orthopteran diversity in temperate and subtropical Eurasia. I–11,main areas of diversity (see text). P, main protected territories important for Orthoptera conservation.

(10) The nemoral regions of East Asia (local endemics include the genera *Uvarovites* Serg. Tarbinsky, *Nigrogryllus* Gorochov, *Clinotettix* Bei-Bienko and others).

(11) Japanese islands (*Parapodisma* L. Mistshenko, the genera of Meconematinae and others).

All these main areas of orthopteran diversity are situated in the southern part of the Palaearctic, particularly in mountainous, desert and Mediterranean regions.

Overall, the distribution of these centres coincides with the centres of diversity of many other animals and plants. This is important in that most of these areas are arid or semi-arid, and both lowlands and mountains.

Some of these orthopteran insects are protected in nature reserves. Many rare and important genera and species inhabit montane, steppe and desert reserves. Among them is *Bienkoxenus beykienkoi* (I. Stebaev) (in the Ubsunur Reserve, on the border of the southern Siberian Mountains and Mongolia), *Ammoxenulus* spp. (in the Repetek Reserve, in the Turan Desert), *Paracyphoderris erebeus* Storozhenko (in the Komsomolsky Reserve, in the southern taiga of the Far East), many endemic *Conophyma* spp. (in some montane reserves of the Central Asian mountains) and a few local species of *Primnoa* Fischer de Waldheim (in the Ussuriysky Reserve, the deciduous forests of the Far East). Not all centres of biological diversity coincide with distribution of natural reserves, national parks, etc. and many rare orthopteran insects are distributed in unprotected areas that have been changed by human activity (Fig. 1). It is important that new natural reserves are created, particularly in the mountains of temperate Asia.

Eurasian Orthoptera and the Red Lists

Another issue concerns international, national and regional 'Red Data Books' (RDBs) and the 'Red Lists'. The new Red List categories (IUCN, 1994) are a valuable starting point, but most of the criteria can be used for insects only after expensive and focused studies.

The most recent list, *1996 IUCN Red List of Threatened Animals* (IUCN, 1996) and its updated electronic edition (www.wcmc.org.uk/species/animals) may be criticized with respect to threatened orthopteran taxa of temperate and subtropical Asia. Most Eurasian species on this list are distributed in Hungary and Romania (nine out of 13) and one in Spain. Yet three of these are widely distributed in the steppe and semi-desert regions of Eurasia (*Saga pedo* (Pallas), *Onconotus servillei* Fischer de Waldheim and *Stenobothrus eurasius*

Zubovsky) and are not confined to Hungary and Romania. *Stenbothrus eurasius* is widely distributed and is abundant in the Siberian and Central Asian steppes. *Stenbothrus eurasius* should therefore be excluded from the Red List. Conservation of this grasshopper in Hungary however, may be of local importance.

In contrast, some very rare taxa are omitted from the Red List. An example is *Bradyporus multituberculatus* Fischer de Waldheim which should be rated as critically endangered (CR) or endangered (EN). Two Iberian species (*Steropleurus castellanus* I. Bolivar and *Omocestus burri* Uvarov) appear to be extinct (EX) (Gangwere and de Viedma, 1984).

Some common orthopteran insects have been included in regional RDBs, including the Russian one. Certain species listed as CE or EX have severely fragmented populations and should really be regarded as endangered (EN) or vulnerable (VU). Indeed, some of them are widely distributed (*S. pedo*, *Ceraeocerus fuscipennis* Uvarov, etc.). The majority of these rarer species inhabit mountainous or desert regions, mostly in the main centres of biological diversity. Many of these species are especially threatened by overgrazing and deforestation. However, most should be regarded as data deficient (DD).

However, if we take this approach, many endemic species, particularly those inhabiting centres of high diversity, will be assigned DD in both the international Red List and the national RDBs. The result would be long lists with little meaning.

Our field experience in Eurasia suggests that most of these endemic species need no special management. Often we catalogue species as rare, simply because it was missed during surveys. Often this is because the species lives in a specific habitat or is active for only a short time, etc. For example, the well-known katydid *S. pedo* colonizes not only native meadows and shrubs but also anthropogenic habitats. The local populations of this species appear to be viable, but, in addition, *S. pedo* also now inhabits some parts of western North America (Cantrall, 1972). Should we be including this species on the Red List? Another example is the Pamiro-Allay montane endemic *Bienkoa fedtschenkoi* (Zubovsky). This species actively uses anthropogenically disturbed areas, including fallows for egg laying and migration (Tchernjachovskij, 1988). So although this species is very rare, it appears that certain anthropogenic disturbances are enhancing its chances of survival.

To include a species on the Red List or in an RDB we clearly need at least some basic information on population distribution and dynamics.

Biodiversity related to landscape changes and population structure

Landscape scale is an important aspect of biodiversity conservation (Bridgewater *et al.*, 1996). Human activity usually changes local natural landscapes in a way that is often important for orthopteran insects. The changes brought about depend on how the landscapes are used (grazing, crops, urban expansion, etc.). In cases of severe landscape fragmentation and attrition, orthopteran populations can become dispersed and highly localized (Samways, 1997; Samways and Sergeev, 1997). Most species have a low level of abundance. As a result, population decrease and fragmentation of many grasshoppers and katydids are mainly determined by overgrazing and landscape disturbances (building and road construction, ploughing, irrigation, etc.). However, many orthopteran species use changed landscapes successfully, while Rentz (1993) emphasized the importance of small patches of remnant, native vegetation for orthopteran conservation.

Our data show that low to medium levels of human disturbance can create highly heterogeneous landscapes which support high orthopteran diversity. Such landscapes consist of complex mosaics of stable and unstable plots with different types of habitats in which orthopteran populations survive.

In many cases, new habitat types are created by human activity and such habitats can be important for allowing an increase in geographical distribution of both some native and exotic forms.

The landscape of the Central Altai Mountains (the Edigan River basin) is a mosaic of natural (forests with clearings, meadows, steppes and semi-desert) and anthropogenic (agricultural fields, grazed meadows, roadsides and clearings) patches. The areas occupied by these different habitat patches are more or less equal, with a high Orthoptera species richness. Indeed, 44 species of Orthoptera occur in an area less than 50 km^2 (Sergeev and Kazakova, 1994). Almost half the species are relatively abundant (usually more than 100 specimens per hour of searching). It is interesting that some grasshoppers (*Podisma pedestris* (Linnaeus), *Ognevia longipennis* (Shiraki), *Chorthippus hammarstroemi* (Miram)) frequently colonize and become abundant in anthropogenic habitats (fields and roadsides). In other valleys of Central Altai, orthopteran diversity is relatively low, usually with approximately 26 species per 50 km^2 (Muravjeva, 1997). The main reason for these lower richness seems to be reduced landscape heterogeneity in these other areas of the Central Altai.

Another area which has been intensively studied is the southern environs of Novosibirsk (Novosibirsk Akademgorodok). Local landscape patches include forests, forest-steppes, steppes, meadows, swamps and diversity of anthropogenic habitats (fields, fallows, pastures, gardens, roads, roadside verges and buildings), the patches of which occur in approximately equal proportions. Here, orthopteran diversity was slightly lower (34 species) (Sergeev, 1987). Human activity here has been comparatively high, which seems to have caused some species to become locally extinct (*P. pedestris* and *Myrmeleotettix maculatus* (Thunberg)). However, some xerophilous species have established in this area, e.g. *Dociostaurus brevicollis* (Eversmann) *Glyptobothrus dubius* (Zubovsky), *Oedipoda caerulescens* (Linnaeus) by northward spread and *Chorthippus fallax* (Zubovsky) by westward spread. *Dociostaurus brevicollis*, *G. dubius* and *O. caerulescens* readily use dry roadsides, as well as the natural habitat of sand bars. *Chorthippus fallax* prefers dry, grazed meadows or lawns on southern slopes.

We studied re-establishment of orthopteran communities and diversity on the two neighbouring meadow plots. Vegetation and soil cover of one of them was destroyed during building construction in 1986. Although vegetation cover had not yet reached a plagioclimax, species diversity and community structure were almost equal on both plots after four years (Fig. 2).

Analysis of geographical distribution patterns of three closely related species (*Chorthippus parallelus* (Zetterstedt), *Chorthippus montanus* (Charpentier), and *Chorthippus fallax*) has shown that they occupy different habitats in both Central Altai and in Novosibirsk. *Chorthippus parallelus* is abundant in meadow and steppe habitats, while *Chorthippus montanus* prefers wet meadows and forest clearings. In contrast, *Chorthippus fallax* occurs in dry steppes and meadows, under significant anthropogenic pressure. This means that heterogenous landscape structures allow all three species to occupy the same local area without competing with each other for resources.

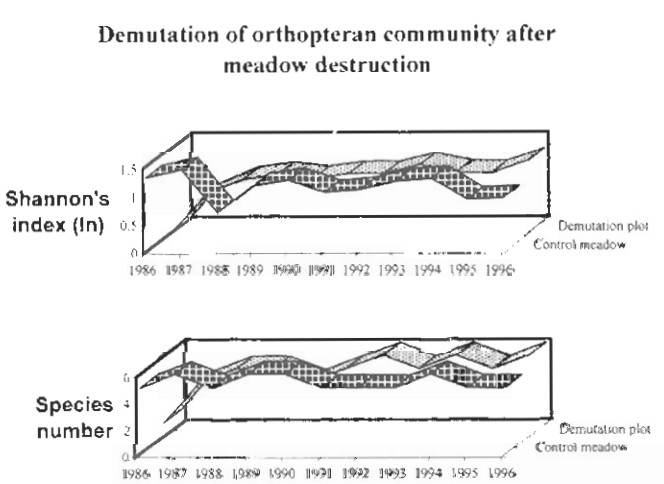

Figure 2. Long-term dynamics of meadow orthopteran communities in the vicinity of Novosibirsk.

Similar changes have also been described for Central Europe. Nagy (1987) emphasized the role of human activity at the landscape scale in decreasing and fragmenting locally characteristic and zoogeographically interesting (particularly relic and endemic) species associations (e.g. *S. pedo*, *Paracaloptenus caloptenoides* (Brunner) and *Pararcyptera microptera* (Fischer de Waldheim) around Budapest. Some formerly rare Orthoptera species now seem to be extinct in the area owing to human activities (deforestation, building, road construction and tourism). In contrast, other species (e.g. *Pholidoptera aptera* (Fabricius)) have benefited from disturbed landscapes (particularly openings and clearings) and have increased their range and population density. Some Mediterranean species (*Omocestus petraeus* (Brisout-Barneville), *Euchorthippus pulvinatus* (Fischer de Waldheim), *Oedaleus decorus* (Germar) *et al.*) have used sandy habitats and steppe slopes for spreading northwards.

Köhler (1996) assessed population vulnerability of grasshoppers and katydids in highly fragmented Central European landscapes. He emphasized that some small orthopteran populations (approximately 50–200 specimens) in very small habitats (100–600 m^2) can persist for a long time. For instance, small populations of *Oedipoda germanica* (Latreille) survive in suitable habitats of less than 500 m^2 for several years (Wagner and Berger, 1996). *Oedipoda caerulescens* is another example of a grasshopper with a highly-localized, insular-type population distribution in Central Europe (Appelt, 1996). This species colonizes approximately half of the suitable biotopes near Haale/Saale (Germany). It is able to establish on dry, stony fields and use them as corridors for spreading. A similar situation exists for the katydid *Platycleis albopunctata* (Goeze) (Gottschalk 1996). This species is able to cross unsuitable landscapes by using patches of suitable habitats as stepping stones for several generations.

Conclusion

All centres of orthopteran diversity and endemism should be recognized as important conservation hot

spots. Most of the rare species are distributed inside such areas. However, in temperate and subtropical Eurasia, these centres often coincide or overlap with areas of locust and grasshopper outbreaks (Sergeev, 1997). This makes it essential to change the pest protection strategy so as not to affect these rarer species adversely.

Human disturbance needs to be modified, with grazing, ploughing and logging being more strongly regulated. This is particularly important in arid and montane areas of temperate and subtropical Eurasia. However, in many cases, less intense human activity, which creates heterogenous landscapes, is important for increasing orthopteran diversity and for allowing others to spread. Populations of non-native species often occur in heterogenous landscapes. Such intermediately disturbed areas can also be important for re-establishment and support of orthopteran diversity.

We should aim at studying each particular species using temporal and spatial approaches at the different scales. Assessing a small spatial part of a population or a community or simply a geographic range is insufficient for assessing the survival potential of a species. In addition, we should change our Orthoptera conservation strategy and management in Eurasia, with much more emphasis on conserving whole ecosystems, landscapes and regions, of which Orthoptera species are part.

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