

Monochamus alternatus (Japanese Pine Sawyer Beetle) Degree-Day Model Documentation

Len Coop Apr 25, 2016 vers. 1.0 (For APHIS PPQ CPHST)

Sources and Data:

(Note significant data used in final model highlighted in Salmon color)

1. NAPPFAST Model Documentation June 2008

Aphis 1; generic Dds; Base Temp. 13C 981 DD total

Egg 85, larvae 369, pupae 333.3, adult 193 based on Enda 1975, Okuda 1973, Park et al 1992, and Rutherford et al 1987

Exclusion: Aphis 1 Generic 1; X < A where Avg temp -25C

Prob of 1-3 gens

Exclus: Prob of unfav temps -25C

2. Park, C.G, DS Kim, SM Lee, YS Moon, YJ Chung, DS Kim. 2014. A forecasting model for the adult emergence of overwintered Monochamus alternatus (Coleoptera: Cerambycidae) larvae based on degree-days in Korea. Appl Entomol. Zool: 49:35-42

Selected Jan 1 start date; 11.9C as best low temp threshold

3 types of models for when they OW as: 4th instar (advance mode), 3rd instar (delay mode), regular mode (blend of 3rd and 4th instars

DD reqs: 5% emerg 10% emerg 25% emerg 50% emerg 75% emerg 90% emerg

preliminary (ignc 210 240 321 416 510 591

advance year 200 230 260 340 405 584

Regular year 204 270 350 420 500 600

Delay year 245 310 410 500 580 635

avg of adv+reg 202 250 305 380 452.5 592

avg of adv+reg 196 243 297 370 440 576 Convert 11.9 to 12.2 Tlower

3. Kobayashi F, Yamane A, Ikeda T (1984) The Japanese pine sawyerbeetle as the vector of pine wilt disease. Annu Rev Entomol 29:115-135

Tlow=11.9 or 12.5C

DD to 50% emerge: 540 (11.9base) or 500 (12.5base)

(and see below)

3. Togashi, K. 1989. Development of Monochamus alternatus Hope (Coleoptera: Cerambycidae) in relation to oviposition time. Jap. J. Appl. Entomol. Zool. 33: 1-8.

Ovip sometimes as late as Oct in central Japan

4. Togashi and Magira 1981.

Avg life-span of adults is 7 weeks in outdoor cages in central Japan,

5. Song et al 1991

Avg life-span of adults is 12-13 weeks in outdoor cages in Guangdong

Bivoltine, adults first emerge Apr-May, 1st gen July-Aug

If trivoltine emerge Mar-Apr, June-July, mid-Oct-early Nov

6. Ma, R-Y, S.-G. Hao, W-N Kong, J.-H. Sun, and L. Kang. 2006. Cold hardiness as a factor for assessing the potential distribution of the Japanese pine sawyer Monochamus alternatus

(Coleoptera: Cerambycidae) in China. Ann. For. Sci. 63:449-456.

7. Misc notes from CABI data sheet: <http://www.cabi.org/isc/datasheet/34719>

Wang 1988.

Univoltine in Jiansu China, bi or trivoltine in Guangdong (Song et al 1991)

Adults emerge reproductively immature; feed on bark of pine twigs; males take at least 5 days before mating; females take at least 3 weeks before able to oviposit; large variation in Pre-OV period

Immature adults disperse in random direction; attracted to extracts from healthy Pinus tree trunks.

Mature adults attracted by monoterpenes and ethanol emitted from damaged/dying Pinus trees.

Not a strong flyer, fly more while immature; found to move 7 to 40 m per week in Pinus thunbergii stands (Togashi 1990)

Known to fly up to 1-2 km (Fujioka 1993)

Adults are nocturnal (Nishimura 1973)

Age-specific fecundity curve is unimodal under outdoor conditions; Mean fecundity was 86 in Ishikawa (Togashi and Magira 1981)

Mean fecund was 33 in Nara (Shibata 1987); 157, 78, and 24 for early, mid, and late emerged females (Togashi and Magira, 1981)

Mean fecund was 88 in Jiangu China (Wang, 1988)

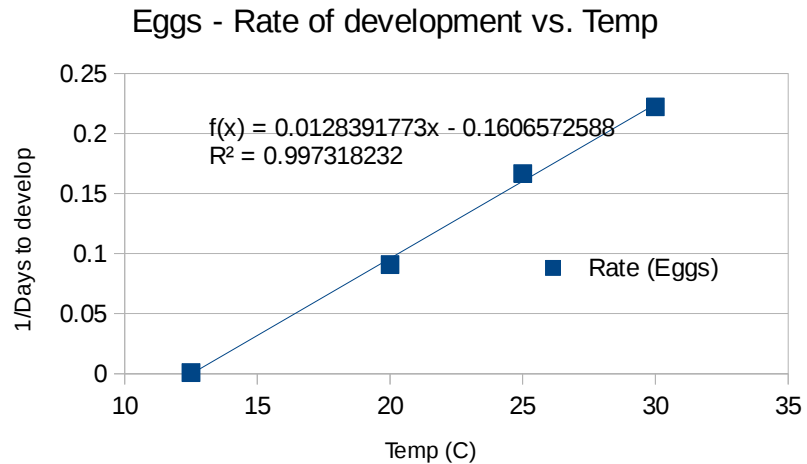
Lifetime fecund range 0 to 343.

Summary of Degree-Day Estimates

	DD reqs: C	Tlow ©	Notes	Ref
Eggs	85.5	12.9	10 to 12 days at 20 C, 5-7 days at 25 C, and 4-5 days at 30 C	Okuda 1973 rev. by Kobiashi et al. 1984

X-intercept method using Okuda 1973 data:

Temp	Rate (Eggs)	days
12.5	0.001001001	999
20	0.090909091	11
25	0.166666667	6
30	0.222222222	4.5
Slope	0.012839177	
Intercept	0.160657259	
R2	0.9973	
1/Slope	77.88661038	
X-intercept	-12.51304932	



65	12.7
89	13
80	12.5 Based on all of the above

rev. by Kobiashi et al. 1984
rev. by Kobiashi et al. 1984

Larvae feed on inner bark to develop
 3rd and 4th instars excavate a tunnel in wood & enter when danger occurs
 central Japan OW at 1st to 4th instar larvae
 diapause terminated by cold (chilling units) in winter; by mid-Feb in the field

Togashi 1989
 Togashi 1991

333.3 12.6 for post-diapause larvae to pupate
 526.3 11.9 for post-diapause larvae to adults
 625 12.5 full non-diapause larval development
 540 12.5 time to 50% adult emerg in spring from OW larvae (maybe warmer climate)

Enda 1975
 Enda 1975
 rev. by Kobiashi et al. 1984 (Okuda 1973)
 rev. by Kobiashi et al. 1984 (Okuda 1973)

Pupae 12-13 days at 25 C

Yamane 1974

X-intercept method using Yamane 1974 data:

Temp	Rate (pupae)	days
12.2	0.00010001	9999
25	0.08	12.5
slope	0.006242187	
intercept	0.076054668	
1/slope	160.2002708	
160	12.5 Estim. From above data point by Yamane 1974	

diapause obligate in Japan and facultative in Taiwan
 in nature 17-19 days
 187 10.6 Refs 13,17 in review article

Okuda 1969 & Enda and Kitajima 1990
 rev. by Kobiashi et al. 1984
 rev. by Kobiashi et al. 1984

Adult Pre-OV mating begins 10 days after emergence; eggs not yet mature in females upon emerg
 rev. by Kobiashi et al. 1984

100 12.5 rough estim. From above assuming emerge mid-late march

Adult OV peak OV at 45 days after emerg.
 OV period ranges from 20 to 30 days with threshold of 21.3 C

rev. by Kobiashi et al. 1984
 rev. by Kobiashi et al. 1984 (59 & 184)

X-intercept method using above data:

X-intercept method using above data; forced through 12.5 C Tlow

Temp	Rate (PreOV)	days	Temp	Rate (PreOV)	days
21	0.001001001	999	12.5	0.001001001	999
24	0.022727273	44	24	0.022727273	44
28	0.041666667	24	28	0.041666667	24
30	0.05	20	30	0.05	20
slope	0.005368667		slope	0.002713458	
intercept	0.109394441		intercept	0.037761854	
1/slope	186.2659763		1/slope	368.5334767	

(this is coarse and could be improved with access to refs such as 184, Takizawa 1980)

Therefore a rough estimate of OV period is 368 DD (12.5 Tlow)
 50% OV period would be 184 DD (12.5 Tlow), estim. 35% OV would be 100 DD (rough estim.)

OV for gens 100 12.5 value to use to estimate generation time

Adults adult flight ceases below 18 C rev. by Kobiashi et al. 1984
 movement (dispersal) ranges from 800m to 3.3 km rev. by Kobiashi et al. 1984

Gen Time Normal: 1 gen/yr; cooler climate: 1 gen/2 yrs; rev. by Kobiashi et al. 1984
 1065 12.5 Estimated from above (Egg+Larvae+Pupae+PreOV+35%OV); mainly Okuda 1973
 981 13 Nappfast model
 1133 11.9 Estimated conversion from 1065 at 12.5 (see Appendix 1)
 1102 12.2 Estimated conversion from 1065 at 12.5 (see Appendix 1)

OW to 5% (first) emerge
 202 11.9 Park et al 2014 (Korea); table above
 196 12.2 Estimated conversion from 202 at 11.9 (see Appendix 1)

OW to 50% emerge
 500 11.9 time to 50% adult emerg in spring from OW larvae (maybe cooler climate) rev. by Kobiashi et al. 1984
 540 12.5 time to 50% adult emerg in spring from OW larvae (maybe warmer climate) rev. by Kobiashi et al. 1984 (Okuda 1973)
 380 11.9 Park et al 2014 (Korea)
 370 12.2 Estimated conversion from 380 at 11.9 (see Appendix 1)

OW to 90% emerge
 592 11.9 Park et al 2014 (Korea)
 576 12.2 Estimated conversion from 592 at 11.9 (see Appendix 1)

Summary of Phenology Model for Monochamus alternatus (using a common lower threshold of 12.2 C)

Start Date: January 1st
 Calc Method: Single Sine

	<u>Deg. C</u>	<u>Deg. F</u>
Tlower	12.2	54.0
Tupper	38	100.4

<u>Event</u>	<u>DD C</u>	<u>DD F</u>
OW to 5% (first) emerge	196	353
OW to 50% emerge	370	666
OW to 90% emerge	576	1037
2 nd Generation 5% emerge	1298	2336
2 nd Generation 50% emerge	1472	2650
2 nd Generation 90% emerge	1678	3020
3 rd Generation 5% emerge	2400	4320
Full generation time (35% OV to 35% OV)	1102	1984

Note: only adult OV indicated to have a significantly higher Tlower = 21.3 C;

Appendix – Estimated conversion from 12.5 C 1065DD → 11.9 and to 12.2 C (=54F)

Strt Apr 1 Method used: 3 yrs x 4 locations where insect is likely to survive; calc Date of 1065 Dds @ 12.5; change Tlow to find Dds for same date

Code	AP525	AP525	AP525	KBGD	KBGD	KBGD
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Loc	Anderson CA	Anderson CA	Anderson CA	Borger CO	Borger CO	Borger CO	
Date 1065	07/23/15	07/28/14	07/23/13	07/25/15	07/20/14	07/16/13	
Dds @ 11.9	1128	1145	1135	1133	1139	1120	
Dds @ 12.2	1101	1112	1101	1101	1109	1092	

KPBF	KPBF	KPBF	NNAG1	NNAG1	NNAG1	Average
Pine Bluff AR	Pine Bluff AR	Pine Bluff AR	Newnan GA	Newnan GA	Newnan GA	
07/13/15	07/22/14	07/20/13	07/12/15	07/22/14	07/26/13	
1143	1128	1127	1128	1133	1140	1133
1112	1097	1097	1097	1100	1107	1102