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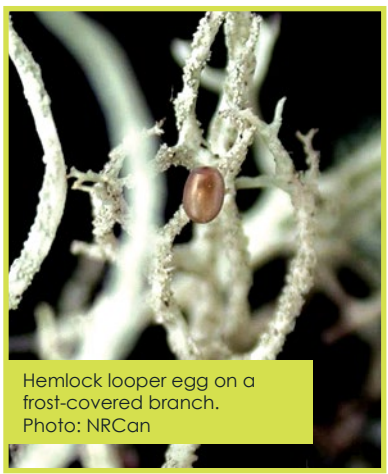
Branching Out
from the Canadian Forest Service - Laurentian Forestry Centre

Is Intense Cold a Threat to the Survival of Hemlock Looper Eggs?

Climate change is expected to increase the frequency and intensity of extreme weather events, such as cold spells. Consequently, insects will have to adapt in order to withstand sudden changes in temperature. These insects include the hemlock looper, a major pest attacking balsam fir trees in eastern Canada. Canadian Forest Service and Université Laval researchers have been studying cold tolerance in hemlock looper eggs and the impact of intense cold on insect population dynamics.

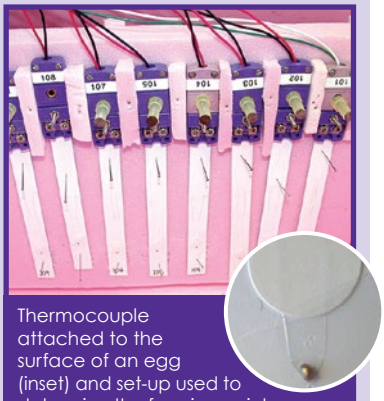
One problem, two solutions

Insects have developed two mechanisms to withstand harsh winter conditions. Certain so-called "freeze-tolerant" insects can tolerate the controlled formation of ice crystals outside their cells. Other, so-called "freeze-intolerant", insects lower their freezing point by synthesizing antifreeze compounds, such as glycerol. Body fluids thus remain liquid below 0°C. This latter mechanism is used by most insects living in areas with a northern temperate climate, such as Canada.



Hemlock looper egg on a frost-covered branch.
Photo: NRCan

Some freeze-intolerant species die as soon as the air temperature drops to their freezing point, while others die at temperatures above their freezing point.



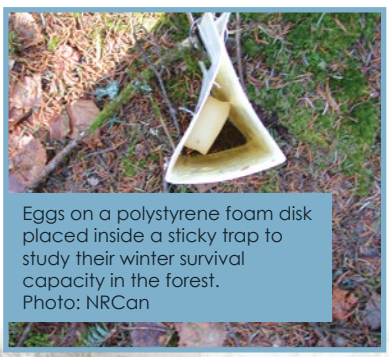
Thermocouple attached to the surface of an egg (inset) and set-up used to determine the freezing point of several eggs simultaneously.
Photo: NRCan

Freezing point: a point of no return

To determine the freezing point of eggs, researchers attached a thermocouple to the exterior surface of hemlock looper eggs, then gradually lowered the temperature inside the freezer. They discovered that the eggs froze at an average temperature of -40°C, which corresponds to their freezing point.

Getting through the winter

To study the winter survival capacity of the hemlock looper, eggs were set out at four sites in the fall of 2008: Quebec City, QC; Petit Lac à l'Épaule in the Laurentian Wildlife Reserve, QC; Armagh, QC; and Corner Brook, NL. In Quebec City and Corner Brook, the researchers estimated the winter survival capacity of the overall population to be 60%, while at Petit Lac à l'Épaule and in Armagh, none of the eggs set out in the forest survived the winter.



Eggs on a polystyrene foam disk placed inside a sticky trap to study their winter survival capacity in the forest.
Photo: NRCan

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The winter temperatures in 2009 may explain these findings. In Corner Brook, the temperature did not fall below -20°C, while in Quebec City, the coldest temperature was -31°C for a period of 30 min. By comparison, the lowest temperature recorded in Armagh and at Petit Lac à l'Épaule was -40°C for a period of at least 1 h, which was enough to kill all of the eggs. To determine whether or not all of the eggs died at that time, it is necessary to study the insects' cold tolerance.

Temperature recorders programmed to record the temperature every 15 min are able to detect sudden temperature changes.
Photo: NRCan

Cold tolerance

To fully understand cold tolerance, it is not enough to be able to determine the minimum lethal temperature. It is also necessary to know the exposure time needed to kill the insect at a given temperature.

Cold tolerance tests have shown that 50% of eggs die after 4 h of exposure at -35°C, whereas 100% died after 2 h of exposure at -37°C. This demonstrates the high degree of vulnerability of hemlock looper eggs to intense cold spells lasting only a few hours per day.

Eggs placed in bottles that are then placed in a freezer to study their cold tolerance.
Photos: NRCan

Cold tolerance should therefore be measured in hours rather days of exposure to extremely cold temperatures.

Therefore, based on these findings, determination of the freezing point does not seem to be as reliable and realistic a method as cold tolerance tests in estimating the survival probability of hemlock looper eggs. In fact, the eggs may be killed by cold or even frost well before the air temperature falls to -40°C.

Protective effect of snow

If eggs are laid in places with less exposure than branches—for example, where snow cover provides protection against the cold, such as the base of tree trunks or the surface of the ground—the larval density in the following spring may be higher than anticipated.

This protection against the winter cold undoubtedly contributed to the gradual establishment followed by a steep rise in the hemlock looper population throughout the area around Petit Lac à l'Épaule in the fall of 2012. Additional contributing factors were the mild winters and hot summers from 2010 to 2012.

All of these experiments provide researchers with a better understanding of the importance of cold temperatures in the dynamics of hemlock looper populations in eastern Canada. Moreover, all of this information helps forest managers to make more informed decisions as to whether or not it is necessary to take action in the following spring against the larval populations of this major pest.

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