LARVAL DIAPAUSE IN *SCOLYTUS VENTRALIS* (COLEOPTERA: SCOLYTIDAE)[1]

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ABSTRACT

When **Scolytus ventralis** was reared under relatively constant temperatures 50-70% of the brood developed rapidly and emerged within 70 days. The remainder emerged gradually over the 130 days following the first emergence peak. Exposure to field conditions resulted in retarded emergence of the rapidly-developing proportion of the population and increased synchrony in the emergence pattern. Increasing exposures to cold temperatures in the field resulted in increased emergence synchrony, and a shorter developmental time when exposed to warmer temperatures in the laboratory. It was concluded that the rapidly-developing portion of the population may enter a facultative diapause while the remainder enters an obligatory diapause under normal field conditions.

INTRODUCTION

The fir engraver, *Scolytus ventralis* LeConte, infesting grand fir, *Abies grandis* (Douglas) Lindley, is normally univoltine in northern Idaho. Struble (1957) noted that the fir engraver population produced a partial second generation annually on south-facing slopes at 4000 ft. elevation in the California Sierra Nevada. In laboratory rearings about 50% of the brood emerged within 90 days of attack while the remainder emerged over the next 100 days or died (Scott and Berryman 1971), suggesting that a significant portion of the population ordinarily enters diapause. The present study reports on the effects of winter exposure on the development rate and emergence synchronization of the fir engraver.

MATERIALS AND METHODS

Six living grand firs, about 50 years of age, were felled on 8 July, 1969, during the flight period of *S. ventralis*. The trees were attacked 1 or 2 days after felling. Fifteen days after attack 24 one-foot-long bolts were cut from these trees and brought into the laboratory. Another 16 bolts were cut and brought into the laboratory on 24 November, 1969, 137 days after attack; 8 on 5 February, 1970, 220 days after attack; and 16 on 7 May, 1970, 301 days after attack.

All bolts were maintained at 25 - 30° C, 50 - 60% RH, and 16-hour photoperiod. Emergence was recorded at approximately 10-day intervals by counting and marking new emergence holes.

Mean development time from attack to peak emergence (T) was calculated by

$$T = \frac{(Xi \cdot Fi)}{N}$$

where Xi = number of days from attack to the ith emergence period, Fi = emergence during the ith period, and N = total beetles emerging. Thirty days after emergence had started to decline, the bolts were debarked and the following data collected: number of successful attacks, length of egg galleries, number and stage of the surviving brood. The bark was then dissected and the brood within recorded. Five of the bolts from the first sampling (July) were not debarked until 215 days after attack.

RESULTS AND DISCUSSION

Logs in the field were considered to be under the influence of cold temperatures during those months when the average monthly maximum temperature was below 15° C; *i.e.*, from 1 October, 1969 to 1 May, 1970 (Table 1).

TABLE 1. Average maximum and minimum daily temperatures (°C) from Potlatch, Idaho (U.S. Weather Bureau Climatological Data).

Month	Maximum	Minimum
September, 1969	21.7	4.3
October	12.7	—0.6
November	8.6	—1.8
December	2.5	—4.6
January, 1970	1.7	—5.2
February	7.7	—1.7
March	7.7	—3.3
April	9.6	—1.1
May	18.3	3.2

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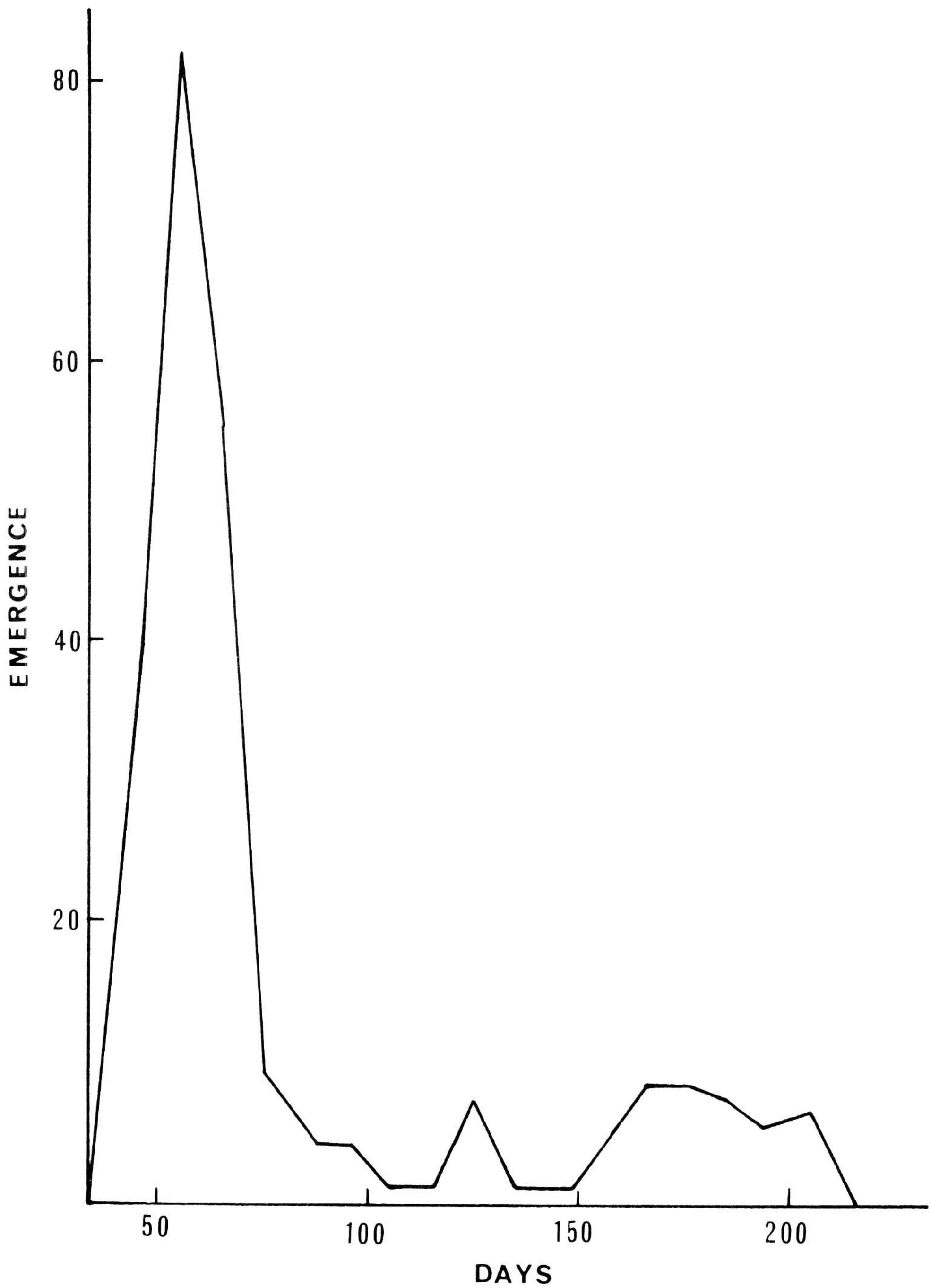

Fig. 1. Emergence pattern of **S. ventralis** reared in the laboratory without cold exposure.

TABLE II. Mean development time and emergence synchrony of **S. ventralis** in the first emergence peak after different lengths of exposure to field temperatures.

Date Sampled	No. of Bolts	Days in the field		Days in Laboratory*	Total Development Time	Per cent Emergence **
		Max.temp. > 15°C	Max.Temp. < 15°C			
7-25-69	19	15	0	43	58	68.50
11-24-69	16	82	55	58	195	90.36
2-5-70	8	82	138	34	254	98.27
5-7-70	16	82	219	30	331	100.00

*Total time in the laboratory up to the mean of the first emergence peak.
**Per cent of the population emerging within 30 days of the first emergence peak.

The first group of bolts, brought into the laboratory on 25 July, 1969, did not experience cold temperatures. At this time the fir engraver brood was in the egg and first two larval stages. Figure 1 shows the emergence pattern of *S. ventralis* from 5 of these bolts over a period of 215 days from the time of attack. Dissection of the bolts at the end of this period showed that all brood had either emerged or died. It is apparent that most emergence occurred 50-70 days after attack followed by gradual emergence with a minor peak between 150 and 210 days. The remaining 19 bolts of this group were dissected 30 days after the first emergence peak or 88 days from the time of attack. At this time 68.5% of the brood had emerged (Table 2). These results, and those of Scott and Berryman (1971), show that 50 - 70% of the brood develop rapidly at relatively constant temperatures and probably represent the proportion of the population which completes two generations a year under suitable climatic conditions in the field (Struble 1957). The development of the remaining 30 - 50% of the brood was retarded having presumably entered obligate larval diapause. This proportion probably produces a single annual generation under most field conditions.

The effects of exposure to cold temperatures on the development of *S. ventralis* was examined by collecting infested bolts from the field at three intervals during winter. The bolts brought into the laboratory in November had experienced about 55 days of temperatures below 15° C. This treatment resulted in an increased proportion of the brood emerging during the first emergence peak (Table 2); *i.e.*, diapause was broken in about 70% of the brood with an obligate larval diapause. However, it required 58 days rearing in the laboratory to reach mean emergence, or 15 days more than the brood receiving no cold treatment (Table 2). This increased development time was greater than is indicated in Table 2 because the sample taken in November had experienced 100 extra days of field temperatures in the range favorable for development. Furthermore, brood in the earlier sample was in the egg and first two larval stages while in the later sample all brood was in the mature larva or prepupal stage. These results indicate that the rapidly developing proportion of the brood had entered a facultative larvae diapause conditioned by environmental stimuli; possibly temperature or photoperiod.

The time required in the laboratory for mean emergence to occur in samples taken in February and May was reduced (Table 2). Furthermore, emergence was synchronized to a greater degree by the longer cold temperatures (Table 2). This indicated that diapause requirements for most of the larvae was satisfied by 150-200 days cold exposure.

The results of this study suggest that 50 - 70% of the larvae of *S. ventralis* have a facultative diapause initiated by undetermined environmental stimuli and that 30 - 50% have an obligatory diapause. The diapause conditions are apparently broken by exposures to cold temperatures, longer cold exposures resulting in a higher degree of emergence synchronization and a shorter period to peak emergence.

References

Scott, B. A., Jr., and A. A. Berryman. 1971. Laboratory rearing techniques for **Scolytus ventralis** (Coleoptera: Scolytidae). Wash. Agric. Expt. Sta. Bull 741, 9pp.

Struble, G. R. 1957. The fir engraver, a serious enemy of western true firs. U.S.D.A. Proc. Res. Rep. 11, 18 pp.

THE DOOMSDAY BOOK

by GORDON RATTRAY TAYLOR
A Fawcett Crest Book,
World Publishing Company,
New York & Toronto.
Pp. 320. $1.25

Until such time as Paul and Anne Ehrlich's well researched hard-cover "Population, Resources, Environment" also appears in paperback, "The Doomsday Book" remains, in my view, the most readable, and probably the most important of the spate of popular, doom-and-gloom, ecology books; it has been in paperback only since September, 1971. It may be that the author's 1968 "The Biological Time Bomb" will prove more prophetic and in the long run more important, but it lacks the immediacy and urgency of the present work. This time the author avoids speculation and extrapolation wherever possible; instead he presents a fairly low-keyed digest of recently published work, lightly footnoted, annotated, referenced, and indexed. The data are largely from reputable original sources and reviews, notably and frequently from Nature, Science, New Scientist, Science News, and Scientific American.

Isaac Asimov refers to The Doomsday Book as "cool and unimpassioned", which well describes the writing. The tone should be acceptable both to the converted and to any layman who is not very clear on the ecology furore but is not about to be stampeded by rhetoric or emotion. A few degrees of emotional heat do break through occasionally, for example in the section on radioactivity (chap. 8).

In any book as wide ranging as this, nit picking is easy. On p.85 we read that "the Tasmanian 'wolf' was . . . believed to be a predator — actually it is not a carnivore but a marsupial like a kangaroo." It is a marsupial alright, but a predator too — and probably extinct by now. Some examples from entomology are greatly oversimplified, e.g. the case of the codling moth (p.84). Aldrin and dieldrin (p.128) are the terrible organophosphorus twins. Plague is spread by lice (p.77). But a dividend from the all-embracing approach is that DDT loses some of its preeminence and falls into its proper place as merely the most widespread and one of the most damaging pollutants amongst such other horrors as cadmium, mercury, lead, polycholoro-biphenyls, asbestos, carbon monoxide, nitrites, nitrogen oxides, and radioactive wastes.

In "Ice Age or Heat Death" (chap.3) the conflicting arguments for both fates will probably confuse the reader. But he can hardly fail to realize, first, that astonishingly small inputs to the atmosphere will surely have an effects of some kind on the earth, ". . . climate is nothing like as stable as we tend to think," (p. 79); and second, that the whole earth is so closely tied to and affected by its atmosphere and climate that unpleasant changes may appear at several removes from the triggering mechanism," . . . the web of cause and effect is too complicated for our present levels of scientific understanding. . . ." (p.73).

The author is at his best on the food and population crises and in marshalling his arguments against nuclear power. The views of Gofman and Tamplin are presented at some length in a 30-page section on radioactivity (chap.8).

It takes two full pages to acknowledge those who helped the author, including 18 very distinguished discussants (e.g. La Mont Cole, Fraser Darling, Kingsley Davis, Paul Ehrlich, Glenn Seaborg, Stewart Udall), and 56 others with impeccable affiliations, who gave help and information, including Barry Commoner, J. W. Gofman, Chas. F. Wurster and many Europeans.

On the cover of the paperback the publisher has put the cheering message: "Mankind can survive." The author seems to be less than certain.

H. R. MacCarthy