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Oxycarenus lavaterae Fabricius, an Invasive Species for *Tilia* spp. in Cluj-Napoca, Romania

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Abstract

In urban landscape design, *Tilia* spp. (Linden trees) are frequently used due to their aesthetic value. Among the pests affecting Linden trees, the most significant are the eriophyid mites, *Eriophyes tiliae* Pagenstecher, and aphids. Since 1985, the invasive species *Oxycarenus lavaterae* Fabricius has been reported on the European continent, and it entered Romania in 2009. In Cluj-Napoca, Romania, this pest has been monitored during the period 2021-2022. Most hibernating colonies are found on Tilia cordata Mill., while fewer are observed on *Tilia platyphyllos* Scop. The colony size ranges from 8 to 18 cm^2, with 785 to 3428 individuals per colony and an average of 2117 individuals. In the studied area, the species exhibits a single generation. Hibernating adults begin to migrate into the tree's canopy in the second half of May. The adults of the first generation are observed in August, and from September, they retreat for hibernal diapause.

Keywords: monitoring, morphology, *Oxycarenus lavaterae* Fabricius, *Tilia* spp.

1. Introduction

The seed bug, *Oxycarenus lavaterae* Fabricius (Lygaeidae, Heteroptera), is a non-native, invasive species in Europe. Its first record was in 1985 in Montenegro [36], and subsequently, it has been reported in many European countries in the following years. The expansion of its distribution range is attributed to several factors. Being a Mediterranean species, climate change characterized by global warming and its easy acclimatization have facilitated its spread from southern regions of Europe to the central ones [3, 15].

The species has a high capacity for population growth and migration [32]. *Oxycarenus lavaterae Fabricius* is an example of an invasive species that rapidly spreads to new areas [24]. Furthermore, the spread of this species also occurs through infested vegetative material, especially with seedlings of *Tilia* spp. sourced from infested nurseries and planted in suburban and urban habitats [19, 30]. The phytosanitary quarantine control during the import of dendrological material is often insufficient [4]. Passive dispersal through human-mediated translocations, such as through clothing, vehicles, etc., is another cause of its spread [26, 35].

Due to a lack of awareness regarding new invasive species and their effects, appropriate preventive measures are often lacking [9].

Distribution of *Oxycarenus lavaterae* Fabricius. On the European continent, this species has been reported in the following years and countries: 1994 in Hungary [8, 22]; 1995 in Slovakia [6] and Spain [14]; 1996 in Serbia [29]; 1998 in Bulgaria [11] and Bosnia and Herzegovina [13]; 1999 in France [12]; 2001 in Austria [31]; 2002 in Switzerland [39]; 2003 in Finland [20, 26]; 2004 in Germany [7]; Czech Republic [21] and

Croatia [13]; 2007 in Netherlands [2] and England [16]; 2009 in Romania [20], Slovenia [28], and Greece [35]; 2014 in Poland [15] and Belgium [37]; 2017 in Turkey [1]; 2018 in Macedonia [9]; 2019 in Luxemburg [32]; 2020 in Russia [27].

Additionally, the species is also reported in the eastern Mediterranean zone in Saudi Arabia and Yemen, as well as in tropical Africa, extending southwards to South Africa [1, 31].

Description of *Oxycarenus lavaterae* Fabricius. *Oxycarenus lavaterae* Fabricius exhibits sexual dimorphism, where females have a length of 4.4–5.4 mm and a width of 1.5 - 1.75 mm, while males have a body length of 4.2–5 mm and a width of 1.3 - 1.5 mm. The length/width ratio is 3.2:1 for both sexes. The weight of females at the beginning of diapause ranges from 3.8 to 5.8 mg, while males weigh between 2.2 and 4.1 mg [1, 15]. In Europe, there are four species of the genus *Oxycarenus* (*O. hyalinipennis* Costa, *O. modestus* Fallén, *O. pallens* Herrich-Schaeffer, and *O. lavaterae* Fabricius), and *O. lavaterae* Fabricius is the largest species in the genus [15].

Adults have a black head, pronotum, scutellum, antennae, and legs. The upper part of the abdomen is brick-red, while the ventral part is blackish. The front wings have a reddish to brownish-red color, and the wing membrane is shiny, extending beyond the tip of the abdomen. The hind wings are colorless and transparent. Larvae have a black head, red abdomen, and completely black wings [1, 15].

Biological cycle of *Oxycarenus lavaterae* Fabricius. The species, *Oxycarenus lavaterae* Fabricius, overwinters in the adult stage, forming compact colonies on the trunks and branches of lime trees (*Tilia americana*, *Tilia cordata*, *Tilia parviflora*, *Tilia platyphyllos*), occasionally on other plants (*Populus*, *Platanus*, *Aesculus hippocastanum*), usually on bark exposed to the sun [1, 11, 39]. Occasionally, a few hibernating larvae are also reported [4].

The colonies have various shapes, often rounded or oval, elongated, and the hibernating adults can be found in stacked layers with thousands of individuals [5]. The largest colonies can be over 70 cm in length and more than 15 cm in width [27]. On a single tree, there can be several colonies, leading to even hundreds of thousands of individuals. On one square meter of surface, there have been over 250,000 individuals [33].

The species can tolerate temperatures as low as -10°C, but in regions where winter temperatures drop below -15°C, up to 99% of the hibernating population can perish [17, 18, 39]. This insect seems to remain in diapause until May when the lime trees bloom, and their seeds become available [25, 35]. Hibernating adults spread throughout the crown of the trees, and additional feeding occurs on the leaves and immature fruits of the lime trees. The longevity of adults ranges from 63 to 113 days [25]. The average fecundity is about 390 eggs, with a maximum of 589 eggs, and the oviposition rate is approximately 4 eggs per day [26].

From mid-September to October, depending on the region, the adults withdraw and gather for hibernation [3, 35]. The number of annual generations depends on the thermal conditions of each zone. In the natural distribution area in southern Europe, the species develops three to four generations [17, 35, 36, 39]. In Germany, there are not more than two generations [5]. In Romania, the species has only one annual generation [3]. In Bulgaria, there are 1 to 3 overlapping annual generations [17, 18]. In Bulgaria, the adults of the first generation appear in mid-June, the second in late July, and the third at the end of September [11]. In Italy, there are 2 generations per year [10].

Being a relatively new species to Europe, no beneficial insect species specific to it have been reported, although the parasitoid *Phasia pusilla* Meigen (Diptera: Tachinidae) has been noted as parasitizing it [38].

Host-plants and damages. *Oxycarenus lavaterae* Fabricius is a polyphagous species, but it prefers plants from the Malvaceae and Tiliaceae families, where it is most commonly found with numerous populations.

Among the preferred plants from the Tiliaceae family are *Tilia cordata* Mill., *Tilia platyphyllos* Scop., and *Tilia tomentosa* Moench, which are commonly used in urban landscaping [17, 36, 30]. However, *Tilia platyphyllos* Scop. is sometimes avoided because its seeds have a thicker tegument, even though this lime tree species is frequently used for hibernation [12, 20, 23]. Smaller populations can also be found on other lime tree species, such as *Tilia parvifolia*, *T. argentea*, *T. rubra*, *T. americana*, *T. euchlora*, and *T. begoniifolia* [17, 27].

Both adults and larvae feed on the generative organs of the lime trees (flowers, especially seeds), as well as on the leaves and young shoots [1, 35, 36]. Strong and frequent attacks can lead to wilting and early defoliation, weakening the tree [36, 15], as well as reducing seed germination [35].

The species can also be found on plants from the Malvaceae family, including *Althea officinalis* L., *Althea rosea* L., *Hibiscus syriacus* L.,

Lavatera oblia L. (from which the species name is derived), *Lavatera cretica* L., *Lagunaria patersonii* Andrews, *Malva sylvestris* L., *Malva* spp., *Gossypium* spp., and *Sterculia* spp., but it does not cause significant damage to these plants [20, 27].

Additionally, *O. lavaterae* Fabricius has been reported on plants from other families, such as Asteraceae (*Cynara scolymus* L., *Helianthus annuus* L.), Betulaceae (*Corylus avellana* L.), Geraniaceae (*Geranium sanguineum* L., *G. Sylvaticum* L.), Platanaceae (*Platanus acerifolia* Willd.), Rosaceae (*Prunus* spp.), Rutaceae (*Citrus sinensis* L.), Salicaceae (*Populus* spp.), Sapindaceae (*Aesculus hippocastanum* L.), and Vitaceae (*Vitis* spp.) [1, 10, 15, 20, 30]. *O. lavaterae* Fabricius also transmits the eukaryotic pathogen *Phytomonas oxycareni* n. sp. (Trypanosomatida: Trypanosomatida), which has been reported in the salivary glands of the species [34]. As the species can enter dwellings during flight, it may trigger entomophobic reactions [20, 39].

2. Material and method

During the period of April-May 2021-2022, we conducted an investigation on the presence of hibernating colonies of *Oxycarenus lavaterae* Fabricius on trees of *Tilia cordata* Mill., *Tilia platyphyllos* Scop., and *Tilia tomentosa* Moench, located along the streets in Cluj-Napoca municipality. We assessed the frequency of infested trees, the number of hibernating colonies per tree, the shape of the colonies, and the number of individuals within a colony.

Additionally, we presented some aspects of external morphology based on the collected biological material and took a series of photographs.

3. Results and discussions

The species has been reported on all types of lime trees, but the frequency of infested trees varies. We observed hibernating colonies on 3% of the checked *Tilia cordata* Mill. trees, 1% of the *Tilia tomentosa* Moench trees, and less than 1% on *Tilia platyphyllos* Scop. trees. Specialized literature also mentions the presence of hibernating colonies on *Tilia platyphyllos* Scop., but it is not a preferred host for adults and larvae during their feeding period due to the thicker tegument of its seeds [20].

The shape of the colonies varies significantly [5], but among the observed colonies, triangular (Fig. 1a), elongated linear (Fig. 1b), and rounded (Fig. 1c) forms predominated.

The size of a colony ranges from 8 to 18 cm^2, with the number of individuals within a colony varying between 785 and 3428, with an average of 2117. The insects are arranged in stacked layers (Fig. 2). When the colonies are disturbed, the insects quickly spread along the trunk of the lime tree and can form much smaller secondary colonies (Fig. 1c).

a. **b.** **c.**

Figure 1. The shape of the colonies: a. triangular, b. elongated linear, c. rounded (original)

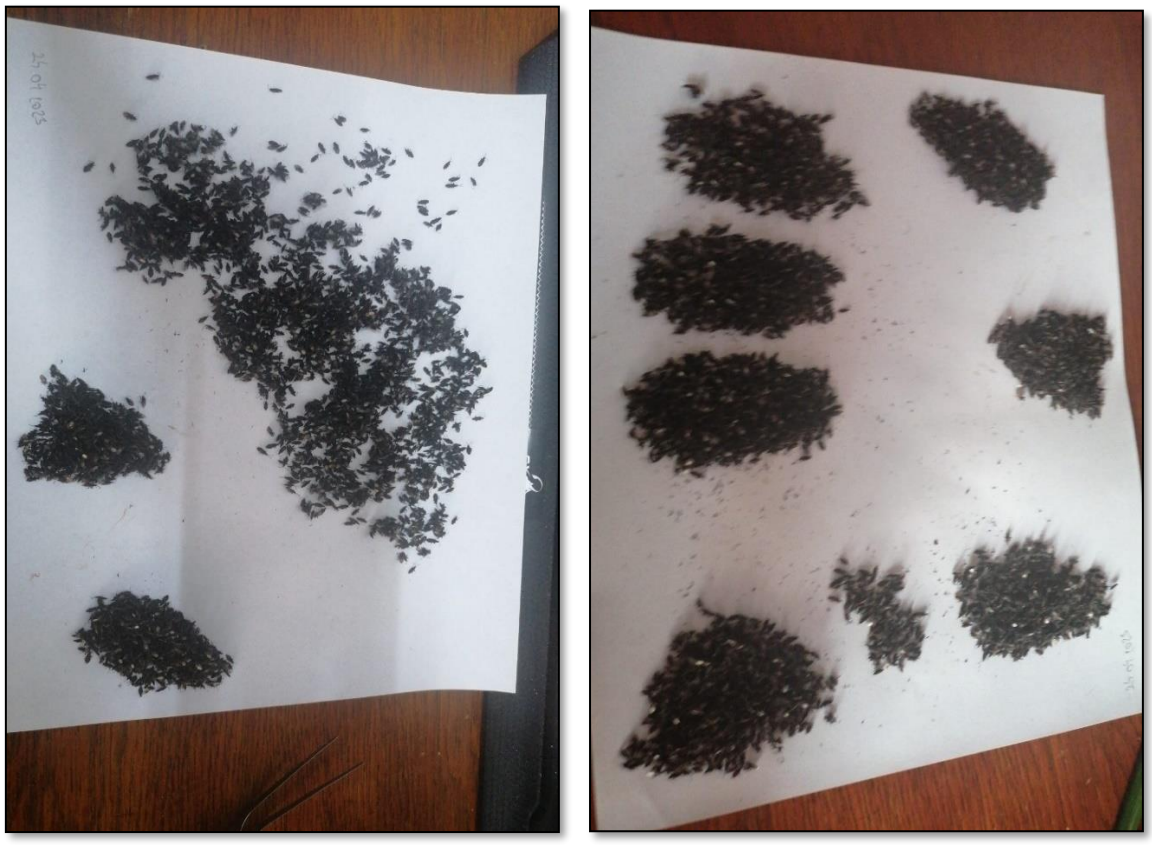

Figure 2. Analysis of individuals from an *Oxycarenus lavaterae* Fabricius colony (original)

The number of colonies found on a single tree ranged from 1 to 6 colonies. The majority of colonies were located on the upper part of the trunk, mainly at the point of branch insertion.

Biological material was collected from the field at the end of April in 2021 and the beginning of May in 2022. In the Entomology laboratory at the University of Agricultural Sciences and Veterinary Medicine in Cluj-Napoca, some observations on the external morphology of the adults were made. The size of the adults ranged from 4.3 to 5.2 mm, with an average of 4.91 ± 0.09 mm. The head, pronotum, and mesonotum exhibited ornamental structures on the cuticle, while the mesoscutellum had a triangular shape (Fig. 3). The forewings extended beyond the distal part of the abdomen (Fig. 4a).

The mouthpart, in the form of a stylet, had a length approximately equal to the size of the antenna (Fig. 5a and 5b).

Figure 3. Adult, *Oxycarenus lavaterae* Fabricius (original)

a. **b.**

Figure 4. Adult, *Oxycarenus lavaterae* Fabricius: a. dorsal, b. ventral (original photo)

a. **b.**

Figure 5. The mouthparts in adult *Oxycarenus lavaterae* Fabricius are as follows: a. dorsal, b. ventral (original)

Hibernating adults, starting from the second decade of May, began migrating from hibernating colonies and spread throughout the canopy of the trees. This activity coincided with the appearance of floral buds on later blooming lime trees and the blooming of earlier species. After a period of supplementary feeding, mating and egg-laying commenced, and the first larvae were reported in July. In August, adults of the first generation emerged, and the first hibernating colonies located on the trunks of the lime trees were observed on September 5th in 2021 and September 17th in 2022. The formation of hibernating colonies continued until October.

4. Conclusions

Oxycarenus lavaterae Fabricius, an invasive species, has been reported on lime trees located along the streets of Cluj-Napoca municipality. The lime tree species most affected by this pest is *Tilia cordata* Mill., while *Tilia platyphyllos* Scop. is the least affected. The size of the hibernating colonies ranges from 8 to 18 cm^2, with an average of 2117 individuals per colony. In the investigated area, the species exhibits a single generation. Hibernating adults begin their migration into the tree canopy in the second decade of May. Adults of the first generation are reported in August, and from September onwards, they withdraw for hibernation.

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