On the road to becoming an invasive species? First record of the onion aphid *Neotoxoptera formosana* (Hemiptera: Aphididae) in Austria

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Abstract: The first Austrian record of the onion aphid *Neotoxoptera formosana* is reported. It was made in the outskirts of the city of Graz. The find is remarkable for several reasons. Firstly, numerous winged viviparous females were observed. Furthermore, contrary to previous observations in Europe, the origin of the population was attributed to active dispersal. In addition, activity was observed under winter conditions, which was previously unknown for this subtropical species. It is possible that the spreading aphid is on the threshold of invasive behaviour.

Zusammenfassung: Auf dem Weg zu einer invasiven Art? Erstnachweis der Zwiebelblattlaus *Neotoxoptera formosana* (Hemiptera: Aphididae) in Österreich. − Der erste österreichische Nachweis der Zwiebelblattlaus *Neotoxoptera formosana* wird gemeldet. Er erfolgte am Stadtrand von Graz. Der Fund ist aus mehreren Gründen bemerkenswert. Zum einen konnten zahlreiche geflügelte vivipare Weibchen beobachten werden. Weiters konnte die Herkunft der Population entgegen bisheriger Beobachtungen in Europa auf aktive Ausbreitung zurückgeführt werden. Außerdem wurde Aktivität unter winterlichen Bedingungen beobachtet, was für die subtropische Art bislang unbekannt war. Möglicherweise steht die sich ausbreitende Zwiebelblattlaus an der Schwelle zu einem invasiven Verhalten.

Keywords: Neobiota, biological invasion, onion aphid, *Neotoxoptera formosana*, Austria.

Schlüsselwörter: Neobiota, biologische Invasion, Zwiebelblattlaus, *Neotoxoptera formosana*, Österreich.

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1. Introduction

Biological invasions pose a significant threat to ecosystems worldwide, disrupting native biodiversity and causing economic losses. Invasive species can rapidly establish themselves in new environments, outcompeting native species and spreading plant diseases (Garcia-Lozano et al. 2025). Aphids (Insecta, Hemiptera), as an example of invasive insects, often thrive in agricultural and natural habitats due to their high reproductive rates and adaptability, leading to severe ecological and economic consequences. Understanding the impact of these invasions and developing effective control strategies is crucial to mitigating their harmful effects (Wieczorek et al. 2025).

The onion aphid *Neotoxoptera formosana* (Takahashi, 1921), described from Taiwan and originally native to south and southeast Asia, is now distributed almost worldwide in subtropical and tropical regions (Favret C. & Aphid Taxon Community 2025). The first European records were made in France in 1984 (Leclant 1999), then in Finland in 1994 (Blackman & Eastop 2000), in the UK in 1999 (Halstead 2000) and in Germany in 2006 (Thieme et al. 2024). Finds have also been made in other Austrian neighbouring countries, namely for the first time in 2000 in Italy (Barbagallo & Ciampolini 2000) and in 2008 in Switzerland (cited in Wuest & Hollier 2021). This aphid, which affects both wild and cultivated *Allium* species, has been recorded on hosts such as *Allium ascalonicum*, *A. cepa*, *A. chinense*, *A. fistulosum*, *A. porrum*, *A. sativum*, *A. schoenoprasum* or *A. tuberosum*.

The spread of the oligophagous and not host alternate aphid, which sucks on various *Alium* species, apparently occurs primarily passively through vegetable transport. This has been proven, for example, for the first Finnish discovery, which could be traced back to an introduction through onion shipments from the Netherlands (Blackman & Eastop 2000). Although the exact origin of onion aphids usually remains unclear, the British first record from a model Vegetable Garden at RHS Wisley, Surrey, the Dutch first record from a garden centre and the one from Italy from a chives culture in a glass house also indicate passive dispersal. The comparatively slow spread and establishment in the countries mentioned also speaks in favour of a predominantly passive spread. Added to this is the rare occurrence of winged morphs. This can be seen, for example, in studies by Piron (2010), who was unable to observe any winged specimen within two months despite high population density and rapid development. Similar results were obtained by Thieme et al. (2024), who were unable to breed any winged individuals despite controlled laboratory conditions with artificially increased

density ('crowding effect'). Finds of winged morphs from 12 m high aerial suction traps in Britain (MacLeod 2007) suggest that *N. formosana* may have a greater dispersal ability than previously assumed. Although the species is mainly thought to spread passively, its field populations are now well established in the UK (Dransfield & Brightwell 2025), indicating that occasional active dispersal may also play a role.

The effects of environmental factors, in particular of temperature on the biological characteristics of *N. formosana* are only partly known. Liu et al. (2025) constructed life tables to explore the effects of temperature on the development, reproduction and population dynamics of this species for different regimes. It was found that the developmental threshold temperature of the whole nymph stage was 4.0 °C and that *N. formosana* developed well at 12 °C, indicating that lower temperatures are favoured by this aphid. But there are no data regarding European winter conditions, except for the UK, where the insects were found again on *Allium* at RHS Wisley in May 2000, having likely overwintered on garlic cloves in a cold frame (Dransfield & Brightwell 2025).

The aim of this study is to document the first occurrence of *Neotoxoptera formosana* in Austria and to analyze its potential pathways of introduction and establishment in the region's climatic conditions.

2. Materials and methods

The investigation was conducted for a period of two months, from December 2023 to January 2024 in a small private garden in the outskirts of the city of Graz: Austria, Styria, Graz-Eggenberg, 47°03'41"N, 15°23'31"E, 364 m a. s. l. (Fig. 1). Live specimens of aphids (n = 28) were collected directly from the host plant and partly preserved in 70 % and 98 % ethanol (C. Hohl leg.). Insects were slide-mounted using the method of Wieczorek in Wieczorek & Chłond (2020) and examined using a Nikon Ni-U light microscope equipped with a phase contrast system. Voucher specimens were deposited in the collections of the Universalmuseum Joanneum (Studienzentrum Naturkunde) in Graz, Austria (E1044, 5 alate viviparous females, 5 apterous viviparous females, 12 immature nymphs, C. Hohl & W. Paill det.) and the University of Silesia in Katowice, Poland (DZUS: SA02-229-01-003, *Neotoxoptera formosana*, Graz, Austria, 2 apterous viviparous females, 1 alate viviparous female 05.01.2023 *Alium fistulosum*, K. Wieczorek det., SA02-229-01-004, *Neotoxoptera formosana*, Graz, Austria, 2 apterous viviparous females, 1 alate viviparous female 05.01.2023 *Alium fistulosum*, K. Wieczorek det.).

The temperature conditions were available from a nearby measuring station in Graz/Straßgang.

3. Results and discussion

The colony of viviparous females included at least ten winged individuals and numerous nymphs (Figs 2–3) of *N. formosana*. It was observed from 20.12.2023 to 10.01.2024 on several *Allium fistulosum* plants cultivated without cover (partially wilted, according to the season) in the house garden.

The observation took place in mid-winter, i. e. outside the normal activity period of aphids under field conditions. The temperatures in the period of field observations with an average daily temperature of 3.8 °C, an average daily maximal temperature of 8.1 °C and an average daily minimal temperature of –0.6 °C were favourable enough to allow activity of the studied species. Not even a night-time frost phase lasting over 5 days from 27.12.–31.12.2023 with average daily minimum temperatures of –2.2 °C (lowest value: –3.9 °C) could stop the activity of the species. However, it was observed that the aphids retreated to the leaf base during the night, only to leave it again during the day. Though, daytime temperatures rose relatively sharply during this period, with daily maximum temperatures of 7.7 to 11.2 °C (average value: 9.9 °C). Only a cold drop on 10.01.2024 with a daily minimum of –5.3 °C and a daily maximum of only 2.0 °C stopped the activity of the local population of *N. formosana*. However, the vitality of the host plants obviously also suffered greatly under the frosty conditions (Figs 4–5). From this point onwards, no more aphids could be observed.

The origin of the observed population of *N. formosana* can definitely not be attributed to a passive introduction via the host plant. The *A. fistulosum* individuals had been on site for over two years (from summer 2021), had already survived two long winters and were cared for, used and continuously observed with interest by the second author. In addition, the plants came from a small farm in another part of Graz (see Fig. 1), where they had already been kept for several years. Overall, it is assumed that the insects had not been overlooked for a long time, but had only recently flown in actively.

Neotoxoptera formosana causes damage to crops of importance to humans (e. g. Barbagallo & Ciampolini 2000; Zhang et al. 2024; Liu et al. 2025) and is also known to transmit plant diseases (e.g. Yasuda et al. 1998). Nevertheless, the species, which is classified as a non-native species in Europe, is on this continent currently considered to be of little economic relevance. It remains to be seen whether this will be assessed differently in the future with successful overwintering under increasingly favourable climatic conditions coupled with increased active dispersal rates. In any case, consistent monitoring of the population development of the species seems advisable.

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Fig. 1: Finding of *Neotoxoptera formosana* in the city of Graz (closed square) and place of origin of the host plants (open square) (base layer: GIS Steiermark).

Abb. 1: Fundort von *Neotoxoptera formosana* in Graz (gefülltes Quadrat) und Herkunftsort der Wirtspflanzen (offenes Quadrat) (Kartenhintergrund: GIS Steiermark).

Figs 2–3: *Neotoxoptera formosana*, immature nymph and adult winged (alate) viviparous female. Graz, Austria (photos: C. Hohl).

Abb. 2–3: *Neotoxoptera formosana*, unreifes Nymphenstadium und geflügeltes vivipares Weibchen. Graz, Österreich (Fotos: C. Hohl).

Figs 4–5: Cultivated *Allium fistulosum*, infested by *Neotoxoptera formosana* and damaged by low temperatures. Graz, Austria (photos: C. Hohl).

Abb. 4–5: Kultur von *Allium fistulosum*, befallen von *Neotoxoptera formosana* und geschädigt durch tiefe Temperaturen. Graz, Österreich (Fotos: C. Hohl).

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