IPPC Phenology/Degree-Day Model Analysis – Mar 27, 2017 – Len Coop

Japanese Flower Thrips *Thrips setosus* (Thysanoptera: Thripidae)

Goal: Develop a phenology model based on available literature (currently 1 publication) and weather data analysis

Source 1. Murai, T. 2001. Life history study of Thrips setosus. Entomol. Experim. et Applicata. 100:245-251

- Studied in Japan
- Lab development 6 temperatures reared on kidney bean (Phaseolus vulgaris)
- Results reported suggest ca Tlow (low threshold) of ca. 8C for eggs, 10C for larvae+pupae, and 17.5 for pre-OV. This disparity creates a problem for the simple DD model that requires a common threshold. One solution is to lean more heavily on stages taking the longest (larvae+pupae), less heavily on stages taking the shortest time (pre-OV)
- Also cooler temperatures were not tested in this study, which would be needed to reach better estimates for Tlow for each stage.
- From analysis below, where we "solved" for a best common threshold, we propose a compromise threshold of 11.11 C or 52 F. This could be rather high for eggs, only slightly high for larvae and pupae, and very low for PreOV;
- NOTE PreOV results in this study are also weakest for (only 3 temps used; the 20C point is not well lined up with the other two points, suggesting that the Tlow suggested (17.5C) may be high.

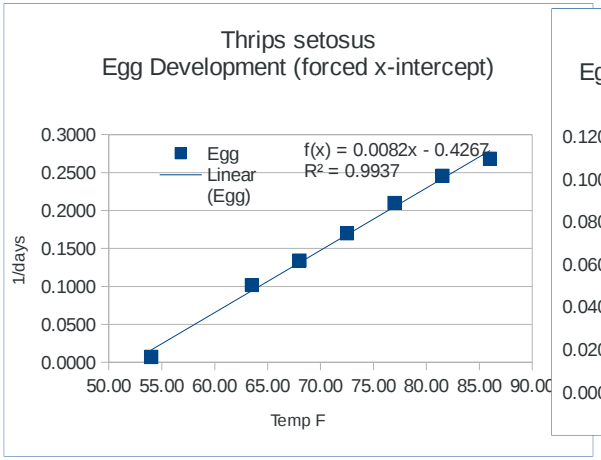
1. Re-interpret temperature vs. development rate data to solve for best overall common threshold and corresponding developmental DDs:

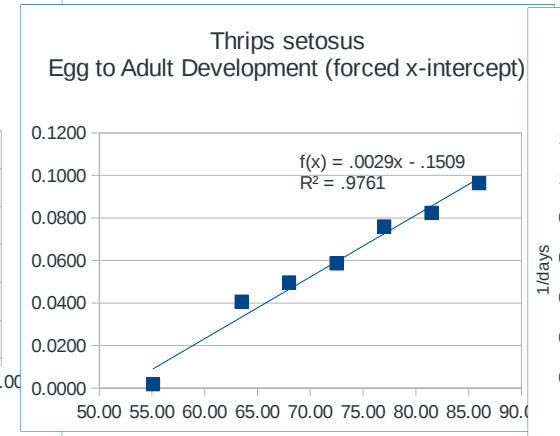
Yellow background: point added to force x-intercept

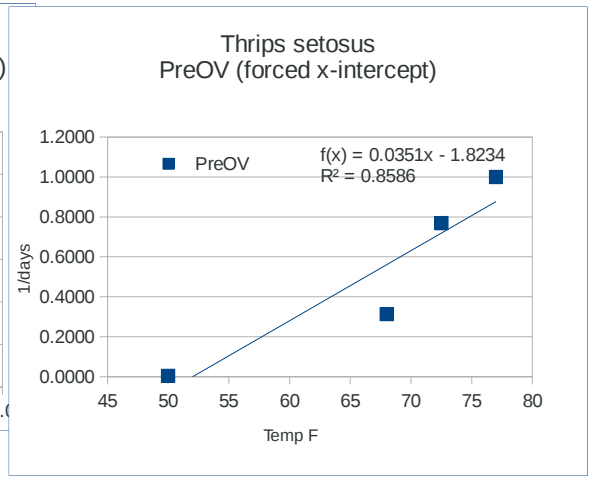
Salmon background: most relevant results

From Table 1: (use the x-intercept method to find Tlow and developmental (DD) requirements for major stages):

	Days Development						Devel. Rate 1/days		1/days		1/days		
Temp C	Egg	Larvae	Prepupa	Pupa	Total	PreOV	Temp F	**Egg**	Temp F	**EggtoAdult**	TempF	**PreOV**	days
	140				550		54.00	0.0071	55.10	0.0018	50	0.0042	240
17.5	9.8	8.2	1.9	4.7	24.6		63.50	0.1017	63.5	0.0406	68.0	0.3125	3.2
20	7.5	7.1	1.7	3.9	20.2	3.2	68.00	0.1340	68	0.0496	72.5	0.7692	1.3
22.5	5.9	6.0	1.7	3.5	17.1	1.3	72.50	0.1701	72.5	0.0586	77.0	1	1
25	4.8	4.7	1.0	2.7	13.2	1	77.00	0.2101	77	0.0759			
27.5	4.1	4.7	1.0	2.4	12.1		81.50	0.2457	81.5	0.0824			
30	3.7	3.7	0.9	2.0	10.4		86.00	0.2681	86	0.0963			
							slope:	0.00821	slope:	0.00290	slope:	0.03506	
							intercept:	-0.42673	intercept:	-0.15094	intercept:	-1.82339	
							R-sq:	0.99373	R-sq:	0.97608	R-sq:	0.85863	
						Tlow =	-a/b	52.00	Tlow =	-a/b	52.00	11.11085	-a/b	52.00
						Dds devel =	1/slope	121.8	Dds devel	1/slope	344.5	191.3866	1/slope	28.5







Results: The proposed 11.11C/52F Tlow fits rather well for eggs, larvae, and PreOV (excluding the one point at 20C)

At this threshold we get the following DD requirements:

	DDsC11.11	DDsF52
Egg	**67.8**	**122**
Larvae	**123.9**	**223**
Egg-Adult	**191.7**	**345**
Pre-OV	**15.6**	**28**

2. Oviposition Period: Use same thresholds: **52F** **11.11 C**

From Fig. 1: (approx interpretation) **(USE THIS as "PEAK OVIPOSITION")**

TempC	Days to 5% egg	DDs 11.11C	DDs 52F	Days to 30% egg	DDs 11.11C	DDs 52F	Days to 50% egg	DDs 11.11C	DDs 52F	Days to 90% egg	DDs 11.11C	DDs 52F
20	4	35.6	64.0	15	133.4	240.0	24	213.4	384.0	45	400.1	720.1
22.5	3	34.2	61.5	12	136.7	246.0	17	193.6	348.5	35	398.7	717.6
25	2.5	34.7	62.5	10	138.9	250.0	14	194.5	350.0	30	416.7	750.1
Mean	3.2	34.8	62.7	12.3	136.3	245.4	18.3	200.5	360.9	36.7	405.1	729.2

Results: Select time to 30% ovipostiion to use for avg generation time = 136 DDC, 245 DDF
Also: time to first or 5% oviposition for minimum gen. time = 35 DDC, 68 DDF

3. Evidence for spring activity:

notes: reproductive diapause; overwinter as adults; photoperiod for induction and completion of reproductive diapause ca. 12 hr

-Noted to enter reproductive diapause by late Oct in W. Japan; springtime activity not reported

-A 12hr critical photoperiod corresponds to completion of diapause around the Spring equinox, Mar 20th.

Using Weather Underground data for IZUMO Japan (RJOC), 2013 & 2014:

https://www.wunderground.com/history/airport/RJOC/2014/1/1/CustomHistory.html?dayend=31&monthend=12&yearend=2014&req_city=&req_state=&req_statename=&reqdb.zip=&reqdb.magic=&re

Single Sine DDs (52 Tlow 100 Tupper):

Date	DD52	
03/20/13	68	<---
03/20/14	29	
03/29/14	72	<---
04/15/13	125	
04/15/14	125	
04/30/13	198	
04/30/14	247	
05/01/14	259	<---
05/09/13	251	<---
05/10/13	261	
05/10/14	340	

Use 68 DDF as a conservative (error on the side of too-early predictions) for first spring OV

Notes: corresponds with reported photoperiod response (ends reproductive diapause around Mar. 20)

Use 250 DDF as a conservative est. for peak spring OV

Notes: This species has a very "flat" oviposition schedule that continues for 40+ days; therefore this number is rather arbitrary; however as mortality continually occurs, most females never reach full potential reproduction, this is a rationale for selecting 30% of maximum OV rather than 50% as the representative of "peak" (or midpoint) of oviposition.

4. Model Stages Summary

Species:	*Thrips setosus*	
Common Name:	Japanese Flower Thrips	
Country of Origin, data from:	Japan	
Potential Pest of:	Vegetables including tomato, beans, also tobacco; potential vector of Tomato spotted wilt virus	
Validation Status:	Not validated; no spring activity data available to calibrate model initialization (this model is therefore conservative and may predict too early)	

	Deg.s (C)	Deg.s (F)	Notes:
Lower Threshold:	11.11	52	Best overall Tlow for all stages, egg and larvae may be slightly lower; Pre-OV & OV slightly higher
Upper Threshold:	37.78	100	Nominal, does not appear overly sensitive to high temperatures
Calculation Method:		Single Sine	
Model Start:		January 1st	Temperate adapted species OW in reproductive diapause, may become active around 12hr Daylength (ca. Mar 20)

Degree-Day Requirements	**DDs (C)**	**DDs (F)**
Egg	67.8	122
Larvae	123.9	223
Egg-to-Adult	191.7	345
Pre-OV	15.6	28
Dds to First OV	37.8	68
Dds to Peak OV	138.9	250
Dds to 90% OV	405.0	729
Egg-to-1st-OV (min gen. time)	229.4	413
Egg-to-Peak-OV (avg gen. time)	330.6	595

5. Model Degree-Day Events Summary	**DDs (C)**	**DDs (F)**
First Spring Egg-Laying	38	68
Peak Spring Egg-Laying	139	250
First adults G1	229	413
Peak 1st Gen. Egg-Laying	469	845
Peak 2nd Gen. Egg-Laying	800	1440
Peak 3rd Gen. Egg-Laying	1131	2035
Peak 4th Gen. Egg-Laying	1461	2630
Peak 5th Gen. Egg-Laying	1792	3225
Peak 6th Gen. Egg-Laying	2122	3820
Peak 7th Gen. Egg-Laying	2453	4415
Peak 8th Gen. Egg-Laying	2783	5010

6. Model Degree-Day Event Ranges Summary	**Begin C**	**End C**	**Begin F**	**End F**
OW Adults in Reproductive Diapause	0	38	0	68
1st Spring Egg-Laying by OW Adults	38	267	68	480
1st Gen. Adults Egg-Laying	267	496	481	893
1st and 2nd Gen. Adults	497	726	894	1306
Max. 3rd Gen. Adults; Peak 2nd Gen.	726	955	1307	1719
Max. 4th Gen. Adults; Peak 3rd Gen.	956	1184	1720	2132
Max. 5th Gen. Adults	1185	1414	2133	2545
Max. 6th Gen. Adults; Peak 4th Gen.	1414	1643	2546	2958
Max. 7th Gen. Adults; Peak 5th Gen.	1644	1873	2959	3371
Max. 8th Gen. Adults	1873	2102	3372	3784
Max. 9th Gen. Adults; Peak 6th Gen.	2103	2332	3785	4197
Max. 10th Gen. Adults; Peak 7th Gen.	2332	2561	4198	4610
Max. 11th Gen. Adults; Peak 8th Gen.	2562	2791	4611	5023
Max. 12th Gen. Adults	2791	3020	5024	5436
9 to 13 or more overlapping generations	3021	5556	5437	10000