Invasion *Leptoglossus occidentalis* Heidemann, 1910 (Heteroptera: Coreidae) in the conditions of Voronezh (Russia)

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Abstract. The article presents new data on the distribution and acclimatization of an alien species of the American coniferous bug (*Leptoglossus occidentalis* Heidemann, 1910) from the European part of Russia. This bug was discovered in the autumn of 2019 on the territory of the city of Voronezh in the Arboretum of the Voronezh State University of Forestry and Technologies. Currently, *L. occidentalis* spreads on the territory of Russia only in an urban environment, where it finds optimal environmental conditions (suitable temperature, humidity and shelter for winter locations). Surveys of a number of park and forest park zones, squares and separately growing coniferous trees conducted in 2019-2020 in Voronezh did not reveal the presence of this species. At the moment, in the conditions of the Voronezh region, the center of the spread of this bug is located only in the Arboretum of the Voronezh State University of Forestry and Technologies. In 2020, an increase in the number of the identified group of *L. occidentalis* was recorded. Further spread of the bug is predicted on the territory of Voronezh. At the moment, no danger to conifers in the European part of Russia from *L. occidentalis* has been identified and is not yet expected, but constant monitoring of the detected group is required.

1. Introduction

*Leptoglossus occidentalis* Heidemann, 1910 is currently considered a serious pest of coniferous tree seeds in a number of countries [1]. The native range of this species is western North America (from southern Canada to Mexico). In the second half of the 20th century, the species expanded its range to the eastern United States, as well as to the Midwest, Mid-Atlantic States, New England, and Texas. And later, the species reached many European countries, Turkey, Israel and was discovered in Japan, China and South Korea [2-8]. In 2010, the bug was first discovered in Ukraine and Russia [9]. Thus, at present time, *L. occidentalis* is found almost throughout the entire territory of Eurasia. In recent years, it has been found in Chile, Argentina, Uruguay and Brazil [10-13]. It is also found in Africa (Tunisia, Morocco, South Africa) [13, 14].

The spread of this alien species into new territories and the formation of secondary habitats there are of great concern. One of the reasons for the successful invasion of insects (in particular, bugs) is the widespread and rather sharp climate change towards warming [15]. There are several ways how
*L. occidentalis* can move to the new territories. The natural way is explained by the fairly well-developed ability to fly. Some authors note that this species can migrate to intrazonal habitats where suitable forage plants are available [16]. Another way of invasion is explained by the import of planting material. It is also known that, for example, in the United States, *L. occidentalis* was able to enter a new territory together with coniferous trees felled for the Christmas holidays [16].

*L. occidentalis* is trophically related to various trees of the Pinaceae family. This alien species is known to attack about 40 species of coniferous trees: pines, cedars, firs and spruces. The bug was also found on pistachio trees (*Pistacia vera* L.) [1]. Currently, no significant harm has been reported outside the native range (no such data in Europe). The question of the harmfulness of *L. occidentalis* in the invasive area has not yet been completely resolved. However, in North America, it is classified as a pest of forestry, because it reduces the germination of coniferous seeds [9]. *L. occidentalis* was included in the Unified List of Quarantine Objects of the Eurasian Economic Union, approved by the Decision of the Council of the Eurasian Economic Commission of November 30, 2016, no. 158 (as amended on March 30, 2018).

Usually, in a new territory, *L. occidentalis* is found during its migration to the wintering grounds. At this time, the adult bugs are often found in various houses and farm buildings. And since this is a rather large insect (some specimens reach a length of up to 20 mm), its presence immediately becomes noticeable. The bug hibernates at the imago stage, reaching a large concentration of insects in the winter locations [9, 16].

In the European part of Russia, *L. occidentalis* was first found in Rostov-on-Don, and later in Krasnodar and Novorossiysk. Russian entomologist Dmitry Gapon predicted the further expansion of the range of this bug species, suggesting its invasion almost throughout the south of the European part of Russia [9, 17]. At the moment, the insect species is spread throughout the Russian Black Sea coast of the Caucasus (figure 1), and is also known in the Transcaucasia (Georgia and Armenia). [9, 17-22]. And, according to the prediction, soon *L. occidentalis* began to be found in the territories of other regions. In 2019, we found this species in the Voronezh region on the territory of the city of Voronezh in the Arboretum (founded in 1951) of the Voronezh State University of Forestry and Technologies (VSUFT) [21]. The arboretum has the status of a natural monument of regional significance. The total area are 4.2 ha. Its collection fund includes more than 2 thousand species of trees and shrubs.

![Figure 1. Map of the distribution of the bug *L. occidentalis* on the territory of Russia.](image)
2. Methodology
The research took place in 2019-2020. It turned out to be difficult to detect the presence of a bug in a timely manner (before migrating to winter locations) using the usual entomological methods in the conditions of the arboretum, because *L. occidentalis* is localized on trees whose height is 25-30 m. The cones, the seeds of which it feeds on, grow at height of 20-30 m. In this regard, it is impossible to detect a bug on trees by simple, easily accessible methods.

To detect the presence of *L. occidentalis* in arboretum we did the following. The whole arboretum was divided into squares of 5-6 trees. These squares were examined with a certain frequency (once per decade) for traces of the presence of *L. occidentalis* (figure 2). The most reliable early method for detecting the bug was collecting molted skins, which began to be found regularly from the beginning of August on the soil. Sometimes there were also larvae (apparently blown from the trees by the wind). Thus, the groups of potential forage trees were identified (*Picea abies* L. H. Karst (1881), and *Pinus strobes* L. (1753)), and they were constantly under observation for the purpose of detecting *L. occidentalis*. Some of the collected specimens of *L. occidentalis* were dissected in laboratory conditions for the presence of internal parasites – larvae of tachin flies (Tachinidae: Phasiinae).

![Figure 2. The appearance of the bug *L. occidentalis* specimen collected in Voronezh (European part of Russia): adult (a-c) and larva (d).](image)

3. Results and discussion
During the autumn period of 2019, on the territory of the Arboretum of the VSUFT, we collected 11 specimens (6♂ and 5♀) of the bug [21]. At that time, we were not fully convinced that *L. occidentalis* would be able to successfully overwinter and acclimatize in the conditions of the region, since the closest previously indicated point of finding the bug (Rostov-on-Don) is located 500 km south of Voronezh. However, time has shown that the species has successfully taken root in the new territory and its numbers began to gradually grow.

In 2020, taking into account the high degree of activity of *L. occidentalis* and the well-developed ability to fly, we examined various parks, squares and forest areas in Voronezh that have suitable forage plants. However, the species was found only in the place of the initial spot (Arboretum of the VSUFT).

In total, during the study period in 2020, we collected 57 specimens of *L. occidentalis*: 29 – larvae and 28 – adults (15♂ and 13♀). About 300 exuviae from larvae of different ages were collected. In addition to the collected material, we also observed imagos of *L. occidentalis*, which flew from tree to tree. However, we admit the possibility that we could not find the species in other places, but it is still there in small quantities. The reason for this assumption is related to the unfavorable epidemiological
situation in the city, which has developed due to the spread of the SARS-CoV-2. As a result, it was extremely difficult to conduct the same full-fledged large-scale research that we organized in the Arboretum of the VSUFT in other places of the city. But most likely at the moment there are no other spots of L. occidentalis in the city.

In 2019, we could not identify L. occidentalis fodder plants in the arboretum, because we found a bug during its seasonal migration to winter locations. Our work continued in 2020. The arboretum contains various types of conifers, the age of which varies from 25 to 65 years. As a result of examination of these trees, bugs were found in two species: Picea abies L. H. Karst (1881), and Pinus strobus L. (1753). The age of these trees is 70-75 (pines) and 65-70 (spruces) years.

Since the species was not found in other places of the city, we suggested that the bug entered the territory of Voronezh together with the planting material. There are private houses near the arboretum, which inhabitants possibly used materials that had not undergone high-quality processing in landscape gardening. And in this regard, the arboretum, due to the presence of various species of conifers (including rare introduced species), has become for L. occidentalis a kind of reserve (refugium), in which it has taken root.

In the issue of acclimatization of the bug in the territory of Voronezh, obviously, along with the availability of suitable forage plants, global climate change plays is of great importance. It is known that in large cities the air temperature is higher than in the surrounding areas. L. occidentalis in secondary habitats, as we see from the available data, is found mainly in urban landscapes. In addition, in recent years, the city of Voronezh has experienced milder winters. For example, the average monthly air temperature in Voronezh in the winter of 2019-2020 was mainly above 0°C. This gave the bug the opportunity to overwinter in the conditions of the city.

Also, a complex of parasites that could restrain the growth of the number of L. occidentalis has not yet been identified on the territory of Voronezh (as well as throughout Russia). In the native area, the larvae of the tachina Trichopoda pennipes (Fabricius, 1781) (Diptera: Tachinidae) parasitize in the bug [23]. This tachina is not found in Russia. In Europe was detected parasitism of the tachina Ectophasia crassipennis (Fabricius, 1794) in this bug [24]. This tachina is widespread in the European part of Russia, including the Voronezh region. However, we were unable to detect E. crassipennis larvae in the studied L. occidentalis specimens. Currently, there is no data on the possible parasitism of E. crassipennis in this bug in Russia.

In October – November 2020, we also surveyed various suspected winter locations for L. occidentalis. They were not found in natural conditions. Obviously, the bug overwinters in various buildings, where it finds suitable places in attics, cavities and crevices. Previously, it was proposed to predict the distribution of L. occidentalis on the planet based on the effect of geographic background and equilibrium state on niche model transferability [25]. In North America, where this species lived originally, the climate in most of the country is subtropical, and temperate in the north (as in most of Europe). Locations of L. occidentalis in Russia are found mainly in the southern territories (Republic of North Ossetia - Alania, Stavropol Territory, Krasnodar Territory, Rostov Region, Voronezh Region) [17, 18, 20, 21]. Moreover, in most cases, bugs of this species are found in these territories exclusively in cities, where the temperature is always higher (“urban heat island”).

4. Conclusion
The results of our research show that at the moment the number of L. occidentalis on the territory of the Arboretum of the VSUFT remains low, however, while its obvious growth is observed. The success of acclimatization of the bug can probably be due to the presence of various farm buildings in which L. occidentalis finds suitable conditions for wintering [25]. It is considered, that in years with favorable weather conditions and due to global warming, the bug can significantly increase its number in the territory of the secondary range [26]. Significant importance in the settlement of this bug is associated with the possibility of spreading over long distances due to economic and commercial human activities. Moreover, repeated cases of such importation give the species the possibility of repeated attempts to successfully acclimatize to new territories [27].
At the moment, *L. occidentalis* does not present any significant harm to the coniferous trees growing in Voronezh on the surveyed territory. Currently, the expansion of this bug is continuing in Russia. In 2021, it was discovered in the Smolensk region [28]. This indication goes beyond the boundaries of all previously known finds in the country and shows that it is possible for the bug to enter even northern parts of the country. However, in Smolensk, the bug is known from a single find [28]. It probably entered the region from neighboring Belarus, where the species was discovered earlier [29]; or it was delivered with planting material.

Given that *L. occidentalis* is found in many countries bordering Russia, it is possible that the expansion of this bug into the territory of the country will continue in different directions. At the same time, it seems that initially *L. occidentalis* will be found in urban ecosystems, where the temperature is more optimal and there are more shelters for winter locations.

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