How Do Cold February Temperatures Affect Insects That Overwinter?

The month of February can be a time of significant temperature extremes through much of the crop growing regions of the United States and Canada. Cold snaps that occur in February, or even during March or April, may cause people to ask if fluctuating temperatures can adversely impact the survival of insect pests, and ultimately affect their populations in the spring and summer months. The short answer is, "probably not."[1] Entomologists and other experts that have studied the impact of extreme cold temperatures on the survival of insects have found that there are a variety of ways subzero temperatures can affect insect populations and that the insect ecosystem is extremely complex, which makes it difficult to predict summer populations based on winter temperatures.[2]

How Do Insects Survive Freezing Temperatures?

Insects have evolved coping mechanisms that allow them to survive the fluctuating temperatures that often occur in winter. Most insects overwinter in a certain development stage – egg, larva, nymph, or adult. The two primary strategies for survival are *freeze avoidance* and *freeze tolerance*.

One way that freeze avoidance can be achieved is by simply avoiding freezing temperatures. A classic example of this is the migration of the monarch butterfly to Mexico. During the overwintering period, subsequent generations are produced that will make their way in turn to northern regions in the spring.[3]

Insects that do overwinter must seek shelter to buffer them from extreme temperatures or must possess a mechanism that can help them *avoid* or *tolerate* freezing through biochemical means. *Freeze-avoidant* insects can tolerate a certain degree of chilling, but do not die until the temperature falls below the freezing point for their body fluids – i.e., when ice crystals begin to form in their bodies, rupturing cells and damaging organs. This is because they have the ability to form a type of anti-freeze in their cells prior to winter. The anti-freeze, or cryoprotectant, lowers the freezing point of the body fluid. For many freeze-avoidant species, this lower freezing point is likely between zero and –20 °F (–18 and –29 °C).[1,2] Examples of anti-freeze that can be produced by insects include glycerol (the same chemical that is often used to prevent freezing in windshield washer fluids in automobiles) and sugars called trehalose and mannitol. Insects begin acclimating to the cold weather by producing these cryoprotectants in the fall, as the weather turns cooler. [3]

In comparison, *freeze-tolerant* insects are able to withstand the formation of ice crystals in their bodies by producing proteins that "control" the freezing process. Examples of freeze-tolerant insects include cockroaches, midges, and woolly caterpillars. A second-generation European corn borer can survive in the pupal stage for three continuous months at temperatures as low as –4 °F (–20 °C), even with ice crystals in its body.[3]

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Cold Weather Protection Using Overwintering Sites

Some overwintering insects find places that protect them from extreme air temperatures and biting wind chills. For example, corn rootworms, Japanese beetles, and wireworms overwinter in the soil, which provides a buffer from extremely cold temperatures and can be further insulated with a blanket of snow. However, dry soil is more susceptible to deeper frost and greater temperature fluctuations than wet soil, and a combination of dry soil and no snow can further reduce the temperature protection available to overwintering insects. Because of this, insects that lay eggs in the soil, such as corn rootworm beetles, typically lay overwintering eggs in the upper 4 inches (10 cm) of moist soil, though they do lay eggs deeper if the upper soil is too dry.

Temperatures below 14 °F (–10 °C) must be sustained for more than one week to increase the mortality rate of western corn rootworm (WCR) eggs.[4] In 2021, soil temperatures were monitored at five locations following a cold snap in Nebraska in which air temperatures dropped to –30 °F (–34 °C). Despite the rapid drop in air temperatures, temperature changed very little four inches (10 cm) beneath the soil, ranging from a 1 to 8 °F decrease from their initial temperatures of 30 to 35.6 °F (–1 to 2 °C). At all locations, soil temperatures remained well above the 14 °F (–10 °C) threshold necessary to kill WCR eggs.[5]

Alternatively, insects that overwinter above ground—such as bean leaf beetles and European corn borers—shelter in plant debris and crop residue. Bean leaf beetles overwinter as adults and can only survive temperatures above 20 °F (–6.6 °C), so they must seek shelter in wooded areas or under plant litter to avoid extremely cold temperatures. Southwestern corn borers can survive temperatures of 14 to 19 °F (–10 to –7 °C) for several days if they are dry and overwintering in the root crowns of corn. A study done over three winters near Evansville, IN found that even though air temperatures fell below –2.2 °F (–19 °C) for up to five consecutive days, the temperature inside the root crowns averaged 17.6 °F (–8 °C) for periods of a few hours, which the researchers attributed to the temperature-buffering effects of freezing soil water. While the air temperature was low enough to be lethal to the southwestern corn borers, they did not experience those temperatures inside their overwintering sites.[6]

How Do Extreme Cold Temperatures Affect Stored Grain Insects?

Stored grain is well insulated. Especially in large quantities, it prevents cold temperatures from reaching the center of the mass. One laboratory study examined the survival of six major stored grain insect species exposed to temperatures of 32 °F (0 °C) for seven days. Five of the six species tested survived that exposure, and only the population of rice weevils was reduced. In another study conducted at Winnipeg, MB, the rusty grain beetle survived two winters in metal structures that contained 1000 bushels of wheat. Outside air temperatures ranged from –4 to –22 °F (–20 to –30 °C) during the two coldest months. Rusty grain beetles will not freeze until temperatures reach –4 °F (–20 °C), so the combination of their freeze tolerance and the insulation from the stored grain allowed them to survive inside the grain mass despite the low temperatures outside the container.[7]

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Effects of a Mild Winter

Mild winter weather that does not expose insects to potentially lethal temperatures can cause insects to resume activity early in the spring before plants have regrown. Insects that emerge too early can deplete their energy reserves before food sources are readily available, so some insect species rely on cues other than temperature—such as day length—before becoming active again.[1]

Effects of Cold Snaps and Fluctuating Temperatures

Sublethal temperatures, while not low enough to cause mortality, can still reduce insect growth, development, and the reproductive potential. The impact of repeated cold cycles is highly dependent on the duration of those cold temperatures.[1]

What Happens if Spring Arrives, Followed by a Deep Freeze?

If insect activity has resumed due to a mild winter and/or an early spring, reproduction is likely to follow. Insects use a large amount of stored fat and sugars to survive the winter, potentially leaving them with low reserves in spring that could be further taxed by reproduction. Therefore, if a sudden cold snap occurs in late March or early April, for example, some insect populations could be devastated because they lack the resources to survive the cold.[2]

Summary

Insects are very adaptable creatures. The survival mechanisms that they have developed in response to cold winter weather make it unlikely that insect mortality will be high in any given year, except under particularly unusual circumstances.

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