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EUROPEAN CORN BORER

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European corn borer (ECB *Ostrinia nubilalis* Hübner) 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**). 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**)

Recent investigations by Perennia show that both univoltine and bivoltine ecotypes are present in Nova Scotia, meaning that we can have multiple generations per year here. Univoltine species are usually the most common ecotype in Northern Regions, but there can be shifts in the populations depending on the length of 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 (sometimes called the New York strain) and a Z pheromone (sometimes called the Iowa strain). Both univoltine and bivoltine ECB can be attracted to one or the other pheromones (**Knodel & Calles-Torrez, 2019**). Recent investigations by Perennia have also shown that as a result of breeding between the Z and E types, a hybrid is also present in Nova Scotia corn fields. If you don't know which strain is present in your fields, it is best to have both pheromone lures in the field for an accurate ECB population indication. If you are using both lures, they need to be spaced at least 200 m (650 ft) apart. Typically, it is the Z strain or Iowa strain, which is more common in non-corn host crops. It can be challenging for growers to distinguish between the different ecotypes, and therefore when measures need to be implemented for control (**Knodel & Calles-Torrez, 2019**).

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 will develop around 15°C 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.
http://extensionpublications.unl.edu/assets/html/g1783/build/g1783.htm

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 Larvae. Photo credit: University of Missouri Integrated Pest Management. **https://ipm.missouri.edu/pestMonitoring/ecb/identification.cfm**

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 fungus and pathogens to enter the plant (**Krupke, Bledsoe, & Obermeyer, 2010**).

Figure 3. Stalk entry hole and frass. Photo credit: B. Christine Purdue University. **https://extension.entm.purdue.edu/fieldcropsipm/insects/euro-cornborer.php**

Figure 4. Borer damage inside corn ear. Photo credit: Eric Bohnenblust. **https://phys.org/news/2013-12-corn-pest-decline-farmers-money.html**

Figure 5. Corn lodging due to stalk boring. Photo credit: North Carolina State University, Dept. of Plant Pathology. **https://wiki.bugwood.org/NPIPM:Ostrinia_nubilalis_(corn)**

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 in 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 2019, we do not have 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 the field corn 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 the point of death down to the cause. If you see a hole with sawdust-like frass around it where the bine goes from being alive to dead, you know ECB is the culprit. Damage is usually found after the bines are over the wire. 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 a hop leaf. Photo credit: Rosalie Gillis-Madden.

Figure 7: European Corn Borer entry point into a hop bine. Note sawdust-like frass around entry hole. Photo credit: Rosalie Gillis-Madden.

Larvae will 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 though 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 Pupae. Photo credit: J. Obermeyer. **https://extension.entm.purdue.edu/fieldcropsipm/insects/euro-cornborer.php**

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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 the zigzag lines and yellow patches. Moths nocturnal, 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 her lifetime. Adults typically survive for 18-24 days in total (**Capinera, 2017**). Adult moths have been documented to migrate 120km before laying eggs on favorable host crops.

Figure 9: Adult corn borer. **https://extension.entm.purdue.edu/radicalbugs/default.php?page=pests/european_corn_borer**

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 ectoypes and can be monitored and predicted with GDD calculations (**Table 1**). Control methods are employed during crucial growth stages. During the adult stage, the moth population can be monitored using the Heliothis 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 the adults go in between flights. Be sure to place your trap 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 gauge the population size present in the field (**Hagerman, 1998**). It is important to use the correct lure based on ecotype. If you are unsure, use both the E and Z strain, in separate traps (they cannot be combined), spaced at least 200 m or 650 ft apart.

Figure 10: A Heliothis (L) and Hartstack (R) pheromone trap near a corn field. Photo credit: Eric Burkness (bugwood.org) **https://www.canr.msu.edu/resources/video_tutorials_on_using_pheromone_traps_to_monitor_corn_ear_worm_in_sweet**

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

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Control Technology

Corn

Most farmers are using Bt corn as a control method for European corn borer and other insect pests. Bt corn is a strain that has been genetically modified to produce Bt proteins. Genes are taken from *Bacillus thuringiensis*, a naturally occurring soil bacterium and inserted into the corn DNA. These Bt genes produce a protein that kills Lepidoptera larvae (caterpillars), which includes corn borers. In Bt corn, it is the delta endotoxin that was selected as it is highly effective at controlling caterpillar larvae. Although the gene does an excellent job at controlling larvae, it is safe for other orders of insect species such as beetles, wasps, bees and flies; this makes it a suitable biological control. To have control on the target pest, the Bt protein must be ingested. Not all parts of the plant have the same concentration of the Bt protein. The protein goes to work in just minutes, coating the gut wall and the insect will then stop feeding. Within hours, the gut wall completely breaks down and the existing gut bacteria then take over the body cavity. Lepidoptera larvae all differ in their response to the Bt protein (**Bessin, 2019**).

Bt corn technology has been available since the mid-90s; and it has worked consistently well up until 2018. In 2018, near Truro, Nova Scotia, a Bt corn hybrid created with the Cry1F protein was found with ECB damage (**King, 2020**). In 2018, Dr. Jocelyn Smith from the University of Guelph collected samples from four fields in the Truro area to be tested. All four of the samples displayed high resistance to the Bt Cry1F gene. ECB samples that were collected from the Annapolis Valley also displayed high resistance resistance, which is why farmers have been observing damage in their Bt corn (**King, 2020**). In 2019, further samples were collected from neighbouring provinces: Prince Edward Island, Quebec, Eastern Ontario and more from the Annapolis Valley to survey other populations for Bt resistance. One possible solution to resistance is to use a different Bt protein, or a combination of them; high-dose toxins such as Cry1F, Cry1Ab, Cry1A.105 and Cry2Ab2 are all effective against ECB (King, 2020).

If refuge has not been included in the bag of seed corn, it has been recommended to plant a minimum of 20% refuge plants when using Bt corn, the refuge guidelines should be followed to minimize pest resistance (**Krupke, Bledsoe, & Obermeyer, 2010**). This creates a refuge area for susceptible corn borers that have yet to be exposed to the Bt toxin. The individuals from the refuge area will mate with the resistant individuals that are 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 refer to the **handy Bt table** to understand which insect pests are controlled by each Bt protein and the refuge requirements.

Non-corn host crops

Using pheromone traps and monitoring GDD accumulation to predict flights would be 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 the larva has burrowed into the plant, the sprays will no longer be effective. Annually Perennia updates their crop pest management guides. Each crop has its own guide that lists which products can be used on that crop-pest. Please check out the Perennia crop pages for the latest editions: **https://www.perennia.ca/agriculture/commodity-information/**

Natural Enemies

There are many native species parasites and predators that provide some level of control on the ECB population. Imported parasitoids, such as *Lydella thompsoni*, *Eriborus terebrans* and *Simpiesis viridula* have been shown to have a greater level of control (**Capinera, 2017**). Native predators that effect the eggs and young larvae are the insidious flower bug (*Orius insidious*), green lacewings (*Chrysoperla* spp.) and several ladybird beeltes (**Capinera, 2017**). Insect predators have been known to wipe out between 10-20% of the population. 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.

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Damage Prevention

Cultural practices are key for lowering your risk of having issues with ECB. Residue left in the field post-harvest is a key host site for overwintering larvae. Disking in corn residue has not been found to be adequate, it is strongly recommended to plow residue in to a depth of at least 20cm to destroy the larvae. Mowing stalks close to the ground combined with plowing is also effective. Minimum tillage practices that leave a significant amount of plant residue on the soil surface puts you at a higher risk factor for further infection (**Capinera, 2017**). Timing of corn planting has been tested for its effectiveness for reducing infection 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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