

European Corn Borer

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European corn borer (ECB, *Ostrinia nubilalis*) is a pest that invades over 200 species of plants. It was first discovered in Boston, Massachusetts, in 1917 and has now spread to all corn-producing areas of North America (Capinera, 2017), including Nova Scotia, since 1929. In Canada, there are two types of corn borer commonly found: univoltine and bivoltine ecotypes. Univoltine ECB produce one generation per year, while bivoltine ECB produce two generations per year (Dekalb, n.d.). This pest has a large range of hosts and, other than corn, can be found on potatoes, tomatoes, peppers, hops, snap beans and dry beans, ornamental flowers, buckwheat, oats, millet, soybeans and many weed species (Capinera, 2017) (Bohenblust & Tooker, 2010)

Univoltine species are usually the most common ecotypes in Northern Regions, but there can be shifts in the populations depending on the length of the season. In summers with lower growing degree day accumulations, the second generation of bivoltine ecotypes may not mature fully. There are two types of pheromones used to trap these pests: an E pheromone (New York strain) and a Z pheromone (Iowa strain). Both univoltine and bivoltine ECB can be attracted to one or the other pheromones (Knodel & Calles-Torrez, 2019). Monitoring via pheromone traps by Perennia in association with the Atlantic Grains Council indicates that both E and Z strain populations are present in the Maritimes and there appear to be bivoltine as well as univoltine populations present in Nova Scotia. As a result of breeding between the Z and E types, a hybrid is also present in Nova Scotia and New Brunswick corn fields. It is recommended to have multiple pheromone lures in a single field to obtain a more accurate indication of the local ECB population. If multiple lures are being used within a field, they need to be spaced at least 30m (100ft) apart to prevent pheromone interference (OMAFRA, 2020).

IDENTIFICATION & LIFE CYCLE

Eggs: ECB borer eggs are typically oval in shape, flattened, iridescent and overlap, similar to the appearance of fish scales. They can be found on the underside of leaves in clusters of 15-20. They typically darken in colour as they age. Eggs require a temperature of around 15°C to promote development and hatch in four to nine days (Capinera, 2017). Egg mortality is typically quite low (15%) and is generally caused by predators and parasites (Capinera, 2017).



Figure 1. European corn borer egg mass.
Photo credit: UNL Department of Entomology.

Larva: Larvae tend to be light brown or white and slightly pink or grey on their backs. They have a brown or black head with round dark spots on each body segment. Sawdust-like frass (ECB droppings) can typically be found at the entry hole, which is another good identifying factor.



Figure 2. European corn borer larva. Photo credit: Caitlin Congdon, Perennia.

Larva Habit by Crop:

Corn: Young larvae are typically found feeding on the whorl initially, as well as the tassel. Once the tassel emerges from the whorl, they then migrate down to the stalk and ear, where they burrow inside. The damage can cause leaves to drop off at the point where the borer entered. They continue chewing their way down the inside of the stalk, all while excreting frass, a sawdust-like material. These bore tunnels cut off nutrient transport and weaken the strength of the stalk; this can cause breakage later on in the season. Entry points are an ideal location for fungi and pathogens to enter the plant (Krupke, Bledsoe, & Obermeyer, 2010).



Figure 3. Entry point into the stalk. Photo credit: Caitlin Congdon, Perennia.



Figure 4. Characteristic shot-hole feeding in a corn leaf. Photo credit: Caitlin Congdon, Perennia.



Figure 5. Tassel lodging caused by larvae boring into the stalk. Photo credit: Caitlin Congdon, Perennia.

Pepper, Eggplant, and Tomatoes: Larvae can enter the stem and cause wilting or death. They are also attracted to the fruit, starting when it is roughly walnut-sized (3 cm in diameter) all the way through to harvest. They enter the fruit either through the side or at the top of the fruit under the stem cap. Varieties with a tighter stem cap tend to have less damage. Typically, a secondary pathogen will colonize the hole, resulting in fruit rot. It is usually the second generation of ECB that affects peppers and eggplant from mid-July through September (OMAFRA, 2009.) Hot peppers tend to be more resistant to damage than sweet peppers. Note: ECB larvae and damage can be confused with Pepper maggot (which, as of 2023, have not been recorded in Nova Scotia).

Potatoes: ECB is a sporadic pest in potatoes, more often found in cool seasons when corn planting is delayed. Egg masses are laid on the undersides of the leaves, and when the larvae hatch, they'll feed on the leaves for a few days before migrating into the vascular tissue of the plant. This destroys the pith and vascular tissue, causing damaged stems to wilt and then die. Damage can occur as early as mid-June for bivoltine types of ECB (OMAFRA, 2009).

Beans (snap and dry): ECB predation on beans can happen in a cool summer if field corn development is delayed or late in the summer if field corn dries down early. ECB larvae will feed on leaves, bean pods and stems. Grading out infested pods can be challenging, as only a small hole will be visible.

Hops: ECB is usually first noticed in hops as the cause of bine wilting or death. ECB larvae disrupt the flow of nutrients and water. When one bine on a string dies, it is always best to trace from the point of death, down the stem, to the cause. Holes with sawdust-like frass around it where the bine goes from being alive to dead are a good indication of ECB tunnelling. Damage is usually found after the bines have grown over the wire of the trellis system. Note: ECB damage can be confused with mechanical damage to the bine (i.e. mower death or wind damage).

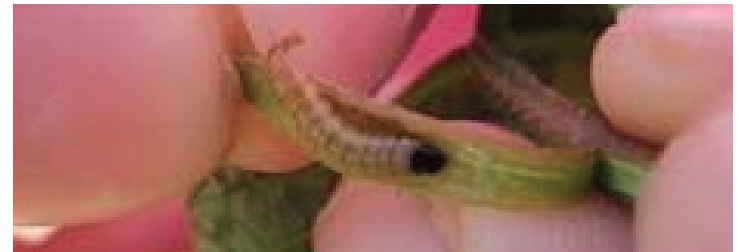


Figure 6. European corn borer burrowing into the petiole of leaf on a hop plant. Photo credit: Rosalie Gillis-Madden, Perennia.



Figure 7. European corn borer entry point into a hop bine. Note sawdust-like frass around entry hole. Photo credit: Rosalie Gillis-Madden, Perennia.

Larvae can experience a high rate of mortality in the first few days while they are outside the plant; once they burrow in, they are protected from predation and many pesticides. It usually takes approximately 50 days to move through the entire development cycle of all six instars, but it is very dependent on temperature and weather conditions (Capinera, 2017).

Pupa: Larvae generally form pupae in May or June and are yellow-brown in colour. They average 13-17mm in length and 2-4mm wide, depending on gender. This developmental stage is also temperature dependent; when it is 13°C, it will last for 12 days and will be shorter if it is warmer (Capinera, 2017).



Figure 8. European corn borer pupa in a corn stalk. Photo credit: Caitlin Congdon, Perennia.

Adult: Corn borer moths are small in size, they have a wingspan ranging from 20-34mm, depending on the gender of the moth. Female moths are usually light brown or pale yellow in colour; their forewing and hind wings are crossed by zigzag lines, having pale yellow patches. Males are darker in colour and pale brown or grey-brown. They also exhibit zigzag lines and yellow patches. Moths are nocturnal, and they are most active for the first couple hours after sunset. Adult moths can lay eggs for up to 14 days. Females lay 20-50 eggs per day, laying several hundred eggs during their lifetime. Adults typically survive for 18-24 days in total (Capinera, 2017). Adult moths have been documented to migrate 120km before laying eggs on favourable host crops.



Figure 9. European corn borer moths. Photo credit: Caitlin Congdon, Perennia.

MANAGEMENT

Scouting is essential for determining pest populations. Insect development is more closely related to temperature than calendar dates; there is a minimum temperature that must be reached before development will begin. Therefore, knowing when to begin scouting is determined by growing degree day (GDD) accumulation (Table 1). Scouting begins by closely examining a minimum of 10 plants (check the whorls in corn) in 10 different locations in the field. Keep track of the locations that have been examined in the field, and make sure to record findings for further monitoring and population records. Check for egg masses on the underside of leaves and examine the stalks and stems for pin holes and sawdust-like frass (Dekalb, n.d.). Each growth stage of the insect needs a certain increase in GDD to advance in stages.

MONITORING OF CORN BORER MOTHS

Peak flights occur at defined times for both univoltine and bivoltine ecotypes and can be monitored and predicted using GDD calculations (Table 1), facilitating the use of control methods during critical insect development stages. A project is underway (as of 2023) at the University of Guelph to validate the GDD model for Eastern Canada. During the adult stage, the moth population can be monitored using the Heliopsis or Hartstack traps that are baited with pheromone lures. It is recommended to set up the traps in the grassy areas surrounding the fields, as this is where adults shelter in between flights. Traps should be placed in an area that is not protected from the wind, as wind is key to distributing the pheromone scent (Werling & Schuh, 2017). Traps will capture the male adult moths and can be used to estimate the population size present in the field (Hagerman, 1998). It is important to use the correct lure based on ecotype. Multiple lure strains can be used in the same field but in separate traps (they cannot be combined), spaced at least 30m (100ft) apart.



Figure 10. Heliopsis (L) and Hartstack (R) pheromone traps near a corn field. Photo credit: Eric Burkness, bugwood.org.

Strain	Generation	Event	Predicted GDD
Univoltine	1 st Generation	First Catch	300
		Peak Flight	650-700
Bivoltine	1 st Generation	First Catch	150
		Peak Flight	300-350
	2 nd Generation	First Catch	700
		Peak Flight	1050

Growing Degree Days (GDD) = [(maximum temperature + minimum temperature)/2-10°C and were accumulated from April 1st until September 30th

Table 1. European corn borer flight prediction by growing degree days.

CONTROL TECHNOLOGY

Corn:

Bacillus thuringiensis (Bt) is a naturally occurring soil bacterium which produces insecticidal proteins that target certain pests including ECB. Bt is the active ingredient in several biological insecticides and has been incorporated into genetically modified corn, enabling the plant to produce insecticidal proteins, which are, in turn, ingested by susceptible larvae. Once ingested, the protein quickly coats the gut wall, causing the insect to stop feeding. Within hours, the gut wall has broken down completely, and the existing gut bacteria take over the body cavity, killing the insect. Lepidopteran larvae differ in their response to the various Bt-proteins (Bessin, 2019).

Bt-corn hybrids have been the main method of control for European corn borer and other insect pests since commercialization in the mid-1990s. There are multiple Bt-proteins which target specific pests, so it is important to know which Bt-proteins are effective against each target pest. Although the proteins in Bt-corn do an excellent job at controlling the target larvae, it is safe for other orders of insect species such as beetles, wasps, bees and flies. Not all parts of the plant have the same concentration of Bt-protein.

Bt-corn technology has worked consistently well for managing ECB up until 2018. In 2018, near Truro, Nova Scotia, unexpected damage was found in a field of Bt-corn containing the Cry1F protein. Dr. Jocelyn Smith from the University of Guelph collected sample larval populations from four fields in the Truro area to be tested for Cry1F resistance. All four of the sample populations displayed high levels of resistance to the Bt-Cry1F protein (>80% at 200ng/cm²) in laboratory diet bioassays (Smith, 2019). A larval population collected from the Annapolis Valley also displayed high levels of resistance to Cry1F. Since 2019, Cry1F-resistant ECB populations have been identified at single sites in Quebec, Manitoba, and Sussex, New Brunswick.

In 2022, a population of ECB larvae was collected from a Bt-corn field with unexpected damage in the same area near Truro, NS, where the original Cry1F resistant populations were found. Subsequent laboratory diet bioassays confirmed suspected resistance to a second Bt-protein, Cry1Ab (CCPC, 2023).

Bt-corn must be planted with a refuge (non-Bt) area for resistance management. If refuge is not incorporated into the bag of corn seed (RIB or refuge-in-bag), it is recommended to plant a minimum of 20% refuge plants adjacent to the Bt-corn. This creates an area for susceptible corn borers that have yet to be exposed to the Bt toxin. The individuals from the refuge area will mate with resistant individuals emerging from the Bt-corn. Bt-susceptibility is then passed on to their offspring (Cullen & Wedberg, 2005). When selecting field and sweet corn varieties, it is important to understand which insect pests are controlled by each Bt protein and the refuge requirements. Refer to [this](#) handy table, produced annually by the Canadian Corn Pest Coalition, to see the pest-protein relationship.

Non-corn host crops:

Using pheromone traps and monitoring GDD accumulation to predict flights are considered best management practices

in non-corn host crops such as peppers, tomatoes, potatoes, beans, hops, etc. Timely sprays are a key intervention with this pest, and most pesticides (both organic and conventional) are contact-only, meaning that once a larva has burrowed into the plant, the spray application will no longer be effective. Perennia updates its crop pest management guides annually, which list the products that are registered for use on that crop pest. Please check out the [Perennia crop pages](#) for the latest guides.

NATURAL ENEMIES

There are many native species, parasites, and predators that may provide some level of control on ECB populations. Native predators that affect the eggs and young larvae include the insidious flower bug (*Orius insidiosus*), green lacewings (*Chrysoperla spp.*) and several ladybird beetles (Capinera, 2017). Insect predators have been known to decrease populations by 10-20%. Avian species of Downy woodpecker, hairy woodpecker and the yellow-shafted flicker have been known to control between 20-30% of the overwintering larvae (Capinera, 2017).



Figure 11. Green lacewing eggs. Photo credit: Rosalie Gillis-Madden, Perennia.

Trichogramma (*Trichogramma ostriniae*) are tiny parasitic wasps which parasitize egg masses of several moth and butterfly species, including ECB. Commercially available Trichogramma has been used successfully for ECB control in commercial sweet corn production in Quebec, with the potential to reduce the number of insecticide applications required by 81% in fresh market sweet corn and by 100% in processing sweet corn (Charbonneau, 2018). Release of Trichogramma into the crop has traditionally been manual, requiring "trichocards" containing sterilized *Ephestia sp.* eggs parasitized by *T. ostriniae*, which emerge in two groups at 24-48 hours and 5-6 days after deployment. This approach requires multiple "releases" with timing determined using the growing degree day model for ECB development. While found to be both equally effective and economically viable in comparison to insecticide applications in processing sweet corn (Gagnon, 2016), this approach may not be economically feasible for use in field corn. However, UAS (drone) deployment of Trichogramma could be effective for increasing parasitism

on ECB egg masses (Martel, 2021) and could be a more economical application method than manual deployment.

DAMAGE PREVENTION

Cultural practices are key for lowering your risk of having issues with ECB. The residue left in the field post-harvest is a key host site for overwintering larvae. Flail mowing stalks close to the ground has been found to reduce the overwintering population by up to 76%, while mouldboard plowing the residue achieved a 22-33% reduction (Schaafsma, 1996). Minimum tillage practices that leave a significant amount of plant residue on the soil surface present a higher risk for further infestation (Capinera, 2017). The timing of corn planting has been tested for its effectiveness in reducing infestation risk. It has been found that very early planting of corn creates taller, more attractive stalks at the typical time of infestation. Later planting could be a good strategy for areas that experience a single generation per year (Capinera, 2017). It is recommended to keep the grass surrounding fields mowed as adult moths have been found to linger in the grass around fields before emerging to lay eggs on the host crop in the evening.

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