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Invasions of Cave Camel Crickets of the Genus *Tachycines* Adelung, 1902 (Orthoptera: Rhaphidophoridae) into Russia: Historical Aspect

S. V. Lapteva[a, *] (ORCID: 0009-0005-5949-9904), M. G. Sergeev[b, c, **, *] (ORCID: 0000-0003-2179-0921), V. V. Molodtsov[b, ****] (ORCID: 0000-0001-9169-9934), and S. Yu. Storozhenko[a, *****] (ORCID: 0000-0001-9269-4043)**

[a] *Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch, Russian Academy of Sciences, Vladivostok, 690022 Russia*

[b] *Novosibirsk State University, Novosibirsk, 630090 Russia*

[c] *Institute of Systematics and Ecology of Animals, Siberian Branch, Russian Academy of Sciences, Novosibirsk, 630091 Russia*

**e-mail: lapteva.sv24@gmail.com*

***e-mail: mgs@fen.nsu.ru*

****e-mail: mgsergeev@aol.com*

*****e-mail: vv@fen.nsu.ru*

******e-mail: storozhenko@biosoil.ru*

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Abstract—The invasion of the species of the genus *Tachycines* into Russia occurred at the end of the 19th century, when *T. asynamorus* was discovered in St. Petersburg. Almost 100 years later, another species of this genus, *T. coreanus*, was found in the Russian Far East. Data on the history of the distribution of these two synanthropic species are presented, as well as information about their behavior, biology and ecology.

Keywords: Rhaphidophoridae, Aemodogryllinae, *Tachycines asynamorus*, *Tachycines coreanus*, biological invasion, Primorsky Territory, European part of Russia

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INTRODUCTION

More than 560 species of cave camel crickets of the subfamily Aemodogryllinae (Orthoptera: Rhaphidophoridae) occur mainly in East and Southeast Asia (Cigliano et al., 2025). In the subfamily, the genus *Tachycines* Adelung is the most diverse. It includes more than 100 species known from Japan, Korea, China, Myanmar, Vietnam, and the Philippines (Lapteva and Storozhenko, 2024; Cigliano et al., 2025). According to their bionomics, members of the genus can be divided into two quite different ecological groups. The first one is formed by facultative troglophiles that live in forest litter and use caves or other similar spaces as temporary shelters. They are usually the variegated species with large, well-pigmented eyes (Figs. 1, 2). Species of the second group (the so-called troglobionts) occur at the depths of caves. They are characterized by a pale yellow body colour and some prominent eye reduction. Most species of the genus *Tachycines* are local endemics, but two of them, namely *T. asynamorus* Adelung and *T. coreanus* Yamasaki, became invaders and began to spread over areas and habitats outside their natural ranges. Both species are typical synanthropes inhabiting various structures created by humans and are suitable as living places. They settle in such habitats both inside and especially outside their native ranges. As a result, their environments are more or less the same across quite different natural regions. This is why it is very difficult, almost impossible, to assess the ecological and geographical properties of their ranges (including making a forecast of possible changes in their distribution), via the use of bioclimatic data commonly adapted for the so-called species distribution modeling. In this context, it is interesting and important to compare the histories of invasive dispersal of the two model species occurred with an interval of 100 years and to estimate some possible invasion of *T. coreanus* to different regions of Russia.

MATERIALS AND METHODS

The individuals of *T. coreanus* in Russia were collected by authors (Lapteva and Storozhenko, 2024) in Vladivostok in 1999, 2008, and 2020–2024. Almost all specimens were stored in the collections of the Federal Scientific Center of the East Asia Terrestrial Biodiversity (Vladivostok). In 2023–2024, some individuals were also kept in the insectarium of the Center, and

Fig. 1. *Tachycines coreanus*, female (Vladivostok, November 27, 2023) (photo by S.V. Lapteva).

Fig. 2. *Tachycines coreanus*, female with spermatophore (Vladivostok, December 1, 2023) (photo by S.V. Lapteva).

their biological peculiarities, including feeding, were observed. Information on the distribution of *T. coreanus* outside of Russia was summarized from published studies (Yamasaki, 1969; Kim, J.-I. and Kim, T.-W., 2002; Ichikawa et al., 2006; Kim, 2007; Storozhenko et al., 2015; Yamamoto and Ito, 2020; Won et al., 2023; Kim et al., 2024; Lee et al., 2024; GBIF, 2025b). The published data on the distribution of *T. asynamorus*

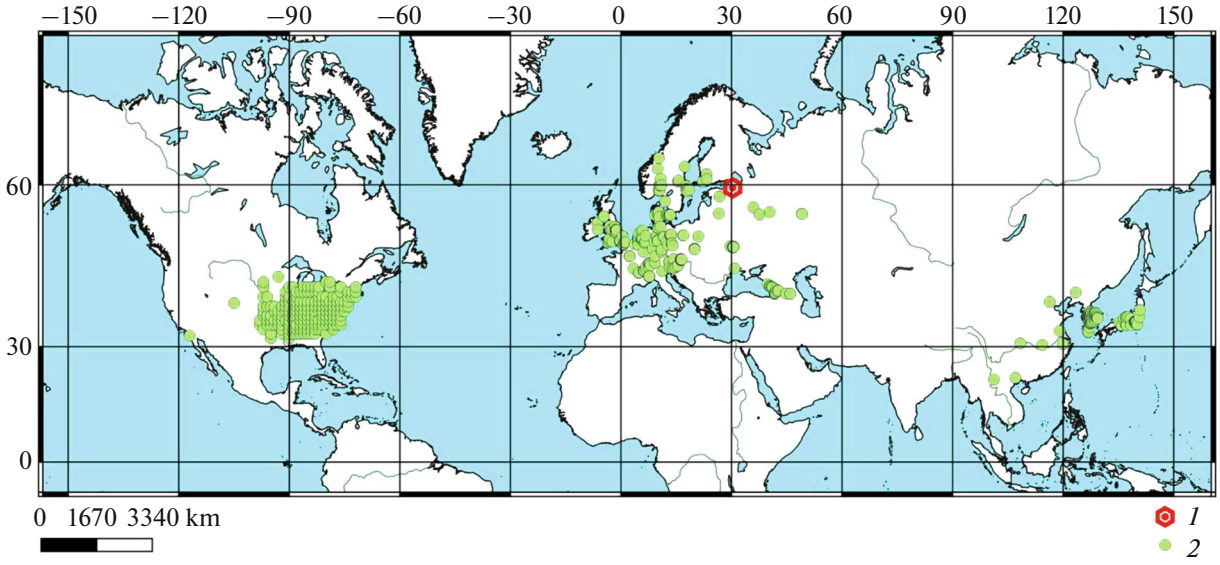

Fig. 3. Distribution of *Tachycines asynamorus*. (*1*) Type locality (Adelung, 1902); (*2*) other known localities (Boldyrev, 1911; Lapteva and Storozhenko, 2024; GBIF, 2025a) (scale bar is given along equator).

(Adelung, 1902; Boldyrev, 1911; Lapteva and Storozhenko, 2024; GBIF, 2025a) were exploited as well.

We used either the Glonass/GPS handheld gadgets or Google Earth Pro (©Google 2022) to determine geographic coordinates. The maps of locality distributions were compiled via QGIS 3.18.3 on the following projections: the WGS84/World Mercator conformal projection for *T. asynamorus* and the Lambert conformal conic projection for *T. coreanus*.

RESULTS AND DISCUSSION

What Do We Know about Greenhouse Camel Cricket Invasions?

The greenhouse camel cricket (*T. asynamorus*) was described from specimens found in the Eilers greenhouse at St. Petersburg in 1896 (Adelung, 1902). The species was undoubtedly brought to Russia with exotic plants, but its native region can only be guessed at. Adelung (1902) cited two very different opinions concerning this issue, one from the head of the greenhouse farm, which assumed that this species was introduced from Columbia (South America), and the other from the well-known orthopterist C. Brunner von Wattenwyl, who suggested that the species' original range was in Japan. Soon after, the greenhouse camel cricket was also found at conservatories in several European countries (Boas, 1906; Feigl, 1909; Chopard, 1913, 1914) and the USA (Rehn, 1944). Although the species was described only in 1902, its first known record in Europe dates back to 1891, when it was brought with planting material to Prague, and to 1892, when it was discovered in greenhouses in Hamburg as well (Ingrisch and Köhler, 1998). We may hypothesize that several independent introductions into different countries of Europe and North America took place almost simultaneously at the end of 19th century.

The native range of *T. asynamorus* is at East China, the Korean Peninsula, and Japan (Ichikawa et al., 2006; Storozhenko et al., 2015). Currently, the species is widely distributed outside its natural range (Fig. 3). Since the beginning of the 20th century, *T. asynamorus* has been found in numerous conservatories, botanical and zoological gardens, and aquarium and botanical exhibitions in Europe, from its southern parts up to the southern areas of Scandinavia: e.g., in Austria (Feigl, 1909), Croatia (Skejo et al., 2018), Finland (Albrecht, 1979), France (Chopard, 1913), Georgia (Mistshenko, 1972), Germany (Boas, 1906), Hungary (Chopard, 1914), Ireland (Marshall, 1974; Sutton et al., 2017), Italy (Massa et al., 2012), Latvia (Gailis et al., 2003), Poland (Żurawlew et al., 2022), Ukraine (Kryshtal, 1987), and the United Kingdom (Marshall, 1974; Sutton et al., 2017). In the USA, the greenhouse camel cricket invaded greenhouses in 1898 (Rehn, 1944). Later, it was reported from Canada and Greenland as well (Vickery and Kevan, 1983).

In Russia, in addition to St. Petersburg, *T. asynamorus* was found in Moscow and Kirov (Boldyrev, 1911; Beloselskaya and Silvestrov, 1953; Kopysov, 1970). In 2005, it was observed in Penza (Kudryashov and Polumordvinov, 2006). In 2019, the species was collected in Kazan (Karmazina et al., 2020), as well as in Sochi (Lapteva and Storozhenko, 2024). In Russia, the greenhouse camel cricket is a synanthropic species that inhabits quite different buildings with relatively stable warm (preferably with temperatures about 17–22°C) and wet environments, such as greenhouses,

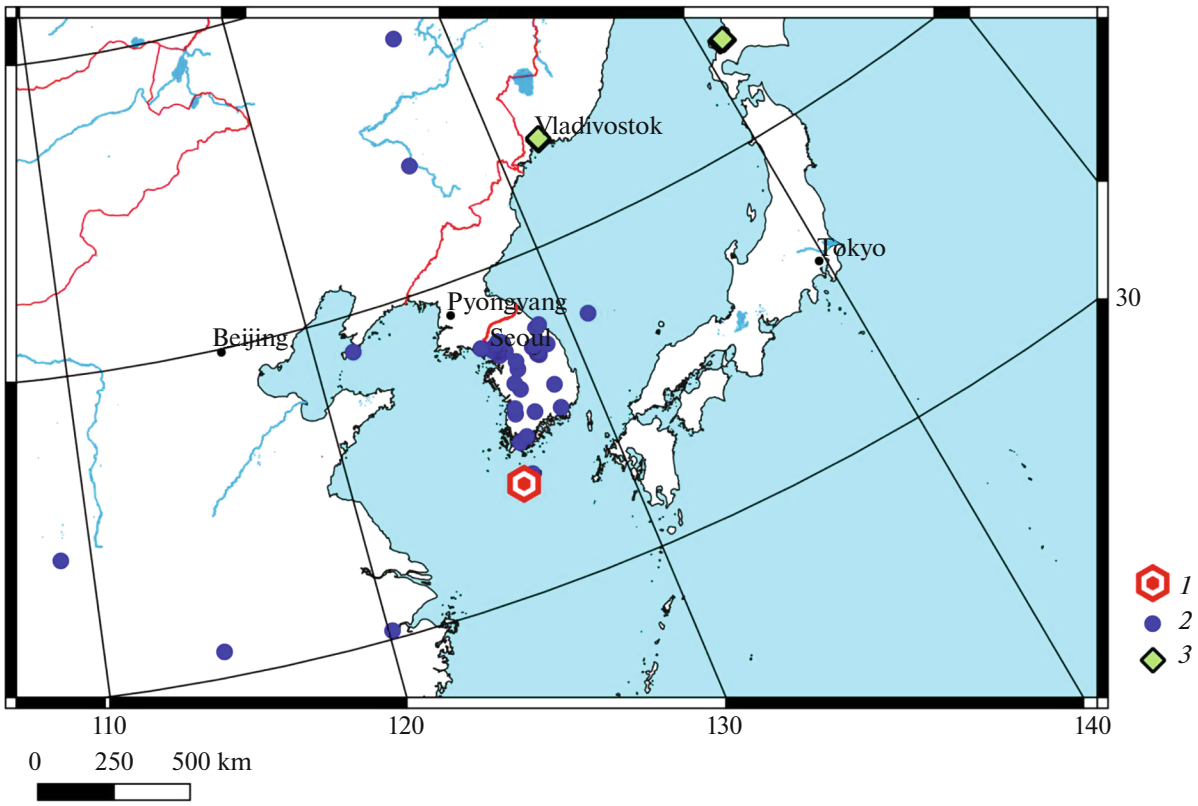

Fig. 4. Distribution of *Tachycines coreanus*. (*1*) Type locality (Yamasaki, 1969); (*2*) other known localities (Kim, J.-I. and Kim, T.-W., 2002; Ichikawa et al., 2006; Kim, 2007; Storozhenko et al., 2015; Won et al., 2023; Kim et al., 2024; Lee et al., 2024; GBIF, 2025b); (*3*) points of invasions in Japan (Yamamoto and Ito, 2020) and Russia.

botanical and zoological gardens, basements of buildings, sewer collectors etc. (Boldyrev, 1911; Lapteva and Storozhenko, 2024). From these microhabitats it can penetrate into apartments or other parts of edifices through ventilation systems. In the Caucasus, particularly in Abkhazia, in addition to buildings and other constructions, the greenhouse camel cricket is found throughout vegetable gardens and curtilages (Karmazina et al., 2020). At present, the species is widespread across Georgia (Lapteva and Storozhenko, 2024). It lives here in residential buildings, their yards, city squares, and wine cellars. This finds indicates that *T. asynamorus* has become naturalized over the Caucasus, leastwise at its humid parts.

The greenhouse camel cricket feeds mainly on snails, earthworms and other small invertebrates. It can damage some soft parts of cultivated plants. Sometimes, the species is qualified as the pest in greenhouses (Boldyrev, 1911; Mistshenko, 1972). Under suitable conditions, in humid, warm and dark habitats, and when there is excess food, *T. asynamorus* can increase in number very quickly. In conservatories and hothouses in Europe, it does not negatively affect plants. Moreover, this predominantly predatory species can even be beneficial (Żurawlew, 2022). Mating of the camel crickets in the greenhouses occurs in the dark, with the male getting under the female and attaching a spermatophore to her genital opening, which is then gradually eaten by the female (Boldyrev, 1912).

Korean Camel Cricket: Is a New Invasion in Russia Starting?

The Korean camel cricket (*T. coreanus*) was described from Jeju (Cheju) Island, Republic of Korea (Yamasaki, 1969) (Fig. 4). This species was later found to be widespread across the south of the Korean Peninsula and in some areas of China and Japan, and was noted not only in natural habitats (on rocky screes under the forest canopy and near entrances of caves), but also in traditional Korean houses and monasteries as well (Storozhenko et al., 2015).

Tachycines coreanus was likely brought to Russia at the end of the 20th century as a result of increased trade exchanges between the Republic of Korea and the Russian Federation. The first specimen of the Korean camel cricket was found in 1999 in downtown of Vladivostok. However, due to the lack of new findings, the species was not included in the list of the Russian Ensifera (Storozhenko, 2004). Nevertheless, in 2008, several specimens were found again in the ter-

Fig. 5. Dense group of *Tachycines coreanus* adults and larvae on the walls of an abandoned underground structure in Vladivostok (November 23, 2019) (photo by A.I. Romanenko).

ritory of the Pokrovsky Park in downtown of Vladivostok. This shows a successful invasion of the species in Russia because it was discovered at the same location both in 1999 and 2008 (Pokrovsky Park and neighboring residential buildings) (Storozhenko, 2008). For over 25 years, the Korean camel cricket has spread throughout the territory of Vladivostok. It lives in flower shops, heated warehouses, basements of buildings, sewer collectors and abandoned underground structures. A similar invasion was described for Hokkaido (Japan), where the species was found in 2015–2018 across harbor and urban areas of Otaru City (Yamamoto and Ito, 2020). In China, all or almost all findings of *T. coreanus* with high probability are the result of its introduction (Fig. 4) as well.

Notably, four species of the cave camel crickets of the subfamily Aemodogryllinae are known from the vicinities of Vladivostok (Lapteva, 2024). Three of them live in the wild but *Diestrammena unicolor* (Brunner von Wattenwyl) sometimes occurs together with *T. coreanus* at abandoned underground constructions. According to our observations in 2021–2024, *T. coreanus* often forms massive aggregations on the walls of underground structures (Fig. 5). It is currently the most common species of the camel crickets in the city.

The Korean camel cricket feeds on insects, fungi, and plant remnants. In addition, cannibalism was observed when kept in cages. Under optimal conditions and with sufficient food, the Korean camel cricket can reproduce continuously throughout a year. Mating in *T. coreanus* occurs in the same way as in *T. asynamorus* (Fig. 2), but the aggressive behavior of the dominant male toward other males during courtship of the female has been observed in cages.

CONCLUSIONS

Both species of the cave camel crickets studied are the typical synanthropes, inside their native ranges (where they certainly occur in local natural habitats) and outside them. Within their invasive ranges, they prefer dark environments with relatively stable warm and wet conditions. The behavior and biology of these two species are very similar. The invasions of *T. asynamorus* started at the end of the 19th century (Ingrisch and Köhler, 1998; Massa et al., 2012) and went different ways. As a result, the species became widely distributed across the temperate and subtropical areas of Europe and North America. Its populations are common in many applicable habitats; though, in England and Poland, some of them have been eliminated as a result of pest control and technical improvements in greenhouses (Sutton et al., 2017; Żurawlew et al., 2022).

The first known invasion of *T. coreanus* began a century after the first discovery of the greenhouse camel cricket in Europe. Nevertheless, because Vladivostok is a major logistic center in the Russian Far East, from which goods from Asia are transported to Siberia and the European part of the Russian Federation, the species may invade very rapidly suitable habitats at cities of the Russian Far East, South Siberia, and European Russia. The similar situation may also be predicted for North and North-East China and Japan.

Invasions of both species raise the questions concerning some possible changes in the synanthropic communities of insects, the patterns of which remain understudied, as researchers usually actively study medically/veterinary and/or economically important insects, such as parasites, pests, and vectors, and attempt to understand how their assemblages can evolve. This is why many synanthropes remain outside the studies of invasion patterns (Epps et al., 2014; Petrosyan et al., 2023; Kulessa et al., 2024). This applies fully to camel crickets. However, these invasions should be considered significant events whose consequences are not explicit and difficult to predict (cf. Khlyap and Warshavsky, 2010; Kulessa et al., 2024). For example, in the eastern parts of North America, *T. asynamorus* became extremely abundant in residential buildings and their curtilages and was often more numerous than native camel crickets (Epps et al., 2014). Another question arises: how can we quantitatively describe the ecological niches of synanthropes inhabiting various buildings and similar constructions (cf. Shea and Chesson, 2002; Simberloff et al., 2013) since this requires collecting data specially on environmental parameters (temperature, humidity, etc.) in structures where these species live? In this context, alien cave camel crickets, especially *T. coreanus*, can serve as actual and very interesting models of synanthropic invasions because their dispersal began recently, especially in comparison with classical synanthropes (Khlyap and Warshavsky, 2010; Smith et al., 2020). This allows us to identify patterns of the initial stages of such invasions in the future.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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