CHAPTER 13

Reduction of Euonymus Scale, a Pest of Landscape Shrubs

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NON-TECHNICAL SUMMARY

Euonymus scale (*Unaspis euonymi*) (Hemiptera: Diaspididae) is a problem to the nursery industry because it makes growing euonymus shrubs for sale more costly and requires the use of pesticides for the scale's control. It is a problem for homeowners, small businesses, and apartment owners, who often use euonymus shrubs to landscape their properties because the scale makes the plants grow poorly and increases the number of plants that die prematurely. The lady beetle *Chilocorus kuwanae* (Coleoptera: Coccinellidae) reduced the number of heavily infested shrubs by about half (down from 20.9% pre-project to 11.6%) within 12 years (1989/1990 to 2002). The parasitoid *Coccobius* nr. *fulvus* (Hymenoptera: Aphelinidae) also caused 21% mortality of adult female scales by 2006/2007. The combined impacts of this parasitoid with predation from the lady beetle have not been evaluated but are likely to have further reduced scale density since the last evaluation in 2002.

Most euonymus species used in landscaping are from Asia, so this project was not intended to protect native biodiversity. However, a U.S.-native euonymous species (*Euonymus aericansus*) is damaged by the scale and benefits from this biocontrol project. There is no impact of the project on the winged euonymous (*Euoymus alatus*), an invasive plant in eastern U.S. forests because it is not attacked by the scale in the first place. Conversely, two Asian euonymus species on which the scale feeds (*Euonymus fortunei* and *E. japonica*) are sometimes invasive (Parker and Acevedo-Rodriguez, 2017). These two invasive species benefited from the esablishment of *C. kuwanae* and *C.* nr. *fluvus*.

HISTORY OF INVASION AND NATURE OF PROBLEM

Scales (various families of insects, including armored scales, soft scales, and others) are among the most highly invasive of insect groups because they are highly fecund, tightly adhered to plants, inconspicuous, occur in groups on their host plants, and some species are all females. Because of this final characteristic, a single insect can start a new population. Human movement of plants among the world's continents has led

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to many scales being spread to new countries. When only a few scales are transported, it is very easy for the specialized parasitoids that keep most scales in check to be left behind. Population explosions of the scales follow, which can be highly damaging because imported scales are usually not suppressed by local generalist natural enemies. In the United States, at least 19 species of invasive scales in six families have been targeted for biological control by introducing missing natural enemies. Most of these pests (11 species) are armored scales, many of which attack citrus (Clausen, 1978). One of these eleven armored scales is the euonymus scale, *Unaspis euonymi* (Hemiptera: Diaspididae), a pest of landscape woody plants.

Euonymus scale (**Fig. 1a,b**) was first described in 1881 as *Chionaspis euonymi* from scales collected in Norfolk, Virginia, on *Euonymus latifolia* (Scalenet, 2020). This scale is now found in many parts of the United States and around the world, except in Australia. The native range of this scale is believed to be Japan and China. It was accidentally imported into the United States in the 19th century, likely on imported woody nursery plants (Johnson and Lyon, 1991). While it is most widely known as a pest of the evergreen species of *Euonymus*, such as *E. japonica*, it also feeds on species of many other shrubs used to landscape homes and businesses, including plants in the genera *Camelia, Buxus, Celastrus, Daphne, Eugenia, Hedera, Hibiscus, Ilex, Jasminum, Ligustrum, Lonicera, Olea, Paxistima, Pachysandra, Solanum*, and *Prunus* (Johnson and Lyon, 1991). Heavy infestations can defoliate and kill host plants. As an aside, it is worth noting that winged euonymus (*Euonymus alatus*), which invades forests in the northeastern United States (Ecological Landscaping Alliance, 2020), is not a host of euonymus scale. A polyphagous scale parasitoid, *Encarsia citrina* (Hymenoptera: Aphelinidae), commonly parasitized this scale before the initiation of this biocontrol project. While this parasitoid was both widespread and abundant (e.g., Matadha et al., 2003), it did not suppress euonymus scale density (R. Van Driesche, pers. obs.).

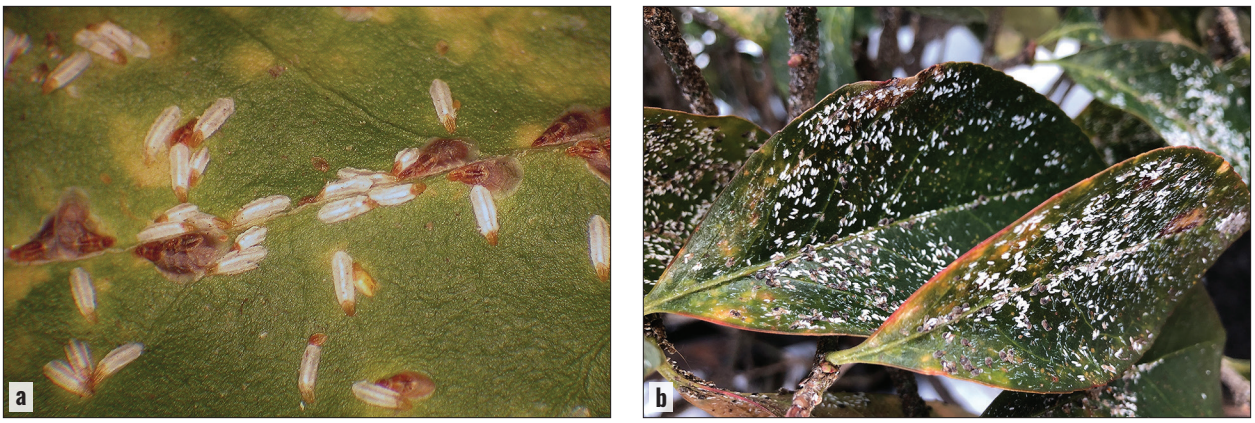

Figure 1. Euonymus scale (*Unaspis euonymi*) on leaf (a) close-up of white males and larger brown females; (b) white males, brown females, and yellow leaf chlorosis. (a: Lisa Ames, University of Georgia, Bugwood.org CC BY US 3.0; b: Susan J. Hewitt, iNaturalist.org CC BY-NC 4.0)

From 1991 to 1994, the impact of euonymus scale on survival of *Euonymus fortunei* plants in commercial and residential landscapes in southern New England (Massachusetts, Connecticut, Rhode Island) was assessed by multi-year field assessments of year-to-year survival of tagged plants. Plants that were heavily infested with euonymus scale suffered 12.1% mortality within the following year, a 4-fold increase compared to non-infested or less infested plants. Of 3,549 landscape euonymus plants in Massachusetts examined from 1989 to 1992, 20.9% had heavy scale infestations. Using this information, the annual economic loss from euonymus scale in Massachusetts (at $22.50 per replacement plant, value from the time of this study) was estimated as $355,568, or for southern New England as a whole, $711,135, in dollars of that period (Van Driesche et al., 1998a).

WHY CONTROL THIS INVASIVE SPECIES?

The goal of this biological control project was to lower scale density on landscape euonymus plants, as only heavy infestations (**Fig. 2**) defoliate and kill plants (Van Driesche et al., 1998a).

Figure 2. Euonymus shrub with dead patch killed by heavy euonymus scale (*Unaspis euonymi*) infestation. (© Chrisky, stack.exchange.com)

THE ECOLOGY OF THE PROBLEM

The ecology of this system is simple: an exotic plant was imported for commercial use as a landscape plant; later, one of the pests in its native range (euonymus scale) was accidentally imported as well. The pest spread throughout the United States, both naturally through wind dispersal of young scales and by shipping of infested nursery stock. The desired goal was to suppress the pest enough to continue the commercial use of euonymus plants, which are the scale's preferred hosts.

PROJECT HISTORY THROUGH AGENT ESTABLISHMENT

Efforts to suppress euonymus scale with natural enemies from Asia occurred three times: once in the 1980s in the Mid-Atlantic states, again in the 1990s in New England, and again from 1987 to 2000 in New Jersey. The first effort was based on importation from Korea by Robert Hendrickson of the USDA of two predatory beetles found feeding there on euonymus scale. The larger beetle was the lady *Chilocorus kuwanae*[1] (Coleoptera: Coccinellidae; **Fig. 3a**). The second imported species was a much smaller beetle in the family Cybocephalidae called *Cybocephalus* nr. *nipponicus* (**Fig. 3b**). The lady beetle is a relatively large predator that seeks out high-density patches of scale, where the adult feeds on scales and lays its eggs. Lady larvae then

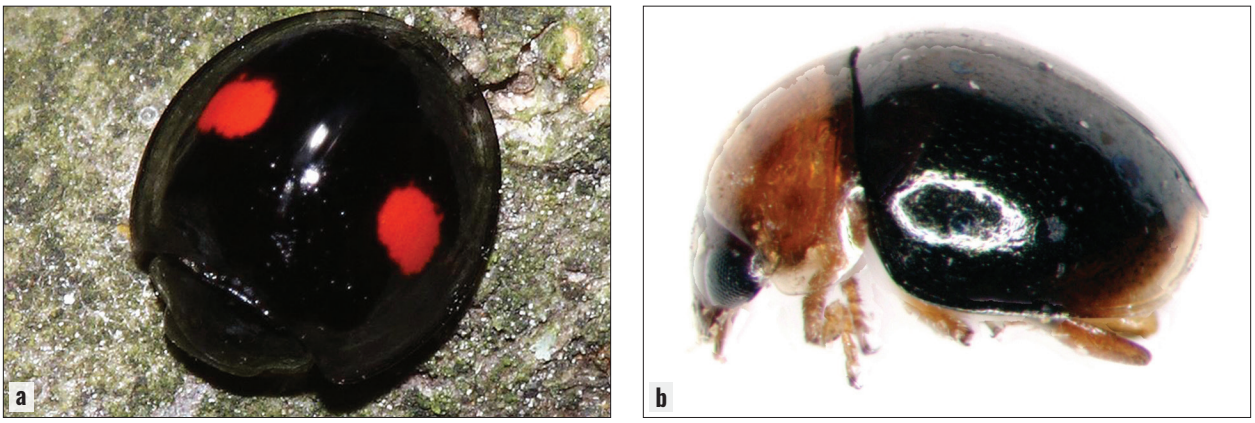

Figure 3. (a) The introduced Asian lady beetle *Chilocorus kuwanae*; (b) *Cybocephalus* nr. *nipponicus*. (a: Tom Murray, Bugwood.org, CC BY US 3.0; b: Pennsylvania Department of Conservation and Natural Resources, Bugwood.org, CC BY US 3.0)

[1] A recent morphological paper suggests this species is the same as *C. renipustulatus*, which is found in western Europe (Bieńkowski and Orlova-Bienkowskaja, 2020). However, this finding was based solely on morphological measurements, without DNA analysis. Consequently, it is unclear if this suggested synonymy should be accepted.

also feed on scales, eating many throughout their development. In contrast, the smaller *C.* nr. *nipponicus* lays its eggs on individual scales. The larvae of *C.* nr. *nipponicus* then consume scales sequentially, requiring an average of 20 scales to grow to adults (Alvarez and Van Driesche, 1998).

Chilocorus kuwanae and *C.* nr. *nipponicus* were both collected in Korea and released in the United States, starting in 1984. Both species successfully established in several states, including Massachusetts and Mid-Atlantic states (Drea and Carlson, 1987, 1988), and *C. kuwanae* was later widely redistributed in the eastern United States (Hendrickson et al., 1991). However, no detailed assessments were reported for the impact of these releases on euonymus scale populations in the region.

A second round of importations of euonymus scale natural enemies was made in New England from 1991 to 1994, during which the same two predatory beetles plus three parasitoid species were imported from China by USDA-APHIS and Mike Rose of Texas A & M University. These species were released in New England through Roy Van Driesche of the University of Massachusetts/Amherst (Van Driesche et al., 1998b). Both predators, *C. kuwanae* and *C.* nr. *nipponicus*, established in Massachusetts—especially *C. kuwanae*, which was recovered throughout the state. In addition, two parasitoids of euonymus scale, *Encarsia* sp. nr. *diaspidicola* and *Coccobius* nr. *fulvus*[1] (both Hymenoptera: Aphelinidae) were released and initially recovered at some sites. A third parasitoid, *Aphytis yanonensis*[2] (Hymenoptera: Aphelinidae) was also released but did not appear to have become established (Van Driesche et al., 1998b).

A third effort was conducted by the New Jersey State Department of Agriculture in cooperation with APHIS. From 1987 to 2001, they mass produced and released the five agents previously collected from China (the two predators, plus the three parasitoids *E.* nr. *diaspidicola*, *A. yanonensis* [at the time known as *A. proclivia*], and *Coccobius* [at the time, *Physcus*] nr. *fulvus*) throughout New Jersey. Both *C. kuwanae* and *C.* nr. *nipponicus* became widely established, but the parasitoids were not recovered (Matadha et al., 2003).

HOW WELL DID IT WORK

The only follow-up studies on the effects of natural enemy releases against euonymus scale that went beyond simple confirmation of establishment were done in New England (Van Driesche et al., 1998c; Van Driesche and Nunn, 2003; O'Reilly and Van Driesche, 2009). Before the Massachusetts biocontrol program, surveys in planted residential and commercial landscapes in southern New England from 1989 to 1992 found that 20.9% of *E. fortunei* shrubs examined had heavy euonymus scale infestations (Van Driesche et al., 1998a). The impact of the predator *C. kuwanae* was first evaluated in research plots (1991–1995) at 14 sites where releases of this species were made, with these plots being compared to 13 similar control sites where releases had not been made (Van Driesche et al., 1998c). The predator suppressed scale numbers at nine of the 14 release sites. At three sites, *C. kuwanae* did not become abundant, and at two sites, the owners removed the shrubs during the test. Of the 13 control sites, three developed large populations of *C. kuwanae* due to natural spread of the predator during the experiment. Of the 10 control sites where *C. kuwanae* remained absent or rare, scale numbers on average did not change (going up at four locations, down at four sites, and staying the same at two).

In the second experiment in our study, we released beetles at a large apartment complex landscaped with 110 euonymus shrubs on a 32-ha (79-acre) site (Van Driesche et al., 1998c). Within four months, *C. kuwanae* spread to 64% of the euonymus plants on the property, and within one year, the proportion of plants with heavy scale infestations dropped from 46% to only 13%.

The third evaluation of *C. kuwanae* in Massachusetts was based on two statewide surveys, one done in 1994 and the other in 2002. In 1994, we found no significant change had yet occurred in the proportion

[1] *Coccobius* nr. *fulvus* may be the same as *Coccobius fulvus*. This is consistent with a recent revision of Chinese *Coccobius* (Wang et al., 2014). However, direct genetic comparisons have not been made.

[2] Some literature refers to this species as *Aphytis proclia*; for species description see DeBach and Rosen, 1982.

of euonymus that had heavy scale infestations (Van Driesche et al., 1998c). However, in 2002, we found that the percentage of shrubs with heavy scale infestations had dropped from 20.9% in the pre-project survey in 1989/1990 (Van Driesche et al., 1998a), to 11.6% in 2002 (Van Driesche and Nunn, 2003), a drop of 44%. In 2002, *C. kuwanae* was present on 43.1% of all plants in our survey that had heavy scale infestations.

A fourth evaluation, done in 2006/2007, focused on estimating the rate of parasitism from the parasitoid species released from 1991 to 1994, at the beginning of the project. Of the three species introduced, *C.* nr. *fulvus* was well established in 2006/2007 and was common in urban areas of the Connecticut River Valley of Massachusetts (Van Driesche and O'Reilly, 2009). *Coccobius* nr. *fulvus* was found at 87% of all locations sampled and parasitized an average of 21% of the adult female scales (the stage examined). *Encarsia* nr. *diaspidicola*, which was presumed established from 1991 to 1994, was not detected in 2006/2007. No further assessments of this pest and its control have been made since 2007.

BENEFITS OF BIOLOGICAL CONTROL OF EUONYMUS SCALE

The benefits of this project consisted of reduced costs to homeowners and businesses to replace euonymus shrubs killed by scale. Because these plants are not native, there were no obvious ecological benefits. In southern New England, various species of euonymus (especially *E. fortunei*) are commonly used for landscaping. In the late 1990s, the number of evergreen euonymus shrubs in the landscape was estimated at 821,846. (Van Driesche et al., 1998a). At that time, 20.9% (171,766) of these plants were heavily infested with euonymus scale and were likely to suffer about 12% mortality annually due to the scale. This would result in the deaths of about 15,803 euonymus plants per year. The cost to consumers to replace these 15,803 dead plants was estimated (at $22.50 per replacement plant) as $355,568 in Massachusetts alone (Van Driesche et al., 1998a). By 2002, the percentage of heavily infested plants had declined to 11.6% (Van Driesche and Nunn, 2003), reducing the number of plants dying per year by nearly 6,000 (down from 15,803 per year) producing a savings in that year alone of $127,756. Further declines in the rate of heavily infested shrubs may have occurred since, leading to further savings, but no surveys have been run since 2002.

REMAINING WORK

No assessment of this system has been made since 2002, a current gap of 19 years. It would be useful to update knowledge of this project by remeasuring the percentage of euonymus shrubs with heavy scale infestations. Also, in 2007, surveys showed that one of the introduced parasitoids, *C.* nr. *fulvus*, had increased and spread. The status and the degree of impact of this parasitoid need to be remeasured throughout the region.

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