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Degree-Days for Five Ornamental Pests from an 11-Year Field Study[1]

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Degree-days are a tool used to aid in arthropod prediction and timing of control measures. Many university cooperative extension programs disseminate degree-day information for those purposes. Through Pennsylvania State University's cooperative extension, a collaborative group called the Southeast Pennsylvania Integrated Pest Management Research Group (SE PA IPM RG) was formed to research ornamental pests. Collaborators were professionals in the green industry (as defined by Hinson and Pinel 2004, Louisiana Agric. 47: 12-15) in Pennsylvania and Delaware. From 1991-2001, the SE PA IPM RG accumulated degree-day data for over 100 arthropod species. This database lists life history events (i.e., stages) of arthropods indexed to the degree-day accumulation at the site where each event occurred. From this database we present first occurrence and ranges of occurrence for life stages of birch leafminer, *Fenusa pusilla* (Lepeletier), fall webworm, *Hyphantria cunea* (Drury), mimosa webworm, *Homadaula anisocentra* (Meyrick), oak lace bug, *Corythuca arcuata* (Say), and pine needle scale, *Chionaspis pinifoliae* (Fitch), which are vulnerable to control measures.

These insects were chosen because they are prevalent and important ornamental pests, were well-represented in the database, and degree-day data were verified through systematic scouting (Richardson 2002, Senior thesis, University of Delaware, Newark). Also, whereas degree-day data have been reported for three of these species (Bastian and Hart 1991, Environ. Entomol. 20: 1141-1148; Mussey and Potter 1997, J. Econ. Entomol. 90: 1615-1627), field data were collected for only two (Mussey and Potter 1997, J. Econ. Entomol. 90: 1615-1627). Degree-day models should be developed from field data because models formed from laboratory data are seldom accurate predictors of insect development under natural conditions (Hawthorne et al. 1988, Environ. Entomol. 17: 40-46; Rock et al. 1993, Environ. Entomol. 22: 716-725).

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Database records were from 27 sites in the following southeastern Pennsylvania counties: Berks, Bucks, Chester, DE, Lancaster, Lehigh, Montgomery, Northampton, and Philadelphia. In addition, records were from four sites in New Castle Co., DE. The SE PA IPM RG asked cooperators at each location to scout for insects weekly from 1 March through 31 October. When an insect was found, the insect and its life stage were identified and the degree-day total was noted. To obtain site-specific degree-day information, each cooperator was issued a Wescor Biophenometer Datalogger (Wescor, Inc., Logan, UT), which used a standard averaging method to calculate degree-days (Richardson and Caron 2005, HortTech. 15: 572-576). Degree-day accumulations were calculated from 1 March through 31 October. The SE PA IPM RG's database includes degree-day accumulations calculated from base temperatures of 32 (0.0°C), 40 (4.4°C), 43 (6.1°C), 47 (8.3°C), and 50°F (10.0°C). Fahrenheit base temperatures are commonly used because of their familiarity to Cooperative Extension personnel and professionals in the green industry (Pruess 1983, Environ. Entomol. 12: 613-619). We present results for base 50°F only because insect development is generally limited below this temperature (Barton et al. 2000, Penn. State Univ. Coop. Ext. IPM Fact Sheet #9).

Ranges for insect pests. For each species, degree-day ranges for life stages most vulnerable to control measures are listed in Table 1. Table 2 lists degree-day ranges for each generation of multigenerational species. Life stages in Table 2 vary from Table 1 because we used whichever life stage permitted distinction between generations.

Birch leafminer can have two to four generations per year. Database records indicate that two generations per year in southeast Pennsylvania and northern Delaware cause significant damage. Larvae cannot be easily controlled because they are leafminers, thus, targeting adults is more effective. Fall webworm has multiple generations per year and larvae should be targeted for control. The number of generations is highly dependent on the length of time that heat accumulation occurs. The second generation is typically the most damaging, but in warm years, a third generation may occur. Mimosa webworm has multiple generations per year, but we do not list degree-day ranges for each generation. Mimosa webworm appears to have two generations in the MidAtlantic, but they overlap and cannot be distinguished. Mimosa webworm are vulnerable to control measures as larvae. Oak lace bug over-winters as

Table 1. Degree-day ranges and first occurrence of life stages susceptible to control measures for 5 insects, derived from the Southeast Pennsylvania Integrated Pest Management Research Group's 1991-2001 database

Insects	Insect event	# of records	Degree-day range*	Avg. first occurrence
Birch leafminer	Adult	89	86-1148 (48-637)	117 (65)
Fall webworm	Larva	372	543-3226 (301-1790)	757 (420)
Mimosa webworm	Larva	92	750-3216 (416-1785)	978 (543)
Oak lace bug	Adult	242	180-3710 (100-2059)	286 (159)
	Hatch	17	560-2353 (311-1306)	681 (378)
Pine needle scale	Hatch	37	63-2723 (35-1511)	378 (210)

* Centigrade degree-days in parenthesis.

Table 2. Degree-day ranges for each generation for 5 insects, derived from the Southeast Pennsylvania Integrated Pest Management Research Group's 1991-2001 database

Insect	Insect event*	# of records	Degree-day range†
Birch leafminer			
1st generation	Adult	67	86-365 (48-203)
2nd generation	Adult	18	575-945 (319-524)
Fall webworm			
1st generation	Hatch, larva	94	631-1350 (350-749)
2nd generation	Hatch, larva	245	1426-2775 (791-1540)
3rd generation	Hatch, larve	20	2847-3226 (1580-1790)
Mimosa webworm			
1st generation	Larva	NA**	CND‡
2nd generation	Larva	NA**	CND‡
Oak lace bug			
1st generation	Hatch	9	560-1175 (311-652)
2nd generation	Hatch	6	1566-1889 (869-1048)
3rd generation	Hatch	2	2271-2353 (1260-1306)
Pine needle scale			
1st generation	Hatch	32	63-947 (35-526)
2nd generation	Hatch	5	2000-2723 (1110-1511)

* Insect event that most easily distinguished among generations.
** NA, not applicable.
† Centrigrade degree-days in parentheses.
‡ CND, could not determine (overlapping generations).

an adult and has multiple overlapping generations per year. We distinguished three generations in the MidAtlantic region from hatch records. Control measures can be effective during any life stage, except the egg stage. Pine needle scale has one or two generations per year. The generations overlap, but were distinguished by hatch records. The most vulnerable life stages are crawlers and early instars.

First occurrence of insects. In most cases, timing control measures with first occurrence is more effective than targeting the entire range of occurrence. Younger and smaller pests are typically more vulnerable to control measures and less caustic chemicals. Because these five species are multigenerational, targeting insects at first sighting will limit future generations. The SE PA IPM RG collected enough data to predict average first occurrence (Table 1).

As far as we are aware, no other group has collected data for this duration or over such a large geographic area. Although not absolute, degree-days have been shown to be an accurate and practical means of predicting heat units and for use in pest management programs (Wang 1960, Ecology 41: 785-790; Higley et al. 1986, Environ. Entomol. 15: 999-1016). Degree-day correlations provided here, however, should only be applied as a predictive tool in the MidAtlantic region, unless other regions verify that these data correlate with their phenological data.

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