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Brief Communications

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Expanded geographic range and novel host association of elm zigzag sawfly (Hymenoptera: Argidae) with *Zelkova serrata* in North America

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Abstract

The elm zigzag sawfly (EZS), *Aproceros leucopoda* Takeuchi (Hymenoptera: Argidae), is a rapidly spreading invasive defoliator threatening North American elms (*Ulmus* spp.). Native to East Asia, EZS has established itself across Europe and Russia and was first detected in North America in 2020. Its parthenogenetic reproduction, high fecundity, and multiple dispersal pathways facilitate rapid range expansion and by 2025, EZS had been documented in 14 U.S. states and 4 Canadian provinces. In North America, human-assisted dispersal via vehicles, wood products, and potentially nursery soil may accelerate its spread beyond natural dispersal distances. This paper documents the first observation of EZS on Japanese zelkova (*Zelkova serrata*), an ornamental tree within Ulmaceae. In field choice assays, EZS oviposited, fed, and pupated on *Z. serrata* "Musashino" early in the growing season, although subsequent generations did not utilize the host. This suggests that *Z. serrata* may serve as an alternate host, likely influenced by earlier leaf-out relative to elm.

Keywords: elm, sawfly, defoliator, invasive species, zelkova

Introduction

Elm zigzag sawfly (EZS), *Aproceros leucopoda* Takeuchi (Hymenoptera: Argidae), is a rapidly spreading invasive sawfly with the potential to cause widespread ecological and economic damage in North America. Native to East Asia, it has established itself across Europe, parts of Russia, and, most recently, North America (Blank et al. 2010, Blank et al. 2014, Oten et al. 2023). Named for the characteristic zigzag feeding pattern created by its larvae, it was first detected in North America in 2020 and has since expanded its range at an alarming pace (Martel et al. 2022, Oten et al. 2023). Its high fecundity, parthenogenetic reproduction, and multiple dispersal pathways make it a growing threat to elm populations already threatened by Dutch elm disease.

Elm zigzag sawfly voltinism is highly variable for reasons that remain unclear, but up to 5 generations per year have been observed in North Carolina, providing potential for exponential population growth through the growing season. They reproduce by thelytoky, a type of parthenogenesis in which unfertilized eggs produce only females (Blank et al. 2010). Adults are small, reaching 7 to 8 mm in length. They are shiny black with pale legs and smoky-brown wings (Fig. 1C). Females, which first emerge in the spring, do not require feeding before oviposition and may begin laying eggs immediately after eclosion. A single female can lay between 7 to 49 eggs, depositing them singly along leaf margins (Fig. 1D), and they eclose within 4 to 8 d (Blank et al. 2010, Martynov and Nikulina 2017). Elm zigzag sawfly larvae are small, reaching 10 to 11 mm in length at maturity. Neonates are grayish-white, while older larvae are light green with a black band on their head. Diagnostic features include T-shaped brown or black markings above the second and third pair of thoracic legs (Fig. 1A). Larvae feed for 10 to 18 d and progress through 6 instars (Blank et al. 2010, Martynov and Nikulina 2017). Pupation occurs within seasonally dimorphic cocoons, either net-like summer cocoons or densely woven cocoons associated with overwintering. Summer cocoons are often attached to twigs and leaf undersides (Fig. 1B) with pupation occurring within 2 to 3 d and adult emergence following in 4 to 7 d (Blank et al. 2010). Overwintering cocoons are primarily found in the leaf litter or within the top 5 cm of soil and emerge the following spring (Wu 2006, Blank et al. 2010). Overwintering cocoons are produced throughout

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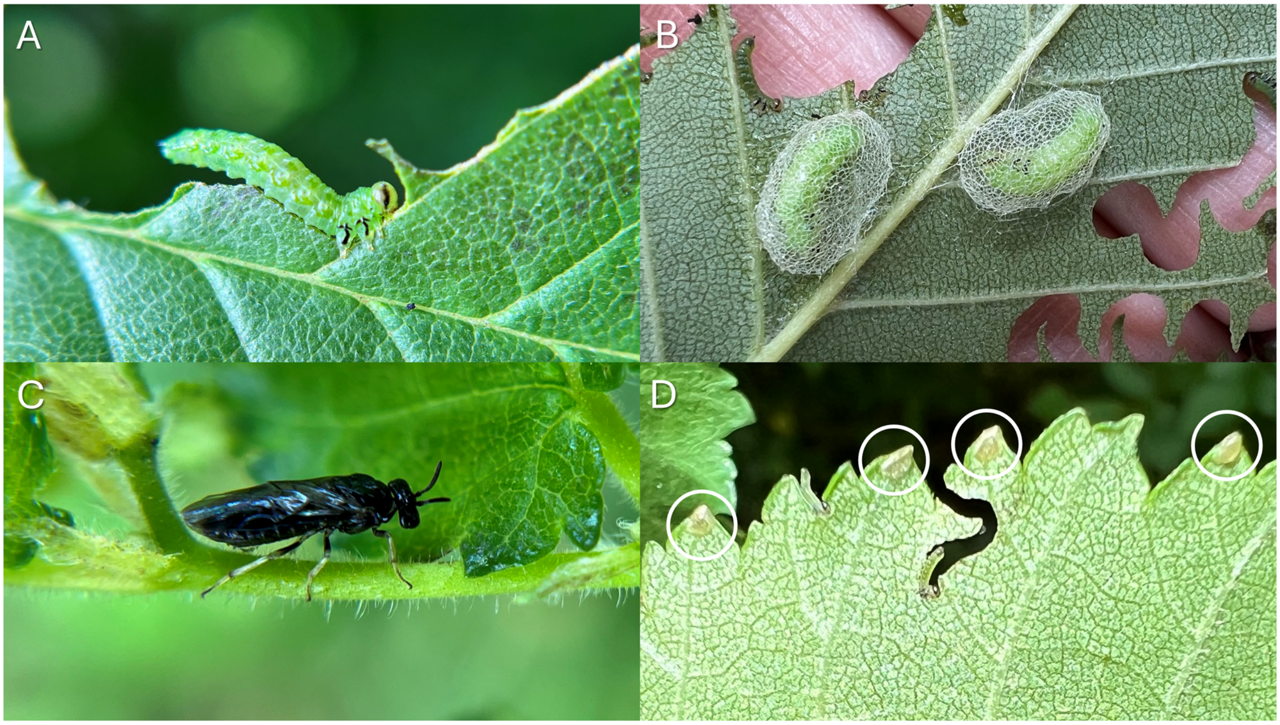

Fig. 1. Elm zigzag sawfly larva A), summer cocoon B), adult C), and eggs D), circled. Photos by KLFO.

the season—not just in late-season generations—suggesting an adaptation for unpredictable early winter conditions (Blank et al. 2010, Martel et al. 2022).

In North America, EZS feeding damage ranges from inconspicuous to severe (Fig. 2A). Early instars produce the species' characteristic zigzag-shaped feeding pattern as they consume leaf tissue starting at the margin and moving towards the midvein (Fig. 2B). As larvae mature, they feed more extensively, often stripping leaves to the mid-vein and major lateral veins (Martynov and Nikulina 2017) (Fig. 2C). This more extensive feeding can obscure the diagnostic zigzag pattern characteristic of younger instars, making it difficult to detect infestations in the absence of the larvae. Although most insect herbivory causes limited long-term damage, repeated severe defoliation events can substantially weaken or even kill host trees (Parry and McCullough 2004, Coyle et al. 2008). In Europe, elms severely defoliated by EZS often produce a secondary flush within the same growing season or reflush the following spring; however, recurrent defoliation has been associated with branch dieback and suppressed growth (Blank et al. 2010, Zandigiacomo et al. 2011). In North Carolina, branch dieback has been observed on elm following 3 yr of EZS defoliation.

Another concern is the added threat that EZS poses to elms already imperiled by Dutch elm disease, a lethal vascular wilt disease that devastated North American elm populations in the mid-1900s. The disease is caused by *Ophiostoma* fungi (Ophiostomatales: Ophiostomataceae) and vectored by 3 bark beetles (Coleoptera: Curculionidae): native elm bark beetle (*Hylurgopinus rufipes*), smaller European bark beetle (*Scolytus multistriatus*), and the banded elm bark beetle (*S. schevyrewi*). Feeding by EZS could further weaken trees, potentially making even disease-resistant elms more susceptible to beetle attack and increasing disease pressure.

Expanded Geographic Range

The first North American record of EZS occurred in Québec, Canada, in 2020 (Martel et al. 2022), followed by its detection in Virginia, USA, in 2021 and in 4 additional states in 2022 (Oten et al. 2023). Since then, the range of EZS has expanded rapidly. By 2025, EZS had been confirmed in 14 states and 4 Canadian provinces, spanning from New Hampshire south to North Carolina and west to Winnipeg, Canada, and Minnesota (Fig. 3).

The range expansion of EZS was foreseeable, given adults can actively disperse 45 to 90 km per year (Blank et al. 2014). However, human-mediated movement likely poses an even greater threat. Summer EZS cocoons have been observed attached to items with high transport potential, such as wood products (Oten et al. 2023) and vehicles (Fig. 4), raising concerns about long-distance dispersal. Overwintering cocoons may also be transported in soil of nursery stock, or eggs, larvae, or summer cocoons could be transported on nursery stock, though these have yet to be confirmed. Together, these human-assisted pathways increase the risk of EZS introduction into new regions beyond what natural dispersal alone would permit.

Novel Host Association with *Zelkova serrata*

Previously, EZS was believed to feed exclusively on the foliage of native, non-native, and cultivated *Ulmus* spp. (elm; Ulmaceae) (Blank et al. 2010, Blank et al. 2014, Oten et al.

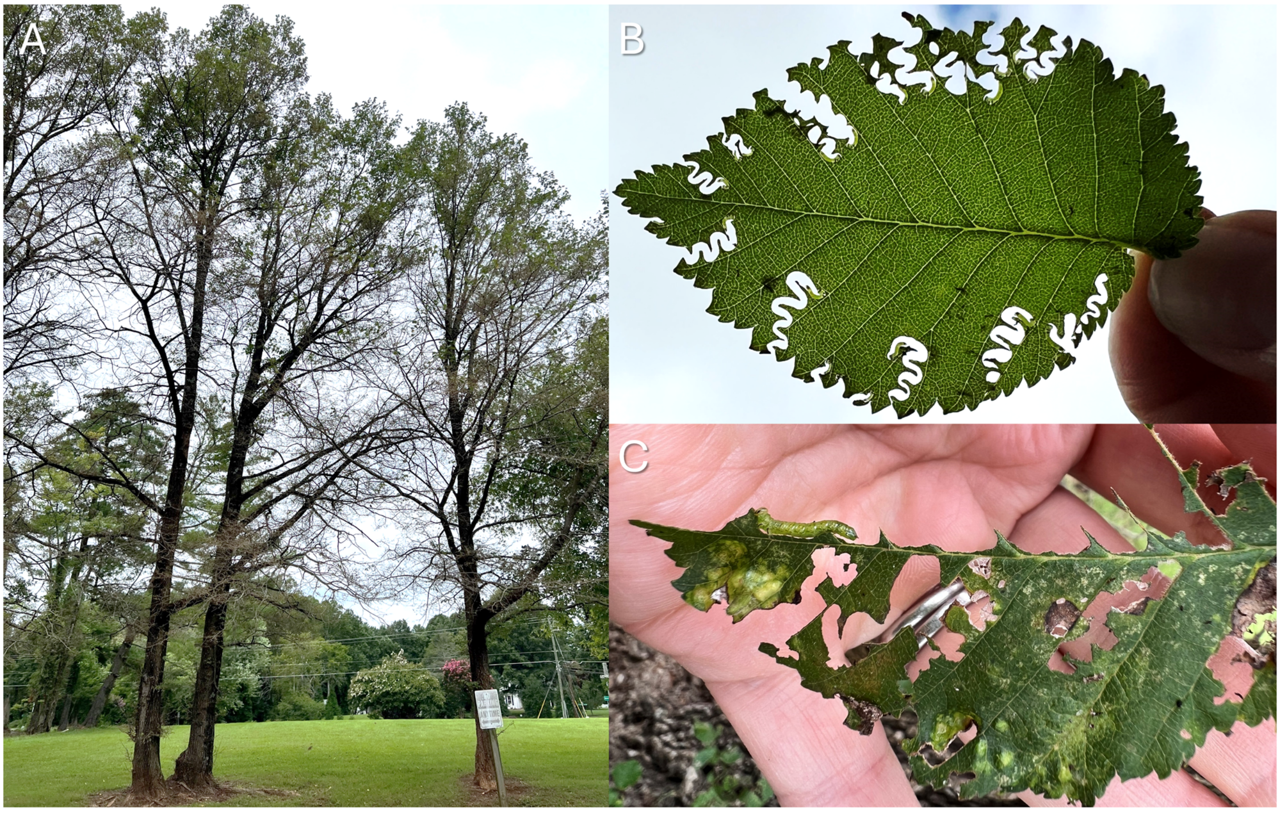

Fig. 2. Extensive defoliation of winged elm, Ulmus alata A). Characteristic zigzag defoliation pattern of early instars B) and more complete defoliation of later instars C). Photos by KLFO.

2023, Vétek et al. 2022). Vétek et al. (2022) performed no-choice host range assays and recorded oviposition and larval feeding on *Hemiptelea davidii* (Hance) Plance (Ulmaceae), but all larvae died after a few days. These trials also included Japanese zelkova, *Zelkova serrata* (Thunb.) Makino (Ulmaceae), on which EZS did not oviposit. However, given the high value of Japanese zelkova as an ornamental tree and its close phylogenetic relationship to elm within the family Ulmaceae, further investigation was warranted.

The site of our observational study was the U.S. Forest Service Northern Research Station in Delaware, Ohio, and is home to a large American elm breeding program focused on identifying Dutch elm disease-resistant elms and establishing seed orchards to generate disease-resistant trees for forest restoration. There are 15 acres of experimental plantings of thousands of American elm trees. In July 2023, EZS was detected at the site. On 16 April 2025, we planted 4 15-gallon Japanese zelkova trees; 2 were *Z. serrata* "Musashino" (Musashino1 and Musashino2), and 2 were *Z. serrata* "Village Green" (VillageGreen1 and VillageGreen2). Therefore, the Japanese zelkova plantings served as an open-field choice assay, planted within an EZS-infested elm planting, approx. 160 yards from the 3 elm trees that were observed as part of the study and approximately 5 m from the nearest elm canopy. From 10 April to 9 September 2025, weekly observations were conducted by examining all leaves on the 4 Japanese zelkova saplings, examining 3 American elm trees with high EZS abundance the previous year, and 6 yellow sticky traps hung on the lower branches (~1.5 to 2 m from the ground) of those elms. The part of the elm planting monitored for EZS activity contained clones of large survivor American elm trees from the Midwest that had previously been tested for resistance to Dutch elm disease. The elms chosen were 2 "Lake Odessa" and one "Bellevue" selection, 10 to 15 cm DBH, located on the western edge of the planting where they received ample sunlight. The spacing of elms in this part of the planting is 2.4 m by 2.4 m, and the elm tree canopies touch their neighbors, creating a closed canopy environment.

On 22 April, initial EZS emergence was recorded on the yellow sticky traps. At the time, the zelkova trees had fully expanded leaves, while elms were just beginning to leaf out. On 5 May, EZS feeding was observed on one of the *Z. serrata* "Musashino" trees (Musashino1), but no larvae were detected (Fig. 5A). Considering the distance from the nearest elm (~5 m), larval feeding on zelkova is most plausibly explained by oviposition rather than larval dispersal. On 13 May, there were no larvae observed, but whole leaf defoliation, consistent with older instar EZS feeding, was noted on Musashino1, Musashino2, and VillageGreen2. Overall, defoliation on Japanese zelkova was minimal and confined to only a few zigzag feeding patterns. On 27 May, EZS pupae in summer cocoons were observed on Musashino1 (Fig. 5B and C); one was light green, suggesting a newly developed pupa, and the other was black, resembling a nearly completely developed adult. On 3 June, these cocoons were empty, indicative of eclosion, and an additional summer cocoon with black pupa was observed on the same tree. On 10 June, leaves with feeding damage

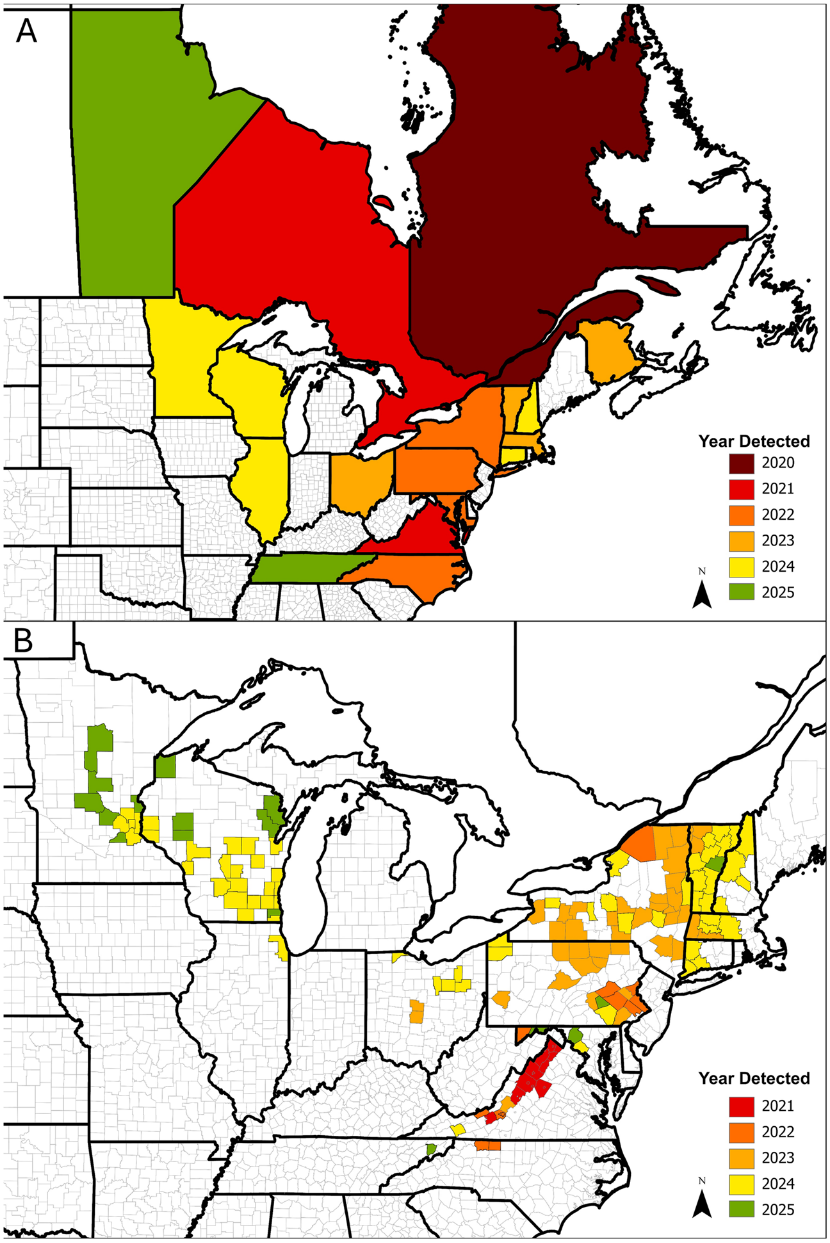

Fig. 3. Elm zigzag sawfly detections in Canadian provinces and U.S. states in North America (A) and county-level detections in the U.S. (B), 2020-September 2025. Maps created 11 September 2025 by KLFO.

and cocoons were collected and pressed. Upon inspection, structures resembling EZS egg chorions and consistent with the expected size of EZS eggs were noted at the tips of 2 leaf serrations (Fig. 6). Throughout the season, 5 distinct generations were observed, with activity ending by 9 September when no EZS were found on traps or leaves. After the first generation of EZS was observed on Japanese zelkova, no subsequent EZS were observed on those trees. Larvae and cocoons were also observed on American elm trees. First generation EZS utilized both Japanese zelkova and American elms, while the second, third, and fourth generations only utilized the American elms.

Based on these observations, we conclude that EZS will oviposit, feed, and complete development at least to its pupal stage on Japanese zelkova. Given the distance from the nearest elms, the absence of fully expanded elm foliage at the time of adult eclosion, and the presence of structures resembling EZS eggs on infested zelkova, we suggest that oviposition is the most likely pathway for EZS infestation. However, the absence of subsequent generations of EZS on the trees suggests that initial attraction was likely driven by phenological alignment, as the zelkova leaves were fully expanded and the elm leaves were not. This indicates Japanese zelkova may serve as an alternate, but not preferred, host when elm is present.

Fig. 4. Elm zigzag sawfly cocoons attached to a truck, beneath the side mirror (A) and in the wheel well (B), with arrows pointing to cocoons. Photos by Jared Beach.

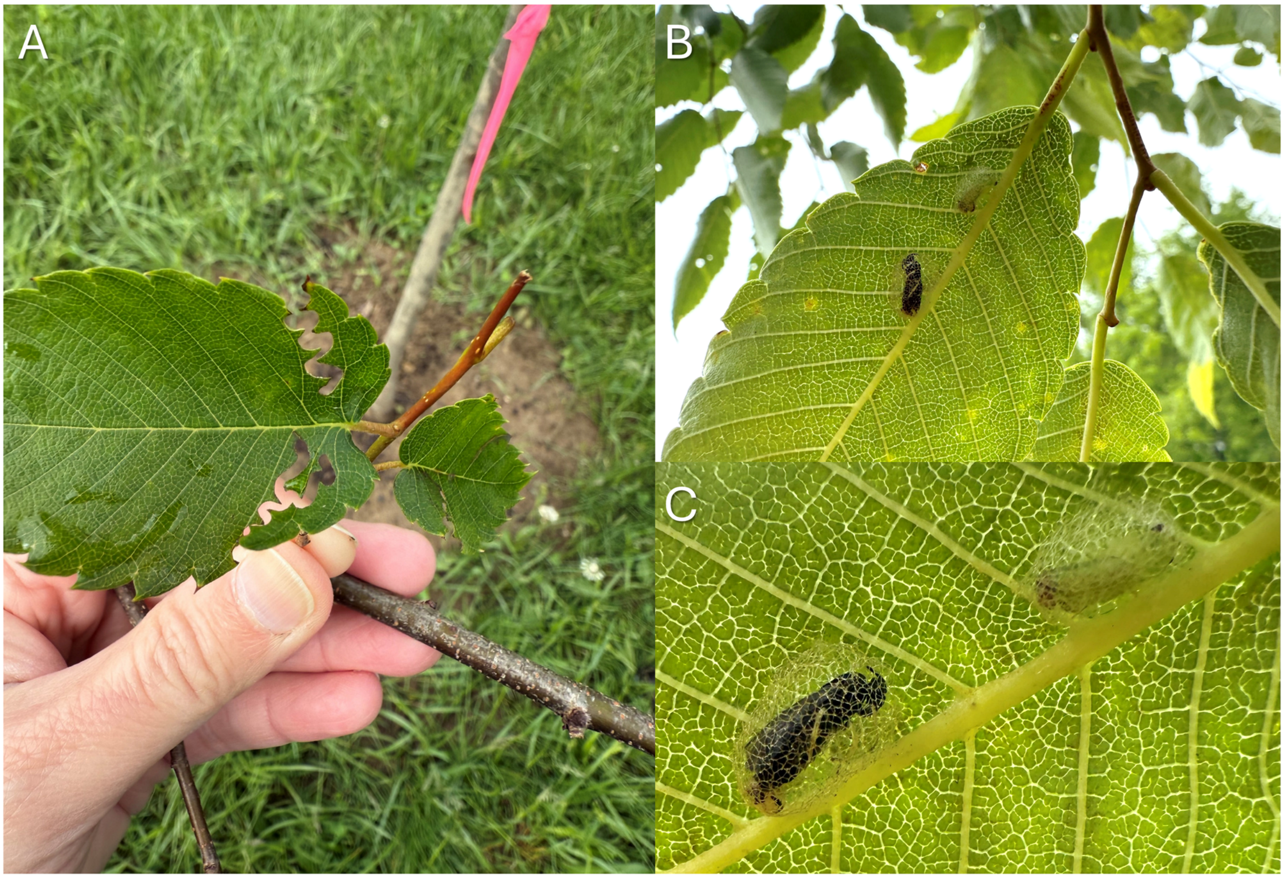

Fig. 5. Elm zigzag sawfly feeding activity (A) and pupation within summer cocoons (B, C) on Japanese zelkova, *Zelkova serrata*. Photos by KSK.

Discussion

Given EZS's high reproductive potential and dispersal capabilities, its rapid spread into new areas was expected. Ongoing detections underscore the importance of coordinated monitoring to track its distribution and assess potential impacts on forest and ornamental elms.

Future research should focus on assessing both spread capabilities and mitigating pathways of human-mediated spread. Our observations represent the first record of EZS oviposition and development on Japanese zelkova, a valuable ornamental and street tree in North America, widely planted as a replacement following widespread elm mortality due to Dutch elm disease.

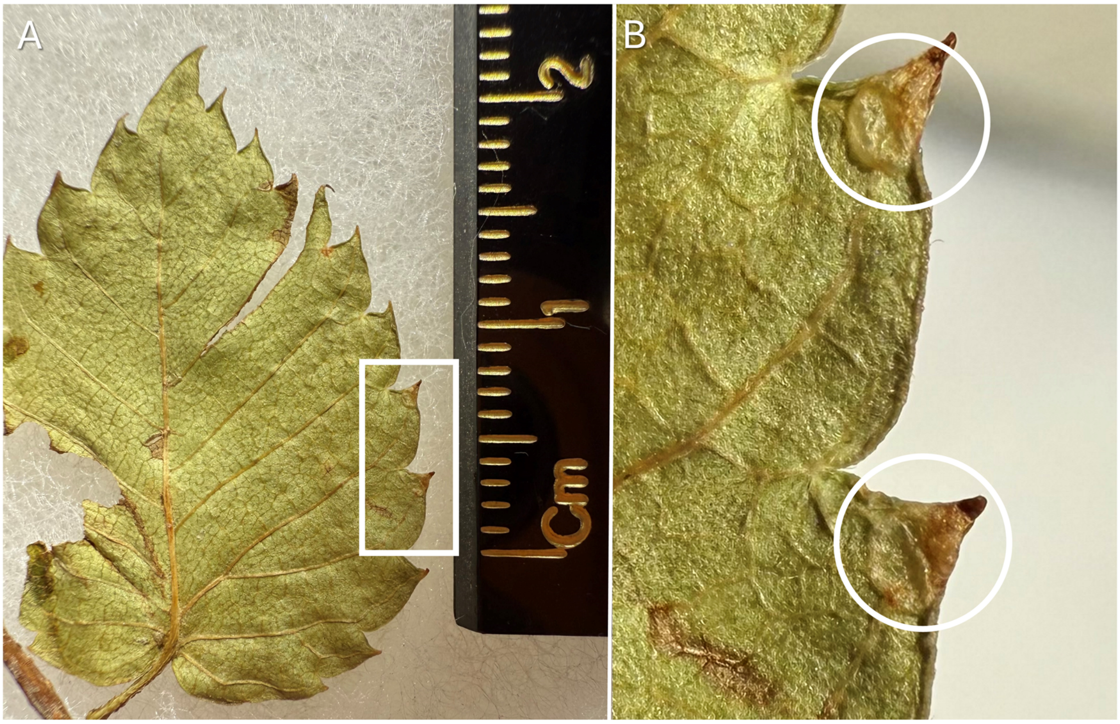

Fig. 6. Pressed Japanese zelkova leaf showing feeding damage on the left side and structures resembling elm zigzag sawfly egg chorions on the right, with the close-up area indicated (A). Close-up (B) shows possible elm zigzag sawfly egg chorions at the tips of leaf serrations (circled). Photos by KSK.

Initial observations suggest it may be an alternate host in the absence of elm foliage, but further research is needed to evaluate EZS host preference, the susceptibility of different Zelkova species and cultivars, and the impact of the host on EZS fitness.

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Author Contributions

Kelly Oten (Conceptualization [lead], Data curation [equal], Funding acquisition [lead], Resources [lead], Supervision [lead], Writing—original draft [lead]), Abigail R Ratcliff (Data curation [equal], Investigation [supporting], Writing—review & editing [supporting]), Delaney L Serpan (Investigation [equal], Writing—review & editing [equal]), Haley Marcum (Investigation [supporting], Writing—review & editing [supporting]), and Kathleen Knight (Conceptualization [equal], Data curation [equal], Formal analysis [equal], Writing—original draft [supporting], Writing—review & editing [supporting]

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Conflicts of Interest

The authors declare no potential conflicts of interest.

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