Cereal leaf beetle – degree-day/phenology model
Model synthesis/adaptation/summary by Len Coop, OSU IPPC – version August 20, 2009

Sources Summary table starts cell B169

1. Fulton and Haynes 1975 Env. Ent. 4:357-360 (Michigan)
3. Guppy and Harcourt 1978. Can Ent. 110:257-263 (Ontario Canada)
4. MSU Extension model pub: Blodgett, Tharp, and Kephart 2004 MT200406AG (Montana)
http://msuextension.org/publications/AgandNaturalResources/MT200406AG.pdf
5. OSU seed extension pub: Hoffman, Rao, Ehrensing 2005 (W. Oregon – spring planted Oats)
http://cropandsoil.oregonstate.edu/seed-ext/Pub/2005/19.pdf
"+see below for others

1. Fulton and Haynes 1975 Env. Ent. 4:357-360 (Michigan)

	Dds F (45)	Dds C (7)est	Dds F (48)	Dds C (9)
50% adults leave OW sit	119.79	66.55	99	55
50% egg laying	331.06	183.92	273.6	152
50% egg hatch	511.83	284.35	423	235
50% 3rd instar	729.63	405.35	603	335
50% 4th instar	801.5	445.28	662.4	368
50% pupae	1285.02	713.9	1062	590
50% summer adult emer	1568.16	871.2	1296	720

2. APHIS PPQ /NAPPFAST PEST ASSESSMENT (May 27,2003) estimates derived from Guppy & Harcourt and various assumptions
Tlow: 9 C = 48.2 F

Event	DdsF (48.2)	DdsC (9)
Adult Acitivity 1	9	5
Adult Acitivity 2	45	25
Eggs Begin	46.8	26
Eggs End	203.4	113
Larvae Begin	205.2	114
Larvae End	457.2	254
Pupae Begin	459	255
Pupae End	880.2	489
Adult Emerge	882	490

Reasons to reduce emphasis on the above: While based primarily on 1 good (but limited) lab study (Guppy and Harcourt 78), the assumption of adult activity beginning at 5 Dds (C) is not based
on field data, plus the stage durations are inappropriately applied to beginning appearance to end appearance of stages when they only apply to for example
from 50% to 50% (1% to 1% etc) stage development between stages, and were not compared to actual field data, which is abundantly available to develop proper start times and field comparisons
For example, Guppy and Harcourt use field data to validate their parameters starting June 19, which would be a much higher DD accumulation than 5-25 Dds as assumed above

3. Guppy & Harcourt 1978

Tlow: 44.6F	Dds F (45)	Dds C (7)	Dds F (48)	Dds C (9)	
eggs	221	105	188.6	87	
larvae	299	166	278.6	137	
pupae	508	282	453.2	234	
gen time	1028	571.11	856.4	458	"<-does not include adult activities
					"(mating, pre-OV, etc; estim 50-70 Dds C(9))

4. Blodgett et al (Tlow 44.6 F)

					avg date normal	dds normals
early adult activity	176	97.78	138.2	59	05/13/00	59
1st egg laying	253	140.56	192.2	89	05/22/00	89

avg Dds < Apr 16: 83

5. Hoffman et al. (Tlow 4

	Dds F (45)	Dds C (7)	Dds F (48)	Dds C (9)	reported Dds (8.9 C)> Apr 16 nominal start date:
approx 1st eggs	280	106.48	158.4	88	5
peak egglaying	663.4	257.73	383.4	213	130
90 egglaying	951.4	451.33	671.4	373	290
98% egglaying	1113.4	560.23	833.4	463	380

Notes: Spring planted grains – winter wheat would show earlier activity

6. Evans, Karren, Israelsen 2006 JEE:99:1967-73 (N. Utah)

Tlow: 48.0 F (8.9 C) (converted on the fly to 45 F using concurrent calculations using Logan Utah airport data 30yr avg data+2005-2009 data) reported Dds > Jan 1 (8.9 C) nominal start date

	Dds F (45)	Dds C (7)	Dds F (48)	Dds C (8.9)	date	ratio (9 vs 7)
approx 1st eggs	252	140	162	90	05/10/05	1.56
peak egglaying	396	220	270	150	05/23/05	1.47
early (10%) larvae	295.2	164	189	105	05/14/05	1.56
peak larvae	612	340	432	240	06/07/05	1.42
90% larvae	1224	680	936	520	07/06/05	1.31

7. Gage and Haynes (1975) weather station: Kellogg Metar Mich.

	Dds F (45)	Dds C (7)	deg F (48)	deg C (8.9)	avg date	ratio (9 vs	1971 deg F (48)	1972 deg F (48	1973 deg F (48)
CLB larval 2% emerg	520	288.89	395	219.44	05/28/00	1.32	355	400	430
CLB larval 50% emerg	816	453.33	640	355.56	06/12/00	1.28	560	620	740
CLB larval 90% emerg	1020	566.67	813.33	451.85	06/21/00	1.25	750	740	950
summer CLB adults 2%	1285	713.89	1145	636.11	07/02/00	1.12	1100	1190	
summer CLB adults 50%	1620	900	1350	750	07/15/00	1.2	1250	1450	

summer CLB adults 90%	1830	1016.67	1520	844.44	07/23/00	1.2	1440	1600

8. Kidd, K.A. Cereal Leaf Beetle Parasitoid Insectary Program 2002 (N. Carolina)
http://www.ncagr.gov/plantindustry/plant/bioctrl/documents/02AR.pdf

					2001		2002	
Approx events:	Dds F (45)	Dds C (7)	Dds F (48)	Dds C (8.9)	date	Dds48	date	Dds48
					04/09/01	242	04/15/02	353
					04/20/01	430	04/20/02	480
1st larvae found	420	233.33	297.5	165.28	04/09/01	242	04/15/02	353
peak larvae found	821	456.11	629	349.44	05/03/01	558	05/01/02	700
end eggs found	890	494.44	687.5	381.94	05/03/01	558	05/09/02	817
end larvae found	1078	598.89	845	469.44	05/15/01	768	05/15/02	922

9. Miczulski et al. 1975 Studies regarding the bionomics, economic importance and natural control factors affecting Oulema Spp. (cereal leaf beetles) in Poland – Final Report P.L. 480 (unpubl. from IPPC library)
Notes: Winter and spring planted grains (wheat, oats, barley, rye); sample dates and Dds not very precise
Tlow: 50 F (10.0C) (converted on the fly to 45 F similar to above w/ same Latitude (51.3) from Saaverage approx date

Approx events:	Dds F (45)	Dds C (7)	Dds F (48)	Dds C (9)	Dds F (50)	Dds C (10)	approx da	Saskatch	ratio 7 vs 9
approx 1st adults	70.2	39	37.8	21	25.2	14	04/20/74	04/30/00	1.86
approx peak adults	198	110	136.8	76	108	60	05/15/74	05/17/00	1.45
approx last adults	1117.8	621	867.6	482	738	410	07/10/74	06/05/00	1.29
1st eggs found	118.8	66	75.6	42	54	30	05/05/74	05/08/00	1.57
peak eggs found	342	190	246.6	137	198	110	06/01/74	05/29/00	1.39
last eggs found	648	360	484.2	269	405	225	06/24/74	06/17/00	1.34
1st larvae found	513	285	374.4	208	306	170	06/20/74	06/09/00	1.37
peak larvae	702	390	529.2	294	441	245	07/04/74	06/20/00	1.33
last larvae	1197	665	941.4	523	810	450	07/20/74	07/14/00	1.27

10. State Extension Resources online

Mich. State Univ. Pest alerts 2009 – 1 gen/yr in Mich. - adults in summer feed briefly then become inactive around field margins before overwintering
Vermont Extension – Egg laying ranges from late March to early May, Adult beetles emerge in late May and June; only 1 gen/year
http://www.pubs.ext.vt.edu/444/444-350/444-350.html

N. Carolina Extension – CLB adults dormant until Mid-April 2009
http://cleveland.ces.ncsu.edu/files/library/23/fieldcrops%20newsletter%20May%202009.pdf

11. Notes on biology:

-Adult beetles complete diapause in December and become active with warm temperatures in the Spring, in Mich -> early April (Wellso and Hoxie 1981)
-Spring adult activity and oviposition are in part determined by host crop phenology and suitability, but wheat, barley and oates show little difference when of the same planting data (various sources)
It is presumed that activity on winter wheat would precede spring wheat, but the later planted crops indicate the potential for late egglaying, even as late as mid July in Oregon (Hoffman et al 2005)

-Last OW adults can overlap with 1st summer adults (various sources)
Release of parasitoid Tetrastichus Julis can begin as soon as 1st instar larvae are present (Evans et al 2006)

-Females have mature ovaries once temp > 10C after Jan 1; adults leave OW sites once 3 days reach a Tavg of 15.4 C (Gutierrez et al. 1974 J. Anim. Ecol. 43:627-40)
Wheat and Oats are mature enough for infestation after 27.7 Dds (10C) of growth (Ibid)

Synthesis Tables

Color codes:
"=derived using field data+Guppy and Harcourt devel. table
"=rough estimate from Guppy and Harcourt, Fulton and Haynes
Assumptions: converting from base of 8.9 to 9.0 C is of minimal error

Combined Model – Dds C (base 9C) after Jan 1
rank of emphasis: Fulton & Haynes, Evans et al, Hoffman et al, Gage & Haynes, Blodgett et al, Kidd, Miczulski

Event	Combined Dds C (9)	Michigan 1 Fulton	Utah 6. Evans	Oregon 5. Hoffman	Michigan 7. Gage	Montana 4. Blodget	N. Carolin 8. Kidd	Poland 9. Miczulski
1st adult emerge	50	55				59		21
1st egg laying	80		90	88	123	89	78	42
50%/peak egg laying	150	152	150	213			193.5	137
1st egg hatch	165		177	175	210		165	208
early/10% larvae	180		105	195	219			
50%/peak egg hatch	240	235	237	300	268		262	
90% egg laying	340			373				
peak larvae	360	350	240	367	355		349	294
end (90%) egg hatch	420			550			382	269
90% larvae/end larvae	500		520	527	452		469	523
end OW adults	520							482
1st summer adult emerge	550	550		546	636		536	
50% summer adult emerge	730	720			750		583	
90% summer adult emerge	850				844		703	

Summary Table:

Event	Combined Dds C (9)	Convert Dds F (48)
1st adult emerge	50	90
1st egg laying	80	144
50%/peak egg laying	150	270
1st egg hatch	165	297
early/10% larvae	180	324
50%/peak egg hatch	240	432
90% egg laying	340	612
peak larvae	360	648
end (90%) egg hatch	420	756
90% larvae/end larvae	500	900
end OW adults	520	936
1st summer adult emerge	550	990
50% summer adult emer	730	1314
90% summer adult emer	850	1530

Combined cross check	combined	Ref value Guppy&Harcourt
diff 1st OV, 1st Hatch	85	87
diff 50% OV, 50% Hatch	90	87
diff 90% OV, 90% hatch	80	87
diff 1st OV, peak larval	280	305.5
diff 1st OV, 1st summer adult	470	458
diff 1st OW adult, 1st summe	500	530
diff 50% egg lay, 50% sumn	580	645
diff 90% egg lay, 90% sumn	510	??