A COMPARISON OF DIAPAUSE IN THE ASIAN AND NORTH AMERICAN GYPSY MOTH—IMPLICATIONS FOR POPULATION ESTABLISHMENT

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Abstract

The Asian gypsy moth, *Lymantria dispar* L., (AGM) represents a significant threat to North America. In contrast to the North American strain (NAGM) that was introduced to the eastern U.S. circa 1868 (Liebhold et al. 1989) which feeds almost exclusively on deciduous hosts, and whose females are incapable of flight, the AGM has an extensive deciduous and coniferous host range, and females are strong fliers. Accidental introductions have occurred in British Columbia (1991), Washington (1997), Oregon (2000) and North Carolina (1993). Future introductions are virtually certain.

Successful establishment following an introduction has several requirements. Among these is that insect seasonality be satisfied. Seasonality is the predictable "occurrence of [a life stage event] within a definite limited period or periods of the astronomic (solar, calendar) year" (Leith 1974). Implicit in this definition for gypsy moth is that eggs will hatch coincidentally with the emergence of new foliage of host plants, that the cold-hardy, and low-temperature-requiring diapause phase (Leonard 1968, Gray et al. 2001) will coincide with winter, and that these events will coincide sufficiently each year for the continual survival of the population. Thus a multi-generational phenology model can directly assess one criterion of the risk of establishment of an introduced population to a new environment. It can make this assessment by quantifying the likelihood that temperature regimes in the environment will consistently produce seasonal development. Gray (2004) estimated the risk of establishment of the NAGM in this way. Before a similar estimation of the risk of establishment of the AGM can be done, the thermal requirements of diapause must be determined.

Keena (1996) showed that when eggs are exposured to various durations of 5 °C, a Russian population of AGM will hatch sooner than a NAGM population after the temperature is raised to 25 °C. The difference between strains increases as exposure duration decreases. As exposure duration decrease to 90d and lower, the hatch success of NAGM decreases sharply, whereas hatch of AGM is not noticably affected. This suggests that diapause requirments of AGM are more rapidly satisfied than those of NAGM at 5 °C. However, it is not sufficient information to construct the temperature-developmental rate relationships that are necessary for a phenology model.

As a first approximation to estimating the temperature developmental rate relationships in the AGM diapause we reared 30 AGM egg masses at 25 °C for 30d immediately after oviposition. This provided sufficient heat units to satisfy prediapause (Gray et al. 1991), and to initiate diapause, but not advance diapause development (Gray et al. 2001). We then divided each egg mass into 10 approx. equal samples and randomly assigned each of the 300 samples to one of 17 rearing treatments. Sixteen treatments each constituted a temporal sequence of

Table 1.—The number of days after diapause initiation that eggs were transferred to each temperature in the rearing regimetreatment.

Tk (°C)	treatments 1-4 transfer day				treatments 5-8 transfer day				treatments 9-12 transfer day				treatments 13-16 transfer day			
	7.5	Tk	7.5	25	7.5	Tk	7.5	25	7.5	Tk	7.5	25	7.5	Tk	7.5	25
-5	--	0	14	104	0	30	44	104	0	50	64	104	0	60	74	104
15	--	0	14	104	0	30	44	104	0	50	57	97	0	60	65	95
20	--	0	14	104	0	30	44	104	0	50	55	95	0	60	63	93
25	--	0	14	104	0	30	44	104	0	50	55	95	0	60	62	92

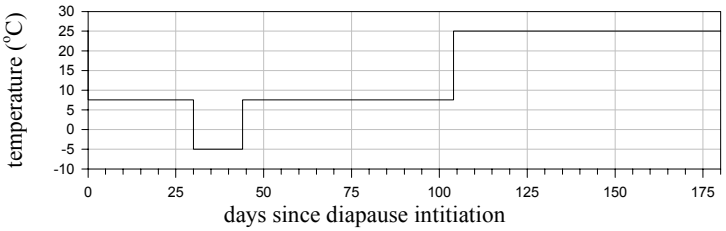

Figure 1.—Illustrates the temporal pattern of temperatures in the rearing treatment W2T1.

the temperatures shown in Table 1. Eggs in the 17th treatment served as a "control" and were reared at 7.5 °C for 90 d and then transferred to 25 °C. Thus all eggs received 90d at 7.5 °C between diapause initiation and transfer to 25 °C; eggs in the 16 treatments were also exposed to an "experimental" temperature for two to 14d. Figure 1 illustrates the temporal sequence of temperatures for the highlighted treatment of Table 1. The AGM strain was collected in the Russian far east near Mineralni (133°E, 44N°) and had been in quarantine at Hamden, CT for two generations.

Egg hatch was monitored thrice weekly, and daily percent cumulative egg hatch was calculated when egg hatch was completed. Daily percent cumulative diapause completion in each treatment was estimated by assuming that AGM post-diapause developmental rates and variability are equivalent to those observed in NAGM, and running the post-diapause model (Gray et al. 1995) in reverse to determine the number of individuals that likely completed diapause on each day. The functional relationships controlling diapause development were estimated by fitting the diapause model of Gray et al. (Gray et al. 2001) to the estimated dates of diapause completion. We assume that the putative mechanism governing developmental response in diapause is not different between the NAGM and the AGM, but that parameter values describing the relationships differ.

A comparison of the functional relationships controlling diapause is shown in Figure 2. Gray et al. (Gray et al. 2001) provided a detailed description of each parameter, and of the putative diapause mechanism. Briefly, an inhibitory compound reduces the potential developmental rate (*PDR*(T)) response to temperature. The reduction in *PDR* is proportional to the titre of the compound and its activity level at temperature T (AT). Actual developmental rate (i.e. the progression toward diapause completion) at any given temperature is a function of the titre of the inhibitory compound, its activity level, and *PDR*. The inhibitory compound is removed from the system by exposure to low temperature.

The comparison suggests that the inhibitory compound expresses a virtually identical temperature-dependent activity (A(T)) in the two strains. However, its rate of removal is markedly different. The inhibitory compound is removed more quickly in the AGM than in the NAGM in response to low temperature exposure. And at high temperatures, where there is no reduction in inhibitory compound in the NAGM, the compound is still slightly reduced in the AGM. At the low temperatures that would predominate during winter in the majority of the range of both strains, *PDR* is slightly higher in the AGM than the NAGM.

These differences will result in a more rapid completion of diapause in the AGM than the NAGM. In addition, diapause may be completed by the AGM in locations where winter temperatures are not sufficiently cold, or of sufficient duration to satisfy diapause in the NAGM, leading to an area of potential establishment that is greater for the the AGM than for the NAGM.

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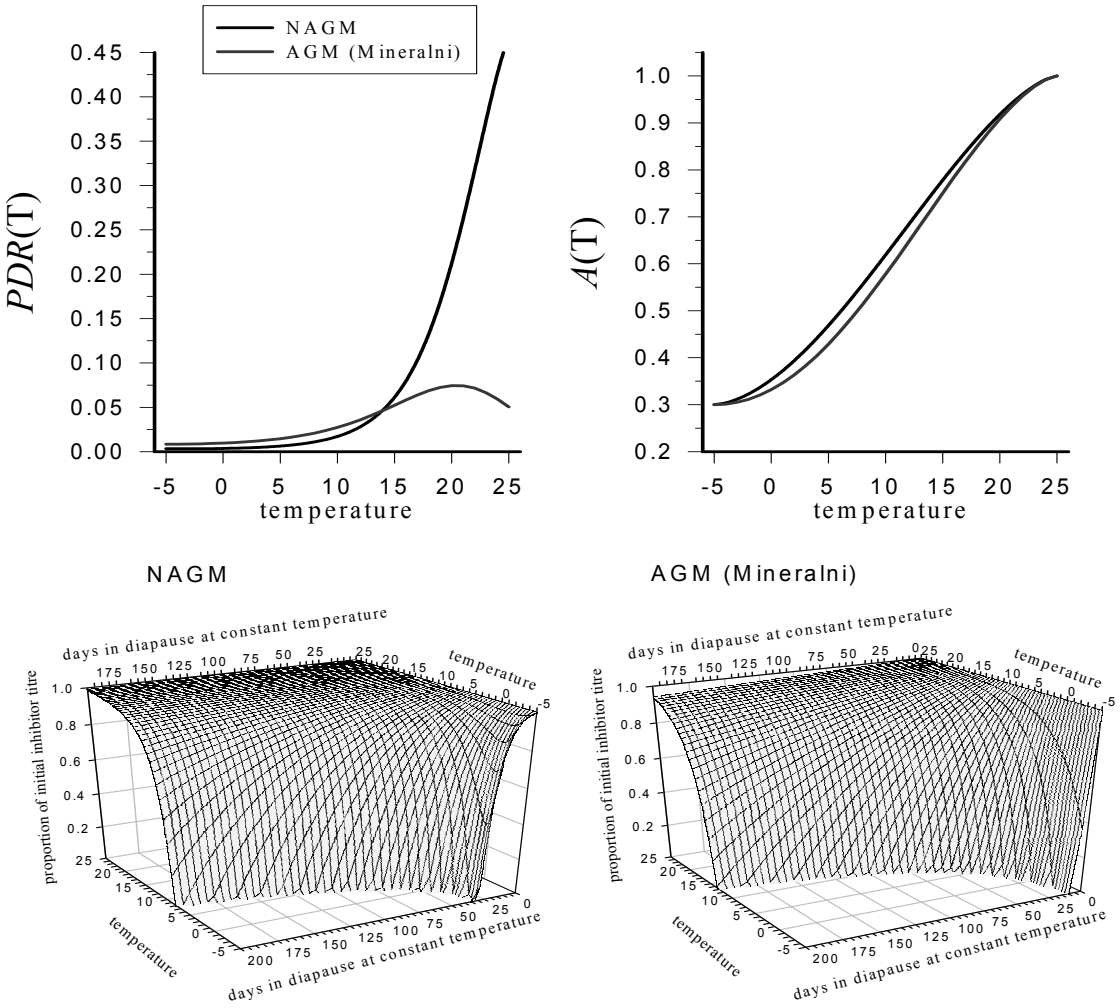

Figure 2.—Illustrates the differences between the NAGM and the AGM in the functional relationships governing diapause development. All temperatures in °C.

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