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INFLUENCE OF TEMPERATURE INVERSION ON DEVELOPMENT OF SPRUCE BEETLE, *DENDROCTONUS OBESUS* (MANNERHEIM) (COLEOPTERA: SCOLYTIDAE)

By E. D. A. DYER[1]

ABSTRACT

In the East Kootenay region of British Columbia, spruce logs infested by **Dendroctonus obesus** (Mannerheim) were placed beside thermographs at three sites. Throughout the summer, the mean and minimum air temperatures were higher on a mountain slope than in two valley bottoms at similar or lower elevations. Beetle development was faster on the mountain slope, where it continued until frost occurred in October, at which time 96% of the progeny were mature. In the lower valley bottom the minimum temperature fell 3.9 and 2.8°C (7 and 5°F.) below freezing on successive nights in August and larval development stopped. In the valley bottoms only 13 and 9% of the broods matured before winter. Temperature conditions that allow most broods of **D. obesus** to mature in one season may result in a critical addition to the normal number of beetles that mature after 2 years' development.

Introduction

Dendroctonus obesus (Mannerheim) is the most destructive bark beetle of mature spruce forests (Swaine, 1924; Woods, 1963). Endemic populations breed in wind-thrown trees and logging slash, but when the population is large the beetles frequently attack and kill the largest trees over extensive areas (Swaine, 1924; Massey and Wygant, 1954).

In spruce forests growing at northern latitudes and high elevations most spruce beetles require 2 years to reach maturity, but during hot summers and in warm locations many of the young mature in a single season (Watson, 1928; Massey and Wygant, 1954; Knight, 1961). In western North America, only the beetles that have passed the winter as adults reproduce the next summer (Massey

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and Wygant, 1954; Knight, 1961). The developmental rate therefore, has a direct effect on the number of adults capable of invading new hosts the following year.

Methods

The Agroclimatology Sector of A.R.D.A. (Agricultural and Rural Development Act Administration of Canada) has recently taken thermograph records at several locations in the Rocky Mountain trench in southeastern British Columbia.

Three locations were near spruce forests and accessible when the *D. obesus* flight began in early June 1967. Site A (4,700 a.s.l.) was on a mountain slope, about 2,000 feet above the valley. Site B (3,500 a.s.l.) was approximately 50 miles to the north in a valley bottom. Both sites were adjacent to the Rocky Mountain trench near the source of the Columbia River. Site C (4,600 a.s.l.), another valley bottom, was in the Flathead River drainage near the Alberta border.

Six recently - cut 30 - inch - long spruce logs were placed on the ground in the shade of scattered small trees near the thermograph at each site. The instruments were in Stevenson screens in cleared areas.

On 5 June, beetles had entered the bark of logs moved on that date from a nearby valley to site A. One of these logs was placed as a control with uninfested logs at site B, where natural beetle attack was observed the same day. Uninfested logs were placed at site C on 6 June.

Samples of bark were removed from the logs at sites A and B on 23 and 24 August, respectively. Larvae, pupae and young adults were counted, and the larvae individually measured to determine their stage of development. Site C could not be reached at that time. On 18 October, the broods in logs from all three sites were examined to determine the degree of development for the season. An index of development was calculated from these samples, in which 100% eggs equalled 100, and 100% young adults equalled 700.

Results and Discussion

The minimum temperature for spruce beetle brood development has been determined in laboratory studies to be approximately 43° F. The accumulated degree-hours air temperature above this threshold, plotted each 2 weeks for sites A and B, are shown in Fig. 1 along with the index of development.

The mean and minimum temperature was consistently warmer at site A on the mountain slope, than at site B in the valley bottom (Figs. 1-2). Such summer temperature inversions in this mountainous region are common; Hayes (1941) has shown that inversion occurred on 90 to 99% of nights from May to September during 4 years in Idaho. The median magnitude of night temperature difference between the colder valley bottom (2300 a.s.l.) and the warmer mountainside (3800 a.s.l.) was 9° to 18°F in May and June, respectively, and 15° to 18° from July to September.

Brood development at sites A and B, as shown by the index (Fig. 1), proceeded at a rate parallel to that of the respective accumulated degree-hours at each site until late August. After this the temperature accumulation rate declined at both sites. At site A the brood continued to develop at a reduced rate until nearly all reached maturity, whereas at B, development almost stopped at the end of August and most of the brood overwintered as larvae.

A possible explanation for the difference in development during the latter part of the season is illustrated in Fig. 2. The maximum temperatures throughout August and September

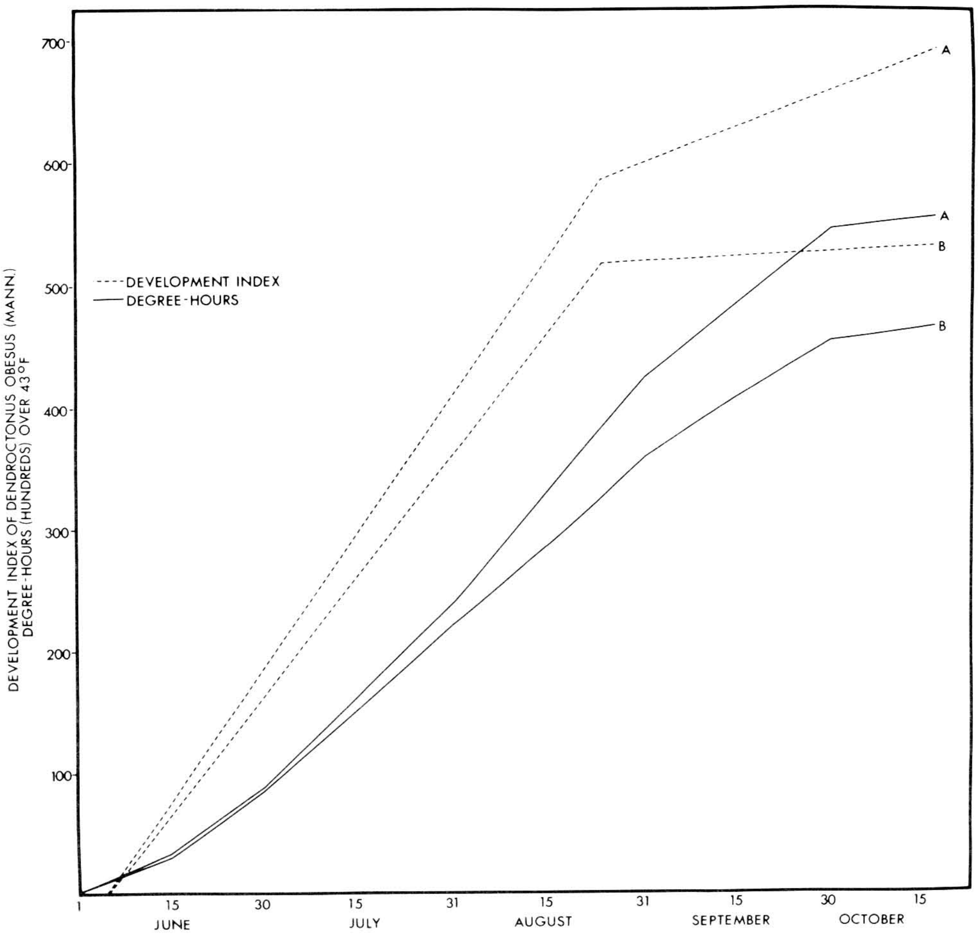

Fig. 1. Index of brood development and accumulated degree-hours above 43°F. (6.1°C) from 1 June to 18 October, 1967, at site A, on a mountain slope and at B, in a valley bottom.

were about the same at sites A and B, but the minimum temperatures were much higher at A. At B they dropped 5° and 7°F below freezing on successive nights in late August. At site A no frost occurred until mid-October.

The percentages of fourth-instar larvae, pupae and adults in samples collected in August and October from the logs at sites A and B are shown in Table 1. At site A both larvae and pupae continued to mature and 96% became adults by October. At site B, the percentage of larvae remained almost the same from August to October, although the pupae completed development.

At site C, the mean temperature was consistently lower (1-4°F) than at site B for every 2-week period from June to October. However, the minimum temperature in August was 3°F higher than at site B. By October, the brood development at site C was nearly the same as at site B (Table 1). Larval development at site C, although slower, was possibly not terminated so early as at site B where lower minimum temperatures occurred in late August.

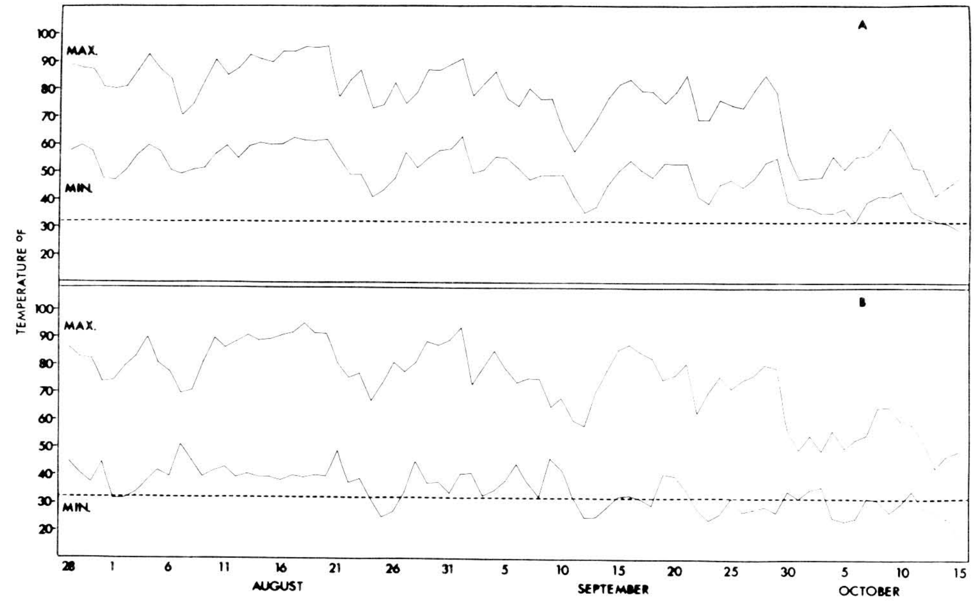

Fig. 2. Maximum and minimum daily temperatures from 28 July to 15 October 1967, at site A, on a mountain slope and at B, in a valley bottom.

Conclusions

Accumulated degree-hours above the development threshold and the date and severity of the first late-summer frost are important factors that affect the seasonal rate of *D. obesus* brood development. A very slight increase in accumulated heat during the season can make the difference between mature and immature broods.

In summer the valley bottoms are frequently as warm during the day as the higher areas on adjacent slopes. At night, they are often colder. The night temperature inversion creates a zone on the slopes with more degree-hours of heat and higher minimum temperatures than in the valleys, particularly during late summer. Within this higher zone a larger percentage of *D. obesus* broods can mature in one season.

When the location of abundant breeding material, such as windfall, coincides with zones of rapid beetle development, the population of mature beetles greatly increases in one season. These beetles, combined with beetles maturing after 2 years in cooler sites, result in greater populations flying and attacking new hosts the following spring. The sudden increase in the pressure for suitable breeding sites may result in the invasion and death of standing timber.

TABLE 1

Percentage of larvae, pupae, and young adults in spruce logs on a mountain slope (site A) and in two valley bottoms (sites B and C) in 1967.

Site	23-24 August			18 October		
	Larvae[1]	Pupae	Adults	Larvae[1]	Pupae	Adults
A	38.6	38.6	22.8	4.0	0.0	96.0
B	84.7	13.8	1.5	86.6	0.0	13.4
C	-	-	-	89.7	1.0	9.3

[1]Larvae in last instar.

Acknowledgment

I thank L. H. McMullen and M. D. Atkins for critically reviewing the manuscript and D. W. Taylor and W. Kusy for assistance in the field. The temperature data were obtained through the courtesy of J. R. Marshall, Agroclimatology Sector of A.R.D.A. in British Columbia.

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SOME OBSERVATIONS ON FLIGHT IN *ONCOPELTUS FASCIATUS* (HEMIPTERA: LYGAEIDAE)[1]

R. J. HEWSON

ABSTRACT

Oncopeltus fasciatus (Dallas) is a typical Hemipteran with fore-wings modified to form hemielytra and membraneous hind-wings. During flight, these two pairs of wings are linked together by a wing coupling apparatus. Observations were made on normal insects and insects with either fore- or hind-wings removed. The experiments demonstrated that the mesothorax with the fore-wings is the most important segment of the pterothorax in this insect. It was shown that the fore-wings provide the main propulsive force for flight and also provide much of the lift: the hind-wings provide extra surface for lift, but this is effective only if the wings are coupled together. As in the Lepidoptera and Hymenoptera, where the two pairs of wings are also linked together by a wing coupling apparatus, it appears that the musculature of the mesothorax may be the "driving force" for both pairs of wings.

Introduction

The Hemiptera (Heteroptera) possess two pairs of dissimilar wings; the fore-wings or hemielytra are modified and partially sclerotized, the hind-wings are thin and membranous. The two pairs of wings are normally hooked together during flight by a coupling apparatus (Weber, 1930). Comparing the Heteroptera with the Coleoptera, it might seem that the hemielytra would play little part in flight, most of the propulsion being provided by the hind-wings. However, comparison with the Lepidoptera suggests that the fore-wings might be the more important, with the hind-wings of the Heteroptera receiving their power through the wing-coupling mechanism. The studies of Scudder (1967) on flight muscle polymorphism in Notonectidae show that the mesothoracic flight muscles may be reduced in flightless members of this group, with little or no change in the metathoracic musculature. Scudder therefore suggested that the mesothoracic segment with its hemielytra is the

[1] Part of a thesis for the M.Sc. degree in the Department of Zoology, University of British Columbia, Vancouver 8, Canada.