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Douglas-fir Tussock Moth Egg Hatch and Larval Movement from Egg Masses in Central British Columbia

Abstract

Patterns of Douglas-fir tussock moth (*Orgyia pseudotsugata* McD) egg hatch and movement of larvae from egg masses were studied at a site near Heffley Creek, 25 km north of Kamloops, British Columbia, in June 1975. A majority of the eggs (65 percent) hatched between 0800 and 1600 hours (PST) and 45.8 percent hatched between 0800 and 1200. Egg hatching was complete in nine days. Peak hatch occurred after four days, and peak movement of larvae from the egg masses occurred three days later. Patterns of larval movement from the egg masses during the day were similar to egg hatching patterns. Average percent eclosion of eggs was 20.5 percent. Cumulative egg hatch at the British Columbia site was reasonably well predicted with the equation $y = -88.78 + 97.45 \log x$, where y = cumulative percentage hatch, and x = cumulative degree days after hatch initiation above a base of 5.6°C. The model was constructed using independent data from California and Oregon.

Introduction

The Douglas-fir tussock moth (*Orgyia pseudotsugata* McD), a univoltine insect, defoliates true firs (*Abies* spp.) and Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn.] Franco) in western North America (Wickman *et al.*, 1973). Defoliated trees may be killed outright or top-killed with resulting loss of growth.

Egg hatching has been studied by Cameron (1970) and Edwards (1965) in the laboratory and by Wickman (1976 a and b) in the field in California and Oregon, respectively. The objectives of this study were to (1) study patterns of egg hatching and larval movement from the egg masses at a field site in British Columbia, (2) study egg viability, and (3) develop a predictive model for egg hatching.

Methods

Study Site

The study site was located approximately 25 km north of Kamloops, British Columbia, near Heffley Creek at an elevation of approximately 750 m. Dominant vegetation was Douglas-fir and ponderosa pine (*Pinus ponderosa* Laws.), and the trees were widely spaced. The Douglas-fir trees were extensively defoliated in 1974 and large numbers of egg masses were present in the tree canopies. The study was conducted from 2 to 13 June 1975.

Egg Hatching

Egg masses were collected from small trees and the lower branches of large trees. Hatch was observed on 25 masses set approximately 1.5 m from the forest floor on a tree. The egg masses were glued to paper on a 5 x 5 grid, 10 cm apart. Egg masses faced south and east. Egg hatch was also observed on 25 egg masses on paper laid on the forest floor using the same grid pattern. Larvae were removed with tweezers each hour from

0800 to 1600 hours (PST). Hatching was also studied in the period from 1600 to 0800 hours.

Larval Movement from Egg Masses

The number of larvae moving from 31 egg masses on the tree and 20 egg masses on the forest floor was studied hourly each day from 0800 to 1600 hours and from 1600 to 0800 hours. Egg masses were glued to paper as they were in the hatching observations. A larva was considered to have left an egg mass when it moved more than 1.5 cm from the edge of the egg mass.

Egg Viability

The total number of eggs in each egg mass was recorded in both the hatching and dispersing observations in order to ascertain egg viability. Percent eclosion was ascertained as (no. of eggs hatched/total no. of eggs) x 100.

Temperature Data

Temperature data were obtained from hygrothermograph (Casella) set in a clearing approximately 100 m from the specific study site. Degree day determinations were calculated using average daily temperatures and a base of 5.6°C (42°F). This threshold temperature was suggested by Wickman (1976 a and b).

Results and Discussion

Pattern of Egg Hatching throughout the Day

Table 1 shows egg hatching patterns observed during the day. For combined egg masses on the tree and forest floor, 35 percent of the eggs hatched between 1600 and 0800 hours and 65 percent of the eggs hatched from 0800 to 1600 hours. Thus a majority of the eggs hatched during daylight hours, in general before noon; 45.8 percent hatched between 0800 and 1200 hours. There appeared to be a slight afternoon peak between 1300 and 1400 hours for the eggs on the tree, but hatching patterns on the tree and forest floor were not vastly different.

TABLE 1. Average percentage of eggs hatching from egg masses on the tree and forest floor and combined tree and forest floor egg hatch each hour from 0800 to 1600 and from 1600 to 0800 from 3 to 12 June 1975.

Time of Day (PST)	Percentage Hatch		
	Egg Masses on Tree	Egg Masses on Forest Floor	Combined Forest Floor and Tree Egg Masses
1600-0800	35.1	35.4	35.0
0800-0900	17.8	27.3	24.0
0900-1000	14.8	5.9	8.8
1000-1100	4.3	8.1	6.9
1100-1200	5.6	6.3	6.1
1200-1300	8.0	6.6	7.1
1300-1400	12.4	4.8	7.3
1400-1500	2.0	5.6	4.8
1500-1600	0.0	0.0	0.0

In a laboratory study in British Columbia by Edwards (1965), 90 percent of egg hatching occurred between 0600 and 1800 hours, 65 percent occurred between 0600

and 1200 hours, but no hatching occurred between 2400 and 0600 hours. This pattern of hatching contrasts with that found in a similar laboratory study in California by Cameron (1970), who found that egg hatch was evenly distributed throughout the day. Fifty-eight percent of the eggs hatched from 0600 to 1800 hours at 24°C, and there was considerable hatching (18 percent) between 2400 and 0600. Unfortunately, egg hatch was not observed at the study site from midnight to 0600 hours; thus, there is no way to tell which laboratory study the field hatching patterns most closely resemble.

Length of Egg Hatching Period

Hatching commenced on 3 June for both sets of egg masses and was complete by 11 June (9 days) on the tree (Figure 1a) and on the forest floor (Figure 1b). Further south in Oregon in 1973, Wickman (1976b) found hatch periods in the field ranging from 7 to 14 days. Hatch periods in California in 1972 were about 10 days (Wickman, 1976a). The period from initiation to end of hatching thus was similar at the California, Oregon, and British Columbia sites.

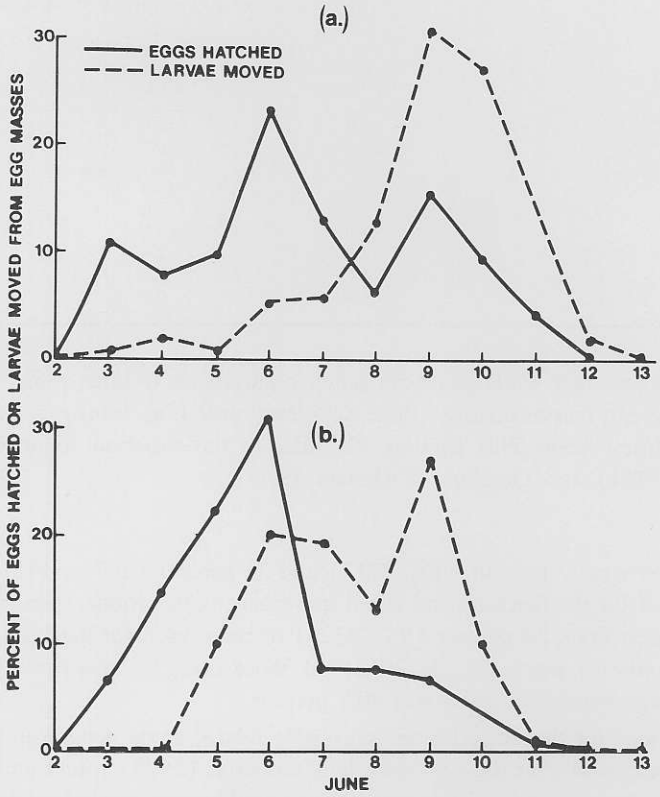

Figure 1. Percentage of eggs hatched and larvae dispersed from egg masses on (a) the tree and (b) the forest floor from 2 to 13 June 1975.

Maximum egg hatch was recorded on the fourth day after hatch initiation on both sets of egg masses (Figure 1). Similar results for the time of maximum hatching were found by Wickman (1976a) in California (2-4 days after initiation). In Oregon, however, maximum hatching occurred from 4 days to 10 days after initiation (Wickman,

1976b), and at one site hatching was bimodal with peaks at 3 and 10 days.

Movement of Larvae from Egg Masses

For the combined egg masses on the forest floor and tree the pattern of movement of larvae from the egg masses during the day (Table 2) resembled egg hatching patterns (Table 1). Between 1600 and 0800 hours, 37.6 percent of the larvae left the egg masses, 62.4 percent left between 0800 and 1600 hours, and 47.7 percent left between 0800 and 1200 hours (Table 2). Considerably more larvae moved from the egg masses on the tree before 0900 hours (69.6 percent) than from the egg masses on the ground (38.3 percent), perhaps reflecting slight differences in microclimate, especially exposure to radiation.

TABLE 2. Average percentage of larvae moving from egg masses on the tree and forest floor and movement from combined tree and forest floor egg masses from 0800 to 1600 and 1600 to 0800 from 3 to 13 June 1975.

	Percentage of larvae moved from egg masses		
Time of Day (PST)	Egg Masses on Tree	Egg Masses on Forest Floor	Combined Forest Floor and Tree Egg Masses
1600-0800	43.9	12.8	37.6
0800-0900	25.7	25.5	25.7
0900-1000	6.8	19.7	9.4
1000-1100	5.9	16.0	7.9
1100-1200	4.0	7.3	4.7
1200-1300	4.9	13.1	6.6
1300-1400	4.3	3.6	4.2
1400-1500	4.5	1.8	3.9
1500-1600	0.0	0.0	0.0

Figure 1 shows that while peak egg hatch occurred on 6 June, peak movement of larvae from the egg masses occurred three days later on 9 June from egg masses on both the tree and forest floor. This finding is similar to the situation found in California (Wickman, 1976a) and Oregon (Wickman, 1976b).

Egg Viability

Percent eclosion was 17 percent (461/2717) and 24 percent (1074/4461) for the eggs on the tree used for the hatching and larval movement observations, respectively. Of the eggs on the forest floor, 28 percent (937/3329) of those used for hatching observations hatched, but only 13 percent (274/2063) of those used for movement observations hatched. Average percent eclosion was 20.5 percent.

This low value for percent eclosion is probably related to the length and temperature of the exposure period after the eggs were laid. Cameron (1970) found under laboratory conditions that long periods of egg exposure to cold storage periods resulted in a decrease in percent eclosion. He found eclosion to be 48 percent following 67 days exposure to temperatures of approximately 3°C, but this figure fell to about 20 percent after 147 days, and to 12 percent after 186 days. No larvae hatched after storage for 360 days. Assuming that eggs in the field in British Columbia were exposed to approximately 170 days of average temperatures <3°C (from Kamloops Airport weather data), then the field and laboratory data match.

Prediction of Egg Hatching

The predictive model was constructed using the basic premise that cumulative hatch is determined by degree day accumulations after hatch initiation regardless of the location; i.e., throughout the range of the Douglas-fir tussock moth. Hatch data from California (Wickman, 1976a) and Oregon (Wickman, 1976b) were used along with degree day determinations, to construct a semilogarithmic linear regression model of the form:

$$y = a + b \quad \log x$$

where y = cumulative percentage hatch,

x = degree day accumulations after hatch initiation above a base of 5.6°C, and a and b are the usual constants.

The following model equation resulted:

$$y = -88.78 + 97.45 \quad \log x$$

The correlation coefficient for this regression was $r = 0.7836$ (significant at the 99 percent level, $n = 23$) and $r^2 = 0.6140$. Observed versus predicted values in Figure 2 show that this model predicts cumulative hatch rather well. Thus the model assumption is apparently reasonable.

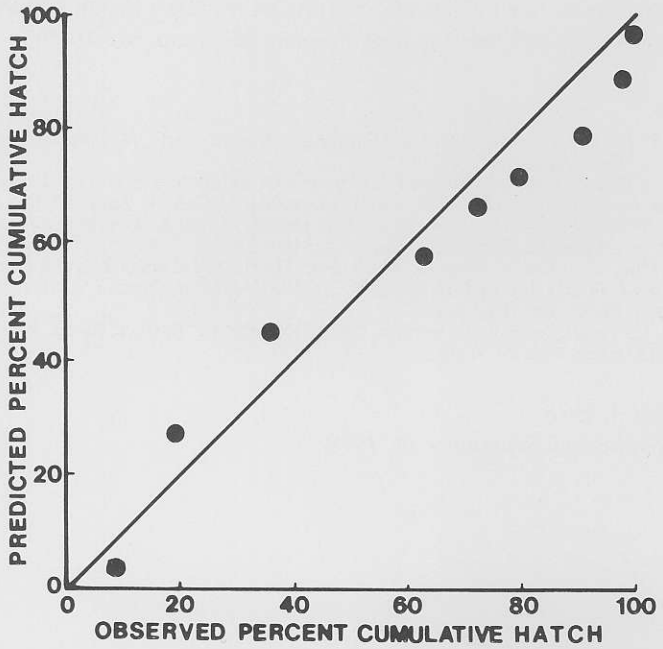

Figure 2. Observed cumulative percentage egg hatch at the British Columbia site versus predicted cumulative percentage egg hatch based on the equation $y = -88.78 + 97.45 \log x$, where y = cumulative percentage hatch, and x = cumulative degree days after hatch initiation above a base of 5.6°C. Solid line indicates perfect agreement.

Using the Kamloops data alone, however, the relationship between cumulative percentage hatch and log degree day accumulation was even better, giving $r = 0.9787$ (significant at the 99% level, $n = 9$) and $r^2 = 0.9579$ for $y = -104.42 + 111.13 \log x$. This finding perhaps indicates the closer relationship between the hatch location and the location of the temperature sensor at the British Columbia site.

Summary and Conclusion

A majority of the eggs (65 percent) at the British Columbia site hatched between 0800 and 1600 hours and 45.8 percent hatched between 0800 and 1200 hours. Egg hatch was complete in nine days, which is similar to that found in California and Oregon. Maximum egg hatch was recorded on the fourth day, and peak movement of larvae from egg masses occurred three days later. The pattern of larval movement during the day was similar to the egg hatching pattern in that 62.4 percent of the larvae left the egg masses between 0800 and 1600 hours and 47.7 percent left between 0800 and 1200 hours. Average percent eclosion was 20.5 percent.

Cumulative egg hatch at the British Columbia site was predicted reasonably well using the regression model $y = -88.78 + 97.45 \log x$ where $y =$ cumulative percentage hatch, and $x =$ degree day accumulations after hatch initiation above a base of 5.6°C.

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