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Contribution to the knowledge of the apterous genus *Zubovskya* Dovnar-Zapolskij, 1932 (Orthoptera: Acrididae: Melanoplinae). Taxonomic composition, notes on *Zubovskya koeppeni* (Zubovsky, 1900), and entomogeographic studies on *Z. mongolica* Storozhenko, 1986

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Abstract

Taxonomic status and composition of the genus *Zubovskya* Dovnar-Zapolskij, 1932 are discussed. The following synonymy is proposed: *Zubovskya koeppeni koeppeni* (Zubovsky, 1900) = *Zubovskya eyouqiensis* Li, Li & Yin, 2015, **syn. nov.** and *Zubovskya koeppeni parvula* (Ikonnikov, 1911) = *Zubovskya xiai* Li, Li & Yin, 2015, **syn. nov.** Distribution patterns of the rare apterous grasshopper *Zubovskya mongolica* Storozhenko, 1986 are revealed. The species is known only from several localities with geographic coordinates determined. Its populations are characterized by relatively low abundance and are found at altitudes exceeding 1700 m. Their contemporary conservation status currently does not raise any serious concerns. However, if the global warming trend continues, the areas suitable for the existence of the species will be significantly reduced, since the axial parts of the local ridges are mainly located at altitudes between 1800 and 2500 m.

Key words: entomogeography, species range, population, species conservation, Altai-Sayan Mts

Introduction

In 1986, S. Storozhenko revised the genus *Zubovskya* Dovnar-Zapolskij, 1932 and described the new species *Z. mongolica* Storozhenko from North Mongolia (western side of Khövsgöl, or Khuvsgul Lake). Later, wider distribution of the species was revealed (Sergeev 1991; Storozhenko 2004; Sergeev *et al.* 2019)—from the NE Altai Mts. to the Mongolian part of the East Sayan Mts. Nevertheless, it remains one of the rarest and least known species of Orthoptera in temperate Eurasia. The goals of this article are to clarify the taxonomical position of the species and to reveal the patterns of its distribution.

Material and methods

This paper is based on the collections of Novosibirsk State University and the Institute of Systematics and Ecology of Animals (Novosibirsk, Russia) as well as on our own studies (1995–2018) and a critical analysis of published data. Seven occurrence points with the known geographic coordinates were used to analyze a species distribution. All maps were generated with help of QGIS 3.18.3 software and on a Lambert conformal conic projection. The maximum entropy approach (Maxent 3.4.4) was used to model species prevalence (Phillips *et al.* 2017). The main constrains of this method are described in several articles (Phillips *et al.* 2017; Morales *et al.* 2017). However, the distribution modelling of rare mountain species is associated with great difficulties, which are determined by a few

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number of locations and the pronounced heterogeneity of living conditions in mountains. In this case, adding the data on monthly solar radiations and altitudes can result in generating higher quality models (Sergeev *et al.* 2024a). The full sets of bioclimatic variables, monthly solar radiations and elevations at the 30 arcsecond spatial resolution (Fick & Hijmans 2017) were used. The main parameters of these approaches applied to different orthopteran species, including some rare forms, were described earlier (Storozhenko *et al.* 2023; Baturina *et al.* 2024).

Taxonomy

Family Acrididae MacLeay, 1821

Subfamily Melanoplinae Scudder, 1897

Tribe Podismini Jacobson, 1905

Genus *Zubovskya* Dovnar-Zapolskij, 1932

Zubovskya Dovnar-Zapolskij, 1932: 258; Mistshenko 1952: 348; Storozhenko 1986: 478; Sergeev 1986: 195; Sergeev *et al.* 2019: 11; Li *et al.* 2015: 111.
Zubowskya [sic!] Dovnar-Zapolskij, 1932: 255.
Zubovskia [invalid emendation] Mistshenko, 1951: 214.
Eozubovskya Li & Yin, 2009: 1141.
Bienkoa: Li *et al.* 2015: 111 (partim).
Kingdonella: Li *et al.* 2015: 111 (partim).

Type species. *Podisma parvula* Ikonnikov, 1911, by original designation.

Remarks. The genus *Zubovskya* was erected by Dovnar-Zapolskij (1932) as a result of the revision of the Palaearctic Podismini (Melanoplinae). He included three species in this genus, namely *Podisma parvula* Ikonnikov, 1911 (as the type species), *P. koeppeni* Zubovsky, 1900, and *P. morii* Bey-Bienko, 1931. Later, Mistshenko (1952) described *Zubovskya koreana* from the Korean Peninsula and Kis (1965) characterized *Z. banatica* from a very remote and unexpected mountain region in Europe, namely the Southern Carpathians. In the 1980s, several new taxa were described by Storozhenko (*Z. mistshenkoi* from the southern part of the Russian Far East (Storozhenko 1980) and *Z. mongolica* from North Mongolia (Storozhenko 1986)), by Zhang & Jin (1985) (*Z. planicaudata* from NE China, Inner Mongolia), and by Huang (1987) (*Z. brachycercata*, *Z. dolichocercata*, and *Z. striata*—all from NE China, Heilongjiang and Jilin). In addition, Storozhenko (1986) showed that *Zubovskya parvula* should be considered as the subspecies of *Z. koeppeni*. In 1995, Zheng *et al.* (1995) described *Z. weishanensis* from NE China as well. Later, Kim *et al.* (2017) redescribed *Z. morii* and synonymized *Z. longifurcula* (originally described as *Eozubovskya longifurcula* (Jin *et al.*, 2011)) and *Z. koreana*.

According the Orthoptera Species File (Cigliano *et al.* 2025), the genus includes 12 species, namely *Zubovskya banatica*, *Z. brachycercata*, *Z. dolichocercata*, *Z. eyouqiensis*, *Z. koeppeni*, *Z. koreana*, *Z. mistshenkoi*, *Z. mongolica*, *Z. morii*, *Z. planicaudata*, *Z. weishanensis*, and *Z. xiai.* However, Storozhenko (1998) proved synonymy of *Zubovskya koeppeni parvula* and *Z. brachycercata*, *Z. mistshenkoi* and *Z. striata*, and showed that *Z. dolichocercata* should be considered as the subspecies of *Z. koeppeni*. Morphological variability of both species described by Li *et al.* (2015), namely *Z. eyouqiensis* and *Z. xiai,* from NE China corresponds to that of known subspecies of *Z. koeppeni* (cf. Storozhenko 1986; Storozhenko *et al.* 2015). This is why we suggest to synonymize them: *Zubovskya koeppeni koeppeni* (Zubovsky, 1900) = *Zubovskya eyouqiensis* Li Li, & Yin, 2015, **syn. nov.** and *Zubovskya koeppeni parvula* (Ikonnikov, 1911) = *Zubovska xiai* Li, Li & Yin, 2015, **syn. nov.**

Several teams of orthopterists tried either to erect a new genus (e.g. *Eozubovskya* Li & Yin, 2009) for *Z. koreana* or to move some species to other genera (*Z. morii* to *Bienkoa* Mistshenko, 1950 and *Z. mongolica* to *Kingdonella* Uvarov, 1933 (Li *et al.* 2015)). The genera *Eozubovskya* and *Zubovskya* were synonymized by Storozhenko *et al.* (2015). The *Z. morii*'s generic assignment to *Zubovskya* was confirmed by Kim *et al.* (2017) and the same for *Z. mongolica*—by Sergeev *et al.* (2019). Besides, some authors suggested to include the genus *Zubovskya* in the subfamily Conophymatinae Mistshenko, 1952 based mainly on the complete absence of wings in many

representatives of both Conophymatinae sensu Mistshenko and Melanoplinae. However, a century ago, Uvarov (1928) noted that winglessness of some genera is certainly secondary phenomena which can be observed on quite different tribes and subfamilies, especially in mountain endemics. In addition, the trait that is often used in keys to distinguish acridid subfamilies and tribes, namely an outer apical spine of hind tibia (its presence or absence), is commonly useful but, unfortunately, not universal and required and cannot be used as the only one (cf. Latchininsky *et al.* 2002; Kim *et al.* 2017). Moreover, in some species, its intraspecific variation can be revealed, e.g. the type series of *Conophyma turkestanicum* Sergeev, 1984 (Conophymatinae) includes some specimens without the outer apical spine of hind tibia and one specimen without both spines (outer and inner) (Sergeev 1984). In addition, the molecular markers studied confirm the position of *Zubovskya* in the clade together with other taxa of the subfamily Melanoplinae and the quite different and separate clade for members of the subfamily Conophymatinae (Sukhikh *et al.* 2019).

Composition. Now only 8 species can be included in the genus *Zubovskya*:

Z. banatica Kis, 1965 (Europe: Southern Carpathians)

Z. koeppeni (Zubovsky, 1900) (from the Altai-Sayan Mts. up to the south Arctic and the Russian Far East, NE China, Korean Peninsula, and Japan: Hokkaido)

Z. koreana Mistshenko, 1952 (Korean Peninsula)

Z. mistshenkoi Storozhenko, 1980 (the southern part of the Russian Far East, NE China)

Z. mongolica Storozhenko, 1986 (Altai-Sayan Mts. in S Siberia and N Mongolia)

Z. morii (Bey-Bienko, 1931) (Korean Peninsula; probably, some adjacent parts of NE China as well)

Z. planicaudata Zhang & Jin, 1985 (NE China)

Z. weishanensis Zheng, Zhang & Ren, 1995 (NE China).

Zubovskya mongolica Storozhenko, 1986

Zubovskya mongolica Storozhenko, 1986: 53; Sergeev 1991: 121; Storozhenko 2004: 24; Sergeev *et al.* 2019: 12.
Kingdonella mongolica: Li *et al*. 2015: 111.

Remarks. The type locality of this species is in vicinities of Khövsgöl Lake in N Mongolia (Storozhenko 1986). Unfortunately, the exact points of occurrences remain unknown. Later, the species was mentioned for the Altai-Sayan Mts. in Russia (NE Altai Mts., Tuva, the southern parts of Krasnoyarsk Region and the Republic of Khakassia (Sergeev 1991; Storozhenko 2004; Sergeev *et al.* 2019)). However, all specimens from Oyskyi Range (West Sayan Mts.) were mistakenly identified (Sergeev *et al.* 2019). In addition, the female with the label "Chadan Experimental Station" in the collections of Siberian Zoological Museum (Institute of Systematics and Ecology of Animals) is obviously mislabeled, because this locality is near the bottom part of the Khemchik Intermountain Basin (W Tuva) with elevations less than 1000 m and where the steppes and dry meadows are usual (Sergeev *et al.* 2019).

Distribution and ecology. Altai-Sayan Mts., from NE Altai to East Sayan Mts. (Fig. 1). All know localities of *Zubovskya mongolica* are inside the range of widely distributed *Z. koeppeni*. However, our field observations show that their altitudinal ecological niches overlap very weakly (Table 1).

TABLE 1. Altitudinal distribution of *Zubovskya mongolica* and *Z. koeppeni* in the Altai-Sayan Mts. (1995–2018).

Altitude, m	Locality	Latitude (N)	Longitude (E)	*Zubovskya mongolica*	*Zubovskya koeppeni*
289–292	Ermakovskoje	53.28	92.45	—	+
697–727	Idzhim	52.34	93.17	—	+
1432–1440	Oyskoe Lake	52.86	93.26	—	+
1470–1630	Oyskoe Lake	52.85	93.27	—	+
1540–1815	Olenja Rechka	52.78	93.25	—	+
1737–1780	Koptu River	51.94	95.50	+	—
1869–1945	Koptu River	51.95	95.52	+	—
2005	Koptu River	51.94	95.55	+	—
2079	Sayanskij Pass	51.72	89.89	+	—

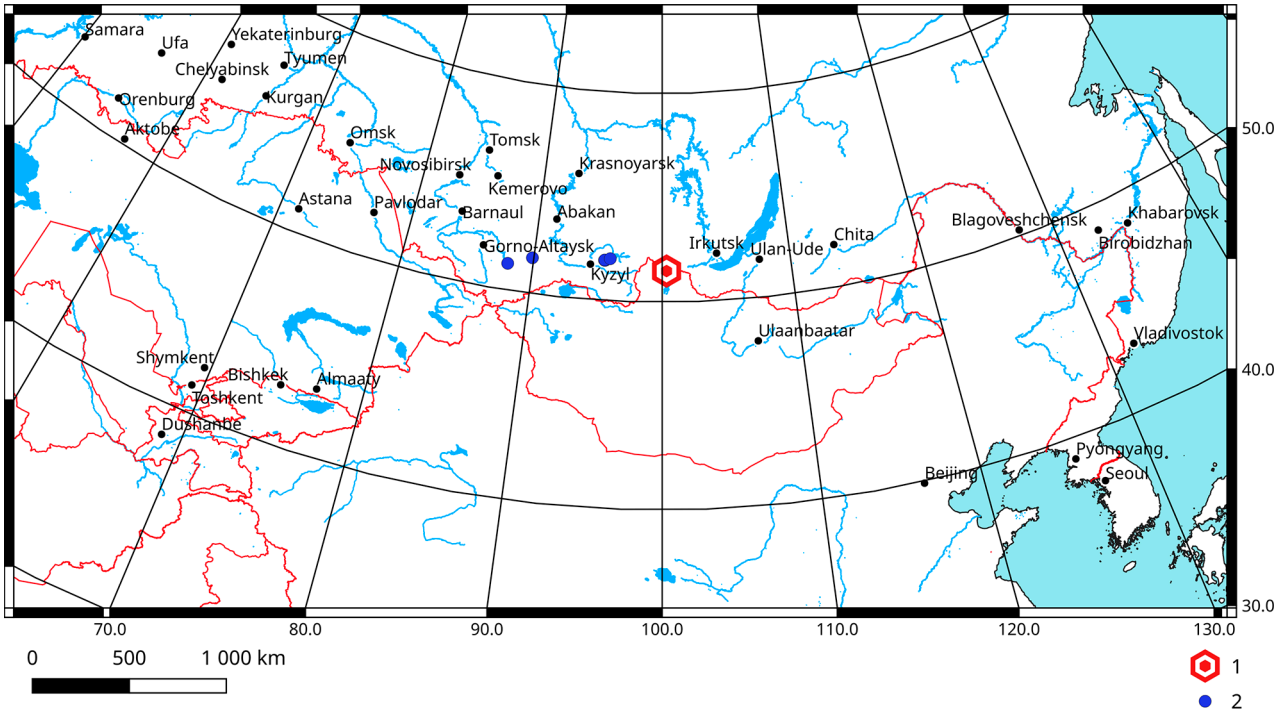

FIGURE 1. The known localities of *Zubovskya mongolica*; 1—type locality; 2—other known localities.

FIGURE 2. The typical habitat of *Zubovskya mongolica* (Tuva, Academician Obruchev Range, southern slope, Koptu (Khapto) River, 1945 m) (Foto M.G. Sergeev).

Zubovskya koeppeni is mainly distributed across the belt of coniferous forests from relatively low altitudes up to the timber-line and rarely above it (Table 1). Its populations can be usually found on wet meadows of openings and clearings. The species is commonly associated with quite different broad leaf plants, e.g. *Veratrum* L., *Aconitum* L., *Potentilla* L., *Phlomoides tuberosa* (L.) Moench, *Geranium* L. The populations of *Zubovskya mongolica* were found between 1700 and 2100 m. The species colonizes openings with wet meadows near the local timber-lines (Fig. 2), alpine meadows and some meadow plots in the mountain tundra. It is clearly associated with the same groups of plants. Its abundance is commonly low or moderate and, according to our data, in August of 2018, varied between 4 and 45 adults per hour.

Ecologo-geographic modelling of *Zubovskya mongolica* distribution

The maximum entropy approach allows to reveal terrains with very suitable conditions for *Z. mongolica* (Fig. 3). All of them are limited by high elevations of the Altai-Sayan Mts. However, the distribution of these areas is wider than the known range of the species (cf. Fig. 1). They include the southern parts of the Altai Mts., Tannu-Ola Ranges in Tuva, the central part of the East Sayan Mts., and several ridges in NW Mongolia. In addition, some applicable territories are traced in the Far East, that is, very far from the modern range of the species. The generated model is well supported (AUC = 0.997). The most significant variables are the solar radiation in November (34.2%) and in March (18.1), what can be associated with the conditions of going into hibernation and coming out of it, and elevations (10.9%). In addition, the Jackknife test allows us to add mean temperatures of the warmest quarter as the significant variable.

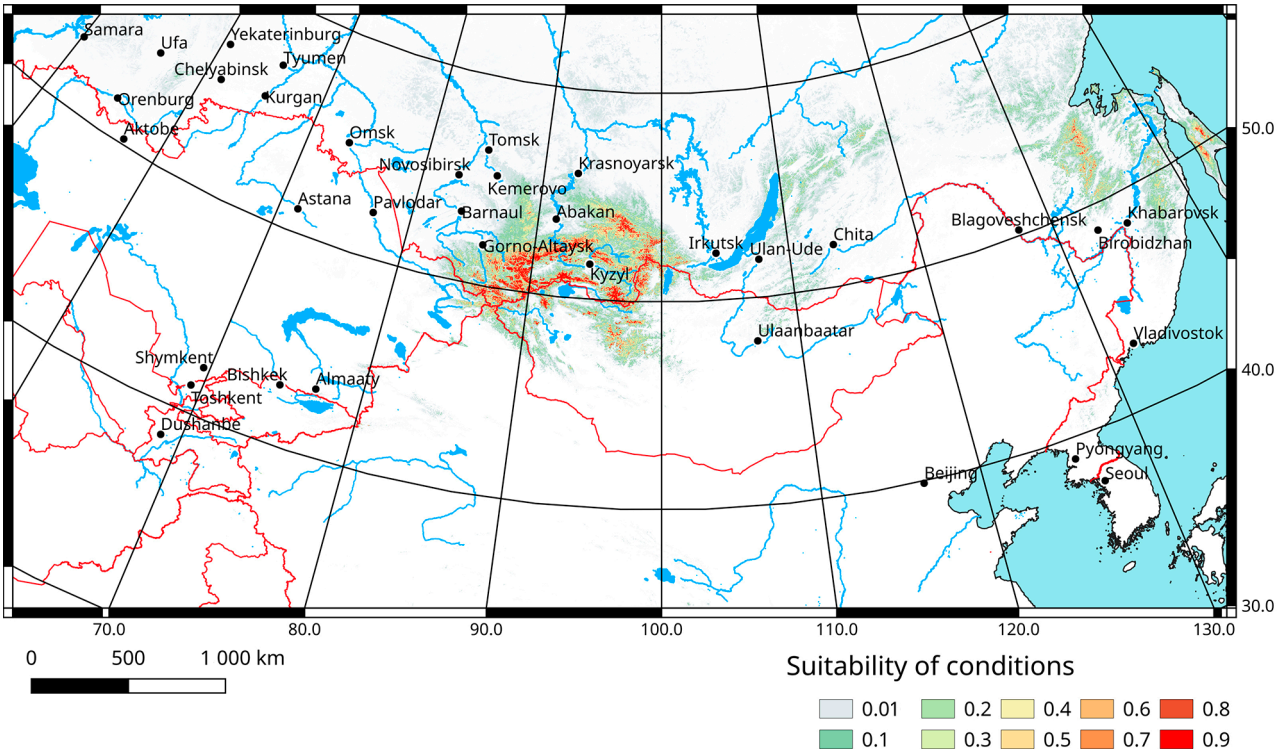

FIGURE 3. Predicted probabilities of suitable conditions for *Zubovskya mongolica* (bioclimatic variables and monthly solar radiation for 1970–2000, and altitudes; point-wise means for 7 replicates).

Discussion

The species distribution modelling allows to identify areas of possible existence of local populations, which is especially important for rare orthopteran species in mountain regions. This has been shown previously for the grasshoppers *Stenobothrus newskii* Zub. (the endemic of the Altai-Sayan Mts.) (Sergeev *et al.* 2023; Sergeev *et al.* 2024a), *S. kirgizorum* Ikonn. (Dzhungarian Alatau) (Sergeev *et al.* 2024a), and the Amurian grig *Paracyphoderris erebeus* Storozhenko (the mountain areas of the southern part of the Khabarovsk Krai and the Jewish Autonomous Region) (Storozhenko *et al.* 2023). For instance, the distribution models generated for *Zubovskya mongolica* (Fig. 3) and *Stenobothrus newskii* (Sergeev *et al.* 2023), both occurred in the Altai-Sayan Mts. and mainly associated with landscapes near and above timber-lines, demonstrate quite similar patterns and show that the local populations of these species may be found in the main part of the East Sayan Mts. almost unexplored from the orthopterological point of view. In both cases, the role of altitudes is very significant. The comparative analysis of the distribution models of *Z. mongolica* and its relative, namely *Prumna primnoa* (Motschulsky) (Sergeev *et al.* 2024b) widely distributed across the southern parts of East Siberia and the Russian Far East, shows some noticeable difference in the most significant variables (heat balance during going into hibernation and coming out of it for the first species and the summer precipitations for the latter one).

Zubovskya mongolica is known only from 7 localities, some of them located more or less close to each other in highlands of Academician Obruchev Range. Although the populations of this species are characterized by relatively low abundance, their status currently does not raise any particular concerns. The species occurs in the Altai Nature Reserve. In addition, its populations most likely live in several other nature reserves at the Altai-Sayan Mts. (e.g. Khakasski, Sayano-Shushenskii, and Uvs Nuur Basin). However, the known populations of *Zubovskya mongolica* are found at altitudes exceeding 1700 m. If the global warming trend continues, the areas suitable for the existence of the species will be significantly reduced (cf. Lockwood & Sergeev 2000; Sergeev *et al.* 2024a), since the axial parts of the local ridges are mainly located at altitudes between 1800 and 2500 m.

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