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Branching Out

2019

from the Canadian Forest Service - Laurentian Forestry Centre

Are mild and cold spells a stress factor for the spruce budworm?

According to the Intergovernmental Panel on Climate Change, extreme weather events are expected to increase in intensity, duration, and frequency with global warming. Intense cold spells as low as -40 to -45°C have swept through Quebec over the past decade. However, more recent winters have generally been milder, especially in 2018, when a long period of thaw was followed by freezing cold in mid-March. These leaps in temperature were an opportunity for Canadian Forest Service researchers to assess the impact of such phenomena on the winter survival of young spruce budworm larvae.

What protects larvae from freezing?

From September to February, the second instar larvae (L2 – see box) of the spruce budworm (SBW) temporarily stop their development (obligatory diapause) inside a silk sheath called a hibernaculum. The larvae spin the cocoon on the bark or floral scars of trees and spend the winter protected inside. Since the SBW cannot tolerate freezing temperatures, it survives the winter by synthesizing glycerol, an antifreeze substance that lowers its supercooling point to temperatures well below 0°C. The supercooling point is the temperature at which a fluid freezes spontaneously. The SBW's supercooling point goes from -35°C in November to -43°C in February, and then goes back up in March. The SBW is well equipped to withstand the rigours of winter.

What kills the larvae, cold or freezing?

Some insects that do not tolerate freezing temperatures die as soon as the air temperature reaches their supercooling point while others die at higher temperatures. In the latter case, the probability of the insect dying of cold will depend on how long it is exposed to these temperatures. Laboratory tests of cold tolerance performed on L2s in January and February 2018 when the mean supercooling point is -42°C showed that more than 60% of the larvae were still living after 10 to 12 hours at temperatures ranging from -39 to -37°C. However, nearly half of the L2s died after 9 hours at -40°C or after 0.8 hour at -41°C, while at -42°C, less than 1 hour was sufficient to kill more than 50%. These results indicate that the SBW can die from cold even before freezing.

Three-sprigged branches of balsam fir with scars from male flowers accommodate the larva as it spins its hibernaculum before entering diapause during its second larval stage.

Photo: NRCan

Biological Cycle

Stage \ Month	J	F	M	A	M	J	J	A	S	O	N	D
Egg								1				
Larva	2				3	4	5	6	1		2	
Pupa												
Adult												

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Hibernaculum, intentionally perforated to expose the larva inside during diapause.

Photo: NRCan

Galvanized wire crates, containing two branches. Four of these crates were assembled to form a tube, which, when installed on the tree, 2 m above ground, was used to test the winter survival of the SBW larvae.

Photo: NRCan

What about its survival in the wild?

Tests assessing winter survival were conducted in 2017 in various regions of Quebec, including Lac-Saint-Jean, the Laurentides Wildlife Reserve, and near Quebec city. The tests showed that more than 75% of the larvae survived when air temperatures were no lower than -36°C. These results are supported by those observed in the laboratory. However, during a second test in 2018, the L2 survival rate —in particular that observed in the Laurentides Wildlife Reserve— was less than 60% compared to more than 75% in the other regions studied. This decline in survival was of interest given that January and February 2018 temperatures were very similar to those of 2017, with one exception.

A puzzle in need of solving

Unlike 2017, the end of winter 2018 was marked by a significant rise in minimum temperatures. These rose from -25 to -10°C on February 26 and remained steady until March 15 for a total of 17 consecutive days of mild temperatures. Subsequently, temperatures dropped to -26°C, especially in the Laurentides Wildlife Reserve, which may explain the high L2 mortality rates in the region.

Is this resistance absolute?

The SBW's diapause ends before the latter part of February. We then witness a gradual rise in supercooling points along with a decrease in glycerol concentrations. This results in a natural loss of cold resistance for this species. However, following the prolonged mild spell in March 2018, researchers believe that this loss of resistance increased to such an extent that the larvae were no longer able to effectively withstand the cold wave that hit the Laurentides Wildlife Reserve, causing higher mortality in the region.

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