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Regression Equations and Table for Estimating Numbers of Eggs in Jack Pine Budworm (Lepidoptera: Tortricidae) Egg Masses in Michigan

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REGRESSION EQUATIONS AND TABLE FOR ESTIMATING NUMBERS OF EGGS IN JACK PINE BUDWORM (LEPIDOPTERA: TORTRICIDAE) EGG MASSES IN MICHIGAN[1]

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ABSTRACT

Three simple linear regression equations were developed to estimate the numbers of eggs in jack pine budworm, *Choristoneura pinus pinus,* egg masses in Michigan. One equation was developed for each of 2-row, 2-row +, and 3-row egg masses. A table of estimated numbers of eggs per egg mass is given for each of the three row types for egg mass lengths from 1 to 25 mm.

Numbers of eggs in jack pine budworm, *Choristoneura pinus pinus* Freeman, egg masses yield useful information for population dynamics studies and general survey assessments (Morris 1955). The objective of this paper is to present prediction models for numbers of eggs in jack pine budworm egg masses in Michigan. These prediction models are the first ones developed for jack pine.

METHODS AND MATERIALS

The data used to develop the prediction models were obtained from samples collected from five jack pine, *Pinus banksiana* Lambert, stands in Michigan's Lower Peninsula from 1981 to 1984, providing egg masses from a range of population densities from sparse to high. The pooled data set included 657 egg masses.

Egg-mass length was measured to the nearest 0.1 mm with a microscope ocular micrometer. Only current-year, nonparasitized egg masses with clearly distinguishable chorions were included in the data set (Jennings and Addy 1968). Numbers of egg rows and numbers of eggs were counted and recorded. Egg masses either had 2 rows, 2 rows + (two rows with a partial third row), or 3 rows (Leonard et al. 1973).

The significance of each regression equation was tested using the F-test (Neter et al. 1985). The analysis of covariance F-test was used to test equality among regression equations (Snedecor and Cochran 1968). Skewness and kurtosis coefficients and correlations between absolute error terms and egg mass lengths showed no serious departures from the assumptions of normality and homogeneity, respectively, for all hypothesis tests (Neter et al. 1985, Snedecor and Cochran 1968). Results of all hypothesis tests were considered significant if the significance probability $P < 0.05$.

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RESULTS

For the pooled data set, plots of numbers of eggs in an egg mass versus egg mass length for each row type indicated positive linear relationships. One simple linear regression was developed for each row type. All prediction models were highly significant (F, $P < 0.001$). The three row-type regressions were significantly different from each other (F, $P < 0.001$).

Table 1 shows the estimated numbers of eggs per egg mass for various egg mass lengths for the three row types. The prediction models for each row type are also shown along with sample sizes (n), standard errors of the estimate ($s_{y.x}$) and coefficients of determination (r^2).

Table 1. The estimated number of eggs per egg mass for various egg mass lengths for the three row types in Michigan, and the prediction models for each row type.

Length (mm)	Row Type		
	2-Row[a]	2-Row+[b]	3-Row[c]
1.0	—	1.23	6.81
1.5	—	3.38	9.09
2.0	1.93	5.52	11.38
2.5	4.03	7.66	13.66
3.0	6.13	9.80	15.94
3.5	8.23	11.95	18.23
4.0	10.33	14.09	20.51
4.5	12.43	16.23	22.79
5.0	14.53	18.38	25.08
5.5	16.63	20.52	27.36
6.0	18.73	22.66	29.64
6.5	20.83	24.80	31.93
7.0	22.93	26.95	34.21
7.5	25.03	29.09	36.49
8.0	27.13	31.23	38.78
8.5	29.23	33.37	41.06
9.0	31.33	35.52	43.34
9.5	33.43	37.66	45.63
10.0	35.54	39.80	47.91
10.5	37.64	41.95	50.19
11.0	39.74	44.09	52.48
11.5	41.84	46.23	54.76
12.0	43.94	48.37	57.04
12.5	46.04	50.52	59.33
13.0	48.14	52.66	61.61
13.5	50.24	54.80	63.89
14.0	52.34	56.94	66.18
14.5	54.44	55.09	68.46
15.0	56.54	61.23	70.74
15.5	58.64	63.37	73.03
16.0	60.74	65.51	75.31
16.5	62.84	67.66	77.59
17.0	64.94	69.80	79.88
17.5	67.04	71.94	82.16
18.0	69.15	74.09	84.44
18.5	71.25	76.23	86.73

Table 1. (continued)

Length (mm)	Row Type		
	2-Row[a]	2-Row+[b]	3-Row[c]
19.0	73.35	78.37	89.01
19.5	75.45	80.51	91.29
20.0	77.55	82.66	93.58
20.5	79.65	84.80	95.86
21.0	81.75	86.94	98.14
21.5	83.85	89.08	100.43
22.0	85.95	91.23	102.71
22.5	88.05	93.37	104.99
23.0	90.15	95.51	107.28
23.5	92.25	97.66	109.56
24.0	94.35	99.80	111.84
24.5	96.45	101.94	114.13
25.0	98.55	104.08	116.41

[a]$\hat{Y}_i = -6.4771 + 4.2012\,X_i$, $n = 230$, $s_{y\cdot x} = 6.6842$, $r^2 = 0.843$
[b]$\hat{Y}_i = -3.0518 + 4.2854\,X_i$, $n = 203$, $s_{y\cdot x} = 7.4899$, $r^2 = 0.790$
[c]$\hat{Y}_i = 2.2450 + 4.5665\,X_i$, $n = 224$, $s_{y\cdot x} = 8.0727$, $r^2 = 0.819$

The average numbers of eggs per egg mass were 38.4, 49.7, and 59.4 for 2-row, 2-row +, and 3-row egg masses, respectively. The average length of egg masses was 10.7, 12.3, and 12.5 mm for 2-row, 2-row +, and 3-row egg masses, respectively. The range of length of egg masses was 2.0–22.5, 4.5–22.5, and 5.5–24.0 mm for 2-row, 2-row +, and 3-row egg masses, respectively.

CONCLUDING REMARKS

These prediction models should be adequate for most applications. However, it should be noted that the relationship between numbers of eggs in an egg mass and egg mass length will vary from stand to stand, over time, and with stage of infestation.

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LITERATURE CITED

Jennings, D. T., and N. D. Addy. 1968. A staining technique for jack pine budworm egg masses. J. Econ. Entomol. 61:1766.

Leonard, D. E., G. A. Simmons, and G. K. Van Derwerker. 1973. Spruce budworm: techniques to improve counting of eggs. J. Econ. Entomol. 66:992.

Morris, R. F. 1955. The development of sampling techniques for forest insect defoliators with particular reference to the spruce budworm. Canadian J. Zool. 33:226–294.

Neter, J., W. Wasserman, and M. H. Kutner. 1985. Applied linear statistical models. Richard D. Irwin, Inc., Homewood, IL.

Snedecor, G. W., and W. G. Cochran. 1968. Statistical methods. The Iowa State Univ. Press, Ames.