UNIVERSITY OF CALIFORNIA AGRICULTURE & NATURAL RESOURCES
UC IPM
Statewide Integrated Pest Management Program

Research and IPM

Models: About Phenology Models

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What is a phenology model?

Phenology models predict time of events in an organism's development. Development of many organisms which cannot internally regulate their own temperature, is dependent on temperatures to which they are exposed in the environment. Plants and invertebrates, including insects and nematodes, require a certain amount of heat to develop from one point in their life-cycle to another, e.g., from eggs to adults. Because of yearly variations in weather, calendar dates are not a good basis for making management decisions. Measuring the amount of heat accumulated over time provides a physiological time scale that is biologically more accurate than calendar days.

Developmental thresholds

Two parameters are used when referring to the effect of temperature on growth and development. The **lower developmental threshold** for a species is the temperature below which development stop. The **upper developmental threshold** is less well defined, but is often taken as the temperature at which the rate of growth or development begins to decrease. For many organisms the upper thresholds are not used because data are lacking to obtain such estimates. Both lower and upper thresholds are determined through carefully controlled research and are unique for a specific organism.

Physiological time

The amount of heat needed by an organism to develop is known as **physiological time**. The amount of heat required to complete a given organism's development does not vary—the combination of temperature (between thresholds) and time will always be the same. **Physiological time is often expressed in units called degree-days**. For instance: if a species has a lower developmental threshold of 52° F, and the temperature remains at 53°F (or 1° above the lower developmental threshold) for 24 hours, one degree-day is accumulated.

Developmental stages

Each stage of an organism's development has its own total heat requirement. Development can be estimated by accumulating degree-days between temperature thresholds throughout the season. The accumulation of degree-days from a starting point can help predict when a developmental stage will be reached. Degree-day monitoring does not indicate whether control action is warranted, but rather when a pest will reach susceptible life stages. If pests are abundant, monitoring degree-days helps to eliminate the guesswork otherwise required to determine the time for a control action.

What does verification mean?

The information in the phenology models database comes from published literature that we have assembled and put in a standard format. To be most confident in a particular model, it should be field tested in your particular area (or a similar area).

A model can be informally or formally tested or verified.

Informal verification of a model simply involves testing a model in your region and observing how it works.

For example, compare the predicted generation time (degree-days) for an insect using a phenology model, and compare it to the actual degree-days for a generation using some sampling method such as a pheromone trap. Each year that you use the model, the more fine-tuned you can make it to your area.

Or, you could observe the occurrence of a generation using some sampling method such as a pheromone trap, then compare the degree-days over that same period with the predicted generation time (in degree-days) from a phenology model of the organism. By observing the same events and comparing with model predictions over several years, you can fine-tune the model for your area.

Formal verification of a model is usually done by scientists and involves: (1) obtaining weather data from a given site (and preferably several other sites, some of which have unique climates or other variables); (2) sampling for the particular arthropod, nematode, or plant species, preferably at several stages of its development; (3) combining the weather and sampling data from a minimum of three years in conjunction with statistical computer programs to compute the degree-days and start dates (or biofixes). Formal verification is not necessary to make a model useful; many of the models in the UC IPM database are reported to function well under informal use.