Hope for California: Updates on Proactive Biological Control of Spotted Lanternfly

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Background

The spotted lanternfly (SLF) [*Lycorma delicatula* (Hemiptera: Fulgoridae)] is a generalist planthopper that has invaded North America (Fig. 1A). The species was accidentally introduced into the United States (US) from China, and since its first record in Berks County, Pennsylvania, in 2014, invasive populations have spread and become established in 18 eastern and mid-western states. The California Department of Food and Agriculture has, on several occasions, intercepted egg masses, often laid indiscriminately on building materials and outdoor furniture, coming into California (Fig. 1B). This is the most likely way SLF will accidentally enter and establish in California. In invaded regions, SLF can reach very high population densities, and this pest can feed on more than 100 species of native, ornamental, and agricultural plants. Significant economic impacts have been observed in vineyards, including cases where severe infestations have resulted in the complete loss of productivity and death of vines. The threat that SLF poses to vineyards presents a serious concern for California's wine and grape industry, which generates more than $170 billion in annual economic activity in the US. Additionally, recent findings suggest that SLF might also pose a threat to the citrus industry, for which California accounts for approximately 79% of the total US production.

Although SLF is not yet present in California, its accidental introduction is anticipated. Because it is likely that SLF will eventually invade and establish in California, our team at UC Riverside has adopted a proactive approach to identify solutions for managing SLF *before* it invades and establishes here. Our first proactive project assessed the potential of the parasitoid, *Anastatus orientalis*, which parasitizes the eggs of SLF in its native range (i.e., China), as a biological control agent for potential future use against

SLF in California. Unfortunately, these experiments revealed that *A. orientalis* is a generalist, and its introduction into the US to control SLF is not recommended, as it might pose a threat to non-target native species, including several species of native Lepidoptera (butterflies and moths) and Hemiptera (stink bugs). However, the generalist ecology of *Anastatus* parasitoids raises an intriguing possibility: could *Anastatus* species native to the US, including California, provide some level of control of SLF and function as naturally-occurring biological control agents? Building on this question, our team focused on identifying native US *Anastatus* to evaluate their potential as biological control agents of SLF.

Searching for native US parasitoids

Since SLF belongs to the insect family Fulgoridae, the first step was to identify parasitoids of native US Fulgoridae, for which no data were available when we started this project. Additionally, although numerous fulgorid species have been collected in the US, with the richest diversity being located in the southwest US (i.e., the sky island mountains of southeastern Arizona), nothing is known about the biology of these species. Of specimens deposited into museums, most were not described and lacked scientific names when we started this work. So, our project on native lanternfly egg parasitoids faced two significant obstacles, no parasitoid species were known and the majority of collected native lanternflies were undescribed species in museum collections! This situation needed urgent attention.

During the monsoon season (August 2023), blacklight sampling was performed at the Southwestern Research Station (SWRS, Portal, AZ) in the Chiricahua Mountains (Fig. 2 and 3), where high abundance and diversity of native lanternflies is known to occur. Two species of Fulgoridae [*Scaralina aethrinsula* and *S. cristata* (named and described as part of this project)] were collected and reared in mesh cages installed on their host plant [*Quercus arizonica* (this was another puzzle we had to solve, what do native lanternflies feed on?)] (Fig. 4). From these caged rearing efforts, 40 native lantern fly egg masses were obtained and attached to native oak trees as ‘sentinel egg masses’ in an attempt to encourage parasitism by native egg parasitoids living in lanternfly habitat (Fig. 5). After an exposure period of 15 to 40 days, the egg masses were collected and stored in an incubator at the University of California Riverside’s Insectary and

Quarantine Facility (UCR-I&Q). A total of 46 egg parasitoids emerged from four sentinel egg masses. These parasitoids are two new undescribed species, and females of one of these native species (Fig. 6) successfully parasitized a SLF egg mass in the UCR quarantine facility.

Another egg parasitoid, *Anastatus reduvii*, native to and widespread in North America (including California), was evaluated for its potential as a biological control agent for SLF (Fig. 7). *Anastatus reduvii* reproduces parthenogenetically, with most offspring being female and males only produced rarely. This widespread parasitoid has emerged from field-collected SLF egg masses in the eastern US, suggesting it may be a promising natural enemy of this pest. SLF egg masses exposed to *A. reduvii* showed a significantly lower survival rate (33%) than egg masses not exposed to parasitoids (90%). The mortality of SLF eggs caused by *A. reduvii* was due to a mix of factors, including successful parasitism, and unknown causes which may be attributable to host feeding or incomplete parasitoid development within eggs. Host feeding is an important source of mortality and occurs when female parasitoids "eat" their hosts to obtain protein needed to mature eggs within their ovaries. When females host feed, they are acting as predators, and hosts killed via feeding don't produce offspring. Parasitism, on the other hand, results in the death of the host egg, and because parasitism is a reproductive event, generation of new parasitoids results, which boosts natural enemy population growth. Pest population control can be substantial when female parasitoids engage in both host feeding (predation) and parasitism (reproduction).

Final thoughts

The findings from our proactive studies represent important milestones in biological control programs targeting SLF in California, and just as importantly, areas of the US where SLF is established. Having a biological control agent approved for use before the anticipated SLF invasion in California would help mitigate the negative effects of this pest during the early stages of the incursion, when pest populations are relatively small and isolated. Releases of native parasitoids that attack SLF eggs may be a powerful tool to use in situations where insecticide use may not be possible for controlling or eradicating SLF, like in urban areas, where SLF is most likely to establish first in California. In preparation for such an event, the

California Department of Food and Agriculture is maintaining colonies of *A. reduvii* for possible future use against SLF.

Additional information on proactive work on SLF

Gómez Marco F, Yanega D, Ruiz M, Hoddle MS. 2023. Proactive classical biological control of *Lycorma delicatula* (Hemiptera: Fulgoridae) in California (US): Host range testing of *Anastatus orientalis* (Hymenoptera: Eupelmidae). *Frontiers in Insect Science*. 3: 1134889.

Molfini M, West M, Gómez Marco F, Torres JB, Hoddle MS. 2024. Is spotted lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae), a blooming threat to citrus? *Journal of Economic Entomology*. 117: 2194–2198.

West M, Molfini M, Hoddle SM. 2025. Proactive assessment of a native North American egg parasitoid, *Anastatus reduvii* (Hymenoptera: Eupelmidae), as a potential biological control agent of *Lycorma delicatula* (Hemiptera: Fulgoridae), in California. *Biological Control*. 200: 105687.

Acknowledgments

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Fig. 1. (A) Spotted lanternfly is an invasive pest in the US that is native to Asia. This insect, not yet present in California, poses a significant threat to grape industries (Credit: USDA-ARS, Stephen Ausmus). (B) SLF lays eggs on inert objects, like pallets, outdoor equipment, and firewood, which greatly increases the risk of accidental introduction into California. (Credit: USDA, Lance Cheung).

Fig. 2. Native habitat that was sampled for native lanternflies and parasitoids at the Southwest Research Station in Portal Arizona, in the in the Chiricahua Mountains. (Credit: Marco Molfini, UC Riverside)

Fig. 3. Native lantern flies are attracted to blacklights that were set up at the Southwestern Research Station. Adult lantern flies attracted to black lights were captured and caged onto native oak trees to stimulate mating and egg laying (Credit: Marco Molfini, UC Riverside).

Fig. 4. A female *Scaralina* sp. laying an egg mass on the netting of a cage that was used to enclose native lanternflies on *Quercus arizonica*, a native oak species that lanternflies use for feeding and breeding. These lanternfly egg masses were harvested and deployed as "sentinels" to survey for native species of egg parasitoids. (Credit: Marco Molfini, UC Riverside).

Fig. 5. An example of a sentinel egg mass of a *Scaralina* sp. attached to a native oak tree and exposed for possible attack by native parasitoids in that same habitat that native lanternflies were captured at blacklights at the Southwestern Research Station. (Credit: Marco Molfini, UC Riverside).

Fig. 6. Female of a native undescribed *Anastatus* sp. that was reared from a native “sentinel” lanternfly egg mass that was deployed at the Southwestern Research Station (Credit: Serguei Triapitsyn, UC Riverside)

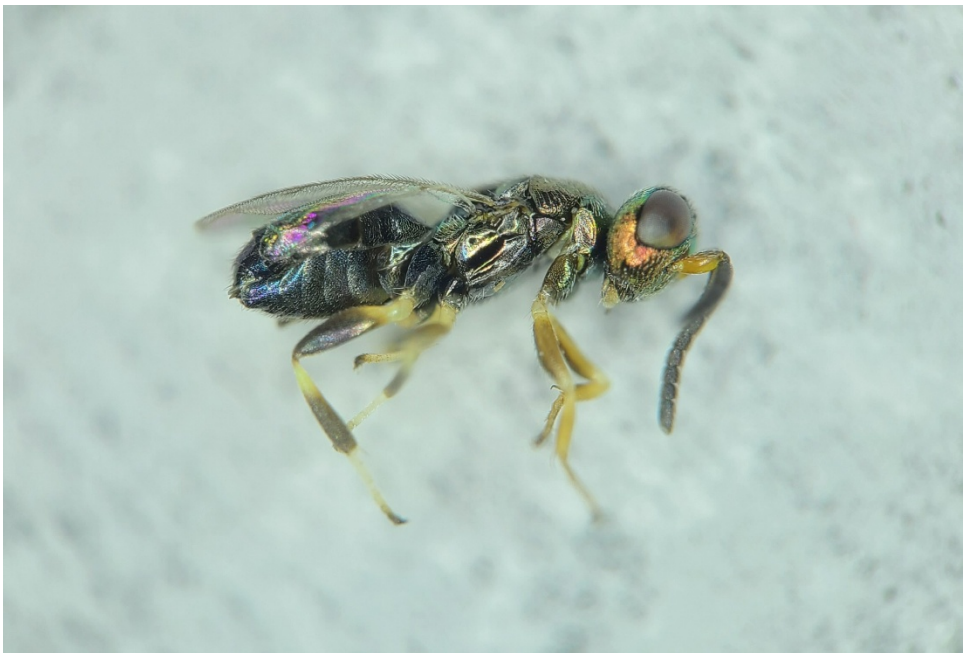

Fig. 7. A female of *Anastatus reduvii*. This species of egg parasitoid has potential for use against SLF in biological control programs in California. The California Department of Food and Agriculture is maintaining colonies of this parasitoid. (Credit: Marco Molfini, UC Riverside).