ABS ACTA BIOLOGICA SIBIRICA
A journal on the biodiversity of Siberia and the adjacent lands

Acta Biologica Sibirica 11: 1055–1075 (2025)
doi: 10.5281/zenodo.17364861
http://journal.asu.ru

RESEARCH ARTICLE

# Distribution patterns of the common predatory bush-cricket *Saga pedo* (Pallas, 1771) (Orthoptera, Tettigoniidae) in the Asian part of its range: Real rarity or mysterious commonness

Ekaterina S. Shibkova[1], Vladimir V. Molodtsov[1], Muratbek K. Childebaev[2], Oxana V. Yefremova[1], Michael G. Sergeev[1, 3]

**1** *Novosibirsk State University,1 Pirogova Street, Novosibirsk, 630090, Russia*
**2** *Institute of Zoology, 93 Al-Farabi Avenue, Almaty, 050060, Kazakhstan*
**3** *Institute of Systematics and Ecology of Animals, Siberian Branch of the Russian Academy of Sciences, 11 Frunze Street, Novosibirsk, 630091, Russia*

Corresponding author: Michael G. Sergeev (mgs@fen.nsu.ru; mgsergeev@aol.com)

Academic editor: R. Yakovlev | Received 11 August 2025 | Accepted 16 September 2025 | Published 18 October 2025

*http://zoobank.org/2BDFD71A-D1D2-4AC3-8B23-CED8ADD71803*

**Citation:** Shibkova ES, Molodtsov VV, Childebaev MK, Yefremova OV, Sergeev MG (2025) Distribution patterns of the common predatory bush-cricket *Saga pedo* (Pallas, 1771) (Orthoptera, Tettigoniidae) in the Asian part of its range: Real rarity or mysterious commonness. Acta Biologica Sibirica 11: 1055–1075. https://doi.org/10.5281/zenodo.17364861

## Abstract

The distribution patterns of the common predatory bush-cricket *Saga pedo* (Pallas, 1771) across the Asian part of its geographic range are revealed. It is the most widespread member of the genus and is the only species crossing the 55th parallel in the north direction. Preferable habitats of *S. pedo* are more or less uniform across its range, it favors variable steppe or steppe-like habitats covering by relatively dense grass vegetation with presence of forbs and especially shrubs. In the western parts of its range, the species is commonly distributed across regions with the subtropical Mediterranean and the temperate southern broadleaf forests, and its populations are mainly associated with local open landscapes. In the central and eastern parts, its distribution is different, because it is usually found over the forest-steppe, steppe and semi-desert life zones and also in the mountains of Middle Asia. The MaxEnt models produced for the contemporary period and for 2021-2040 and 2041-2060 according the Shared Socioeconomic Pathway 3-7.0 and the global climate model CNRM-ESM2-1 provide an opportunity to estimate the suitability of conditions for the species and demonstrate that, in the future, the general character of its distribution may change very significantly, especially in the southern half of

the West Siberian Plain. The conservation status of *S. pedo* is discussed for the Asian part of its range as well.

**Keywords**
Saginae, South Siberia, Middle Asia, rare species, steppe, forest-steppe, semi-desert, mountains, modelling, forecast

## Introduction

More than 250 years ago, P.S. Pallas (1771) described the unique species *Gryllys* (*Tettigonia*) *pedo* from some unknown locality. Later, it was included in the genus *Saga* Charpentier, 1825, the type species of which was *Locusta serrata* Fabricius, 1793 (= *Saga pedo*) by original monotypy (Cigliano et al. 2025). Today we commonly call this species not only the formal name, but either the common predatory bush-cricket or the matriarchal katydid. The uniqueness of this bush-cricket (Fig. 1) is determined by a combination of several peculiarities: (1) its large size (*S. pedo* is one of the largest species of Orthoptera in general), (2) winglessness, (3) its tetraploid chromosome number and parthenogenetic reproduction (Goldschmidt 1946; Kolics et al. 2012), and (4) a secretive lifestyle, since it is a typical ambush predator with predominantly nocturnal activity of adults. In addition, it is the most widely distributed species of the genus *Saga* despite the specificity of its reproduction and limited migratory capabilities (Kolics et al 2012). Furthermore, *S. pedo* was introduced in the area of the Great Lakes in North America (Cantrall 1972). *S. pedo* is the only member of this genus included in the IUCN Red List and in many regional Red Books and Red Lists (Hochkirch et al. 2016).

In the European parts of its range, the general patterns of the species distribution and bionomics were described and discussed in many publications (Kaltenbach 1964; Holuša et al. 2013; Lemonnier-Darcemont et al. 2016; Anselmo 2022; Ancillotto and Labadessa 2023; Repetto et al. 2024; Brandmayr et al. 2025; Della Rocca et al. 2025). The species distribution models were produced recently as well (Ancillotto and Labadessa 2023). However, the similar data for the Asian parts of the species range remain limited and scattered across various publications, mainly some regional Red Books. The aims of this article are to reveal general patterns of the species distribution across the Asian parts of its range, to characterize some peculiarities of its ecology, and to produce several models of its distribution for the present and future periods.

## Materials and methods

Field data were collected from 1975 until 2023 in the southern part of West Siberia and in Kazakhstan. The quantitative and qualitative sampling of insects was

employed to characterize the species distribution patterns across local ecosystems. In accordance with this approach, insects were seized with a standard net (40 cm diameter) over a period of 10-30 minutes (Gause 1930; Sergeev 1986, 1992). In addition, each habitat was surveyed to find species not collected during the census per se. The Glonass/GPS handheld gizmos were used to determine geographical coordinates. For the locations of the species in earlier periods, we used Google Earth Pro (©Google, 2020) to assess these parameters. We have also used some data on general distribution of the species from the collections of Zoological Institute (Saint Petersburg), from several books and articles and also Internet resources (Adelung 1906a, 1906b; Uvarov 1910; Pylnov 1914; Bey-Bienko 1928, 1929; Nefedov and Miram 1939; Bekuzin 1972; Guseva 1986; Kadyrbekov et al. 2017; Temreshev and Esinbekova 2017; Gerasimov and Krivosheev 2018; Krasutsky et al. 2022; Snegovaya and Kerimova 2022; Childebaev and Taranov 2023; GBIF 2025).

**Figure 1.** *Saga pedo* in the Kulunda steppe (W Bor-Forpost, Altai Krai) (Photo M.G. Sergeev).

Our database of the *S. pedo* occurrences across the Asian part of its range and the adjacent, south-eastern parts of Europe includes 242 records (See Suppl. material 1: Table S1). We exploited the QGIS 3.18.3 software (QGIS 2025) and a Lambert conformal conic projection to produce maps. The Maxent 3.4.4 software (Phillips et al. 2006, 2017; Elith et al. 2011) was used to model the species ecological-geographical distribution. The full packages of the bioclimatic variables at the 30 arcsecond spatial resolution (Fick and Hijmans 2017; WorldClim 2022) were used to produce

such models for the current period. In addition, the model based on a combination of the bioclimatic variables, monthly solar radiations and elevations was generated as well. The "Future climate data" for two periods (2021-2040 and 2041-2060) downscaled from the global climate model CNRM-ESM2-1 (Séférian 2018) at the 30 arcsecond spatial resolution and for the Shared Socioeconomic Pathway 3-7.0 (Meinshausen et al. 2020) were used to reveal some viable changes in the species distribution. The accuracies of these models were rated by the AUC (the area under the receiver operating characteristic curve) values for set of 25 replicates with cross-validation. The significance of variables was revealed on the basis of their predictive contributions and the Jackknife tests.

## Results and discussion

### Ecological-geographical peculiarities of *Saga pedo*

*S. pedo* is widely distributed across the southern regions of Europe (Kaltenbach 1964), from the central parts of the Iberian Peninsula up to the central and southeastern parts of European Russia and North-West Kazakhstan and from the southern parts of the Czech Republic and the Republics of Tatarstan and Bashkortostan (Russia) up to Sicily and the North Caucasus, but its range is insular, especially near the northern boundary (Kolics et al. 2012; Hochkirch et al. 2016). In Europe, the species is commonly distributed across the areas occupied once upon a time by the subtropical Mediterranean and temperate southern broadleaf forests. Its populations are mainly associated with local open landscapes either transformed or mountain, e.g., clearings, other openings, abandoned vineyards (Anselmo 2019). On the East European Plain, its distribution is quite different, because in the region, *S. pedo* is usually found at the forest-steppe and steppe life zones. The known northern boundary of the species range corresponds well to the northern boundary of the forest-steppe life zone. In the easternmost parts of this Plain, some localities of *S. pedo* are found near the 55th parallel (Fig. 2) (Karmazina and Shulaev 2015; GBIF 2025). *S. pedo* slightly penetrates also to the South Caucasian region along both the coast of the Black Sea (at least up to the Gelendzhik vicinities, i.e. across the areas with the Mediterranean climate) (our data; GBIF 2025) and the coast of the Caspian Sea in North-East Azerbaijan (Snegovaya and Kerimova 2022). All other indications of the presence of the species in the South Caucasus (especially for Georgia and Armenia, and for the Sochi region in Russia) should be checked as they most likely relate to *Saga ephippigera* Fischer de Waldheim, 1846 (Tarbinsky 1940).

In the Asian part of the range, *S. pedo* is widely distributed across the forest-steppe and steppe life zones of the West Siberian Plain from the Ural Mts. to the Kulunda steppe between the Irtysh and Ob Rivers (Fig. 2) (Sergeev 2021a). In the westernmost part of the Plain, *S. pedo* crosses the latitude of 55° N. Moreover, in 1968, the species was found in Ekaterinburg (about 56°46' N) (Gorbunov and Olsh-

vang 2018), however, this single finding could have been the result of an accidental introduction of this bush-cricket, since, firstly, it was found within the boundaries of a large city, and secondly, this city is located in the forest life zone not very suitable for the species. That is why this locality was excluded from our analysis. From the west to the east, the northern boundary of the species distribution shifts southward. In the south-eastern parts of the West Siberian Plain, all known occurrence points of *S. pedo* are located south of 55° N. The southern boundary of the species range corresponds to the southern boundaries of the semi-deserts. However, in South-East Kazakstan, it occurs in the northern desert life zone, but in azonal habitats, e.g., on meadows of local flood-plains (Childebaev 2007). Across the local plains and hills of the Kazakh Uplands (Saryarka), mean temperatures are relatively moderate (average temperatures of July are from 17 °C to 25 °C, the same for January: from –13 °C to –19 °C), and annual precipitation ranges amongst 246 and 530 mm (Isachenko 1985)). In addition, its several local populations were found in the mountains of Tien Shan, Hissaro-Alay, and Kopet Dagh (Bekuzin 1972; Huang and Yu 1987; Chelpakova 2006; Kokanova 2011; Kreuzberg 2019). In the mountains of Middle Asia, they are commonly associated with middle elevations and mountain steppe habitats.

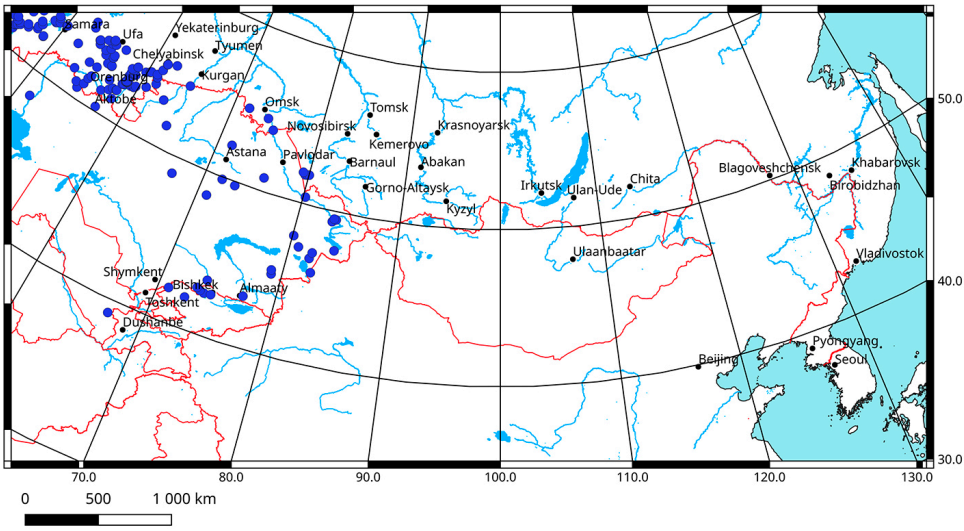


**Figure 2.** Distribution of *Saga pedo* in the eastern parts of its range.

Preferable habitats of this species are more or less uniform across its range. From South-West Europe up to the Kulunda steppe, *S. pedo* favors variable steppe or steppe-like habitats covering by relatively dense grass vegetation with presence of forbs and especially shrubs (Childebaev and Storozhenko 2004; Della Rocca et al. 2025), however, according our data, the height of the vegetation cover is not very important (cf. Holuša et al. 2013). We observed this species on plots with both

high (Fig. 3) and low vegetation (Fig. 4). In mountains of South Europe, it often prefers landscapes with limestone or dolomite bedrocks at low and middle elevations (Krištín and Kaňuch 2007; Lemonnier et al. 2009; Brandmayr et al. 2025; Della Rocca et al. 2025). Adults are usually active at dusk and at night, larvae can be active during the daytime (Lemonnier et al. 2009). In suitable habitats, the species density can vary between 30 and 120 individuals per ha (Krištín and Kaňuch 2007). Both adults and larvae predate small animals, usually other insects, especially grasshoppers, other orthopteran insects, and praying mantises (Dvorskaya 2006; Krištín and Kaňuch 2007; Anselmo 2019). Larvae may also feed on nectar (McGrath 2020). As a rule, individuals of this species very rarely catch the eye of researchers unless they are being specifically searched for (Holuša et al. 2010; Anselmo 2022; Repetto et al. 2024). The sizes of local populations can vary greatly (Repetto et al. 2024), since due to parthenogenetic reproduction there are no restrictions on inbreeding. However, in most cases, they apparently do not occupy large areas, since the possibilities for the dispersal of individuals are limited (Holuša et al. 2013; Anselmo 2022; Repetto et al. 2024; Varga et al. 2025).

**Figure 3.** The female of *Saga pedo* in the typical mountain meadow habitat (Kyrgyz Ala-Too, Tien Shan, Kazakhstan) (Photo M.K. Childebaev).

According our data, in the applicable habitats of the semi-deserts, the species abundance varies between 6 and 12 individuals per hour. In the steppe life zone, it can be relatively low (about 1 per hour). However, *S. pedo* is often found across local transformed ecosystems suitable for the species, such as abandoned fields, strips between agricultural fields and verges. It was also found in safflower fields (South-East Kazakhstan, Jetisu (Zhetysu) Oblast) (Dvorskaya 2006).

**Figure 4.** The habitat of *Saga pedo* in the Kulunda steppe (W Bor-Forpost, Altai Krai) (Photo M.G. Sergeev).

## Ecological models of the species distribution

The model produced for the climatic data of the end of the 20th century uncovers that the optimal areas of the species range are in the westernmost parts of the West Siberian Plain (near the Ural Mts.) and locally in the southern part of the Kulunda steppe, the eastern part of the Kazakh Uplands, and the northern parts of the mountains of Middle Asia (Fig. 5A). The model based on the extended set of variables including not only the bioclimatic data, but also the data on monthly solar radiations and elevations, is very similar (Fig. 5B), but, in the easternmost parts of the species range, the suitability of conditions is a little lower. Both models are well supported statistically (AUC = 0.958 and 0.965 respectively) (Fig. 6).

The main bioclimatic variables clarifying the species distribution are annual mean temperatures, precipitations of the driest quarter, precipitations of the driest month, and maximal temperatures of the warmest month (Table 1). However, adding of solar irradiance distribution and elevations significantly changes and somewhat evens out the predictive contributions of almost all variables. Precipitations of the driest month, precipitations of the driest quarter, the precipitation seasonality, and the solar radiation in August and December are the most significant. The Jackknife tests give opportunities to add several other variables, namely the precipitation seasonality and mean temperatures of the warmest quarter for the first set of variables and the solar radiation in January, February and November for the second one. Almost all important variables are essential either for the species development

during summer, especially in the end of this season, when ovipositions may occur, or for an overwintering period.

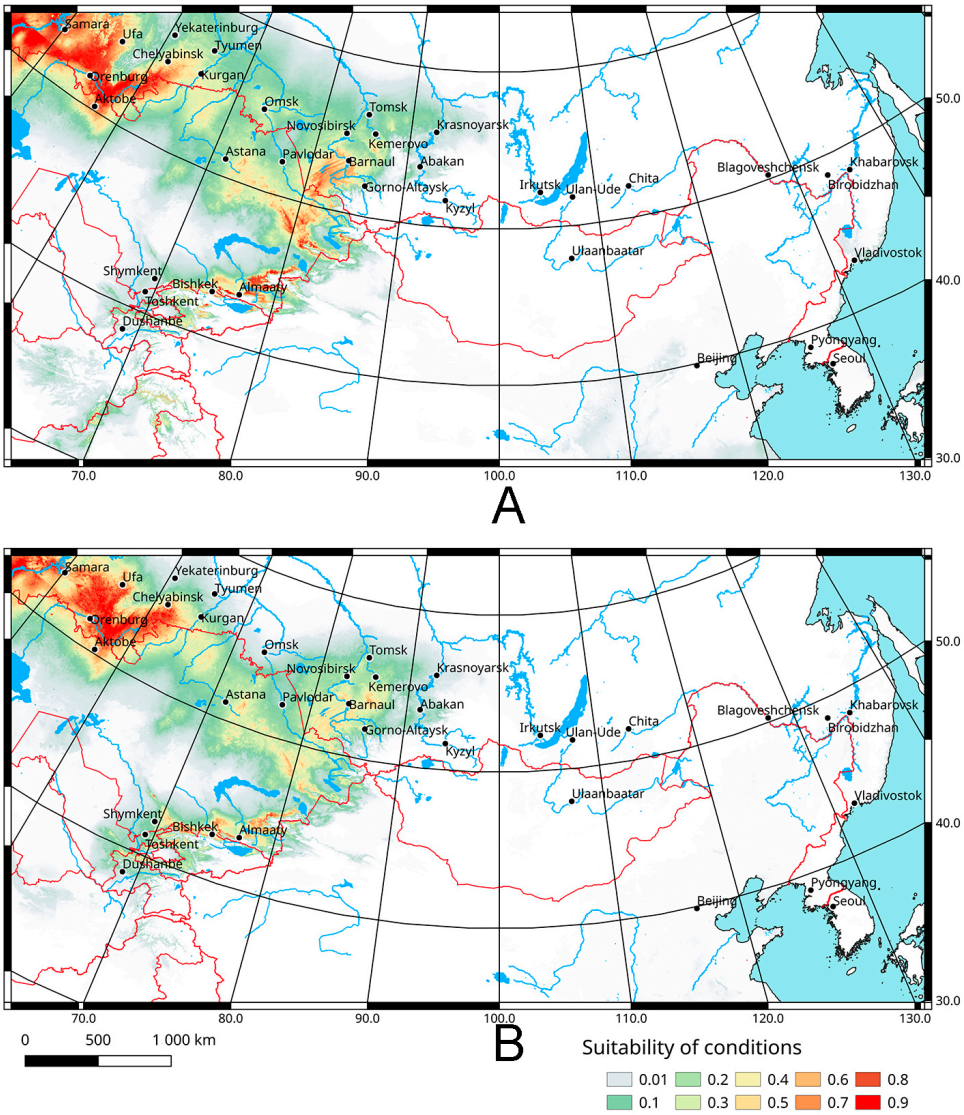


**Figure 5.** Predicted probabilities of suitable conditions for *Saga pedo* in the eastern parts of its range: all bioclimatic variables for 1970–2000 (**A**) and all bioclimatic variables, elevations, and monthly solar radiation (**B**) (point-wise means for 25 replicates with cross-validation).

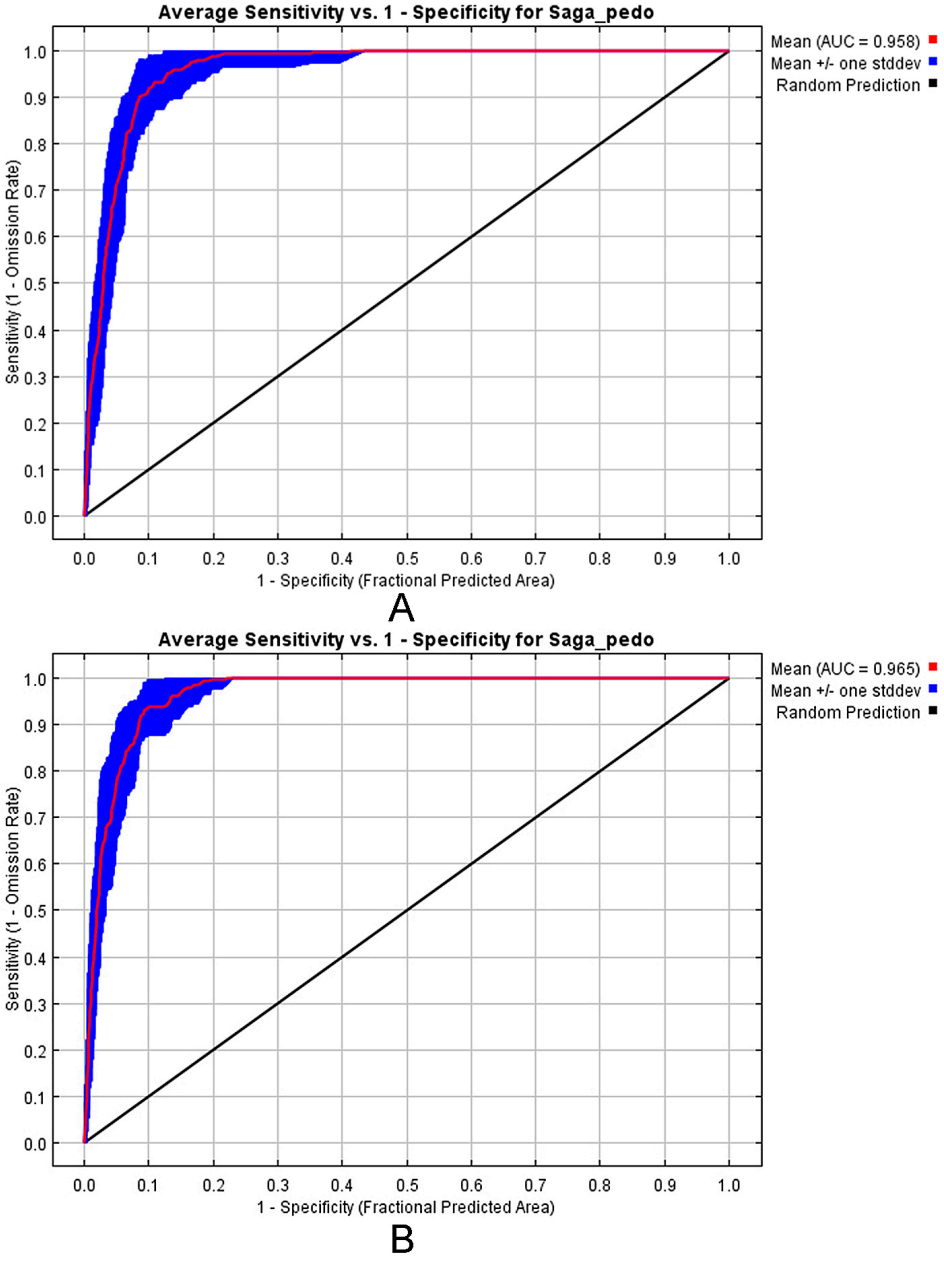


**Figure 6.** Reliability tests for the *Saga pedo* distribution models in the eastern parts of its range: all bioclimatic variables for 1970–2000 (**A**) and all bioclimatic variables, elevations, and monthly solar radiation (**B**) (25 replicates with cross-validation).

**Table 1.** Predictive contributions for all data

| Variable | Bioclimatic variables only | | Bioclimatic variables + elevation + monthly solar radiation | |
|---|---|---|---|---|
| | Percent contribution | Permutation importance | Percent contribution | Permutation importance |
| 1 — Annual mean temperature | **25.1** | 6.4 | 2.4 | 3.6 |
| 2 — Mean diurnal range | 0.5 | 0.1 | 0.6 | 1.4 |
| 3 — Isothermality | 0.7 | 1.7 | 0.4 | 1.8 |
| 4 — Temperature seasonality | 1.3 | 5.5 | 0.6 | 18.4 |
| 5 — Max temperature of warmest month | **7.3** | 27.3 | 0.6 | 3.7 |
| 6 — Min temperature of coldest month | 6.5 | 0.1 | 0.7 | 0 |
| 7 — Temperature annual range | 2 | 5.6 | 2 | 0.1 |
| 8 — Mean temperature of wettest quarter | 0.2 | 0.5 | 0.2 | 0.6 |
| 9 — Mean temperature of driest quarter | 0.8 | 1.4 | 0.6 | 0.8 |
| 10 — Mean temperature of warmest quarter | 0 | 0 | 0.5 | 1.6 |
| 11 — Mean temperature of coldest quarter | 0.8 | 23.9 | 0.3 | 0.1 |
| 12 — Annual precipitation | 3 | 11.7 | 0.8 | 3.8 |
| 13 — Precipitation of wettest month | 0.1 | 0 | 0.1 | 0 |
| 14 — Precipitation of driest month | **11.5** | 1.8 | **19.6** | 2.5 |
| 15 — Precipitation seasonality | 6.2 | 7.4 | **6.7** | 0.2 |
| 16 — Precipitation of wettest quarter | 3.3 | 0.7 | 3.5 | 1.9 |
| 17 — Precipitation of driest quarter | **22.2** | 0.4 | **16** | 0.7 |
| 18 — Precipitation of warmest quarter | **8.5** | 0.9 | 0.2 | 0.2 |
| 19 — Precipitation of coldest quarter | 0.2 | 4.5 | 0.9 | 1.2 |
| Elevation | – | – | 0.7 | 0.5 |
| Solar radiation in January | – | – | 0.2 | 0 |
| Solar radiation in February | – | – | 0.6 | 0 |
| Solar radiation in March | – | – | 0.1 | 0 |
| Solar radiation in April | – | – | 1.4 | 4.5 |
| Solar radiation in May | – | – | 0.2 | 0.1 |

| Variable | Bioclimatic variables only | | Bioclimatic variables + elevation + monthly solar radiation | |
|---|---|---|---|---|
| | Percent contribution | Permutation importance | Percent contribution | Permutation importance |
| Solar radiation in June | – | – | 2.7 | 10.5 |
| Solar radiation in July | – | – | 6.3 | 0.1 |
| Solar radiation in August | – | – | **9.8** | 23.3 |
| Solar radiation in September | – | – | 0.2 | 0.6 |
| Solar radiation in October | – | – | 0.1 | 0 |
| Solar radiation in November | – | – | 1.7 | 16.4 |
| Solar radiation in December | – | – | **19.3** | 1.2 |

Note: In bold – the most significant variables.

The models generated for the climatic conditions in the future predict some dramatic shifts (Fig. 7). The territories with the suitable conditions may occupy almost the entire southern half of the West Siberian Plain up to the latitude of 60° N in 2041–2060, except the terrains near the Irtysh River in the north-eastern parts of Kazakhstan. However, this vast area (mainly between 55° N and 60° N) is now covered mostly by coniferous (taiga) and mixed forests. Therefore, the dispersal of *S. pedo* in the future is possible only with the appearance of suitable open steppe or steppe-like habitats, that is, after a very noticeable transformation of the landscapes.

Therefore, many terrains at the southern parts of the West Siberian Plain and the Kazakh Uplands are suitable for *S. pedo*. Consequently, we can assume the existence of numerous populations of this species across this territory. A series of recent discoveries of *S. pedo* in the Chelyabinsk Oblast (Lagunov and Krasutskiy 2017; 1978; Childebaev and Storozhenko 2004; Krasutskiy et al. 2022) supports this hypothesis. There are some insular populations of the species in the mountains of Tien Shan, Hissaro-Alay, and Kopet Dagh as well. This means the species is much more widespread here than previously thought (Pravdin 1978; Childebaev, Storozhenko 2004; Storozhenko 2004). However, our knowledge concerning the species distribution across the region remains limited since data on the occurrences and population status of this species are still scarce, especially when compared with data for Europe, even its southeastern parts (Republic of Bashkortostan, Samara, Saratov and Volgograd Oblasts) (Fig. 2, Table 2). This largely determines that the species is involved in the Red Books of Kazakhstan, Kyrgyzstan, Russia (including Red Books of almost all steppe and forest-steppe regions of Russia between the Black Sea and the Altai-Sayan Mts.), Turkmenistan, and Uzbekistan. Unfortunately, the lack of data determines chiefly the pronounced inconsistency in determining the conservation status of the species (Table 2), although it is clear that the situation with its populations across different territories varies.

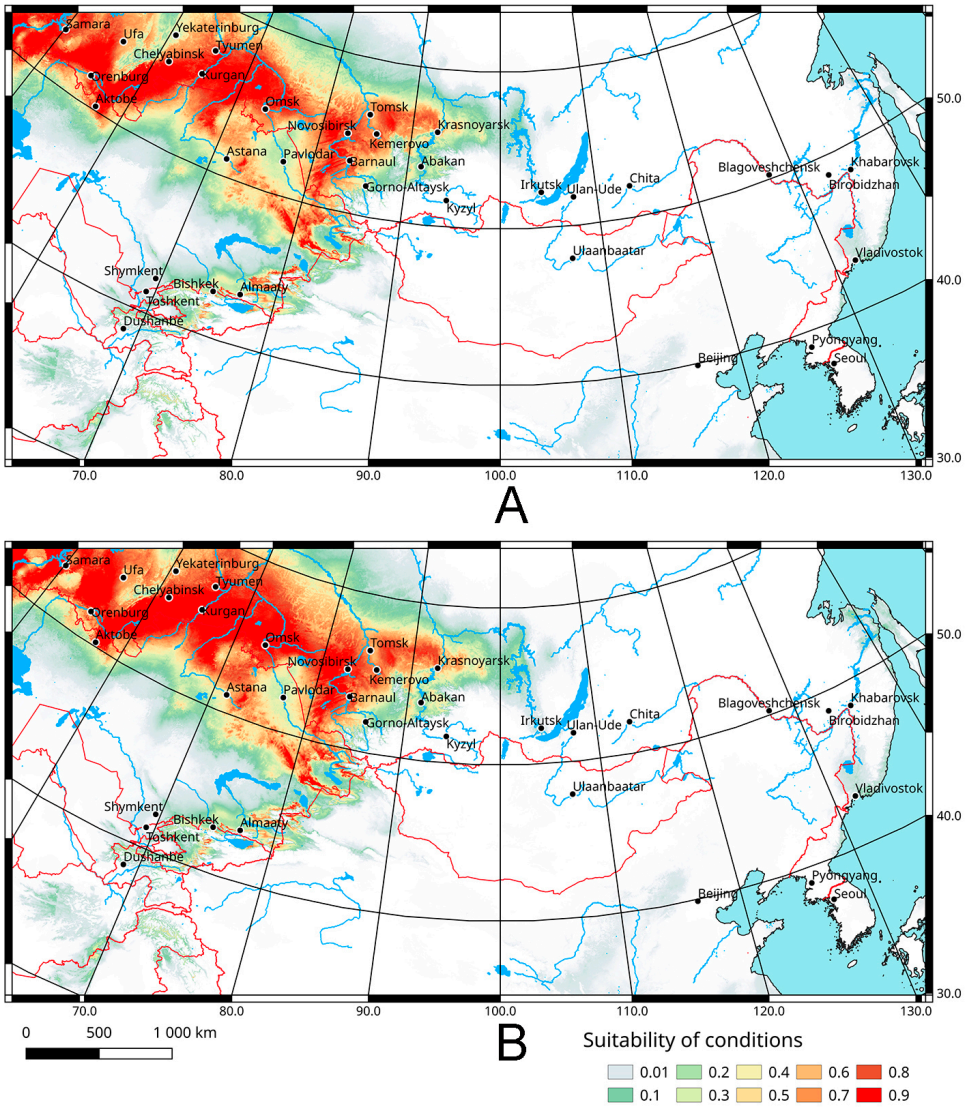


**Figure 7.** Predicted probabilities of suitable conditions for *Saga pedo* in the eastern parts of its range: forecasts of bioclimatic variables for 2021-2040 (**A**) and 2041–2060 (**B**) according the global climate model CNRM-ESM2-1 (Séférian 2018) and the 3-7.0 Shared Socioeconomic Pathway based on high greenhouse gas emissions (Meinshausen et al. 2020) (pointwise means for 25 replicates with cross-validation).

**Table 2.** Rarity categories proposed for *Saga pedo*

| Country/Region | Category | | Source | Number of occurrences according the GBIF database (2025) |
|---|---|---|---|---|
| | Traditional – cf. (Mace and Lande 1991) | IUCN (2001) | | |
| **IUCN Red List: Global** | – | Vulnerable | Orthopteroid Specialist Group 1996 | 5561 |
| **IUCN Red List: European assessment** | – | Least Concern | Hochkirch et al. 2016 | 5487 |
| **Russian Federation** | Vulnerable (2) | Vulnerable | Storozhenko 2021 | 255 |
| Republic of Bashkortostan | Rare (III) | – | Olshvang 2014 | 43 |
| Altai Krai | Vulnerable (II) | – | Perunov and Jakovlev 2016 | 0 |
| Astrakhan Oblast | Endangered (1) | – | Pirogovskii 2014 | 5 |
| Chelyabinsk Oblast | Rare (3) | Near Threatened | Lagunov and Krasutskiy 2017 | 13 |
| Kurgan Oblast | Vulnerable (2) | – | Utkin and Balakhonova 2012 | 0 |
| Novosibirsk Oblast | Vulnerable (2) | – | Sergeev 2018 | 0 |
| Omsk Oblast | Endangered (1) | – | Sidorov and Kassal 2015 | 0 |
| Orenburg Oblast | Recovering (5) | – | Nemkov 2019 | 7 |
| Samara Oblast | Rare (III) | – | Diuzhaeva and Liubvina 2009 | 11 |
| Saratov Oblast | Rare (3) | Vulnerable | Sinichkina 2021 | 35 |
| Sverdlovsk Oblast | Rare (3) | – | Gorbunov and Olshvang 2018 | 0 |
| Volgograd Oblast | Vulnerable (2) | Least Concern | Komarov and Brekhov 2017 | 42 |
| **Republic of Kazakhstan** | Vulnerable (4) | Vulnerable | Nasyrova 2003 | 11 |
| **Kyrgyz Republic** | Vulnerable (II) | Vulnerable | Chelpakova 2006 | 1 |
| **Turkmenistan** | Endangered (II) | Endangered | Kokanova 2011 | 0 |
| **Republic of Uzbekistan** | Endangered (I) | Endangered | Kreuzberg 2019 | 0 |

There is no doubt that at the forest-steppes, steppes, and semi-deserts, despite the agricultural transformation of many local ecosystems, areas suitable for the existence of populations of this bush-cricket have been preserved. This is especially noticeable in areas with complicated, especially hilly, terrains with various slopes, terraces, and balkas and with plain territories where diversified farming systems de-

veloped with various agricultural fields, including the abandoned ones, their edges, pastures, verges, forest shelter belts etc. The species populations may be found in the steppe or steppe-like habitats with natural or semi-natural grassy vegetation and especially with presence of some shrubs and/or high forbs. In addition, the bush-cricket may occur in human-dominated ecosystems, such as fallow fields, strips between agricultural fields, and verges. The main limitations for researchers are determined by the secretive lifestyle of these insects. Individuals of *S. pedo* must be specifically sought out. This requires considerable time and labor. However, activities of researchers, citizen scientists and casual observers may significantly change our ideas about the distribution and rarity of the species and affect its conservation status in a region (Table 2).

The model produced for the climatic data at the end of the 20th century is quite similar to the model generated for Europe (Ancillotto and Labadessa 2023) in its south-eastern parts despite significant differences in datasets and modelling approaches. Over the next few decades, there is a potential for a significant increase in the area of habitats suitable for the model species, especially in the southern half of the West Siberian Plain.

## Conclusions

There are significant differences between distribution and conservation statuses of *S. pedo* at the southern half of Europe (except its south-eastern areas) and the Asian parts of its range. In Europe, its populations are mainly at the broadleaf forest and Mediterranean life zones. They are commonly associated with relatively open steppe-like habitats either distributed across mountain slopes at middle altitudes or formed as a result of human activity often associated with agricultural development and combined deforestation (Repetto et al. 2024; Brandmayr et al. 2025; Della Rocca et al 2025). This is why some forms of modest human activity, e.g., traditional agropastoralism, create favorable conditions for *S. pedo* (Della Rocca et al 2025). In the region, populations of this species may be eliminated or their abundance can decrease as a result of agriculture intensification or afforestation (Repetto et al 20240. The similar problems were revealed for the European populations of another steppe species, namely the grasshopper *Bryodemella tuberculata* (Fabricius, 1775) (Dey et al 2021).

In Asia and the south-eastern parts of Europe, the main habitats of *S. pedo* are at the forest-steppe, steppe and semi-desert life zones where open, steppe or steppe-like ecosystems were and, in some areas, are still dominated. The main threats to this species are related to the intensification of agriculture, plowing of steppes and overgrazing. However, *S. pedo* occurs here not only in natural or semi-natural ecosystems, but also at heterogeneous landscapes in which it may use mosaically distributed plots with suitable conditions. This suggests that the situation with this species does not cause concern, and its populations, at least some of them, are at

applicable conditions now and, according the models for the future periods, may become more wealthy in the future. The distribution of suitable terrains and the foretold shifts are similar to those for another steppe bush-cricket, namely *Miramiola pusilla* (Miram, 1927) (Sergeev and Molodtsov 2024), and two grasshopper species (*Asiotmethis jubatus* (Uvarov, 1926) and *Mesasippis arenosus* (Bey-Bienko, 1930) (Baturina et al. 2024). However, the predicted changes of the *S. pedo* distribution are more pronounced and clearly expressed in large northward shifts. In the mountains of Middle Asia, the populations of the common predatory bush-cricket are most likely very local and associated with middle altitudes of outer ranges of Tien Shan, Gissaro-Alay, and Kopet Dagh. These colonies may be affected by overgrazing and some changes in the altitudinal distribution of mountain steppes due to global warming. Unfortunately, the areas where the environmental conditions are very suitable for *S. pedo* almost match the similar areas for very important pests, namely the Italian locust *Calliptamus italicus* (Linnaeus, 1858) (Sergeev 2021b; Sergeev et al. 2025) and the handsome cross grasshopper *Oedaleus decorus* (Germar, 1825) (Popova et al 2022). Moreover, *S. pedo* can occur in the same local habitats as these two species. Therefore, treatments against these pests may result in the elimination of the local populations of *S. pedo* (Sergeev 1996, 1998, 2021b).

In any case, *S. pedo* is included in almost all national and regional Red Books (Table 2). However, the conservation statuses of this species are quite different, from "Endangered" in Turkmenistan, Uzbekistan, and two region of Russia (Astrakhan and Omsk) to "Least Concern" in the Volgograd Oblast and in Europe as well and even "Recovering" in the Orenburg Oblast. Such a diversity of assessments, on the one hand, is undoubtedly due to the uniqueness of each region, and on the other hand, is often determined by the degree of study of the model species, the search for which often requires significant effort and time. It should also be noted, the species populations can exist in the several nature reserves, namely Orenburg (Russia), Naurzum, Korgalzhyn, and Alakol (Kazakhstan), Köpetdag and Köýtendag (Turkmenistan), and some national parks (e.g., Tarbagatai and Bayanaul in Kazakhstan).

## Acknowledgements

We wish to express our thanks to the late L.L. Mistshenko (St. Petersburg) for his advices and cooperation and to all collectors of specimens. We are also indebted to all companions of our numerous field trips to the region studied. We also thank anonymous reviewers for their valuable comments and suggestions.

Our researches were financially supported by the grant of the Russian Science Foundation 22-66-00031 (https://rscf.ru/en/project/22-66-00031).

## References

Adelung NN (1906a) Orthopterans collected by P.P. Sushkin in the Turgai region in the summer of 1898. Materialy k pozhaniu fauny i flory Rossiyskoi Imperii. Zoologia 6: 82–92. [In Russian]

Adelung NN (1906b) To the knowledge of Orthoptera fauna of the Tobolsk Province. Ezhegodink Tobolskogi gubernskogo muzeia 15: 1–18. [In Russian]

Ancillotto L, Labadessa R (2023) Can protected areas and habitats preserve the vulnerable predatory bush cricket *Saga pedo*? Journal of Insect Conservation 27: 615–624. https://doi.org/10.1007/s10841-023-00484-w

Anselmo L (2019) Habitat selection and morphology of *Saga pedo* (Pallas, 1771) in Alps (Susa Valley, Piedmont, NW Italy) (Insecta: Orthoptera, Tettigoniidae, Saginae). Fragmenta Entomologica 51(1): 63–74.

Anselmo L (2022) A field study on *Saga pedo* (Ensifera, Tettigoniidae, Saginae): Spatial behavior of adult specimens. Journal of Orthoptera Research 31(1): 41–46. https://doi.org/10.3897/jor.31.69425

Baturina NS, Kim-Kashmenskaya MN, Molodtsov VV, Popova KV, Sergeev MG (2024) Endemic grasshoppers (Orthoptera, Acridoidea) of the steppes of West Siberia and North-East Kazakhstan: How can we estimate their future? Acta Biologica Sibirica 10: 819–834. https://doi.org/10.5281/zenodo.13379288

Bekuzin AA (1972) To the knowledge of bush-crickets (Tettigonioidea, Orthoptera) of West Tien Shan. Nauchnye trudy Tashkentskogo gosudarstvennogo universiteta 398: 149–157. [In Russian]

Bey-Bienko GJa (1928) Notes on Mantidae, Tettigoniidae and Gryllidae (Orthoptera) of Orenburg vicinities. Revue Russe d'Entomologie 22(1–2): 124–128. [In Russian]

Bey-Bienko GJa (1929) Beiträge zur Kenntnis der Verbreitung der Orthopteren im Asiatischen Russland. Zoologischer Anzeiger 81(1–4): 65–72.

Brandmayr P, Mazzei A, Bonacci T, Surdo S, Massa B (2025) One hundred and eighty years of *Saga pedo* (Pallas, 1771) (Orthoptera, Tettigoniidae) findings in Italy diachronically revisited. The European Zoological Journal 92(1): 51–60. https://doi.org/10.1080/24750263.2024.2439843

Cantrall IJ (1972) *Saga pedo* (Pallas) (Tettigoniidae: Saginae) an old world katydid new to Michigan. Great Lakes Entomologist 5: 103–106. https://doi.org/10.22543/0090-0222.1224

Chelpakova ZM (2006) *Saga pedo* (Pallas, 1771). In: Kyrgyz Republic Red Data Book. Bishkek, 252–253 p. [In Kyrgyz, Russian and English]

Childebaev MK (2007) Annotated list of orthopterans (Orthopteroidea) of Alalkol Nature Protected Area. Tethys. Entomological Research 15: 5–26. [In Russian]

Childebaev MK, Storozhenko SYu (2004) An annotated list of long-horned orthopterans (Orthoptera, Ensifera) of Kazakhstan. Tethys. Entomological Research 9: 213–228.

Childebaev MK, Taranov BT (2023) Orthopteroidea of the Tarbagatai State National Nature Park. In: Nasekomye (Insecta) Gosudarstvennogo Nacionalnogo Prirodnogo Parka "Tarbagatai". LEM, Almaty, 26–61 p. [In Russian]

Cigliano MM, Braun H, Eades DC, Otte D (2025) *Saga pedo* (Pallas, 1771). Orthoptera Species File. http://orthoptera.speciesfile.org/otus/804627/overview (accessed on 25 July 2025)

Della Rocca F, Repetto E, De Caria L, Milanesi P (2025) Identifying ecological corridors of the bush cricket *Saga pedo* in fragmented landscapes. Insects 16(3): 279. https://doi.org/10.3390/insects16030279

Dey LS, Simões MVP, Hawlitschek O, Sergeev MG, Xu S-Q, Lkhagvasuren D, Husemann M (2021) Analysis of geographic centrality and genetic diversity in the declining grasshopper species *Bryodemella tuberculata* (Orthoptera: Oedipodinae). Biodiversity and Conservation 30: 2773–2796. https://doi.org/10.1007/s10531-021-02221-8

Diuzhaeva IV, Liubvina IV (2009) *Saga pedo* Pallas, 1771. In: Rozenberh GS, Samsonov SV (Eds) Krasnaya kniga Samarskoi Oblasti 2. IEVB RAN, Kassandra, Tolyatti, 41 p. [In Russian]

Dvorskaya EN (2006) Insects damaging safflower in the south and southeast of Kazakhstan and development of measures to protect crops from safflower weevils. PhD Thesis. Almaty, 25 p. [In Russian]

Elith J, Phillips SJ, Hastie T, Dudík M, Chee YE, Yates CJ (2011) A statistical explanation of MaxEnt for ecologists. Diversity and Distributions 17: 43–57. https://doi.org/10.1111/j.1472-4642.2010.00725.x

Fick SE, Hijmans RJ (2017) WorldClim 2: New 1 km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37: 4302–4315. https://doi.org/10.1002/joc.5086

Gause GF (1930) Studies on the ecology of the Orthoptera. Ecology 11: 307–325. https://doi.org/10.2307/1930266

GBIF (2025) *Saga pedo* (Pallas, 1771). GBIF Occurrence Download (accessed on 25 July 2025). https://doi.org/10.15468/dl.kwwqkm

Gerasimov SV, Krivosheev MM (2018) Finds of rare representatives of Orthoptera at the Republic of Bashkortostan. In: Valuev VA (Ed.) Rare and endangered species of animals and plants of the Republic of Bashkortostan. Bashkirskii gosudarstvennyi universitet, Ufa, 7–11 p. [In Russian]

Goldschmidt E (1946) Polyploidy and Parthenogenesis in the Genus *Saga*. Nature 158: 587–588. https://doi.org/10.1038/158587c0

Gorbunov PJu, Olshvang VN (2018) *Saga pedo* (Pallas, 1771). In: Korytion NS (Ed.) Krasnaya kniga Sverdlovskoi Oblasti. Mir, Ekaterinburg, 116 p. [In Russian]

Guseva VS (1986) Peculiarities of biotopical distribution of some species of Tettigoniidae (Orthoptera) of Naurzum Reservation. Proceedings of the Zoological Institute 143: 14–16. [In Russian]

Hochkirch A, Massa B, Skejo J, Presa JJ, Zuna-Kratky T, Kristin A, Ivkovic S, Korsunovskaya O, Monnerat C, Puskas G, Chobanov DP, Szovenyi G, Kleukers R, Rutschmann F (2016) *Saga pedo* (Europe assessment). The IUCN Red List of Threatened Species 2016: e.T19811A74624296. (accessed on 14 July 2025).

Holuša J, Kočárek P, Vlk R (2010) Occurrence of *Saga pedo* (Orthoptera, Tettigoniidae) in the Czech Republic: review of faunistic data. North-Western Journal of Zoology 6(2): 218–224.

Holuša J, Kočárek P, Vlk R (2013) Monitoring and conservation of *Saga pedo* (Orthoptera: Tettigoniidae) in an isolated nothwestern population. Journal of Insect Conservation 17: 663–669. https://doi.org/10.1007/s10841-013-9550-3

Huang R, Yu Y (1987) New record of Chinese Saginae. Entomotaxonomia 8(4): 290. [In Chinese]

Isachenko AG (1985) Landscapes of the USSR. Leningrad University Publ., Leningrad, 320 pp. [In Russian]

IUCN (2001) IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission, Gland and Cambridge, 30 pp.

Kadyrbekov RH, Childebaev MK, Zhdanko AB, Tleppaeva AM, Kolov SV (2017) Impact of anthropogenic and abiotic factors on the structure of the insect fauna of the steppe life zone of Kazakhstan in contemporary environments. Almaty, 460 pp. [In Russian]

Kaltenbach A (1964) Zur Systematik und Verbreitung der Raubheuschrecken (Tettigoniidae – Saginae), insbesondere der eurpäischen Arten der Gattung *Saga* Charpentier. Zeitschrift der Arbeitsgemeinschaft Österreichischer 16(1–3): 68–82.

Karmazina IO, Shulaev NV (2015) Ecological and faunistic review of Orthoptera in the central part of the Volga-Kama Region (Republic of Tatarstan). Entomological Review 95(7): 832–851. https://doi.org/10.1134/S0013873815070039

Kokanova E (2011) *Saga pedo* (Pallas, 1771). In: Annabaýramow B (Ed.) The Red Data Book of Turkmenistan 2. Ylym, Ashgabat, 46 p. [In Turkmen, English and Russian]

Kolics B, Ács Z, Chobanov DP, Orci KM, Qiang LS, Kovács B, Kondorosy E, Decsi K, Taller J, Specziár A, Orbán L, Müller T (2012) Re-visiting phylogenetic and taxonomic relationships in the genus *Saga* (Insecta: Orthoptera). PLoS ONE 7(8): e42229. https://doi.org/10.1371/journal.pone.0042229

Komarov EV, Brekhov OG (2017) *Saga pedo* (Pallas, 1771) In: Krasnaya kniga Volgogradskoi Oblasti 1. Volgograd, 50 p. [In Russian]

Krasutskiy BV, Gashek VA, Polyakov VE (2022) New records of the invertebrates from the Chelyabinsk region Red Data Book. Fauna of the Urals and Siberia 2: 39–49. https://doi.org/10.56268/24110051_2022_2_39 [In Russian]

Kreuzberg AV-A (2019) Predatory bush cricket *Saga pedo* (Pallas, 1771). In: Akhmedov MH, Abdullaev II (Eds) Krasnaya kniga Respubliki Uzbekistan 2. Chinor ENK, Toshkent, 41 p. [In Uzbek, Russian, and English]

Krištín A, Kaňuch P (2007) Population, ecology and morphology of *Saga pedo* (Orthoptera: Tettigoniidae) at the northern limit of its distribution. European Journal of Entomology 104: 73–79. https://doi.org/10.14411/eje.2007.012

Lagunov AV, Krasutskiy BV (2017) *Saga pedo* (Pallas, 1771). In: Lagunov AV (Ed.) Krasnaya kniga Cheliabinskoi Oblasti. Moscow, 100 p. [In Russian]

Lemonnier-Darcemont M, Bernie C, Darcemont C (2009) Field and breeding data on the European species of the genus *Saga* (Orthoptera: Tettigoniidae). Articulata 24(1/2): 1–14.

Lemonnier-Darcemont M, Darcemont C, Heller K-G, Dutrillaux A-M, Dutrillaux B (2016) Saginae of Europe – Les Saginae d'Europe. G.E.E.M., Cannes, 208 pp.

Mace GM, Lande R (1991) Assessing extinction threats: Toward a reevaluation of IUCN threatened species categories. Conservation Biology 5(2): 148–157. https://doi.org/10.1111/j.1523-1739.1991.tb00119.x

McGrath PE (2020) Nectar feeding in the carnivorous bush cricket, *Saga pedo* (Orthoptera, Tettigoniidae). Antenna 44(4): 152.

Meinshausen M, Nicholls ZRJ, Lewis J, Gidden MJ, Vogel E, Freund M, Beyerle U, Gessner C, Nauels A, Bauer N, Canadell JG, Daniel JS, John A, Krummel PB, Luderer G, Meinshausen N, Montzka SA, Rayner PJ, Reimann S, Smith SJ, van den Berg M, Velders GJM, Vollmer MK, Wang RHJ (2020) The shared socioeconomic pathway (SSP) greenhouse gas concentrations and their extensions to 2500. Geoscientific Model Development 13: 3571–3605. https://doi.org/10.5194/gmd-13-3571-2020

Nasyrova SR (2003). In: Mitiaev ID (Ed.) Red Data Book of Kazakhstan 1(2). Tethys, Almaty, 74–75 p. [In Russian]

Nefedov NI, Miram EF (1939) About fauna and ecology of Tettigoniidae of the Troitsk Natural Reserve. News of Perm Biological Research Institute 11(9–10): 265–278. [In Russian]

Nemkov VA (2019) *Saga pedo* (Pallas, 1771). In: Belov VS (Ed.) Krasnaya kniga Orenburgskoi Oblasti. Mir, Voronezh, 17–18 p. [In Russian]

Olshvang VN (2014) *Saga pedo* (Pallas, 1771). Krasnaya kniga Respubliki Bashkortostan 2. Infromreklama, Ufa, 22–23 p. [In Russian]

Orthopteroid Specialist Group (1996) *Saga pedo*. The IUCN Red List of Threatened Species 1996: e.T19811A9018679. https://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T19811A9018679.en (accessed on 14 July 2025).

Pallas PS (1771) Reise durch verschiedene Provinzen des Russischen Reichs 1. St. Petersburg, 504 pp.

Perunov JuE, Jakovlev RV (2016) *Saga pedo* (Pallas, 1771). In: Irisova NL, Shapet'ko EV, Jakovlev RV (Eds) Krasnaya kniga Altaiskogo Kraya 2. Altai State University, Barnaul, 34 p. [In Russian]

Phillips SJ, Anderson RP, Schapire RE (2006) Maximum entropy modeling of species geographic distributions. Ecological Modelling 190: 231–259. https://doi.org/10.1016/j.ecolmodel.2005.03.026

Phillips SJ, Anderson RP, Dudík M, Schapire RE, Blair B (2017) Opening the black box: An open-source release of Maxent. Ecography 40: 887–893. https://doi.org/10.1111/ecog.03049

Pirogovskii MI (2014) *Saga pedo* (Pallas, 1771) In: Krasnaya kniga Astrakhanskoi Oblasti. Astrakhan, 164–165 p. [In Russian]

Popova KV, Baturina NS, Molodtsov VV, Yefremova OV, Zharkov VD, Sergeev MG (2022) The handsome cross grasshopper *Oedaleus decorus* (Germar, 1825) (Orthoptera: Acrididae) as a neglected pest in the south-eastern part of West Siberian Plain. Insects 13: 49. https://doi.org/10.3390/insects13010049

Pradvin FN (1978) Ecological geography of insects of Middle Asia. Orthopteroidea. Nauka Publ., Moscow, 271 pp. [In Russian]

Pylnov E (1914) About fauna of Orthoptera of Asian Russia. Revue Russe d'Entomologie 14(1): 107–110. [In Russian]

QGIS (2025) QGIS. A free and open source geographic information system. https://www.qgis.org

Repetto E, Milanesi P, De Caria L, Della Rocca F (2024) Ecology and abundance of a relict population of the bush cricket *Saga pedo* in the Northern Apennines, Italy. Ecology and Evolution 14: e11381. https://doi.org/10.1002/ece3.11381

Séférian R (2018) CNRM-CERFACS CNRM-ESM2-1 Model Output Prepared for CMIP6 CMIP Amip. Version 20211010. Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.3924

Sergeev MG (1986) Distribution patterns of Orthoptera in North Asia. Nauka Publ., Novosibirsk, 237 pp. [In Russian]

Sergeev MG (1992) Distribution patterns of Orthoptera in North and Central Asia. Journal of Orthoptera Research 1: 14–24. https://doi.org/10.2307/3503557

Sergeev MG (1996) La sécheresse et les schémas de distribution des criquets en Asie centrale et septentrionale. Secheresse 7(2): 129–132.

Sergeev MG (1998) Conservation of orthopteran biological diversity relative to landscape change in temperate Eurasia. Journal of Insect Conservation 2: 247–252. https://doi.org/ 10.1023/A:1009620519058

Sergeev MG (2018) *Saga pedo* (Pallas, 1771). In: Glupov VV, Shaulo DN (Eds) Krasnaya kniga Novosibirskoi Oblasti. Andrey Khristolyubov's Printing House, Novosibirsk, 46 p. [In Russian]

Sergeev MG (2021a) Distribution patterns of grasshoppers and their kin over the Eurasian steppes. Insects 12: 77. https://doi.org/10.3390/insects12010077

Sergeev MG (2021b) Ups and downs of the Italian locust (*Calliptamus italicus* L.) populations in the Siberian steppes: On the horns of dilemmas. Agronomy 11: 746. https://doi.org/10.3390/agronomy11040746

Sergeev MG, Childebaev MK, Ji R, Molodtsov VV, Baturina NS, Van'kova IA, Kim-Kashmenskaya MN, Popova KV, Zharkov VD, Yefremova OV (2025) Ecologo-geographic distribution patterns of the Italian locust *Calliptamus italicus* (Linnaeus) (Orthoptera: Acrididae) in the easternmost part of its range. Insects 16: 211. https://doi.org/10.3390/insects16020211

Sergeev MG, Molodtsov VV (2024) New data on distribution of *Miramiola pusilla* (Miram, 1927) (Orthoptera: Tettigoniidae). Far Eastern Entomologist 496: 16–24. https://doi.org/ 10.25221/fee.496.4

Sidorov GN, Kassal BJu (2015) *Saga pedo* Pallas, 1771 In: Sidorov GN, Plikina NV (Eds) Krasnaya kniga Omskoi Oblasti. Omsk State Pedagogical University, Omsk, 61–62 p. [In Russian]

Sinichkina OV (2021) *Saga pedo* (Pallas, 1771). In: Krasnaya kniga Saratovskoi Oblasti. Papirus, Saratov, 274–275 p. [In Russian]

Snegovaya N, Kerimova I (2022) A check-list of the Orthoptera of Azerbaijan Republic. Munis Entomology & Zoology 17(1): 545–572.

Storozhenko SYu (2004) Long-horned orthopterans (Orthoptera: Ensifera) of the Asiatic part of Russia. Dalnauka, Vladivostok, 280 p. [In Russian]
Storozhenko SYu (2021) *Saga pedo* (Pallas, 1771) In: Krasnaya kniga Rossiiskoi Federacii [Red Data Book of the Russian Federation]. Animals. Moscow, 116–117 p. [In Russian]
Tarbinsky SP (1940) The saltatorian orthopterous insects of the Azerbaidzhan SSR. USSR Academy of Sciences Publ., Moscow & Leningrad, 245 pp. [In Russian]
Temreshev II, Esenbekova PA (2017). Ortopteroid insects (Insecta, Orthopteroidea) of the Tasotkel water reservoir area (Kazakhstan). Acta Biologica Sibirica 3(1): 13–22. [In Russian]
Utkin NA, Balakhonova VA (2012) *Saga pedo* (Pallas, 1771). In: Krasnaya kniga Kurganskoi Oblasti. Kurgan State University, Kurgan, 112 p. [In Russian]
Uvarov BP (1910) Data on orthopteran fauna of the Ural Oblast. Horae Societatis Entomologicae Rossicae 39: 359–390. [In Russian]
Varga, S, Riezing, N, Kenyeres, Z (2025) A fűrészlábú szöcske (*Saga pedo*) aktivitásának jelölésvisszafogás vizsgálata a csákvári Nagy-Vásár-hegyen. Természetvédelmi Közlemények 31: 19162. https://doi.org/10.20332/tvk-jnatconserv.2025.31.19162 [In Hungarian]
WorldClim (2022) WorldClim https://worldclim.org/data/index.html

## Supplementary material 1

**Table S1. Known localities of *Saga pedo* in the eastern part of its range**

Authors: Ekaterina S. Shibkova, Vladimir V. Molodtsov, Muratbek K. Childebaev, Oxana V. Yefremova, Michael G. Sergeev
Data type: table

Link: https://journal.asu.ru/biol/article/view/18045/15491