

# IPPC Synthesis Analysis – Apr 28, 2011 1st draft/preliminary analysis – Len Coop

Brown Marmorated Stink Bug Degree-Day Model: *Halyomorpha halys* (Stal)

Model Proposed: biofix Jan 1 Tlow 54 Thi 92 F ( 12.2 & 33.3 C)	DD (F)	DD {C}
Female adults begin reproductive maturation	85	47
1st Spring adults active /captured in blacklight traps	360	200
1st egg laying	566	314
1st nymphs summer gen	700	389
1st adult emergence summer gen	1608	893
Peak 3rd instar nymphs (avg mid-season crops)	1734	963
1st egg hatch 2nd gen (Southern states only)	2022	1123
Final peak summer gen nymphs	2092	1162
Peak summer gen adults	2213	1229
1st 2nd gen adults (Southern states only)	2905	1614

## 1. Main Source of model: Nielsen and Hamilton Env Ent 2008 37:346-354

Model used in pub: dds total: female maturity (147.65DD) + total development (537.6 DD) = 685 DD  
 Tlow = 14.17 ← this threshold included development at 15C (100% mortality), so should be rejected

### from Table 1:

temp c	f	egg days	egg+nymph total days	Nymphs only days	Female preoviposition period			
					Time to mate days	Preov days	Est Dds 54 Dds	Est Dds 50 Dds
15		59	22					
17		62.6	17.2	121.5	104.3			
20		68	11.5	81.2	69.7			
25		77	6.1	44.9	38.8	5	13	
27		80.6	4.87	35.8	30.93			
30		86	3	33.4	30.4			
33		91.4	4	37.8	33.8			

### eggs

temp F	1/days	Nymphs		Egg+Nymphs Fitted w/			
		temp F	1/days	Temp	1/days	Tlow=54F	Tlow=50F
59	0.05						
62.6	0.06	62.6	0.01	62.6	0.008	0.0084	0.0103
68	0.09	68	0.01	68	0.012	0.0137	0.0147
77	0.16	77	0.03	77	0.022	0.0225	0.0220
80.6	0.21	80.6	0.03	80.6	0.028	0.0260	0.0250
86	0.33	86	0.03	86	0.030	0.0313	0.0294
91.4	0.25	91.4	0.03	91.4	0.026		
rsq	6temps only				0.981		
slope	0.0098373		0.0010962		0.0009977	0.00097847	0.00081633
intercept	-0.5614		-0.0591		-0.0545	-0.0528	-0.0408
x-intercept	57.07		53.87		54.65	54	50
1/slope	101.65		912.27		1002.34	1022	1225

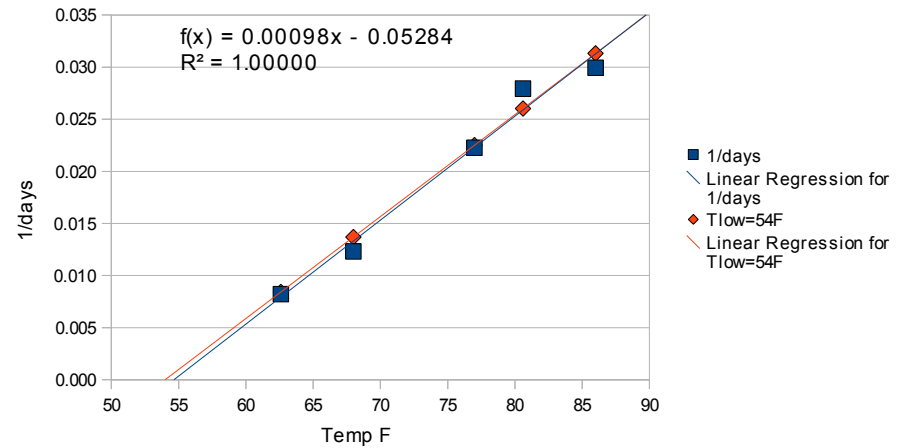
Deg C x-intercept  
 Deg C 1/slope

12.59      12.22      10  
 556.85      567.78      680.56

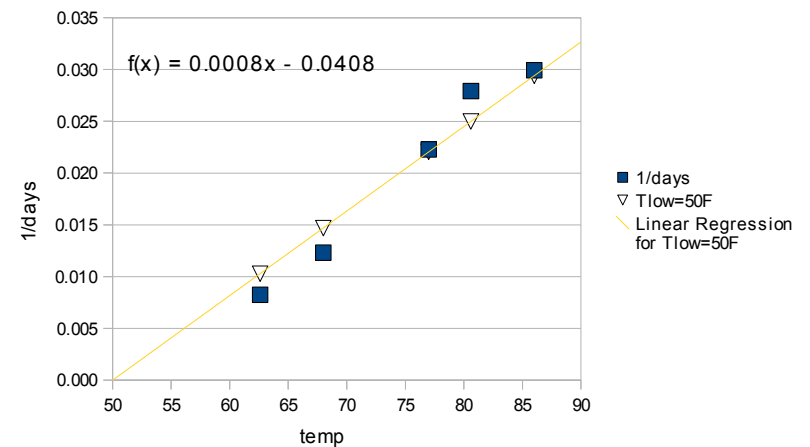
minor adj.s to Pre-OV May 3, x-check May 6, 2011

## IPPC model fitted to Nielsen et al data:

### Egg+Nymphal Development with fitted model using Tlow=54F



### Fitted to Tlow=50F



**2. Additional data from:**

**Nielsen and Hamilton JEE June 2009**

Macungie, PA – blacklight trap data 4.7km from Allentown PA

	pear	pear	apple
	2006	2007	2007
1 <sup>st</sup> adults activ	05/25/06	05/31/07	05/31/07
1 <sup>st</sup> eggs		07/02/07	
mean eggs		08/01/07	
1 <sup>st</sup> nymphs	07/10/06	07/01/07	07/10/07
2 <sup>nd</sup> gen adults	08/14/06	08/13/07	08/08/07

Est Date beginning female repro maturation  
 (subtract 147.7 Tlow 14.17C before May 31)  
 (subtract 339 Tlow 54F before May 31)

**3. Female Maturity (May 31 biofix)**

**cross check on female maturity (not used)**

	2005	2006	2007	2008	2009	2010		
Deg C (Tlow 14.17)	Est / reported	147.65	06/17/05	06/23/06	06/19/07	06/16/08	06/27/09	
Deg F (Tlow 57.5)		265.77				06/20/10	mean	
Est C Tlow 12.22	<b>188.5</b>	180	195	181	180	200	195	
Est F Tlow 54	<b>339.3</b>	<b>← compare to 414 Dds @ 25C lab data</b>						188.5
Est F Tlow 54 (Apr 1 biofix)		615	718	705	606	726	819	
Est F Tlow 54 (Mar 1 biofix)		620	758	735	614	745	863	
Est F Tlow 54 (Jan 1 biofix)		628	766	744	624	749	865	
							729.33	
							91.34	

**Total Egg to Female Mature**

Est C Tlow 12.22	<b>797.78</b>
Est F Tlow 54	<b>1436</b> ← total Egg, Nymphal, Pre-oviposition time

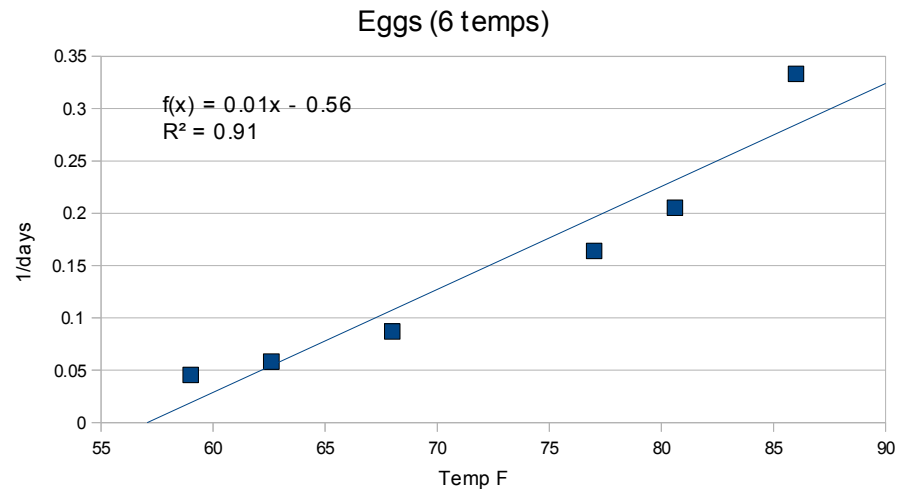
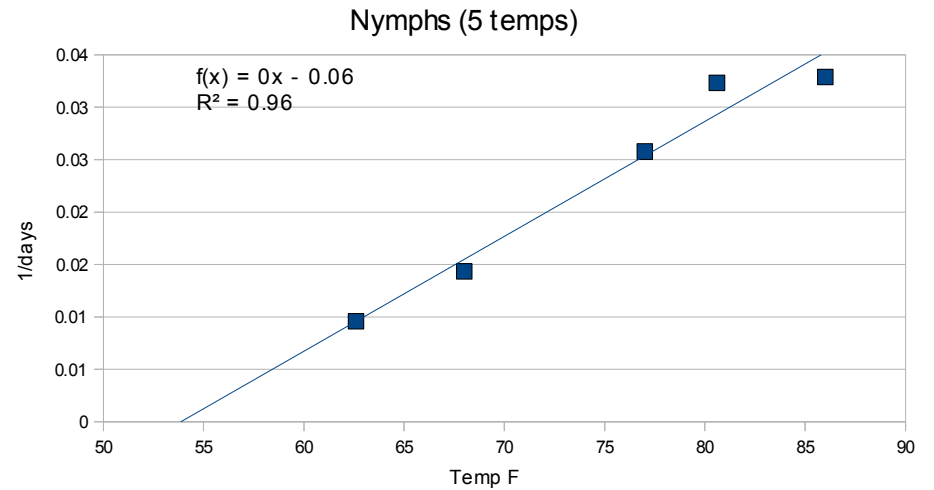
**4. Additional data from:**

**Nielsen and Hamilton AESA 608-616 2009**

NE US (Allentown, PA	date	DD	date	
Biofix May 31		2005 Tlow=54		2006
1 <sup>st</sup> adults(reprod. Immature)				
		2005	2006	2007
1 <sup>st</sup> eggs	(Dds > May 31 Tlow=14.2 Tr	104	82	53
	Date	06/13/05	06/15/06	06/07/07
peak nymphs	(Dds > May 31 Tlow=14.2 Tr	700	590	580
	Date	08/13/05	08/05/06	08/08/07
	Dds > Jan 1 Tlow=54 Thi=92	1808	1703	1691

Dds used: Tlow=14.17C = 57.5F

Nielsen data plotted (indicates threshold ca. 54F for Nymphs, ca. 57F for eggs)



**5. IPPC rationale for Thi=92F**

Lab data shows upper threshold ca. 86; add 6 for behavioral compensation+standard weather shelter vs. tree in-canopy temperature differences.

**6. Model assembly:**

**Model development table estimated values in:**

**Observed dates in bold+black, calculated values in normal+black**

Date females 1st post-repro. (est. from sampled nymphs or imag eclos for 2006)  
 Date 1st spring adults blacklight traps (est 2005 from 1st nymphs sampled)  
 Date 1<sup>st</sup> eggs sampled  
 Date / Dds eggs 1st laid (est from sampled nymphs)  
 Date / Dds eggs 1st laid (est from later imaginal eclosion – 1022DDs)  
 Date 1<sup>st</sup> Nymphs sampled  
 Peak 1<sup>st</sup> instar Nymphs sampled  
 Peak 3rd instar Nymphs observed (overall average mid season crops)  
 Date Imaginal Eclosion (550 DD 2006; 575 DD 2007, est from 1<sup>st</sup> eggs 2005)  
 Date final Nymphal peak  
 Date peak 2<sup>nd</sup> gen adults  
 Date 2nd gen 1st egg hatch (Southern states only)

**Model 1 – Biofix Jan 1 Tlow 54 Thi 92**

	2005	2005 Dds	2006	2006 Dds	2007	2007 Dds	Avg Dds
Date females 1st post-repro. (est. from sampled nymphs or imag eclos for 2006)	04/08/05	35	04/26/06	161	04/21/07	60	85
Date 1st spring adults blacklight traps (est 2005 from 1st nymphs sampled)	06/02/05	317	05/25/06	331	05/31/07	432	360
Date 1 <sup>st</sup> eggs sampled	06/13/05	539	06/15/06	618	06/07/07	540	566
Date / Dds eggs 1st laid (est from sampled nymphs)	06/10/05	449	06/17/06	637	05/29/07	391	492
Date / Dds eggs 1st laid (est from later imaginal eclosion – 1022DDs)	06/15/05	559	06/11/06	575	06/12/07	623	586
Date 1 <sup>st</sup> Nymphs sampled	06/20/05	657	06/27/06	845	06/10/07	599	700
Peak 1 <sup>st</sup> instar Nymphs sampled					06/13/07	650	
Peak 3rd instar Nymphs observed (overall average mid season crops)	08/13/05	1808	08/05/06	1703	08/08/07	1691	1734
Date Imaginal Eclosion (550 DD 2006; 575 DD 2007, est from 1 <sup>st</sup> eggs 2005)	08/04/05	1581	08/01/06	1597	08/06/07	1645	1608
Date final Nymphal peak	08/30/05	2149	08/29/06	2146	08/25/07	1981	2092
Date peak 2 <sup>nd</sup> gen adults	09/08/05	2287	09/02/06	2182	09/06/07	2170	2213
Date 2nd gen 1st egg hatch (Southern states only)	08/22/05	1995	08/22/06	2011	08/30/07	2059	2022

**7. Final model v. 1.0 (copy at top)**

Model Proposed: biofix Jan 1 Tlow 54 Thi 92 F ( 12.2 & 33.3 C)	DD (F)	DD {C}
Female adults begin reproductive maturation	85	47
1st Spring adults active /captured in blacklight traps	360	200
1 <sup>st</sup> egg laying	566	314
1 <sup>st</sup> nymphs summer gen	700	389
1 <sup>st</sup> adult emergence summer gen	1608	893
Peak 3rd instar nymphs (avg mid-season crops)	1734	963
1 <sup>st</sup> egg hatch 2 <sup>nd</sup> gen (Southern states only)	2022	1123
Final peak summer gen nymphs	2092	1162
Peak summer gen adults	2213	1229
1 <sup>st</sup> 2 <sup>nd</sup> gen adults (Southern states only)	2905	1614

**Alternate model (use Tlow 50 Thi 92); see #12 Model assembly**

Female adults begin reproductive maturation	143	80
1st Spring adults active /captured in blacklight traps	524	291
1 <sup>st</sup> egg laying	778	432
1 <sup>st</sup> nymphs summer gen	941	523
1 <sup>st</sup> adult emergence summer gen	2038	1132
Peak 3rd instar nymphs (avg mid-season crops)	2175	1208
1 <sup>st</sup> egg hatch 2 <sup>nd</sup> gen (Southern states only)	2544	1413
Final peak summer gen nymphs	2611	1450
Peak summer gen adults	2775	1542
1 <sup>st</sup> 2 <sup>nd</sup> gen adults (Southern states only)	3602	2001

**8. Compare Mich State Univ/APHIS PPQ model (Tlow=50F)**

Note: PPQ uses MSU (547DD)

as 1<sup>st</sup> emergence of adults (which matches IPPC model rather well):

Emergence Spring Adults (predicted only; no data available)

2011 MSU/PPQ IPPC

CoffeevilleBase 50 DiBase 54 DComment

04/25/11 558 407 IPPC 7 days earlier

04/18/11 493 360

Modesto CA

05/04/11 550 354 IPPC 1 day later

05/05/11 575 360

Red Bluff CA

04/25/11 555 347 IPPC 2 days later

04/27/11 572 360

Cape Gir. MO

04/30/11 553 392 IPPC 3 days earlier

04/27/11 514 360

**9. Est egg, instar devel Dds from Nielsen et al 2008 using proportionate development**

temp F	egg	1 <sup>st</sup>	2 <sup>nd</sup> days	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	total
20		11.5	9.34	16.25	11.78	13.66	82.69
25		6.1	4.82	9.62	7.08	7.38	45.44
27		4.87	4.25	7.64	5.49	5.9	35.96
30		3	3.7	7.05	6.11	6.1	34.43
		proportion					
20		0.14	0.11	0.2	0.14	0.17	0.24
25		0.13	0.11	0.21	0.16	0.16	0.23
27		0.14	0.12	0.21	0.15	0.16	0.22
30		0.09	0.11	0.2	0.18	0.18	0.25
Average (20-30)		0.12	0.11	0.21	0.16	0.17	0.23
<b>Average (20-27)</b>		<b>0.14</b>	<b>0.11</b>	<b>0.21</b>	<b>0.15</b>	<b>0.16</b>	<b>0.23</b>
Est Dds (54F;1022 total)		126.7	113.62	210.9	160.56	170.89	239.34
<b>Est Dds (54F;1022 total)</b>		<b>139.25</b>	<b>114.88</b>	<b>211.45</b>	<b>153.62</b>	<b>167.5</b>	<b>235.31</b>
Est Dds (50F;1225 total)		166.9	137.7	253.45	184.13	200.77	282.05

base50	base54F
1225	1022
249.52	208.17

Egg+60% 1<sup>st</sup> instar for interval 1<sup>st</sup> eggs to 1<sup>st</sup> sampled nymphs

566.66	472.76
--------	--------

50% egg dev. to mid 3rd Instar

574.89	479.62
--------	--------

mid 3<sup>rd</sup> instar to adult

**10. Brown Marm Stink Bug DD model – Notes from Mich. State Univ.:**

<http://www.ipmnews.msu.edu/fruit/Fruit/tabid/123/articleType/ArticleView/articleId/3247/Brown-Marmorated-Stink-Bug.aspx>

Michigan base 50F ← this should be 55F see 13. below  
 538 DD egg to adult “<- this is the Celsius value; fahrenheit would be ca. 968 DD  
 148 DD preov time at 77F “<- this is the Celsius value; fahrenheit would be ca. 266 DD

biofix full leaf in Allentown Penn.  
 adults emerge from OW sites mid-spring in northern states  
 first OV 1<sup>st</sup> week of June  
 molt to adults end of July/1<sup>st</sup> of Aug assoc w/large peak in flight activity  
 Fall adults continue to feed before moving to OW sites beginn. Early Sept.

validation data set:

**11. Compare USDA ARS/West Virginia Data to model**

(slide 94 of presentation at):

[http://stream.ucanr.org/fps\\_stinkbug/index.html](http://stream.ucanr.org/fps_stinkbug/index.html)

Note 1: adults gathered for caging may not have been 1<sup>st</sup> of season

Note 2: cage study will influence phenology (earlier events than expected)

Weather station used: C5204 Elev 442 Harpers Ferry, WV

	Cages		IPPC model pred.	
	Earliest dt	Last dt	Date	Dds
Egg masses observed	05/26/10	06/07/10	05/29/10	360
Summer Generation Adults	07/19/10	07/27/10	07/18/10	1608
2 <sup>nd</sup> gen eggs observed	07/26/10	07/28/10	07/28/10	1882
2 <sup>nd</sup> gen adults present	09/13/10	-	09/17/10	2905

Summary: generally adequate match

**12. Alternate model assembly: (Tlow 50F, Thi 92F)**

**Model development table estimated values in:**

**Observed dates in bold+black, calculated values in normal+black**

Date females 1st post-repro. (est. from sampled nymphs or imag eclos for 2006)	
Date 1st spring adults blacklight traps (est 2005 from 1st nymphs sampled)	
Date 1 <sup>st</sup> eggs sampled	
Date / Dds eggs 1st laid (est from sampled nymphs)	
Date / Dds eggs 1st laid (est from later imaginal eclosion – 1022DDs)	
Date 1 <sup>st</sup> Nymphs sampled	
Peak 1 <sup>st</sup> instar Nymphs sampled	
Peak 3rd instar Nymphs observed (overall average mid season crops)	
Date Imaginal Eclosion (550 DD 2006; 575 DD 2007, est from 1 <sup>st</sup> eggs 2005)	
Date final Nymphal peak	
Date peak 2 <sup>nd</sup> gen adults	
Date 2nd gen 1st egg hatch (Southern states only)	

**Model 2 – Biofix Jan 1 Tlow 50 Thi 92**

2005	2005 Dds	2006	2006 Dds	2007	2007 Dds	Avg Dds
04/08/05	69	04/26/06	252	04/21/07	109	143
06/02/05	480	<b>05/25/06</b>	501	<b>05/31/07</b>	591	524
06/13/05	739	06/15/06	869	06/07/07	726	778
06/10/05	653	06/17/06	905	05/29/07	549	702
06/15/05	799	06/11/06	811	06/12/07	841	817
<b>06/20/05</b>	884	<b>06/27/06</b>	1143	<b>06/10/07</b>	796	941
08/13/05	2258	08/05/06	2137	08/08/07	2129	2175
08/04/05	2013	<b>08/01/06</b>	2035	<b>08/06/07</b>	2066	2038
<b>08/30/05</b>	2659	<b>08/29/06</b>	2695	<b>08/25/07</b>	2478	2611
09/08/05	2843	09/02/06	2757	09/06/07	2725	2775
08/22/05	2493	08/22/06	2546	08/30/07	2593	2544

**13. Double check model from Nielsen et al. 2008 (refer to 10. above)**

Egg + Nymphal Devel. (from Table 2)

Pub. Included 537.63 C DD for devel but did not mention the associated Tlow, derived here:

C	1/days	Fitted to pub
17	0.008	<b>0.0078</b>
20	0.012	<b>0.0134</b>
25	0.022	<b>0.0227</b>
27	0.028	<b>0.0264</b>
30	0.030	<b>0.0320</b>
	<b>0.00185874</b>	
	<b>-0.0238</b>	
	<b>12.8</b>	← Tlow C needed to get 538 C DD
	<b>538</b>	
	<b>55.04</b>	← Tlow F needed to get 968 F DD
	<b>968.4</b>	

**Conclusion: use IPPC derived values as more appropriate for actual model use**

**Regression lines using Nielsen et al. Data:**

