

5.1 TEMPERATURE EFFECTS ON INSECT DEVELOPMENT

Fact Sheet Objectives

- Introduce the concept of heat accumulation in relation to insect development.
- Explain degree-day unit
- Explain how temperature affects insect life cycles (number of generations per year)

Heat and insect growth

All animals need heat to function and grow.

- Insects are said to be "cold blooded." What this means is that unlike mammals, insects do not generate their own heat and must rely on their environment (i.e. the sun) for warmth.
- For insects therefore, the surrounding temperature plays a major role in determining how fast they develop.
- At each stage of an insect's life cycle a certain amount of heat is needed to complete the development of that stage.

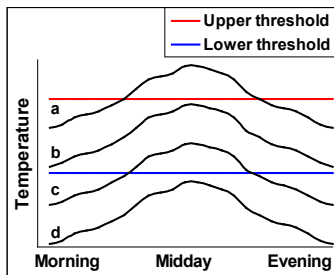


Figure 1. The hourly temperatures on four days (a ... d) are shown in relation to an insect's development thresholds.



Lightbrown Apple Moth
(*Leafroller*)

Temperature range for development

Each insect species has an optimum temperature at which it will develop at its fastest rate, and this can vary for each stage of its life cycle.

- Every insect also has a minimum and maximum temperature range, outside of which there is no development of immature stages.
- Insects will develop faster when they spend the most time within their threshold temperatures for development (line b, Figure 1).
- Less development occurs on days when the temperature becomes either too hot (e.g. line a, Figure 1) or too cold (e.g. line c, Figure 1) for part of the time.
- No development occurs if the temperature does not reach the lower threshold (line d, Figure 1).

Insect temperature development thresholds

Temperature development thresholds vary from insect to insect and between different stages (Table 1).

- Typically the minimum and maximum temperature thresholds are around 10 °C and 32 °C respectively.
- Below and above these thresholds an insect will stop developing, but will not be killed until a lethal temperature is reached.

Degree-days

The amount of heat that an insect accumulates for its development is measured in units called degree-days (written as °D).

- Degree-days are a combination of daily temperatures and the time that an insect spends within the temperature range suitable for its development.
- One degree-day results when the average temperature for one day is one degree above the lower development threshold temperature.
- Degree-days are added up over several weeks and used to predict when certain biological events occur, such as egg laying, egg hatch, or moth emergence.
- Insects accumulate the most degree days (and develop faster) when temperatures stay longer within the thresholds for development.
- Note that on any given day different pest species will accumulate a different number of degree-days, unless their temperature development thresholds are the same (Table 2).

Table 1: Development thresholds (°C) for some common pests

Pest	Lower	Upper
Codling Moth	10	31
Lightbrown Apple Moth	7	32
San José Scale	10.5	32

Biofix

Degree-days are added up from a starting point in time called a Biofix.

- The Biofix can be any convenient point in an insect's life cycle.
- Usually the start of a generation for determining a Biofix is used as this can be easily determined.
- For example, Biofix can be when moths begin to be caught in traps in spring or when scale crawlers emerge.

Table 2: Number of degree-days to complete one generation for some common pests

Pest	°D
Codling Moth	610
Lightbrown Apple Moth	630
San José Scale	741

Effect of temperature on life cycles-example

Lightbrown Apple Moth has 2 - 4 generations per year in New Zealand depending on latitude.

- LBAM has 4 generations in Auckland, 3 in Hawke's Bay, but only 2 in Central Otago.
- These regional differences are solely due to the lower number of degree-days available for development as a result of cooler climate encountered the further south you go.
- Because it is warmer in the north, each generation takes a shorter time to complete, and there are more days when temperatures are within the development thresholds.

Summary

- Insects cannot generate their own warmth so the temperature of their environment controls how fast they develop.
- Every insect species and each stage of its life cycle has a range of temperature in which all development occurs. Development is quickest when temperatures are around the optimum for the longest time.
- The degree-day is the unit of heat accumulation and is a combination of daily temperature and time within development thresholds.
- Each species has a fixed number of degree-days needed to complete one generation. The number of degree-days in a year determines how many generations insects have.

Further information

www.hortnet.co.nz

www.ipm.ucdavis.edu/WEATHER/ddconcepts.htm

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