

Michigan, Wisconsin, Maine, and Minnesota have experienced extensive mortality of tamarack (eastern larch) (*Larix laricina*). The Minnesota Department of Natural Resources reported tamarack mortality on 54,000 acres of Minnesota forests between 2001 and 2006 (Minnesota Department of Natural Resources 2006). Although the exact cause of tree mortality has been difficult to determine, eastern larch beetle (*Dendroctonus simplex*) may be playing a key role (Minnesota Department of Natural Resources, Division of Forestry; U.S. Department of Agriculture Forest Service 2006). Although eastern larch beetles often attack stressed tamarack, recent attacks in Minnesota have occurred on healthy trees. Similar observations were made in New York and Vermont during the 1970s (Drooz 1985).

Recent warm winters in Minnesota may have allowed a greater fraction of the eastern larch beetle population to survive the winter, which could put greater pressure on tamarack during subsequent spring and summer months. The insect overwinters as adults, pupae (rarely), or late instars. Eastern larch beetle is a freeze-intolerant species (A. Walter, unpublished data)<sup>2</sup>; individuals will die if they freeze. To survive winters, eastern larch beetles lower the temperature at which they freeze. The supercooling point is the lowest temperature

an insect's body will reach before it freezes. A fraction of the population may also die from chill injury prior to freezing. The objectives of this study were to measure seasonal changes in the supercooling point and lower lethal temperature of eastern larch beetle and to relate these measures to historical winter temperature records in Minnesota.

### Methods

Naturally infested tamarack was cut in July and September 2007 from a field site near Swan Lake, MN. Bolts from the September collection were stored outside at St. Paul, MN. At monthly intervals, bark was peeled from at least one randomly selected bolt. All available eastern larch beetle life stages were collected, and sex of adults was determined. The supercooling point and lower lethal temperature were measured following established protocols (Carrillo and others 2004, 2005). Temperature treatments for the lower lethal temperature assay were 0, -5, -10, -15, -20, and -25 °C for insects collected in July and 0, -15, -30, -40, -50, and -55 °C for insects collected in December and April. Results were compared with the supercooling point of the insects at the time the studies were conducted. Because of the difficulty in determining whether diapausing larvae were alive or dead, lower lethal temperatures were

# Chapter 16. Connecting Overwintering Success of Eastern Larch Beetle to Health of Tamarack

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<sup>2</sup> Walter, A. 2008. Observations on larch beetle freeze intolerance. Unpublished data. Data on file with: R.C. Venette, Northern Research Station, 1992 Folwell Av., St. Paul, MN 55108.

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measured for adults. In this report, we only present results for July 2007 (summer baseline), December 2007 (lowest mean supercooling point), and April 2008 (spring reference). Pairwise nonparametric statistics (Kruskal-Wallis) were used to compare supercooling points among months and life stages, i.e., month x life stage was coded as the treatment. A Bonferroni adjustment was applied to account for the number of comparisons and to maintain an overall alpha of 0.05. Kruskal-Wallis tests were used to compare potential differences in supercooling points among males and females within each month, respectively. Nonparametric tests were used due to heterogeneity of variance and nonnormality of data in some seasons.

### Results and Discussion

The overwintering population of eastern larch beetle was comprised entirely of adults and larvae. The mean supercooling points of adults and larvae changed seasonally (fig. 16.1). In July, supercooling points for larvae and adults did not differ and were approximately  $-16\text{ }^{\circ}\text{C}$  ( $-3.2\text{ }^{\circ}\text{F}$ ). In December, larvae typically supercooled at a lower temperature [ $-49\text{ }^{\circ}\text{C}$  ( $-56\text{ }^{\circ}\text{F}$ )] than adults [ $-42\text{ }^{\circ}\text{C}$  ( $-43\text{ }^{\circ}\text{F}$ )]. In April, supercooling points for larvae were no different from the summer baseline, but adults supercooled about  $3\text{ }^{\circ}\text{C}$  colder. These results

should be interpreted with some caution. The design of the experiment did not allow us to separate the effects of season from the potential effects of a single log on supercooling point, and greater variation may exist among individuals than we observed due to host effects. Sex of the beetle did not affect the supercooling point on any observation date.

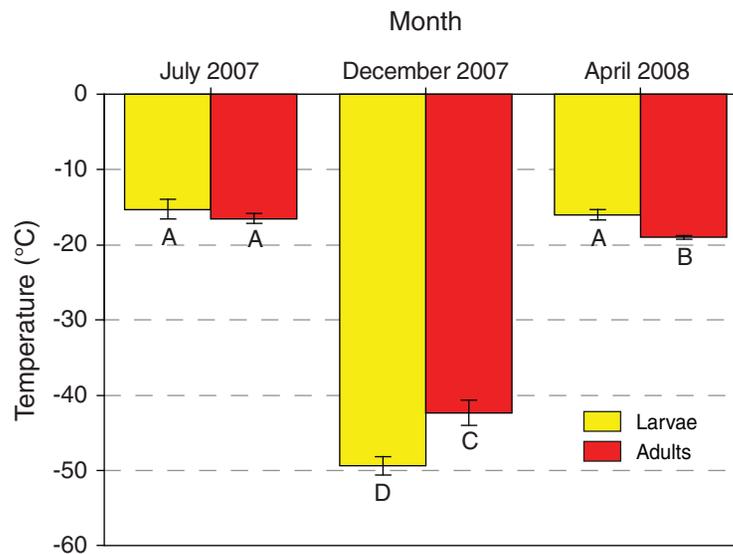


Figure 16.1—Seasonal changes in the mean supercooling point ( $\pm$ SEM) of larval and adult *Dendroctonus simplex*. Mean separation tests are based on pairwise Kruskal-Wallis tests with a Bonferroni adjustment (overall  $\alpha = 0.05$ )

Lower lethal temperatures were determined in December on cold-acclimated adults and in April on adults that had survived the winter but were less cold acclimated than in December. At both time periods, mortality was not significantly different from the control (0 °C treatment) until temperatures were very near to the adult supercooling point (data not shown). These results suggest that adults do not experience much mortality from chill injury.

Over the past 40 years, winters have become less severe in Minnesota (fig. 16.2). Low winter

temperatures in Isle, MN, for example, have increased approximately 0.25 °C per year from 1964–2004. Larvae are extremely cold tolerant and were consistently predicted to have a high degree of winter survivorship (fig. 16.2). Survivorship of adults, however, seems more sensitive to winter temperatures. On average, adult survivorship has increased 0.7 percent per year from 1964–2004. Greater overwintering success by *D. simplex* places greater pressure on tamarack, which may lead to tree mortality.

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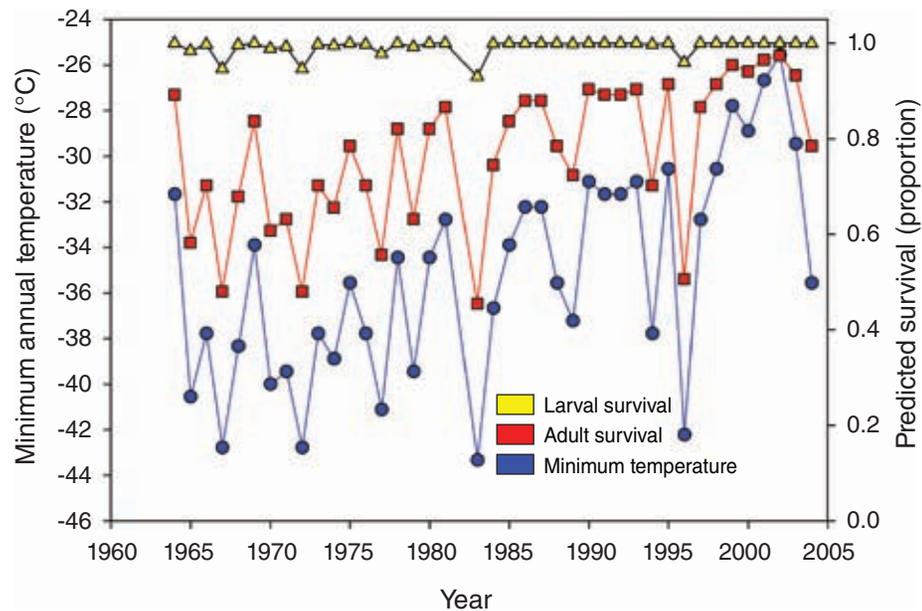


Figure 16.2—A comparison of annual lowest temperature recorded and predicted larval and adult survivorship of *Dendroctonus simplex* in Isle, MN.