EMERGENCE AND ORIENTATION BEHAVIOR OF BROOD *TRYPODENDRON LINEATUM* (COLEOPTERA: SCOLYTIDAE)[1]

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ABSTRACT

Emergence of **Trypodendron lineatum** from caged naturally infested host logs occurred from June 2 to August 27, 1969. Approximately 30% of the parent beetles emerged before June 30, when the first major brood emergence took place. The sporadic brood emergence was apparently influenced by maturation, and markedly by environmental temperature. A daily emergence. A total of 6,539 beetles emerged, with a ♂ : ♀ sex ratio of .997. Emergent brood beetles were hygronegative and strongly photopositive, indicating that behavioral reversals in both humidity and photic responses must occur since the beetles select and occupy moist, dark overwintering sites.

INTRODUCTION

Brood *Trypodendron lineatum* emerge from their host in mid to late summer and fly to overwinter in the litter and duff of the forest floor, in rotting stumps or under the bark scales of standing trees (Kinghorn and Chapman 1959, Chapman 1960). Very little is known about the behavior of these beetles prior to their entring an overwintering site where they remain in a reproductive diapause (Fockler and Borden 1972) for the winter months. However, emergent beetles in the summer appear to be photo-positive (Dyer and Kinghorn 1961), even though they eventually orient to sites where light intensity is minimal. A knowledge of the behaviour of brood beetles may lead to their eventual manipulation and control.

This paper describes the emergence behavior and orientation to humidity and light of brood *T. lineatum* from coastal British Columbia.

EMERGENCE FROM HOST LOGS

Thirteen logs, .5 to .8 m long and 18 to 24 cm in diamter, were removed from naturally-infested Douglas fir slash near Brackendale, B.C. First attack was noted on May 1, 1969 and the heavily infested logs collected on May 23. They were transported to Simon Fraser University and placed in screened cages (approx. 1 m) in an outdoor enclosure with a translucent roof. Temperature and humidity were monitored with a portable hygrothermograph placed in one of the cages. Each day, insects emerging from the logs were collected intermittently until 9:00 p.m. Beetles were sexed on collection.

The enclosure of field-collected logs permitted a more precise observation of emergence (Fig. 1) than through interpretation of the numbers of beetles trapped in flight (Chapman and Dyer 1960; Rudinsky and Daterman 1964). A total of 6,539 beetles emerged (♂:♀ sex ratio .997), commencing on June 2. Observations ceased on August 27 following 2 weeks of consistently low emergence. Log dissections on June 4 to 12 disclosed that no brood had yet pupated indicating that the first emergence consisted entirely of parent adults. Since approximately 10 days are required for pupation (Prebble and Graham 1957), the June 30 emergence peak probably represents the first major brood emergence. Of the 1076 beetles collected before June 30, 199 were prematurely emerging callow adults. The remaining 877 beetles were presumably parents representing approximately 30% of the attacking population (there were 1531 attacks counted on the debarked logs following emergence). The June 30 emergence occurred 48 days after the initial attack, a period 21 days shorter than under field conditions in Europe (Hadorn 1933). At this time many galleries still contained eggs and early instar larvae. The peak emergence in the first 3 weeks of July was as much as one month earlier than noted for beetles in the field (Chapman and Dyer 1960; Rudinsky and Daterman 1964) but maturation was probably influenced by high cage temperatures.

Mortality was severe, possibly due to a fungus found growing profusely in many tunnels. Only 4.3 beetles emerged per gallery, far less than the minimum expected number of 10 emergent brood beetles (Hadhorn 1933). Thus, a conservative estimate of brood mortality would be at least 50%. A similar mortality rate of parent beetles would leave

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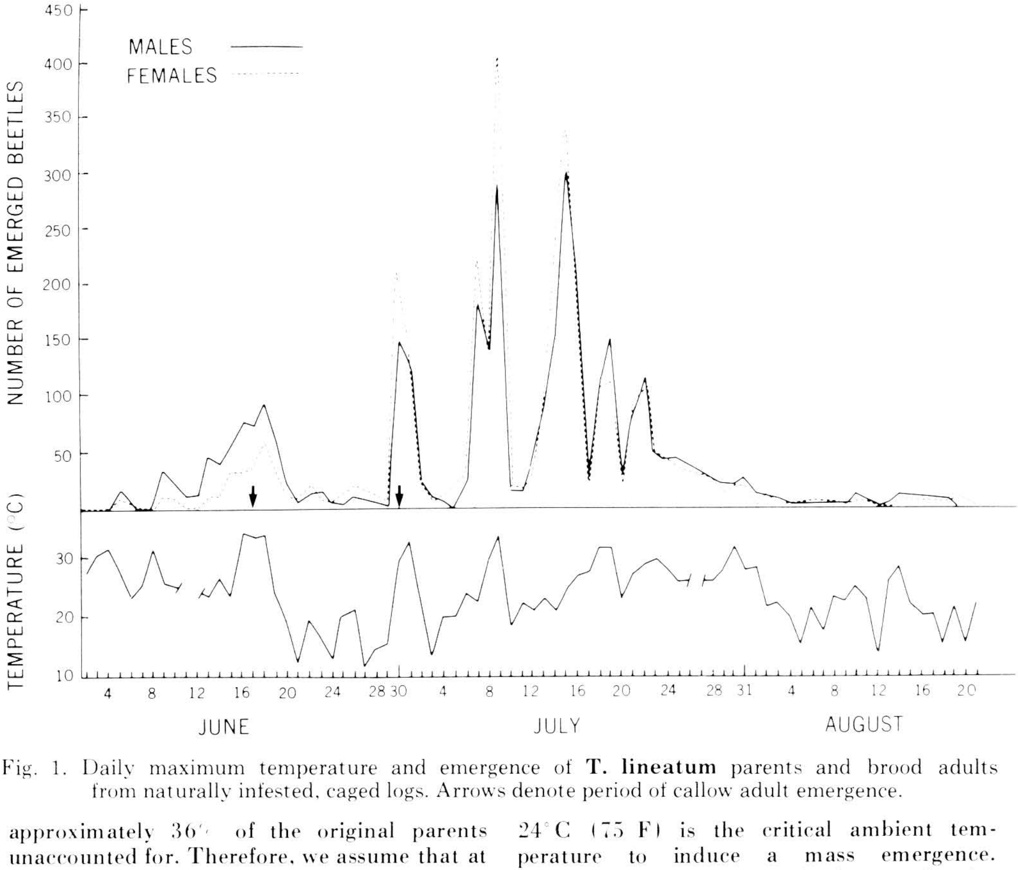

Fig. 1. Daily maximum temperature and emergence of **T. lineatum** parents and brood adults from naturally infested, caged logs. Arrows denote period of callow adult emergence.

approximately 36% of the original parents unaccounted for. Therefore, we assume that at least 80% of the 5,463 beetles which emerged after June 30 were brood beetles. Some of the higher female emergence after June 24 (Fig. 1) undoubtedly represents parent females.

The sporadic emergence during July appeared to reflect brood maturation trends and the occurrence of sufficiently high temperatures to stimulate emergence. Minimum temperatures were often similar. However, most emergence peaks coincided with high maximum temperatures (Fig. 1). From June 29 to July 25, emergence was analyzed in two groups: days when less than 100 beetles emerged, and days when more than 100 beetles emerged. For the former, the daily mean maximum temperature and emergence, respectively, were 24.1° C (range = 14.4 to 31.1° C) and 44.6 beetles, while for the latter, they were 31.3° C (range = 23.3 to 37.8° C) and 332 beetles. On 7 occasions, fewer than 100 beetles emerged on days when maximum temperature was higher than 24° C. However, on only one day did more than 100 beetles emerge when the maximum temperature did not reach 24° C. Therefore, we conclude that 24° C (75° F) is the critical ambient temperature to induce a mass emergence. Following cool periods a lack of mature beetles apparently delayed peak emergence. For example, only 50 beetles emerged on July 6 when the maximum temperature reached 26.7° C, but 350 beetles emerged on July 7 with a maximum temperature of 25.6° C.

ORIENTATION OF BROOD BEETLES TO HUMIDITY AND LIGHT

After June 30, beetles were collected for experimentation within 2 hours of emergence and held at approximately 4° C and 100% Relative Humidity (R.H.). The only flight possible was in the small emergence cage prior to collection.

Humidity preference at 20° C was examined in a 2-choice apparatus consisting of a cylindrical plastic vessel 10 cm in diameter and 11 cm deep, with a plastic lid. A screen mesh arena separated the upper and lower halves of the apparatus. A partition in the lower half extended to the screen mes, creating 2 chambers in which humidity was controlled by CaCl crystals (0%), concentrated aqueous solutions of MgCl (34%) and NaCl (77%), and water (100%) (Janisch 1938). The upper half of the chamber was also divided by a partition in line with the lower but leaving an 8 mm space above the screen on which walking beetles could freely choose a desired atmosphere.

Prior to each test, the apparatus was allowed to equilibrate with 2 experimental solutions for ½ hour, and the beetles were conditioned to room temperature for 15 minutes. Two replicates of 20 beetles were run for each sex in light and dark conditions for 3 humidity alternatives: 0-34%, 0-77% and 0-100%. Controls were run in light conditions at 77-77% R.H. The apparatus was placed in the centre of a square, unmarked box and rotated 180 halfway through each experiment. The position of test beetles was noted at one-minute intervals for 30 minutes, and the mean response calculated. Counting beetles in dark tests necessitated brief exposure to a very dim light held directly above the chamber.

At alternatives of 0-77% and 0-100% for both sexes under both light and dark conditions, and at 0-34% for males in the dark, the drier atmosphere was clearly preferred (Table 1). All the above preferences were significantly different from the controls (t-test, $P < .01$). The reduced ability to discriminate between 0 and 34% R.H. suggests that humidity discrimination at this stage of the beetle's life need only differentiate between conditions of high and low moisture, the circumstances most likely to occur during emergence from host logs.

The photic orientation of emerging beetles was examined on July 16 at the University of British Columbia Research Forest, Maple Ridge, B.C. Twelve logs infested in early May were piled in the centre of a 2.1 m cage covered with white cloth which allowed diffuse, but relatively natural lighting. Light intensity readings were recorded every 30 minutes from 11:00 a.m. to 9:00 p.m. at 8 positions around the cage periphery and the number of emergent beetles in each position on the cage walls was recorded.

A prounounced photopositive orientation of emerging beetles was evident (Table 2). The apparent aversion to the highest light intensity from 4:00 to 8:00 p.m. (Table 2) apparently is an artifact caused by the reluctance of beetles in a corner position of the cage to move as the sun shifted in position. In a laboratory choice chamber, a few tests also revealed a strong response to light at both 100% and 0% R.H. However, no heat controls for the light source were included. The photopositive nature of emergent brood beetles suggests that they may respond to visible or ultraviolet radiation and may be susceptible to manipulation with such stimuli at this stage of their life.

Relative Humidity Alternatives %	Females		Males	
	Light	Dark	Light	Dark
Controls				
77-77	50.2	-	48.0	-
Experimentals				
0-34	48.8	45.9	50.4	58.5
0-77	60.5	59.7	62.9	75.1
0-100	64.5	69.1	59.1	67.1

Table 1. Percent of emerged brood adult **Trypodendron lineatum** choosing the dry alternative when given a choice of 2 relative humidities under light and dark conditions. Mean of 2 replicates of 20 beetles for each test.

Time of Observation	Mean Temperature in Cage (C°).	No. beetles on walls of cage at positions ranked by decreasing light intensity for each time period.							
		1	2	3	4	5	6	7	8
12-1	17.4	5	-	-	-	-	-	-	-
1-2	18.3	16	2	1	-	-	-	-	-
2-3	19.1	29	3	2	-	-	-	-	-
3-4	20.4	38	3	2	-	-	-	-	-
4-5	25.2	4	37	12	1	-	-	-	-
5-6	28.9	6	25	20	1	-	-	-	-
6-7	28.9	7	18	16	-	-	-	-	-
7-8	24.3	10	26	9	-	-	-	-	-
8-9	19.4	8	5	16	-	-	-	-	-

Table 2. Orientation of emerged brood adult **Trypodendron lineatum** to light in a field cage.

The humidity and photic responses of brood *T. lineatum* were very different from those of parent beetles excised from host logs (Pulliainen 1965). Reproducing parents were strongly photonegative at high humidity levels, and were very hygropositive, being able to discriminate between 100 and 97% R.H. The difference in orientation can be explained through an examination of the biology of the 2 stages. Reproducing parents remain in dark galleries and rely heavily on moist conditions for both direct survival and fungus cultivation. However, brood beetles emerge into an environment which must be dry and well lighted to enable them to fly to an overwintering location and perceive a dark and moist site in which to overwinter.

It is evident that reversals in both photic and humidity response occur in brood beetles. To locate and remain in the overwintering site, they must become photonegative and hygropositive. The shift in photic to chemotactic response in spring beetles occurs after a prerequisite period of flight (Graham 1959, 1960; Bennett and Borden 1971) and as in *Dendroctonus pseudotsugae*, may also be associated with lipid content (Atkins 1966a, b, 1969) and selective lipid oxidation (Thomposn and Bennett 1971). Such physiological activity could provide an effective, internal feedback mechanism which would allow a behavioral reversal only after an insect had achieved a desired physiological condition. The known or postulated mechanisms controlling behavioral reversals in spring beetles may lead to effective means of investigating the reversals of photic and humidity response in brood *Trypodendron lineatum*.

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Dempsey, M. W. Ed-in-Chief

THE WORLD OF INSECTS

Reference Library Books
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Philadelphia. 1971
60¢

From time to time this society has debated proposals to publish an elementary handbook on insects of the province for use in schools. Committees have even been struck to begin writing, but no manuscript has been forthcoming. Probably the members discovered that it is extraordinarily difficult to produce a regional guide to insects for young readers who are making a standing start. Some basic knowledge has to be assumed or provided. The two levels of information are not easy to combine into a small book and always there is the problem of illustration.

Now appears another rock-bottom elementary booklet, not slanted to this area admittedly, but at 60¢ priced below anything this society could hope for, well and interestingly written without gee-whiz superlatives, brilliantly illustrated in color to the Queen's taste, and factual enough for Chas. Darwin himself. It is one of a series of 12 (Birds, Fishes, The Earth, etc.). The cover blurb reads: ". . . Over 80 full-colored pictures. In dictionary form for quick, easy reference. All fundamentals and essential facts for a basic grasp of subject. An implement for educational advancement." All true.

The problem in writing such as this is one of choice: what to use from the mountains of available information, so that the beginner is not bored and turned off. Here the statements are so attractively illustrated as to lessen the importance of the examples chosen. Moreover, despite a faint British flavor, the examples are mostly so general that we have in this province similar forms or relatives close enough to recognize.

All the land arthropods are touched on, including three pages on spiders. There is a two-page index, an excellent family tree of 15 Orders of insects from Collembola up, and a table of 24 Orders organized by metamorphosis, with round numbers of species in each. One page is devoted to collecting methods.

The question remains: should we still try to produce a handbook for B.C. schools or rely on such books as this? The problem resolves itself into three parts: What information to present? How to illustrate it? Who should pay?

H. R. MacCarthy