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Codling moth

A learning model : Univoltine and Polyvoltine individuals

Within a Codling Moth population there are genetically univoltine individuals that make only one generation per year regardless the conditions, and polyvoltine individuals that can make multiple generations.

The univoltine part of the population secures the persistence of the population in any climate zone where apples are growing.

The Polyvoltine part are the 'explorers' that try if in the local climate more than one generation is possible. If they succeed, their fraction in the population increases gradually.

At higher latitudes climatic selection has led to a majority of univoltine individuals. A sudden warm summer will not immediately lead to an important second generation. At lower latitude almost all individuals are polyvoltine.

In the first year you run RIMpro for a location, the model estimates the fraction of uni- and polyvoltine individuals in the population based on the latitude of the location. In the following years the model learns and adapts to climatic trends. In warm summers, the polyvoltine fraction is successful and grows. The following years the chance for an important second generation increases.

You can overrule the estimated polyvoltine fraction for each location and year in the local biofixsettings.

Diapause termination and post diapause development

Codling Moth populations winter as full-grown larvae in diapause. Diapause ends in spring when the days get longer. The critical day-length for diapause termination for the population is depending on the global position and is determined using the coordinates in the setup of the weather station in RIMpro.

It may take 50 days before all larvae have terminated their diapause.

After diapause termination the larvae pupate. The larvae on the sun-exposed side of the tree develop faster as they receive a higher temperature. The model corrects the stem temperature for the incoming solar radiation. Read the section "Correction of habitat temperature" to learn how RIMpro estimates the temperature in different tree compartments.

Only if your weather data are not complete from the start of season, or the model predicts the first moths considerably earlier or later than first moths that have been caught in pheromone traps in your region, you have set a Biofix date. You do this under the 'Local Parameters' for each station.

In this case the model skips the procedures for diapause termination and pupation, and moths emerge depending on temperature development. You can set the heat sum for 50% emergence of moths.

Egg Deposition

Depending on the weather conditions, female moths can live up to four weeks.

Female Codling Moths mate during one of the first suitable evenings after they emerge from their pupae, but particularly in spring, there is a one to three week delay between moth emerge and first egg deposition. This delay is called pre-oviposition period.

Development rate of Eggs, Larvae and Pupae

The development rate of eggs, larvae, and pupae, is depending on temperature. This relation is not linear. Below 9°C there is no development. Between 10 and 30 °C the development rate increases with temperature, but declines again over 30 °C. Above 34 °C development stops.

Published results of research on the duration of the individual biological stages are inconsistent. The default values used in RIMpro are our interpretation of the published information.

Codling Moth larvae live and develop in fruits. Larvae in sun-exposed fruits receive a higher temperature, and develop faster than expected based on air temperature. Read the section on 'Correction of habitat temperatures' to understand how RIMpro estimates the temperature in different parts of the tree.

In each stage a part of the individuals die from natural causes.

Diapause Induction

When full-grown polyvoltine larvae leave the fruits and the days are still long enough, they pupate and continue development in a next generation. When the days get shorter, an increasing part of the full-grown polyvoltine larvae stop further development and go in diapause. The CPhP50 of the population, = the day-length where 50% of the larvae decide to go in diapause, is related to latitude.

An algorithm published by Riedl in 1976 is implemented to calculate CPhP50 from latitude for each location.

Correction of Habitat Temperature

Insect development is driven by their habitat temperature. Not in all stages and all places the insects receive the air temperature as recorded by your weather station, or provided by the meteoservice. Only at north- and shaded positions in the tree, insect body temperature will resemble air temperature. At sun exposed fruits and branches they will reach a higher temperature.

The RIMpro-Cydia model uses the concept of 'corrected habitat temperatures'. During spring pupation and the larval development in fruits the population is subdivided over three tree compartments with a different habitat temperature. Parallel simulations are made for the insects in these separate compartments.

If the station uses MeteoBlue weather forecast, or is a virtual station, the MeteoBlue global radiation data are saved and used to correct the stem and fruit temperature. Tree stem temperature is calculated according a model published by Graf in 2001.