WINTER MORTALITY IN *ADELGES TSUGAE* POPULATIONS IN 2003 AND 2004

Kathleen S. Shields[1] and Carole A. S-J. Cheah[2]

[1]USDA Forest Service, Northeastern Center for Forest Health Research
51 Mill Pond Road, Hamden, CT 06514

[2]Connecticut Agricultural Experiment Station, Valley Laboratory
153 Cook Hill Road, Windsor, CT 06095

ABSTRACT

We assessed the mortality of hemlock woolly adelgid populations in the northeastern U.S. after the winters of 2002-2003 and 2003-2004. In 2003, adelgid winter mortality averaged 86.0% at 29 sites in New York and New England, 73.8% at six Pennsylvania sites, and 11.2% at a North Carolina site. In 2004, adelgid winter mortality averaged 93.6% at 17 New York and New England sites, 78.4% at seven Pennsylvania sites, and 21.1% at the North Carolina site. Mortality was positively correlated with degrees of latitude and the minimum temperature recorded at each site.

KEY WORDS

Hemlock woolly adelgid, mortality.

INTRODUCTION

The hemlock woolly adelgid (HWA), *Adelges tsugae* Annand, a destructive invasive species native to Asia, is a serious pest of hemlock trees in the eastern U.S. It was first found in eastern North America in Virginia in the 1950s and since that time has spread to locations from southern Maine to Georgia. The range of eastern hemlock extends well into Canada, but cold winter temperatures could be a factor in limiting the northward spread of this pest. We assessed the mortality of HWA populations after the winter of 2002-2003 and 2003-2004, the coldest winters recorded in the Northeast in the past decade (National Weather Service data).

METHODS

Between the beginning of March and the end of April 2003, we sampled HWA populations at 36 sites in New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, and North Carolina. During a similar period in 2004 we sampled populations at 35 sites in ME, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, and North Carolina. At each site, one or two branch tips (30-40 cm long) were cut from 10 eastern hemlock, *Tsuga canadensis* (L.) Carrière, that had new growth, no history of fertilization or insecticide treatment, and light to moderate HWA infestations. Samples were examined within two to five days of collection. The length of new growth and the number of living and dead HWA sistens that were 2nd, 3rd, or 4th stage nymphs or adults were counted. First instar nymphs also were counted but not included in the assessment of winter mortality. Mortality assessments were made by carefully probing each woolly mass and adelgid found on the new growth of branch tips. Where possible, at least 100 HWA sistens, nymphal stage 2 or older, were examined from each of the 10 trees at each site, totaling at least 1,000 HWA per site. In addition, in 2004, a determination was made of the life stage of each living and dead adelgid on the branch tips collected from one of the 10 trees at each site. Latitude, longitude, and elevation were recorded at each site. Highest and lowest daily temperatures for the period November 2002 through March 2003 were obtained from the National Climate Data Center for the weather station closest to each site. Available data were analyzed using the Spearman rank correlation test and multiple regression. Values of $P < 0.05$ were considered significant.

RESULTS AND DISCUSSION

In the northeastern U.S., HWA sistens aestivate during the summer months as first instars and many do not survive the summer. In October, surviving nymphs begin feeding and resume development through four instars, generally maturing by February or March. Because samples were collected and evaluated in March and April, living HWA were adults, or in some cases 3rd or 4th stage nymphs. Dead adelgids ranged from 1st stage nymphs to adults. Percent mortality of adelgids that broke aestivation was highest in the 2nd and 3rd nymphal stages (32 and 54%, respectively); comparatively few adelgids died as 4th instars (12%) or adults (2%).

In 2003, mortality of HWA sistens that had successfully molted into 2nd stage nymphs averaged 86.0% at 29 sites in New York and New England, 73.8% at six Pennsylvania sites, and 11.2% at a North Carolina site; highest mortality observed was 99.4% at a New Hampshire site. In 2004, HWA winter mortality averaged 93.6% at 17 New York and New England sites, 78.4% at seven Pennsylvania sites, and 21.1% at the North Carolina site; highest mortality observed was 100% at a New York site. Analysis of data from the winter of 2002-2003 indicates that mortality was positively correlated with degrees of latitude ($r = 0.422$, $P = 0.010$), even when the outlying North Carolina site was excluded ($r = .371$, $P = 0.028$), and negatively correlated with mean daily low temperature ($r = -0.626$, $P = 0.03$). There were no significant correlations between percent mortality and plant hardiness zone, longitude, or elevation, but there was a slight negative correlation between percent mortality and the minimum temperature recorded at each site ($r = 0.333$, $P = 0.047$). This may indicate that high mortality is more the result of long-term low temperatures over the course of the winter than of a cold period of short duration.

Compared with sites examined in 2003, the 35 sites sampled in 2004 extended over a greater part of the adelgid's current range and as a result, there was a stronger positive correlation between adelgid mortality and degrees of latitude ($r = 0.590$, $P = 0.0002$). Mortality was negatively correlated with degrees of longitude ($r = 0.624$, $P = <0.0001$) and elevation ($r = 0.395$, $P = 0.0190$). (Verified weather data for 2004 are not yet available.) Based on multiple regression analysis, only latitude accounted for a significant amount of the variance in percent mortality (P = 0.0321). This may be because the more western sites tended to be farther south and at higher elevations.

Although HWA populations are established in the eastern U.S. as far north as the Catskills in New York and southeastern New Hampshire and ME, existing populations are restricted to plant hardiness zone 5A (min. low of -26.5° to -28.8°C), or warmer. Based on the high winter mortality experienced by northern HWA populations in 2003 and 2004, we speculate that cold winter temperatures will limit the rate and extent of its northward spread.

ACKNOWLEDGMENT

We gratefully acknowledge the technical assistance of D. Mikus, R. Hirth, J. Fagan, and K. McManus of the USDA Forest Service, R. Hiskes and R. Cowles of the Connecticut Agricultural Experiment Station, and the many state and federal cooperators who provided us with samples.