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STATUS OF EUONYMUS SCALE IN MASSACHUSETTS FOURTEEN YEARS AFTER RELEASE OF *CHILOCORUS KUWANAE* (COLEOPTERA: COCCINELLIDAE)

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Chilocorus kuwanae (Silvestri) (Coleoptera: Coccinellidae) was imported to the United States from Korea in the 1980s and established in the Washington, D.C. area for control of euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae) (Drea & Carlson 1987). Limited releases of this population were made in Massachusetts in 1988 and 1989. In 1990, additional adults of *C. kuwanae* were collected near Bejing, China, and used to make a larger set of releases in New England from 1991 to 1994 (Van Driesche et al. 1998a). Widespread establishment occurred (Van Driesche et al. 1998a) and studies indicated that this beetle's presence was correlated with reductions in euonymus scale populations at the level of local study sites that received releases of the beetle (Van Driesche et al. 1998b). The proportion of shrubs heavily infested by euonymus scale at one 50-ha apartment complex with over 100 euonymus plants scattered over the property declined from 46% to 14% between 1991 (year of release) and 1995 (last year of study) (Van Driesche et al. 1998b).

County by county surveys in Massachusetts of euonymus plants in the public landscape (plantings around commercial buildings, institutions, parks or apartment complexes) were conducted from 1989 to 1994. Each year, nine to eleven counties were surveyed over the entire state (except Boston and the islands of Nantucket and Martha's Vineyard), with 475 to 1107 plants per year examined and classified as none, light, medium, or heavy scale infestation (see Van Driesche et al. [1998c] for definitions of categories). The presence of *Chilocorus* sp. beetles on plants was also recorded. Nearly all (>99%) of these were *C. kuwanae*, but a few were the native species *Chilocorus stigma* (Say). For the six year study period, the percentage of shrubs in the heavily infested category averaged 17.9% (n = 5662), ranging from 9.4 to 24.6% (Van Driesche et al. 1998c). For just the two years (1989-1990) of the project before the new biological control agent became widespread at the landscape level, 19.2% of plants had heavy scale infestations.

In 2002, we again conducted a survey of euonymus scale on landscape shrubs in Massachusetts using the same protocols as in Van Driesche et al. (1998c) to measure the percentage of euonymus plants with heavy euonymus scale infestations. Our intention was to compare this value to the average from the 1989-1994 period to see if infestation levels had changed. Between late August and mid October (the same time period as in the earlier surveys), 1119 euonymus plants were randomly located in the public landscape (in eleven counties, approx. 100 plants per county, with approx. three communities examined per county).

In 2002, the percentage of plants in scale infestation categories were as follows: no scale—38.5% (431/1119 plants), light infestation—38.8% (434/1119), medium infestation—11.1% (124/1119), and heavy infestation—11.6% (130/1119). Only plants in the heavy infestation category are at increased risk of dying over a 1 yr period (Van Driesche et al. 1998c) and so it is change in number of shrubs in this category that is of greatest importance. The percentage of plants with heavy scale infestations in 2002 (11.6%), while within the range of values seen in the 1989-1994 surveys, was significantly lower than the average value (17.9%) for that period (χ^2 = 26.03, df = 1, P < 0.005). This is a 35% decrease in the proportion of landscape plants in the heavily infested group (compared to the 1989-1994 average) and a 39.6% drop from the two survey years (1989-1990 before the widespread release of *C. kuwanae* in the area).

When data were grouped into coastal (Barnstable, Plymouth, Bristol, Essex) versus inland counties (Worcester, Franklin, Hampden, Berkshire, Hampshire, Norfolk, and Middlesex), coastal counties had a significantly lower percentage of heavily infested plants (8.5%, 35/410) than did inland counties (13.4%, 95/709) (χ^2 = 6.08, df = 1, P < 0.025). Also, coastal plants with heavy scale infestations were significantly more likely to have *C. kuwanae* beetles on the plants when surveyed (57%, 20/35) compared to inland counties (38%, 36/94) (χ^2 = 3.95, df = 1, P < 0.05). Coastal counties have milder winter temperatures and this may favor survival of this predacious beetle and the associated scale reduction. Indeed, the greatest difference among counties in the survey was between the most coastal county (Barnstable, which is Cape Cod, with 4.1% [4/98] plants with heavy scale infestations and 50% [2/4] of such plants with *C. kuwanae* present) versus the most inland, hilly county (Berkshire, with 19.8% [20/101] plants with heavy scale infestations and 0% [0/20] of these plants with *C. kuwanae* present).

The decline in proportions of euonymus plants heavily infested with scale in the earlier evaluation compared to the survey in 2002 was correlated with increases in the frequency with which the predatory beetle *C. kuwanae* was found on euonymus plants in 2002 compared to previously

published values for 1992-1994 (for MA + RI + CT, Van Driesche et al. 1998a). The percentage of plants on which *C. kuwanae* beetles were found increased in all categories with scale: light infestation from 6% (84/1401) to 15% (65/434), medium infestation from 12.5% (93/745) to 37.9% (47/124), and heavy infestation from 26% (259/995) to 43.1% (65/130), but not for uninfested plants (from 1% [17/1702] to 0.2% [1/431]). Increases in rates of detection of *C. kuwanae* were significant for plants in all three categories of scale infestation: light (χ^2 = 36.6, df = 1, P < 0.005), medium (χ^2 = 50.8, df = 1, P < 0.005), and heavy (χ^2 = 17.5, df = 1, P < 0.005), but not for uninfested plants (χ^2 = 2.52, df = 1, P < 0.25).

Van Driesche et al. (1998c) speculated that if the percentage of landscape plants with heavy scale infestation should decline eventually by the same degree (69%) as seen in the project's study plots (Van Driesche et al. 1998b), then the annual savings to southern New England (MA, RI, CT) from the introduction of *C. kuwanae* would be $436,154. Data from our 2002 survey suggest that substantial, though smaller, savings may have been the actual result. Taking values for the estimated number of euonymus plants in MA (821,000) and increased annual mortality rate of heavily infested shrubs compared to uninfested shrubs (12.1 vs. 3.0%) from Van Driesche et al. (1998c) and the observed decrease in the percentage of MA plants in the heavy scale infestation category (from 19.2% for 1989-1990, the pre-introduction period to 11.6% in 2002), we calculated that within this population of plants, mortality has decreased from 14,345 to 8667 plants in MA annually. If we assume that owners were to replace dead plants with the same species and that replacements for these plants were still valued at $22.50 (the figure in Van Driesche et al. 1998c), this would result in savings of $127,756, which when doubled (as per Van Driesche et al. 1998c) to represent all of southern New England, gives a value of $255,512 (compared to the figure in Van Driesche et al. 1998c of $436,154). To have realized the full projected benefits, the percentage of plants in the landscape that were heavily infested with scale would have had to have fallen to 6.0%, a value lower than that actually observed (11.6%) in 2002. However, because the proportion of plants in coastal areas with heavy scale infestations did fall further (to 8.5% in MA coastal counties), our analysis may underestimate benefits for southern New England because MA values are applied to CT and RI, which because they are predominantly coastal, may have lower heavy scale infestation rates, more similar to those of just the coastal counties of MA. But data are not available for such an analysis.

We conclude that this project is now returning 2.1 fold in benefits annually (based on values in Van Driesche et al. 1998c and a 35% decline in heavily infested plants) given the amount of money originally invested in the project. These benefits are accumulating with each subsequent year, with no further cost. These savings suggest that this was a successful biological control project.

Summary

The percentage of euonymus plants in the landscape in Massachusetts with heavy euonymus scale infestations has dropped from 19.2% in 1989-1990 to 11.6% in 2002, a 35% decline. For euonymus plants with scale, the proportion of plants on which *C. kuwanae* was present increased between the two survey periods, with this predator being detected at 43.1% of all plants with heavy scale infestation. The percentage of plants infested with euonymus scale was lower in coastal vs. inland counties. Numbers of plants in Massachusetts dying due to scale infestations have been reduced by nearly 6000 per year, with cost savings of at least $127,756.

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