LARVAL DIAPAUSE IN *DENDROCTONUS OBESUS* (MANNERHEIM) (COLEOPTERA: SCOLYTIDAE)

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ABSTRACT

Dendroctonus obesus (Mannerheim)[1] larvae diapaused in the last instar during laboratory rearing with warm thermoperiods reduced to 12 hours or less, mean temperatures of 50°-56°F. (10°-13.3°C) and at least one minimum subcortical temperature near or below the larval development threshold during the third and fourth instars. Larvae reared at constant temperature of 70°F (21.1°C) did not diapause. Prediction of beetle populations and forest damage is dependent on a knowledge of the seasonal meteorological conditions that affect larval dispause and subsequently the numbers of mature beetles capable of initiating attacks. Further investigation is required to determine the separate effects of brood age, temperatures and thermoperiods on diapause.

INTRODUCTION

The spruce beetle, *Dendroctonus obesus* (Mannerheim)[1], kills large volumes of white (*Picea glauca* (Moench) Voss) and Engelmann spruce (*P. engelmannii* Parry) in western North America (Massey and Wygant, 1954; Wood, 1963). In this region, only those beetles that have passed the winter as adults reproduce the next summer (Massey and Wygant, 1954; Knight, 1961). The development rate therefore has a direct effect on the number of adults capable of invading new hosts at any time during the following year. Warm seasons, in which subcortical temperatures are maintained above the threshold for larval development, provide an opportunity for most larvae to develop quickly, pupate and mature before winter. However, meteorological conditions with minimums below this threshold may prevent a high percentage of the larvae from pupating until the next spring (Dyer, 1969). A preliminary experiment was conducted to determine whether larval or prepupal diapause could be demonstrated in the laboratory by rearing *D. obesus* from eggs in logs, under various temperature conditions. The maximum and minimum range was chosen to simulate a late-summer climate in the field.

METHODS

One hundred and sixty pairs of reproductive adults were released on six freshly cut spruce logs. These produced about 5.3 attacks per square foot of bark. After 19 days at constant 70°F and 12 hours' light, the logs were separated at random into 3 pairs: A, B and C. C logs were held at constant temperature and daylength of 70°F and 12 hours until day 83. A and B were placed in an incubator where thermoperiods of 17 hours warm and 7 hours cool were commenced with maximum, minimum and mean temperatures as shown (Fig. 1). A daylength of 17 hours coincided with the warm thermoperiod. On day 27, the warm thermoperiod (and photoperiod) for A and B logs was reduced to 16 hours, on day 41, to 12 hours and on day 55, to 10 hours. On day 47, A and B logs were cooled to 30°F for 4 hours, resulting in a minimum subcortical temperature of 45°F, just above the larval development threshold of about 43°F (Dyer, *et al.*, 1968). On days 49 and 50, B logs were cooled to 19°F for 4 and 7 hours, respectively, with resulting subcortical temperatures of 29°F and 25°F. On day 83, A, B and C logs were held at 33°F for 5 days and then at 70°F until day 138, the end of the experiment.

Two half-square-foot samples of brood under the bark of A, B and C logs were examined on days 20, 28, 41, 55, 69, 83, 110 and 138. The total progeny per square foot and the per cent in each of seven stages of development were recorded at each date.

RESULTS AND DISCUSSION

Table 1 shows seven stages of brood as they occurred at each sampling date. By day 55, the majority of larvae in all logs had reached the last instar or had become pupae or adults. Ninety-nine per cent of the brood in C logs had become adults by day 69 without any pause in development. After this date the larvae in the B logs stopped development beyond the fourth instar; no more pupation occurred during the next 41 days even though, for most of this period, the temperature was much above the development threshold (Fig. 1, Table 1).

Some pupation commenced again during the last 28 days at constant 70°F, although about 40 per cent of the progeny in the B logs still remained larvae after 138 days (Table 1). The suppression of development just before pupation is characteristic of larval or pre-pupal diapause (Beck, 1968). In the B logs, the intense diapause commitment of the remaining larvae had continued after 50 days of exposure to constant temperature suitable for development.

[1] According to Wood, S. L., the name **D. rufipennis** (Kirby) now has precedence. Great Basin Naturalist 29 (3): 116, 121, 1969.

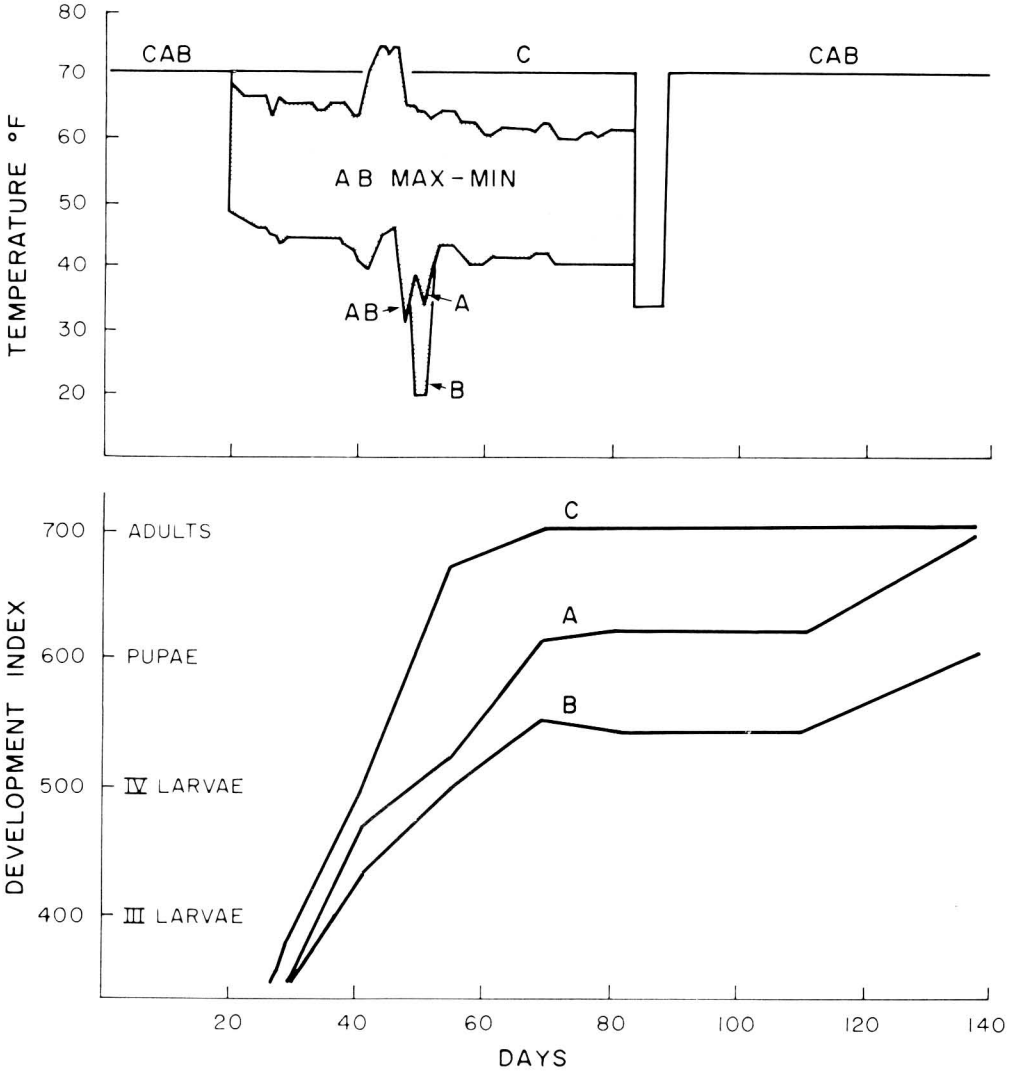

Fig. 1. Temperature regimes and corresponding development of **D. obesus** brood in logs C at constant temperature and logs A and B exposed to cooler diurnal thermoperiods with maximum and minimum range shaded.

Diapause in *D. obesus* larvae is likely to be determined by environmental conditions preceding the actual manifestation (Beck, 1968). It appears to be dependent on some combination of thermoperiod length, mean and minimum subcortical temperature, and stage of development when the critical diapause-inducing conditions occur. No diapause resulted when larvae were reared at a constant warm temperature (70°F). The mean and the minimum temperatures appeared to be related to the more intense diapause induction in broods of B logs than of A logs. The stage of development when the minimum subcortical temperatures occurred might also have had some relation to the percentage of brood entering diapause, because larvae in A logs were slightly more advanced than those in B logs.

Daylength or photoperiod seems unlikely to affect larval development under bark. However, in natural environments, thermoperiod is closely synchronized with photoperiod and may replace the latter in its effect on diapause induction. Beck (1968) reports that diapause in mature larvae of the European corn borer, *Ostrinia nubilalis* (Hübner), is induced by short-day photoperiods during larval growth, but its

Table 1. Development of *Dendroctonus obesus* brood occurring in two half-square-foot samples of bark from logs C at constant temperature and from A and B logs at cooler diurnal thermoperiods. Each stage is expressed as a percentage of the total progeny sampled.

LOGS	TOTAL PROGENY SAMPLED	DAY SAMPLED	PER CENT BROOD						
			EGGS	LARVAE				PUPAE	ADULTS
				I	II	III	IV		
C	170	20	35	7	58				
	179	28	5	2	19	66	8		
	166	41				2	94	4	
	124	55					4	21	75
	160	69					0.5	0.5	99
	151	83							100
	127	110							100
	54*	138							100
A	312	20	29	30	41				
	185	28	16		18	66			
	205	41	5			14	80	1	
	167	55				4	70	26	
	174	69					26	37	37
	141	83					35	8	57
	159	110					41	1	58
	181*	138					2	2	96
B	312	20	56	18	26				
	201	28	8	2	41	49			
	222	41	7		7	30	56		
	138	55			2	3	93	2	
	119	69					61	30	9
	154	83					79		21
	154	110					82		18
	120*	138					40	18	42

Samples taken on 0.5 to 0.75 sq. ft.

incidence is influenced by low temperature during the dark phase. He also points out that thermoperiod may, under some circumstances, substitute for photoperiod in determination of diapause. The Indian meal moth, *Plodia interpunctella* Hübner, requires an intermediate temperature (68°F) during the last two instars for 100 per cent induction of larval diapause. Higher temperature of 86°F is effective in averting diapause (Tsuji, 1963). Mansingh and Smallman (1966) show that complete induction of pupal diapause in *Hyalophora cecropia* Linnaeus and *Antheraea polyphemus* Cramer occurs following short-day (12-hour) photoperiod during the second last larval instar. Further experiments are required to determine the separate effects of mean and minimum temperature, thermoperiod length and brood age when diapause is initiated in *D. obesus*.

Larval diapause probably has survival value to bark beetle populations in very cold climates where severe cold might cause pupal mortality. Larvae which diapause in the autumn will pupate and become adults the following summer, but these adults will not attack new hosts until they have passed another winter. Thus, seasonal temperatures that induce a high percentage of larval diapause will delay for one year the potential of that population to damage trees.

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MALE RESPONSE TO FEMALES IN THE MARSH CRANE FLY, *TIPULA PALUDOSA MG.* (DIPTERA: TIPULIDAE)

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ABSTRACT

Laboratory and field experiments suggest that male **T. paludosa** receive a specific mating stimulus only in close proximity of a female. The anterior part of the female rather than the isolated abdomen is the source of the sex pheromone. Attempts to extract the material were unsuccessful.

INTRODUCTION

The biology and control of *Tipula paludosa Mg.* and its occurrence in North America have been reviewed by Wilkinson and MacCarthy (1967). In the field mating takes place immediately following the female's emergence which peaks about 11:00 p.m. and the eggs are mostly laid before morning (Coulson, 1962). Thus control by adult extermination is ineffective. The following preliminary experiments were intended to define the role of sex pheromone with a view to control by means of a metarchon (Wright, 1964).

METHODS AND RESULTS

Larvae collected in June and July 1969 were held in soil seeded with lawn grass. The pupae were sexed and held separately in 30 x 30 x 30 cm cages in separate rooms under natural illumination but with supplementary light during the day from fluorescent lamps. An intact female pupa placed in a cage with ten unmated males was ignored until the first stage of emergence. Then mating attempts began and the males helped to dislodge the pupal integument. The pheromone was effective over a very short distance only as shown by the following experiments.

On five occasions, at different stages of the diel cycle of illumination, 1 to 3 unmated females (1-2 days old) were placed in a cylindrical cell (5 cm x 5 cm) with bronze mesh at each end. The cells were introduced into cages containing males and were ignored by them until the females were released when mating took place immediately.

A cylinder containing three females placed upwind of ten males in a wind tunnel (Kellogg and

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