A MODEL TO PREDICT DAMAGE REDUCTION TO FLOWER BUDS OR FRUIT BY HELIOTHIS SPP.[1/] IN THE ABSENCE OR PRESENCE OF TWO COLEOPTERA PREDATORS.

J.H. Young and L.J. Willson

Department of Entomology and Department of Statistics
Oklahoma State University
Stillwater, OK 74078

ABSTRACT

A model is presented for predicting cotton fruit damage reduction potential of the convergent lady beetle, *Hippodamia convergens* Guerin-Meneville, and the soft flower beetle, *Collops quadrimaculatus* (F) from the bollworm, *Heliothis zea* (Boddie), and the budworm, *H. virescens* (F).

The model predicts damage reduction by estimating percent occupancy of the two species in 1/5000 acre quadrats. The correlation between occupancy and damage reduction is 0.99, indicating that if 1 or more convergent lady beetles or *Collops* spp. are present, damage is unlikely to occur. The data were taken from cotton fields in southwestern Oklahoma.

INTRODUCTION

The importance of predators in the control of *Heliothis zea* (Boddie) and *H. virescens* (F.) is well known (Quaintance and Brues 1905). Research in South western Oklahoma has shown that the two most numerous predators in the area are the convergent lady beetle, *Hippodamia convergens*(Guerin-Meneville) and soft flower beetle, *Collops quadrimaculatus* (F.) (See Hill et. al. 1975, Burleigh et. al. 1973, and Johnson et. al. 1976).

The interaction of the bollworm-budworm complex with its predators, especially the cause and effect relationships associated with varying numbers of bollworms and budworms, has received the attention of several investigators (Burleigh et. al. 1973, Massey and Young 1975, Johnson et. al. 1976). This relationship is important in making integrated pest management decisions. Investigations were conducted from 1971 through 1982 on the cotton agro-ecosystem in Tillman and Jackson counties in southwestern Oklahoma. This paper is a report on the predator-prey relationships found in this study.

MATERIALS AND METHODS

Populations of Heliothis zea, *H. virescens*, predators and parasites were monitored in Jackson and Tillman counties from 1971-1982. Five fields were monitored in each county. The sampling was stratified random with whole plant examination. The sampling unit was 1/5000 acre (2.61 row feet or 1/12372 hectare; see Hill et. al. (1975). For the years 1971-79 and ½ of 1980 the coefficient of variation (C.V.) controlling method of Rojas (1964) was used; that is, sampling continued until

$$n \geq \frac{\frac{1}{\hat{K}} + \frac{1}{\bar{X}}}{C^2} \qquad (1)$$

1/ Lepidoptera: Noctuidae

where n = sample number
$\hat{K}$ = an estimate of the aggregation parameter K, of the negative binomial distribution
$\bar{X}$ = sample mean
C = amount of C.V. control (0.1 was used in this study)
In all cases $\hat{K}$ was calculated in the field using the method of moments,

$$\hat{K} = \frac{\bar{X}}{s^2 - \bar{X}} \tag{2}$$

where s^2 is the sample variance and $\bar{X}$ is the sample mean.

Beginning in August of 1980 and through 1982, the sequential sampling method of Willson (1981) was used. Observations were taken until

$$n > \frac{1}{C^2\hat{K}} - \frac{1}{\hat{K}} \text{ and } TN \geq \frac{n\hat{K}}{C^2(n\hat{K}+1)-1} \tag{3}$$

where TN is the total number of insects and n, $\hat{K}$, and C are as above. Estimation of K in 1981 also was changed to the method of Willson (1981).

A chi-square goodness-of-fit test was conducted to verify that the negative binomial distribution fit the sample values. See table 1. The expected frequencies were generated using

$$\phi(0) = \left(\frac{\hat{K}}{\hat{K}+\bar{X}}\right)^{\hat{K}} N \tag{4}$$

and

$$\phi(x) = \left(\frac{\hat{K}+x-1}{x}\right)\left(\frac{\bar{X}}{\hat{K}+\bar{X}}\right)\phi(x-1),\ x > 0 \tag{5}$$

where N is the sample size.

In addition to the fields mentioned above, tests were made on pest management strategies in 1972-76 (Johnson et. al. 1976, Massey and Young 1975, Burleigh et. al. 1973); these included strip-cropping and insecticide tests. In all cases, the fields had one part sprayed to kill predators, thus predisposing the field to bollworm attack and one part left unsprayed. Damage was estimated by collecting 500 unflared squares from each plot. Fields included in analysis contained both Heliothis and predator populations. Many fields did not develop one or the other.

RESULTS

Numerous models were calculated in order to find a relationship between the amount of damage which occurred and the number of budworms, bollworms, and predators present in the plots. Only one model showed a consistent significant relationship. This model is:

$$DR_i = .98\ PO_i + e_i \tag{6}$$

where DR_i = the percent reduction in damage from the treated to the non-treated plot in field i.
PO_i = the percentage of quadrats occupied by at least one lady beetle or Collops in the unsprayed part of field i.
e_i = random error associated with field i.

The slope of .98 was obtained by least squares regression. The fit was good (r^2 = .99).

A chi-square test of independence supported the assumption that the number of lady beetles and *Collops* spp. present in a field are independent (P = .95). Hence, PO was calculated as

$$PO = \left[1 - \left(\frac{\hat{K}_c}{\hat{K}_c + \bar{X}_c} \right)^{\hat{K}_c} \left(\frac{\hat{K}_{LB}}{\hat{K}_{LB} + \bar{X}_{LB}} \right)^{\hat{K}_{LB}} \right] 100 \qquad (7)$$

where $\hat{K}_c = \hat{K}$ for *Collops*
$\hat{K}_{LB} = \hat{K}$ for lady beetles
$\bar{X}_c = \bar{X}$ for *Collops*
$\bar{X}_{LB} = \bar{X}$ for lady beetles

Other predators found consistently were *Chrysopa* spp., *Nabis* spp., *Geocoris* spp., and various species of spiders. However, no good correlation was found between budworm, bollworm population fluctuations and these predators when tested individually or collectively. This is probably due to the predominance of *Collops* and lady beetles in these fields. Figure 1 shows the relationships described above.

One other assumption was that the sprayed field and the unsprayed part have equal attractiveness to bollworms and budworms as oviposition sites. We did not test this and we had only circumstantial evidence. The equation fitted all historical and current data.

It should be noted that the highest bollworm-budworm larval count was 46,000 per acre. Most of the larvae were bollworms. In no case were there more than 10% budworms.

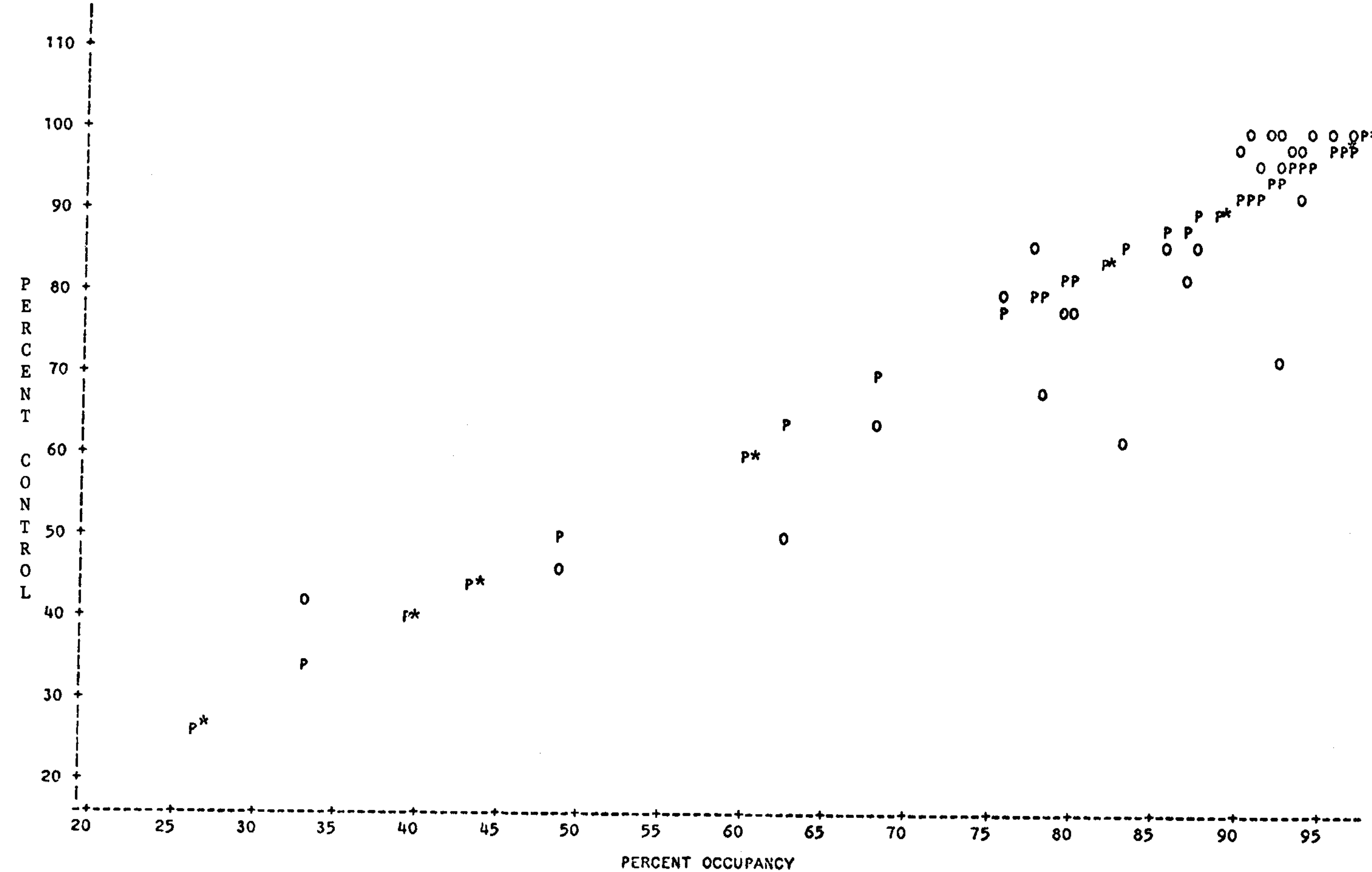
CONCLUSIONS

This study shows that if one or more soft flower beetle or lady beetles are present in a quadrat, 1/5000 A (2.61 row feet), damage from bollworms and budworms is unlikely to occur. This result holds over a diverse and long term data set. Equation (7) shows this occupancy was 1 minus the product of the estimated probabilities of 0 *Collops* and 0 lady beetles in a quadrat, and this is multiplied by 100 to put it on a percentage basis. These data are claimed only for conditions in the rolling plains area of Oklahoma. It is possible that adjustments will be needed for areas with higher numbers of pest larvae, or alternate hosts, taller cotton, or different predator complexes.

TABLE I. Interaction of the Bollworm Complex and 2 Major Predators

Field	Year	Collops		Lady Beetle		No. of Samples	Chi-square goodnes of fit	
		K	$\bar{X}/\frac{1}{5000a}$	K	$\bar{X}/\frac{1}{5000}$		Collops	Lady Beetles
1	71	3.91	1.21	1.94	2.32	110	.90	.95
2	71	4.02	0.61	2.25	1.11	189	.95	.85
3	72	4.22	0.42	2.02	0.62	212	.99	.95
4	72	3.87	4.21	2.34	0.51	240	.80	.90
5	72	3.94	0.23	1.63	0.32	460	.99	.90
6	73	4.26	1.2	1.72	1.62	120	.80	.80
7	73	4.47	1.4	1.72	2.71	94	.99	.75
8	73	4.52	0.89	1.54	0.21	545	.90	.90
9	73	2.91	2.3	----	----	78	.99	- --
10	74	3.62	1.2	2.18	0.61	210	.75	.85
11	74	4.13	0.62	2.97	0.11	1010	.99	.90
12	74	----*	----	1.84	1.66	115	- --	.90
13	74	----*	----	1.71	2.81	94	- --	.90
14	75	3.94	1.23	2.18	2.32	107	.90	.85
15	75	4.24	1.11	2.09	0.82	170	.90	.90
16	75	4.33	4.21	1.83	1.22	137	.95	.75
17	75	3.82	3.26	1.74	2.81	93	.99	.85
18	76	3.09	0.21	2.65	0.11	947	.99	.95
19	76	4.21	1.22	2.16	1.52	112	.90	.95
20	76	4.31	1.32	2.07	1.64	110	.85	.95
21	76	4.22	6.89	2.84	0.92	144	.95	.90
22	77	2.63	0.62	2.71	0.51	200	.85	.75
23	77	3.74	1.67	3.11	5.34	87	.80	.80
24	77	4.18	6.31	2.33	2.34	86	.85	.85
25	77	2.82	1.33	2.32	1.43	114	.99	.80
26	77	3.65	0.41	2.11	0.82	271	.99	.75
27	78	4.76	1.42	2.02	1.83	104	.99	.80
28	78	3.91	1.42	1.67	3.62	96	.80	.80
29	78	3.88	1.92	1.81	2.31	100	.80	.75
30	78	3.97	0.61	1.99	1.72	189	.85	.75
31	79	3.76	0.42	1.86	2.31	265	.95	.95
32	79	4.15	4.21	1.82	0.93	162	.75	.90
33	79	4.04	1.36	2.00	1.63	111	.80	.90
34	79	4.13	2.13	2.18	1.05	141	.90	.90
35	79	3.82	2.09	1.98	2.10	98	.90	.90
36	80	3.94	3.12	1.87	0.62	215	.95	.95
37	80	4.56	0.32	1.20	0.11	992	.80	.95
38	80	3.75	2.31	1.97	1.21	133	.90	.95
39	80	4.34	1.22	2.41	1.24	122	.80	.90
40	81	5.23	1.31	2.31	2.42	95	.75	.90
41	81	4.12	2.31	2.42	4.52	67	.90	.90

* Only 1 predator present



NOTE: FIGURE 1. Percent Heliothis damage reduction by collops and lady beetles.

* Represents both predicted and observed.

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