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DEVELOPMENT OF BIOLOGICAL CONTROL METHODS AGAINST THE INVASIVE SPOTTED LANTERNFLY

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ABSTRACT

Eradication and containment of the spotted lanternfly (SLF), *Lycorma delicatula* (White), has been considerably challenging, and this devastating exotic pest has now spread to five states. Because eradication is unlikely, scientists are pursuing management strategies such as biological control. USDA scientists have been collaborating with researchers at the Chinese Academy of Forestry since 2015 to search for natural enemies of SLF throughout China. Exploratory surveys were conducted in 27 provinces in China, where scientists collected SLF egg masses and nymphs. SLF was found to be widely distributed throughout China, being recovered in 21 of the 27 provinces surveyed. To date, we have recovered one egg parasitoid, *Anastatus orientalis* Yang & Choi (Hymenoptera: Eupelmidae) and one nymphal parasitoid, *Dryinus sinicus* Olmi (Hymenoptera: Dryinidae).

Anastatus orientalis was discovered parasitizing SLF eggs in northern China in 2011 (as part of exploration for natural enemies of SLF in Korea). This parasitoid was reported to parasitized 20% of egg masses and 40% of the eggs within these masses during one of its purported two generations per year. It has established in Korea, although information on its effectiveness there is lacking. Parasitized egg masses were shipped from China to the USDA-APHIS quarantine laboratory in Massachusetts, and we have been conducting biological studies to better understand how to rear and utilize this potential biocontrol agent. Research has concentrated on parasitoid life-history (life-cycle, sex ratio, longevity and fecundity), behavior (superparasitism, competition, attractants), and optimizing rearing (oviposition, development, storage, and how to initiate and break diapause).

Researchers in China have reported that *A. orientalis* has two periods of emergence from SLF egg masses (May and September). It was hypothesized that female wasps oviposit into fresh SLF egg masses in the fall, adults emerge in the spring, and emerging adults parasitize as yet un-emerged SLF eggs. Field data from China suggested this might not be the case. Our collaborators collected egg masses in April and the emerging adults were allowed to oviposit on those masses. A month later, when the eggs were dissected, many eggs contained developing parasitoid larvae, as anticipated. However, a sample collected in the field in late July revealed very few parasitoid larvae; they had all emerged prior to collection. There are no SLF eggs available for oviposition in July in China, so it is likely they were using at least one host other than SLF for reproduction. We designed a study to elucidate the particulars of the *A. orientalis* life-cycle. One hundred egg masses were collected in Beijing in early March and shipped to the APHIS quarantine facility in Massachusetts. Fifty egg masses were placed in a growth chamber that mimicked the temperature and day length of Beijing, China, and the remaining egg masses were reared under conditions that mimicked Pottstown, Pennsylvania. Emerging wasps were collected daily and provided new egg masses to parasitize. Under Beijing conditions, *A. orientalis* adults started emerging in early July, which would explain our field observations. This population went on to have a third generation in the fall, when SLF

egg masses would be available in the field. Pennsylvania temperatures are generally cooler than those in Beijing, and emergence of adults in both May and July was slightly later than that observed in China. However, there was no fall generation of *A. orientalis* under Pennsylvania conditions. While SLF is moving south to where conditions would more closely resemble those found in Beijing, the extra summer generation is still problematic. We compared the climate throughout China to those in Pennsylvania and have identified locations where parasitoid populations might be better synchronized with SLF. In one of those locations, Yantai (Shandong Province), some egg parasitoids did not emerge in the spring like *A. orientalis* and might be a species with a one-year life-cycle. We plan to collect egg masses from Yantai and investigate a possible new species.

If *A. orientalis* has a summer generation, which our evidence suggests it does, then it will need to attack at least one host other than SLF. We conducted host specificity testing, prioritizing large, univoltine planthoppers that are closely related to SLF and overwinter as eggs. To date we have seen reproduction in seven of the 18 species tested (39%). This includes one Fulgoridae (*Poblicia fulginosa*), four Pentatomidae (*Euschistis servus, Chinavia hilaris, Podisus maculiventris,* and *Halyomorpha halys*) one Coreidae (*Anasa armigera*), and one Saturniidae (*Antheraea* sp.). We also observed oviposition on another Pentatomid (*Thanta custator*) and a Bombycidae (*Bombyx mori*), although as of this writing it is too early to know if progeny will be produced. All of the species produced males, but female adults emerged from only three of the non-target hosts. These females were smaller than females emerging from SLF, however, they were able to produce progeny when provided SLF eggs. Future research on SLF egg parasitoids will include 1) collection of egg masses in Yantai to determine if there is another species/biotype, 2) confirm a July generation of *A. orientalis* in China, 3) collect non-target species related to SLF in China to determine if they are attacked by *A. orientalis*, 4) conduct choice tests for species that *A. orientalis* attacked in no choice tests, and 5) conduct life-table studies in South Korea to determine if *A. orientalis* is contributing to the decline of SLF populations in that country.

We have conducted less research on the nymphal parasitoid *Dryinus sinicus* because we collected it later (2018), it is univoltine, and rearing its host, second instar SLF nymphs, is challenging. Female wasps have raptorial forelegs that they use for gasping SLF nymphs, which they temporarily parasitize during oviposition. Parasitoid larvae develop on the outside of the SLF nymph in a protective sac called a thalacium. A conservative estimate of parasitism levels is 20-40%. We currently have this species in colony, where it is overwintering as pupae in cocoons, and this spring we will be concentrating on developing effective methods to rear this species.

In conclusion, we have discovered and are studying two potential biocontrol agents and hope to discover more in China. There is still much research to be done, however, before a biocontrol program against the SLF can be implemented.