IPPC Model Analysis Summary – Aug. 23, 2017 vers. 1.0

Northern Tamarisk Beetle (Diorhabda carinulata Brulle) Phenology (degree-day) Model

By Len Coop for use at Oregon State University's Integrated Plant Protection Center website http://uspest.org

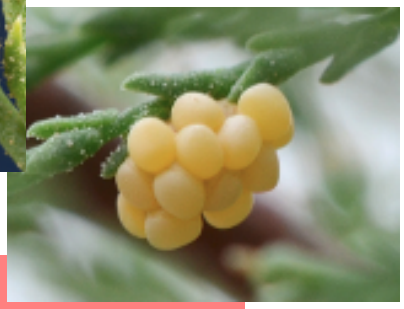
Developed for a biocontrol agent of Saltcedar (Tamarix spp.) for DoD SERDP project

"phenology modeling with photoperiod response", F. Grevstad, project P.I.

Model abbrev: dca

note significant data used in final model in salmon background

note points added to force x-intercept method in yellow



Parameters:	Celsius	Fahrenheit	
Lower Threshold:	11.11	52	
Upper threshold:	36.7	98	
Start Date:	Jan. 1st (adults overwinter in repro. diapause respond)		
Calculation Method:	single sine (U.C. Davis IPM recommended default method)		
Region of Known use:	Developed for use in the Western U.S.		
Validation status:	1st version based solely on analysis of sources below		
	Including Lab and field data; more data needed for validation.		

Summary of DD requirements for life stages:

Stage	DDs11.1 (C)	DDs52 (F)	notes
Eggs	95	171	
Larvae I-III	186	336	←obtain by subtracting egg and pupae from egg-to-adult
Pupae	188	338	
Egg-to-Adult	469	844	
Pre-OV	51	91	
Oviposition	156	281	
ca. 20% OV (use for gen time)	31	56	← expect to calibrate from field data peak to peak DD values
Gen time (expected peak to peak)	551	991	← expect to calibrate from field data peak to peak DD values
Spring first adults in sweep samples:	128	230	

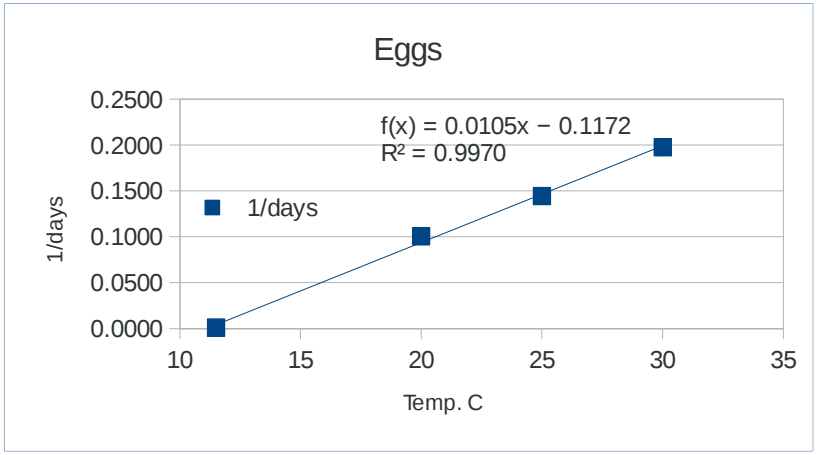
Model parameters from above: (use start date Jan 1):

Event	DDs11.1 (C)	DDs52 (F)	notes
Spring first adults in sweep samples:	128	230	
First egg hatch	248	446	← assume 1st adults were 50% done with Pre-OV
Peak egg hatch	279	502	← assume median/peak oviposition is 20% of Dds for full interval
Peak G1 larvae	372	670	
First G1 adults sens. to photoperiod	627	1128	← assume first adults w/10% of Pre-OV stage is sensitive
Peak G1 adults	653	1175	
Peak G2 larvae	923	1661	
First G2 adults sens. to photoperiod	1177	2119	
Peak G3 larvae	1473	2652	
First G3 adults sens. to photoperiod	1728	3110	
Peak G4 larvae	2024	3643	
First G4 adults sens. to photoperiod	2279	4101	

1. Herrera, A.M., D.D. Dahlsten, N. Tomic-Carruthers, and R.I. Carruthers. 2005. Estimating Temperature-Dependent Developmental Rates of Diorhabda elongata (Col: Chrysomelidae), a Biological Contral Agent of Saltcedar (Tamarix spp.). Env. Entomol. 34:775-784.

Table 1. **Eggs**

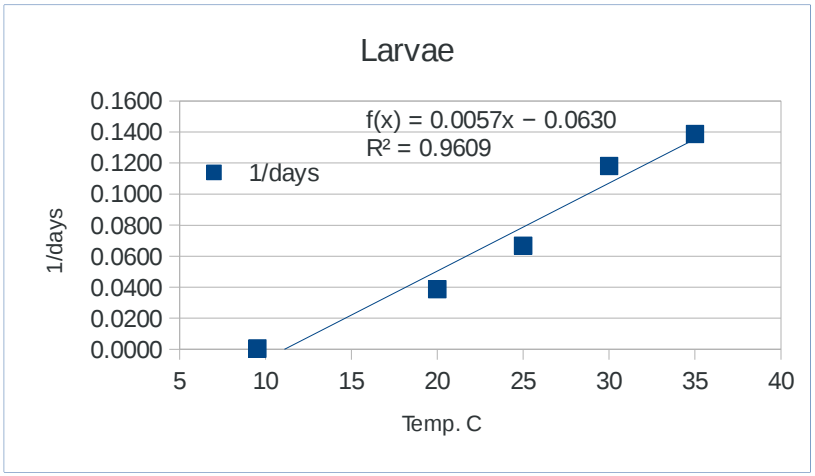
		Temp. C	1/days	Days
		11.5023	0.0010	1000
		20	0.1006	9.94
		25	0.1445	6.92
		30	0.1976	5.06
delete non-linear point--→			0.2092	4.78
		Slope=b	0.0105	
		intercept=a	-0.1172	
	Tlow	X-interc -a/b	11.1100	
	DD-req	1/slope	94.79	
		RSQ	0.9970	



Notes: Eggs are only stage with a Tlow significantly lower than other stages; 11.11 proposed as best overall Tlow

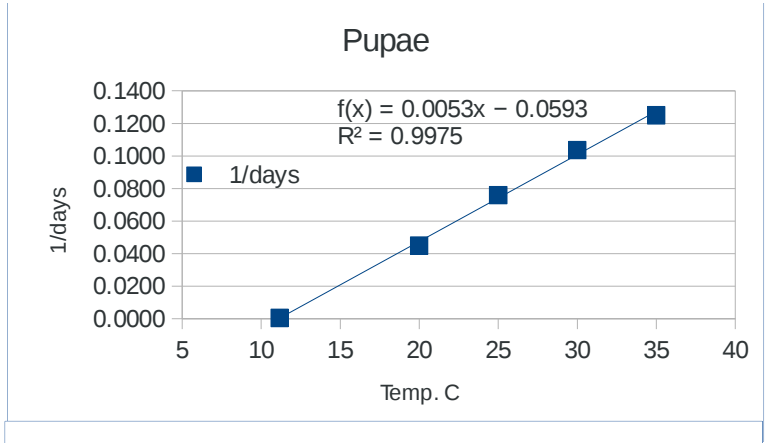
Larvae I-III

		Temp. C	1/days	Days
		9.5353	0.0005	2000
		20	0.0388	25.79
		25	0.0667	15
		30	0.1181	8.47
		35	0.1387	7.21
		Slope=b	0.0057	
		intercept=a	-0.0630	
		X-interc -a/b	11.1100	
	DD-req	1/slope	176.41	
		RSQ	0.9609	

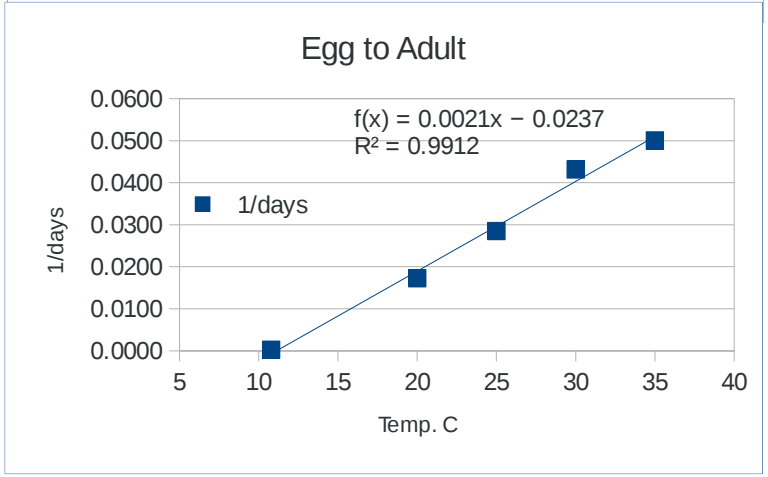


Notes: Larvae is stage with apparent highest Tlow, but 11.11 not far out-of-range; actual Tlow for larvae more like 13 C

Pupae	Temp. C	1/days	Days
	11.1622	0.0005	2000
	20	0.0449	22.29
	25	0.0759	13.17
	30	0.1036	9.65
	35	0.1250	8
	Slope=b	0.0053	
	intercept=a	-0.0593	
	X-interc -a/b	11.1100	
DD-req	1/slope	187.51	
	RSQ	0.9975	



Egg-to-Adult	Temp. C	1/days	Days
	10.7818	0.0003	4000
	20	0.0172	58.02
	25	0.0285	35.09
	30	0.0431	23.18
	35	0.0500	19.99
	Slope=b	0.0021	
	intercept=a	-0.0237	
	X-interc -a/b	11.1100	
DD-req	1/slope	468.79	
0.9911	RSQ	0.9912	

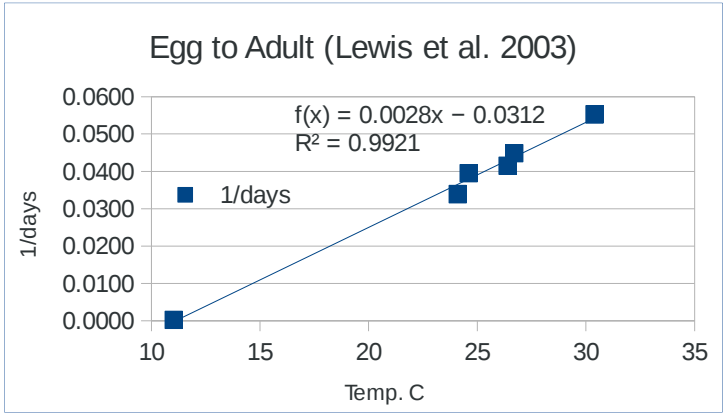


Notes: Egg-to-Adult curve fits 11.11 C Tlow fairly well

2. Lewis, P.A., C.J. DeLoach, A.E. Knutson, J.L. Tracy, and T.O. Robbins. 2003. Biology of Diorhabda elongata deserticula (Col: Chrysomelidae) an Asian leaf beetle for the biological control of saltcedars (Tamarix spp.) in the United States. Biol. Control. 27:101-116.

Table 2.

Egg-Adult	Temp. C	1/days	Days
	11.025	0.0003	4000
	24.1	0.0339	29.5
	24.6	0.0395	25.3
	26.4	0.0415	24.1
	26.7	0.0448	22.3
	30.4	0.0552	18.1
	Slope=b	0.0028	
	intercept=a	-0.0312	
	X-interc -a/b	11.1100	
DD-req	1/slope	355.69	
0.9921	RSQ	0.9921	



Notes: significantly fewer egg-to-adult DDs (113) required than source #1.

	Temp. C	1/days	Days	
Pre-OV				DD-req
	24.1	0.2564	3.9	50.7 ← = 24.1-11.11 x 3.9 days

Notes: the preovipostion period appears to be about 50.7 DDs at Tlow=11.11; more data is needed to improve this estimate

	Temp. C	1/days	Days	
Adult OV				DD-req
	24.1	0.0833	12	155.9 ← = 24.1-11.11 x 12 days

Notes: the female ovipostion period appears to be about 156 DDs at Tlow=11.11; more data is needed to improve this estimate
also having full data to model the shape of the oviposition curve would be helpful in population modeling

3. Field data on first collection of adults (use lowest C.V. method to estimate Tlow and DDs to first springtime activity) Tupper=98F

data from Grand Junction CO collected by Colorado State Biological Control program (D. Bean, pers. Correspond.)
example command to run: (in Directory /usr/local/dds/bin):
./run_batch_dds.pl station=GDVC2 calc=S1 year=2012 start=01-01 end=04-19 final_only=1 tlow=50 tlowmax=56 thi=98 thimax=98

			Tlow F						
	Sample Date	sta=KGJT	50	51	52	53	54	55	56
	04/19/12		291.7	266.7	243.1	220.9	200.2	180.7	162.6
	04/30/13		223.5	201.7	181.5	162.8	145.5	129.3	114.6
	05/02/14		234.6	207.2	182.3	159.9	139.8	121.9	105.9
	04/14/15		260.2	233.8	209.1	185.9	164.5	144.8	126.7
	04/26/16		229.4	204.8	182	161	141.9	124.2	108.1
Outlier year removed →	04/21/17								
		Avg DDs	247.9	222.8	199.6	178.1	158.4	140.2	123.6
		stdev	28.2	27.7	27.0	26.2	25.3	24.3	23.3
		CV	11.38	12.41	13.53	14.72	16.00	17.37	18.83

Notes: this is Grand Junction airport weather

		sta=GDVC2	50	51	52	53	54	55	56
	04/19/12		328.8	301.3	275.7	251.5	228.5	206.8	186.4
	04/30/13		302.4	273.8	247.4	222.9	200.3	179.6	160.6
	05/02/14		339.4	304	271	240.4	212.4	187.1	164.3
	04/14/15		358.6	325.6	294.6	265.6	238.5	213	189.2
	04/26/16		327.2	294.6	264.4	236.7	211.1	187.5	165.6
2017 was confirmed	04/21/17		434.3	396.3	360.6	326.9	295.4	266.1	238.8
as an outlier, this result		Avg DDs	348.5	315.9	285.6	257.3	231.0	206.7	184.2
not used.		stdev	45.9	42.8	39.8	37.0	34.3	31.8	29.4
		CV	13.16	13.53	13.94	14.37	14.86	15.38	15.94

Notes: redo with dropping of possibly late sampling date during 2017; need to check raw data to confirm this assumption

		sta=GDVC2	50	51	52	53	54	55	56
	04/19/12		328.8	301.3	275.7	251.5	228.5	206.8	186.4
	04/30/13		302.4	273.8	247.4	222.9	200.3	179.6	160.6
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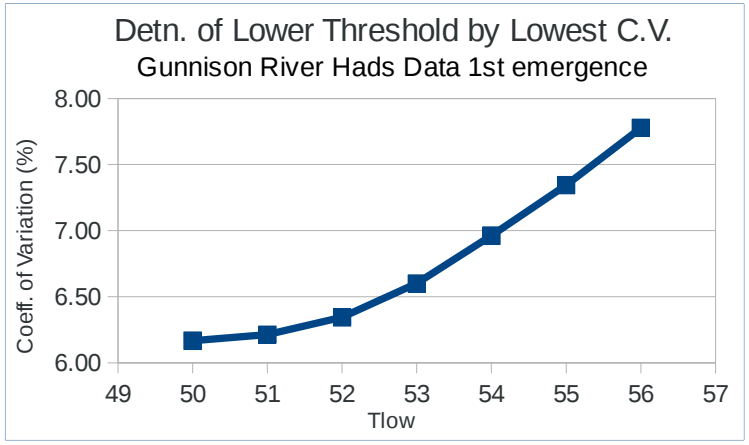
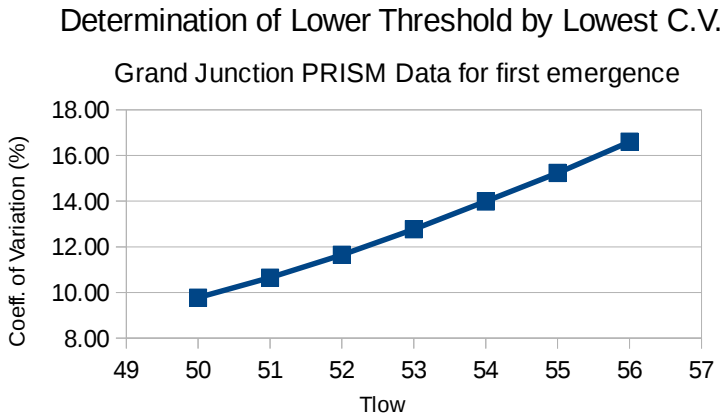
	04/14/15		358.6	325.6	294.6	265.6	238.5	213	189.2
	04/26/16		327.2	294.6	264.4	236.7	211.1	187.5	165.6
Outlier year removed →	04/21/17								
		Avg DDs	331.3	299.9	270.6	243.4	218.2	194.8	173.2
		stdev	20.4	18.6	17.2	16.1	15.2	14.3	13.5
		Temp F:	50	51	52	53	54	55	56
		CV	6.17	6.21	6.34	6.60	6.96	7.34	7.78



sta=PRISMDATAEXPLOR Grand Junction CO Lat:39.076 Long:-108.5139 (data from PRISM Data Explorer)

			50	51	52	53	54	55	56
	04/19/12		303.2	277.6	253.5	230.9	209.8	189.9	171.3
	04/30/13		237.3	213.8	191.8	171.3	152.4	135.2	119.3
	05/02/14		255.8	226.6	199.8	175.5	153.5	133.8	116.1
	04/14/15		289.3	261.1	234.5	209.7	186.5	164.9	145.2
Outlier year removed →	04/26/16		264	237	212	188.8	167.4	147.7	129.6
	04/21/17								
		Avg DDs	269.9	243.2	218.3	195.2	173.9	154.3	136.3
		stdev	26.4	25.9	25.4	24.9	24.3	23.5	22.6
		Temp F:	50	51	52	53	54	55	56
		CV	9.77	10.65	11.65	12.77	13.99	15.23	16.59



Notes: expected range of “best” tlow is 52-55 F; C.V. continues to decrease with leveling near 52, indicate 52 as best Tlow

Average of locations used above:

Temp F	52.00
avg	229.51
stdev	23.20
CV	8.99

Notes: Average DDs @Tlow=52F is 230 for first emergence in the Grand Junction CO area. More data from additional locations would be helpful.

4. Rationale for selection of common Tlow and Tupper values for DD modeling:

Candidate Tlow values: Note Lewis et al. 2003 published 12.5 C (54.5 F) as the developmental Tlow

Deg. F	Deg. C	
51	10.56	
52	11.11	←accommodate egg stage, first spring adults lowest C.V. analysis
53	11.67	
54	12.22	← would use as better threshold for larval+pupal only development
55	12.78	

Candidate Tupper values: From temp-devel studies, some stages w/mortality at 35 C

98	36.67	← use this value for Tupper until better info is available
99	37.22	
100	37.78	