Forecast models for springtime hatching of three Christmas tree pests

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Highlights

These simple forecast models are adapted for Québec and are meant to help growers and field consultants screen for springtime hatching of the balsam twig aphid *Mindarus abietinus*, the spruce spider mite *Oligonychus ununguis*, and the pine needle scale *Chionaspis pinifoliae* (Figure 1). In order to predict the mean eclosion date for all three pests, growing degree-days (GDD) accumulated in the field were calculated from the beginning of March using an alternative method, which is available as a spreadsheet. The model should predict mean egg eclosion within around five days of the actual date (Doherty *et al*. 2018), which could allow growers and field consultants to concentrate their screening efforts in the early season.

Results and recommendations

Overwintering eggs were sampled from commercial balsam fir plantations in southern Québec (Estrie and Chaudière-Appalaches). For modelling purposes, the development rates of all three pests were measured at several temperatures in the laboratory. In order to validate model predictions, egg hatching was monitored in the plantations for three consecutive years. Local temperatures were measured in parallel using weather recording devices.

This information was used to follow the accumulation of GDD starting from the 1st of March, according to a variant of the average method:

$$\text{Daily accumulation of Growing Degree-Days} = [(T_{min} + T_{max}) / 2] - T_{threshold}$$

T_{min} and T_{max} represent the observed minimum and maximum daily temperatures, respectively. The development threshold is represented by $T_{threshold}$, which is the lowest temperature at which development in the egg is possible. This method, considered more effective for springtime temperatures, follows the subsequent rules:

- If the minimum daily temperature (T_{min}) falls below the development threshold ($T_{threshold}$), it is replaced by $T_{threshold}$ in the formula.

- If the maximum daily temperature (T_{max}) falls below the development threshold ($T_{threshold}$), it is replaced by $T_{threshold}$ in the formula.

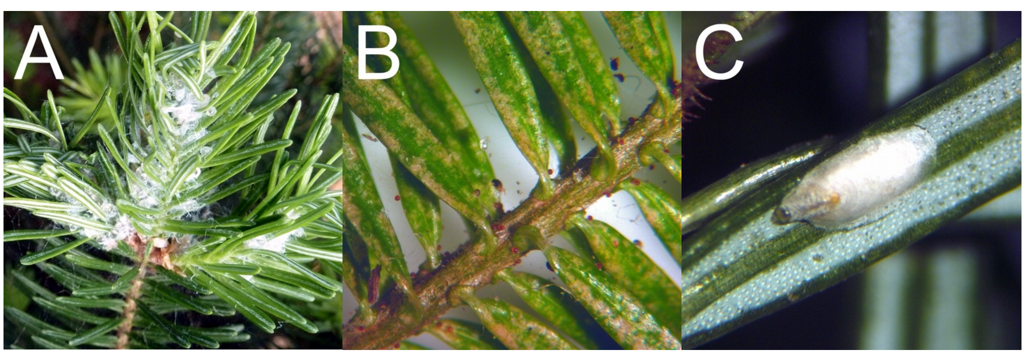

Figure 1 A. Balsam twig aphid colony; B. Bronzing caused by spruce spider mites; C. Waxy scale from the pine needle scale.

Pest	Development threshold	Thermal constant
Balsam twig aphid	5.4 °C	105.9 GDD
Spruce spider mite	7.1 °C	161.2 GDD
Pine needle scale	9.3 °C	277.8 GDD

Table 1 Forecast models for springtime hatching of Christmas tree pest overwintering eggs.

In the spreadsheet file attached to this leaflet (see Figure 2), the minimum (T_{min}) and maximum (T_{max}) daily temperatures as of March 1st should be logged and recorded into the appropriate columns for an automatic calculation of accumulated GDD for all three pests. This has to be repeated every day until the thermal constant is met, which is the amount of total accumulated GDD required for egg eclosion of the target species (Table 1).

In order to maximise the precision of the models, it is best to monitor temperatures directly in the plantation that is being screened for pests. This could be done by using a temperature logger installed in the middle of a tree, close to the trunk, in order to avoid direct sunlight. If this is not possible, it is recommended to use daily temperature data from the closest weather station.

	A	B	C	D	E
1	**Month**	**Day**	T_{min}	T_{max}	**Total accumulated GDD**
2	**March**	1	-11,5	7,8	2,4
3		2	-17,9	-7,1	2,4
4		3	-21,3	-14,5	2,4
5		4	-20,9	-6,3	2,4
6		5	-10,5	5,5	2,5
7		6	-5,0	5,7	2,8
8		7	0,9	7,9	5,3
9		8	-11,8	6,0	5,9

Figure 2 Example of the spreadsheet used to calculate the accumulation of growing degree-days to predict the egg eclosion of a pest. The minimum and maximum daily temperatures must be entered in columns C and D respectively. The accumulation of growing degree-days can be followed in column E until the appropriate thermal constant is reached, depending on the pest, which indicates the mean date of egg hatching.

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