Grasshoppers in steppe areas of the south-eastern West Siberian Plain: Centennial transformations of biodiversity

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Abstract. The goal of this paper is to evaluate some general trends of species range shifts in the steppe areas of the south-eastern West Siberian Plain. Two sets of distribution data of grasshoppers are compared: (1) for the first half of 20th century and (2) for 1972–2019. A series of digital maps was generated by MapInfo. Shifts of species distribution patterns are discussed. All grasshopper species may be split into three groups: (1) acridids without evident changes in their distribution; (2) species with local range boundaries shifted northwards and northeastwards; new colonies of such forms are usually found in the northern steppe and even in the forest-steppe and/or on the right side of the Ob River; (3) grasshoppers which became rare. Among them is the Siberian grasshopper, the very common pest in the first half of the 20th century. Some changes into grasshopper distribution may be associated with global warming, but others can be explained by regional and local variations in human activities. Extension, intensification, and changes of human activities may result in continuous elimination of some local populations. This means that the general strategy of management of acridid assemblages and populations should incorporate both data and technologies concerning rare species populations and new approaches to pest control and monitoring.

1. Introduction
Grasshoppers (Orthoptera, Acridoidea) are well known insects, often very common in grasslands. Some of them can damage crops, pastures, and hayfields and may be considered as possible pests, especially in agricultural regions. In South Siberia, dense populations of several widely distributed acridid species may be observed, especially during outbreaks. However, this taxon also includes some endemic and rare species deserving conservation measures, e.g., in the local steppes and in the adjacent mountains [1–4]. Besides, the south-eastern part of West Siberian Plain has been significantly transformed by human activity, especially in the beginning and in the middle of the 20th century. Such regional and local transformations and/or also climate changes may result in some shifts in species and population distribution.

Some data describing grasshopper diversity and distribution over the south-eastern part of West Siberian Plain were published in the 19th century, but more or less comprehensive studies of local grasshoppers started only in the 1920s [5–8]. Almost all data for the first half of the 20th century were analyzed and summarized by R.P. Berezhkov [9]. He listed numerous localities of acridid species known from West Siberia. This allows us to compare shifts in species distribution for the first half of
the last century and for last several decades. The goal of this publication is to evaluate some general trends of species range shifts in steppe areas of the south-eastern West Siberian Plain.

2. Materials and Methods
Original data were collected from 1979 until 2019 in the south-eastern West Siberian Plain. This huge area borders the Irtysh River to the west and south-west, Kuznetsk Alatau to the east, and the Altay Mts. to the south-east. Its northern boundary is approximately defined by the 56th parallel north. This territory was covered with natural vegetation such as grasslands (from meadows to dry steppes) and forests [10]. The main part of the plains was transformed in agricultural lands (fields and pastures). There are also some flood-plains with meadows and forest patches, river and lake terraces with meadows, steppes and some forests, solonchaks, and swamps.

The acridid ecological distribution patterns were characterized by quantitative and qualitative samples collected in natural and transformed ecosystems, usually in the middle of summer when adults dominated. Samples captured during a fixed period of time were made in each plot investigated [1, 11, 12]. Using this method, insects were caught with a standard net (40 cm diameter) over a period of 10–30 minutes. Results for each sample were recalculated for an hour. In many habitats, acridid densities were also counted on 25–150 randomly placed plots 0.25 x 0.25 m² (in some cases 0.5 x 0.5 m²). After that the average densities were estimated for every habitat studied. Some old materials, mainly from the expeditions of Novosibirsk State University (1972–1977), were also used. In this case, we tried to check and correct previous species identifications.

We obtained geographical coordinates by the Glonass/GPS receivers. For localities studied before 2000 we used Google Earth Pro (©Google, 2020) to get the same parameters. The main part of studied specimens is in the collections of Novosibirsk State University and the Institute of Systematics and Ecology of Animals (Novosibirsk).

We analyzed data from different publications for the first half of the 20th century [5–9] and determined geographic coordinates for almost all localities. In 1972–2019 data were collected in 81 localities in the Baraba and Kulunda steppes (between the Irtysh and Ob Rivers) [13] and 39 localities on the right side of the Ob River. Maps of species distribution were produced on the basis of geographic coordinates with MapInfo 12.03.

3. Results and Discussion

3.1. New colonies of the steppe species on the right side of the Ob River
Until the middle of the 20th century many acridid species associated with the steppe life zone were distributed mainly over the Kulunda steppe between the Irtysh and Ob Rivers [9]. As a rule, their populations did not occur on the right (eastern) side of the Ob River, except the area near Meret settlement (now in the south-eastern part of the Novosibirsk Region) (53.57°N 82.04°E), where some populations of several species had been found (Calliptamus italicus (L.), Dociostaurus brevicollis (Ev.), Stenobothrus eurasius Zub., Oedaleus decorus (Germ.) (= Oe. infernalis auct.) [9, 14].

In 1979 and later, new populations of Dociostaurus brevicollis were found in the forest-steppe areas on the right side of the Ob River [15, 16] across the wide territory from Novosibirsk to Biysk. Its colonies were distributed along roadsides, overgrazed plots, and dry lawns. In 1984, a female of Oedipoda caerulescens (L.) was collected on sandy roadside in the southern part of Novosibirsk [17]. Later adults of this species were found mainly on sandy beaches of the Novosibirsk Reservoir [18]. During last decades adults of Oedaleus decorus and Epacromius pulverulentus (F.d.W. ) were also found in the transformed ecosystems in the southern part of Novosibirsk and in its vicinities [19]. Later the last species became very common on the dry lawns and also was found in the Kuznetsk steppe [20].

New finds of Oedaleus decorus and Oedipoda caerulescens are especially important and intriguing, because until the middle of 20th century these species were mainly distributed over the southern parts of the Kulunda steppe [9]. Some serious shifts of their ranges during last decades may
be associated with global warming. However, almost all colonies of every above mentioned species on the right side of the Ob River related and relate to transformed habitats, such as roadsides, dry lawns, overgrazed pastures, abandoned fields. This means species distribution changes might and may be resulted from some serious changes in human activity.

3.2. Pest species
In the steppe areas of the south-eastern West Siberian Plain, there are several pest acridid species [21, 22]. Sometimes they may significantly damage agricultural fields and pasturcelands. Among them are two locust species, namely the Italian locust (Calliptamus italicus) and the Migratory locust (Locusta migratoria L.). Both are characterized by some possible significant changes in their behaviour and morphology during their outbreaks, while hopper bands and adult swarms can be very abundant, dense and mobile. Other harmful species are more or less typical grasshoppers [9, 21, 22]. Among them are Gomphocerus sibiricus (L.), Arcyptera microptera (F.d.W.), Dociostaurus brevicollis (Ev.), D. kraussi (Ingen.), Stauroderus scalaris (F.d.W.), Chorthippus albomarginatus (DeG.), s.l. (i.e. Ch. albomarginatus s. str. + Ch. karelini (Uv.)), Oedaleus decorus (Germ.).

In the steppes and partly in the forest-steppes of West Siberia, the Italian locust was and is widely distributed. In the so-called Baraba steppe (actually the forest-steppe between the Irtysh and Ob Rivers), the species colonies are sporadic, and may be found on overgrazed plain pastures. Further south, in the Kulunda steppe, its populations are distributed over local watershed plains, terraces, upper flood plains, and the stony southern slopes of hills.

In the first half of the 20th century, adults of the Migratory locust were found in many localities, but almost all specimens were mainly originated from the south-eastern Kazakhstan [9] where its permanent breeding areas were and are in the northern desert life zone and where mass reproduction could begin. However, at least several stable populations were known in the south-eastern part of the Plain [9]. They might be recognized by common presence of hoppers and young adults [9]. Nowadays several populations of the Migratory locust exist in the region [13, 23, 24].

A comparative analysis of pest grasshoppers’ distribution allows us to distinguish several species groups. The distribution patterns of Arcyptera microptera, Dociostaurus brevicollis, Stauroderus scalaris, and Chorthippus albomarginatus s.l. between the Irtysh and Ob Rivers did not change significantly during last decades. These species were and are widely distributed over this territory. However, Dociostaurus brevicollis also occupied huge areas on the right side of the Ob River (see the subsection 3.1), while the stable populations of other species from this group existed in this region at least during the last century [8, 9].

The local range boundaries of two grasshoppers, namely D. kraussi and Oedaleus decorus, shifted northwards and north-eastwards. Nowadays the first species is distributed over the dry and typical steppe of the western part of the Kulunda steppe, really up to the northern parts of the Pavlodar and Altaj Regions. The colonies of Oe. decorus occur in the southern part of the forest-steppes including the territories on the right side of the Ob River (cf. the subsection 3.1).

The most intriguing changes are revealed for the Siberian grasshopper Gomphocerus sibiricus. Until the middle of the 20th century, this species was very widely distributed over the south-eastern West Siberian Plain (figure 1). This species was one of the main pests [9, 13, 25]. Its abundance was very high, especially during acridid outbreaks, while the Siberian grasshopper could seriously damage crops, pastures and hayfields. However, in the second half of the last century this species became relatively rare (figure 1), especially after 1985. These transformations may be associated mainly with the co-called Virgin Land campaign, when vast steppe areas had been ploughed and remaining steppe habitats had become overgrazed. As a result, many habitats of grasshoppers had been destroyed or damaged.

Thus, the situation with possible acridid pests changed significantly during the 20th century. In its first half, the Siberian grasshopper caused the main problems, in the end of the century the Italian locust became the main pest in the region [3]. Besides, Oedaleus decorus became widely distributed and relatively abundant species that may accompany the Italian locust during its outbreaks. This shift
is also important, because the Italian locust commonly prefers dicots and Oe. decorus mainly consumes monocots. During upsurges both species may complement each other.

Figure 1. Distribution of the Siberian grasshopper in the south-eastern part of West Siberian Plain until the 1950s and after 1972.

3.3. Rare species
Recently we analyzed the distribution patterns of rare acridid species over the Baraba and Kulunda steppes [13]. We considered some species which have been collected only in a few localities as rare forms for last several decades. Such species comprise about 24% of local acridid fauna (14 species from 59) [9, 12]. There are no endemic forms, however, the ranges of two taxa, namely Asiotmethis jubatus (Uv.) and Mesasippus arenosus (B.-Bien.), are limited by the Kulunda steppe and the adjacent semi-deserts of East Kazakhstan. Besides, Aeropedellus baliolus Mistsh. is also distributed over the Kulunda steppe and central and north-eastern Kazakhstan.

The rare species can be split into three groups [13]:

(1) Several species, namely: Asiotmethis muricatus (Pall.), Notostaurus albicornis (Ev.), Eremippus simplex (Ev.), Myrmeleotettix antennatus (Fieb.), Gomphocerippus rufus (L.), Mesasippus arenosus, and Mecostethus parapleurus (Hagen.) and the Migratory locust too — see the subsection 3.3), did not change their distribution significantly. Aeropedellus baliolus can be added to this group.

(2) Two species (Megaulacobothrus aethalinus (Zub.) and Aeropedellus variegatus (F.d.W.)) were found recently in the region.

(3) Four taxa (Asiotmethis jubatus, Arcyptera fusca (Pall.), Stenobothrus carbonarius (Ev.), and Sphingonotus coerulipes Uv.) were relatively common, at least in some habitats, in the first half of the 20\textsuperscript{th} century, but nowadays they become very rare.

The shifts of the last species group distribution may be explained by havoc, disintegration or transformation of many habitats during the Virgin Land campaign in the middle of the 20\textsuperscript{th} century.
Conclusion
Our studies during last decades allow us to add only two acridid species to the fauna of steppe in the south-eastern West Siberian Plain, namely *Megaulacobothrus aethalinus* and *Aeropedellus variegatus* (all old mentions of the last species for the local steppes [9] should be associated with *Ae. baliolus* [13]). Besides, two other species (*Chorthippus karelini* and *Glyptobothrus porphyropterus* (Vor.)) should be added to the list, but this is a result of some taxonomic revisions of two species complexes (*Chorthippus albomarginatus* [26] and *Glyptobothrus biguttulus* [27] respectively).

All grasshopper species known from the local steppes may be split into three groups. The first one includes many acridids without evident changes in their distribution over the region, however, a few insular populations of some species might and may be eliminated [2, 18]. The second group consists of the species with local range boundaries shifted northwards and northeastwards. New colonies of such forms are usually found in the northern steppes of Kulunda and even in the Baraba steppe and/or on the right side of the Ob River. The last group includes grasshoppers which became relatively rare or extremely rare. Among them is the Siberian grasshopper, the very common pest in the first half of the 20th century. This indicates rather different trends of range shifts in species occurred in steppes of the south-eastern West Siberian Plain. Some changes may be associated with global warming, but others can be explained by regional and local variations in human activities. Extension, intensification, and changes of human activities (including pest control during acridid upsurges) may result in continuous elimination of some local populations [2]. Thus, the general strategy of management of acridid assemblages and populations should incorporate both data and technologies concerning rare species populations and their habitats/ecosystems' conservation and new approaches to pest control and monitoring.

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