Zootaxa 5566 (1): 173–184
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5566.1.8
http://zoobank.org/urn:lsid:zoobank.org:pub:A237C310-87F1-4855-9C43-26645A832114

Taxonomy, distribution patterns and ecological and geographic modelling of *Clinotettix ussuriensis* Bey-Bienko, 1933 (Orthoptera: Tetrigidae)

MICHAEL G. SERGEEV[1,2], VLADIMIR V. MOLODTSOV[1,2], SVETLANA V. LAPTEVA[3] & SERGEY YU. STOROZHENKO[3*]

[1]*Novosibirsk State University, Novosibirsk, 1 Pirogova Street, 630090, Russia*
mgs@fen.nsu.ru; https://orcid.org/0000-0003-2179-0921
vv@fen.nsu.ru; https://orcid.org/0000-0001-9169-9934
[2]*Institute of Systematics and Ecology of Animals, Siberian Branch of the Russian Academy of Sciences, 11 Frunze Street, Novosibirsk, 630091, Russia*
[3]*Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 690022, Russia*
lapteva.sv24@gmail.com; https://orcid.org/0009-0005-5949-9904
storozhenko@biosoil.ru; https://orcid.org/0000-0001-9269-4043
**Corresponding author*

Abstract

Clinotettix Bey-Bienko, 1933 is the small genus similar to *Tetrix* Latreille, 1802 but easy recognizable from the latter in the shape of a head. Two species of *Clinotettex* are distributed in the Russian Far East, North-East China, and Korean Peninsula. The type species of this genus is *Clinotettix ussuriensis* Bey-Bienko, 1933, not *Acrydium sibiricum ussurianum* Bey-Bienko, 1929 as erroneously considered by some researches. We also confirm that *Clinotettix chanbaishanensis* Wang, Wang et Ren, 2004 is a junior objective synonym of *Clinotettix ussuriensis*. The data on distribution of *C. ussuriensis* are summarized. It is the endemic of the temperate deciduous and mixed forest life subzones of the Far East. Its populations are widely distributed, but look like insular. The species abundance is usually low. Hence, *C. ussuriensis* can be qualified as an endangered species. In any case, a few populations of *C. ussuriensies* are protected in several Russian nature reserves (zapovedniks), namely Kedrovaya Pad, Ussuriisky, and Sikhote-Alinsky. The species distribution models based on two different approaches (maximum entropy and multidimensional ellipsoid) generated for the contemporary climatic conditions fit well the distribution of the species known localities, but show there are some areas suitable for the species outside its modern range. The models generated for the future climatic conditions demonstrate possible increase of condition suitability over the whole modern species range. Besides, almost all favorable areas outside the actual species range may remain beneficial for the species as well.

Key words: pygmy grasshoppers, *Clinotettix*, taxonomy, distribution, modelling, forecast, Russian Far East, North-East China, Korean Peninsula

Introduction

The monotypic genus *Clinotettix* Bey-Bienko, 1933 was established for *C. ussuriensis* Bey-Bienko, 1933 from the Russian Far East (Bey-Bienko, 1933). The second species was described from North-East China based only on females (Zheng & Ren, 1996); the description of males of *C. jilinensis* Zheng et Ren, 1996 was given later (Wang & Ren, 2007). The third species, *C. chanbaishanensis* Wang, Wang et Ren, 2004, was described from North-East China as well (Wang *et al*., 2004) but later was synonymized under *C. ussuriensis* (Storozhenko & Paik, 2010). Unfortunately, taxonomy of this genus and its species is confused and some references are also given incorrectly (Otte, 1997; Cigliano *et al*., 2024). Here, we clarify such taxonomic problems, summarize the data on distribution of *C. ussuriensis*, and try to use two approaches to species distribution modelling to estimate possible changes of its range relative to actual and future climate changes.

Accepted by R. Mariño-Pérez: 12 Nov. 2024; published: 7 Jan. 2025

Material and methods

This paper is based on the collections of the Zoological Institute of the Russian Academy of Sciences (St. Petersburg, Russia) and the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences (Vladivostok, Russia), as well as on our own observations in 1976–2020 and critical analysis of published data. 21 localities with the known geographic coordinates were used for an analysis and modelling.

Nomenclature is given according to rules of the International Code of the Zoological Nomenclature (ICZN, 1999). The morphological terminology and measurements follow those of Tumbrinck (2014). Photographs were taken with an Olympus SZX16 stereomicroscope and an Olympus DP74 digital camera, and then stacked using Helicon Focus software. The final illustrations were post-processed for contrast and brightness using Adobe® Photoshop® software.

QGIS 3.18.3 and a Lambert conformal conic projection were used to produce all maps. Two different approaches to species distribution modelling, namely the maximum entropy algorithm (Maxent 3.4.4) and the ecological niche mapping, were utilized to shape the potential species range shifts in the modern and future constraints. The first one is based on the machine learning technique (Phillips *et al.,* 2017) and is widely used to model the distribution of rare, invasive or pest forms from different taxa. The latter is associated with generation of multidimensional ellipsoid models of ecological niches (Cobos *et al*., 2023). Some limitations of both approaches are well described in several publications (Phillips *et al.,* 2017; Morales *et al*., 2017; Cobos *et al*., 2023). The full collection of bioclimatic variables (the so-called "Historical climate data" and "Future climate data" for 2021–20140 and 2041–2060 at the 30 arcsecond spatial resolution (Fick & Hijmans, 2017)) was used for the maximum entropy modelling, and the selected variables were used to produce ellipsoid models. In the both cases, 21 replicates were counted. The main parameters of these approaches applied to different orthopteran species were described earlier (Dey *et al*., 2021; Popova *et al*., 2022; Storozhenko *et al*., 2023; Baturina *et al*., 2024b).

Taxonomy

Family Tetrigidae Rambur, 1838

Subfamily Tetriginae Rambur, 1838

Genus *Clinotettix* Bey-Bienko, 1933

Clinotettix Bey-Bienko, 1933: 327; Bey-Bienko, 1951: 101; Steinmann, 1964: 457, 465; Steinmann, 1971: 331; Podgornaja, 1976: 8; Podgornaja, 1983: 67; Storozhenko, 1986: 274; Blackith, 1992: 24; Yin *et al*., 1996: 858; Liang & Zheng, 1998: 180, 248, 257; Kim & Kim, 2004: 263; Storozhenko & Paik, 2007: 128; Storozhenko & Paik, 2010: 39; Storozhenko *et al*., 2015: 173.

Tetrix: Rehn & Grant, 1961: 43 (partim); Otte, 1997: 124 (partim).

Type species: *Clinotettix ussuriensis* Bey-Bienko, 1933, by original designation.

Redescription. Body medium size for subfamily. Head with frons strongly slanted; frontal ridges weakly emarginated between the eyes and roundly protruding between the antennal sockets. Antennae filiform, 14–16-segmented; antennal sockets situated at the lower margins of eyes. Eyes not protruding above vertex in lateral view. Fastigium in dorsal view apically angulated, much wider than width of an eye, its median carina distinct but not merging with frontal costa; in lateral view fastigium considerably produced in front of eyes. Dorsal side of pronotum flat, with almost straight or indistinctly triangular anterior margin; median carina developed as well as the lateral carinae; in lateral view median carina straight or weakly arched near the transverse furrows, but always low and almost disappear near anterior margin of promotum; the oblique carinae not reaching the humeral angles; posterior process of pronotum long, but relatively broad at apex. Lateral lobes of pronotum with hind margin bisinuate, the upper (tegminal) sinus almost as deep as lower one. Tegmina ovate; hind wings with scalloped inner margin, almost reaching or slightly surpassing the apex of posterior process of the pronotum. Lower side of fore and mid femora indistinctly sinuate or almost straight; upper and lower sides of hind femur finely serrated. First tarsal segment of hind legs longer than 3rd one, with rather pointed ventral pads. Male subgenital plate triangular with apex shallowly notched. Female subgenital plate with triangular posterior margin; dorsal valves of ovipositor thick, at about 3 times as long as wide; ventral valves narrower, 4.5 times as long as wide.

Remarks. Taxonomy of the genus is confused till now. Rehn & Grant (1961) compared the original description of *Clinotettix ussuriensis* with Nearctic *Tetrix brunnerii* (Bolívar, 1887) and considered the genus *Clinotettix* as a synonym of *Tetrix* Latreille, 1802. Later Podgornaja (1976) resurrected *Clinotettix* as the distinct genus. Otte (1997) again placed *Clinotettix* under the synonym of *Tetrix* and erroneously mentioned *Acrydium sibiricum ussurianum* Bey-Bienko, 1929 as the type species of *Clinotettix*. The taxon described as the subspecies of *A. sibiricum* I. Bolívar, 1887 from the Russian Far East (Bey-Bienko, 1929) is not conspecific with *Clinotetttix ussuriensis*. Moreover *A. sibiricum ussurianum* was synonymized with *Tetrix japonica* (I. Bolívar, 1887) by Bey-Bienko (1951). Unfortunately, till now such incorrect data are present in the Orthoptera Species File database (Cigliano *et al*., 2024).

The genus *Clinotetttix* is most similar to *Tetrix* Latreille, 1802 but differs from the latter in the strongly slanted frons and the fastigium considerably produced in front of eyes (in *Tetrix*, the frons more or less vertical and fastigium rather short and roundly truncated).

Composition. This genus consists of *Clinotettix jilinensis* Zheng et Ren, 1996 from Jilin Province of China and the type species. A key to species is given below.

Key to species of *Clinotettix*

1(2) Hind femora slender, 3.0–3.75 times as long as wide. Fastigium only 2.2–2.6 times as wide as an eye from above . . . . *C. ussuriensis*

2(1) Hind femora broad, 2.7 times as long as wide. Fastigium 3.0–3.3 times as wide as an eye from above. . . . . *C. jilinensis*

Clinotettix ussuriensis Bey-Bienko, 1933

Figs 1–13

Clinotettix ussuriensis Bey-Bienko, 1933: 329, figs. 9, 10 (holotype—female, Russia: "Tigrivaya, Suchan district, Ussuri region" (=Tigrovoi, Partizanskii district, Primorskiy krai), 9.VI 1927, A.A. Stackelberg"; deposited in ZIN); Bey-Bienko, 1951: 101, fig. 59; Steinmann, 1964: 465, fig. 9; Steinmann, 1971: 331; Pravdin & Cherniakhovsky, 1975: 369; Podgornaja, 1976: 9; Podgornaja, 1983: 68, figs. 3, 92, 93; Storozhenko, 1986: 274, fig. 132, *3*; Sergeev, 1986: 189; Zheng, 1989: 67; Blackith, 1992: 24; Kostia, 1995: 264, figs. 9–10; Yin *et al*., 1996: 858; Liang & Zheng, 1998: 180, 257, fig. 128; Wang *et al*., 2004: 730, 732; Kim & Kim, 2004: 264, fig. 6; Storozhenko, 2006: 96; Storozhenko & Paik, 2007: 129, figs. 361, 362; Storozhenko, 2009: 48; Storozhenko & Paik, 2010: 40: 128, figs. 1–7; Kim, 2013: 260; Storozhenko *et al*., 2015: 173, figs. 425, 426, 452–454.

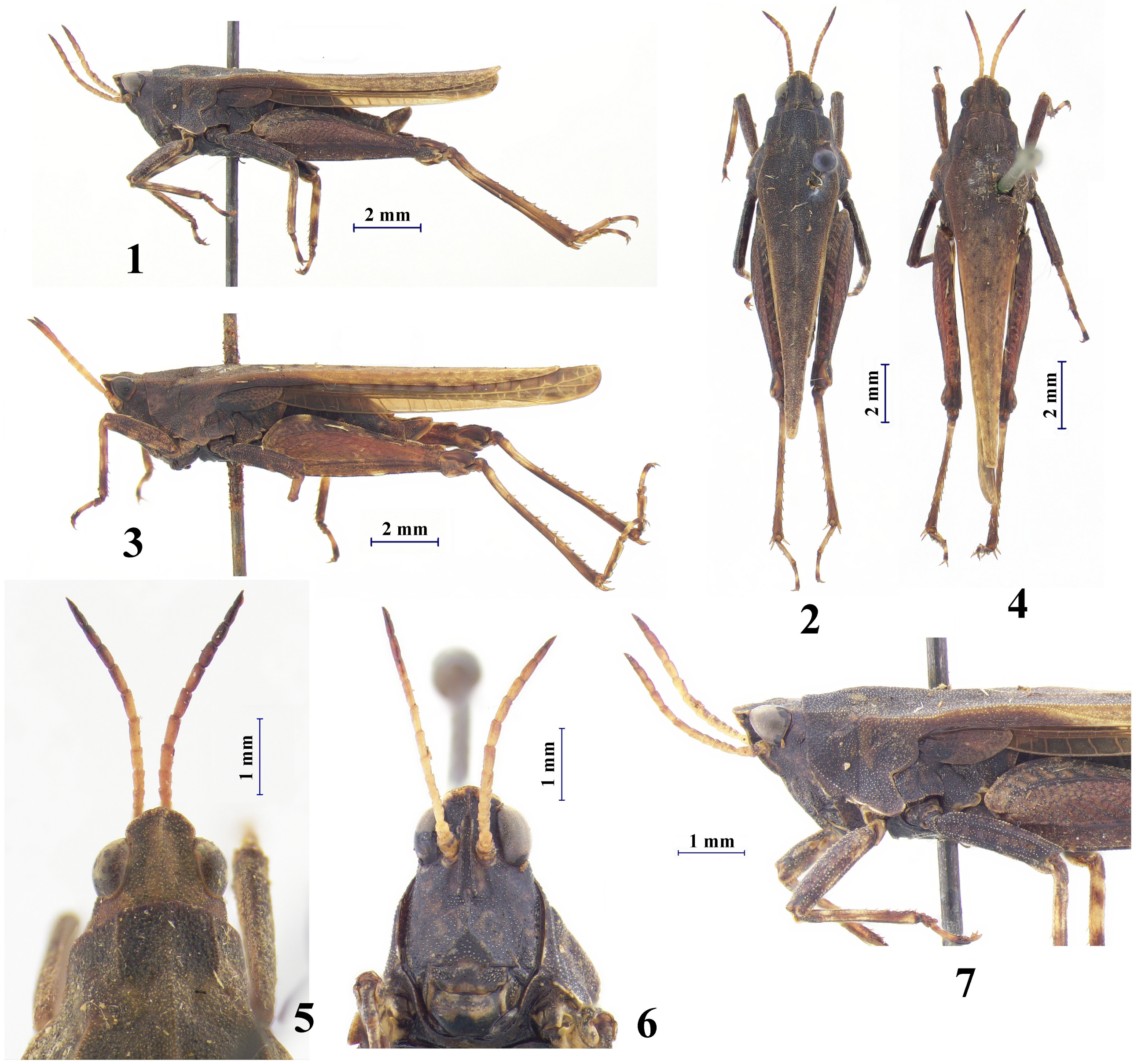
Tetrix ussuriensis: Rehn & Grant, 1961: 43.

Tetrix ussuriensis (nec Bey-Bienko, 1933): Otte, 1997: 134.

Clinotettix chanbaishanensis Wang *et al*., 2004: 730, 731, figs. 1, 2 (holotype—male, China: "Jilin Province, Hengshan Station south hillside of Mt. Changbai, 2.VIII.1983, B.-Zh. Ren"; deposited in the School of Life Science, Northeast Normal University, Changchun, China); synonymized by Storozhenko & Paik (2010).

Type material examined. Holotype—female, Tigrivaya, Suchan district, Ussuri region, 9.VI.1927, leg. A.A. Stackelberg (ZIN).

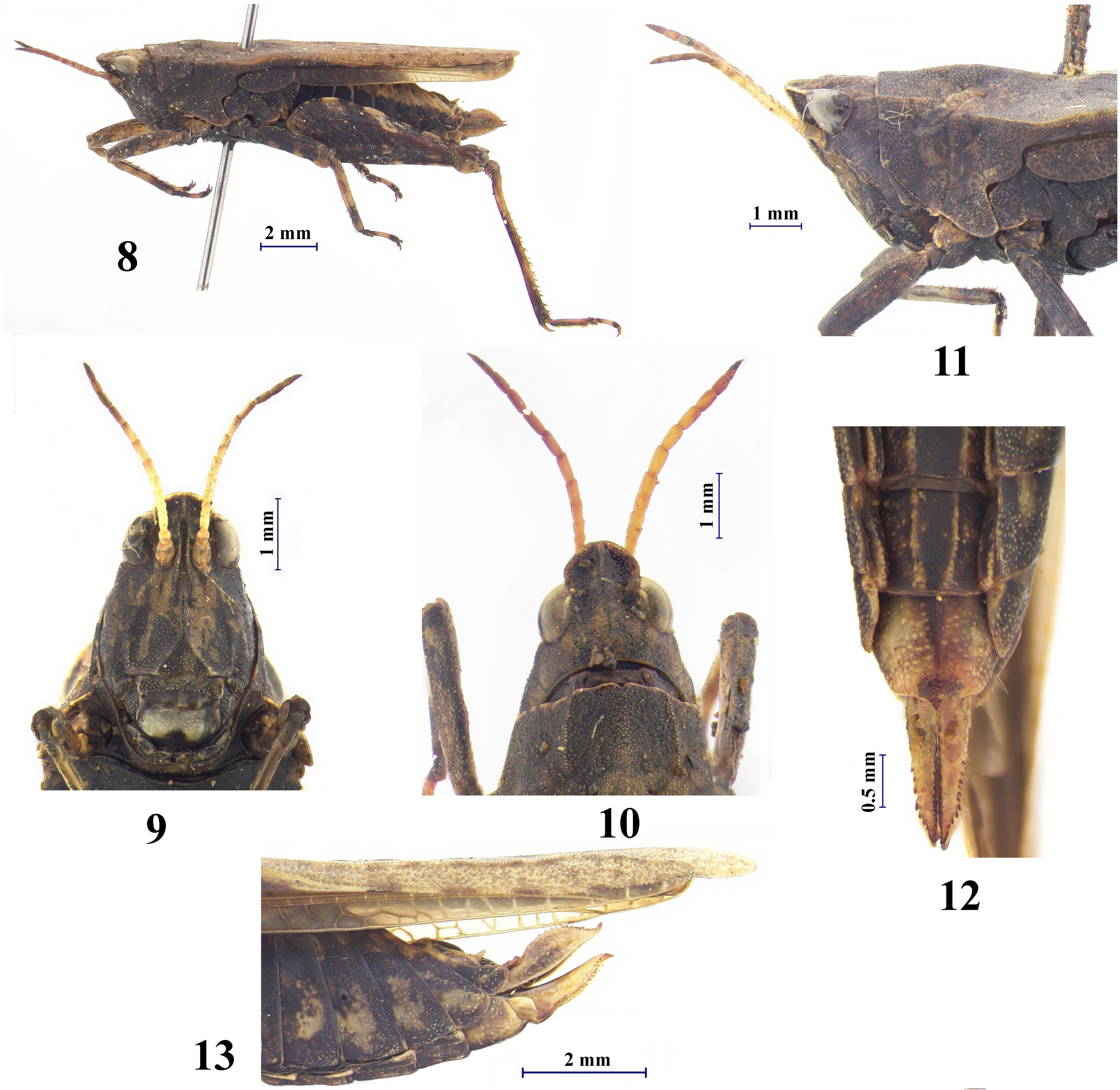
Other material examined. Russia: Primorsky Krai: Kedrovaya Pad Nature Reserve, 43.13°N, 131.56°E, 07.VII.1975, 1♂, 1♀ (V. Makarkin, A. Ryabukhin); middle course of Krounovka River, 43.66°N, 131.57°E, 04.VI.1986, 2♂, 2♀ (S. Storozhenko); the same locality, 05–09.VII.1993, 1♂ (S. Storozhenko); Nezhinka River, Koreiskiy brook, 43.50°N, 131.56°E, 07–09.VI.1986, 7♂, 7♀, 4 nymphs (S. Storozhenko); Malaya Ananevka River, Kabarginskiy brook, 43.41°N, 131.58°E, 10.VI.1986, 1♀ (S. Storozhenko); vicinity of Komissarovo, 44.97°N, 131.77°E, 12.VII.1980, 6♂, 10♀ (S. Storozhenko); Ussuriisky Nature Reserve, 43.65°N, 132.50°E, 29.V.1969, 1♂ (M. Chernyakhovsky); Partizanskaya River, 42.87°N, 133.01°E, 06.VI.1986, 1♂, 5♀ (A. Plutenko); Partizansky Ridge, Povorotnaya River, 43.41°N, 133.52°E, 06.VIII.1986, 1♂, 1♀ (S. Storozhenko); Slinkino, 43.59°N, 133.38°E, 22–23.VI.1981, 1♂, 5♀ (A. Plutenko); Anuchinsky district, Vinogradovka, 43.76°N, 132.96°E, 2♀ (ZIN); Chuguevsky district, Chuguevka, Berezoviy brook, 44.20°N, 133.87°E, 8♂, 9♀ (ZIN); Sikhote-Alinsky Nature Reserve, Zabolochenaya River, 45.31°N, 136.48°E, 01.VI.2020, 1♀ (M.E. Sergeev). Khabarovsky Krai: Konin River, 1♂ (ZIN); Verhnebureinsky district, Chegdomyn, 51.13°N, 132.96°E, 10.VII.2000, 2♀ (A. Blummer).



FIGURES 1–7. *Clinotettix ussuriensis*, male. 1, 3. Body, lateral view; 2, 4. Same, dorsal view; 5. Head and anterior part of pronotum, dorsal view; 6. Head, frontal view; 6. Anterior part of body, lateral view.

Literature data. China: Jilin Province: Hengshon station, Mt. Changbai, 43.75°N, 126.62°E, 02.VIII.1983, 1♀ (Wang *et. al*., 2004); Liaoning Province: Shenyang, 41.73°N, 123.33°E; Qianshan, 41.06°N, 123.95°E (Liang & Jang, 1998). **Democratic People's Republic of Korea**: Jamo-ri near Sunchon, 39.69°N, 126.03°E, 27.V.1965, 5♂, 6♀; Sokam-Chosudji, 39.60°N, 126.07°E, 21.V.1965, 1♀; the same locality, 02.XI.1970, 1♂ (Kostia, 1995). **Republic of Korea**: Gyeonggi-do: Munsan, 37.89°N, 126.79°E, 09.X.1972, 1♂; Gangwon-do: Jangneung Yeongweol, 37.72°N, 128.82°E, 17.IV.2004, 1♀ (Kim & Kim, 2004).

Redescription. Fastigium in male 1.7–2.2 times, in female 2.2–2.6 times wider than width of an eye from above. Lateral ocelli situated slightly below the lower one-third of eyes. Frontal ridge near the base of the antennae distinctly narrower than 1st antennal segment (scapus). Length of antennae 1.4–1.7 times more than length of the fore femur; mid segments of antennae 1.3–2.1 times as long as wide. Prozona of pronotum transverse, 1.2–1.4 times as wide as long. Width of visible part of the tegmen almost equal to width of mid femur. Hind femur 3.0–3.75 times as long as wide; both upper and lower sides of femora without lappets. First tarsal segment of hind legs 1.3–1.5 times longer than the combined length of 2nd and 3rd segments.



FIGURES 8-13. *Clinotettix ussuriensis*, female. 8. Body, lateral view; 9. Head, frontal view; 10. Head and anterior part of pronotum, dorsal view; 11. Same, lateral view; 12. Apex of abdomen, ventral view; 13. Same, lateral view.

Body blackish brown, dorsally without dark spots. Antennae yellow with black apex. Fore and hind femora with few light marks, mid femora blackish. Fore and mid tibia blackish brown with light brown rings; hind tibia brown with light brown ring near the base. Abdomen dorsally brown, laterally and ventrally black. Ovipositor light brown.

Measurements (in mm). Length of body (from anterior margin of fastigium of vertex to the apex of the posterior process of pronotum) male 9.8–14.5, female 14.0–19.0; pronotum male 10.3–12.6, female 12.5–16.3; fore femur male 2.0–2.4, female 2.4–2.9; mid femur male 2.1–2.6, female 2.5–3.3; hind femur male 5.8–6.6, female 7.0–8.4; ovipositor 1.6–2.0.

Habitat. According to our observations in Russia, *Clinotettix ussuriensis* is a stenobiont species and is strictly confined to the banks of rivers and lower reaches of streams in the mountain regions at an altitude of 200–500 m above sea level, where it occurs exclusively in the sunlit places. It prefers to settle on pebbly areas overgrown with sparse vegetation, poorly turf meadows or on fallen trees. This species does not depend much on the slope exposure and is found in the subzones of broadleaf and coniferous-broadleaf forests.

Distribution. Russia (Primorsky Krai, southern part of Khabarovsky Krai), Democratic People's Republic of Korea (Hamgyeongbuk-do and Hamgyeongnam-do) and Republic of Korea (northern parts of Gangweon-do and Gyeonggi-do near the demarcation line), NE China (Jilin and Liaoning provinces) (Fig. 14). The northernmost known locality of the species is in the central part of the Khabarovsky Krai between 54 and 54°N: the Konin River, the left (northern) tributary of the Tugur River. The southernmost ones are in the central parts of Korean Peninsula.

Notes. According to Storozhenko & Paik (2010) *Clinotettix chanbaishanensis* was synonymized with *C. ussuriensis,* while, in the Orthoptera Species File, the former is listed as a distinct species (Cigliano *et al*., 2024). Here we confirm that both taxa are conspecific, because are represented by two forms, brachypronotal or brachypterous (Figs 1, 2) and macropronotal or macropterous (Figs 3, 4), often occurring coincidently. We also examined the images of *Clinotettix* from Gangwon-do (Cheorwon, Hoengseong, and Yeongwol) in South Korea from internet recourses (iNaturalist; https://www.inaturalist.org/taxa/761810-Clinotettix-ussuriensis) and find that these specimens have broad hind femora and wide fastigium. Therefore, the records of *C. ussuriensis* from these localities seem to belong to *C. jilinensis*.

Ecologo-geographic modelling

The models generated for the contemporary climatic conditions (Figs 15, 16) fit well the distribution of the species known localities with defined geographic coordinates (21) (Fig. 14). The optimal region for *C. ussuriensis* is in the deciduous (broadleaf) and mixed forest life subzones of the temperate and continental parts of the Far East. The MaxEnt model is well supported (Fig. 17) with AUC = 0.965. The main factors explaining these patterns are precipitations of the wettest quarter (37.9 % contribution), precipitations of the warmest quarter (12.8), and annual mean temperatures (10.8). The Jackknife test shows quite similar roles of the variables, but permits to add two other factors, namely annual precipitations and precipitations of the wettest month as well. Therefore, the distribution of *C. ussuriensis* depends mainly on the levels of precipitations during summer seasons.

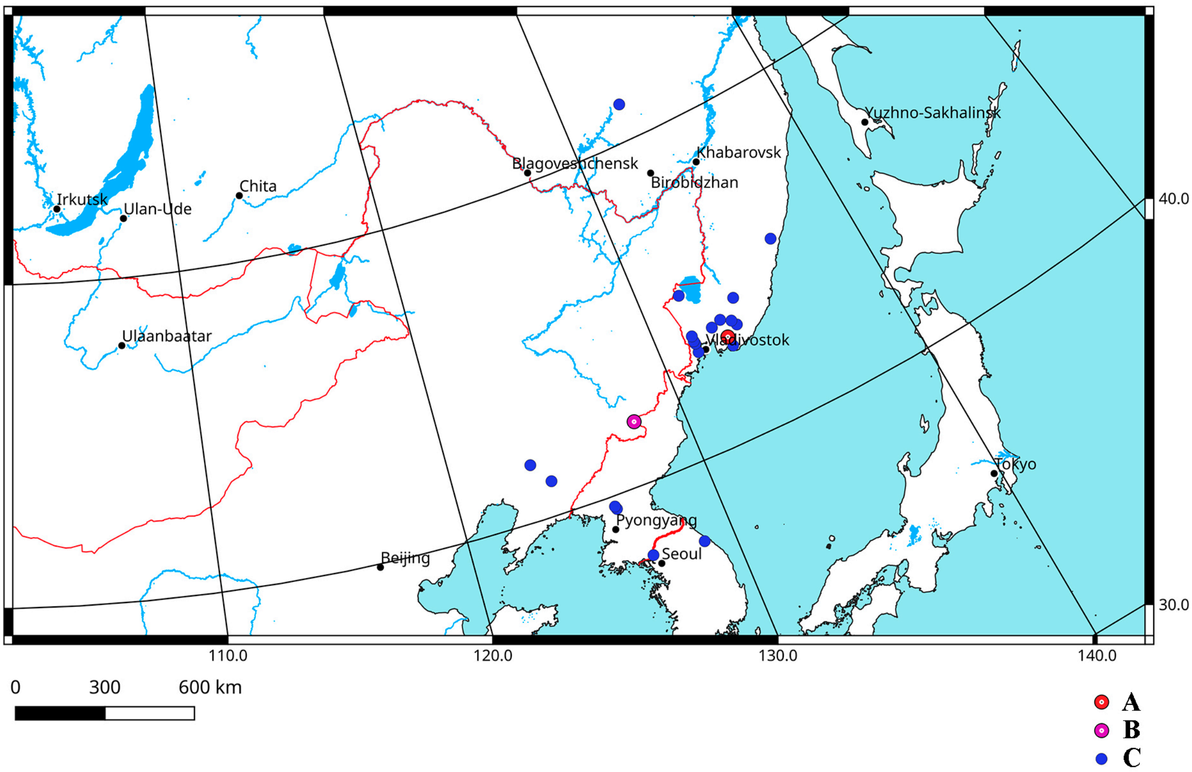


FIGURE 14. The known localities of *Clinotettix ussuriensis*. A. Type locality of *C. ussuriensis*; B. Type locality of *C. chanbaishanensis*; C. Other known localities.

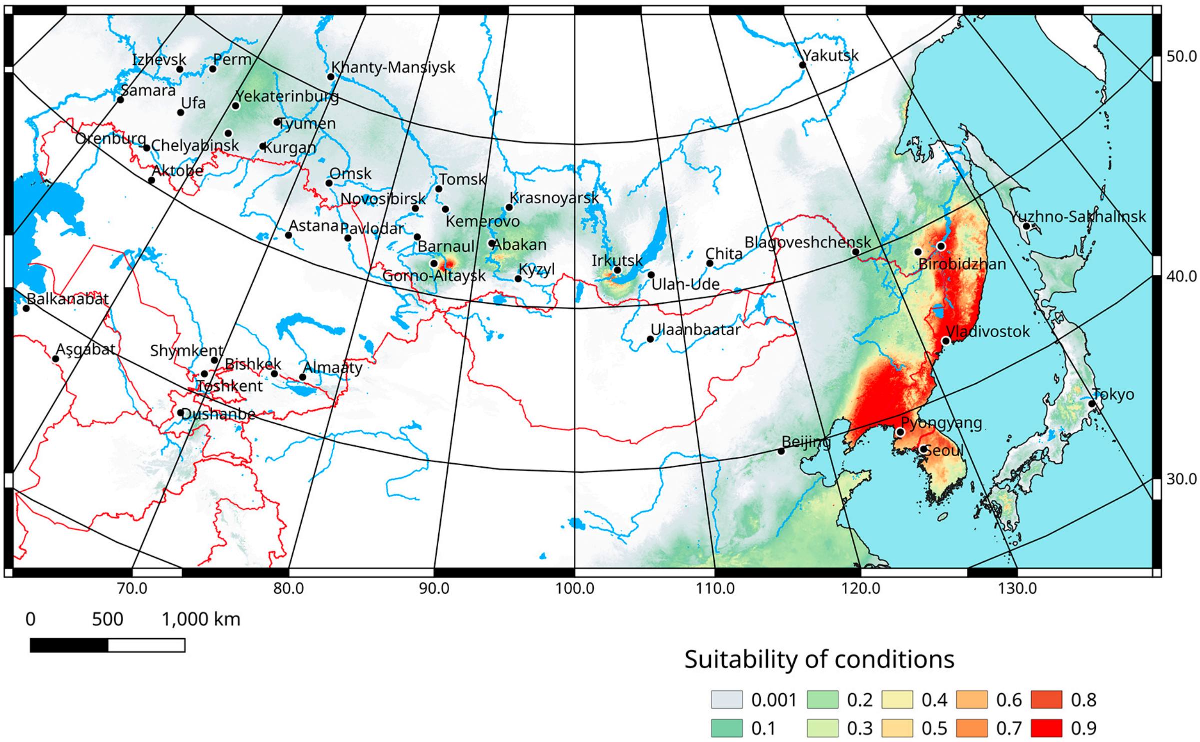


FIGURE 15. Predicted probabilities of suitable conditions for *Clinotettix ussuriensis* (MaxEnt model, all bioclimatic variables for 1970–2000; point-wise means for 21 replicates with cross-validation).

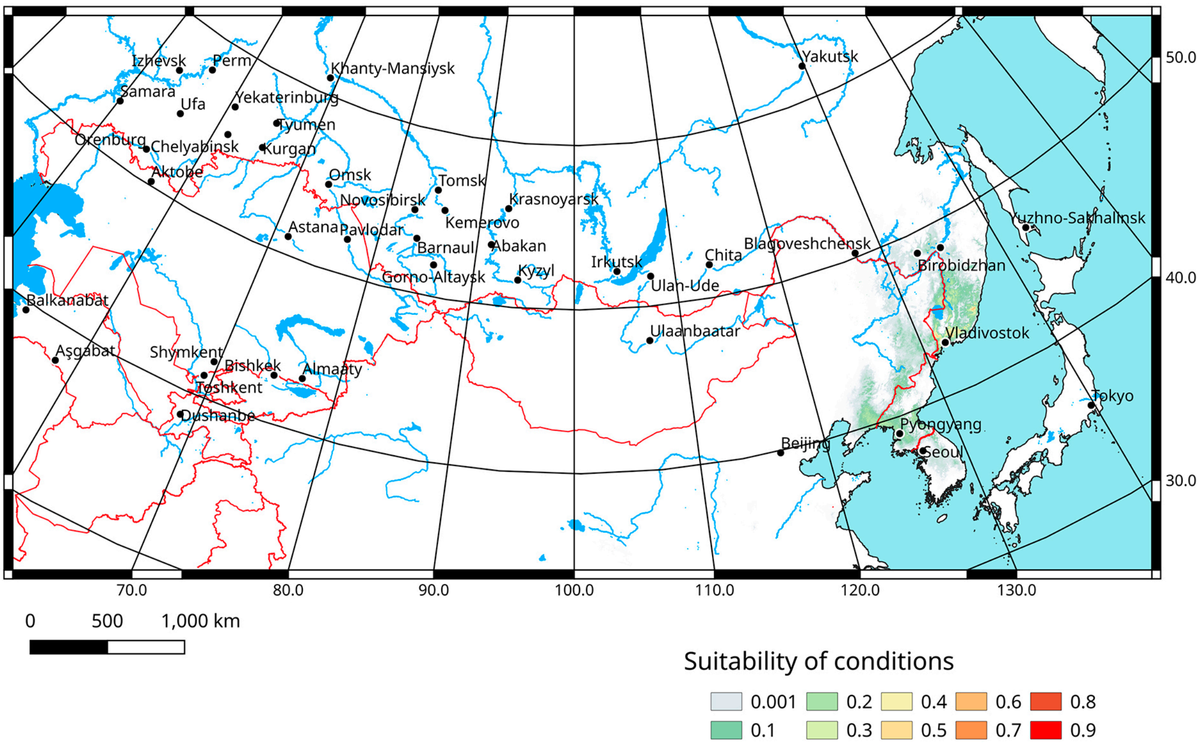


FIGURE 16. Predicted probabilities of suitable conditions for *Clinotettix ussuriensis* (multidimensional ellipsoid model, bioclimatic variables for 1970–2000: annual mean temperature, maximal temperature of warmest month, minimal temperature of coldest month, annual precipitation, precipitation of warmest quarter, precipitation of coldest quarter; point-wise means for 21 replicates).

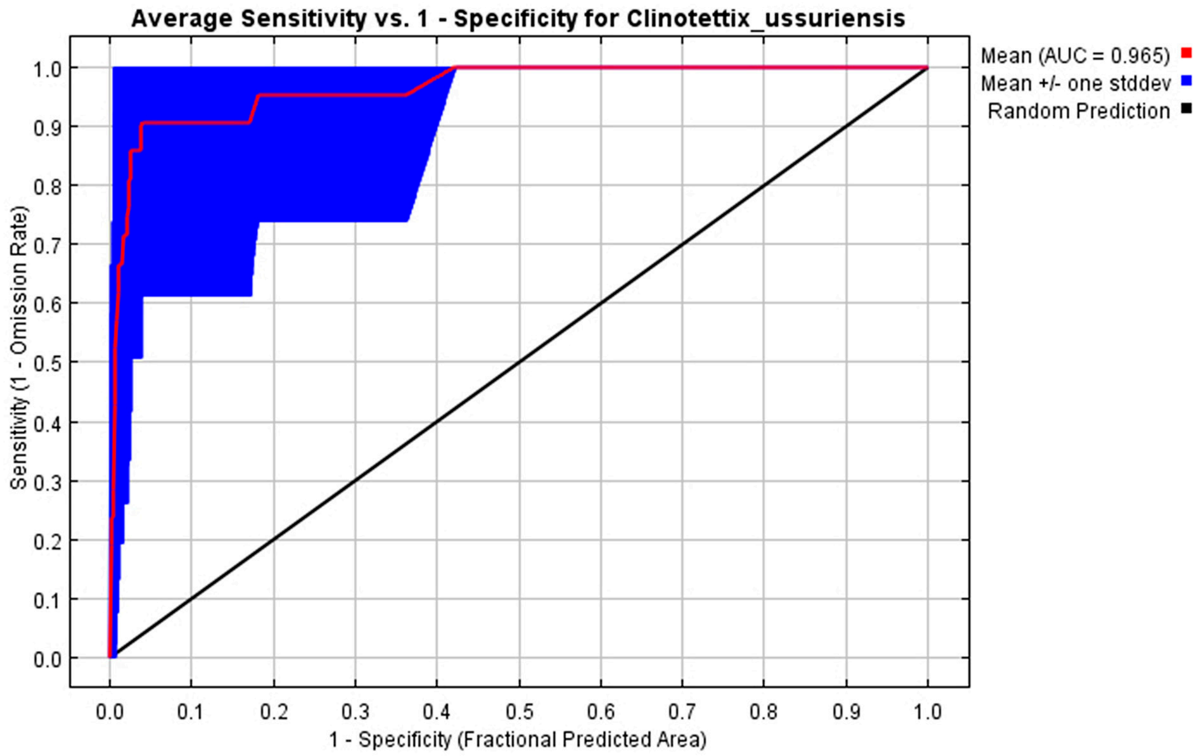


FIGURE 17. Reliability test for the *Clinotettix ussuriensis* distribution model (all bioclimatic variables for 1970–2000; 21 replicates with cross-validation).

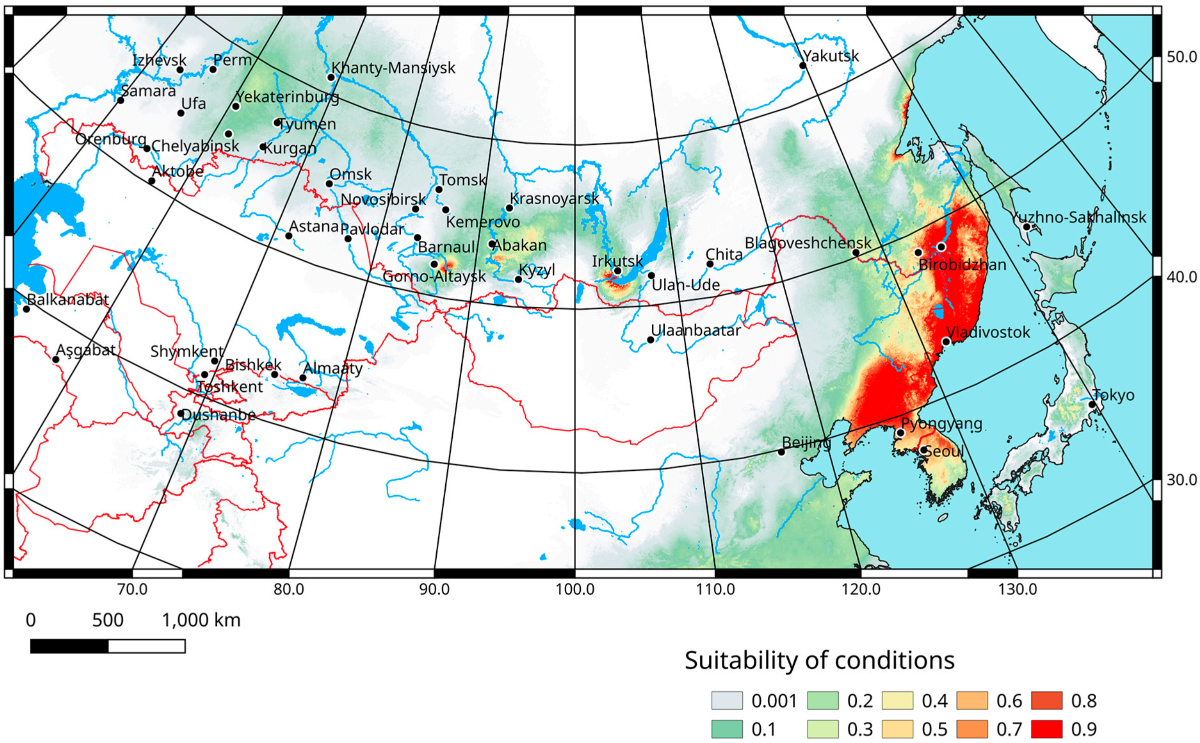


FIGURE 18. Predicted probabilities of suitable conditions for *Clinotettix ussuriensis* (forecasts of all bioclimatic variables for 2021–2040 according the global climate model CNRM-ESM2-1 (Séférian, 2018) and the 3–7.0 Shared Socioeconomic Pathway (Meinshausen *et al.,* 2020); point-wise mean for 21 replicates).

Interestingly, the areas relatively suitable for the species are not only in the continental part of the temperate Far East, but also in the subtropical mountains of the Shandong (Juaodong) Peninsula (E China), the southern parts of the Korean Peninsula, and Kyushu (S Japan). Moreover, the models predicts also favorable conditions for faraway territories inside temperate Asia (Fig. 15), such as the mountains near the southern parts of Baikal Lake, the central part of the Sayan Mts, and the northern parts of the Altai Mts. All these areas are characterized by relatively high levels of precipitations and occurrence of some species associated mainly with the deciduous and mixed forest regions of the Far East, e.g. *Ognevia longipennis* (Shiraki), *Megaulacobothrus aethalinus* (Zubovsky), and *Schmidtiacris schmidti* (Ikonnikov) (Sergeev *et al.*, 2019).

The models generated for the future climatic conditions predicted on the basis of the so-called 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) (Figs 18, 19) show possible increase of condition suitability over the whole modern species range, especially in the local mountains and particularly in the second half of the 21st century. Besides, almost all favorable areas outside the actual species range including some coastal areas of the Sea of Okhotsk may remain beneficial for the species as well.

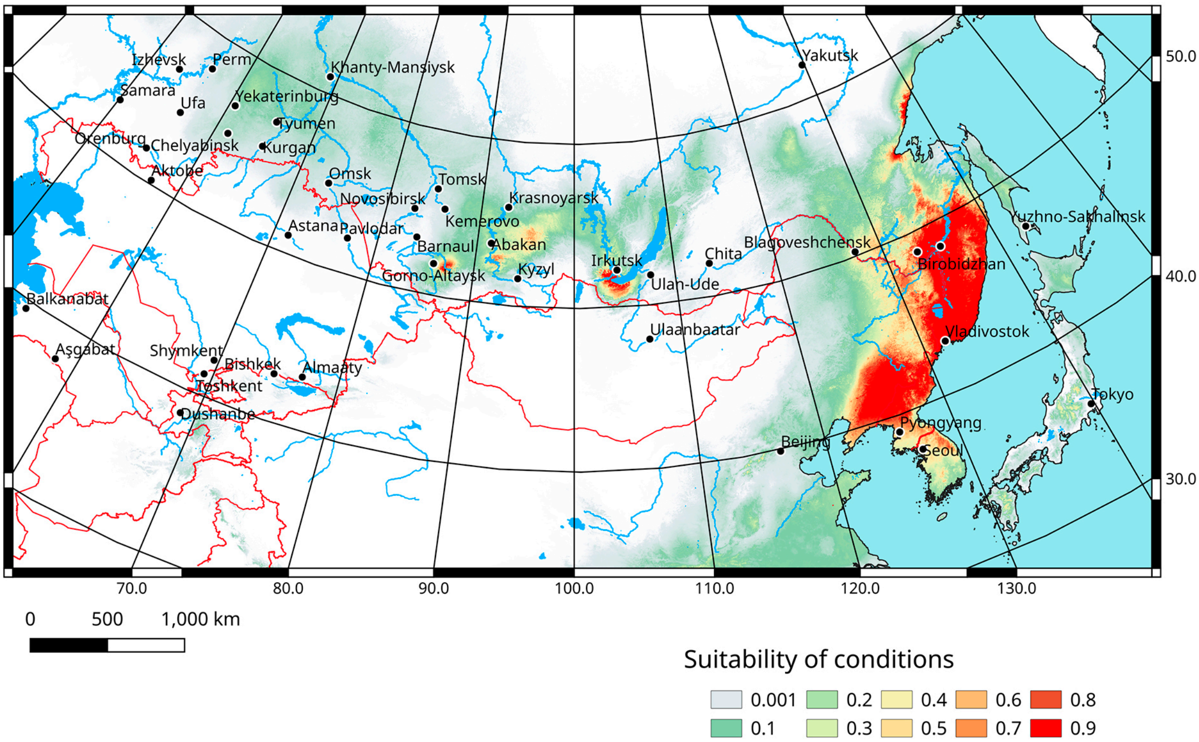


FIGURE 19. Predicted probabilities of suitable conditions for *Clinotettix ussuriensis* (forecasts of all bioclimatic variables for 2041–2060 according the global climate model CNRM-ESM2-1 (Séférian, 2018) and the 3–7.0 Shared Socioeconomic Pathway (Meinshausen *et al.,* 2020); point-wise mean for 21 replicates).

Discussion

Clinotettix ussuriensis is the endemic of the temperate deciduous and mixed forest life subzones of the Far East. Its populations are widely distributed inside this region, but they commonly look like insular, because the species occurs in the limited types of habitats only, such as river/stream banks, at elevations between 200 and 500 m. The species abundance is usually low. However, its typical habitats may be completely destroyed by human activities.

This means *C. ussuriensis* can be qualified as an endangered species. The possible issues concerning this species partly resemble the deals with another orthopteran species, namely *Bryodemella tuberculata* (Fabricius), in Western Europe (Dey *et al.*, 2021), where its local populations often have been formerly limited by stony flood-plains of mountain streams, those have been later destroyed or modified over and over during the 20th century. In any case, a few populations of *C. ussuriensies* are protected in several Russian nature reserves, namely Kedrovaya Pad, Ussuriisky, and Sikhote-Alinsky.

A comparative analysis of the models produced for several orthopteran species, namely *C. ussuriensis*, *Paracyphoderris erebeus* Storozhenko (Storozhenko *et al.,* 2023), *Elimaea fallax* Bey-Bienko (Baturina *et al.,* 2024a), and *Decticus nigrescens* Serg. Tarbinsky (Sergeev *et al.,* 2023), associated with the temperate Far East reveals both similar and quite different patterns. In any case, all predictions show that some populations of these species can exist outside their known localities. The distribution of all species can be mainly explained by levels of precipitations, especially during warm seasons. Some analogies are also demonstrated for two pairs of the species. Our predictions for *C. ussuriensis* and *P. erebeus* show that the additional favorable area for them is near the southern part of Baikal Lake. The similar outlying region with the appropriate conditions for *C. ussuriensis* and *D. nigrescens* is in the northern parts of the Altai Mts. However, the predicted distributions of suitable conditions, apart from the above-mentioned similarities, look like quite different, especially in details. Such diversity may be determined by the general ecologo-geographical dissimilarities of the species. The future predictions produced for *P. erebeus* associated mainly with mountains of the taiga (coniferous forests) life zone show that its range appears to be relatively stable but some declines in population sizes and the ensuing fragmentation of the species population system are possible (Storozenko *et al.,* 2023). The distribution of *E. fallax* limited mostly by local plains and valleys with dominance of the broadleaf forests and low altitudes may remain stable, but suitability of conditions may significantly increase (Baturina *et al.,* 2024a). The more noticeable shifts are predicted for *C. ussuriensis* primarily related to some open habitats of river valleys on relatively low altitudes. The general suitability of conditions may significantly increase, especially in the local mountains, such as Sikhote-Alin.

Funding

The study was financially supported by the grant of the Russian Science Foundation 22-66-00031 (https://rscf.ru/en/project/22-66-00031).

Acknowledgements

We thank A.V. Gorochov (St. Petersburg, Russia) for the opportunity to study the collections of the Zoological Institute. The taxonomic part of research was carried out within the state assignment of Ministry of Science and Higher Education of the Russian Federation (theme No. 124012400285-7). We thank the two anonymous reviewers for their valuable comments and proposals.

References

Baturina, N.S., Molodtsov, V.V., Sergeev, M.G. & Storozhenko, S.Yu. (2024a) Distribution of the leaf katydid *Elimaea fallax* (Orthoptera: Tettigoniidae: Phaneropterinae) in the countries of the Japan Sea Basin. *A.I. Kurentsov's Annual Memorial Meetings*, 35, 70–75.
https://doi.org/10.25221/kurentzov.35.4

Baturina, N.S., Molodtsov, V.V., Shamychkova, A.A., Storozhenko, S.Yu. & Sergeev, M.G. (2024b) The distribution patterns of the two-coloured bush-cricket *Bicolorana bicolor* (Philippi, 1830) (Orthoptera: Tettigoniidae) across the Asian part of its range. *Russian Entomological Journal*, 33 (2), 153–162.
https://doi.org/10.15298/rusentj.33.2.02

Bey-Bienko, G.Ya. (1929) Notes on the Siberian representatives of the genus *Acrydium* Geoffr. (Orthoptera). *Eos, Revista española de Entomología*, 5 (4), 365–373.

Bey-Bienko, G.Ya. (1933) Records and description of some Orthoptera from USSR. *Boletin de la Real Socidad Española de Historia Natural*, 33 (8), 317–341.

Bey-Bienko, G.Ya. (1951) Family Tetrigidae. *In*: Bey-Bienko, G.Ya. & Mistshenko, L.L. (Eds.) *Locusts and grasshoppers of the USSR and adjacent countries. Vol. 1*. Moscow-Leningrad, Nauka Publ., 380 pp. [in Russian]

Blackith, R.E. (1992) *Tetrigidae (Insecta: Orthoptera) of South-East Asia: Annotated catalogue with partial translated keys and bibliography*. JAPAGA, Ashford Co., Ireland, Rockbottom, 248 pp.

Cigliano, M.M., Braun, H., Eades, D.C. & Otte, D. (2024) Orthoptera Species File. Taxonomic database of the world's grasshoppers, locusts, katydids, crickets, and related insects. Available from: http://orthoptera.speciesfile.org (accessed 11 June 2024)

Cobos, M.E., Osorio-Olvera, L., Soberón, J., Peterson, A.T., Barve, V. & Barve, N. (2023) Ellipsenm: An R package for ecological niche's characterization using ellipsoids. Available from: https://github.com/marlonecobos/ellipsenm#ellipsenm-an-r-package-for-ecological-niches-characterization-usingellipsoids (accesses 10 August 2023)

Dey, L.S., Simões, M.V.P., Hawlitschek, O., Sergeev, M.G., 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

Fick, S.E. & Hijmans, R.J. (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

International Commission on Zoological Nomenclature. (1999) *International code of zoological nomenclature, Fourth Edition*. London, International Trust for Zoological Nomenclature, 306 pp.

Kim, T.W. (2013) *Orthoptera of Korea*. GEO Book, 381 pp. [in Korean]

Kim, T.W. & Kim, J.I. (2004) A taxonomic study of Korean Tetrigidae (Orthoptera: Caelifera: Tetrigoidea). *Entomological Research*, 34 (4), 261–267.

Kostia, D. (1995) The Tetrigidae (Orthoptera) found in North Korea. *Acta Zoologica Cracoviensia*, 38 (2), 257–265.

Liang, G. & Zheng, Z. (1998) *Fauna Sinica. Insecta. Vol. 12. Orthoptera. Tetrigoidea*. Beijing, Science Press, 288 pp. [in Chinese with English summary]

Meinshausen, M., Nicholls, Z.R.J., Lewis, J., Gidden, M.J., Vogel, E., Freund, M., Beyerle, U., Gessner, C., Nauels, A., Bauer, N., Canadell, J.G., Daniel, J.S., John, A., Krummel, P.B., Luderer, G., Meinshausen, N., Montzka, S.A., Rayner, P.J., Reimann, S., Smith, S. J., van den Berg, M., Velders, G.J.M., Vollmer, M.K. & Wang, R.H.J. (2020) The shared socio-economic 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

Morales, N.S., Fernándex, I.C. & Baca-Gonzáles, V. (2017) MaxEnts′ parameter configuration and small samples: are we paying attention to recommendations? A systematic review. *PeerJ,* 5, e3093.
https://doi.org/10.7717/peerj.3093

Otte, D. (1997) *Orthoptera Species File 6. Tetrigoidea and Tridactyloidea (Orthoptera: Caelifera) and Addenda to OSF Vols. 1-5*. Philadelphia: Orthopterists' Society & Academy of Natural Sciences of Philadelphia, Philadelphia, 261 pp.

Phillips, S.J., Anderson, R.P., Dudík, M., Schapire, R.E. & Blair, B. (2017) Opening the black box: An open-source release of Maxent. *Ecography,* 40, 887–893.
https://doi.org/10.1111/ecog.03049

Podgornaja, L.I. (1976) On the distinctness of the genus *Clinotettix* B.-Bienko (Orthoptera, Tetrigidae). *Proceedings of the Zoological Institute, USSR Academy of Sciences*, 67, 7–10. [in Russian]

Podgornaja, L.I. (1983) Orthopteran insects of the family Tetrigidae (Orthoptera) of the fauna of the USSR. *Proceedings of the Zoological Institute, USSR Academy of Sciences*, 112, 1–96. [in Russian]

Popova, K.V., Baturina, N.S., Molodtsov, V.V., Yefremova, O.V., Zharkov, V.D. & Sergeev M.G. (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

Pravdin, F.N. & Cherniakhovsky, M.E. (1975) Regularities of the ecological distribution of the orthopteroid insects (Orthopteroidea) in the southern part of the Maritime Territory. *Entomologicheskoe Obozrenie*, 54 (2), 360–373. [in Russian]

Rehn, J.A.G. & Grant, H.J. (1961) A monograph of the Orthoptera of North America (North of Mexico). I. *Monographs of the Academy of Natural Sciences of Philadelphia*, 12, 1–257.

Séférian R. (2018) CNRM-CERFACS CNRM-ESM2-1 Model Output Prepared for CMIP6 CMIP Amip. Version 20211010. Earth System Grid Federation. (accessed 10 October 2021).
https://doi.org/10.22033/ESGF/CMIP6.3924

Sergeev, M.G. (1986) *Patterns of Orthoptera Distribution in North Asia*. Novosibirsk, Nauka, 237 pp. [in Russian]

Sergeev, M.G., Storozhenko, S.Yu. & Benediktov, A.A. (2019) An annotated check-list of Orthoptera of Tuva and adjacent regions. Part 2. Suborder Caelifera. Tridactylidae, Tetrigidae, Acrididae: Melanoplinae, Calliptaminae, and Gomphocerinae (except Gomphocerini). *Far Eastern Entomologist*, 389, 7–44.
https://doi.org/10.25221/fee.389.2

Sergeev, M.G., Molodtsov, V.V. & Storozhenko, S.Yu. (2023) New data on distribution of *Decticus nigrescens* Tarbinsky, 1930 (Orthoptera: Tettigoniidae) in Russia. *Far Eastern Entomologist*, 487, 21–28.
https://doi.org/10.25221/fee.487.2

Steinmann, H. (1964) Some new tetrigid species and subspecies from Asia (Orthoptera: Tetrigidae). *Acta Zoologica Academiae Scientiarum Hungaricae*, 10 (3-4), 457–468.

Steinmann, H. (1971) The Tetricidae (Orthoptera) of the Palaearctic Fauna. *Folia Entomologica Hungarica*, 24 (29), 323–332.

Storozhenko, S.Yu. (1986) Orthoptera (Saltatoria). *In*: Lehr, P.A. (Ed.). *Keys to the Insects of the Russian Far East*, *Vol. 1*. Leningrad, Nauka, pp. 241–317. [in Russian]

Storozhenko, S.Yu. (2006) Orthopteroid insects (Orthoptera, Blattoptera, Grylloblattida, Dermaptera) of the Kedrovaya Pad Nature Reserve. *In*: Makarchenko, E.A. (Ed.). *Flora and fauna of Kedrovaya Pad Nature Reserve*. Vladivostok, Dalnauka, pp. 91–105. [in Russian]

Storozhenko, S.Yu. (2009) Order Orthoptera. *In*: Storozhenko, S.Yu. (Ed.). *Insects of Lazovsky Nature Reserve*. Vladivostok, Dalnauka, pp. 46–50. [in Russian]

Storozhenko, S.Yu., Kim, T.W. & Jeon, M.J. (2015) *Monograph of Korean Orthoptera*. National Institute of Biological Resources, Incheon, 377 pp.

Storozhenko, S.Yu., Molodtsov, V.V. & Sergeev M.G. (2023) The mysterious Amurian grig *Paracyphoderris erebeus* Storozhenko, 1980 (Orthoptera: Prophalangopsidae): New data on its distribution, ecology and biology. *Insects*, 2023, 14, 789. http://doi.org/10.3390/insects14100789

Storozhenko, S.Yu. & Paik, J.-Ch. (2007) *Orthoptera of Korea*. Vladivostok, Dalnauka, 232 pp.

Storozhenko, S.Yu. & Paik, J.-Ch. (2010) Review of Orthoptera of Eastern Palaearctic: genus *Clinotettix* Bey-Bienko, 1933 (Tetrigidae, Tetriginae). *The Korean Journal of Soil Zoology*, 14 (1-2), 39–42.

Tumbrinck, J. (2014) Taxonomic revision of the Cladonotinae (Orthoptera: Tetrigidae) from the islands of South-East Asia and from Australia, with general remarks to the classification and morphology of the Tetrigidae and descriptions of new genera and species from New Guinea and New Caledonia. *In*: Telnov, D. (Ed.), *Biodiversity, biogeography and nature conservation in Wallacea and New Guinea. Vol. II*. The Entomological Society of Latvia, Riga, pp. 345–396, pls. 64–91.

Wang, L.-M. & Ren, B.-Z. (2007) The discover of male of *Clinotettix* Zheng et Ren. *Journal of Northeast Normal University* (*Natural Science Edition*), 39 (1), 136–137. [in Chinese with English abstract]

Wang, R.-X., Wang, L.-M. & Ren, B.-Z. (2004) A new species of the genus *Clinotettix* B.-Bienko (Orthoptera, Tetrigidae) from China. *Acta Zootaxonomica Sinica*, 29 (4), 730–732. [in Chinese with English abstract]

Yin, X.-C., Shi, J.-P. & Yin, Z. (1996) *A synonymic catalogue of grasshoppers and their allies of the World. Orthoptera: Caelifera*. Beijing, China Forestry Publishing House, 1266 pp.

Zheng, Z.-M. (1989) A preliminary survey of grasshoppers from Liaoning Province (Orthoptera). *Journal of Hubei University* (*Natural Science*), 11 (4), 67–75. [in Chinese with English abstract]

Zheng, Z.-M. & Ren, B.-Z. (1996) A new species of *Clinotettix* B.-Bienko from Jilin Province (Tetrigoidea: Tetrigidae). *Journal of Northeast Normal University*, 1, 81–82. [in Chinese with English abstract]