DEVELOPMENT OF IMPROVED DENSITY ESTIMATORS FOR LARVAE OF THE CEREAL LEAF BEETLE, *OULEMA MELANOPUS* (L.)

By

Patrick A. Logan

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ABSTRACT

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Good pest management decisions begin with an accurate estimate of pest density and rely on close predictions of future densities. Sweepnet sampling was evaluated as a low cost method of arriving at an index of density. Attempts at determining instar specific multiplication factors to convert catch per sweep to catch per square foot lacked precision. Incorporation of degree days, windspeed, rainfall and crop height into the conversion factors did little to improve the model. Use of logarithmic transforms (i.e., a multiplicative model) improved the characteristics of the statistical residuals slightly. An additional data set was also evaluated, but this served only to cloud the picture, casting doubt on the generality of the conversion factors.

"Two linear feet" or square foot quadrat samples were also evaluated. Instability of the variance of egg and larval counts was characterized by a double log second order relationship with the mean. Taylor's "power law" was brought to question as a result and was found to be subject to density dependent mortality effects. Negative binomial statistics were calculated for all samples and a common k was derived and found to be independent of mean density and population age structure. The search for variance stabilizing transforms led to selection of a simple log transform over inverse hyperbolic sine, power or more complex log transforms, although the differences were small.

Of several environmental factors, crop height and degree days were found to be of most use in fitting density data. Instar, rainfall, field moisture and sprouting date by themselves were less significant, though some of this may have been due to measurement error. A simple regression of degree days (2nd order), crop height and an interaction term was used to develop a filter for conserving previous measurement information, allowing its incorporation into present measurement estimates. Extension of the density rate change equation to prediction of seasonal incidence curves was also attempted and may have general utility in extension work.

Extension of sweepnet, quadrat and filtering from CLB larvae to the problem of sampling internal larval parasitoids was impaired by inaccuracies in the dissection data.

to Ron Wilson, Bert Murray, and Jack Mullins

for getting it all started

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"...always bear two points in mind: firstly, that to the biologist computation is always a means to an end, the real objective being some greater insight into a biological problem; secondly, that the ease with which computation is now possible places on the biologist an even greater responsibility than before to understand something of the principles on which his numerical or statistical analyses are based."

(Davies, 1971)

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INTRODUCTION

1.1 Statement of the thesis problem

The absolute density of a phytophagous insect population is assumed to relate predictably to future densities and thus to the potential for insect induced crop damage. Decisions on whether or not to suppress the insect are based on these predictions. The value of a pest management decision depends on information that is only as good as the accuracy of the estimate of absolute density and the closeness of the pest's predicted density to its actual future density.

Many pest ecosystems include beneficial predators or parasitoids. Optimization of management decisions over more than one year requires a prediction of interactions between pests and beneficials. The limitations of sampling and prediction are confounded when more than one population is involved.

This thesis is an attempt to improve the ability of pest management specialists to estimate and thence to predict larval densities of a small grain pest, Oulema melanopus (L.) (Coleoptera: Chrysomelidae), the cereal leaf beetle (CLB). Since the density of the larval parasitoid Tetrastichus julis (Walker) (Hymenoptera: Eulophidae), may also be obtained from CLB larval sampling, this problem will also be discussed.

There are at least two reasons for wanting to improve density estimates and predictions. First, a sample taken early in the growing season could be used as a basis for implementing appropriate management strategies during the same season. Second, management strategies must also include consideration of the between generation population dynamics of the beetle and its parasitoids. For example, a slightly increased loss during the current growing season resulting from refraining from insecticide use may be more than offset by the beneficial effects of parasitoids in subsequent years. Prediction of between generation dynamics rests on the accuracy of initial density estimates and on the corresponding projection of the within generation dynamics of both populations.

This thesis, accordingly, deals with two problems. The first is the problem of estimating absolute density of the larval cereal leaf beetle. The second is predicting within generation dynamics of CLB larvae. Before evaluation of the accuracy of the density estimate and prior to analysis of environmental or biological factors affecting the dynamics, fundamental statistical problems must be addressed. Most of the concern of this thesis is thus directed toward solution of these underlying statistical questions.

Data for the following studies was gathered under a joint pilot research program involving the Agricultural Research Service (USDA) and Purdue and Michigan State Universities, titled "The Effect of Pubescent Wheat on the Population Dynamics of the Cereal Leaf Beetle". This program is being conducted (1975-1978) in a 16 square mile area near Galien, Michigan, where the CLB was first discovered in North America. In 1975, the area had a high density of beetles and well established populations of egg and larval parasitoids.

Although this thesis is meant to emphasize the goals stated above, additional information from the Pubescent Wheat Study (PWS) will be included in appendices for future reference. The results of 3 years of MSU CLB population dynamics survey work are also relegated to the appendix. Finally, a laboratory and field study of some aspects of noncrop populations of the CLB and T. julis are also included in the appendix. In this way I hope to attain a meaningful balance between conciseness in reaching thesis goals and completeness in presenting reference data for future use.

1.2 Literature review

The cereal leaf beetle is an economically important pest on small grains. Originating in Europe, it was found in southwest Michigan in the 1950's but was not identified until 1962 (Castro, Ruppel, and Gomulinski 1965). Information for constructing life table responses to several environmental parameters was obtained by Yun (1967), Castro et al. (1965) and by Shade, Hansen, and Wilson (1970). Helgeson and Haynes (1972) have presented a model for within generation population dynamics. Haynes (1973) has reviewed features of CLB life history of most importance in developing pest management models. Several aspects of the ecology of the CLB and its principle larval parasitoid, T. julis, have been summarized in a simulation of the beetle ecosystem by Tummala, Ruesink, and Haynes (1975).

T. julis was first released at the MSU W. K. Kellogg Biological Station Experimental Farm in 1966 and was established by 1969 (Stehr 1970). This parasitoid is bivoltine and has a facultative diapause. Some of the offspring of the first generation emerge in midseason while the rest enter diapause. Diapausing first generation parasitoids and all of the second generation winter in soil in the pupal cells of the host. There are usually 4 to 6 parasitoids per host larva.

North American releases of other CLB parasitoids are documented by Dysart, Maltby, and Brunson (1973). These include the egg parasitoid *Anaphes flavipes* (Foerster) and 3 larval parasitoids, *Lemophagus curtus* Townes, *Diaparsis carinifer* (Thompson), and *Diaparsis* new species. It is uncertain whether *D. carinifer* has become established to date (Miller 1977). Further subcolonizations and recoveries made by the CLB Parasitoid Rearing Laboratory, Niles, Michigan, are updated annually by the Animal and Plant Health Inspection Services (USDA-APHIS 1972a,b; 1974).

T. julis was the subject of an extensive subcolonization program throughout the lower peninsula in 1971-1974. Agents from the Michigan Cooperative Extension Service collected parasitized larvae from the Kellogg Farm area and released them at preselected nursery sites in their home counties. A follow-up Extension Service recovery program in 1972-1975 revealed widespread establishment and dispersal (Fig. 1; Appendix 1).

1.3 Biomonitoring and cereal leaf beetle management

In an optimal pest management program the tactics chosen should supplement the effects of natural control agents if possible (Rabb 1970). Following its successful subcolonization, *T. julis* may be regarded as a natural control agent for the cereal leaf beetle. Pest control recommendations should be adjusted accordingly. This requires identification and quantification of the relationships between pest density, a critical set of biotic and abiotic factors (eg. parasitoid density and accumulated heat units) and crop damage.

To a certain extent, many biotic states can be related to abiotic

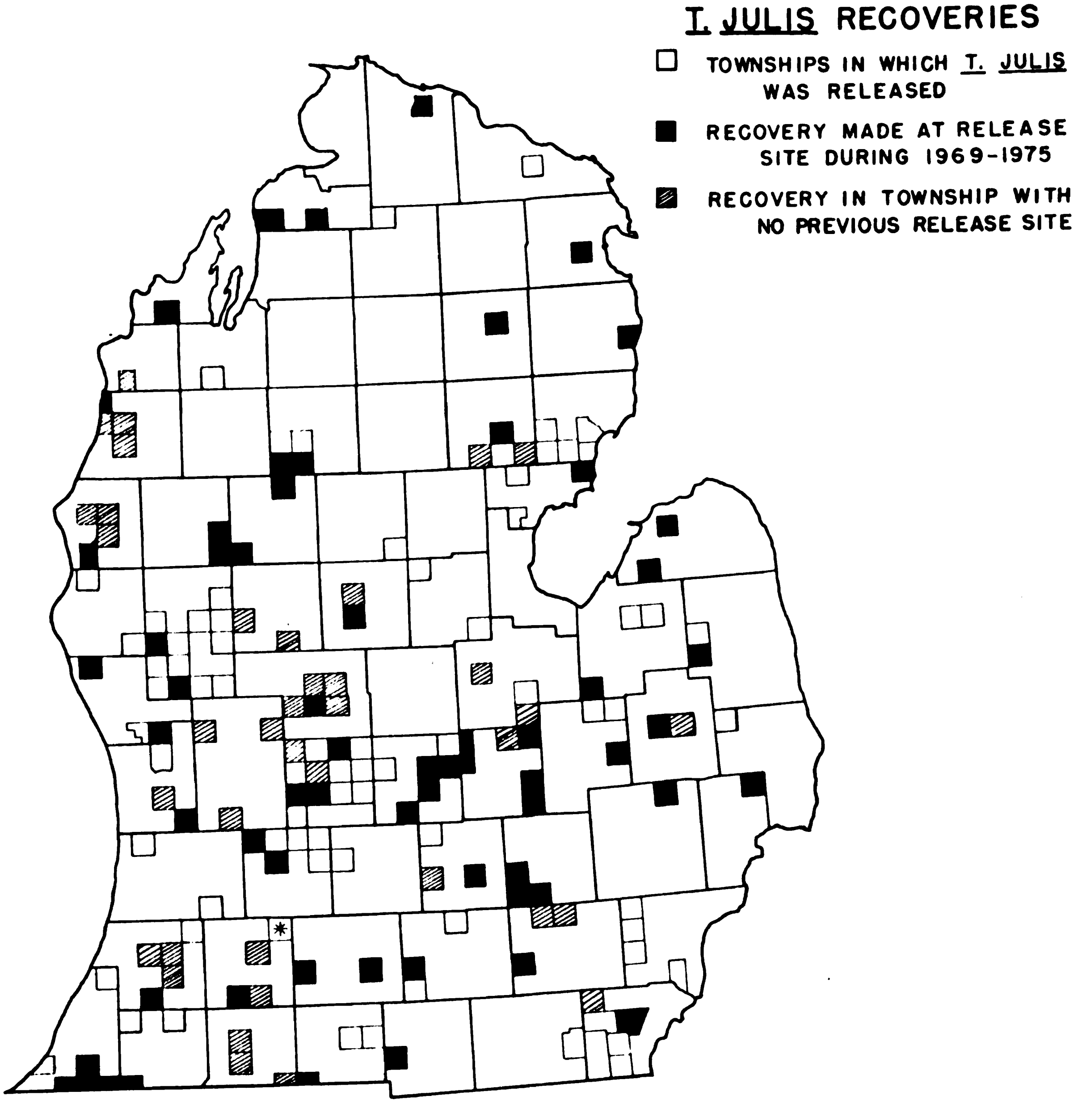

Fig. 1. Michigan townships in which T. julis has been released and/or recovered, 1966-1975.

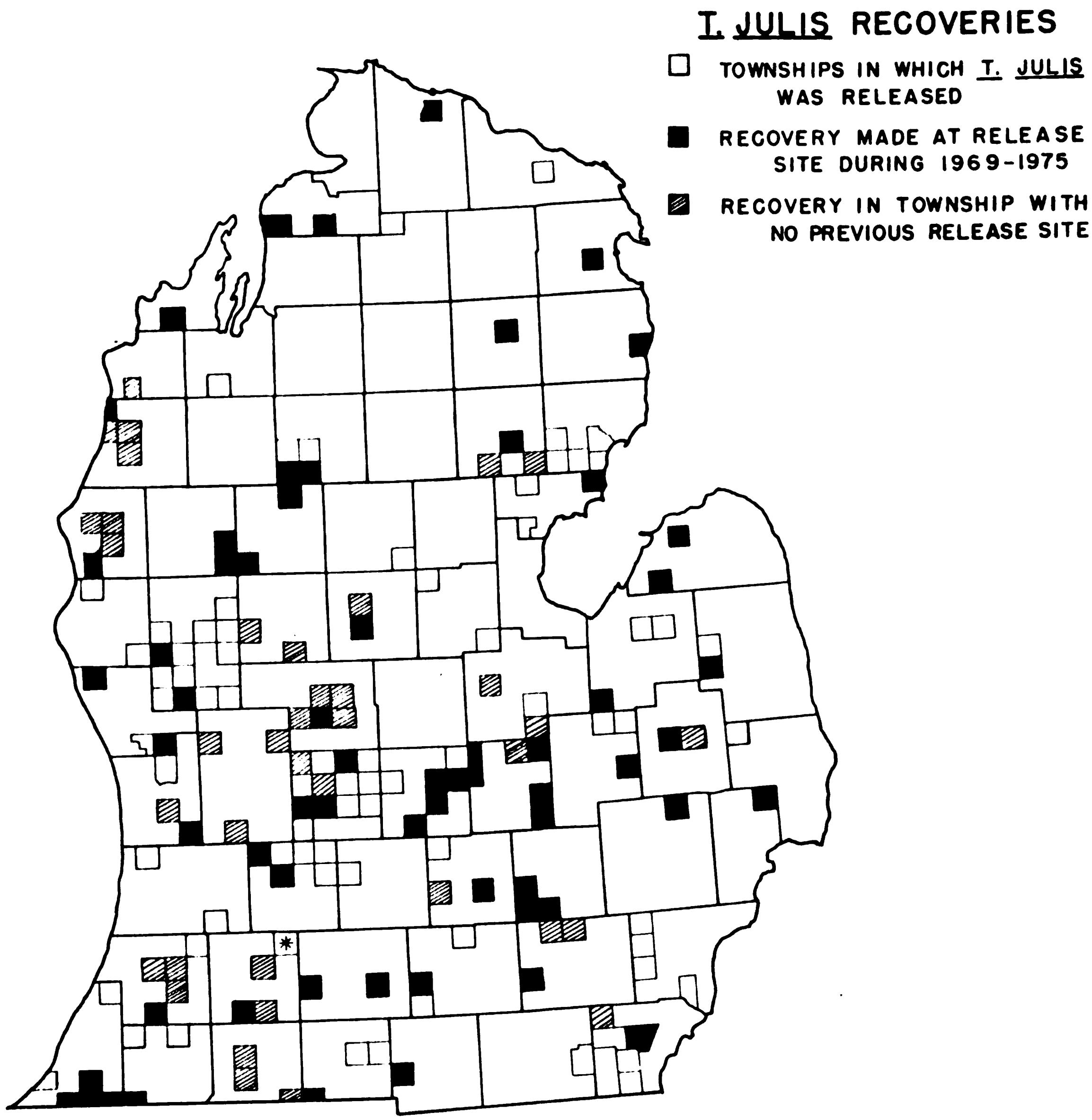

Fig. 1. Michigan townships in which *T. julis* has been released and/or recovered, 1966-1975.

factors. Plant growth, for example, may be predicted from plant age, rainfall, temperature, and soil nutrients. Since monitoring abiotic factors can often be done cheaply and in an automated fashion (Haynes, Brandenburg and Fisher 1973), there have been attempts to use abiotic measurements to make regional projections of biotic states (eg. population maturity) (Fulton and Haynes 1977). The reliability of population projections is restricted by the fidelity of the predictive models and the accuracy of the initial measurements on the population.

Since projection errors will arise from even the highest resolution models, periodic field measurement are needed for recalibration. The nature of these measurements, ie. the design of the sampling program, depends on the type of projection being made. An individual farmer will tend to be most interested in the within generation dynamics of a pest. His sampling program would be intensive, marked by somewhat detailed and frequent counts of pest density, measurements of average larval size, feeding damage, etc. If a population management approach is being used, between generation dynamics of the pest and major biological control agents should also be of interest. Here, the sampling would be over a larger region and would be limited in detail and frequency by the logistics and economics involved.

A general requirement of pest management schemes is that the cost of information must be lower than the cost of proceeding without it (Headley 1975). For several years, the sweepnet has been used to sample CLB adult and larval populations as part of a continual monitoring of several major small grain producing regions in Michigan, Indiana, Ohio, Pennsylvania and Canada (Fulton, Haynes, unpublished reports). The sweepnet has the advantages of low cost per sample, factors. Plant growth, for example, may be predicted from plant age, rainfall, temperature, and soil nutrients. Since monitoring abiotic factors can often be done cheaply and in an automated fashion (Haynes, Brandenburg and Fisher 1973), there have been attempts to use abiotic measurements to make regional projections of biotic states (eg. population maturity) (Fulton and Haynes 1977). The reliability of population projections is restricted by the fidelity of the predictive models and the accuracy of the initial measurements on the population.

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The sweepnet's value as a sampling tool rests on the assumption that the number of insects per sweep can be converted to an estimate of absolute density. Ruesink and Haynes (1973) developed a multiplicative conversion factor for adult CLB's that was affected by crop height, wind, temperature, and solar radiation. For larvae, they could find no relationship between the conversion factor and the environmental factors. They settled on a coefficient of 1.02 to convert sweep catch to a square foot density estimate. Recent questions (Gage 1974, Fulton 1976) have prompted a reevaluation of this relationship. This is presented in section 2.

In addition to possible biases in sweep catch, the sweepnet is not useful when the crop is short. For the intensive early season sampling needed for the within generation forecasts of most concern to farmers, a more direct population estimate is needed. Square foot quadrats (or equivalently 2 linear feet of crop row) and individual stem counts have been used as sample units. Square foot units were used in this study because past experience indicated this provided the best tradeoff between variance and sample cost (Southwood 1966, Helgeson and Haynes 1972).

A statistical artifact of such counts is the dependency of their variance on the mean. There are two problems caused by this. Since counts which have a higher mean also tend to have a higher variance, a standard error on the estimate is not usable (Sokal and Rohlf 1969, p 381f). This must be replaced by a skewed confidence interval with width dependent on the mean. The second problem caused by the instability of the variance (ie. dependency of the variance on the mean) is the violation of normality assumptions necessary for performing hypothesis tests or analyses of variance. These difficulties are discussed in section 3.

Density is a function not only of time but also of accumulated heat, rainfall, windspeed, and probably other environmental factors. Many of the relationships between environmental factors and fecundity, mortality, and development rates have been studied previously (Castro et al. 1965, Yun 1967, Helgeson and Haynes 1972, Gage 1974). The role of these factors is reexamined in section 4 using new data and a transformation developed in section 3.

Estimates of changes in populations of _T. julis_ are most directly made by sampling adults. However, the parasitism rates of CLB larvae and pupae also contain usable information on parasitoid density. Larval samples are much easier and less costly to obtain than pupal samples. For purposes of between generation regional projections of parasitoid densities, larval samples may be optimal, despite the difficulties of estimating seasonal density. These problems and estimation procedures are discussed in section 5.

A CEREAL LEAF BEETLE LARVAL SWEEPNET MODEL

2.1 The sweepnet as a sampling tool for cereal leaf beetles

Accuracy in biomonitoring is the result of the mechanical efficiency of the sampling method in detecting (capturing) the creature being monitored. Although direct counts of such torpid insects as cereal leaf beetle larvae are generally accurate, the cost of making enough counts to obtain a minimal acceptable sampling variance (ie. variance within 10% of the mean) may be prohibitive for most survey programs. A less accurate index such as sweepnet count is frequently the only acceptable alternative.

The sweepcatch index is related to other factors in addition to density (Morris 1960). Delong (1932), in one of the first reports on factors affecting sweep efficiency, reported that capture of active insects such as leafhopper adults varied with temperature, plant height, and type of stroke or backstroke. Hughes (1955) found wind affected catches of a chloropid fly in wheat. Larval size and time of season affected sweepnet efficiency with green cloverworm in soybeans (Shepard, Carver and Turnipseed 1974). Time of day and changes in vertical distribution also affected sweep catch of several small grain insects (Vickerman and Sunderland 1975).

Ruesink and Haynes (1973) developed 2 models for sweepnet sampling of the cereal leaf beetle. A conceptual model related the "multiplication factor", M, required to convert sweep catch to density, to net diameter, d, length of the sweep stroke, l, the proportion of the

population in the net's path, b, and the probability of getting caught, p, once in the path. That is,

$$M = 1 / (dlbp). \quad (1)$$

A regression model for each instar suggested that wind, crop height, temperature or cloud cover did not affect M. There were no conclusive differences in M values between the instars (for the ranges; crop height, 38 to 112 cm; temperature, 24 to 29°C; wind, 6.4 to 16 kph; and solar radiation, .7 to 1.1 cal/cm^2/min). Relating this to the conceptual model, there were no detectable differences in instar specific probabilities of getting into the path of the sweepnet or of getting caught once there.

This conclusion was in conflict with an earlier Ruesink data set (Ruesink 1970) which found higher M values for younger larvae (averaging 1.41, 0.84, 0.72, and 0.40 for 1st through 4th instars). However, the inability to accurately determine instar and small sample size (5 fields in the original data set, 10 in the later) made both sets of results inconclusive. The instar determination problem has since been solved (Hoxie and Wellso 1974). Head capsule widths have 4 discrete ranges and are now used regularly to determine the 4 instars. The ranges established by Hoxie have been found to apply to Michigan CLB survey data from 1971-72 (Fulton 1975) and 1973-74 (Logan, unpublished data).

Gage (1974) found that catch per sweep underestimated the total larvae per square foot by at least half, noting that very few 1st instar larvae were being caught in the net. Fulton (1975) reported serious discrepancies between instar proportions in sweepnet samples and the proportions found in square foot samples taken at the same time and place. Fulton concluded that sweepnets are unreliable as a method to assess average age of the population.

Reasons for the discrepancies in instar specific catch efficiency were not given by any of the above. Ruesink (1970) found more younger larvae on the lower 2/3rds of 38 inch wheat but was unable to establish this as a general rule. Jackman (1976) found the majority of all instars were on the upper 3 blades of oats throughout the season. Wellso and Cress (1973) observed a significant difference in oviposition and feeding between top and next lower blades with most eggs laid on the upper, more succulent leaves. Thus it is still indefinite what factors affect the probability of a CLB larva getting into the path of the sweepnet. Also, there have been no studies of the factors influencing the probability of getting knocked off the plant and into the net.

Because the many advantages of the sweepnet were placed in jeopardy by questions of its accuracy, a large set of sweep and square foot samples were gathered for comparison as part of the PWS (section 1.1) program. Methods used are described in section 2.2. Correlations and simple regressions of sweep and square foot catches are given in section 2.3. Section 2.4 presents an outline of a statistical technique appropriate to analysis of subsample data. Section 2.5 further examines the data to determine whether more detailed statistical models would improve sweepnet conversion factors. Section 2.6 presents an additional data set and its implication (and, alas, complications) for the sweepnet model.

2.2.1 Sweepnet and quadrat sampling methods

Wheat and oats were sampled in the PWS area near Galien. Sweeps were made after the host field was at least 8 to 10 inches tall. A sweep is one level pass of a 15 inch diameter net. A sweep covers about a 5 foot swath through the top 8 to 15 inches of the crop.

The sweepnet was lined with a new 30 gallon plastic bag for each field to prevent small larvae from working through the mesh and to keep counts from each field distinct. The sweeper took 150 sweeps, beginning 20 to 30 feet from the edge of the field. The choice of 150 sweeps was arbitrary. Previous survey work had used a standard of 100 sweeps. The sweeper walked at a vigorous gait 120 to 180 feet into the field, made a wide u-turn, and exited sweeping until the 150 sweeps were complete. If there appeared to be less than 10 larvae in the bag the sweeper would take 100 more sweeps with the same bag. In practice, workers soon recognized certain fields were sparcely populated and took the 250 sweeps virtually automatically. Having completed the sweeps, the worker washed down the larvae on the sides of the bag with FAA, a preservative, and labeled the bag with field number and date before sealing. We used a formalin:acetic acid:alcohol:water mixture (FAA) in a 2:1:50:47 ratio. This preserved larvae suitably for dissections.

While the sweeper worked, a second sampler made square foot counts. The sampler walked 20 to 30 feet into the field carrying a lightweight 2 foot wooden stake. He tossed this, letting it fall where it would. This was done to help improve the randomness of the quadrat location. Workers took samples from points far apart in the field. The result was a semi-uniform grid of sample areas with a single count taken randomly in each area. The stick was moved 5 feet down the same row to reduce the disrupting effect of the toss. Care was taken to avoid sampling where the field had just been swept. The sampler picked over the plants in 2 feet of 1 row, recording the number of eggs on a hand counter while mentally counting larvae.

The first 50 larvae found were put in a vial for later study of field age distribution. Vials were labeled with date and field number. They were half filled with water and were returned to the lab and frozen.

After collecting the larvae and counting the eggs in a 2 foot section, the sampler moved to another site and again tossed the stick. A minimum of 10 such sample points per field was about as much as could be taken with PWS resources. However, if 50 larvae had not been collected within this minimum, an extra 5 points were covered or enough to get 50 larvae, which ever came first. When time permitted, separate records of each 2 foot egg and larval count were made to provide a measure of within field variance.

The ruled sweepnet handle was used to estimate average standing crop height. Time of day, number of sweeps and square feet, windspeed (taken with a styrofoam ball anemometer), and field wetness were also recorded. Field wetness was classified as either "dry", "wet" (full of dew or fresh rain), or "damp" (not glistening wet but able to dampen trousers of someone walking through it). When possible, sampling was limited to times when fields were dry.

Sweepnet sample bags were taken to the lab and were stored in $9^{o}C$ refrigerators until processing. Three weeks' samples had accumulated before processing began but there was no apparent damage to larvae as a result of the delay. Larvae were removed from the bag by floatation in alcohol.

A sample cleanup unit was constucted from an inverted 5 gallon plastic carboy with the bottom removed (Fig. 2). A large nylon funnel was fit into the carboy to eliminate the shoulder. A 3/4 inch ID clear tygon tube was attached to the bottom of the funnel. A 2 cork system, one on the bottom of the tube and a second attached to a stick and inserted from above into the funnel, allowed rapid isolation of the larvae. The carboy was partially filled with 95% alcohol. The plastic sweep bag was inverted and washed in the alcohol. Insects quickly sank to the bottom, accumulated in the tube, and were drawn off into a 2 oz. plastic cup. Plant debris was skimmed from the surface of the alcohol. Since the volume of alcohol was relatively small, replacement of all the alcohol was infrequent. All that was necessary was a periodic topping up and a daily flushing of the whole system. Two carboys were used and kept one man busy. Labels were transferred to the new cups and date and field number were repeated on the cup lid. After separation alcohol was poured off and fresh FAA was added to the cups.

Larvae and adults were then counted. The contents of a cup were poured onto a tray and sorted. Adults were first removed and their number recorded. Larvae were separated from remaining insect and plant debris as they were counted.

In very large samples (greater than 1000 larvae) a quartering system was used to speed counts. All adults were first counted and removed. A slurry of larvae was made so that larvae were distributed approximately uniformly on the tray. Larvae in 2 opposite quarters were removed. The remaining larvae were again slurried. Counts were

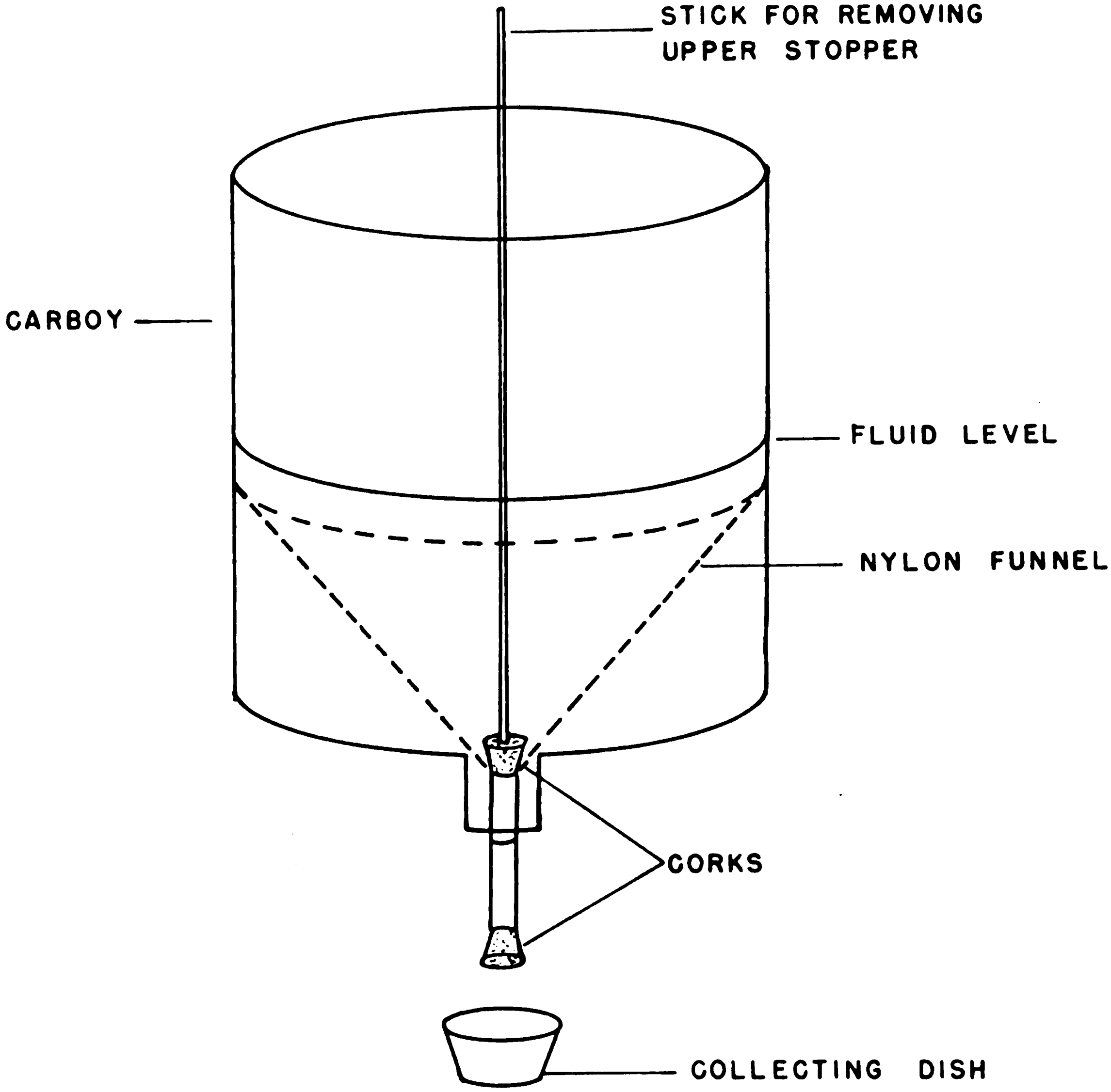


Fig. 2. Carboy unit used to extract cereal leaf beetles from sweepnet sample bags.

made of 2 opposite corners and the result was multiplied by 4. About 5% of all samples had to be treated this way.

Larval instar was determined by measuring head capsules with an ocular micrometer. An aliquot subsample was prepared from the contents of a sample cup. Up to 50 larvae from each sweep collection were measured. All larvae retained from the 2 foot counts were measured. At the same time, the larvae were dissected to determine species, life stage and number of parasites.

2.2.2 Sampling technique errors

Several counting errors can arise during the above processes. Briefly, these are as listed:

A. Precount errors

1) When hand picking, not seeing or losing a larva that is present in the sample quadrat.

2) Sweepnet bias, as discussed in section 2.3.

3) Transfer losses from sweepnet to count dish.

B. Count errors

1) Miscounting.

2) Age group misclassification.

3) Failure to count any members of an age class.

4) Aliquot biases.

C. Analysis errors, as discussed in section 2.4.

With the PWS data set I did not measure the efficiency of finding larvae in the field. I assume 100% of the larvae in a sample unit are found and counted or returned to the lab, as over optimistic as this may be. The washing down of larvae on the sides of sweepnet bags and later removal from the bag is highly efficient. Once in a particular bag, there is little chance that a larva will not make it into a sample cup, ready for counting.

Repetition of counts on a few samples of 50 to 200 larvae indicated precision to be within about 3% of the actual number present. Failure to properly classify the development stage of an insect is unlikely because the overlap of head capsule widths between instars is quite small (Hoxie and Wellso 1974) and ocular micrometer measurement is relatively precise.

By limiting the number of measurements taken from sweep samples to 50, the probability of failing to count any individuals in a particular age class is increased. If there are 4 1st instar larvae in a sweep catch of 100, there is a probability of .34 that the 1sts will be underestimated and .06 that they will not be counted at all in a subsample of 50, all other biases ignored (Larson 1969). Fulton (1975) suggested that the average age of a sample would be estimated with reasonable accuracy (5% of the mean) when 50 larvae were measured. Logistics restricted the measurements done during the PWS to 50 per subsample.

There was a major failing with the aliquot method. Too many large (4th instar) larvae were sampled. This is reflected in Fig. 3 in which 2 groups of 50 larvae were measured from each of 48 samples. The age estimate from the first group varied by roughly .5 to .2 from the second estimate. Because of this, a second batch of up to 50 larvae were measured for all of the samples used in the following analysis. This meant measurement and dissecting an additional 2271 larvae from the oat samples (for a total of 5677 measurements in 85 cases) and an extra 1100 larvae from the wheat samples (total 4136 in 62 cases). In the oat samples, 45 cases had all the larvae in the net measured. The 40

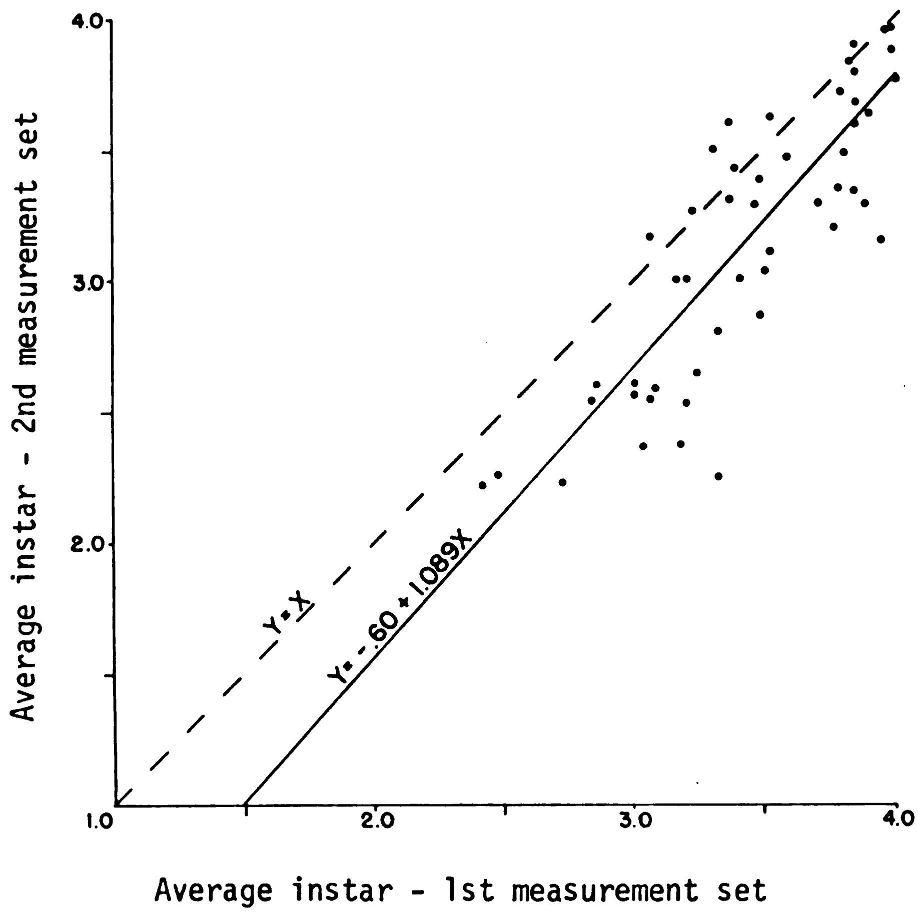


Fig. 3. Error in estimating average age class from sweepnet data.

cases with an incomplete measurement set averaged 89 measurements per case. In the wheat samples, 31 cases had all the larvae measured. The average subsample size for the remaining 31 cases was 70. Table 1 compares the measurement sets further. This includes the slope and intercept coefficients of the square foot and sweep catch regressions.

The problem with interpreting the differences of Table 1 is that there is no way to tell whether the higher proportions of 3rd and 4th instars in the partial measurement samples are the result of measurement bias or are only reflective of the older age structure of the higher density samples. In oats, comparison with associated square foot samples suggests the latter is true. In wheat, there is less of a distinction. The decision to either disgard the incomplete measurement sets or to combine the 2 was resolved in favor of combination (see Table 3), with the caveat that the result may be an overstatement of the relative proportion of older larvae in the sweepnet samples and a corresponding bias in the sweepnet conversion factors.

2.3 Absolute density versus sweep catch: simple correlations and regressions

For a sweepnet index of CLB larval population density to be of use, the catch per sweep of each instar must be correlated to absolute density. Table 2 gives the correlation matrix for the 4 instars in the paired sweep and square foot samples, separated into cases for wheat and oats. Correlation coefficinets significantly different from 0 at the .05, .1, and .2 levels are indicated (Sokal and Rohlf 1969, p. 516). Note the diagonals of the lower left 4 x 4 submatrices, the correlations between sweep and square foot catch for each instar. In oats, the proportion of 4ths in the 2 sample methods is highly

Table 1. The relationship between catch per square foot and catch per sweep for CLB larvae. Y_i = Average catch per square foot of

Table 1. The relationship between catch per square foot and catch per sweep for CLB larvae. y_i = average catch per square foot of instar i, i = 1...4. x_i = average catch per sweep of instar i. s.d. = standard deviation of catch. a_i = intercept. b_i = slope. s.e. = standard error of coefficients. Model is y = a + bx + error.

OATS

(ENTIRE SAMPLE MEASURED)

	Square foot	Sweep
Cases	45	45
Total measurements	1359	2112

Instar (i)	y_i	s.d.	a_i	s.e.	b_i	s.e.	x_i	s.d.
1	.169	.720	.011	.011	31.57	9.651	.005	.010
2	.553	2.211	.199	.404	10.797	7.320	.033	.045
3	.672	2.246	.797	.435	-.843	2.700	.114	.115
4	.196	.199	.133	.041	.393	.185	.159	.156
Mean Instar	3.113	.596						

(PARTIAL SAMPLE MEASURED)

	Square foot	Sweep
Cases	40	40
Total measurements	1757	3565

Instar (i)	y_i	s.d.	a_i	s.e.	b_i	s.e.	x_i	s.d.
1	.07	.167	.078	.028	-.075	1.680	.004	.016
2	.330	.584	.273	.122	.424	.583	.136	.161
3	.798	.894	.364	.179	.365	.108	1.187	1.180
4	1.043	1.187	.150	.177	.533	.075	1.676	1.679
Mean Instar	3.271	.504						

WHEAT

(ENTIRE SAMPLE MEASURED)

	Square foot	Sweep
Cases	31	31
Total measurements	1031	1949

Instar (i)	y_i	s.d.	a_i	s.e.	b_i	s.e.	x_i	s.d.
1	.629	1.179	.298	.253	18.195	8.533	.018	.024
2	1.048	1.591	.426	.475	5.808	3.595	.107	.079
3	.899	1.052	.574	.400	1.435	1.558	.227	.124
4	.122	.195	.009	.029	1.715	.268	.066	.087
Mean Instar	2.332	.405						

(PARTIAL SAMPLE MEASURED)

	Square foot	Sweep
Cases	31	31
Total measurements	1536	2187

Instar (i)	y_i	s.d.	a_i	s.e.	b_i	s.e.	x_i	s.d.
1	1.409	1.734	.980	.313	8.060	2.731	.053	.103
2	1.725	1.704	1.017	.334	.947	.277	.748	.966
3	2.375	2.902	1.553	.545	.390	.134	2.109	3.545
4	.277	.405	.243	.870	.031	.421	1.111	1.770
Mean Instar	2.335	.527						

Table 2. Correlation coefficients for count data from oats and wheat. SW1 = estimated catch of instar 1 per sweep; MISQ = mean instar of square foot catches, etc. ABS (r) = absolute value of the correlation coefficient.

Oats (cases = 85)

r significant at .05 if ABS (r) > .214
r* significant at .10 if ABS (r) > .180
r+ significant at .20 if ABS (r) > .140

	SW1	SW2	SW3	SW4	SQ1	SQ2	SQ3	SQ4	MISW	MISQ
SW1	1.									
SW2	.072	1.								
SW3	-.026	.698	1.							
SW4	.018	.350	.735	1.						
SQ1	.245	.028	-.055	-.082	1.					
SQ2	.262	.052	-.045	-.076	.962	1.				
SQ3	.221	.108	.170+	.150+	.815	.880	1.			
SQ4	.057	.120	.433	.805	-.095	-.068	.140	1.		
MISW	-.259	-.218	.047	.313	-.435	-.461	-.326	.292	1.	
MISQ	-.226	-.056	.085	.261	-.327	-.331	-.269	.338	.637	1.

Wheat (cases = 62)

r significant at .05 if ABS (r) > .250
r* significant at .10 if ABS (r) > .211
r+ significant at .20 if ABS (r) > .163

	SW1	SW2	SW3	SW4	SQ1	SQ2	SQ3	SQ4	MISW	MISQ
SW1	1.									
SW2	.409	1.								
SW3	.337	.636	1.							
SW4	.302	.629	.923	1.						
SQ1	.467	.566	.139	.156	1.					
SQ2	.176+	.447	.376	.297	.551	1.				
SQ3	.059	.408	.513	.464	.213*	.692	1.			
SQ4	-.186+	.107	.170+	.217*	-.018	.197+	.342	1.		
MISW	-.387	-.025	.194+	.332	-.203+	-.006	.253	.429	1.	
MISQ	-.445	-.210+	.180	.146	-.667	-.270	.200+	.436	.601	1.

correlated. Firsts and 3rds are also significantly different from 0 correlation at the .05 and .2 levels, respectively. In wheat, the 4 correlations of interest are all different from 0 at a .1 level. The average age as determined by sweepnet has about a 60% correlation with square foot mean instar in both crops.

Table 3 combines the 2 data sets from Table 1 and describes the data in more detail. For oats, 95% confidence limits on the 1st instar square foot over sweep catch regression overlap the limits for 2nd instar. The confidence limits for 3rd instar surround those for 4ths and in turn fall within those for 2nds. For wheat, distinction between the instars is easier as only 2nd and 3rd instars have overlapping confidence limits. Note that only 2nd instar larvae come close to the slope of approximately 1 suggested by Ruesink and Haynes (1973). The general trends tend to support the findings of Gage (1974) and Fulton (1975), reflecting a sweepnet bias against picking up smaller larvae.

It should be clear from the high coefficients of variability and the low coefficients of determination (R^2 values) (Table 3) that these simple models lack the precision desired for accurate predictions. One difficulty with the regressions is that they all provide nonzero estimates for square foot density even when no larvae are caught in the sweepnet. While this may be useful when the number of sweeps is small (100 or less, say), it may be an overestimation. Table 4 provides the slopes and corresponding confidence intervals for zero-intercept models fit to the same data. These estimators may be more useful when many sweeps are taken at low densities.

An attempt to further improve these regressions by taking into account various environmental factors is made in section 2.5, following

Table 3. Statistics of combined data set, used in simple (y = a + bx) larval sweepnet models. y = catch per square foot; x = catch per sweep.

OATS

Instar (i)	$\bar{y}_i$	s.d.	x_i	s.d.
1	.126	.535	.005	.013
2	.446	1.653	.081	.126
3	.731	1.602	.619	.972
4	.595	.925	.873	1.379

WHEAT

Instar (i)	$\bar{y}_i$	s.d.	x_i	s.d.
1	1.019	1.522	.036	.077
2	1.387	1.670	.428	.752
3	1.637	2.289	1.168	2.662
4	.199	.325	.588	1.350

REGRESSION ANALYSIS

OATS

Instar (i)	a_i	s.e.	b_i	s.e.
1	.081	.060	9.920	4.308
2	.393	.215	.682	1.440
3	.558	.205	.280	.178
4	.123	.071	.540	.044

WHEAT

Instar (i)	a_i	s.e.	b_i	s.e.
1	.687	.190	9.303	2.272
2	.962	.220	.993	.256
3	1.122	.275	.441	.095
4	.169	.044	.052	.030

ANALYSIS OF VARIANCE

OATS

Instar (i)	Source	d.f.	SS	MS	F / SIG	C.V.	R^2
1	Regression (R)	1	1.45	1.45	5.31	413.5	.06
	Residual Error (E)	83	22.62	.27	.024		
2	R	1	.62	.62	.224	370.5	.00
	E	83	228.76	2.76	.637		
3	R	1	6.22	6.22	2.47	217.3	.03
	E	83	209.39	2.52	.120		
4	R	1	46.58	46.58	152.9	92.8	.65
	E	83	25.29	.30	<.001		

WHEAT

Instar (i)	Source	d.f.	SS	MS	F / SIG	C.V.	R^2
1	Regression (R)	1	30.87	30.87	16.8	133.2	.22
	Residual Error (E)	60	110.49	1.84	<.001		
2	R	1	34.05	34.05	15.0	108.7	.20
	E	60	136.14	2.27	<.001		
3	R	1	84.05	84.05	21.4	121.0	.26
	E	60	235.56	3.93	<.011		
4	R	1	.30	.30	2.9	160.4	.05
	E	60	6.14	.10	.09		

Table 4. Zero-intercept (y = bx) larval sweepnet models.

	OATS		WHEAT	
Instar (i)	b_i	95% C.L.	b_i	95% C.L.
1	11.838	3.708,19.967	12.792	8.294,17.289
2	2.116	0. , 4.552	1.549	1.043, 2.055
3	.542	.233, .852	.598	.403, .793
4	.581	.507, .655	.099	.037, .160

a brief statistical argument, presented for future reference in section 2.4.

2.4 Weighted regression analysis

It is important to note that the instar specific variables "catch per sweep" and "catch per square foot" are themselves estimates. They are based on subsamples of larvae. For example, catch per sweep of 2nd instar larvae in sample j is

$$x_{2j} = (I_{2j}/n_j)(L_j/S_j) \quad (2)$$

where I_{2j} is the number of 2nd instar larvae in the subsample n_j; L_j is the total number of larvae from which the subsample was drawn; and S_j is the number of sweeps taken. Sampling errors for these estimates are related to subsample size. Since the standard error of the sample is

$$\text{s.e.} = \text{SQRT} (\Sigma(x_{ij} - \mu_{ij})/n_j^2) \quad (3)$$

where μ_{ij} is the unknown population mean (estimable only in repeated data sets) and SQRT() is the square root operator, sampling error is inversely proportional to square root of subsample size. In this sence larger samples may be said to be more reliable than smaller ones.

There are no standard criteria for evaluating the relative reliability of a sample estimate. By comparing values of 1/n for different n's, Searle (1971, p. 365-73) suggested ratios of such values were possibly useful. Ratios of 4 : 1 or higher were indicative that sample error should be taken into account. It seems clear that there is little loss in reliability in going from a sample size of 100 to 50. This is equivalent to a ratio of 1.41 : 1, which would rule out an adjustment under Searle's criteria. However, comparing samples of 6 and 50 would result in greater than a 4 : 1 ratio. As Searle noted, the 4 : 1 ratio is an arbitrary norm. If one were to use a more conservative 2 : 1 ratio, adjustment of sampling error would be considered appropriate when less than 12 larvae were present in a sample. This assumes that 50 is the optimal sample size (Fulton 1975). (If 30 were considered optimal, based on some other analysis, 8 larvae would be the lower limit, using the 2 : 1 ratio.)

Comparing plots of sample size for the sweepnet samples with their paired square foot samples in Fig. 4, 21 of the cases in oats (24.7%) have at least 1 of the samples smaller than 12. Only 3 (4.9%) of the samples in wheat are less than 12. This suggests that the age specific density estimates in oats ought to be subjected to a weighted regression analysis to adjust for the large percentage of small, "less reliable", subsamples. Here again, the criteria are arbitrary. As a suggestion for future use, perhaps a maximum of 10% "small" samples should be considered as a basis for deciding the appropriateness of such analysis.

To perform a weighted regression analysis, the total sum of squares and the reductions in sums of squares used in the regression must be weighted. This is done by weighting each term in the sum of squares in inverse proportion to the variance (Searle 1971; Steel and Torrie 1960,

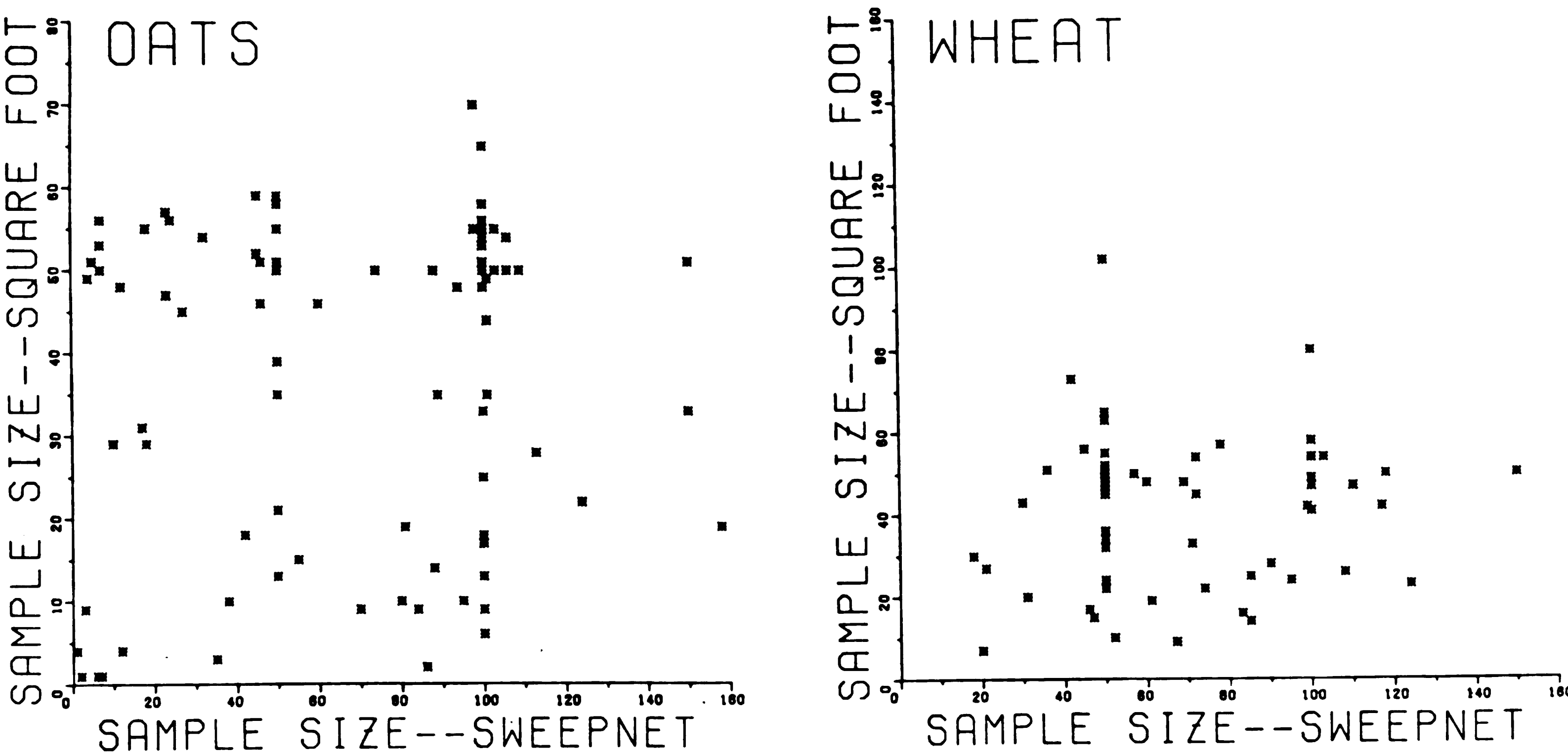


Fig. 4. Distribution of sample sizes for paired data used in sweepnet regressions.

p. 180),

$$w_i = s_{\bar{x}}^2/\mathrm{var}(\bar{x}_i) \tag{4}$$

where w_i is the weighting coefficient, $s_{\bar{x}}^2$ is the variance of all the sample means for variable x, and $\mathrm{var}(\bar{x})$ is the variance associated with the specific subsample mean. The usual simplification of (4), keeping in mind that the variance is inversely proportional to sample size, is to use subsample size over the total number in all subsamples as the weight

$$w_i = n_i/n. \tag{5}$$

where the "n." notation indicates summation over all n (Searle 1966).

Steel and Torrie (1960, p. 181) point out that it is the relative rather than the actual weights that are important. Since samples do not really add new information to the estimates in direct proportion to their sample size, it is proposed that a modification of (5) be used,

$$w_i = \mathrm{SQRT}\ (n_i/n.) \quad .(6)$$

Using a weight proportional to subsample size, a sampling of 100 would count as twice as reliable as a sample of 50. Using weight proportional to square root of subsample size, 100 would only be judged 1.41 times as reliable. Samples less than 12 receive a rapidly decreasing relative weight. This seems a reasonable compromise between using no weights and using subsample size as a weight factor.

Regression based on weighted means uses a weighted variance covariance matrix, each element of which has the general form

$$\mathrm{cov}(x_j,x_k) = \Sigma w_{ij}(x_{ij}-\bar{x}_j)w_{ik}(x_{ik}-\bar{x}_k) \tag{7}$$

where summation is over all i, w_i's are the weights from (6), x_j and x_k are any variables in the regression and $\bar{x}$'s are weighted means,

$$\bar{x} = \Sigma(w_i x_i)/\Sigma w_i$$

Weights are based on (6) for means (number per age class per sample unit) but are set equal to 1 for all other variables. Covariances (and variances by an analogous process) are computed from the expansion of (7),

$$\mathrm{cov}(x_j,x_k) = \Sigma w_{ij}w_{ik}(x_{ij}x_{ik}-x_{ik}\bar{x}_k-x_{ik}\bar{x}_j+\bar{x}_j\bar{x}_k) \tag{9}$$

which for parameters with weights equal 1 reduces the usual form,

$$\mathrm{cov}(x_j,x_k) = [\Sigma(x_{ij}x_{ik})-(\Sigma x_{ij}\Sigma x_{ik})/m]/(m-1) \tag{10}$$

where m is the number of cases. A correlation matrix based on the above with elements

$$r_{jk} = \mathrm{cov}(x_j,x_k)/\mathrm{SQRT}(\mathrm{var}(x_j)\mathrm{var}(x_k) \tag{11}$$

can be used to compute least squares estimates of transformed correlation coefficients, a_i. The normal equations are

$$\begin{bmatrix} 1 & r_{12} & \cdots & r_{1n} \\ r_{21} & 1 & \cdots & r_{2n} \\ \cdots & & & \cdots \\ r_{n1} & r_{n2} & \cdots & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ \cdots \\ a_n \end{bmatrix} = \begin{bmatrix} r_{1y} \\ r_{2y} \\ \cdots \\ r_{ny} \end{bmatrix} \tag{12}$$

with solution

$$\hat{\underline{a}} = \underline{R}_x{}^{-1}\underline{r}_y \tag{.13}$$

Estimates of the original coefficients are obtained from

$$\hat{b}_i = \hat{a}_i \mathrm{SQRT}(\mathrm{var}(y)/\mathrm{var}(x_i)), \tag{14}$$

for i = 1...n, and from

$$\hat{b}_o = \bar{y}-\hat{b}_1x_1-\hat{b}_2x_2-\ldots-\hat{b}_nx_n, \tag{15}$$

where a_i's are the transformed regression coefficients, var(y) and var(x_i) are weighted (by w_i or by unity) variances, and $\bar{y}$ and $\bar{x}_i$ are the weighted means.

It should be noted that the same logic applies to models containing classification terms. For example, if a measurement were assigned a coded (0,1) value depending on whether it was taken from a particular group, mean, variance, and correlation terms could be calculated as above. The normal equations from the transformed correlation coefficients would be

$$\begin{bmatrix} \underline{R}_{X'X} & \underline{R}_{X'Z} \\ \underline{R}_{Z'X} & \underline{R}_{Z'Z} \end{bmatrix} \begin{bmatrix} \underline{a}' \\ \underline{b}' \end{bmatrix} = \begin{bmatrix} \underline{r}'_{a} \\ \underline{r}'_{by} \end{bmatrix} \qquad (16)$$

where the $\underline{R}_{X'X}$ submatrix is an incidence correlation matrix, $\underline{R}_{Z'Z}$ is the regression matrix as in (12). The diagonal of $\underline{R}_{X'X}$ would have all elements equal 1 and all off diagonal elements would be negative with absolute value less than 1.

Having computed the weighted means, variances, and the correlation matrix, standard statistical packages are available to complete (13) through (15)(Nie, Hull, Jenkins, Steinbrenner and Bent 1975). Carrying out the above on the data used for the sweepnet regressions involved weighting only the sweepnet and square foot instar specific densities by subsample size, assigning a weight of 1 to all other measurements. The resulting correlations and regression statistics were not appreciably different from the results presented here, which are based on an unweighted analysis. Since the amount of programming time required to adhere to the weighted regression analysis was not thought to be justified by the refinement in results, the technique was dropped. Apparently there were sufficient cases that disparities caused by small samples were averaged out. With smaller data sets or with sets involving a large number of small sample versus large sample pairs, this may not prove to be the case. Application of the above to a correlation analysis by Fulton (1975) using data with these latter characteristics reversed an original conclusion of no significance between instar specific square foot and sweepnet catches.

2.5 Inclusion of additional variables in the sweepnet models

The simple regression of catch per square foot on catch per sweep (section 2.3) did not provide the precise conversion factors desired for the sweepnet model. It was hypothesized that environmental factors were influencing sweep catch, although this hypothesis was rejected by Ruesink and Haynes (1973). Several environmental measurements had been made for each PWS sweep and square foot density estimate (section 2.2.1). These included crop height and windspeed, which had been taken in each field. Temperature and rainfall were estimated from a single station in the center of the study area, within 3 miles of each field. Because there was some doubt as to the accuracy of the central site thermograph, data from a New Carlisle, Indiana (5 miles south), and a South Bend, Indiana (12 miles southeast), weather station were averaged with the thermograph when computing degree day accumulations. These data are listed in appendix 8. This decision to average may not have been justifiable but was not reconsidered until later (see section 4.3).

The full regression model that was evaluated was

$$y_i = a + b_1 x_i + b_2 dd + b_3 ch + b_4 r24 + b_5 W + e \qquad (17)$$

where y_i = instar specific catch of CLB larvae per square foot;

a = a constant common to all observations;

x_i = instar specific catch of CLB larvae per sweep;

dd = accumulated degree days (base 48F) on sample date;

ch = standing crop height on sample date (inches);

$r24$ = rainfall during previous 24 hours;

W = windspeed (mph) at time of sample;

e = residual error, assumed $\sim N(\underline{0}, \underline{I}\sigma^2)$.

The regressions were carried out in a stepwise inclusion following the initial fitting of sweep catch (see Draper and Smith 1966, p. 171f). Results are listed in Table 5. Most of the parameters in the model (17) are included in the regressions because the regression program used was set for very loose inclusion criteria. For practical purposes, variables that add less than (arbitrarily) 5% to the R^2 values could have been excluded.

The differences between predicted and observed y's are called residuals. For each regression in Table 5, plots of residuals over predicted y and over the independent variables (x,dd,ch,r24, and W) were made. This technique is advocated and well discussed by Draper and Smith (1966, p. 86-99, 132) as a way to check model accuracy. Briefly, these authors recommend examining such plots for dependencies of the variance on the prediction or on the independent variables, a linear slope to the residuals, or curves in the plots of the residuals. These conditions are indicative respectively of variance instability (see section 3), incorrect fit or omission of the intercept, or model inadequacy and a need to include higher order terms or interactions in the model. The first type of abnormality (variance dependent on the predicted y) is especially crucial as a visual test of the critical assumption that the error term is normally distributed, an assumption necessary for valid testing. A few examples of such plots are given in Fig. 5. These indicate, respectively, a) overall model inadequate as there is a clear dependency of the variance on the prediction, b) adequacy over degree days and c) crop height as there are no apparent additional curvatures that would demand higher order terms.

To adjust for the variance instability, a multiplicative model of the form

Table 5. Regressions of catch per square foot (y) on catch per sweep (x), accumulated degree days (dd), crop height (ch), rainfall (r24), and windspeed (W). Catch per sweep was forced into the regression first. C.V. is coefficient of variation. $\hat{\sigma}^2$ is estimated residual error.

OATS

Variable	Order of Inclusion	Regression Coefficient (b)	Standard Error (s.e.b)	R^2
y_1 (independent)				
x_1	1	7.48	4.02	.060
dd	2	-.0019	.0006	.203
r24	3	-1.35	.77	.226
ch	4	-.0083	.0062	.244
W	5	-.0081	.0157	.247
(constant)		1.89	.50	
F = 5.17***	C.V. = 379.5	$\hat{\sigma}^2$ = .229		
y_2 (independent)				
x_2	1	-.39	1.37	.003
dd	2	-.0055	.0017	.163
ch	3	-.04	.02	.198
r24	4	-3.81	2.4	.223
W	5	-.0066	.0497	.223
(constant)		5.36	1.60	
F = 4.53**	C.V. = 335.2	$\hat{\sigma}^2$ = 2.26		
y_3 (independent)				
x_3	1	.19	.17	.029
ch	2	-.005	.020	.136
dd	3	-.0032	.0016	.223
r24	4	-1.84	2.31	.230
W	5	.028	.048	.233
(constant)		4.34	1.51	
F = 4.81**	C.V. = 197.8	$\hat{\sigma}^2$ = 2.09		
y_4 (independent)				
x_4	1	.52	.05	.648
ch	2	-.010	.008	.653
dd	3	.00068	.00065	.656
W	4	.011	.019	.657
r24	5	.32	.89	.658
(constant)		-.27	.57	
F = 30.35***	C.V. = 93.8	$\hat{\sigma}^2$ = .31		

WHEAT

Variable	Order of Inclusion	Regression Coefficient (b)	Standard Error (s.e.b)	R^2
y_1 (independent)				
x_1	1	9.13	2.40	.218
ch	2	-.041	.035	.246
W	3	.14	.10	.256
r24	4	-1.74	1.49	.284
dd	5	-.00071	.007	.284
(constant)		1.57	3.34	
F = 4.45**	C.V. = 131.9	$\hat{\sigma}^2$ = 1.81		
y_2 (independent)				
x_2	1	1.03	.27	.200
r24	2	1.64	1.40	.224
ch	3	-.012	.037	.225
W	4	-.015	.11	.225
dd	n.i.			
(constant)		1.15	2.07	
F = 4.14**	C.V. = 109.7	$\hat{\sigma}^2$ = 2.31		
y_3 (independent)				
x_3	1	.467	.097	.263
ch	2	.11	.05	.320
W	3	.059	.14	.321
r24	4	.85	2.14	.322
dd	5	-.003	.009	.323
(constant)		.159	4.56	
F = 5.35***	C.V. = 120.0	$\hat{\sigma}^2$ = 3.80		
y_4 (independent)				
x_4	1	.022	.026	.047
r24	2	.41	.29	.279
dd	3	.0023	.0013	.328
W	4	.034	.019	.365
ch	5	.0015	.0071	.366
(constant)		-1.43	.63	
F = 6.46***	C.V. = 135.5	$\hat{\sigma}^2$ = .073		

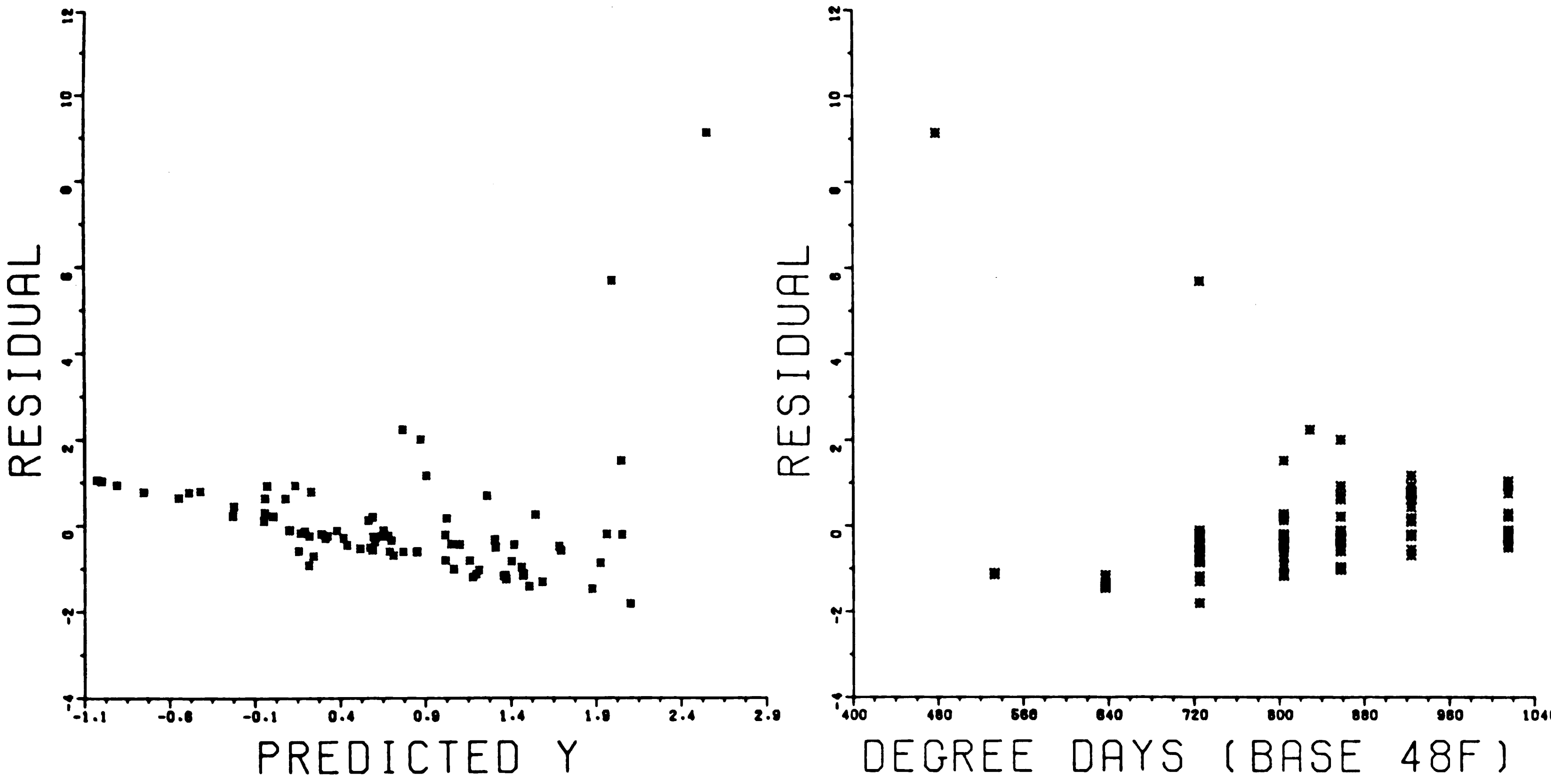


Fig. 5. Plots of residuals $(y_i - \hat{y}_i)$ from sweepnet model for 3rd instar in oats (Table 5) over predicted y and over degree days.

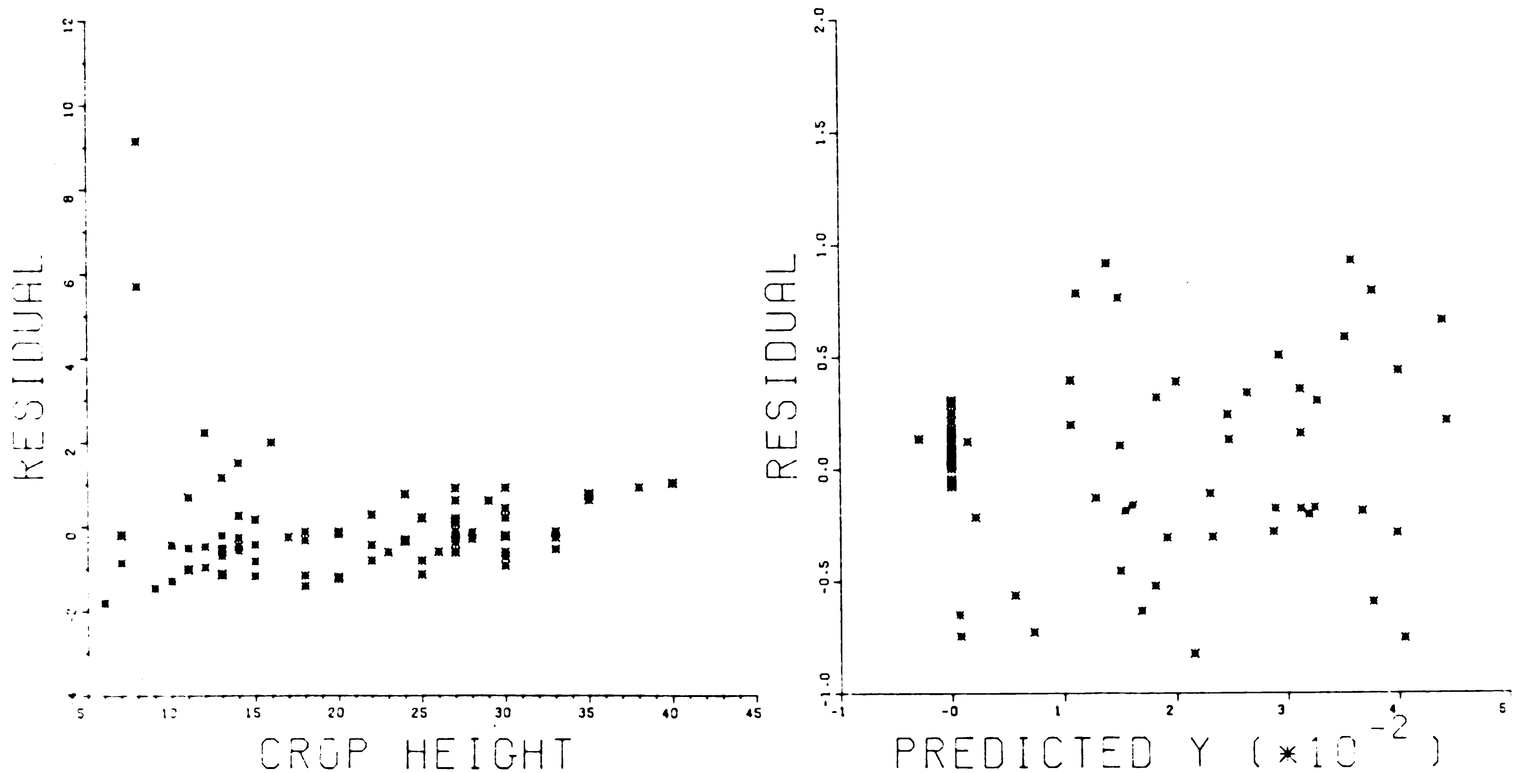


Fig. 5. (cont.) Plot of residuals $(y_i - \hat{y}_i)$ from sweepnet model for 3rd instar in oats (Table 5) over crop height (left). Residuals from transformed model for 3rd instar in oats (Table 6) over predicted (right).

$$y_i = ax^{b_1}dd^{b_2}Ch^{b_3}r24^{b_4}W^{b_5}e$$

was tried, where the variables are defined as on page 30 (eqn. 17). This model was evaluated by first taking logs of both sides. Some variables were recorded by adding 1 to avoid taking logs of 0's (Sokal and Rohlf 1969, p. 384; Draper and Smith 1966, p. 132). The new model was

$$\log(y_i+1) = \log a + b_1\log(x_i+1) + b_2\log dd + b_3\log Ch + b_4\log(r24+1) + b_5\log(W+1) + \log e \quad ..(19)$$

Recoding and transforming the variables did seem to produce a better fit to the data (Table 6). As expected, the effects of outliers are greatly reduced as is indicated by a general increase in R^2 values. The question of whether this makes for a better model, however, is largely a matter of personal statistical preference. Certainly the transformation did reduce the variance instability, as can be seen in the residual plot (Fig. 5d). For most practical purposes, though, the increases in R^2 values caused by adding environmental effects to the sweepnet model do not seem to justify the extra effort needed to take and use the measurements. The predictions still lack precision.

Regretfully, the simple regression models of Tables 3 and 4 are recommended as "best". Instar specific sweep catch does not appear to bear a 1 : 1 relationship to square foot catch. The effort to establish the expected true relationships has led to equations that may be useful yet lack precision.

2.6 An additional data set

Previous data sets comparing sweep catch with absolute density were thought to be either too small or to have unreliable instar identification methods and thus could not serve as a check for the sweepnet

Table 6. Regression of log transforms of catch per square foot (y) on catch per sweep (x), accumulated degree days (dd), crop height (ch), rainfall (r24), and windspeed (W). Catch per sweep was forced into the regression first. C.V. is coefficient of variation. $\hat{\sigma}^2$ is estimated residual error.

OATS

Variable	Order of Inclusion	Regression Coefficient (b)	Standard Error (s.e.b)	R^2
$\log(y_1+1)$ (independent)				
$\log(x_1+1)$	1	2.93	1.51	.063
log dd	2	-.67	.15	.299
log(r24+1)	3	-.87	.33	.354
log ch	4	-.102	.04	.397
log(W+1)	5	.019	.03	.400
(constant)		2.12	.45	
F = 10.52*** C.V. = 113.7		$\hat{\sigma}^2$ = .0056		
$\log(y_2+1)$ (independent)				
$\log(x_2+1)$	1	.13	.34	.012
log ch	2	-.35	.08	.275
log dd	3	-1.01	.28	.395
log(r24+1)	4	-1.02	.60	.420
log(W+1)	5	.05	.06	.426
(constant)		3.45	.81	
F = 11.72*** C.V. = 145.8		$\hat{\sigma}^2$ = .019		
$\log(y_3+1)$ (independent)				
$\log(x_3+1)$	1	.33	.10	.136
log ch	2	-.42	.09	.370
log dd	3	-.62	.32	.406
log(r24+1)	4	-.66	.71	.414
log(W+1)	5	.05	.07	.419
(constant)		2.42	.94	
F = 11.41*** C.V. = 95.8		$\hat{\sigma}^2$ = .026		
$\log(y_4+1)$ (independent)				
$\log(x_4+1)$	1	.58	.06	.626
log ch	2	-.098	.065	.632
log dd	3	.22	.20	.637
log (W+1)	n.i.			
log(r24+1)	n.i.			
(constant)		-.477	.547	
F = 47.43*** C.V. = 68.2		$\hat{\sigma}^2$ = .012		

WHEAT

Variable	Order of Inclusion	Regression Coefficient (b)	Standard Error (s.e.b)	R^2
$\log(y_1+1)$ (independent)				
$\log(x_1+1)$	1	4.03	.99	.250
log(W+1)	2	.27	.15	.280
log dd	3	-.61	1.22	.305
log ch	4	-.30	.28	.316
log(r24+1)	5	-.43	.61	.322
(constant)		2.05	3.20	
F = 5.33*** C.V. = 94.4		$\hat{\sigma}^2$ = .044		
$\log(y_2+1)$ (independent)				
$\log(x_2+1)$	1	.78	.18	.253
log(W+1)	2	.12	.15	.273
log ch	3	-.17	.27	.278
log(r24+1)	4	.26	.51	.282
log dd	n.i.			
(constant)		.349	.390	
F = 5.58*** C.V. = 69.0		$\hat{\sigma}^2$ = .044		
$\log(y_3+1)$ (independent)				
$\log(x_3+1)$	1	.61	.10	.396
log ch	2	.38	.26	.426
log(r24+1)	3	.33	.48	.438
log dd	4	.46	1.04	.440
log(W+1)	n.i.			
(constant)		-1.58	2.70	
F = 11.13*** C.V. = 56.9		$\hat{\sigma}^2$ = .037		
$\log(y_4+1)$ (independent)				
$\log(x_4+1)$	1	.11	.05	.151
log(r24+1)	2	.44	.20	.378
log dd	3	.85	.40	.429
log(W+1)	4	.052	.052	.438
log ch	5	.026	.097	.439
(constant)		-2.33	1.03	
F = 8.76*** C.V. = 106.1		$\hat{\sigma}^2$ = .005		

models developed here. A new set was obtained from the APHIS (USDA) parasitoid rearing laboratory at Niles, Michigan. This included paired sweep and square foot samples from 15 wheat and 13 oats fields. Each field was divided into 14 equal size units and a single square foot was sampled in each unit. All larvae were retained for later age classification. A large portion of each sweep sample was measured and there is no reason to suspect any biases were introduced by the counting or measuring processes.

Table 7 describes the APHIS data set. In comparison with the PWS data (Table 3), all slopes from the square foot over sweep regressions are steeper and all intercepts but for 3rds in wheat are not significantly different from 0. The density per square foot had a higher average for all instars in both crops than the densities found in the fields described in Table 3.

To a certain extent, the high R^2 values for 1st and 2nd instars were aided by the presence of many 0's. There were 53 and 42 pairs of 0's for 1sts in oats and wheat, respectively (51% and 45% of the samples) and 16% of both crops had paired 0 counts for 2nd instars. However, the good fits and high slopes of the regression coefficients in general cannot be explained away. These results were not altered by including windspeed, crop height, or accumulated degree days in the regressions.

It must be concluded that the relationship between sweep and square foot catches of CLB larvae is not well understood. Although differences between sweepers has been thought to be negligible (Ruesink and Haynes 1973), perhaps this should be reinvestigated. Until then, use of sweepnets for intensive population studies of the CLB has been generally curtailed (A. Sawyer, E. Lampert, pers. comm.). When used in

Table 7. The APHIS (USDA) data set, describing the relationship between catch per square foot and catch per sweep for CLB larvae. y_i = average catch per square foot of instar i, i = 1...4. x_i = average catch per sweep of instar i. s.d. = standard deviation of catch. a_i = intercept. b_i = slope. s.e. = standard error of coefficients. Model is $y = a + bx + \text{error}$.

OATS

	Square foot	Sweep
Cases	104	104
Total measurements	5857	5022
Total larvae in sample	14788	5105

Instar (i)	y_i	s.d.	a_i	s.e.	b_i	s.e.	x_i	s.d.
1	.457	1.952	-.131	.154	20.12	2.15	.029	.066
2	1.279	5.082	.118	.576	15.93	4.51	.073	.105
3	4.857	19.674	-2.762	2.532	34.67	8.17	.220	.220
4	3.552	14.706	.658	1.777	17.71	6.68	.164	.211

WHEAT

	Square foot	Sweep
Cases	93	93
Total measurements	7950	5718
Total larvae in sample	20933	6961

Instar (i)	y_i	s.d.	a_i	s.e.	b_i	s.e.	x_i	s.d.
1	1.472	4.657	.329	.379	13.14	1.48	.087	.241
2	2.345	5.774	.244	.449	16.08	1.52	.131	.267
3	7.935	20.436	-5.163	1.564	41.33	3.06	.317	.404
4	4.323	12.667	-1.619	.824	27.80	1.89	.214	.382

Analysis of Variance

OATS

Instar	Source	d.f.	SS	MS	F Sig	C.V.	R^2
1	R (a,b)	1	181.84	--	87.99	314.7	.46
	E	102	210.79	2.07	<.001		
2	R (a,b)	1	289.45	--	12.45	377.0	.11
	E	102	2370.97	23.24	<.001		
3	R (a,b)	1	5988.7	--	18.03	375.3	.15
	E	102	33879.6	332.2	<.001		
4	R (a,b)	1	1435.9	--	7.03	402.4	.06
	E	102	20839.5	204.3	.009		

WHEAT

Instar	Source	d.f.	SS	MS	F Sig	C.V.	R^2
1	R (a,b)	1	923.6	--	78.4	233.2	.46
	E	91	1071.6	11.77	<.001		
2	R (a,b)	1	1693.6	--	112.2	165.7	.55
	E	91	1373.6	15.5	<.001		
3	R (a,b)	1	25655.6	--	182.9	149.3	.67
	E	91	12767.5	140.3	<.001		
4	R (a,b)	1	10396.4	--	216.75	160.2	.70
	E	91	4364.6	47.96	<.001		

extensive surveys, sweepnet samples should be compared to a few sets of paired square foot or other absolute, instar specific density estimates.

ANALYSIS OF QUADRAT SAMPLES OF CEREAL LEAF BEETLE EGGS AND LARVAE

3.1 Introduction

The goal in this section is to improve understanding of the error term that is associated with estimates of CLB larval density. Some characteristics of CLB larval count data are discussed and the relationship between variance and mean for count data is described. Based on this relationship, a choice of transformations is made so that analysis of causes of change in beetle density (section 4) can proceed on valid statistical grounds.

When crops are short (8-10 inches) or when accurate density estimates are desired, sweepnet use is not recommended. Other sample units are selected following criteria like those of Morris (1955). That is, all units in the sampling universe should have an equal chance of selection, the unit should not change size in time, the unit should be easily converted to other unit areas, and the unit should be of such a size as to provide a reasonable balance between variance and cost. For the CLB, selection of square foot units over square yards or individual stems was made by Helgeson and Haynes (1972) on the basis of relative efficiency and expense. Examination of about 3 times as much plant material was needed when using square yards to obtain the same coefficient of variation as from square foot units. In practice, 2 linear feet of row are nearly the same as 1 square foot. The terms are used synonomously here.

A final sample unit selection criteria is that the proportion of the population using the sample unit must not change during the season. Although the expected count per sample will always be the mean density, the variance between counts may change disproportionately, along with the confidence limits on the estimate. The use of Normal Theory statistical techniques will be invalid until an appropriate choice of transform can be made to approximately normalize the frequency distribution of counts. The characteristic statistical distributions of CLB count data are therefore discussed in section 3.2. Using these, several transforms are derived and evaluated in section 3.3.

3.2.1 Pubescent Wheat Study adult sampling methods

During the PWS, simultaneous sets of sweep and square foot counts were taken in each field for adult, egg and larval life stages. Egg and larval sampling was discussed in section 2. Similar procedures were used for adults. In each field, 6 sets of 25 sweeps were taken from different parts of the field. At higher densities, set size was reduced to 10 sweeps. All of the adult beetles were counted and the 6 counts and corresponding number of sweeps were recorded. At the same time, in areas between where the sweeps were made, visual counts were made. The stick toss of section 2 was used to locate a semi-random starting point. A sample set then consisted of either 1) the total count of all adult beetles in 10 linear feet of row (= 5 square feet) or 2) a count of up to at least 10 adults, whichever came first. If no insects were counted in the first 6 sets, 4 more sets were counted. Each of the 6 sets of sweep counts and 6 to 10 sets of square foot counts were converted to either catch per sweep or catch per square foot before calculating mean and variance. Data for adult counts is recorded in appendix 7a and for larval and egg counts in appendix 7b.

Although these procedures introduce biases in the adult data that tend to overestimate the mean and may bias the variance in an unknown direction, the amount of the basis should be low, bias should be restricted to lower densities, and the relationship between mean and variance should be unaffected at higher densities. For egg and larval data, the amount of bias is believed to be negligible as virtually all samples were the same size.

3.2.2. The relationship between variance and mean for CLB counts

Aggregation is a tendency to be found in groups. It is 1 of 3 ways in which insect count data commonly violate the assumptions of the Normal distribution underlying such statistical procedures as the analysis of variance. These procedures were devised for continuous variables, normally distributed with equal variances (Hayman and Lowe 1961). Cereal Leaf Beetle counts from square foot samples differ from these assumptions in 3 ways: They are discrete, they have a skew distribution, and their variance increases with the mean. The problem of discreteness can usually be alleviated by increasing sample size, working in higher density populations, or by using a weighted analysis when a small proportion of the samples are too small (section 2.4).

The essential question when dealing with the other departures from normality is whether ignoring these will produce seriously misleading results. Another way to say this is to ask whether the rejection region of a test (or, alternatively, the test size, α, itself) is sensitive to changes in the underlying distribution. Tests that are not sensitive are called "robust" (Box 1953). Those that are sensitive are "frail" (Kendall 1973). Kendall (1973, chapter 31), summarizing earlier investigations, concluded "whereas tests on population means (ie.

Student's t test for the mean of a normal population and for the difference between means of 2 normal populations with the same variance) are rather insensitive to departures from normality, tests on variances (eg. the χ^2 test for the ratio of 2 normal population variances) are very sensitive to such departures.

If there were doubt about the validity of results, Kendall (1973) suggested 2 alternatives: to transform the data with a simple normalizing function or to use distribution-free procedures. Rather than abandon the more powerful parametric tests, it is usual to seek a transform first. The difficulty with this approach is "that we must have knowledge of the underlying distribution before we know which transformation is best applied, information which is likely to be obtainable in theoretical contexts like the investigation of the sampling distribution of a statistic but is harder to come by when the distribution of interest is arising in experimental work" (Kendall 1973).

The variance x mean relationship of aggregated populations may be characterized as

$$s^2 = Km, \tag{20}$$

or

$$s^2 = m+m^2/k \tag{21}$$

For low density randomly distributed populations (eg. Poisson, or K = 1), (20) may prove useful. At higher densities or in non-uniform habitats, (21) is more often used. More recently, a logarithmic alternative,

$$\log s^2 = a+b \log m \tag{22}$$

has been fit to many examples (Wayman 1959, Hayman and Low 1961, Taylor 1961).

The amount of variance among sample counts from non-uniform populations depends on the size of sample units (Kershaw 1964).

Sweepnet data should be converted to catch per sweep before use. This provides an unbiased estimate of the mean but leaves a bias in computing variance as those sample sets with higher numbers of sweeps hypothetically have a smaller between sample variance, depending on the area covered by the sweeper and the cluster sizes of the population. An example of this comes from the regression for adults by Ruesink (1970) who used sweep samples of from 1 to 50 sweeps per sample with 6 to 63 samples used to compute each mean and variance. The regression equation for within field variance was

$$\log s^2 = .04+1.34\log m, \quad (R^2 = .99, \text{ cases} = 17, p < .001) \qquad (23)$$

for catch per sample. Conversion to catch per sweep gave

$$\log s^2 = -.42+1.26\log m \quad (R^2 = .91, \text{ cases} = 17, p < .001) \qquad .(24)$$

Although establishment of standard numbers of sweeps or square feet for sample size would aid in making comparisons of data sets, this is seldom feasible. Insect numbers fluctuate and logistically demand adjustments in sample size. In making comparisons, one should be careful to note that sample size differences will likely affect variance.

Other studies of the CLB variance x mean relationship include that of Gage (1974) who found a good fit for the standard error of pupal cells per half square yard with the mean (s.e. = .52+.11m, R^2 = .97, range of means: 1 to about 110). Sawyer (1976) reported a good fit for the regression of both egg and larval log variance on log mean for square foot counts. These relationships are summed up in Table 8.

The PWS adults per sweep regression (Table 8) had the same intercept but significantly greater slope than the Ruesink regression. Comparing adults per sweep to adults per square foot for the PWS data

Table 8. The relationship between log within field variance, y and log mean, x. Model is y = a + bx + error.

Source	n	y	s.d.	a	s.e.	b	s.e.	x	s.d.	R^2	t
ADULTS											
Sweepnet											
Ruesink[1]	17	-.512	.925	-.422	.074	1.261	.108	-.072	.700	.910	12.3***
PWS[2]	227	-1.098	.997	-.441	.022	1.660	.039	-.395	.565	.884	41.5***
Square foot											
PWS[2]	335	-1.808	.840	-.382	.015	1.408	.026	-1.013	.562	.887	52.7***
LARVAE											
Sweepnet											
Ruesink[1]	5	-1.419	.812	-.829	.643	.754	.494	-.178	.288	.072	.5n.s.
Square foot											
PWS[2]	92	.356	.837	.179	.030	1.388	.053	.127	.567	.885	26.3***
Sawyer[3]	26	-.019	.965	.256	.026	1.254	.035	-.220	.763	.987	36.6***
EGGS											
Square foot											
PWS[2]	92	.319	.760	.197	.030	1.331	.118	.092	.263	.848	22.4***
Sawyer[3]	39	.285	.803	.239	.027	1.245	.445	.037	.630	.956	28.3***
Gage w.[4]	23	1.758	1.315	.511	.053	1.280	.055	.960	.995	.966	24.5***
Gage o.[4]	24	1.768	1.411	.518	.053	1.363	.053	.916	1.020	.970	26.6***

1 1968, Gull Lake. Wheat, oats, barley, 1 to 50 sweeps/sample, 6 to 63 samples/set, converted to catch/sweep. (Ruesink 1970)

2 1975, Pubescent Wheat Study.

3 1975, Gull Lake. Oats + alfalfa, 30 x 1 square foot/set. (Sawyer, pers. comm.)

4 1970, Gull Lake. w = wheat, o = oats, 30 x 1 square foot/set. (Gage 1972)

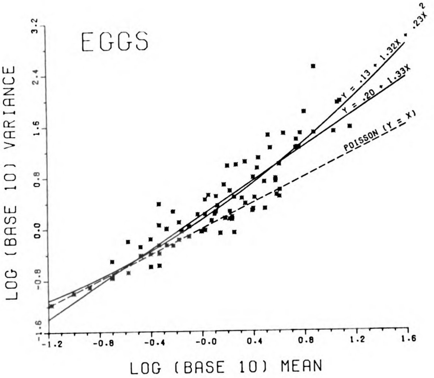
also gave non-different intercepts but a significantly greater slope for the catch per square foot regression. This latter result is especially curious since it seems more logical to expect the relatively greater area covered in the sweepnet samples (50 to 125 square feet per sample) to produce less between sample variance than the approximately 5 square feet covered for each of the absolute counts. The ratio of catch per square foot to catch per sweep, a crude "M" value (as per section 2), for the PWS adult data was 1.96, compared to an average ratio of .66 for 15 sample sets by Ruesink and Haynes (1973). These 2 discrepancies suggest that the adult sweepnet model (Ruesink and Haynes 1973) bears reexamination.

There are no significant differences between the regressions of larvae per square foot from the PWS and the 1975 Gull Lake data (Sawyer 1976)(Table 8). There is also no significance to the difference between PWS and Sawyer data for the egg regressions. It is interesting that the regressions for eggs per square foot fit most closely to the larvae per square foot regressions for the same locations, but, again these differences are not statistically significant.

It is unlikely that there is any difference between the variance x mean relationships for eggs and larvae for wheat, oats, and barley. Ruesink's adult results (Table 8) were from 3 crops and there were no detectable differences. Gage's (1970) data likewise had no difference between wheat and oats (Table 8).

3.2.3 Statistical distributions of CLB egg and larval counts

Although the PWS regressions of Table 8 adequately fit the data (R^2 = .848 and .885 for eggs are larvae), the fitting of 2nd order regressions leads to interesting results (Fig. 6). The 2nd order



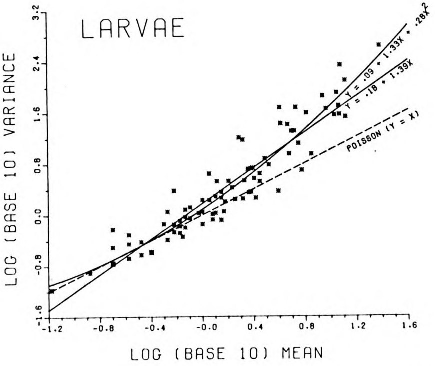


Fig. 6. The relationship between variance and mean for CLB egg and larval count data.

regressions provide only a slight increase in R^2 (.035 and .028), but they do suggest that the variance x mean relationship is not a simple log-linear one. It is useful to establish the significance of this in terms of the underlying distributions.

From Fig. 6 it appears that samples from low densities (less than .5 per square foot) have a poisson variance x mean relation, which is closely approximated by the 2nd order regression. This had been suggested by Ruesink and Haynes (1973). Regressions through those points with mean less than .5 confirms that the variance:mean relationship is approximately 1 : 1. Tests for goodness of fit of the pooled samples' frequency distribution also suggest a poisson (Table 9).

The Poisson distribution is a limiting case of the Negative Binomial. As the negative binomial statistic,

$$k = m^2/(s^2-m) \tag{25}$$

((21) rewritten) goes to infinity, the distribution approaches the Poisson. The variance x mean relationship at higher densities is that of (25) but, from Fig. 6, may be different from that of lower densities. It is therefore reasonable to ask if the distributions of count data are in fact negative binomial and whether they share a common k.

Although several computational schemes exist for estimating k (Anscombe 1949, Beall 1942, Bliss and Fisher 1953, Bliss and Owen 1958) most estimates have biases. An unbiased, not necessarily minimum variance, estimate of k can be obtained from the maximum likelihood estimates (MLE's) of the k's for individual samples, as in Table 10. In Table 10, column 1 refers to the samples listed in appendix 7b. Columns 2 and 3 are the individual sample's mean and variance. The k for the sample, column 4, is computed using Fisher's MLE (Bliss and Fisher 1953,

Table 9. Regressions of log s^2 on log m, using log s^2 = a+b log m, and tests for goodness of fit of joint count frequency distributions to the Poisson for egg and larval samples (given sample mean less than .5 per square foot).

REGRESSION STATISTICS

	Cases	y	s.d.	a	s.e.	b	s.e.	x	s.d.	R^2	t
Eggs	23	-.542	.375	.184	.179	1.207	.045	-.602	.260	.701	7.02***
Larvae	18	-.665	.309	.005	.044	.975	.169	-.697	.265	.700	6.11***

GOODNESS OF FIT

	Count	Observed Frequency	Expected Frequency	Kolmogorov Smirnov	χ^2
Eggs	0	250	241.9		
	1	62	71.4		
	2	9	10.5		
	3+<	4	1.2	K/S = .025; $K/S_{.05(4)}$ = .624	χ^2 = 1.67; $\chi^2_{.05(1)}$ = 3.84
Larvae	0	201	198.2		
	1	41	46.0		
	2+<	8	5.8	K/S = .011; $K/S_{.05(3)}$ = .708	χ^2 = 1.44; $\chi^2_{.05(1)}$ = 3.84

Table 10. Estimated negative binomial k's for egg and larval sample counts and test for goodness of fit using sample k and common k_c.

EGGS

NC.	MEAN	VAR	K	(S.E. K)	--USING SAMPLE K-- CHI-SQUARE (DF)		--USING COMMON K-- CHI-SQUARE (DF)	
					-----TEST FOR GOODNESS OF FIT-----			
1	14.600	35.97	11.85	(6.61)	2.932 (9)		9.286 (8)	
2	13.867	31.12	7.16	(3.58)	3.926 (9)		9.625 (8)	
3	5.933	29.50	1.11	(.46)	4.317 (8)		4.529 (8)	
4	2.533	6.12	2.23	(1.28)	3.266 (4)		3.325 (5)	
5	7.600	30.11	3.05	(1.34)	9.145 (9)		9.170 (9)	
6	6.400	63.11	.43	(.14)	6.035 (6)		30.362 (8)	***
7	12.200	92.31	1.48	(.51)	1.628 (8)		4.869 (8)	
8	3.800	5.89	7.51	(7.83)	5.182 (4)		5.086 (5)	
9	1.200	1.31	50.36	(115.19)	1.768 (2)		2.743 (2)	
10	3.467	17.41	.53	(.27)	6.293 (5)		18.497 (6)	***
11	.533	.98	.37	(.27)	1.488 (1)		3.866 (1)	**
12	.800	1.07	3.18	(5.93)	.008 (1)		.007 (1)	
13	1.300	1.79	4.95	(7.42)	.793 (2)		.786 (2)	
15	.700	.90	4.77	(7.41)	.458 (1)		.575 (1)	
16	2.500	1.83	-7.02	(3.06)	2.313 (2)		7.158 (3)	*
17	1.000	.89	-5.14	(4.26)	.381 (1)		1.607 (1)	
18	2.533	1.98	-8.81	(4.78)	1.540 (2)		6.394 (4)	
19	1.267	1.64	4.99	(8.57)	.554 (2)		.539 (2)	
20	1.667	1.81	104.99	(231.22)	.562 (2)		.376 (2)	
21	1.533	1.41	-9.57	(12.51)	.039 (2)		1.064 (2)	
22	1.733	1.50	-8.56	(9.63)	1.674 (2)		2.580 (3)	
23	11.667	86.81	1.37	(.49)	8.247 (8)		8.743 (7)	
24	7.667	313.10	.36	(.09)	4.061 (7)		44.349 (10)	***
25	3.867	3.27	-16.28	(17.33)	3.335 (4)		7.290 (5)	
26	3.800	5.31	10.90	(13.95)	2.007 (5)		4.739 (6)	
27	5.467	17.41	2.22	(1.12)	3.926 (7)		4.170 (7)	
28	.267	.64	.13	(.14)	.000 (0)	NA	.733 (0)	NA
29	3.100	5.21	5.89	(6.03)	1.274 (3)		1.901 (4)	
30	1.300	3.12	1.66	(.96)	2.493 (2)		1.985 (2)	
32	1.000	.89	-2.20	(1.33)	3.221 (1)	*	5.133 (1)	**
33	4.100	3.89	-20.85	(25.09)	1.334 (3)		7.465 (4)	
34	1.500	4.72	.85	(.58)	.336 (2)		.877 (2)	
35	1.067	.92	-4.28	(2.66)	.429 (1)		1.398 (2)	
36	.667	1.24	.91	(.85)	.142 (1)		.173 (1)	
37	.467	.55	2.78	(8.37)	.511 (1)		.547 (1)	
38	.333	.38	3.72	(11.06)	.003 (0)	NA	.002 (0)	NA
39	4.067	9.64	2.40	(1.57)	2.163 (6)		2.722 (6)	
40	2.067	2.92	5.61	(7.35)	.772 (4)		.998 (4)	
42	5.600	17.97	3.56	(1.53)	4.324 (8)		4.323 (8)	
43	1.067	2.79	.66	(.42)	.095 (2)		1.457 (2)	
44	.600	.54	-2.69	(3.42)	.304 (1)		.146 (1)	
45	1.667	1.38	-6.67	(5.65)	.999 (2)		2.811 (2)	
46	5.800	17.60	4.13	(1.78)	9.968 (8)		11.251 (8)	
47	1.067	1.64	1.72	(1.92)	.690 (2)		.957 (2)	
51	1.000	.89	-2.20	(1.33)	3.221 (1)	*	5.133 (1)	**
53	.600	1.83	.26	(.20)	.000 (1)		1.304 (1)	
54	.400	.69	.61	(.74)	.115 (1)		.166 (1)	
55	.467	1.12	.37	(.34)	.453 (1)		.485 (1)	
57	2.200	10.60	.59	(.32)	1.047 (4)		5.212 (4)	
58	1.133	3.27	.55	(.35)	2.094 (2)		4.200 (2)	
59	2.733	8.50	1.44	(.79)	1.898 (5)		1.855 (5)	
60	5.533	23.55	1.23	(.54)	5.602 (7)		3.956 (8)	
61	3.333	27.67	.37	(.17)	5.307 (4)		23.544 (6)	***
62	2.600	2.97	36.11	(81.89)	1.377 (4)		2.307 (4)	
63	2.800	12.17	.43	(.19)	4.381 (4)		19.755 (5)	***
66	.200	.31	.25	(.34)	.001 (0)	NA	.190 (0)	NA
67	4.067	3.07	-12.28	(5.99)	1.344 (3)		6.663 (5)	
68	.933	1.64	.66	(.47)	2.521 (1)		5.960 (1)	**
71	.467	.41	-2.09	(1.24)	.007 (0)	NA	.428 (1)	
72	1.733	1.35	-5.62	(3.14)	.249 (2)		2.431 (3)	
73	.333	.52	.35	(.47)	1.255 (0)	NA	.387 (0)	NA
74	.333	.38	3.72	(11.06)	.003 (0)	NA	.002 (0)	NA
76	.467	2.41	.07	(.07)	.000 (0)	NA	3.397 (1)	*
77	1.867	9.55	.43	(.21)	1.251 (3)		7.552 (4)	
78	1.333	2.24	1.60	(1.56)	1.469 (2)		2.357 (2)	
79	1.667	3.81	.93	(.56)	3.553 (3)		6.961 (3)	*
80	1.600	9.26	.27	(.13)	.102 (3)		11.123 (3)	**
81	2.800	12.17	.57	(.28)	5.375 (4)		11.941 (5)	**
82	.800	.74	-6.62	(7.69)	.486 (1)		1.708 (1)	
83	4.400	29.40	.61	(.23)	4.881 (6)		18.233 (6)	***
84	.533	.98	.37	(.27)	1.488 (1)		3.866 (1)	**
86	3.133	1.98	-7.61	(2.63)	.245 (3)		6.557 (4)	
87	1.067	.92	-4.28	(2.66)	.423 (1)		1.398 (2)	
90	1.800	3.03	2.55	(2.10)	.973 (3)		1.257 (3)	
91	1.400	.83	-2.87	(.89)	.733 (2)		4.706 (2)	*

ESTIMATED COMMON K: 3.103245 (S.E. K=32.59445). NUMBER OF SAMPLES: 75.

Table 10 (continued)

LARVAE

NO.	MEAN	VAR	K	(S.E. K)	--USING SAMPLE K-- CHI-SQUARE	(DF)		--USING COMMON K-- CHI-SQUARE	(DF)	
1	2.067	1.78	-8.38	(5.33)	1.557	(3)		6.280	(3)	*
2	10.667	35.81	4.76	(2.44)	8.039	(9)		9.700	(7)	
3	2.067	14.92	.33	(.19)	6.200	(3)		10.400	(4)	**
4	24.000	430.57	1.91	(.57)	10.031	(10)		6.971	(10)	
5	9.200	44.74	2.64	(1.20)	8.435	(8)		8.959	(9)	
6	4.067	25.78	.45	(.22)	3.899	(5)		20.502	(7)	***
7	1.933	16.21	.16	(.09)	2.073	(2)		17.125	(4)	***
8	2.600	1.83	-6.42	(2.07)	.129	(2)		6.580	(4)	
10	9.667	71.81	.89	(.32)	2.866	(8)		11.143	(9)	
11	1.300	3.34	1.11	(.80)	.670	(2)		.372	(2)	
12	1.700	2.68	1.99	(2.36)	4.056	(2)		4.201	(2)	
14	2.400	2.27	-13.35	(13.25)	.445	(2)		2.336	(3)	
15	2.800	4.40	5.04	(7.01)	2.215	(4)		1.661	(4)	
17	5.933	4.92	-26.59	(21.40)	3.412	(5)		10.411	(6)	
18	2.800	3.31	32.96	(51.27)	3.842	(4)		4.718	(5)	
19	2.133	3.41	3.56	(3.06)	.948	(4)		.905	(4)	
20	2.533	3.70	5.40	(5.53)	1.765	(4)		.848	(4)	
21	2.400	5.26	1.27	(.86)	8.471	(4)	*	5.320	(4)	
22	11.867	216.12	.81	(.27)	4.725	(9)		15.861	(9)	*
23	6.467	38.84	.44	(.15)	8.030	(5)		24.999	(8)	***
24	3.067	7.50	1.54	(.87)	6.426	(5)		6.793	(5)	
25	2.467	5.41	2.07	(1.54)	1.337	(4)		1.386	(4)	
26	.667	.81	2.39	(4.25)	2.523	(1)		2.520	(1)	
27	.500	.72	.81	(1.20)	1.250	(0)	NA	2.003	(0)	NA
30	1.200	.84	-3.19	(.91)	.221	(1)		2.348	(1)	
31	3.300	6.01	3.70	(3.63)	2.254	(3)		4.965	(4)	
32	2.900	2.32	-9.15	(2.87)	.260	(3)		6.176	(3)	
33	1.000	1.71	1.38	(1.16)	3.083	(2)		3.553	(2)	
34	.600	.54	-2.69	(3.42)	.304	(1)		.218	(1)	
35	.800	1.31	1.38	(1.49)	.069	(2)		.093	(1)	
36	.800	.89	20.86	(53.65)	.022	(1)		.097	(1)	
37	11.133	79.84	2.91	(.91)	7.125	(8)		7.048	(8)	
38	11.667	36.52	5.48	(3.55)	4.182	(8)		9.236	(7)	
40	12.933	124.07	2.43	(.73)	8.065	(9)		8.158	(9)	
41	7.067	8.78	30.62	(79.71)	4.197	(6)		13.217	(7)	*
42	5.333	47.38	.31	(.14)	7.394	(5)		16.562	(7)	**
43	4.733	8.92	7.51	(4.76)	4.323	(6)		8.197	(7)	
44	4.600	25.69	.48	(.21)	9.949	(5)	*	29.801	(7)	***
45	1.267	1.07	-4.51	(2.20)	.406	(2)		2.571	(2)	
47	.700	.46	-1.35	(.35)	.080	(1)		2.095	(1)	
49	.600	.71	5.11	(16.03)	.776	(0)	NA	.564	(0)	NA
50	2.300	2.23	-16.37	(49.93)	.040	(2)		1.432	(3)	
51	1.600	3.38	1.14	(.84)	.478	(2)		1.581	(2)	
52	.733	.64	-2.44	(2.23)	.792	(1)		.224	(1)	
53	1.267	1.92	3.16	(3.22)	.145	(2)		.236	(2)	
54	.933	1.07	12.97	(29.94)	1.674	(1)		1.417	(1)	
55	1.800	1.74	-16.14	(28.60)	2.026	(3)		4.971	(3)	
56	5.600	12.97	6.56	(3.21)	4.249	(8)		6.755	(7)	
57	.600	2.42	.23	(.17)	1.159	(1)		1.411	(1)	
58	13.067	33.64	9.31	(5.26)	3.285	(9)		5.971	(8)	
59	4.000	47.14	.44	(.17)	9.272	(5)	*	15.415	(7)	**
60	11.533	50.27	3.94	(1.72)	4.957	(8)		6.436	(7)	
61	5.200	20.46	1.48	(.73)	6.929	(8)		7.384	(7)	
62	1.133	4.41	.50	(.27)	.653	(2)		1.674	(2)	
63	.600	.54	-2.69	(3.42)	.304	(1)		.218	(1)	
64	.200	.60	.04	(.03)	.000	(-1)	NA	1.215	(0)	NA
65	1.133	1.70	3.71	(3.27)	.809	(2)		1.226	(2)	
67	.733	1.21	1.52	(1.41)	.487	(1)		.230	(1)	
69	1.000	.71	-3.26	(1.45)	.593	(1)		3.785	(1)	*
70	.600	.54	-2.69	(3.42)	.304	(1)		.218	(1)	
71	.667	.52	-1.81	(.43)	.265	(1)		.894	(1)	
72	1.400	2.26	1.95	(2.00)	2.391	(3)		2.356	(3)	
73	.733	.92	3.15	(6.49)	.143	(1)		.091	(1)	
74	1.200	1.03	-5.01	(2.64)	.433	(2)		1.070	(2)	
75	1.467	1.12	-3.86	(2.47)	.781	(2)		4.136	(2)	
76	1.400	1.83	4.41	(6.45)	1.843	(2)		1.880	(2)	
77	.533	1.12	.34	(.28)	.039	(1)		1.409	(1)	
78	2.267	5.21	2.32	(1.38)	1.344	(4)		1.311	(4)	
79	1.200	1.03	-3.73	(2.73)	3.282	(2)		5.871	(2)	*
80	4.933	20.21	1.16	(.51)	5.751	(7)		6.682	(7)	
81	1.400	.83	-2.87	(.39)	.739	(2)		5.447	(2)	*
84	.533	.41	-1.56	(.68)	.010	(0)	NA	1.408	(1)	
85	.333	.38	3.72	(11.06)	.003	(0)	NA	.000	(0)	NA
86	.267	.35	.77	(1.40)	.002	(0)	NA	.047	(0)	NA
89	.200	.31	.25	(.34)	.001	(0)	NA	.178	(0)	NA
92	.267	.50	.14	(.16)	.004	(0)	NA	.701	(0)	NA

ESTIMATED COMMON K: 2.381191 (S.E. K=15.14743). NUMBER OF SAMPLES: 76.

p. 182). For some of the samples, a k was not computable. This was so whenever 1) the mean and variance were equal, giving an infinite k, 2) the mean was close enough to the variance to cause a failure to converge on an estimate of k within a reasonable series of calculations, or 3) the ratio of mean : 1st trial estimate of k was less than -1 (see Davies 1971, p. 368-374). Although the negative binomial parameter k is usually considered to be a positive number, negative estimates were also calculated (cf. Bliss and Owen 1958).

As a check on whether the individual samples were in fact distributed negative binomially, the theoretical sample distributions were generated from sample mean and MLE k. Observed and theoretical distributions were compared by a χ^2 test for goodness of it (Table 10, columns 6 and 7). Of the 68 testable samples of eggs and larvae, only 2 egg and 3 larval count distributions were significantly different from expected at a .1 α level. Due to the small sample size, 10 to 15 counts per sample, the minimum expected cell size for the χ^2 test was set at 1, rather than the usual 5 (see Steel and Torrie 1960, p. 350; Sokal and Rohlf 1969, p. 565). Such test results should be evaluated cautiously, but it is safe to conclude that the samples can be represented by the negative binomial distribution.

From the individual estimates of k and their corresponding variances, a weighted average was computed as the estimated common k,

$$k_c = \Sigma w_i k_i / n \qquad (26)$$

where w_i, the weight, is the inverse of the variance of k_i and n is the number of sample sets (Steel and Torrie 1960, p. 180). The pooled variance estimate is

$$\text{var}(k_c) = \frac{(n_1-1)\text{var}(k_1)+(n_2-1)\text{var}(k_2)+\ldots+(n_m-1)\text{var}(k_m)}{n_1+n_2+\ldots+n_m-m} \qquad (27)$$

These estimates are listed in Table 10 (cf. Bliss and Fisher 1953, p. 194).

Two tests were used to determine the commonness of the estimated k_c's. The individual sample distributions were compared to theoretical distributions generated from k_c and the respective sample mean. Goodness of fit was tested by a χ^2 statistic (Table 10, columns 8 and 9). For eggs, 17 of 70, and for larvae, 13 of 69 testable cases (24 and 19%) were significantly different at $\alpha = .1$, causing some question as to the commonness of the k's. It should be remembered, however, that setting minimum expected cell size to 1 makes the χ^2 test more susceptable to fluctuations in smaller cells.

A 2nd test, illustrated in Fig. 7, was suggested by Bliss and Owen (1958). The individual sample k's are plotted against the sample mean (here transformed to logs to give clearer separation). For neither eggs nor larvae are the points substantially different from the mean common k, and this is confirmed by regression through the points (Table 11). Although there is considerable variance about the k_c's, the estimates are not correlated with the mean.

A check was made to determine if the aggregation of larvae was related to age. Although the individual larval square foot counts were not subdivided into counts of each instar, an overall estimate was made for each field. The individual field MLE k and the variance : mean ratio from Table 10 were each compared to the mean instar for that field (Table 12). There were no correlations and plots of the data suggest no higher order relationships. It is assumed, therefore, that there is no significant change in the distribution of larvae attributable to instar. The common k may be accepted as common for all age

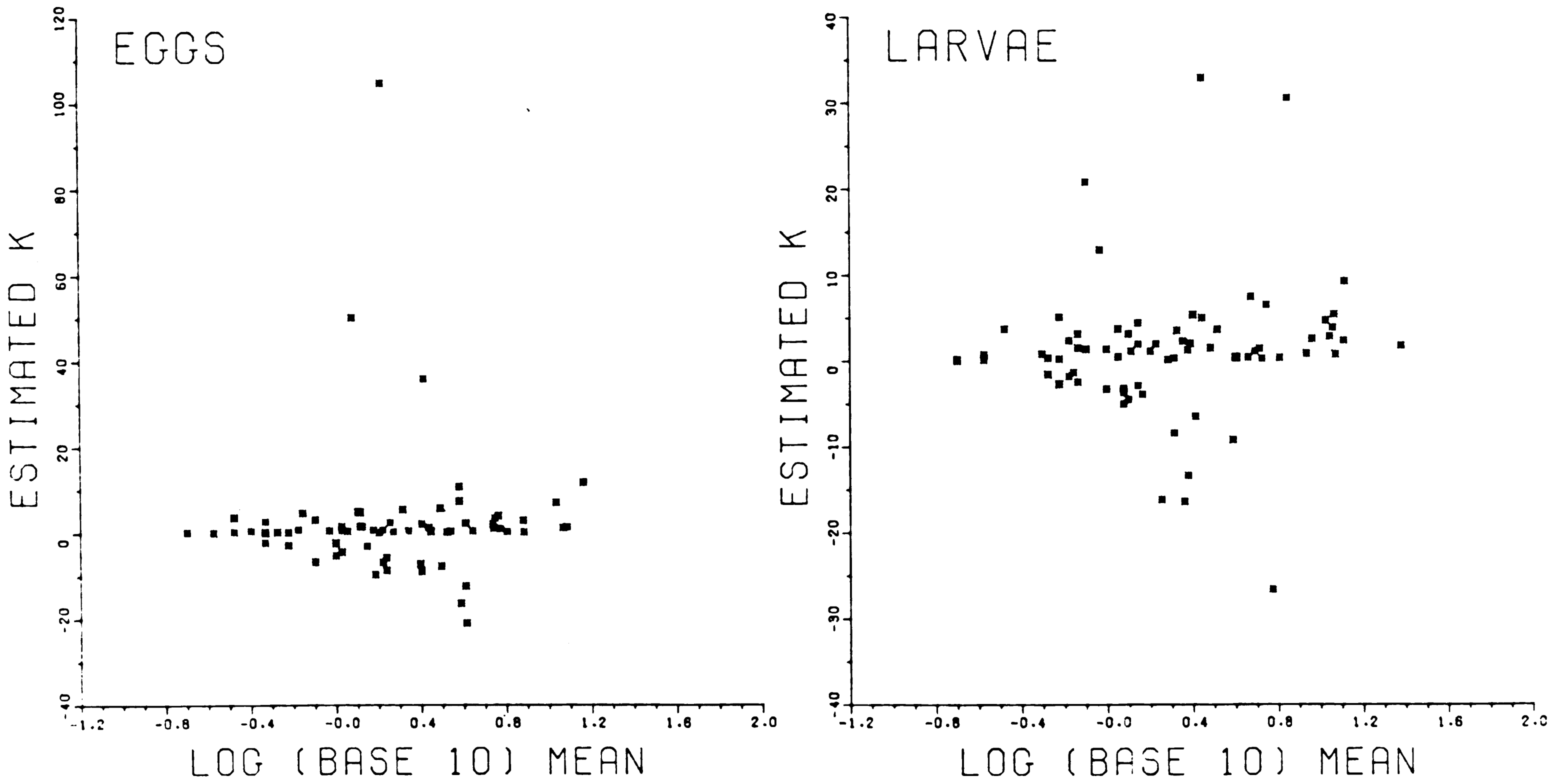


Fig. 7. The relationship between MLE sample k and log of the sample mean for CLB egg and larval count data.

Table 11. The relationship between sample negative binomial k's and log mean for egg and larval counts. Model is $k_i = a+b \log m_i$.

	Cases	$\bar{k}$	s.d.	a	s.e.	b	s.e.	log m	s.d.	R^2	t
Eggs	75	2.35	14.93	2.22	1.73	.59	4.45	.236	.43	.000	.144n.s.
Larvae	76	1.02	7.99	.55	.91	1.74	1.72	.275	.48	.001	.900n.s.

Table 12. The relationship between sample negative binomial k and the variance : mean ratio over mean instar. Model is $y = a + bx$, where y is k_i or Var : m, and x is mean instar.

	Cases	y	s.d.	a	s.e.	b	s.e.	x	s.d.	R^2	t
k	73	1.21	8.05	-2.82	.94	1.26	1.75	3.21	.54	.007	.717n.s.
V : m	73	2.96	3.62	6.05	.42	-.96	.78	3.21	.54	.021	-1.231n.s.

groups.

There seems to be no reason for not taking the estimate of k_c for eggs to be the same as that for larvae, using the above tests. A single estimate of common k, $k_c = 2.75$, is the arithmetic mean of the egg and larval k_c's. It is adopted for the development of the related transforms, below.

3.3 Variance stabilizing transforms

The negative binomial is a skewed distribution, especially at lower densities. Transforms that reduce variance instability (dependency on the mean) may also reduce the skewness of the frequency distributions. Results from different transforms are often similar and choice of transform may be up to user preference, with little apparent difference in the variance : mean relationships after transformation.

The choice of transform depends on the perceived relationship between variance and mean. For contagious negative binomial type distributions, Beall (1942) used an inverse hyperbolic sine transform,

$$z = \sinh^{-1}(\mathrm{SQRT}(kx))/\mathrm{SQRT}(k) \qquad (29)$$

with k, the negative binomial statistic, z, the transformed count, and x, the original count. Kleczkowski (1949) used the simpler

$$z = \log\ (x+c) \qquad (30)$$

with c, a constant. Noting that the transform was less effective at low densities, Kleczkowski (1955) proposed the curvilinear modification

$$z = \log\ ((x+c+\mathrm{SQRT}(x^2+2cx))/2) \qquad .(31)$$

Choice of c was dependent on the intercept of a standard error x mean regression for small, untransformed counts.

To compensate for the apparently common difficulty of transform failure at low density, Hayman and Lowe (1961) used the log variance x log mean relationship (22) of Wayman (1959). This is equivalent to

$$s^2 = 10^a m^b \tag{32}$$

which was simultaneously used by Taylor (1961a) to describe the variance x mean relationship of count data from 24 biological surveys on various animals, from viral lesions to ocean fish. From this relationship, these authors used Kendall's (1973 (1st ed. 1948)) transform,

$$z = \int^x (1/\mathrm{SQRT}(\bar{x}))dx, \tag{33}$$

which leads to

$$z = x^{(1-b/2)} \quad . \tag{34}$$

The "power law", equation 32 (Taylor 1965),and its transform (34) minimized the range of variances of several aphid count sets (Taylor 1970) and was found to be slightly better at this than the commonly used log (x+1). Note that (34) is not useful when b = 2, in which case Taylor used the log transform (Taylor 1961a).

Table 8 suggests that a common regression of

$$\log s^2 = .25+1.33 \log m \tag{35}$$

is a reasonable expression of the within field log variance x log mean relationship for both the egg and larval square foot counts under normal farming conditions. Using Bliss's (1967, p. 128) correction for underestimation of the arithmetic mean from log data,

$$m_a = m_g+1.1513s_g^2 \tag{36}$$

with m_a the arithmetic mean, m_g the geometric mean of the log data, and s_g^2 the error mean square (here the squared average s.e. for eggs and larvae in Table 8), leads to a variance x mean relationship of

$$s^2 = 2.11m^{1.33} \tag{37}$$

for eggs and larvae. Using (34), an appropriate transform is

$$z = x^{.33} \quad . \tag{38}$$

Note that this transform depends on a 1st order relationship between log variance and log mean. Fig. 6 suggests that this may not be valid. Ruesink and Haynes (1973) observed that "b" was closer to unity when the sample means were less than .5 per sample. Perhaps this is why Taylor (1970) found the transform less effective at stabilizing variance at low density. Development of second order regressions, however, leads to expressions which are beyond the scope of this thesis to integrate.

The above transforms are compared in Table 13. Two criteria are used here to evaluate transform effectiveness. The simplest test is to compare the ratio of maximum to minimum variance with a ratio established under normality assumptions (Hayman and Lowe 1961, Taylor 1970). The test statistic is

$$\zeta = (\ln \rho)/2, \qquad (39)$$

a normally distributed variable with variance $\hat{\sigma}^2 = 1/df$, where df is the degrees of freedom of the sample variance, and $\ln \rho$ is the natural logarithm of the ratio of maximum to minimum variance. Here, the average df is 12.1. The expectation of a range in a normal distribution is approximately σSQRT(n), where n is the size of the sample supplying the range (Masayuma 1957). Thus, under normality assumptions, for both eggs and larvae the expected minimum ζ = SQRT(92/12.1)/2 = 1.38.

Initially, all transforms were evaluated using a search technique to minimize ρ, the ratio of maximum to minimum variance. That is, the transforms were optimized for ζ. Constants of transformation were selected and evaluated iteratively until ζ changed by less than .1%. Subsequently, the correlations of the variances and means of the transformed sample counts were computed (Table 13).

Table 13. Comparison of transforms optimized for minimal ζ. ρ = ratio of maximum to minimum variance. r = correlation coefficient, significant at α = .05 if greater than .22. $\zeta = (\ln \rho)/2$.

	Transform	Constant, c	ρ	ζ	r
Eggs	Observed		4696.43	4.23	.921
	log (x+c)	.271	19.54	1.49	.153
	log ((x+c+SQRT(x^2+2cx))/2)	.740	18.03	1.45	.128
	$x^{.33}$		22.02	1.55	.148
	x^c	.335	21.86	1.54	.216
	$\sinh^{-1}$(SQRT(cx))/SQRT(c)	.672	17.99	1.44	.129
	$\sinh^{-1}$(SQRT(cx))/SQRT(c)	2.75 (k_c)	31.14	1.72	.093
	Normal		15.76	1.38	
Larvae	Observed		6458.57	4.39	.941
	log (x+c)	.324	24.11	1.59	.098
	log ((x+c+SQRT(x^2+2cx))/2)	1.29	23.82	1.59	.178
	$x^{.33}$		30.48	1.71	.154
	x^c	.389	25.14	1.61	.350
	$\sinh^{-1}$(SQRT(cx))/SQRT(c)	.388	23.82	1.58	.178
	$\sinh^{-1}$(SQRT(cx))/SQRT(c)	2.75 (k_c)	41.83	1.87	.134
	Normal		15.76	1.38	

Another criteria for optimizing transforms is to select constants so that the correlation between variances and means of the transformed counts is minimal (Table 14). This also tends to reduce the ζ statistic. A graphic check was made to be sure the lack of correlation was not due to an introduced curvilinearity. There is evidence of residual correlation at low density with all transforms (Fig. 8, for example), but only 1/3 of the overall variance after transform could be accounted for by fitting up to 4th order polynomials (Table 15).

The effect of transforms on the sums of squares and the analysis of variance has been discussed by Beall (1941). In general, gross changes in significance of test statistics will not occur as a result of transformation, but some differences about the relative importance of less correlated variables may occur. The log transform of Table 6, for example, changed few of the conclusions from Table 5, except for the cases of 1sts and 2nds in wheat, in which the order of inclusion in the regression was altered.

For all of the transforms evaluated, chosing constants for minimal correlation between variance and mean helped reduce the skewness and kurtosis of the counts, although all remained leptokurtic and somewhat positively skewed. From Tables 13 and 14, all transforms are better than none for reducing variance instability and approximately normalizing the distributions. The simple log transform, with constants .132 and .170 for eggs and larvae, will be used here as it is the simplest and has marginally better ζ's.

Table 14. Comparison of transforms optimized for minimal correlation between transformed variance and mean.

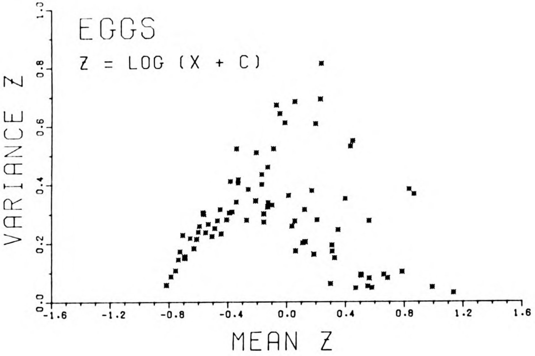
	Transform	Constant, c	ζ
Eggs	Observed		4.23
	log (x+c)	.132	1.64
	log ((x+c+SQRT(x^2+2xc))/2)	.337	1.60
	x^2	.280	1.60
	$\sinh^{-1}$(SQRT(cx)/SQRT(c)	1.485	1.60
Larvae	Observed		4.39
	log (x+c)	.170	1.72
	log ((x+c+SQRT(x^2+2xc))/2)	.450	1.71
	x^c	.283	1.81
	$\sinh^{-1}$(SQRT(cx)/SQRT(c)	1.112	1.71

Table 15. An example of higher order variance dependencies following transform. Model is $y = \underline{b}'\underline{z}$, y is transformed variance, $\underline{z}$ a vector of orders of the transformed mean, using z = log (x+c).

	Variable*	b_i	s.e.	R^2	ΔR^2	Overall F**
Eggs	z^2	-.525	.172	.290	.290	36.83
	z^4	.111	.222	.322	.032	21.12
	z	-.133	.071	.327	.005	14.23
	z^3	.256	.153	.348	.021	11.60
	constant	.386	.024			
Larvae	z^2	-.559	.134	.240	.240	28.39
	z^3	-.043	.193	.331	.091	22.00
	z^4	.247	.198	.334	.003	14.68
	z	.095	.077	.345	.011	11.45
	constant	.340	.021			

* Listed in order of inclusion (Nie et al. 1975)

**All F ratios significant at P <.0001



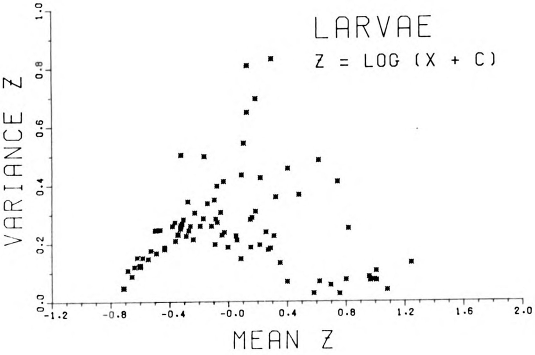


Fig. 8. The relationship between variance and mean for CLB egg and larval counts following transformation.

LINEAR PREDICTORS OF CEREAL LEAF BEETLE DENSITY

4.1 Introduction

The goals of this section are to find a way to use previous measurement information to reduce the error term of estimates of CLB density and to predict seasonal density using early season measurements. This requires a search for relevant environmental factors and linear coefficients relating these to historical changes in density. Rates of population change based on these regressions are then used to estimate present population levels, according to recorded weather and / or biological information. The most recent measurement, if any, may be averaged with the projection for an improved estimate. Models of expected future weather or biological events may be used for a density forecast over an entire season.

The PWS environmental factors measured were temperature (described as degree days, base 48F), windspeed, wetness, rainfall, and crop height (see section 2). Average larval age was estimated from subsample head-capsule measurements. Egg parasitism by *Anaphes flavipes* was determined from laboratory rearing of weekly collected field eggs.

The applicability of statistical description of change in CLB larval numbers in response to the environmental factors may depend on the relationships among the independent variables. Several of these bivariate relationships are discussed in section 4.3. The development of improved estimators for larval density follows in section 4.3. A multivariate regression is fit to the PWS data, using transformed counts as the dependent variable. Partial derivatives of this estimator are then used as "filters", in the sense of Hildebrand (1976) and Sakawa (1971).

4.2 Parameters of the temporal distribution of CLB eggs and larvae.

Multiple regressions tend to mask relationships among variables. For the CLB, these relationships have intrinsic properties of interest which have been studied in an ongoing research program for several years. The PWS data set will be used here as a vehicle for review and corroboration of several of these underlying bivariate relationships.

The distribution of error terms on the independent variables will not be discussed here because most of the field measurements (ie. crop height, windspeed, etc.) were made only once per count period. In future studies, these error terms ought to be given the same attention given to the error term of the dependent variable (section 3)(see Box and Tidwell 1962). Out of necessity, these errors will be considered normally distributed with stable variance.

4.2.1 Adult influx

The most important variable initially affecting egg (and hence larval) density is the spring influx of adults. An estimate of the number of adults available for oviposition may come from regional survey data taken early in the season or from samples near the field of interest. Casagrande (1976) found the rates of adult emergence from wintering sites was quite similar for 4 years of Kellogg Farm data. Regional incidence curves for 3 years of sweepnet data also showed a consistant pattern with peak regional density at roughly 200 dd's and a gradual decline over the next 600 to 800 dd's. This is essentially the pattern for PWS adults (Fig. 9). The PWS peak adult density in wheat was at 206 and 238 dd's for the square foot and sweep sample units. Buildup to this point is quite rapid as the bulk of adult emergence takes place over a relatively short span.

The adult population then decreases in an exponential fashion,

$$N_t = N_p e^{-\lambda(t-200)}, \tag{40}$$

where N_p is the peak population and t is "time" in dd's. The mortality rate, λ, has been estimated to be .0071, .0071, .0037, and .0045 per dd for the 4 years of Kellogg Farm survey. The factors that determine this rate are unknown. Casagrande (1976, p. 29) reported λ was independent of host crop type. The seasonal total of "adult degree days" (the area under the adult incidence curve) is sensitive to this parameter. Mortality rates of .007, .005, and .003 applied to the PWS regional density in wheat at 200 dd's resulted in 55.9, 70.9, and 100.4 adult dd's.

The number of adult dd's may be used to estimate total egg production. Table 16 reports results of several studies. Disregarding the lowest Teofilovic estimate, mean eggs per dd from 6 studies is .35 (s.d. = .044). Wellso (1976) reports average total oviposition per female in laboratory studies is similar to that of field beetles. Multiplying .35 times 1/2 the total adult dd's gives an estimate of total eggs produced.

The rate of adult movement into oats depends on factors which have not yet been analyzed. Oats is a preferred host for CLB's and acts as a sink, with beetles leaving oats more slowly than they arrive (Casagrande 1976, p. 48). Although this should eventually establish an equilibrium with other hosts, the level at which this occurs and the factors

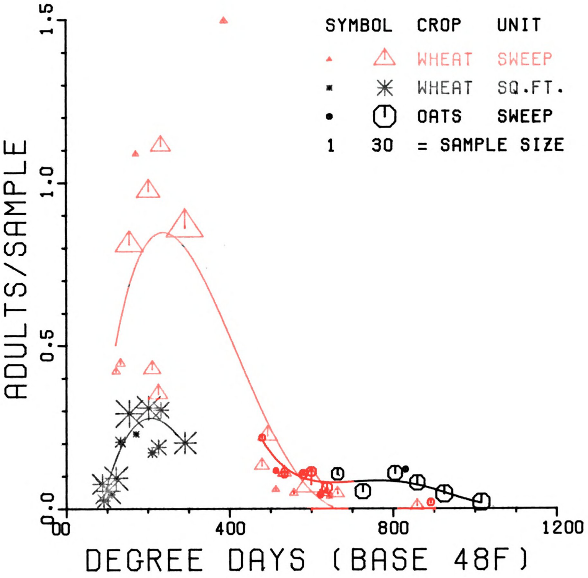


Fig. 9. Changes in adult density over accumulated degree days. Symbol size indicates number of field means included in sample point.

Table 16. Mean eggs per female CLB per degree day (48F).

Source	Eggs/dd	Conditions
Teofilovic (1969; ref. in Wellso, Connin and Hoxie 1973)	.325	30°C (86°F)
	.055	16°C (61°F)
Wellso, Connin and Hoxie (1973)	.272	26.7°C (81°F)[a]
	.362	26.7°C (81°F)[b]
	.381	26.7°C (81°F)[c]
Wellso, Ruesink and Gage (1975)	.388	26.7°C (81°F)[d]
Tummala, Ruesink and Haynes (1972)	.370	unspecified

[a] laboratory cages, equal numbers of both sexes
[b] laboratory cages, sexes separated before oviposition trial
[c] field collected, oviposition measured in laboratory
[d] mated once weekly

determining this level are unknown. In the 1st simulation of the CLB ecosystem, Ruesink (1972) assumed 90% of the beetles in wheat went to oats. Casagrande (1976, p. 144) plotted adult densities in strips of oats. Density increased until it was 10 to 20 times as great as in wheat. The proportions of land area in small grains and in spring grains are important in determining relative densities (Ruesink 1972, p. 28). The spatial arrangement of the host fields is also undoubtedly important in this respect. In the 1975 PWS area, oats were about 12.7% of the small grains and were about evenly interspersed with wheat (map, appendix 4).

The adult incidence curves vary considerably from field to field. Between plus within field variance is more than within field variance for all life stages (Table 17). The Ruesink regressions for adults and larvae in Table 17 are the same because they came from pooled data. There was no visible difference between the regressions for the 2 life stages (Ruesink, pers. comm.). For the PWS data, fields were grouped according to sample date (appendix 7c).

Analysis of variance for the 3 incidence curves in Fig. 9 reveals that much unexplained variance remains after inclusion of many environmental variables and after adjusting for between field differences. Table 18 includes dd's, crop height, windspeed and wetness. Between field differences were handled as classification effects, as were the field wetness ratings. Each field or wetness classification was given either a "0" or a "1", depending on whether a sample fit that classification. Singularities in the $\underline{X}'\underline{X}$ (or the correlation) matrix were avoided by eliminating 1 wetness classification and 1 field, as per Draper and Smith (1966, p. 137-46). Less than 5% of the cases had missing crop height, windspeed, or wetness variables. All cases were used and the correlation matrix was constructed with pairwise deletion of missing variables (Nie et al. 1975).

Apparently, either sample technique or selection of variables were inappropriate for the adult density model. Of the environmental factors, dd's accounted for most of the variance. Between field differences accounted for about 1/3 of the variance (Table 18).

Two final observations on adult densities are appropriate here. The amount of host crop planted is highly susceptable to economic factors that are not necessarily related to pest density. For example, Table 19 shows the change in total acreage and numbers of fields in the PWS area from 1973 to 1975, when the relative value of wheat was

Table 17. The relationship between log between plus within field variance, y, on log mean, x. Model is $y = a + bx + error$.

Source	n	y	s.d.	a	s.e.	b	s.e.	x	s.d.	R^2	t
ADULTS											
Sweepnet											
Ruesink[1]	79	--	--	.093	.083	1.934	.086	--	--	.971	--[2]
PWS[3]	6	.319	.443	.319	.084	2.045	.503	-.157	.204	.889	5.6**
Square foot											
PWS[3]	12	-1.092	.820	.663	.063	1.876	.153	-.936	.426	.949	13.6***
LARVAE											
Sweepnet											
Ruesink[1]	79	--	--	.093	.083	1.934	.086	--	--	.971	--[2]
Square foot											
PWS	6	1.315	.472	.687	.250	1.641	.095	.382	.287	.993	23.9***
EGGS											
Square foot											
PWS	6	1.125	.422	.607	.067	1.547	.279	.335	.264	.937	7.7**

1 1967, 1968, Cooperative CLB survey. Unit is catch per sample. Up to 196 fields of wheat, oats, corn and barley were sample in each of 16 townships. Statistics from Ruesink and Haynes (1973).

2 F tests significant at $p < .001$.

3 Pubescent Wheat Study, 1975.

Table 18. Analyses of variance for adult CLB's per sweep in wheat and oats and for adults per square foot in wheat.[$] Model is $y = \mu + \underline{a}'\underline{x}$ + error, where $\underline{b}' = (dd\ dd^2\ ch\ ch^2\ W\ \underline{m}')$, dd = degree days, ch = crop height, W = windspeed, $\underline{m}'$ = wetness classifications, and $\underline{f}'$ = field effects (0,1).

a	SSR (d.f.)	SSE (d.f.)	F	R^2
Wheat: catch per sweep				
b	44.9 (7)	204.1 (394)	12.38***	.180
f	75.7 (60)	167.3 (364)	2.75***	.379
(b f)'	127.3 (67)	121.7 (334)	5.22***	.511
Wheat: catch per square foot				
b	4.1 (7)	27.1 (396)	8.53***	.131
f	10.0 (63)	21.2 (341)	2.55***	.412
(b f)'	17.2 (70)	14.0 (333)	5.85***	.552
Oats: catch per sweep				
b	.24 (7)	1.45 (125)	2.97**	.143
f	.59 (23)	1.10 (122)	1.33n.s.	.293
(b f)'	.67 (30)	1.02 (102)	2.24***	.397

$ = Reduced models are not to be confused as being parts of compound model. Differences in degrees of freedom are attributable to missing data elements.

Table 19. Wheat and oat planting in the PWS area. Figures in parentheses are for Michigan only. Michigan data, 1973-74, from M. Holmes (APHIS-USDA, pers. comm.). 1974 PWS figures from R. Gallun (USDA, Purdue University, pers. comm.).

	1973		1974		1975	
	Fields	Acres	Fields	Acres	Fields	Acres
Oats	(12)	(115)	14 (11)	n.a.(94)	17 (15)	181 (162)
Wheat	(11)	(111)	46 (45)	n.a.(519)	73 (58)	1234 (933)

responding to high international export volume. Oats acreage was comparatively stable during this time. The presence of a constant CLB population in the area from 1973 to 1975 would have resulted in an apparent decrease in average field density in wheat.

The distribution pattern of agricultural fields may remain stable from year to year. Fig. 10, for example, maps the distribution of 1/4 sections containing oats in the Jackson County, Pulaski township, Michigan, CLB survey site for 1973 to 1975. Although the number of oat fields dropped slightly in this area, there were few sections in 1974 or 1975 which did not contain or were not adjacent to a section with an oat field the previous year. Similar maps of all the CLB survey sites listed in Appendix 2 suggest that this continuity of pattern was general. If the degree of aggregation of a population is intrinsic to a species (D. Kendall 1948, Taylor 1965, 1970), it must nevertheless be susceptable to the spacial dynamics of crop planting pattern. Assuming that the adult spatial wintering pattern is closely related to crop pattern in the previous summer and that the spring host selection flights of adults can cover at least a mile diameter area, present crop planting habits in the Michigan CLB survey areas will do little to alter the between field CLB adult count variance x mean relationship from year to year.

The remaining error in the adult density models is large, but is understandable. Sweepnet and stick toss techniques have long been suspect as adult sampling methods, but have been retained for lack of suitable alternatives. Larger sample size would reduce error in density estimates. Further discussion of the nature and causes of between field variance of adults will be deferred to a later study (A. Sawyer,

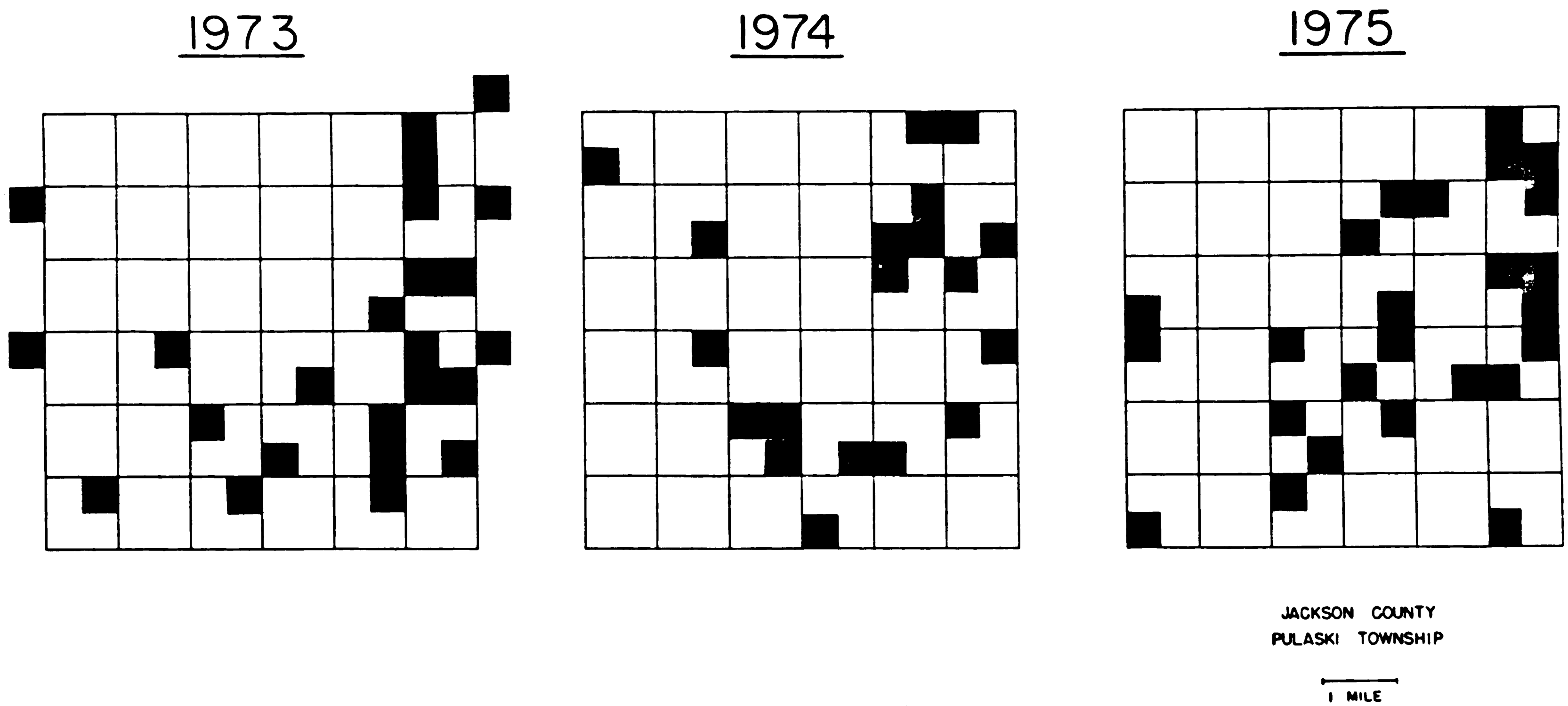


Fig. 10. Locations of quarter sections containing oat fields, Pulaski township, Jackson County, Michigan, 1973-75.

PhD thesis, Michigan State University, ca. 1978).

4.2.2 Crop height

Crop height (ch) is an indicator of several "states" of the plant, including its age. It is an indirect summary of all the factors that have been experienced by the plant, such as fertilizers, water and warmth. Each state in turn may be important for its influence on CLB density.

Those spring crops which are planted late will be exposed to a decreasing regional adult population and will receive fewer eggs, even though younger crops are preferred for oviposition (Shade and Wilson 1964a). There is a tendency for spring grains to have higher densities than the fall planted winter wheat for the same reason.

The relationship between wheat and oat ch and accumulated dd's has been graphically illustrated by Gage (1972) and Sawyer (1976). The relationship is variety specific and consistant, and, like crop maturity, may normally be subject to little modification by other environmental effects (Wiggins 1956). It is essentially that of the PWS data (Fig. 11, but note that a base of 48°F was used, not the more common base 42°F). Further analysis of this relationship suggests that growth of wheat may be much more uniform across the region than the growth of oats (Table 20). Degree days account for over 80% of the seasonal variance for wheat, but less than 40% for oats.

A hypothetical explanation for this lies in the difference in planting times for the 2 crops. Although the pattern will vary from year to year, there was a 12 day period of cool, dry weather in October 1974 (59 dd accumulated) when it is assumed most wheat was planted. Wet

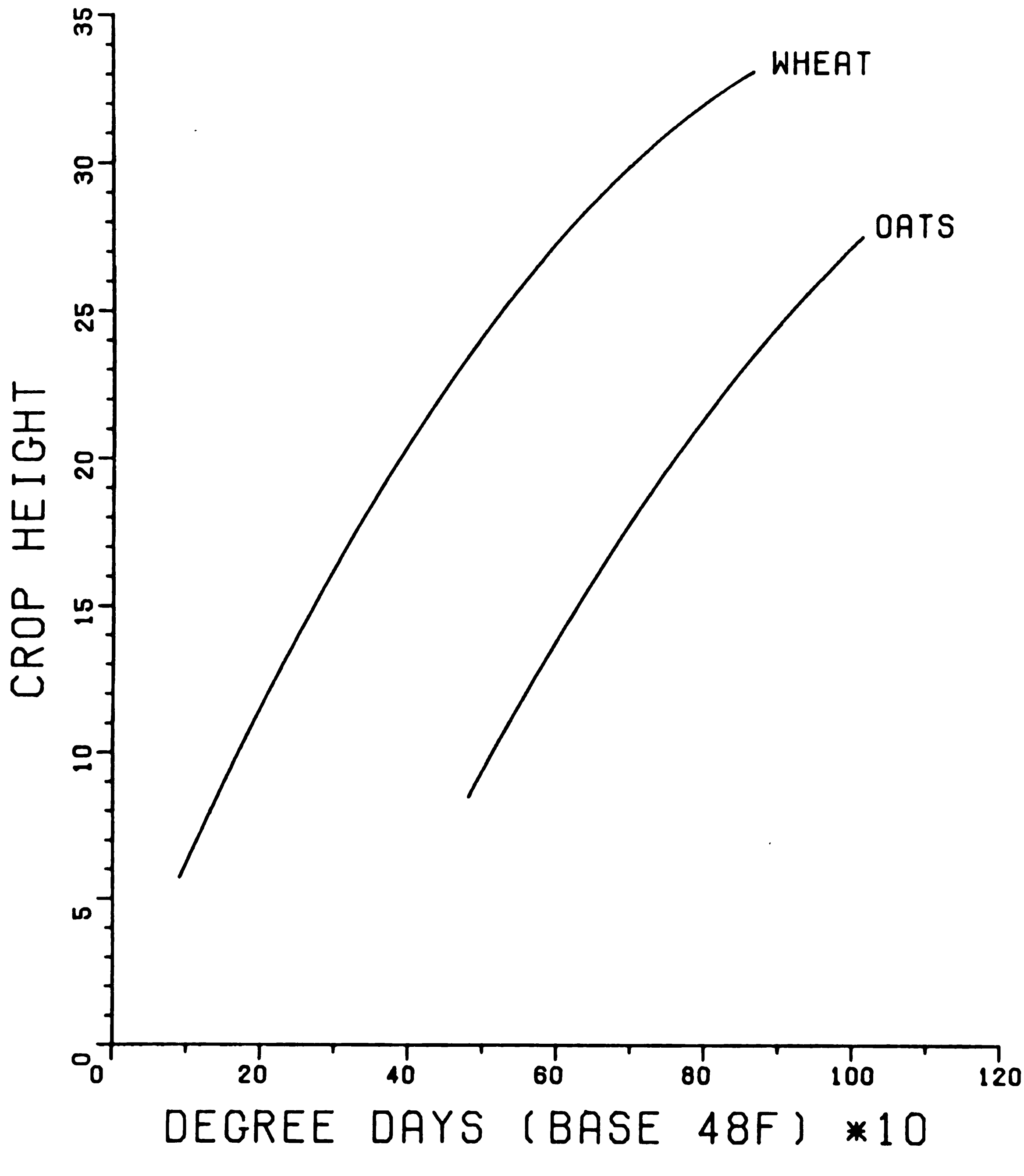


Fig. 11. The relationship between crop height and accumulated degree days for the PWS data. Regressions are: oats... $y = -19.5 + .069x - .000022x^2$, $R^2 = .388$; wheat... $y = .47 + .061x - .000026x^2$, $R^2 = .837$.

Table 20. Analyses of variance for wheat and oat crop height. dd = degree days, f = field effects (0,1). Model is $y = \mu + \underline{a}'\underline{x}$ + error.

a	SSR (d.f.)	SSE (d.f.)	F	R^2
Oats				
dd	5412.5 (1)	8652.6 (172)	107.6***	.385
dd, dd^2	5462.4 (2)	8603.1 (171)	54.3***	.388
dd, dd^2, f	12666.0 (25)	1399.4 (148)	53.6***	.901
Wheat				
dd	46709.0 (1)	10057.0 (840)	3901.0***	.823
dd, dd^2	47515.0 (2)	9251.0 (839)	2154.0***	.837
dd, dd^2, f	52200.0 (65)	4566.0 (776)	136.5***	.919

Table 21. Percentage of eggs parasitized by *Anaphes flavipes*, PWS 1975 (data in Appendix 6).

Date	Degree Day (48°F)	Number of Fields	Number of Eggs Sampled	Mean Percent Parasitized (±s.d.)
Oats				
6/2	565	18	413	11.0 (10.5)
6/9	663	16	435	12.6 (9.4)
6/16	804	16	449	86.6 (14.9)
6/20	924	19	444	94.6 (8.2)
6/25	1067	13	193	98.8 (3.2)
Wheat				
5/14	220	17	960	0.1 (.46)
5/21	345	17	1002	0.0 (0)
5/28	492	17	390	7.3 (6.4)
6/2(3)	565	17	360	21.0 (20.3)

spring weather drew out oat planting times over roughly a 3 week period of 260 dd's in May. The result is a greater spread of oat planting times on a physiological scale than was experienced by wheat, hence the larger between field difference. Inclusion of between field differences in the oat crop height regression thus brings the R^2 value to .90.

4.2.3 Egg parasitism by Anaphes flavipes

Anaphes flavipes is an established CLB egg parasitoid in the Galien area (T. Burger, pers. comm.). In the PWS survey, parasitism was monitored weekly from May 14 to June 2 in wheat and from June 2 to June 25 in oats. Leaves bearing CLB eggs were clipped, returned to the lab, and transferred to a plastic petri dish. Emerged larvae, or eggs with clearly identifiable contents were noted and removed daily. All egg development was usually completed in 7 to 9 days. These data are included in the individual field summaries of Appendix 6 and are summed up in Table 21.

Table 22 lists the mean and standard deviation of total egg counts made in wheat and oats. In addition to the separate egg counts discussed above (section 3), many fields were simply given a total count per 10 or 15 square feet. All egg samples are thus included in Table 22 and the statistics given are the statistics of field means.

The individual field density means were used to determine the least squares fit of density over polynomials in degree days (up to 4th order). The percentages of parasitism in Table 21 were fit with 2nd order curves and the estimated number of parasitized eggs per square foot was calculated (Fig. 12). The areas under the total egg and parasitized egg incidence curves were compared for an estimate of seasonal egg parasi-

Table 22. Statistics of average egg density by date and degree day.

Date	Degree Day (48°F)	Number of Fields	Density (per square foot) Mean	S.D.
Oats				
May 27	478	8	21.133	12.687
30	533	7	4.343	5.111
June 2	565	13	3.195	4.276
3	579	1	.200	0.000
5	621	4	10.500	5.696
6	637	11	3.636	3.261
7	643	1	.500	0.000
9	663	17	2.388	2.202
12	725	19	3.002	3.048
16	804	17	2.543	2.823
17	829	1	4.067	0.000
18	858	21	1.248	1.679
20	924	21	1.457	1.577
25	1015	21	1.111	1.218
Wheat				
May 7	142	27	8.788	13.077
8	154	8	17.600	12.094
9	170	18	2.878	1.783
13	210	33	20.582	21.033
14	220	16	6.850	5.698
16	231	42	22.674	23.985
19	290	4	16.025	13.805
20	320	39	15.105	13.920
21	345	17	18.508	20.854
23	386	5	22.471	16.064
27	478	19	8.684	6.004
28	492	27	3.332	2.587
29	512	6	5.394	4.715
30	533	38	3.266	3.072
June 1	544	5	2.840	2.970
2	565	5	2.220	3.190
5	621	4	1.250	.994
6	637	12	1.281	.729
7	643	5	.347	.345

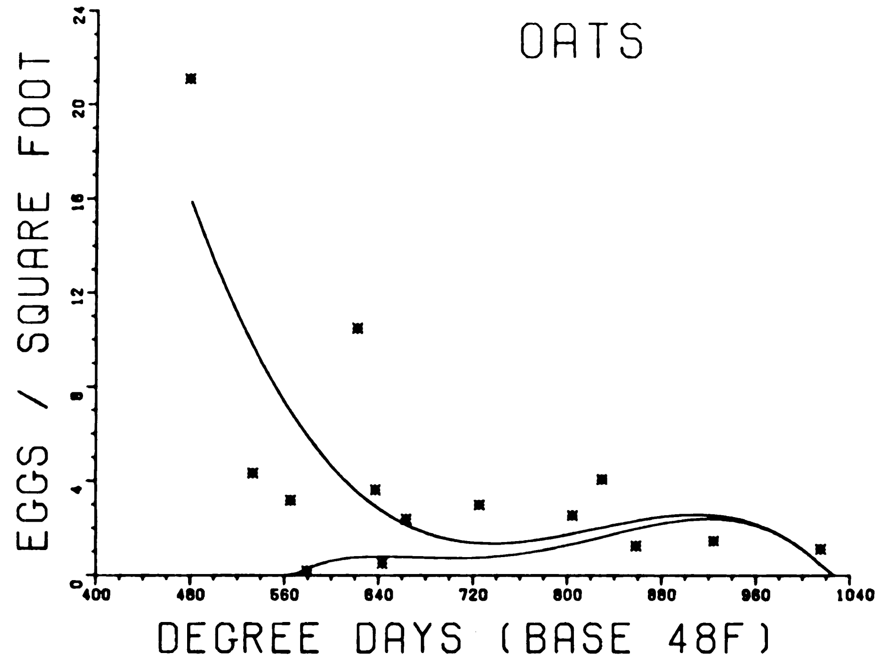
tism. For wheat, this estimate was 2% and for oats 29%, although the early part of the season was apparently missed in many oat fields (Fig. 12).

The effect of egg parasitism was to prevent the later part of the larval incidence curve from developing. A. flavipes thus competes with larval parasitoids, as has been discussed by Haynes and Gage (1972).

The seasonal rate of egg parasitism depends on many as yet unknown factors and varies by region. The extent of egg parasitism has been higher and has occurred sooner in several eastern U.S. survey areas (T. Burger, pers. comm.). Although the biology of A. flavipes has been studied (Anderson and Paschke 1968, 1969, 1970), little is known about native alternate hosts and there is no knowledge of the wintering habits. It is unknown how the A. flavipes density pattern of the Galien area in 1975 related to other areas or times.

4.2.4 Age of the larvae

The average age of larval insects is of interest if it relates to changes in the efficiency of a sampling technique. This problem was discussed above for the CLB. The average age also has value if it is relatable to changes in insect density. If differences in crop planting time, for example, make it impossible for insects to lay eggs in field B until much later than A, the subsequent average age of larvae in B would be expected to be less than that in A at any single time. The incidence curve in B will likewise be shifted to a later part of the time axis. The question then is: If mean instar is substituted for degree days (or another such "time axis") can the predictability of the incidence curve be enhanced?



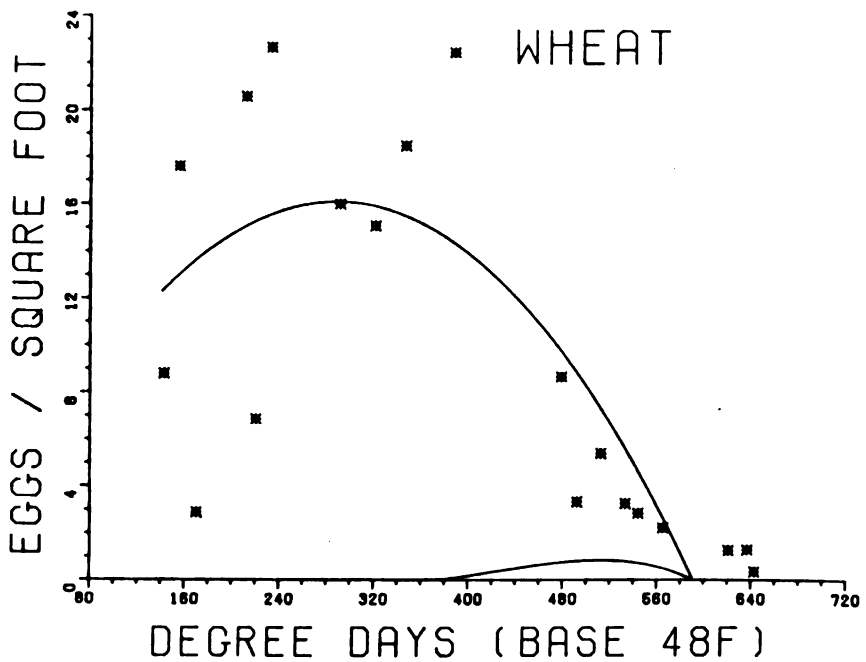


Fig. 12. Mean egg density (upper curve) and estimated incidence curve for eggs parasitized by <u>Anaphes flavipes</u>.

Following the notation of Lee, Barr, Gage and Kharkar (1976, pg. 40-43), the physiological age of an individual CLB can be represented by z, an indicator with a value of $z = 0$ for a newly laid egg and $z = \ell$ for the oldest possible age of an individual. Then at a time, t, the number of individuals in a particular age group between $(z_i, z_i + dz)$ is $x(z_i,t)dz$. For CLB larvae, z takes on the 4 discrete integer values for the 4 instars, as no continuous indicator of age is available. The average for many individuals, however, is a continuous variable, with values from 1 to 4. Lee et al. developed a partial differential equation to describe the maturity distribution of the population as a function of time. For now, the change of the average age of larvae over time, $\Sigma\ x\ (z_i,t)/i$, is all that will be considered.

Fig. 13 shows the relationship between average instar and dd's for wheat and oats. The regression based upon the corrected sweepnet samples is included for comparison. The individual field instar means, as determined by square foot sampling, are plotted but not the means based on sweepnet.

The second order dd equation accounts for approximately 1/3 and 1/2 of the instar variance for square foot counts in oats and wheat (Table 23). Crop height has relatively less relation to instar and inclusion of ch and dd's in one model does not improve fit (Table 23).

For wheat, the regressions of Fig. 13 and Table 23 may not represent the true regional pattern as only a small part of the total number of fields were included in any day's samples (Table 24). Also, the square foot samples in wheat represent only a short part of the total incidence curve. The sweepnet samples are, of course, subject to the

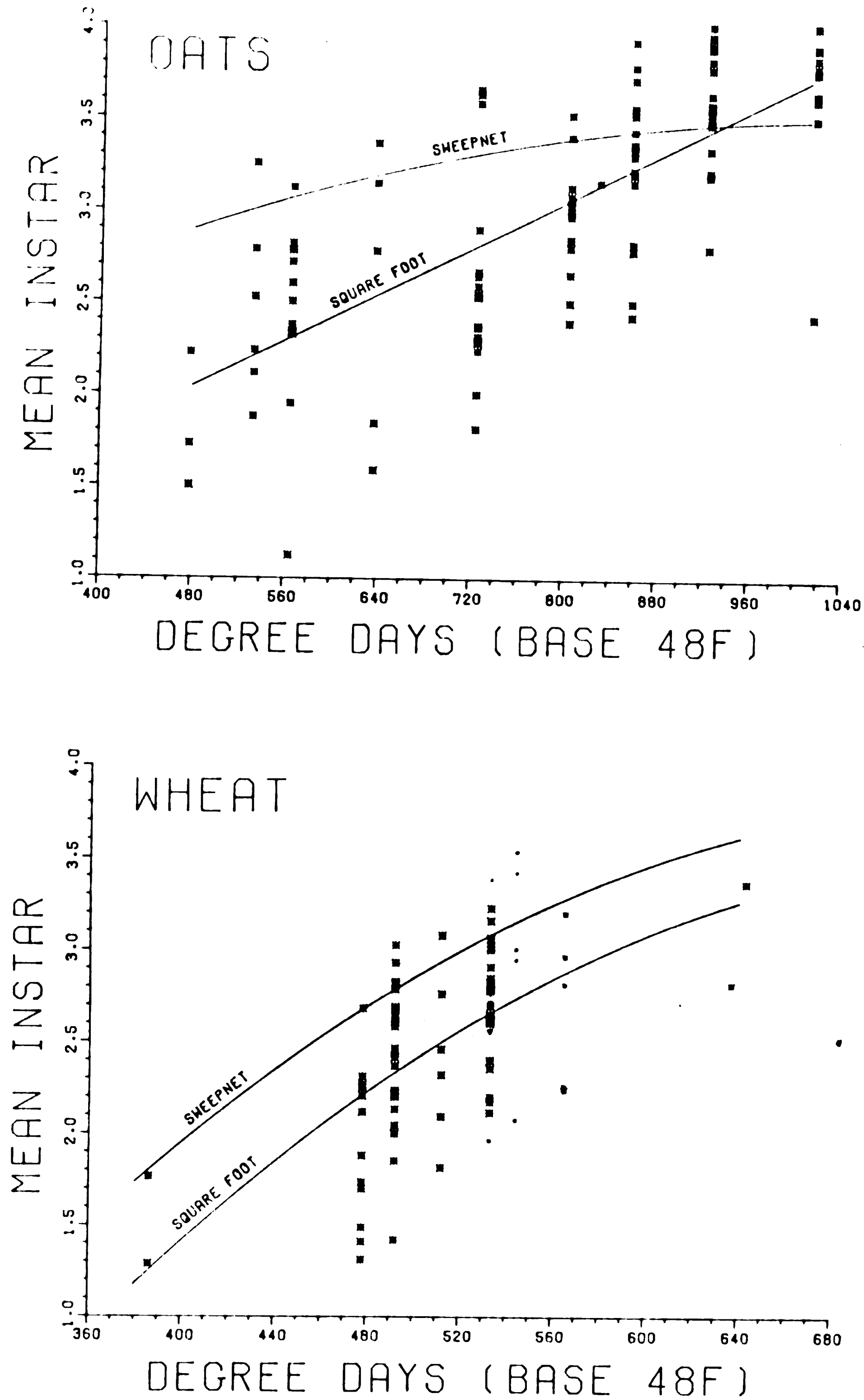


Fig. 13. Relationship between instar and degree days. Plotted points are for square foot samples only.

Table 23. Analyses of variance of larval instar. dd = degree days; ch = crop height. Model is $\hat{y} = a + \underline{bx}$.

$\underline{x}$	SSR (df)	SSE(df)	F	R^2
Oats-Square Foot				
dd	27.32 (1)	22.68 (116)	139.8***	.55
ch, ch^2	10.50 (2)	39.50 (115)	15.3***	.21
dd, dd^2, ch, ch^2	30.70 (4)	19.30 (113)	44.9***	.61
Oats-Sweepnet				
dd, dd^2	3.20 (2)	26.80 (137)	8.2***	.11
ch^2	.18 (1)	29.82 (138)	.8 n.s.	.01
dd, dd^2, ch, ch^2	3.93 (4)	26.08 (135)	5.1**	.13
Wheat-Square Foot				
dd, dd^2	7.96 (2)	14.00 (92)	26.2***	.36
ch	2.22 (1)	19.74 (93)	10.4**	.10
dd, dd^2, ch	8.37 (3)	13.59 (91)	18.7***	.38
Wheat-Sweepnet				
dd, dd^2	35.41 (2)	21.00 (185)	156.0***	.63
ch, ch^2	10.93 (2)	45.47 (185)	22.2***	.19
dd, dd^2, ch, ch^2	35.97 (4)	20.44 (183)	80.5***	.64

Table 24. Summary of larval instar samples.

Date	dd	Square Foot: Number of Fields	Square Foot: Instar Mean	Square Foot: Instar S.D.	Sweepnet: Number of Fields	Sweepnet: Instar Mean	Sweepnet: Instar S.D.
Oats							
May 27	478	3	1.816	.369	3	2.394	.345
29	512				1	1.875	0.000
30	533	6	2.464	.500	2	3.238	.081
June 2	565	12	2.451	.517			
3	579				6	3.118	.189
4	599				7	3.520	.319
5	621				1	3.520	0.000
6	637	5	2.542	.789	10	3.390	.264
7	643				1	2.500	0.000
9	663				12	3.396	.265
12	725	19	2.576	.532	18	3.109	.319
16	804	16	2.953	.288	17	3.196	.563
17	829	1	3.153	0.000	1	3.420	0.000
18	858	20	3.273	.391	17	3.383	.339
19	891				4	3.594	.081
20	924	20	3.601	.307	20	3.617	.215
25	1015	16	3.675	.372	20	3.467	.665
Wheat							
May 23	386	2	1.526	.339	6	1.728	.094
27	478	13	1.970	.414	19	2.705	.277
28	492	26	2.377	.378	27	2.768	.323
29	512	6	2.421	.454	6	2.708	.781
30	533	36	2.706	.312	15	3.207	.279
31	544	5	2.991	.574			
June 1	556	5	2.691	.428	8	3.113	.548
2	565						
3	579				2	3.690	.099
4	599				48	3.525	.343
5	621				6	3.570	.122
6	637	1	2.809	0.000	13	3.575	.274
7	643	1	3.357	0.000	4	3.423	.275
9	663				17	3.478	.232
18	858				17	3.663	.240

sampling biases discussed above. The samples in oats were accumulated over a longer period. A relatively complete representation of the area's fields was obtainable within one day (Table 24).

4.2.5 Rainfall

Shade, Hansen and Wilson (1970) recorded the mortality of the 4 CLB instars during 2 rainstorms in 1966. Third instar larvae experienced a significantly greater mortality than either 1st's or 2nd's. The rate of precipitation in the storms was .31 and .36 inches per hour, falling over periods of 45 and 25 minutes. Total mortality was 14.5 and 13.5 percent for the two storms. Little else has been done to look at the dynamics of populations in storm conditions. Although a rain gage kept track of the precipitation at the center of the PWS area, this is not presumed to be an accurate estimate of the precipitation in all fields. Rainfall is entered in the following regressions only as total inches in the approximate 24 hour period prior to sampling (based on the single rain gage).

4.2.6 Insecticides

One of the reasons that the goodness of fit of instar over degree days (Table 23) is not higher than .55 may be the occurrence of insecticide applications on some of the farms. These roughly coincided with "normal" peak larval density, during a period from 600 to 800 degree days. This is reflected in a decline in mean instar. The mean for the oats' square foot sample on dd 725 (Table 24) was 2.58, which is close to the 533-565 dd measurement (mean instar = 2.46) and is less than the value predicted from the overall regional regression (Fig. 13) (predicted mean instar = 2.85).

Insecticide use on CLB's is extremely common and is a major factor affecting population levels and population dynamics. Although they are usually ignored in studies on the ecology of the CLB, insecticides are in fact a part of the normal agricultural ecology of most regions. Any attempt to predict future regional beetle or parasitoid densities, or to evaluate spatial or temporal distributions, must be preceded by an understanding of the dynamic effect of insecticide usage.

For example, it should be realized that the perception of between-field variance (s^2) x mean (m) relationships may be affected by insecticides. Two cases will illustrate.

Case 1: $\log s^2 = a + b \log m$. The use of sprays at higher density will still produce a 1st order estimator with expected coefficients "a" and "b".

Case 2: $\log s^2 = a + b_1 \log m + b_2(\log m)^2$. If a 1st order equation is fit to the data, the coefficients "a" and "b" will depend on the degree of spraying. Removing those sub-populations with higher means will result in a lower estimate of the 1st order slope. A few moments relfection on Fig. 6 will make this clear (see Pielou 1969, pg. 91-97).

Note that although use of 2nd order equations to describe variance x mean relationships may produce little increase in goodness of fit (section 3.2.4), the resulting estimator may be preferable, depending on the likelihood of insecticide usage.

Although it is not always possible to witness insecticide application directly, the incidence curves for eggs and larvae and the instar curve may contain sufficient information for inference. A precipitous drop in egg and larval density and concurrent retardation of the rate of instar advance may be taken as indicators of insecticide use. Since actual knowledge of whether a field had been sprayed existed for only 5 of the 21 oat fields studied (maps, Appendix 4), a posteriori inference was necessary. Graphs of square foot density and instar changes in each field plus sweepnet and crop height information were all reviewed. On this basis, it was determined that 10 of the fields were not sprayed and 11 probably were. In the following derivation of a filter for reducing measurement error, only the unsprayed 1975 PWS fields were used.

4.3 Filtering

4.3.1 General considerations

Any estimate of beetle density based on count data has an error term associated with it, as discussed in section 3. This section is an evaluation of a process called filtering, which is an attempt to improve current density estimates by using previous measurement information. Extension of this same process to a complete seasonal incidence estimate is also discussed.

Filters are also called "linear minimum variance sequential state estimation algorithms" (Sage and Melsa 1971). Their basic idea is not new (Weiner 1949, Kalman 1960) but application to entomological problems is uncommon (Hildebrand 1976). The parametric approach used here is a very simple "first pass" at using the technique. This section is thus meant to be an evaluation of the potential for developing a complement to the more sophisticated discrete component simulation methods (Gutierriz, et al. 1974; Tummala, Ruesink and Haynes 1975) which will ultimately serve as the basis for an on-line pest management system for CLB (Haynes 1973). In the interim, the predictor may also provide a useful, low-cost estimator of seasonal density.

Gage (1974, p. 79) reported the initial, peak and last CLB larval populations in oats (± s.e.) to occur at 375 (±12), 723 (±25), and 1218 (±16) dd, respectively, for 6 years of Gull Lake Kellogg Farm studies. In what follows, it is assumed that the shape of the larval incidence curve is determined by the environmental factors discussed above plus the available ovipositing adult population. The incidence curve clearly cannot begin until after the crop sprouts. The last eggs will be determined by some unknown combination of adult mortality rate and plant senescence. For normally planted oats it is assumed that the curves should approximate Gage's (1974) characteristics.

The area under the curve also will determine its shape. This area is related to the potential egg input and thus to the adult influx. Either of these could be measured early in the season to be used as an indicator of the larval curve's area, but not without complicating the measuring and modeling errors.

The algorithm used here, which is meant to apply to CLB's but which is generalizable to other pest/crop systems, requires only an initial estimate of larval density and initial environmental conditions. Current environmental measurements plus the derivatives of a multiple regression of historical density and environmental variables are then used to project a current or future point. Since it is beyond the scope of this thesis to evaluate the environmental and sociological factors that govern density patterns in sprayed fields, these were not included in the analysis. The only suitable large data set available for parameter estimation was the 1975 PWS unsprayed oat fields. This provided 80 density measurements in 10 fields. The 1976 PWS data and three fields from the 1974 Kellogg Farm work were available for evaluating the filter.

4.3.2 Density models

Table 25 lists several univariate models of density (transformed as per section 3) over environmental factors for the 10 unsprayed PWS fields. Transformation used the $z = \log(y + c)$ relationship developed in section 3 to improve variance stability prior to analysis. The relationships between log density and dd's or ch (Table 25) are clearly curvilinear for larvae. Eggs show less reliance on higher order terms probably due to failure to sample during the 1st part of the incidence curve. This is because most oat fields were not located until very close to or after peak egg density. The resulting density pattern has a negative decay rate somewhat like the adult mortality pattern (Fig. 9).

The factors, field wetness (m), rainfall in the previous 24 hours (r24), average larval age (i), seem to have little relative influence by themselves on density. This, however, may be due to the way the rainfall was measured (section 4.2.5) and to inaccuracies in instar determinations (section 2.2.2). Certainly, further work on the impact of rainfall is needed.

Sprouting date (s) was also included as a variable. These data were determined by applying the quadratic formula to the ch regression of Fig. 12, adjusting the y-intercept according to a field effect variable. That is, another regression was run using $ch = a + \underline{b}_1'\underline{f} + b_2 dd + b_3 dd^2$ as a model, with ch = height and $\underline{f}$, a vector of field effects, coded (0,1). Combining the constant "a" and the $\underline{b}'\underline{f}$ product into a single term produced a ch equation of the form, $ch = a° + b_1 dd +$

Table 25. Univariate models of density [Y = log (y+c), section 3] over several environmental factors.

Model[a]	Cases	Eggs R^2	Eggs C.V.[b]	Eggs F. sig.[c]	Larvae R^2	Larvae C.V.[b]	Larvae F sig.[c]
dd	80	.327	84.5	.0001	.009	141.4	.393
dd, dd^2	80	.330	84.8	.0001	.323	117.6	.0001
ch	80	.334	84.0	.0001	.012	141.2	.331
ch,ch^2	80	.358	82.5	.0001	.303	119.3	.0001
ch, ch^2,ch^3	80	.359	83.5	.0001	.376	113.7	.0001
f (10)	80	.354	87.4	.0001	.347	119.5	.0001
m_2	79	.009	102.5	.411	.006	141.6	.512
m_3	79	.014	102.3	.305	.012	141.2	.328
m_2,m_3	79	.031	102.0	.304	.014	141.9	.574
r24	80	.039	100.9	.079	-	-	-
i	61	.312	85.6	.0001	.021	140.8	.268
i,i^2	61	.318	86.0	.0001	.104	135.8	.041
s	80	.072	99.2	.016	.037	139.4	.089

[a]Model is of form Y=a + b x, where x includes variables listed: dd=degree-days base 48°F; ch=crop height (in.); f=(0,1) field effect (10 fields); m_2, m_3=damp or wet field conditions; r24= rainfall in previous 24 hours; i=instar; s=sprouting date

[b]Percent

[c]Probability regression is N.S.

b_2dd. The quadratic formula was used to find the roots of this equation, one of which was easily accepted as the degree days accumulated by the sprouting date. The results (Table 25) indicate that sprouting time by itself contributes relatively little to the total variance. Of the variance in larval density explainable simply as between field effects (f), only about 10% could be attributable to sprouting time.

Figure 14 shows the log density regressions over dd's and ch. The predicted density was transformed ($y = 10^z - c$) before plotting. The poor fit to either variable by itself is evident, but not unexpected.

In Table 26, combinations of several of the environmental factors are evaluated. Although inclusion of additional variables will in general improve the R^2 values, up to R^2's of about .78 for full models for both eggs and larvae (Table 26, bottom), these larger models are not very useful. The inclusion of all measured variables plus "field effects" in the full model yields an "adjusted R^2" (Cohen et al. 1976, p. 16) of only .71. The combination of dd's (2nd order), ch, and the dd x ch interaction term provides an adjusted R^2 of .454 for larvae. This combination is simple in terms of numbers of variables to be measured but it provides significance and reasonable fit. The effect of sprouting time could be accounted for in the interaction term. Also, the fit of ch over dd's (Fig. 11) makes substitution possible, facilitating differentiation. This regression is, therefore, chosen for use in the rate calculations.

Supplying the appropriate coefficients, the larval predictor is

$$\log (y + .17) = b_0 + b_1 dd + b_2 dd^2 + b_3 ch + b_4 dc \qquad (41)$$

$$= b_0 + b_1 dd + b_2 dd^2 + b_3(p_1 dds + p_2 dds) + b_4 dd(p_1 dd\dot{s} + p_2 dds)$$

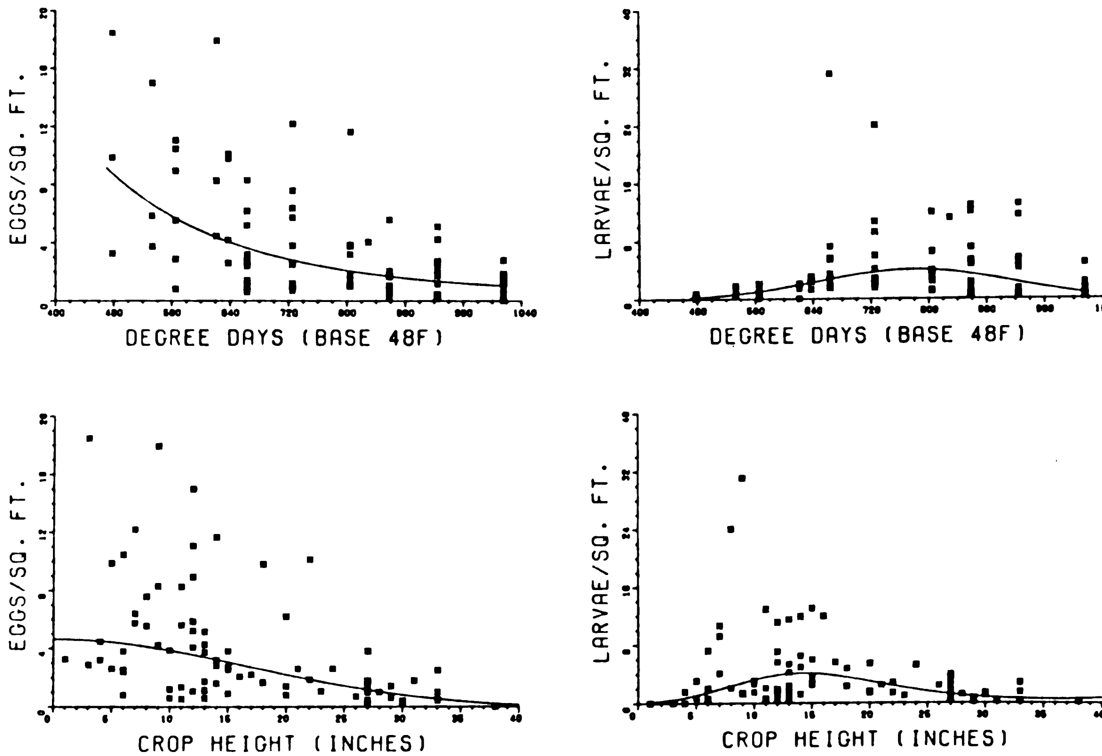


Fig. 14. Relationship between egg and larval densities and degree days and crop height.

Table 26. Representative multivariate models of density [Y = log (y+c), section 3] over several environmental factors.

Model[a]	Cases	Eggs R^2	Eggs C.V.[b]	Eggs F sig.[c]	Larvae R^2	Larvae C.V.[b]	Larvae F sig.[c]
dd,ch,dc	80	.446	77.6	.000	.417	109.9	.000
dd,ch,dd^2,dc	80	.473	76.2	.000	.481	104.3	.000
dd,ch,ch^2,dc	80	.474	76.1	.000	.427	109.6	.000
dd,ch,dd^2,ch^2,dc	80	.438	75.6	.000	.518	101.2	.000
dd,s	80	.404	80.0	.000	.045	139.7	.167
dd,s,dds	80	.459	77.3	.000	.168	128.7	.001
ch,s	80	.391	80.9	.000	.039	140.1	.217
ch,s,chs	80	.418	79.5	.000	.269	123.1	.000
dd,s,dd^2	80	.407	80.3	.000	.362	115.0	.000
ch,s,ch^2	80	.410	80.1	.000	.343	116.6	.000
dd,ch,s,dd^2	80	-- s not entered--			.390	113.2	.000
dd,ch,s,dd^2,ch^2	80	.501	74.6	.000	.525	100.5	.000
dd,ch,s,m,r24,i,dd^2,ch^2,i^2,dds,chs,dd^2s,ch^2s	79	.573	72.2	.000	.594	98.5	.000
dd,ch,s,m,r24,i,dd^2,ch^2,i^2,dds,chs,dd^2s,ch^2s,f (full model)	79	.578	57.0	.000	.781	75.9	.000

[a]Models are of form Y = bX, where elements of X are degree-days base 48°F (dd); crop height (ch); sprouting date (s); plant wetness (m) (see text); rainfall in previous 24 hours (r24); instar (i), and field effects (f), plus intercept (b_o).

[b]Coefficient of variability, percent.

[c]Probability b = 0.

where: $b_0 = -5.516 \pm 1.071$*

$b_1 = 1.345(10^{-2}) \pm 3.12(10^{-3})$,

$b_2 = -6.814(10^{-6}) \pm 2.224(10^{-6})$,

$b_3 = 0.105 \pm 3.302(10^{-2})$

and $b_4 = -1.515(10^{-4}) \pm 4.041(10^{-5})$.

Also, $p_1 = 6.838(10^{-2}) \pm 1.567(10^{-2})$,

and $p_2 = -2.257(10^{-5}) \pm 1.016(10^{-5})$, from Fig. 11.

Then, since

$$\hat{y} = 10^K - .17, \tag{42}$$

where K is the right hand side of (41),

$$\frac{dy}{dd} = (y + .17)(C_1 + C_2 dd + C_3 dd^2) \ln 10, \tag{43}$$

where: $C_1 = b_1 + b_3(p_1 - 2p_2 dds) + b_4(p_1 dds + p_2 dds^2)$,

$C_2 = 2(b_2 + b_3 p_2 + b_4(p_1 - 2p_2 dds))$,

and $C_3 = 3b_4 p_2$,

with dds, the estimated dd's at time of sprouting, as discussed above.

This equation (43) describes the rate of change in the average 1975 PWS unsprayed oat field larval density in response to dd's and ch. To adjust the rate for other densities, the initial measurement in the field is compared to the predicted density from (42). The ratio (measured + .17) / (predicted + .17) is multiplied by the rate (from (43)) to produce a corrected rate. The addition of the .17 was necessary to allow the predicted density to asymptotically approach zero, instead of being restricted to a finite range.

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* $\pm$ standard error of the coefficient

4.3.3 The weighting of the second observation with the predicted density.

An initial field measurement of larval density is needed to start the filter. The rate of change in density (43) can then be applied (section 4.3.4) for an estimate of current density. The question of interest in this section is how to best average this estimate with a corresponding current measurement. The choice is between equal weighting (a simple average) and weighting somehow based on the relative reliability of the 2 numbers. I'll evaluate the latter choice first.

The initial measurement (the one that starts the filter) has a variance associated with it which can either be measured or estimated from the equations of Fig. 6 or from (21) using the common k of Table 10. One approach to weighting is to use a rate of change in this error term similar to the rate of change of the density estimate. A simple version of this was used by Hildegrand (1976) who simply multiplied the variance of earlier measurements by an apparently arbitrary 1.05 per day, "thus weighting the past measurements less." This is intuitively appealing in that older measurements somehow seem less reliable than more current ones.

A similar result is obtainable from evaluating the rate of change of the confidence limits about the prediction equation (42). In general, the symmetric confidence interval around any estimate of E (y_0) corresponding to the set $\underline{x}_0$ is

$$\underline{x}_0'\hat{b} \pm \hat{\sigma}t \quad \underline{x}_0' \, (\underline{X}'\underline{X})^{-1} \, \underline{x}_0 \qquad (46)$$

(Searle 1971, p. 108, eqn. 95), where $\underline{b}$ is the vector of estimated regression coefficients, t is a value of Student's t statistic, $\hat{\sigma}$ is an estimate of residual error variance (Searle 1971, p. 93), $(\underline{X}'\underline{X})$ is from the original data set, and $\underline{x}_0'$ is a specific set of x's. For retransforming from the logarithmic relationship of (43), the confidence limits are

$$10^{\underline{x}_0'\hat{\underline{b}} \pm \hat{\sigma} t \sqrt{\underline{x}_0' (\underline{X}'\underline{X})^{-1} \underline{x}_0'}} - .17 \qquad (47)$$

The derivative of (47) involves the solution of a quadratic of the form d $\underline{x}'\underline{A}\underline{x}$ / dt, which at the time of this writing prohibits further progress.

Neither the divergent trend of Hildebrand's multiplier nor the rate of change of the prediction equation confidence interval is entirely satisfactory. Continuous divergence of the confidence limits is a very conservative approach, eventually negating the worth of early season measurements. Even altering the value of the constant is objectionable until an empirical basis for this change is obtained. On the other hand, the confidence limits of the prediction converge as they move toward the peak density, and diverge away from the peak, ignoring the loss in reliability due to the age of the previous measurement information.

A third approach to the variance estimate is simply to use the estimate from Fig. 6 (or (21)) applied to the predicted current density. This again ignors the age of the previous measurement information. However, it does make the larger densities, which inherently have greater variance, account for less when averaged. This is a problem since the weighted average will be used as the starting point for the next iteration of the filter. The net result will be bias toward low seasonal incidence estimates.

Simple arithmetic averaging of the predicted and the measured density produces an unbiased estimate which incorporates past information, weighting most recent measurements more than previous, though it still ignors the relative ages of the measurements. Despite the latter drawback, it is the averaging technique that will be used in the following.

4.3 Filter operation

The filter algorithm is quite simple. The filter is initiated by the first non-zero field density measurement. CH and dd accumulation are also needed. Ch is incremented in 1 dd steps according to the relationship of Fig. 11. Ch and dd are then entered into the rate equation. The calculated increase is adjusted by a factor that is the ratio of the density measurement to the predicted estimate (from (42)). This same factor is retained for each dd's rate calculation. The amount of increase is added to the density measurement and the process is repeated up until the date of the next measurement. The resulting prediction is then averaged with the observed density, as discussed above. After adjusting for ch error by using the new ch measurement (see below), a new correction factor and a new rate is calculated and the process is repeated.

In evaluating the dd and ch components of the filter, it was noticed that the regional (PWS unsprayed fields) average larval density seemed to peak later than the averages for 6 years of Gull Lake data (Gage 1974, p. 79). Re-examining the dd data used (Appendix 8), I decided that the decision to average the PWS site center data with the New Carlisle and South Bend stations (see 2.5) was a mistake. Rather than convert the dd accumulation, the rate equation was merely shifted to 30 dd's earlier. This was the difference in accumulated dd's between the PWS site center and the average, for the site center 700-750 dd period (the expected peak period).

Filter operation is illustrated in Figs. 15a and b, using 1 field from the 1976 PWS data (Sawyer, pers. comm.) and 1 from the 1974 Gull Lake data (Sawyer 1976). Other fields in these studies were also used to evaluate the filter and these results are listed in Appendix 9.

The filter behaves roughly as expected, with incidence curves similar to Gage's in respect to peak and last observed incidence. Depending on ch, larval density tends to peak at around 750 dd's, and to go to zero near 1150 dd's as in Fig. 14.

The filter also noticeably conserves previous information, which is, of course, its purpose. This makes initial measurement accuracy quite important. A low measurement initially contributes to a low estimate at the next and subsequent observation periods.

The filter is sensitive to the accuracy of the dd day accumulation. A shift of the rate equation a few dd's either way can be quite important. Table 27 shows the effect of the 30 degree day shift mentioned above. The filtered peak density in this example increased 19% following the shift.

There is also a problem with the plant growth equation as used in the filter. Measurement of standing crop height is subject to errors. To allow for changes in crop height (and thus the larval density rate change equation) over time, the crop height over dd equation of Fig. 11 was used to predict the path of crop height between measurement periods. The next new measurement and the prediction were averaged arithmetically and the filtered crop height term was used as the beginning for the next crop height path prediction.

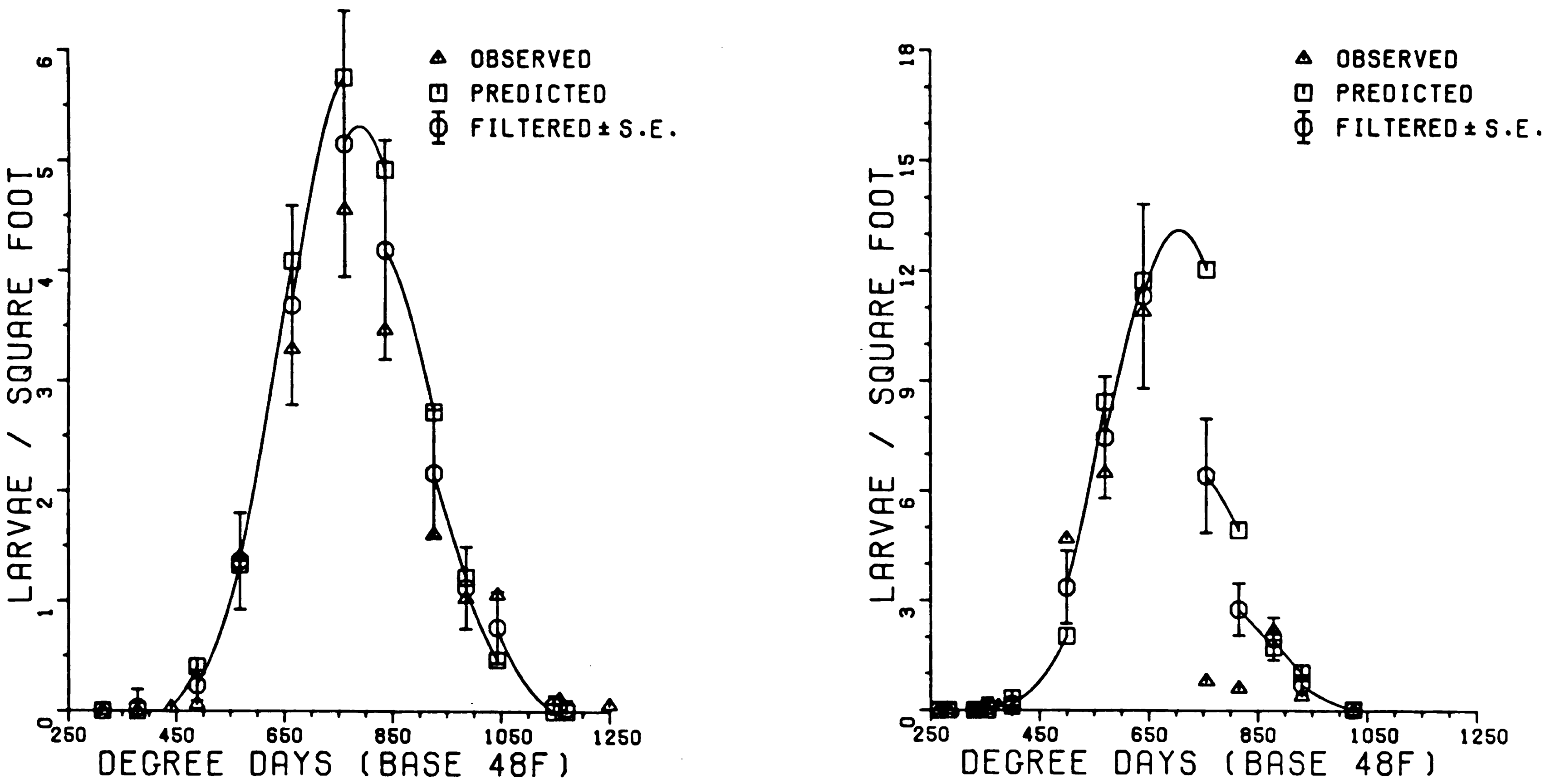

Fig. 15. Examples of filter operation. a) (left). Application to 1976 PWS data (Sawyer, unpublished), each observation based on 15 to 20 2-linear foot samples. b) (right). 1974 Gull Lake data (Sawyer 1976), each observation based on 30 square foot samples.

Table 27. An example of sensitivity of the filter to accumulated degree-days, Gull Lake field 916 (see Fig. 18B). O(Y)= observed larval density; E(Y)=predicted from rate equation; F(Y)=filtered estimate.

	Original			Shifted by 30 dd	
Degree-Day	O(Y)	E(Y)	F(Y)	E(Y)	F(Y)
313	0.00	-	-	-	-
378	0.00	0.00	0.00	0.00	0.00
440	.03	0.00	.03	0.00	.03
488	.06	.35	.20	.39	.22
567	1.40	1.02	1.21	1.28	1.34
663	3.29	2.99	3.14	3.98	3.63
760	4.56	3.99	4.27	5.64	5.10
835	3.47	3.46	3.47	4.87	4.17
926	1.61	1.80	1.71	2.71	2.16
985	1.03	.81	.92	1.21	1.12
1043	1.06	.30	.68	.47	.76
1157	.11	0.00	.06	0.00	.06
1249	.06	0.00	.03	0.00	.03

The ch equation of Fig. 11 needs to be adjusted for the sprouting time of the particular field. One way of doing this is to use the ch curve and the first measurement to project backwards to the zero height (sprouting) dd, as discussed above. Subsequent applications of the ch curve could then be based on this figure. Without knowing the accuracy of the initial measurement, however, there is no reason to accept this sprouting time as correct. This is perhaps more clearly a problem when the field is not located immediately after sprouting but instead is found when it is already, say, 8-12 inches tall, as is most commonly the case in survey work. A better estimate of sprouting time might be the filtered estimate obtained after the second measurement time. But using this procedure a logical question is, why stop here, accepting only one estimate of the sprouting time? In the filter as used here, the approach was taken that each new measurement of ch, filtered using previous measurements, provided a valid estimate of sprouting time. Crop growth rate and density rate equations were thus altered for subsequent prediction periods. There are obvious drawbacks to this approach and refinements could be made. But perhaps the most limiting is the observation that the estimated sprouting date seemed to be later as later measurement information was added. Also, estimates of crop height were most frequently higher than observed, indicating plants were growing more slowly than predicted. For ch to be used in the filter, a better model is needed. In most plant studies, however, yield is emphasized and data on height is often secondary or ignored (eg. Wiggins 1956; Holt, Bula, Miles, Schreiber and Peart 1975; Jackman 1976).

Re-estimation of sprouting time and filtering of ch changes the density rate equation slightly at each time of observation. This change is in addition to the change from the adjustment factor, section 4.3.2. Thus, for observation near peak density, for example, it is possible for a negative predicted trajectory to become positive at the time of a new observation.

An additional application of the density rate equations is to predict seasonal incidence curves. This can be done from a single measurement, projecting both forward and backward in time. Measurement error, however, is extremely critical. Fig. 16 illustrates the use of the rate equations for 3 different observation points, treating each observation as though it were unique.

4.4 Further limitations of the filter

Because of the simplistic nature of the density rate change equation, the effect of many potentially important factors is ignored. Perhaps the most critical is the effect of egg parasitism, which may vary greatly between regions. The net effect of increasing egg parasitism is to accelerate the rate of decline of the larval density in late season. On a dd basis, this may be compensated for by reducing the absolute value of the coefficients of either the 2nd order dd or the interaction term in the larval predictor equation (41). The magnitude of correction necessary for a given level of egg parasitism is unknown but experimentally determinable. The alternative, not explored here because of numerous missing elements in the data set, would be to include egg and parasitized egg densities at previous measurement points as part of the larval density regression. The spacing (separation in dd's) of

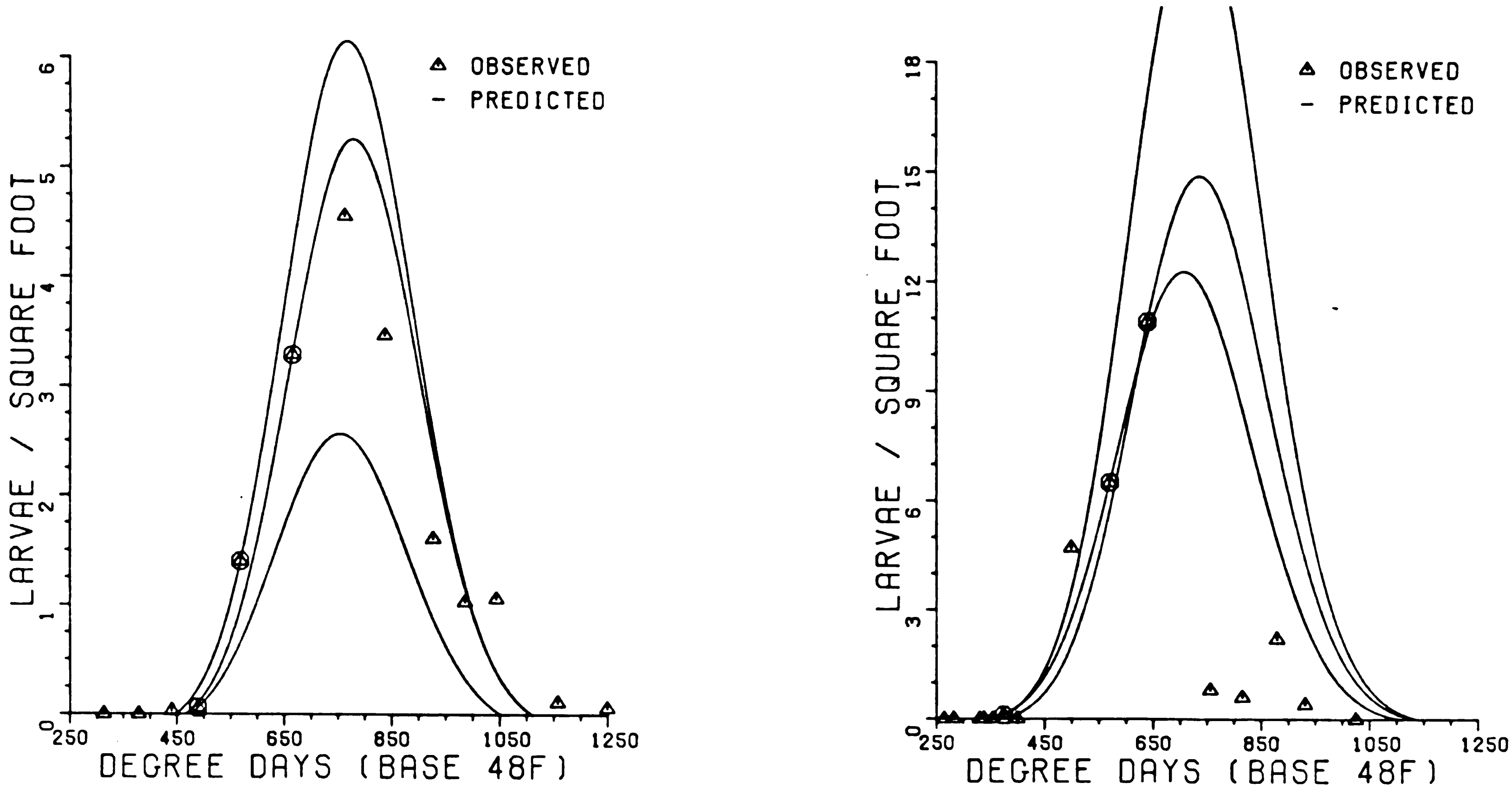

Fig. 16. Use of larval density equations to estimate seasonal incidence. Extrapolation from representative points, Δ , is indicated by solid prediction curve. Left: 1976 PWS data (Sawyer, unpublished). Right: 1974 Gull Lake data (Sawyer 1976).

sample periods and great difficulties in analysis made this approach virtually useless as a practical tool.

Difficulties in estimation and prediction may not be entirely the fault of the filter. Sawyer's (1976) data uniformly showed peak densities of larvae at the 640 dd observation. This is somewhat earlier than expected if the Gage characteristics (Gage 1974, p. 79) are held to be generalizable. This might be attributable to an error in measuring dd accumulation, as it was warm in late March. For several years, it has been customary to begin marking the accumulation of dd's on April 1. There is no reason for this other than the generalization that there usually are no dd's before this in many parts of Michigan. A better standard might be to begin accumulating after the end of the last full 2 week period in which no dd's were accumulated, or to use some similar standard marking the cessation of cold weather. In 1976, there were a few warm days at the end of March which could have contributed to the accumulation of dd's experienced by the population of beetles. The 1976 PWS adult population peaked near the 200 degree-day mark, however (Sawyer, pers. comm.), removing some of the doubt about dd accumulations.

Another cause could have been a more general use of insecticides than was observable. Average density on dd 640 was over 12 larvae per 2 linear feet, with some fields reaching 20 and even 43 larvae per sample. It is not known how farmers perceive these densities, nor what factors go into a decision to spray, but it should be noted that the pattern of field 1024 (Appendix 9), a field known to have been sprayed (Sawyer, pers. comm.) had a below-average density and displayed a less precipitous decline than other fields not labeled as sprayed. Investigation of egg and adult density curves and larval age structure for the

1976 PWS data may shed further light on this problem, but that work is yet to be completed (Sawyer, Ph.D. thesis, Mich. State Univ., ca. 1978).

ESTIMATION OF LARVAL PARASITISM BY *TETRASTICHUS JULIS*

To estimate the fraction of the CLB larval population that is parasitized by *T. julis*, or to obtain density estimates, requires taking a larval sample. The statistical difficulties in this have been discussed above. Several additional technical problems with larval dissections also require investigation before addressing the problem of improved parasitoid density estimators.

Sweepnet sampling to obtain an estimate of larval parasitism is affected by sweepnet bias. The percentage parasitism of each instar must be adjusted by the instar specific catch correction factors. Overall apparent (i.e., at the time of sampling) parasitism rate is thus dependent on the accuracy of the correction factors. For the 85 cases of paired sweep and square foot samples used in section 2, proportions of parasitized and total CLB larvae (Table 28a and b) were corrected by use of the simple multipliers of Table 4. The averages for the corrected samples (Table 28c, column 5) generally reflect the effect of larger numbers of younger instars. Younger instars have lower rates of parasitism (Table 28d). Thus, application of sweepnet bias correction factors lowers the estimated rate of parasitism (Table 28c, column 3).

Use of the correction factor doesn't account for all the differences in parasitism rate between sweepnet and square foot, though. The remaining difference is most probably caused by preservation and/or microscope technique (section 2.2.1). Square foot sample larvae were preserved by freezing and sweepnet samples used FAA. Based on past

Table 28. Average parasitism rates of CLB larvae by *T. julis*, 1975 PWS. d = mean number dissected.

Instar:		1			2			3			4		
DD48F	Cases	d	%TJ	(s.d.)	d	%TJ	(s.d.)	d	%TJ	(s.d.)	d	%TJ	(s.d.)
A. Sweepnet sample													
478	1	5.0	.0	(.0)	15.0	.3	(.0)	7.0	.3	(.0)	.0	.0	(.0)
533	2	.0	.0	(.0)	3.0	.0	(.0)	45.5	42.9	(33.5)	20.5	69.4	(43.3)
637	4	1.25	.0	(.0)	13.25	1.8	(3.6)	37.25	21.1	(23.1)	45.5	33.5	(23.8)
725	18	.44	.0	(.0)	8.06	.5	(1.6)	22.56	4.1	(7.1)	19.28	13.2	(15.8)
804	16	1.13	7.3	(25.1)	6.56	2.7	(6.8)	38.81	7.0	(10.3)	29.94	11.6	(11.4)
829	1	.0	.0	(.0)	2.0	.0	(.0)	25.0	.1	(.0)	23.0	.1	(.0)
858	16	.06	.0	(.0)	4.56	1.1	(3.2)	29.06	3.7	(6.7)	32.88	5.3	(6.5)
924	14	.36	.0	(.0)	2.57	21.3	(36.5)	19.07	29.0	(29.3)	66.07	13.4	(10.7)
1015	13	.0	.0	(.0)	2.0	17.9	(33.4)	11.77	41.8	(41.9)	32.77	50.3	(37.0)
B. Square foot sample													
478	1	7.0	.0	(.0)	21.0	.0	(.0)	17.0	.0	(.0)	.0	.0	(.0)
533	2	1.0	.0	(.0)	6.0	5.0	(7.1)	9.0	18.2	(25.7)	1.5	16.7	(23.6)
637	4	3.25	.0	(.0)	5.0	5.0	(10.0)	7.5	.0	(.0)	8.5	3.2	(3.7)
725	18	3.06	.0	(.0)	10.89	.3	(1.1)	11.72	3.5	(7.4)	6.94	6.7	(23.8)
804	16	1.94	1.3	(5.0)	6.56	.6	(2.5)	16.56	1.5	(3.4)	10.19	2.6	(6.6)
829	1	.0	.0	(.0)	9.0	.0	(.0)	32.0	.0	(.0)	18.0	.0	(.0)
858	16	.63	.0	(.0)	3.06	.0	(.0)	16.56	.7	(1.5)	23.81	1.0	(1.9)
924	14	.14	.0	(.0)	2.43	.0	(.0)	12.50	3.7	(8.2)	29.50	2.9	(4.9)
1015	13	.08	7.7	(27.7)	.77	.0	(.0)	6.08	6.4	(10.1)	23.85	2.5	(4.3)

Table 28 (continued)

C. Average percent parasitism (*T. julis*) for all larval samples.*

DD48F	Cases	Sweepnet	Square Foot	Corrected Sweepnet
478	1	22.22	.0	10.09
533	2	33.51	12.14	29.71
637	4	29.71	1.47	20.54
725	18	10.05	1.41	7.68
804	16	4.48	.69	4.13
829	1	8.0	.0	7.21
858	16	4.08	.72	3.8
924	14	9.63	1.26	9.98
1015	13	62.08	6.32	60.38

D. Parasitism rate by instar, all samples.

	----------Sweepnet------------		---------Square Foot-------	
Instar	No. CLB's	No. Parasitized	No. CLB's	No. Parasitized
1	42	2	121	2
2	461	35	456	4
3	2184	308	1092	28
4	2949	581	1447	42

-----

* Average percent = $100\left(\sum_j \left(\sum_i TJ / \sum_i CLB \right) \right) / n$ ... i = 1..4; j = 1..n

Table 28 (continued)

C. Average percent parasitism (*T. julis*) for all larval samples.*

DD48F	Cases	Sweepnet	Square Foot	Corrected Sweepnet
478	1	22.22	.0	10.09
533	2	33.51	12.14	29.71
637	4	29.71	1.47	20.54
725	18	10.05	1.41	7.68
804	16	4.48	.69	4.13
829	1	8.0	.0	7.21
858	16	4.08	.72	3.8
924	14	9.63	1.26	9.98
1015	13	62.08	6.32	60.38

D. Parasitism rate by instar, all samples.

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1	42	2	121	2
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-----

* Average percent = $100\left(\sum_j \left(\sum_i TJ / \sum_i CLB \right) \right) / n$ ... i = 1..4; j = 1..n

experience with FAA preserved specimens, above stage microscope lighting was used for dissections. The ivory colored _T. julis_ eggs and larvae were teased loose from the beetle body and were easily discernable. This was not the case with the frozen samples, however. When frozen, _T. julis_ eggs and larvae tend to rupture. Detection of the membranous chorion is possible and reportedly there is little confusion with other membranes; but this requires substage lighting. Freezing and dissection with substage lighting has been reported (T. Burger, pers. comm.) to be superior to use of FAA or alcohol preservation and above stage lighting (i.e., the parasitism rates were closer to corresponding live sample results). However, when using above stage lighting, as was the case in the PWS dissections, _T. julis_ eggs and larvae are much more difficult to find. Parasitism rates for square foot samples (Table 28c, column 4) are thus underestimated by an unknown magnitude. These shortcomings in the PWS data set, and in all similar existing sets, make it impossible to meaningfully proceed with development of filters or incidence curve predictors for parasitoids at this time. Nevertheless, it is possible to provide some guidelines for future efforts and to suggest some of the variables that may be most useful in model building, based on previous research on _T. julis_ biology (Gage 1974). Accumulated degree days play an important role in the emergence of adult wasps from wintering sites. The soil temperatures experienced by the wasps will rely on soil type, ground cover and moisture variables, but Gage (1974, p. 39) concluded that at least a field average relationship between soil and air temperatures justified use of air temperatures in predictive equations.

Degree days also can be used to predict the rate of larval development (Gage 1974, p. 32). Unfortunately, the relationship between mortality rate and temperature is less clearly understood. Gage (1974, p. 70) used accumulated dd base 85°F as an index of mortality in the soil but had no data on mortality rate in CLB larvae on foliage. Thus, there is substantial but incomplete evidence, sufficient to suggest the potential utility of heat units as a significant variable for deriving rate equations for filtering.

Just as the CLB larval incidence pattern is affected by the time of host plant sprouting, so T. julis density patterns would be determined by the time of availability of the host. It is not unreasonable to evaluate crop height as an indirect but possibly useful predictive variable (See Gage 1974, p. 92).

The attack behavior of T. julis is apparently greatly affected by wind and rain (Gage 1974, p. 58). Just as with the CLB larval density estimators, a more thorough investigation of the effects of rain duration and intensity is badly needed. Also, a concept of "wind days" above a threshold may have value in predicting rate of parasitism. T. julis is apparently inhibited by winds, so that a higher than average accumulation of wind days would mean a lower than average attack rate.

The development of filtering equations for T. julis density in CLB larvae should consider at least the above set of variables. Development of the rate equations for 1st generation T. julis follows analogously the CLB density change rate equations in section 4. Second generation curves need to include an addition set of factors to account for the diapause rate of T. julis. Considerable work has been done to determine causes of diapause rates (Gage 1974; S. Koul, pers. comm.; Logan, unpublished notes), but neither temperature, soil moisture, age of female, or constant light (e.g., 16 hrP, 8 hrS) regimes definately cause changes in diapause incidence.

Predicting the path of the bimodal parasitized larval incidence curve is difficult due to the number of potentially significant variables affecting rates. Any meaningful attempt at the multiple variate analysis and regression needed to fit data requires reasonably accurate measurement of parasitism rate throughout the season. With the current problems in the PWS and all existing data sets, any effort to develop filters along the guidelines laid down above is presently premature.

SUMMARY AND CONCLUSIONS

6.1 Summary

Sweepnet sampling for cereal leaf beetles is inaccurate. Conversion to square foot density equivalents may be accomplished by use of the multipliers of Table 3 or 4. Inclusion of some additional environmental parameters provides little improvement in the estimator. Sweepnets may be used as tools of detection but statements about the degree of confidence in the detection statement (Ruesink and Haynes 1973) ought to be subject to larval bias corrections.

Analysis of factors affecting changes in low density populations, where some samples are disproportionately more "reliable" than others due to sample size (section 2.4.) may require a weighted regression analysis for correct interpretation.

The variance:mean relationships of CLB egg and larval counts (sections 2.2.1 and 3.2.2) suggests increasing aggregation at higher densities; i.e., variance is unstable. Use of 2nd order log/log transforms produces a nearly Poisson variance:mean relationship at low densities and accounts for increased variance at higher densities.

Taylor's power law, which relies on an assumption of a first order linear relation between log variance and log mean and hypothesizes that the slope for that relationship is a biological constant, is cast in doubt by the second order fitting. Density dependent mortality thus would produce a changing first order slope, according to, for example, the regional tendencies to apply insecticide.

Several transforms are more or less equivalent in reducing variance instability and at normalizing the distribution of egg and larval square foot count data. A log transform was selected from the alternatives due to its simplicity.

Accumulated degree days and crop height are useful in filtering larval density data, accounting for half the variance in the PWS data set. Derivatives of a log transform of density over these terms is useful for predicting future (including total season) densities, and for conserving previous measurement information to improve current density estimates. Inaccuracies in previous measurements will be retained in the filtered estimate.

The use of larval maturity as an improved scale for time (a substitute for degree or calandar days) has limited utility. The numbers of larvae to be collected and measured for precise estimates of proportions is logistically limiting at the initial research stage and would be prohibitive at an implementation phase without low cost automated age group classification techniques.

The problem of estimating T. julis densities within CLB larvae is compounded with the difficulties of larval density estimation. The complexity of the bimodal parasitism curve demands accurate measurement data before parameterization is possible and current data sets are limited in this respect. Although there is sufficient understanding of T. julis biology to allow speculative guidelines for development of filtering algorithms, accurate estimation of parameters will require more precise quantification.

6.2 Concluding Remarks

The review of larval CLB sweepnet models confirmed doubts about the net's sampling accuracy. The 1976 PWS program incorporated this and greatly reduced the use of the sweepnet for sampling.

The work on distribution of count data relative to a standardized sampling scheme has significant applicability in the development of sequential sampling algorithms. Corroboration of the negative binomial relation with a common k along with development of a suitable dynamic damage threshold model for small grains would allow farmers to minimize the expense of detecting currently threatening population densities. The procedure for doing this is laid out in "The Rationale of Sequential Sampling, with Emphasis on its Use in Pest Management" (Tech. Bul. 1526, USDA-ARS, 1976, 19 p.). The use of filtering equations could further reduce the required number of samples for determining an updated density estimate.

Finally, the use of density rate change equations, despite their simplistic assumptions, should provide growers with an improved ability to interpret current density information. In these regards, continuation of the evaluation of and further refinements of the sweepnet and quadrat sampling and the filtering models discussed in this thesis seems certainly merited.

Appendix 1 - Michigan release sites for *Tetrastichus julis* (Walker)

1971

County	Township	Section	County	Township	Section
Alcona	Harrisville	7	Iosco	Sherman	31
Allegan	Otsego	18	"	Reno	31
Alpena	Wilson	21	"	Tawas	29
Antrim	Banks	1,26	Isabella	Deerfield	4
Barry	Carlton	18	Jackson	Concord	23
"	Rutland	3	Kalamazoo	Schoolcraft	11
"	Thornapple	33	Lake	Chase	2
Berrien	Lake	28	"	Pinora	36
"	Watervliet	34	Lapeer	Mayfield	26
Branch	Noble	14	Leelanau	Kasson	34
"	Coldwater	20	Lenawee	Blissfield	17
Calhoun	Eckford	17	Livingston	Putnam	1
Cass	Volinia	35	"	Iosco	27
"	"	4	Macomb	Richmond	19
"	Silver Creek	33	Manistee	Arcadia	24
Charlevoix	Wilson	1	Mason	Riverton	34
Cheboygan	Benton	34	"	"	1
Clare	Sheridan	7	Midland	Warren	33
Clinton	Watertown	22	"	Ingersoll	21
"	Olive	35	Monroe	Bundee	33?
"	Ovid	7	"	Bedford	2
"	Dallas	3	"	Ida	35?
Eaton	Vermontville	18	"	Raisinville	Fr. claims
Genesee	Davison	32	Montcalm	Sidney	3
Grand Traverse	Mayfield	8	Muskegon	Ravenna	25
Hillsdale	Reading	35	"	Montague	5
Huron	Brookfield	10	Newaygo	Dayton	9
Ingham	Ingham	2	Oakland	Oxford	13
Ionia	Boston	12	Oceana	Weare	26
"	Ronald	31	Ogemaw	Churchill	7

County	Township	Section
Osceola	Highland	16
"	Richmond	36
Oscoda	Comins	26
Otsego	Corwith	36
Presque Isle	Belknap	5
Saginaw	Albee	13
St. Clair	Lynn	32
Sanilac	Lamotte	12
Shiawassee	Vernon	7
"	Fairfield	10
Tuscola	Arbela	17
Van Buren	Hamilton	13
"	Pine Grove	20
Wayne	Plymouth	34
1972		
Arenac	Whitney	28
"	"	29
Barry	Thornapple	20
"	Castleton	10
"	Woodland	15
"	"	32
Berrien	Lake	21
Branch	Quincy	23
Calhoun	Leroy	18
Clinton	Watertown	22
"	Bingham	21
"	Ovid	7
Genesee	Forest	32

County	Township	Section
Genesee	Thetford	28
Huron	Chandler	7
Ingham	Ingham	2
Ionia	Berlin	2
"	"	2
"	Campbell	15
"	"	14
Kalamazoo	Schoolcraft	11
Livingston	Unadilla	2
Manistee	Arcadia	24
Monroe	Ida	31
"	"	15
"	Raisinville	Fr. claims
Muskegon	Sullivan	1
Oakland	Oxford	13
Ottawa	Polkton	24
St. Clair	Lynn	32
Sanilac	Marlette	35
Shiawassee	Hazelton	18
"	Middlebury	35
"	Burns	6
Tuscola	Arbela	37
"	Almer	5
Wayne	Northville	9
"	Van Buren	23
"	Canton	36
"	Brownstown	4

1973

County	Township	Section
Arenac	Lincoln	18
"	Clayton	33
Clinton	Duplain	19
Ottawa	Jamestown	24

1974

County	Township	Section
Ionia	Berlin	19
"	Ionia	12
"	"	28
"	Keene	5
"	"	3
"	Orange	29
"	Lyons	30
"	Portland	18
"	"	31
"	Ronald	28
Newaygo	Ashland	9,21,26
"	Big Prarie	17
"	Bridgeton	20
"	Dayton	4,10,20,23,24,29,30
"	Denver	19
"	Ensley	12
"	Garfield	6,16
"	Goodwell	21,28
"	Grant	17

County	Township	Section
Newaygo	Norwich	20
"	Sheridan	4,15
"	Sherman (2 releases)	7,21
"	Wilcox	9
Oceana	Greenwood	12

Appendix 2. Parasitism rates in samples from MSU Department of Entomology CLB state census, 1973-1975.

1973					1974					1975				
Date	D-D[1]	No. of Fields	Mean CLB's[3]	Mean % Parasitism[2]	Date	D-D[1]	No. of Fields	Mean CLB's[3]	Mean % Parasitism[2]	Date	D-D[1]	No. of Fields	Mean CLB's[3]	Mean % Parasitism[2]
Allegan County - Dorr Township														
6/12	755	12	81	18	6/10	625	20	145	27	6/8	560	24	49	40
6/20	935	13	85	2	6/20	750	25	232	8	6/16-7	700	26	33	50
6/26	1050	13	24	37	6/27	830	26	310	7	6/22	840	27	33	31
Barry County - Thornapple Township														
6/14	810	21	220	12	6/12	700	30	213	28	6/8	560	13	114	45
6/20	960	21	116	11	6/20	810	26	207	15	6/16	690	21	33	20
6/26	1080	21	13	62	6/27	920	29	215	13	6/22*	840	3*	89	73
Emmet County - Resort Township														
					6/16	455	19	342	15	6/24	670	19	150	16
					6/26	576	19	71	25					
					7/5	751	21	28	23					
Jackson County - Pulaski Township														
6/11	592	30	45	21	6/5	576	23	6	49	5/31	515	25	6	50
6/18	771	29	99	4	6/12	720	22	31	31	6/6	590	26	6	60
6/25	945	29	13	42	6/21	869	24	30	19	6/12	690	26	5	37
					6/27	948	21	37	10					
Lake County - Chase/Pinora Townships														
6/12	631	11	95	3	6/16	606	14	96	17					
6/22	820	11	108	0	6/27	746	17	166	11					
7/2	987	10	23	20	7/5	911	19	8	8					
Oscoda County - West Comins Township														
6/14	598	5	310	17	6/16	594	3	19	26					
6/19	674	4	860	38	6/25	701	7	11	61					
6/27	824	5	33	36	7/7	937	7	11	57					
Shiawassee County - New Haven Township														
6/13	731	30	363	17	6/12	690	29	506	44	6/4-5	575	30	40	58
6/22	926	29	167	2	6/17**	770	23	389**	38	6/12	690	30	20	52
6/28	1044	6*	7	67	6/25	886	29	708	31					
					7/3	1060	29	50	61					

[1] Degree-days, base 48°F, accumulated from 1 April, at nearest NOAA weather station.

[2] Σ (parasitism rate for field i)/ Σ i, given there were any larvae found.

[3] Mean per 100 sweeps.

*Samples lost in lab accident.

**Samples lost in lab accident; figure known to underestimate mean CLB's/100 sweeps.

Appendix 2b. 1974-76 MSU Cooperative Extension Cereal Leaf Beetle Parsitoid Recovery Program

Key to footnote symbols used in total larvae column:

Symbol	Sample Unit
none	100 sweeps
h	hand picked, no unit
1	25 sweeps
2	50 sweeps
3	125 sweeps
4	150 sweeps
5	200 sweeps
6	250 sweeps
7	300 sweeps

Appendix 2b. 1974-76 MSU Cooperative Extension Service Cereal Leaf Beetle Parasitoid Recovery Program.

County/ Town (sec.)	Date	Host	---Larvae------ Tot	Dis	% Par
Antrim					
Banks (1)	14/6/74	0	158	50	36
	25/6/74		956	50	20
	3/7/74		2	2	0
(7)	14/6/74	W	28	28	7.1
	25/6/74		175	50	6
	3/7/74		70	70	1.4
(22)	23/6/75	0	161	50	0
	23/6/75	W	4	7	0
Barry					
Carlton (24)	9/6/75	W	29	29	0
	17/6/75	W[h]	14	14	21.4
Rutland (4)	27/6/74	0	132	50	44
(10)	10/6/75	W	61	50	20
	17/6/75		37	37	2.7
Thornapple (28)	11/6/74	0	100	50	32
	22/6/74		98	50	8
	27/6/74		120	50	4
Unspecified	20/6/74	W[h]	5	5	20
Benzie					
Joyfield (9)	10/6/75	W[7]	77	50	2
	20/6/75	W[7]	285	50	0
Branch					
Unspecified	31/5/74	W	0	0	0
	11/6/74	W[5]	1	1	0
Calhoun					
Leroy (18)	3/6/74	0	26	26	19.2
	14/6/74		112	112	17
	20/6/74		130	100	23
Unspecified	3/6/74	W[4]	11	11	63.6
	12/6/74	W	4	4	0
Cass					
Volinia (21)	25/6/75	0	120	50	4
(26)	10/6/75	0[6]	300	50	4
	12/6/75	0[5]	593	50	0
Charlevoix					
South Arm (8)	24/6/75	0	68	50	56
	1/7/75		240	50	56
Cheboygan					
Benton (33)	27/6/74	0	74	74	70.3
	5/7/74		7	7	57.1
	12/7/74		8	8	87.5
Clinton					
Bingham (21)	11/6/74	0	42	42	45.2
	25/6/74		51	51	43.3
	3/7/74		19	19	42.1
Ovid (7)	12/6/74	0	23	23	56.5
	25/6/74		33	33	18.2
	3/7/74		5	5	20
Hillsdale					
Reading (35)	31/5/74	0	0	0	0
	12/6/74	0[5]	23	23	21.7
Huron					
Brookfield (10)	14/6/74	0	31	30	33.3
	20/6/74		26	26	65.4
	27/6/74		42	42	19
Ingham					
Aurelius (12)	10/6/75	0[7]	408	50	66

County/ Town (sec.)	Date	Host	----Larvae----- Tot	Dis	% Par
Ingham					
Aurelius (22)	13/6/74	0	216	50	18
	20/6/74		1322	50	14
	27/6/74		616	50	14
Ingham (2)	14/6/74	0[5]	18	17	5.9
	21/6/74		8	8	0
	28/6/74		130	50	4
Ionia					
Berlin (1)	13/6/74	0	202	50	22
	21/6/74		818	50	16
	26/6/74		406	50	10
	8/6/76		37	37	100
	14/6/76		22	22	95.5
	21/6/76		26	26	88.5
(19)	12/6/74	0	32	32	46.9
	19/6/74		703	50	22
	24/6/74		431	50	18
(35)	2/6/75	0	154	50	46
	9/6/75		48	48	68.8
	16/6/75		3	3	66.7
Eaton (2)	6/6/75	W[3]	14	14	78.6
	11/6/75	W[4]	12	12	41.7
	20/6/75	W	4	4	25
Ionia (1)	14/6/76	0	20	20	75
	21/6/75	0	30	30	53.3
Otosco (32)	15/6/75	0	370	50	16
(33)	19/6/75	0	125	50	8
Poland (1)	7/6/76	0	59	59	84.7
Ronald (3)	12/6/74	W	183	50	28
	19/6/74		89	50	20
	24/6/74		39	39	2.6

County Town (sec.)	Date	Host	----Larvae----- Tot	Dis	% Par
Ionia					
Ronald (31)	2/6/75	W	97	50	38
	9/6/75		35	35	45.7
	16/6/75		21	21	14.3
	7/6/76		47	47	84.7
	14/6/76		50	50	80
	21/6/76	0	92	92	79.3
Isabella					
Deerfield (14)	13/6/74	0	51	51	47.3
	20/6/74		225	50	52
	1/7/74		75	50	48
Nottawa (15)	13/6/74	0	13	13	23.1
	20/6/74		74	50	56
	1/7/74		39	38	55.3
Kalamazoo					
Brady (22)	3/6/74	0	36	36	33.3
	12/6/74		279	180	10
	27/6/74		2	2	0
Comstock (32)	7/6/75	0	573	50	2
(34)	30/6/75	0	4	4	75
Schoolcraft (11)	3/6/74	W	2	2	50
	12/6/74		5	5	0
	3/6/74	0	54	54	14.8
	12/6/74		237	50	8
	27/6/74		98	50	18
	7/6/75	W	17	17	0
	7/6/75	0	28	28	0
(14)	30/6/75	0	1	1	0

County/ Town (sec.)	Date	Host	----Larvae----- Tot	Dis	% Par
Lake					
Chase (2)	19/6/74	W	1	1	100
	25/6/74		1	1	0
	2/7/74		1	1	0
	19/6/74	0	31	31	0
	25/6/74		210	50	6
	2/7/74		3	3	0
Pinora (36)	9/6/75	W	13	13	69
	19/6/75		9	9	44.4
Lapeer					
Arcadia (21)	11/6/75	0	12	12	50
	20/6/75		1	1	100
(22)	27/6/75	0	2	1	100
(26)	11/6/75	0	8	8	25
	20/6/75		8	8	25
	27/6/75		16	16	100
Deerfield (23)	7/6/76	0	8	8	100
	14/6/76		4	4	100
	21/6/76		37	37	94.6
Mayfield (27)	15/6/76	0	4	4	75
	22/6/76		2	2	100
Mayfield (31)	10/6/75	W	20	20	50
	20/6/75		3	3	0
Leelanau					
Kasson (21)	14/6/74	W	11	11	0
	24/6/74		12	12	0
	1/7/74		5	5	0

County Town (sec.)	Date	Host	----Larvae----- Tot	Dis	% Par
Leelanau					
Kasson (28)	14/6/74	0(E)	1259	50	16
	24/6/74	0(E)	640	50	2
	1/7/74	0(E)	327	50	6
	14/6/74	0(L)	348	50	2
	24/6/74	0(L)	141	50	0
	1/7/74	0(L)	527	50	4
Livingston					
Brighton (24)	9/6/76	0	24	24	91.7
Genoa (9)	9/6/75	0	19	19	100
	15/6/76		19	19	52.6
	23/6/76		52	52	48.1
Iosco (4)	15/6/76	0	18	18	94.4
(22)	9/6/76	0	18	18	100
	15/6/76		25	25	76
(23)	10/6/74	0	45	45	22.2
	19/6/74		127	50	18
	24/6/74		82	50	18
	9/6/75	0^5	4	4	50
	16/6/75	0^7	33	33	36.4
	23/6/75	0^7	45	45	40
(27)	9/6/76	0	17	17	100
Putnam (2)	10/6/74	0	96	50	44
	19/6/74		1056	50	18
	24/6/74		532	50	6
(11)	9/6/75	0^5	476	50	42
	16/6/75	0^5	220	50	22
	23/6/75	0	44	44	38.6

County/ Town (sec.)	Date	Host	----Larvae----- Tot	Dis	% Par
Livingston					
Unadilla (10)	10/6/74	0	154	50	44
	19/6/74		300	50	22
	24/6/74		63	50	24
(16)	9/6/75	0[5]	27	27	51.9
	16/6/75	0[7]	47	47	53.2
	23/6/75	0	78	50	70
Macomb					
Unspecified	29/6/74	0	61	50	40
Manistee					
Arcadia (12)	21/6/74	0	2729	50	0
	2/7/74		1032	50	0
	10/7/74		232	50	38
Brown (18)	21/6/74	0	415	50	6
Onekama (23)	21/6/74	0	2149	50	2
Bear Lake (18)	17/6/75	0[4]	57	50	2
(34)	16/6/75	0[5]	61	50	2
Mason					
Victory (1)	15/6/76	0	7	7	100
	21/6/76		22	22	77.3
	29/6/76		78	50	58
(15)	20/6/74	0	916	50	18
	28/6/74		454	50	0
	10/6/75		22	22	27.3
	19/6/75		90	50	6
	25/6/75		28	28	3.6

County/ Town (sec.)	Date	Host	----Larvae----- Tot	Dis	% Par
Mason					
Riverton (3)	19/6/74	0	501	50	0
	27/6/74		228	50	0
(14)	19/6/74	0	185	50	6
Sherman (11)	11/6/75	W	12	12	50
	19/6/75		10	10	0
	25/6/75		1	1	0
Custer (16)	12/6/75	0	33	33	12.1
	19/6/75		203	50	2
	25/6/75		85	50	14
Mecosta					
Hinton (2)	13/6/75	0	35	35	51.4
	20/6/75		20	20	35
Mecosta (27)	13/6/75	0[5]	20	20	60
	18/6/75	0[7]	6	6	0
	27/6/75	0	27	27	55.6
Missaukee					
Richland (4)	11/6/76	0	3	3	100
	18/6/76		2	2	100
Riverside (16)	17/6/74	0	212	50	28
	25/6/74		166	50	18
	1/7/74		1	1	0
	11/6/76		2	2	50
	18/6/76		4	4	100
Monroe					
Dundee (33)	4/6/75	0	33	33	24.2
	13/6/75		9	9	0
	20/6/75		11	11	45.5

County/ Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
Munroe					
Milan (4)	5/6/75	0	67	50	0
	13/6/75		26	26	7.7
	19/6/75		23	23	39.1
Raisinville (17)	10/6/76	0	18	18	100
	17/6/76		20	20	80
	23/6/76		9	9	77.8
(21)	6/6/74	0	6	6	16.7
	14/6/74		30	30	16.7
	22/6/74		17	17	5.9
(34)	9/6/76	0	4	4	75
	17/6/76		4	4	100
	23/6/76		20	24	62.5
(35)	4/6/75	0	28	28	28.6
	13/6/75		24	24	0
	19/6/75		16	16	18.7
Montcalm					
Bloomer (17)	8/6/76	0	5	5	100
	16/6/76		5	5	80
Bushnell (18)	8/6/76	0	13	13	84.6
	16/6/76		11	11	63.6
Day (20)	10/6/75	0	26	26	80
	17/6/75		42	42	59.5
	25/6/75		7	7	57.1
Douglas (33)	14/6/74	0	201	50	10
	21/6/74		360	50	2
	27/6/74		303	50	6
	10/6/75		70	50	52
	17/6/75		742	50	12
	24/6/75		195	50	40

County Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
Montcalm					
Evergreen (13)	10/6/75	0	9	9	22.2
	17/6/75		98	50	56
	24/6/75		30	30	60
Fairplains (10)	8/6/76	0	35	35	91.4
	16/6/76		72	72	41.7
	23/6/76		48	48	35.4
Montcalm (24)	10/6/75	0	76	50	60
	17/6/75		94	50	18
	24/6/75		23	23	78.3
(25)	14/6/74	0	448	50	36
	21/6/74		1560	50	14
Pine (2)	9/6/76	0	49	49	81.6
	16/6/76		76	76	63.2
	22/6/76		80	80	15
Muskegon					
Montague (5)	18/6/74	0	105	50	2
	22/6/74		378	50	2
Ravenna (5)	11/6/76	0	112	50	92
	17/6/76		73	50	72
	29/6/76		5	5	80
	11/6/76		50	50	30
	17/6/76		41	41	70.7
	29/6/76		12	12	83.3
(8)	11/6/76	0	18	18	100
	17/6/76		46	46	69.6
	29/6/76		4	4	100
(16)	13/6/75	0^h	5	5	0
(21)	17/6/74	0	405	50	10
	3/7/74		15	15	6.7

County/ Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
Muskegon					
Sullivan (13)	12/6/75	0[h]	662	50	14
Newago					
Ashland (12)	13/6/74	0	96	50	14
	21/6/74		304	50	10
	28/6/74		126	50	4
(41)	10/6/75	0	104	50	24
	18/6/75		158	50	4
	25/6/75		27	27	14.8
Dayton (9)	13/6/74	0	38	37	13.5
	19/6/74		46	46	23.9
	25/6/74		51	51	21.6
	14/6/75		167	50	18
	21/6/75		234	50	2
	30/6/75		1	1	0
	9/6/76		25	25	100
	16/6/76		35	35	60
	21/6/76		11	11	72.7
(22)	13/6/74	0	195	50	26
	20/6/74		518	50	4
	25/6/74		575	50	16
Grant (12)	9/6/76	0	72	72	95.8
	16/6/76		60	60	70
	22/6/76		16	16	56.3
Oceana					
Elbridge (11)	9/6/75	0[1]	104	50	2
	16/6/75	0[1]	100	50	0
Ogemaw					
Unspecified	19/6/74	0	9	9	66.7
	20/6/74		10	10	50
	26/6/74		28	28	85.7
	27/6/74		24	24	70.8
	28/6/74		33	29	62.1
	3/7/74		8	7	100
Osceola					
Hersey (33)	21/6/76	0	86	86	45.3
Highland (16)	14/6/74	0	207	50	62
	20/6/74		203	50	88
	3/7/74		4	4	25
	3/6/75		86	50	92
	10/6/75		50	50	78
	19/6/75		226	50	30
(17)	10/6/76	0	37	37	67.6
	16/6/76		30	30	93.3
	22/6/76		298	50	68
Richmond (17)	2/6/75	0	128	50	58
(36)	13/6/74	0	189	50	20
	19/6/74		887	50	26
	9/6/75		88	50	62
	19/6/75		181	50	42
	7/6/76		37	37	89.2
	15/6/76		29	29	72.4
	22/6/76		179	50	12

County/ Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
Oscoda					
Comins (17)	23/6/75	0	8	8	37.5
	30/6/75		2	2	100
(19)	23/6/75	0	13	13	69.2
	30/6/75		16	16	75
(26)	19/6/74	W	1	1	0
	26/6/74		0	0	0
	5/7/74		0	0	0
	23/6/75	0	1	1	100
Saginaw					
Freemont (22)	20/6/74	0	110	50	20
	27/6/74		101	50	30
	5/7/74		32	32	50
Maple Grove (20)	20/6/74	W	6	6	0
	27/6/74		0	0	0
(21)	20/6/74	0	73	50	46
	27/6/74		101	50	30
St. Clair					
Lynn	7/6/74	G	0	0	0
	13/6/74		7	0	0
	20/6/74		0	0	0
St. Joseph					
Fawn River (7)	3/6/74	0	13	13	38.5
	10/6/74		6	6	16.7
	18/6/74		10	10	10
	3/6/74		32	32	0
	10/6/74	0^h	27	27	0
	24/6/74	0^h	50	50	0

County/ Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
St. Joseph					
Florence (10)	3/6/74	0	130	50	4
	10/6/74		64	50	12
	18/6/74		96	50	8
	5/6/76		74	74	67.6
Lockport (26)	3/6/74	W	62	62	3.2
	10/6/74		4	4	0
	18/6/74		6	6	0
Sturgis (6)	8/6/76	0	52	52	48.1
Sanilac					
Marlette (33)	14/6/74	0	29	29	34.5
Shiawassee					
Burns (6)	14/6/74	0	104	50	48
	26/6/74		117	50	68
	1/7/74		120	50	80
	27/6/75		110	50	84
	3/7/75		15	15	80
Fairfield (10)	14/6/74	0^h	119	50	40
	24/6/74	0^h	118	50	26
	1/7/74	0^h	43	43	46.5
	25/6/75	0	113	50	70
	1/7/75		32	32	87.5
Hazleton (18)	13/6/74	W^h	108	50	22
	24/6/74	W^h	110	50	42
	1/7/74	W^h	158	50	40
Middlebury (26)	24/6/75	0	18	18	72.2
	1/7/75		12	12	83.3
(35)	13/6/74	0^h	103	50	28
	25/6/74	0^h	107	50	24

County/ Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
Shiawassee					
Vernon (7)	13/6/74	0^h	67	50	28
	25/6/74	0^h	128	50	30
	1/7/74	0^h	110	50	38
	27/6/75	0	115	50	76
	2/7/75		34	34	83.3
New Haven (13)	25/6/75	0	95	50	46
	2/7/75		40	40	90
Tuscola					
Arbela (17)	23/6/75	0	56	50	100
(18)	21/6/75	0	258	50	20
	23/6/75		56	50	92
(27)	23/6/75	0	75	50	100
Van buren					
Unspecified	28/5/74	0	0	0	0
	28/5/74		0	0	0
	28/5/74		0	0	0
Arlington (23)	10/6/75	0^2	66	50	0
	19/6/75	0^2	28	28	14.3
Hamilton (1)	15/6/75	0^2	6	6	0
	21/6/75	0^2	1	1	100
Paw Paw (20)	11/6/75	0^2	95	50	0
	19/6/75	0^2	13	13	7.7

County/ Town (sec.)	Date	Host	Larvae Tot	Larvae Dis	Larvae % Par
Washtenaw					
Dexter (36)	31/5/74	0	2	2	0
	10/6/74		94	50	30
	17/6/74		107	50	14
Webster (31)	31/5/74	W	9	9	0
	10/6/74		32	32	15.6
	17/6/74		4	4	0
	3/6/75		52	50	56
	10/6/75		42	42	31
	18/6/75	W^5	7	7	0
	3/6/75	0	181	50	66
	10/6/75	0^7	15	15	60
	18/6/75	0	166	50	8
Sharon (4)	12/6/75	0^7	10	10	20
	20/6/75	0^5	57	50	46

Appendix 3: The Non-crop Larval Ecosystem

Introduction

Not all cereal leaf beetles or *T. julis* are found in fields of cereal grains. Fence rows, pastures, fallow fields, scrub woods and similar uncultivated areas are also capable of supporting beetles. This appendix examines some of the factors that affect the number of CLB's and parasitoids that can be found outside of crops. These include oviposition, survival and development rates, and incidence of parasitism.

Literature Review

The literature on the relationship between the cereal leaf beetle and various hosts is extensive. Hodson (1929) assigned a descending order of feeding preference to barley, oats and wheat, respectively. He also noted that orchard grass (*Dactylis glomerata*) became a staple food after cereal grains had been harvested. Venturi (1942) claimed that the CLB was polyphagous within the Gramineae. Balachowsky (1963) found the CLB in Europe would feed on quack, timothy, rye, orchard, oats and canary grasses, among others.

Wilson and Shade (1964a) described the feeding and oviposition preferences on several grasses and related these to the survival rates of the larvae. They found oats to be preferred over barley and wheat of the same age for oviposition, and the latter 2 were preferred over corn. The age of the plant was a critical factor, however, and wheat or barley were more preferable to oats that was 10 days older.

Wilson and Shade (1964b) also studied differences in post-diapause adult weight gain and survival on different grasses. Any small grain was accepted before sorghum or corn. Foxtails (Setaria sp.) were antibiotic to CLB's. They hypothesized that D. glomerata was used as a spring adult food if small grains were unavailable.

Larval survival and development rate also varied according to host (Wilson and Shade 1965). The small grains plus orchard, timothy, brome, quack and rye grasses all had larval laboratory survival rates above 50%. Corn, which was an acceptable food for prediapause adults, was less suitable for larvae.

Leaf-vein spacing was one factor that affects larval survival (Wilson and Shade 1966). The mouthparts of first-instar larvae were too large for insertion between veins, and the veins themselves were too tough to chew through. Leaf pubescence was also a deterrent to oviposition and feeding (Schillinger and Gallun 1968, Wellso 1973, Webster, et al. 1973).

A general theory of host suitability was developed by Caswell, Reed, Stephenson and Werner (1973). The plants described above as unfavorable or antibiotic to the CLB were found to have a common metabolic pathway, designated C-4. Plants suitable for CLB's had a different pathway, labeled C-3. There was a good correlation between metabolic pathways and leaf-vein spacing.

There are at least 3 reasons to expect to find cereal leaf beetles in wild grasses. Adult beetles may be drawn to non-crops when crop age (Wilson and Shade 1964a). Feeding damage to crops may reduce moisture content and succulence, prematurely aging the crop and causing adults to look for new hosts. Random flight activity may carry adults out of the field, perchance to an acceptable grass host. Surveys of adult beetles at the Kellogg Farm during 1973-1974 (Casagrande 1975) showed that during the spring and early summer grasses in fence rows, pastures, and stubble fields held a sizeable reservoir of adults.

Methods

1. Field studies: Three types of experiments were carried on in the field during the summer of 1973 using the MSU Kellogg Farm as a research area. In one set, large (18 x 6 x 6 cu. ft.) cages were set up half over grass and half over adjoining winter wheat, and others for grass and spring wheat, and grass and oats (as in Figs. 3-1). The cages on wheat were moved later, and the experiment was repeated to look for changes due to the age of the wheat crops. The cages on oats were set up for only one period. For each experimental treatment, 2 cages were used at a time. About 250 adult CLB's were introduced to each cage, and 100 were added 2 days later to make sure there would be a large number of eggs laid. After 1 week, the crop and the grasses were sampled to determine egg counts, densities of various grasses, and distribution of eggs within the cages.

A second field experiment involved taking a sweepnet catch of larvae in both an oat field and an adjoining grass field. Fifty sweeps were taken in oats and 100 sweeps were taken in the grasses, where the density was somewhat lower. This was done as a check on the distributions found in the cage studies.

Finally, beetles that had been reared in the laboratory, and which could not have been previously exposed to parasitoids, were set out on pots in the same oat field and at varying distances into the grass field.

This was to see whether parasitoids could find the larvae in the grasses or whether the parasitoids would avoid this area. After 2 days, the larvae were brought back into the lab and were dissected for parasitoids.

2. Laboratory studies: Four different series of experiments were conducted in the lab. All 4 series were done in the CLB rearing room in the MSU Plant Science greenhouse. The temperature throughout the experiments was a constant 24°C with 60-80% RH and a 16 hour daily photophase. Seeds for 4 grasses were collected near the Kellogg Farm. These included orchard grass (*Dactylus glomerata*), 2 types of brom (*Bromus inermis* and *B. tectorum*) and barley. Timothy (*Phleum pratens*) and quackgrass (*Agropyron repens*) seeds failed to germinate, even when held for 3 months in a refrigerator. It was suggested later that a better way to get quackgrass would be to dig up roots in the autumn. When used in these experiments, all grasses were 4-6' tall.

A test was made to check for oviposition rates on each grass by itself. A minimum of 24 pairs of adult CLB's were set up on individual caged pots for each of the 3 grasses and for barley. The cages were made of "lumite" screening, which fit snugly into a 2-inch flower pot. The cages were checked daily for eggs, the numbers were recorded, and the fresh eggs were removed. Plants were replaced every 3 days. Counts were made daily for 3 weeks.

A 2nd series of experiments was conducted on oviposition preference. For this test, five 2 x 2 x 2 cu. ft. cages were used. In one set of experiments, the 5 cages each held barley, orchard grass and *B. tectorum* ("downy brome"). A second set also included *B. inermis* ("smooth brome") and the timothy that would germinate. A third set added "smooth brome," but had no timothy.

In each cage, 10 pairs of sexually mature adults were established. After 2 days, the plants were removed and counted for eggs.

A 3rd test was run to check egg-laying preference on unequal amounts of orchard grass, "red brome" and barley. Five 2 x 2 x 2 cu. ft. cages were set up with a total of 6 potted plants per cage. The eggs laid were counted at the end of a 3-day period.

A final test was undertaken to study the survival and development rates of larvae on the 4 grasses. A minimum of 30 individually caged pots (like those of the 1st series of lab experiments) were set up for each of the grasses. 2 eggs were placed on the upper side of the lower leaves of the plant. Twice daily checks were made to note the larval instar and when pupation occurred. Survivorship was also noted.

Results

1. Field studies: Cage studies to evaluate the relative oviposition in grasses as crops are extremely susceptible to artifacts. That is, the presence of the cage alters adult behavior. Fig. A3-1 shows the results in 1 of the cages. The beetles tend to pile up along the edges of the cage, especially in corners. Square foot foliage samples taken 1 foot away from the edge have 1/3 the density of eggs as samples taken against the cage wall. In analyzing egg counts, a paired-t test was used, grouping square-foot counts from opposite sides of the cage (eg. 45-20 in Fig. A3-1). Results of the cage counts are given in Table A3-1, with mean egg density for both sides of the cage. In addition to the counts taken in the 4 early season wheat/grasses cages, 3 square-foot foliage samples were taken from each cage. Grasses were divided into 3 distinguishable types: bluegrass (*Poa canadense*), quackgrass and a conglomerate "wild oats," which later proved to be a mixture of timothy, oats (*Avena* sp.) and

142/45	30	50		
10	1	12	Wheat	W S + N E
21	8	9		
------	------	------		
16	7	12		
29	8	7	Grass	
20	27	13		

Figure A3-1. Square foot counts of eggs in a cage study.

Table A3-1. Distribution of eggs per square foot in cage studies, "n" = number of square feet sampled on each side of the cage.

Time of Season	Crop	-n-	Eggs/Sq. Ft. Mean $\pm s_y$ Crop	Grass	Difference	t
Early-10" to 15" Crop height	Winter Wheat	9 9	20.00±10.6 7.67±6.4	18.00±9.0 13.89±12.4	+2.0 -6.22	.30 2.82**
	Spring Wheat	9 9	19.10±9.24 20.67±17.36	14.89±3.02 15.44±8.32	+4.2 +5.23	1.50 .94
Late-wheat in "boot" stage	Winter Wheat	10	3.40±2.72	1.90±1.6	+1.5	1.50
	Spring Wheat	10	3.40±3.6	1.10±1.1	+2.3	2.26*
	Oats	10	14.30±7.4	2.00±1.56	+12.3	5.00**

downy brome, with others possible. The number of stems in each set of 3 sq. ft. and the total eggs on those stems are given in Table A3-2. The "oats" made up only 6 percent of the stems, but contained 41 percent of the eggs. Forty-eight percent of the stems were bluegrass, but these contained only 12 percent of the eggs.

A separate count a week later of eggs on 30 stems gathered in each of 3 cages had a mean eggs per stem of .823, 1.80, and 0.07 for quack, "wild oats" and bluegrass, respectively.

A later repetition of the 30 stem egg count was made in 4 cages, just prior to the "boot" stage in the wheat. By this time timothy had been separated from the other grasses. Egg density was quite low. The average eggs per stem on wheat, quack, timothy and brome (Bromus sp.) grasses was .067, .017, .167, and 0.0, respectively.

Sweepnet catches in an oat field and an adjoining grass field (an alfalfa field over-run by quackgrass), taken at the Kellogg Farm in 1973 (June 13), reflect the same relative preference for oats over grasses. This is summarized in Table A3-3, which also lists results of dissections to estimate parasitism.

There were 7 cases of superparasitism in the 332 larvae dissected for Table A3-3, all of them in the grasses. No hypothesis to explain this relatively high level can be offered at this time. It is known that adult Disparsis n.sp. feeds frequently on a variety of common hosts, including daisy fleabane (Erigeron annus), yarrow (achillea millefolium), chickweed (Stellaria media), and mustards (Lepidium sp., Barbarea vulgaris, and others), (D.C. Miller, pers. comm.). Although these may have been attractants to the grass field, the superparasitism in the face of so many unparasitized larvae remains unexplained.

Table A3-2. Relative frequencies of grass types and eggs laid on them in 4 cage studies (early season - paired with wheat). "Oats" include wild oats, downy brome, and timothy.

Cage	Grass	Stems in 3 Sq. Ft.	Relative Frequency(%)	Eggs in 3 Sq. Ft.	Relative Frequency(%)
1	Quack	497	91	100	77
	"Oats"	42	8	30	23
	Other	7	1	0	
2	Quack	108	23	17	41
	Blue	276	67	6	15
	"Oats"	27	7	18	44
3	Quack	48	11	11	10
	Blue	343	75	13	12
	"Oats"	47	10	86	78
	Clover	19	4	0	0
4	Quack	161	39	22	52
	Blue	253	61	20	48

Table A3-3. Results of sweep catches in oats and an adjoining grass (+ alfalfa) field, Kellogg Farm, June 13, 1973.

Host	Distance from Oat Field (Ft)	Larvae* Sweep	Number Dissected	% Parasitism		
				T. julis	*Diaparsis* Spp.	*L. curtus*
Oats	-	3.22	100	36	3	1
Grass	8	.55	55	14.5**	10.9	2**
	20	.34	34	23.5**	11.7*	
	30	.25	25	28	4	
	40	.46	46	23.9**	10.9**	
	50	.34	34	26.5**	14.7**	
	60	.38	38	34.2**	7.9**	

* 150 sweeps in oats; 100 in grass.

** Results include incidences of multiple parasitism.

Dissection of larvae that were set out on pots showed essentially the same results as Table A3-3. At a distance of 10 feet into the field, there were no larvae parasitized. Perhaps _T. julis_ is able to respond to the presence of oats at that distance so that it spends less time in the grass searching for hosts.

2. _Laboratory studies_: When caged on a single host species, ovipositing CLB females laid more eggs on barley than on orchard grass or brome grasses (Fig. A3-2). There was considerable variation between individual oviposition rates on any host. There was no apparent difference in survival of adults on the 4 hosts over the 2-week period (Fig. A3-3).

When given a choice of plants, barley is clearly preferred for oviposition, over orchard grass, smooth or downy brome, and timothy (Table A3-4a). This is true even when given a surplus of the less favored host (Table A3-4b).

Development time per instar is given in Table A3-5. Larval mortality is not listed in the table because it is not certain which larvae died and which were able to escape the cage. The numbers of larvae in the table reflect lost larvae as well as those found dead.

Discussion

Native grasses are capable of sustaining cereal leaf beetle adults and larvae in different degrees. Some are better as oviposition sites than others. Bluegrass, for example, does not seem to serve well as a host for egg laying.

The role of wild grasses in maintaining a non-crop population of the cereal leaf beetle is a real one. The grasses serve as food during times when the crop is unpalatable. During this time, eggs are laid on the grasses. The grasses are then capable of supporting larval development. The numbers

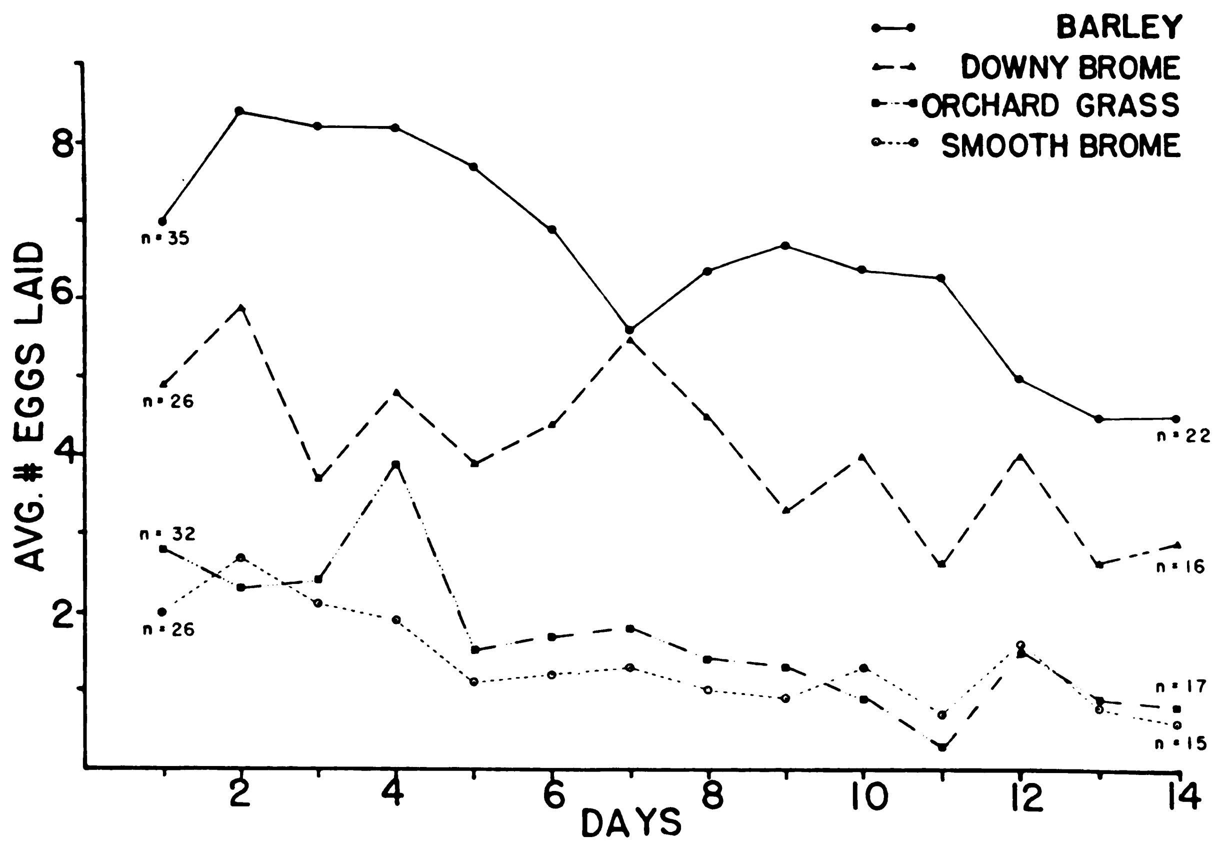


Fig. A3-2. Averal cereal leaf beetle oviposition on 4 hosts. Numbers are the number of ovipositing females at the beginning and end of the experiment. Conditions: temperature, 24-26°C; R.H., 60-80%; daily light, 16 hours.

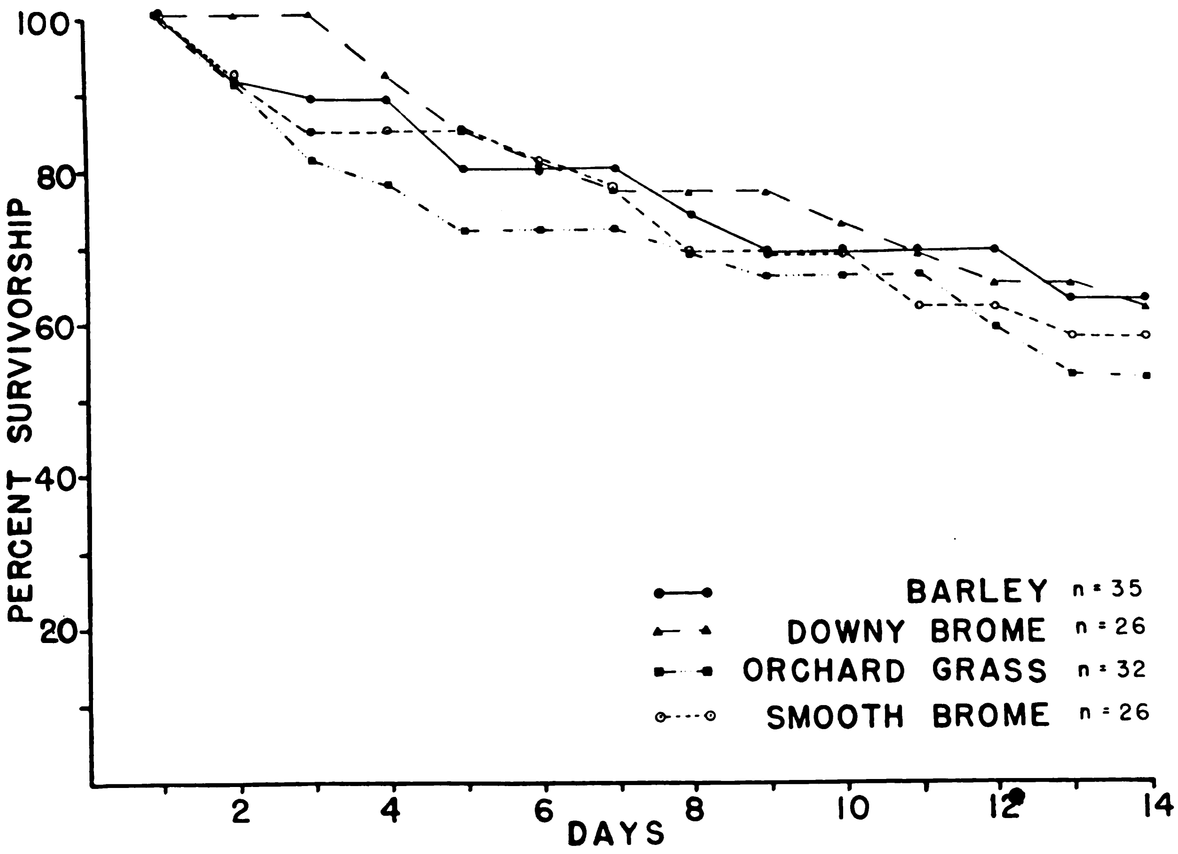


Fig. A3-3. Relative adult mortality on 4 hosts. n=number at start of experiment. Laboratory conditions: temperature, 24-26°C; R.H., 60-80%; daily light, 16 hours.

Table A3-4a. Relative frequencies (% of total) for oviposition when presented with equal numbers of a selection of hosts. n = total number of eggs.

Test Series	Barley	Orchard	Smooth Brome	Downy Brome	Timothy	-n-
1a	44	33	n.a.	22	n.a.	306
b	71	17	n.a.	12	n.a.	579
c	80	8	n.a.	12	n.a.	696
d	57	24	n.a.	18	n.a.	148
2a	51	18	16	8	8	555
b	47	12	15	11	14	307
3	45	19	22	14	n.a.	189

Table A3-4b. Oviposition preferences when given different amounts of each host. No repetitions were made.

Test	Ratio of Plants Barley : Orchard : Downy Brome	Ratio of eggs
1	5 : 1 : --	6.0 : 1
2	1 : 5 : --	2.8 : 1
3	3 : 3 : --	1.7 : 1
4	3 : -- : 3	2.8 : 1
5	-- : 3 : 3	0.3 : 1

Table A3-5. Development times per instar on four hosts. Laboratory condition: temperature, 24-26°C; humidity, 60-80%; daily photophase, 16 hours.

Host	Days per Larval Instar: 1			2			3			4			Total
	-n-	y	s_y	-n-	y	s_y	-n-	y	s_y	-n-	y	s_y	
Barley	26	2.8	.8	24	2.8	.6	22	2.0	.6	7	3.3	1.1	
Smooth brome	25	2.5	.7	23	2.8	.9	15	3.0	.9	7	3.6	.6	
Downy brome	27	2.3	.5	20	2.2	.3	17	3.4	.9	8	4.2	.5	
Orchard grass	27	2.2	.6	25	2.8	1.0	15	2.8	.6	8	4.5	.9	

caught in sweepnet indicate a potentially large number of beetles could be found on other than crop hosts.

Non-crop populations of cereal leaf beetle larvae are in turn capable of supporting larval parasitoid populations. The level of these populations will depend on the suitability of the grasses present and the availability of parasitoid adult food sources. The field studied at the Kellogg Farm could have served well as a reservoir of beetles and parasitoids, acting as a buffer to the effects of insecticide usage in the host crop.

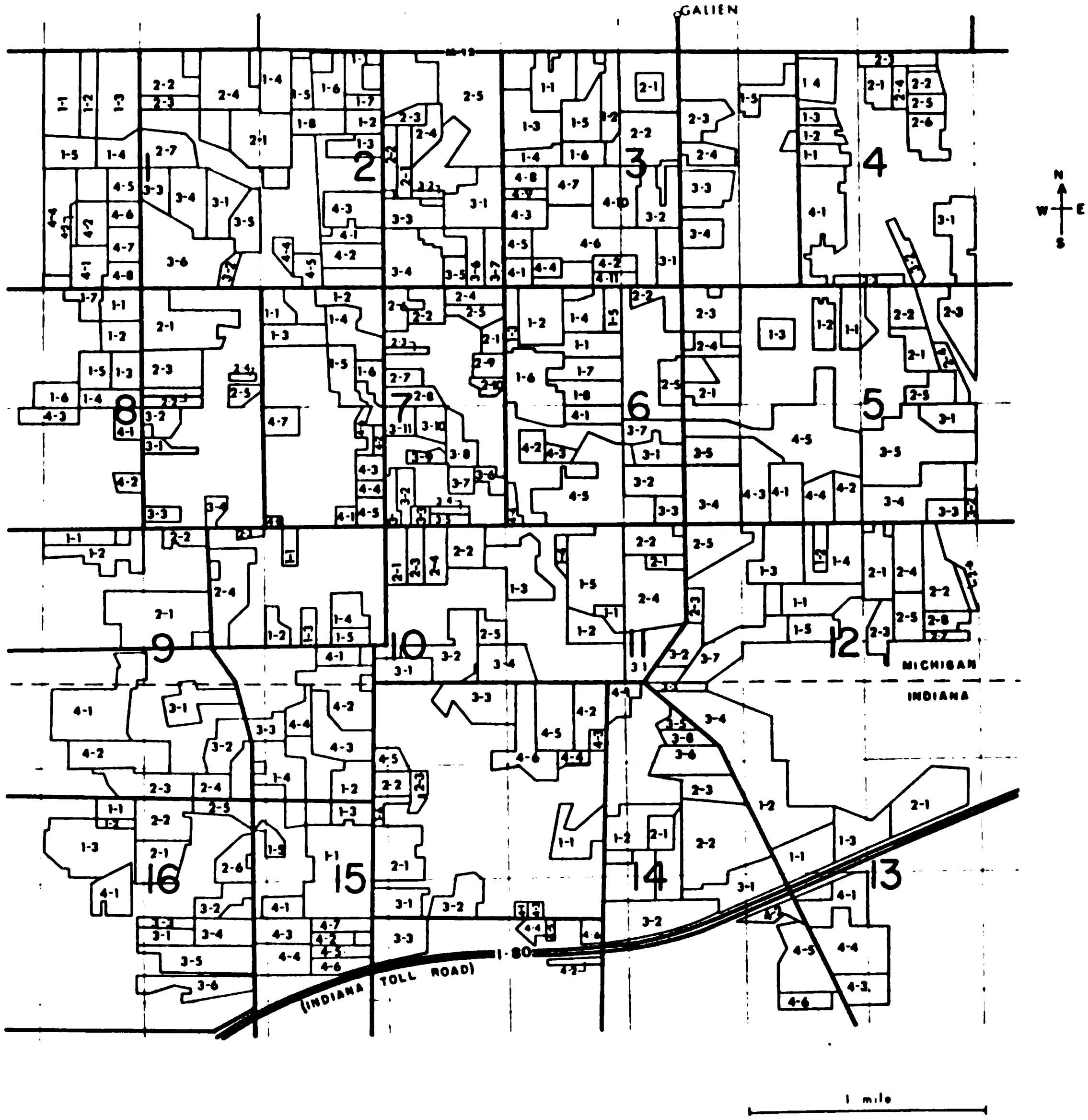
A more complete study of the wild grasses would require an estimate of their relative abundance over large areas. Also, the effect of age and the synchronies of grass types should be evaluated further. As least, this study indicates that significant numbers of beetles and parasitoids may reside outside of host crops.

Appendix 4. 1975 PWS Field Maps

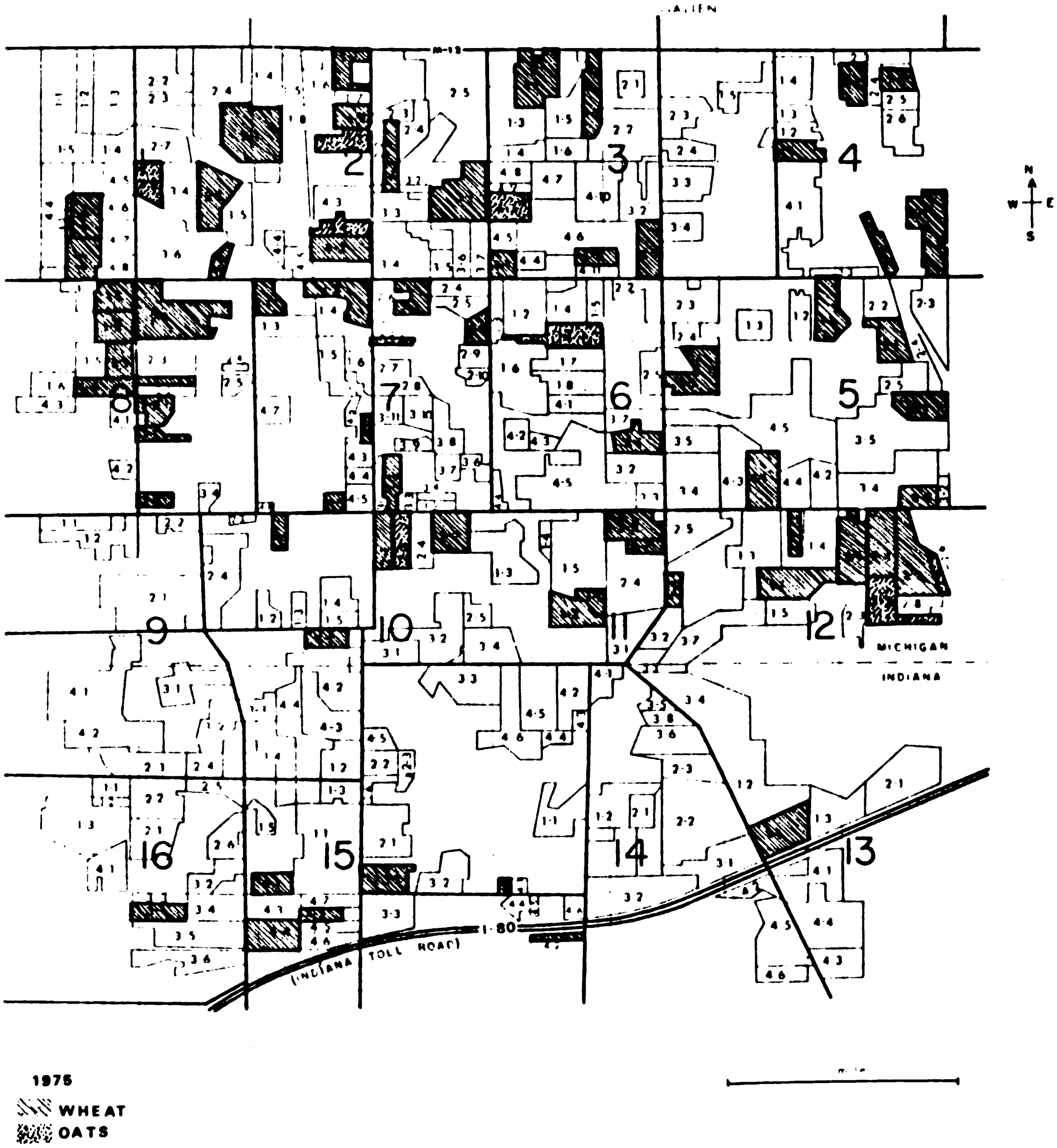
A4-1 Field identification codes (see Appendix 5).

A4-2 1975 PWS Oat and Wheat fields.

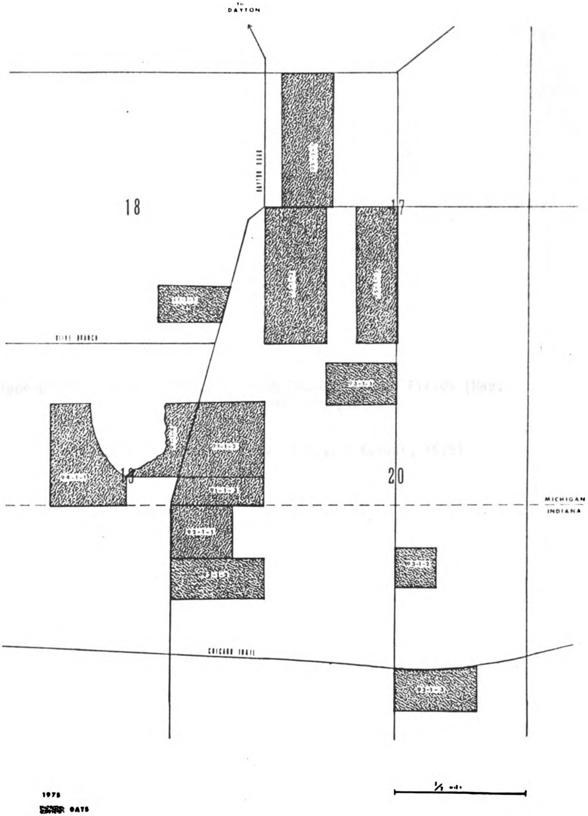
A4-3 Supplementary oat fields used in 1975 PWS study (located approximately 1 mile due east of main study area).



A4-1. Field identification codes (see Appendix 5).



A4-2. 1975 PWS Oat and Wheat fields.



A4-3. Supplementary oat fields used in 1975 PWS study.

Appendix 5. Identification of 1975 PWS Cultivated Fields (Map, Appendix 4) by Crop and Acreage.

(Survey taken 28 July through 1 August, 1975).

Field Identification

Field #	Crop	Acres
1-1-1	Corn	37
1-1-2	Soybean	20
1-1-3	Corn	45
1-1-4	Corn	15.5
1-1-5	Corn	19
1-2-1	Wheat	40.5
1-2-2	Soybean	26.5
1-2-3	Corn	14.5
1-2-4	Soybean	46.5
1-3-1	Wheat	23
1-3-2	Wheat	6
1-3-3	Oat	13.5
1-3-4	Alfalfa	25.5
1-3-5	Soybean	18.5
1-3-6	Corn	68.5
1-4-1	Wheat	20
1-4-2	Wheat	19
1-4-3	Oats	5
1-4-4	Corn	33
1-4-5	Pasture	14.5
1-4-6	Corn	9.5
1-4-7	Hay	12
1-4-8	Corn	11
2-1-1	Wheat	13
2-1-2	Wheat	7
2-1-3	Oat	9
2-1-4	Plowed	28
2-1-5	Hay	11
2-1-6	Soybean	16
2-1-7	Hay	5.5
2-2-1	Wheat	12
2-2-2	Soybean	10.5

Field #	Crop	Acres
2-2-3	Alfalfa	9
2-2-4	Corn	29.5
2-2-5	Hay	79
2-3-1	Wheat	35
2-3-2	Soybean	3.5
2-3-3	Corn	24
2-3-4	Corn	37.5
2-3-5	Hay	7.5
2-3-6	Corn	16
2-3-7	Hay	14.5
2-4-1	Oats	
2-4-2	Wheat	20
3-1-1	Wheat	25.5
3-1-2	Wheat	12
3-1-3	Soybean	31
3-1-4	Hay	10.5
3-1-5	Corn	22
3-1-6	Soybean	15
3-1-7	Hay	
3-2-1	Wheat	9
3-2-2	Corn	40.5
3-2-3	Soybean	24
3-2-4	Hay	12
3-3-1	Wheat	21
3-3-2	Wheat	26.5
3-3-3	Corn	16
3-3-4	Soybean	14.5
3-4-1	Wheat	9.5
3-4-2	Wheat	6.2
3-4-3	Oat	16
3-4-4	Oat	7.5
3-4-5	May	9.5

Field #	Crop	Acres
3-4-6	Corn	67
3-4-7	Soybean	20.5
3-4-8	Corn	9.5
3-4-9	Hay	6
3-4-10	Corn	37
3-4-11	Hay	4.5
4-1-1	Wheat	14
4-1-2	Corn	12
4-1-3	Soybean	9
4-1-4	Corn	21.5
4-1-5	Soybean	17
4-2-1	Wheat	16
4-2-2	Wheat	11
4-2-3	Hay	14
4-2-4	Soybean	8.5
4-2-5	Pasture	11.5
4-2-6	Oat	19.5
4-3-1	Wheat	32
4-3-2	Wheat	10.5
4-3-3	Pasture	8.5
4-4-1	Corn	57
5-1-1	Soybean	22
5-1-2	Pasture	14
5-1-3	Plowed	14
5-2-1	Wheat	18.5
5-2-2	Corn	18
5-2-3	Pasture	30
5-2-4	Pasture	10
5-2-5	Corn	15
5-3-1	Barley	18
5-3-2	Wheat	9
5-3-3	Wheat	10
5-3-4	Alfalfa	49
5-3-5	Corn	74
5-4-1	Wheat	25

Field #	Crop	Acres
5-4-2	Corn	19
5-4-3		34
5-4-4	Hay	17
5-4-5	Corn	90
6-1-1	Oat	21
6-1-2	Corn	32
6-1-3	Hay	10
6-1-4	Pasture	19.5
6-1-5	Alfalfa	11.5
6-1-6	Pasture	46
6-1-7	Corn	17
6-2-1	Wheat	26.5
6-2-2	Corn	12.5
6-2-4	Corn	12
6-2-5	Corn	14.5
6-3-1	Wheat	17.5
6-3-2	Soybean	21.5
6-3-3	Hay	12
6-3-4	Corn	37.5
6-3-5	Hay	19.5
6-3-6	Corn	
6-3-7	Plowed	18.5
6-4-1	Hay	12
6-4-3	Hay	5.5
6-4-4	Hay	7
6-4-5	Pasture	77
7-1-1	Wheat	12
7-1-2	Wheat	21
7-1-3	Soybean	17
7-1-4	Pasture	25
7-1-5	Wheat	22
7-1-6	Wheat	9.5
7-2-1	Wheat	11
7-2-2	Wheat	15
7-2-3	Oat	5

Field #	Crop	Acres
7-2-4	Corn	13
7-2-5	Hay	11.5
7-2-6	Plowed	15
7-2-7	Oat	10
7-2-8	Hay	15
7-2-9	Soybean	8
7-2-10	Corn	5
7-3-1	Rye	8
7-3-2	Wheat	9
7-3-3	Corn	7
7-3-4	Hay	5.5
7-3-5	Corn	6
7-3-6	Hay	7
7-3-7	Hay	9
7-3-8	Hay	16
7-3-9	Hay	7
7-3-10	Hay	12
7-3-11	Hay	10
7-4-1	Wheat	4
7-4-2	Wheat	5
7-4-3	Soybean	10.5
7-4-4	Plowed	6
7-4-5	Corn	10
7-4-6	Hay	9
7-4-7	Corn	11.5
7-4-8	Alfalfa	2.5
8-1-1	Wheat	14
8-1-2	Wheat	15
8-1-3	Wheat	12.5
8-1-4	Wheat	15
8-1-5	Corn	14.5
8-1-6	Corn	14
8-1-7	Corn	10.5

Field #	Crop	Acres
8-2-1	Wheat	49
8-2-2	Wheat	5.5
8-2-3	Corn	29.5
8-2-4	Wheat	4.5
8-2-5	Soybean	7
8-3-1	Wheat	7
8-3-2	Corn	13
8-3-3	Wheat	8
8-3-4	Hay	10
8-4-1	Wheat	9
8-4-2	Plowed	8
8-4-3		11
9-1-1	Wheat	16
9-1-2	Corn	27
9-2-1	Soybean	73
9-2-2	Corn	9
9-2-3	Hay	4
9-2-4	Plowed	24.5
9-3-1	Plowed	28
9-3-2	Plowed	19
9-3-3	Corn	17
9-4-1	Wheat	56
9-4-2	Corn	44
10-1-1	Wheat	9
10-1-2	Hay	12
10-1-3	Plowed	6
10-1-4	Wheat	16
10-1-5	Corn	9
10-2-1	Wheat	16
10-2-2	Wheat	19
10-2-3	Oat	12
10-2-4	Corn	18
10-2-5	Soybean	9.5

Field #	Crop	Acres
10-3-1	Hay	19
10-3-2	Corn	40
10-3-3	Corn	36
10-3-4	Hay	25
10-4-1	Wheat	9
10-4-2	Corn	58.5
10-4-3	Hay	32
10-4-4	Plowed	11.5
10-4-5	Hay	7
11-1-1	Wheat	7
11-1-2	Wheat	20
11-1-3	Hay	33
11-1-4	Hay	6
11-1-5	Corn	56
11-2-1	Wheat	9
11-2-2	Plowed	23
11-2-3	Wheat	9
11-2-4	Soybean	50
11-2-5	Pasture	29
11-2-6	Hay	
11-3-1	Corn	25
11-3-2	Corn	18
11-3-3	Hay	6
11-3-4	Pasture	58
11-3-5	Hay	8
11-3-6	Corn	25
11-3-7	Plowed	37
11-3-8		13.5
11-4-1	Hay	12
11-4-2	Hay	28
11-4-3	Corn	5
11-4-4	Hay	7
11-4-5		33
11-4-6	Corn	37.5

Field #	Crop	Acres
12-1-1	Wheat	27
12-1-2	Wheat	7
12-1-3	Hay	33
12-1-4	Corn	35
12-1-5		18
12-2-1	Wheat	27
12-2-3	Corn	13
12-2-4	Soybean	27
12-2-5	Oat	17
12-2-6	Oat	6.5
12-2-7	Oat	7
12-2-8	Soybean	10
13-1-1	Wheat	28
13-1-2	Pasture	60
13-1-3	Hay	26
13-2-1	Corn	44.5
13-4-1	Wheat	33
13-4-2	Wheat	11
13-4-3	Wheat	20
13-4-4	Corn	46
13-4-5	Corn	37
13-4-6	Soybean	12
14-1-1	Rye	23.5
14-1-2	Hay	30
14-2-1	Corn	14
14-2-2	Corn	70
14-2-3	Hay	23
14-3-1	Pasture	29
14-3-2	Corn	47
14-4-1	Wheat	2
14-4-2	Wheat	6
14-4-3	Pasture	2.5
14-4-4	Pasture	9
14-4-5	Oat	4

Field #	Crop	Acres
14-4-6	Pasture	7.5
15-1-1	Corn	78
15-1-2	Hay	15
15-1-3	Corn	9
15-1-4	Corn	43.5
15-1-5	Pasture	9
15-1-6	Plowed	9.5
15-2-1	Corn	28
15-2-2	Hay	12
15-2-3		9
15-3-1	Wheat	20
15-3-2	Pasture	20
15-3-3	Pasture	25
15-4-1	Wheat	16
15-4-2	Wheat	8
15-4-3	Alfalfa	19
15-4-4	Wheat	25
15-4-5	Corn	11
15-4-6	Soybean	9.5
15-4-7	Soybean	12
16-1-1	Oat	14.5
16-1-2	Corn	7
16-1-3	Alfalfa	
16-2-1	Wheat	31
16-2-2	Hay	34
16-2-3	Wheat	32
16-2-4	Corn	14.5
16-2-5	Soybean	17
16-2-6	Corn	22
16-3-1	Wheat	15
16-3-2	Wheat	17
16-3-3	Corn	7

Field #	Crop	Acres
16-3-4	Alfalfa	22
16-3-5	Alfalfa	37
16-3-6	Corn	28
16-4-1	Corn	23

Appendix 6. Pubescent wheat study total egg, larval, and adult cereal leaf beetle count data.

Appendix 6a. PWS egg count data.

DD = degree days base 48°F

CH = crop height (inches)

M = field wetness (1=dry; 2=damp; 3=wet)

WI = wind speed (mph)

SQFT = number of linear feet of row sampled

TOTE = total eggs counted in SQFT

ED = subsample of eggs dissected (if any)

EP = number of eggs in ED parasitized by *Anaphes flavipes*

FIELD: 1303

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	05	1	06	30	148		
565	08	3	02	30	83	26	0
621	11	1	04	30	124		
663	12	2	12	20	52	29	3
725	07	1	10	30	86		
829	12	1	05	30	61	29	22
858	16	3	00	30	31		
924	17	1	04	30	33	26	24
1015	22	1	03	30	28		
1067						19	18

FIELD: 1403

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	01	1	06	30	49		
565				30	43	34	0
621	04	1	05	30	67		
663	04	1	10	20	32		
725	06	1	15	30	38		
804	13	1	08	30	26	18	14
858	11	3	03	30	8		
924	13	1	02	30	17	29	26
1015	11	1	04	30	20		
1067						18	18

FIELD: 2103

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	03	1	05	30	277		
565	06	3	04	30	157	38	3
621	09	1	07	30	269		
663	09	2	09	20	83	24	4
725	08	1	15	30	114		
804	14	1	05	30	175	26	20
858	11	3	03	30	84		
924	15	1	03	30	41	27	25
1015	13	1	05	30	25		
1067						21	21

FIELD: 2401

DD	CH	M	WI	SQFT	TOTE	ED	EP
725	07	1	15	30	96		
804	14	1	05	30	48		
858	12	3	03	30	16		
924	13	3	03	30	77	31	28
1015	14	1	05	30	24		
1067						18	18

FIELD: 3403

DD	CH	M	WI	SQFT	TOTE	ED	EP
565						25	0
637	05	1	05	30	39		
663	06	2	06	20	24		
725	06	1	05	30	57		

FIELD: 3403

DD	CH	M	WI	SQFT	TOTE	ED	EP
725	07	1	10	30	183		
804	10	1	03	30	58	28	21
858	13	1	03	30	9		
924	13	3	00	30	64	28	25
1015	14	3	08	30	42		
1067						21	21

FIELD: 6101

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	06	3	02	30	12	21	0
637	09	1	03	30	63		
663	10	2	07	20	6	30	4
725	10	1	04	30	18		
804	15	1	04	30	57	33	32
858	18	1	04	30	25		
924	24	2	05	30	39	26	26
1015	20	1	04	30	12		
1067						21	21

FIELD: 7203

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	07	1	04	30	352		
492						13	0
565						31	9
621	16	1	04	30	170		
643	18	3	04	20	5		
663	20	3	00	20	12		
725	20	1	10	30	52		
804	24	1	05	30	79		
858	19	3	00	30	92		
924	19	3	02	30	42		
1015	28	3	05	30	66		

FIELD:10203

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	05	1	00	20	354		
533	08	3	05	30	0		
565	03	3	05	30	0		
663	09	3	06	20	4	19	1
725	12	1	09	30	8		
804	15	1	05	30	4	22	22
858	11	2	00	30	16		
924	14	3	00	30	3	3	2
1015	20	3	05	30	8		

FIELD:12205

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	10	1	07	20	405		
858	28	1	02	30	0		
924	30	2	03	30	3	4	4
1015	25	1	03	30	0		

FIELD:12206

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	08	1	07	20	254		
858	24	1	02	30	0		
924	27	2	03	30	0		
1015	25	1	03	30	1		

FIELD:12207

DD	CH	M	WI	SQFT	TOTE	ED	EP
478	08	1	06	20	127		
858	24	1	02	30	0		
924	27	2	03	30	2		
1015	28	2	03	30	0		

FIELD:91101

DD	CH	M	WI	SQFT	TOTE	ED	EP
533	13	3	05	30	43		
565						29	1
637	22	1	07	30	24		
663	18	2	06	20	13	27	3
725	30	1	10	20	8		
804	27	1	10	20	31	32	22
858	27	3	00	20	22		
924	27	3	00	30	61	31	29
1015	33	3	02	30	48		
1067						22	22

FIELD:91102

DD	CH	M	WI	SQFT	TOTE	ED	EP
533	15	3	04	30	40		
565						20	5
637	23	1	06	30	44		
663	20	2	07	20	14		
725	27	1	10	20	13		
804	30	1	07	20	13	30	30
858	27	3	00	20	3		
924	30	3	00	30	14	27	27
1015	33	3	03	30	16		
1067						18	18

FIELD:91103

DD	CH	M	WI	SQFT	TOTE	ED	EP
533	13	3	05	30	4		
565						16	1
637	22	1	08	30	12		
663	20	2	06	20	4	21	3
725	33	1	12	20	2		
804	30	1	07	20	2	12	7
858	27	3	00	20	1		
924	27	2	00	30	3	11	11
1015	30	2	05	30	4		

FIELD:91104

DD	CH	M	WI	SQFT	TOTE	ED	EP
533	13	3	04	30	56		
565						22	3
637	21	1	06	30	39		
663	20	1	07	20	14	32	2
725	26	2	08	20	7		
804	28	1	07	20	10	26	17
858	27	3	00	20	2		
924	30	3	00	30	6	30	30
1015	33	3	03	30	7		
1067						16	16

FIELD:92101

DD	CH	M	WI	SQFT	TOTE	ED	EP
533	12	3	05	30	88		
565	12	3	00	30	134	10	0
637	22	1	07	30	152		
663	15	2	08	20	9	21	5
725	33	1	15	20	25		
804	27	2	07	20	38	33	33
858	27	3	00	20	10		
924	27	1	03	30	7	28	26
1015	31	2	05	30	27		

FIELD:92102

DD	CH	M	WI	SQFT	TOTE	ED	EP
533	12	3	04	30	225		
565	12	3	00	30	166	22	2
637	18	1	08	30	147		
663	15	2	08	20	27	28	7
725	33	1	15	20	10		
804	27	2	07	20	15	38	38
858	27	3	00	20	18		
924	27	2	00	30	26	30	30
1015	29	2	05	30	21		
1067						5	5

FIELD:93101

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	18	3	02	30	3	16	5

FIELD:93102

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	17	3	02	30	2	16	3

FIELD:93103

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	19	3	02	30	3	15	2
579	19	3	02	30	3		

FIELD:94101

DD	CH	M	WI	SQFT	TOTE	ED	EP
663	20	1	07	20	62	25	9
725	15	1	07	30	38		

FIELD:94101

DD	CH	M	WI	SQFT	TOTE	ED	EP
804	23	1	05	30	16	29	23
858	29	3	03	30	9		
924	30	1	02	30	5	27	27
1015	38	3	04	30	0		

FIELD:95101

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	21	3	03	30	9	30	4
637	18	1	05	30	32		
663	20	2	08	20	16	26	4
725	22	1	11	30	[illegible]		
804	30	2	03	30	10	32	31
858	30	3	04	30	6		
924	35	1	0	30	5	29	29
1015	40	3	04	30	1		
1067						9	5

FIELD:95102

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	20	3	03	30	3	20	1
637	18	1	05	30	17		
663	20	2	08	20	18	17	2
725	22	1	13	30	25		
804	30	2	04	30	7	34	33
858	30	3	03	30	7		
924	35	1	03	30	10		
1015	40	3	05	30	0		
1067						1	1

FIELD:95103

DD	CH	M	WI	SQFT	TOTE	ED	EP
565	19	3	02	30	8	22	5
637	20	1	05	30	31		
663	25	2	06	20	16	32	4
725	25	1	14	30	23		
804	25	2	04	30	5	27	27
858	27	3	02	30	6		
924	35	1	03	30	1	32	32
1015	35	3	04	30	0		
1067						4	[illegible]

FIELD: 1201

DD	CH	M	WI	SQFT	TOTE	ED	EP
170	10	1	06	30	38		
220	16	1	06	20	31		
320	22	1	04	20	14		
492	33	1	05	30	13		

FIELD: 1301

DD	CH	M	WI	SQFT	TOTE	ED	EP
170	12	3	01	30	28		
220	15	2	03	20	163		

DD	CH	M	WI	SQFT	TOTE
FIELD: 1301					
320	20	1	10	20	85
492	35	1	04	30	133
533	35	1	09	20	67
FIELD: 1302					
170	12	3	01	30	63
220	13	2	03	20	19
320	19	1	03	20	16
492	25	1	00	30	8
FIELD: 1402					
170	07	2	05	30	8
220	11	2	03	20	37
320	13	1	04	20	24
492	21	1	03	30	42
FIELD: 2101					
170	07	1	06	30	21
220	11	2	03	20	41
231	12	1	03	20	76
320	15	2	04	20	190
492	33	1	03	30	81
FIELD: 2102					
142	14	1	07	30	62
220	19	2	05	20	92
231	15	1	09	20	139
320	25	1	06	20	63
512	33	1	03	20	43
FIELD: 2201					
142	09	1	07	30	92
220	14	1	05	20	222
231	13	1	08	20	364
320	15	1	03	20	408
512	27	1	03	20	96
FIELD: 2301					
142	07	1	09	30	23
220	09	2	00	20	117
231	09	1	05	20	239
320	13	1	07	20	493
386	17	1	00	20	486
FIELD: 2402					
142	08	1	05	30	17
220	12	1	05	20	48

DD	CH	M	WI	SQFT	TOTE
FIELD: 2402					
231	10	1	10	20	42
320	16	1	06	20	54
512	21	1	08	30	49
FIELD: 3101					
154	09	1	05	30	152
210	08	1	04	20	261
231	06	2	05	20	277
320	17	1	02	20	128
492	19	1	04	20	34
533	24	2	05	20	12
FIELD: 3102					
154	06	1	06	30	209
210	11	1	05	20	150
231	11	2	03	20	240
320	14	1	03	20	172
492	24	1	04	20	9
533	24	2	04	20	4
FIELD: 3301					
142	05	1	15	30	77
210	10	1	02	20	414
231	09	1	03	20	481
320	13	1	03	20	287
478	15	1	05	20	164
533	24	2	05	20	31
FIELD: 3401					
154	10	1	03	30	156
210	14	1	04	20	231
231	20	1	05	20	194
320	21	1	03	20	100
492	26	1	02	20	25
533	27	2	03	20	5
FIELD: 3402					
142	10	1	06	30	114
210	12	1	04	20	89
231	17	1	04	20	47
320	17	1	04	20	49
492	30	1	02	20	32
533	28	2	03	20	16
FIELD: 4101					
154	11	1	06	30	528
210	10	1	02	20	404

DD	CH	M	WI	SQFT	TOTE
FIELD: 4101					
231	12	2	03	20	335
320	14	1	06	20	314
492	23	1	02	20	57
533	25	2	02	20	77
FIELD: 4201					
154	12	1	03	30	466
210	13	1	05	20	556
231	15	3	04	20	459
320	15	1	03	20	212
386	20	1	04	20	192
533	28	3	03	20	67
FIELD: 4202					
154	09	2	30	30	431
210	13	1	05	20	597
231	15	3	04	20	524
320	15	1	03	20	235
386	19	1	04	20	207
533	28	3	03	20	34
FIELD: 4301					
142	08	1	08	30	838
210	13	1	04	20	868
231	17	1	06	20	856
320	20	1	03	20	434
492	30	1	03	20	46
533	33	2	03	20	46
FIELD: 4302					
142	10	1	04	30	636
210	13	1	03	20	608
231	17	1	04	18	954
320	22	1	03	20	379
492	33	1	02	20	36
533	33	2	04	20	13
FIELD: 5101					
210	09	1	04	20	93
FIELD: 5201					
142	09	1	03	30	105
210	11	1	05	20	227
345	12	3	02	20	78
FIELD: 5302					
142	09	1	09	30	336

DD	CH	M	WI	SQFT	TOTE	ED	EP
FIELD: 5302							
210	11	1	02	20	355		
231	12	1	05	20	233		
320	17	1	03	20	163		
492	25	1	02	20	27		
533	21	2	04	20	8		
FIELD: 5303							
142	06	1	05	30	303		
210	09	1	05	20	320		
231	07	1	03	20	331		
320	10	1	05	20	222		
492	20	1	03	20	30		
533	16	2	07	20	29		
FIELD: 5401							
154	08	2	07	30	67		
231	06	1	05	20	77		
320	10	1	04	20	87		
478	18	1	06	20	94		
533	21	2	05	20	17		
FIELD: 6201							
154	11	3	03	30	103		
210	13	2	02	20	177		
220						62	0
231	20	1	05	20	118		
320	17	1	04	20	114		
345	21	2	05	30	77	69	0
478	23	1	04	20	144		
492						29	4
533	25	2	04	20	19		
565	30	2	03	20	8	16	3
637	35	1	03	20	23		
FIELD: 6301							
142	09	1	05	30	128		
210	13	2	03	20	142		
220						38	0
231	15	1	06	20	116		
320	19	1	04	20	58		
345	17	3	03	30	100	54	0
478	29	1	04	20	99		
492						26	4
533	26	2	03	20	23		
565	30	2	04	20	5	31	2
643	35	1	03	30	11		

DD	CH	M	WI	SQFT	TOTE	ED	EP
FIELD: 7101							
142	11	1	04	30	10		
210	11	1	05	20	7		
220						46	0
345	21	1	00	30	20	56	0
478	27	1	07	30	27		
492						24	2
533	30	1	08	30	17		
565						27	14
637	28	1	06	30	15		
FIELD: 7102							
142	09	1	04	30	58		
220						55	0
231	18	1	08	20	147		
345	18	3	00	30	279	47	0
478	25	1	07	30	133		
492						13	0
533	24	1	06	30	69		
565						30	4
637	38	1	05	20	23		
FIELD: 7201							
142	08	1	06	30	203		
220						63	0
231	12	1	03	20	806		
345	13	1	00	30	956	76	0
478	18	1	07	20	136		
492						25	0
533	18	1	06	30	64		
565						20	1
621	25	2	06	30	40		
643	27	2	08	20	7		
FIELD: 7202							
142	10	1	05	30	32		
220						75	0
231				20	53		
345	24	1	06	30	101		
478	27	1	08	20	28		
492						20	1
533	30	1	07	20	16		
565						16	1
637	30	1	02	30	13		
FIELD: 7302							
142	09	1	05	30	114		
210	12	1	05	20	103		

DD	CH	M	WI	SQFT	TOTE	ED	EP
FIELD: 7302							
220						60	0
345	16	3	00	30	161		
478	23	1	09	20	76		
492						26	1
533	24	1	09	20	91		
565						38	7
621	28	2	08	30	7		
643	30	1	09	20	2		
FIELD: 7401							
142	07	1	05	30	48		
210	10	1	05	20	225		
220						63	0
231	12	1	08	20	36		
345	12	3	00	30	26		
478	21	1	07	30	13		
492						12	0
533	22	1	04	30	33		
565						29	12
621	24	2	07	30	18		
643	31	1	08	20	1		
FIELD: 7402							
142	09	1	06	30	17		
210	12	1	04	20	11		
220						70	0
231	14	1	10	20	14		
345	15	3	00	30	22	77	0
478	16	1	05	30	22		
492						25	3
533	23	1	03	30	23		
565						30	6
621	32	1	03	30	10		
643	30	1	02	20	0		
FIELD: 8101							
FIELD: 8102							
FIELD: 8103							
170	05	1	03	30	8		
220	06	1	06	20	42		
320	07	1	08	20	77		
492	10	3	04	30	156		
FIELD: 8104							
170	12	1	07	30	58		

DD	CH	M	WI	SQFT	TOTE	ED	EP
FIELD: 8104							
220	11	2	04	20	32		
320	18	1	06	20	22		
492	26	2	02	30	25		
FIELD: 8201							
170	12	2	03	30	40		
220	14	2	06	20	66		
320	18	1	08	24	36		
492	28	1	02	30	71		
FIELD: 8202							
170	10	1	06	30	58		
220	13	3	05	20	69		
320	14	1	07	20	24		
492	19	2	03	30	35		
FIELD: 8301							
170	11	1	05	30	13		
220	13	2	06	20	11		
320	17	1	07	20	10		
492	27	2	04	30	6		
FIELD: 8302							
170	13	1	05	30	26		
220	13	2	06	20	26		
320	19	1	05	20	16		
FIELD: 8303							
170	10	1	06	30	67		
220	13	2	06	20	80		
320	17	1	07	20	55		
492	28	2	03	30	22		
FIELD:10101							
170	11	1	06	30	37		
220						44	0
231	17	1	05	20	20		
345	16	3	02	30	608	50	0
478	18	1	05	20	120		
492						24	3
533	25	1	07	20	5		
565						11	7
565	25	3	00	20	13		
637	28	1	07	20	5		
FIELD:10201							
170	13	1	03	30	43		

DD	CH	M	WI	SQFT	TOTE	ED	EP
FIELD:10201							
220						53	1
231	14	1	05	20	253		
345	18	3	03	30	552	78	0
478	20	1	04	20	80		
492						17	1
533	25	1	08	20	15		
565	25	3	04	20	6	8	4
637	29	1	07	20	6		
FIELD:10202							
170	11	1	08	30	17		
220						46	0
231	15	1	05	20	86		
345	17	3	02	30	101	26	0
478	20	1	05	20	42		
492						18	0
533	24	1	06	20	7		
565						17	2
637	31	1	07	20	4		
FIELD:10401							
220						28	0
290	19	1	13	20	288		
345	15	3	00	30	966		
478	21	1	08	20	223		
492						28	0
533	21	1	07	20	145		
565	21	3	00	20	79	18	0
637	31	1	08	20	18		
FIELD:11101							
220						49	0
231	12	1	03	20	149		
345	16	3	05	30	417		
386	18	1	00	22	214		
492						23	4
533	19	1	06	20	85		
565						21	0
637	27	1	08	20	20		
FIELD:11102							
220						79	0
231	15	1	04	20	196		
345	16	3	05	30	137	11	0
386	18	1	03	20	44		
492						13	1
533	20	1	07	20	34		

DD	CH	M	WI	SQFT	TOTE	ED	EP
FIELD:11102							
565						15	2
637	25	1	08	20	6		
FIELD:11201							
220						60	0
231	13	1	07	20	351		
345						70	0
478	20	1	03	20	103		
492						38	4
533	22	1	07	20	78		
565						17	0
637	24	1	06	20	19		
FIELD:11202							
FIELD:11203							
142	14	3	10	40	8		
220						69	0
231	17	1	07	20	26		
345						47	0
478	20	1	03	20	51		
492						27	1
533	22	3	06	20	31		
565						16	6
637	26	1	08	20	11		
FIELD:12101							
210	17	1	03	20	17		
231	15	1	03	20	12		
533	21	2	07	30	12		
FIELD:12102							
170	05	1	04	30	74		
210	09	1	04	20	152		
231	12	1	04	20	190		
320	07	1	06	20	214		
478	15	1	05	20	151		
FIELD:12201							
170	11	1	06	30	74		
210	14	1	03	20	38		
231	15	2	04	20	15		
320	12	1	04	20	56		
478	18	1	07	20	9		
533	23	2	03	20	8		

DD	CH	M	WI	SQFT	TOTE
FIELD:12202					
170	10	1	05	30	104
210	12	1	05	20	28
231	17	3	03	20	118
320	13	1	06	20	127
492	23	1	02	20	18
533	24	2	05	30	17
FIELD:12204					
210	14	1	05	20	7
231	17	2	03	20	9
345	15	3	04	20	53
492	30	1	02	20	5
533	21	2	05	30	5
FIELD:13101					
142	09	1	20	30	3
210	13	3	03	20	14
231	17	1	03	20	23
320	16	1	06	20	36
492	28	1	04	30	22
544	24	3	03	30	12
FIELD:14401					
142	09	1	10	30	22
210	11	2	03	20	44
231	15	1	06	20	83
320	20	1	00	20	161
492	24	1	02	30	63
533	25	3	05	30	59
FIELD:14402					
142	08	1	15	30	9
210	10	2	07	20	34
231	09	1	08	20	14
320	11	1	03	20	23
492	15	1	00	30	29
533	21	3	06	30	43
FIELD:15301					
142	08	1	10	30	176
210				20	257
231	13	1	07	20	268
320	17	1	03	20	293
492	21	1	06	30	39
544	22	1	06	20	18

DD	CH	M	WI	SQFT	TOTE
FIELD:15401					
142	10	1	10	30	36
210	15	1	04	20	57
290	17	1	05	20	70
512	27	1	04	30	18
544	26	3	05	20	18
FIELD:15402					
142	08	1	10	30	46
210	11	1	10	20	164
231	14	1	08	20	396
320	17	1	10	20	456
492	22	1	05	30	126
533	22	1	05	20	31
FIELD:15404					
210	15	1	04	20	101
290	16	1	09	20	268
512	24	1	03	20	127
544	33	1	02	20	81
FIELD:16301					
142	09	1	10	30	48
210	13	1	07	20	42
290	17	1	07	20	15
512	31	1	04	20	13
544	27	1	02	20	17
FIELD: 7403					
FIELD: 1401					
170	06	2	04	30	10
220	10	2	02	20	3
320	13	1	00	20	6
492	16	1	04	30	41

Appendix 6b. PWS larval count data.

DD = degree days base 48°F

CH = crop height (inches)

M = field wetness (1=dry; 2=damp; 3=wet)

WI = wind speed (mph)

UNIT = either linear feet (SQFT) or sweeps

NSU = number of UNITS sampled

TOTC = total count of larvae in NSU UNITS

1...4 = numbers of larvae in a subsample grouped by instar. First number of pair is the number of that instar in the subsample. Second number of pair is the number that were parasitized by *Tetrastichus julis*.

FIELD: 1303

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	05	1	06	SQFT	30	11	4- 0	6- 0	1- 0	0- 0
512				SWPS	300	24	7- 0	13- 5	4- 0	0- 0
565	08	3	02	SQFT	30	31	5- 0	5- 0	14- 1	0- 0
599				SWPS	150	54	0- 0	0- 0	16-11	34-29
621	11	1	04	SQFT	30	31				
663	12	2	12	SWPS	150	213				
663	12	2	12	SQFT	20	56				
725	07	1	10	SWPS	150	91	0- 0	2- 0	31- 5	17- 3
725	07	1	10	SQFT	30	160	9- 0	21- 1	17- 0	4- 0
829	12	1	05	SWPS	150	584	0- 0	2- 0	25- 2	23- 2
829	12	1	05	SQFT	30	167	0- 0	9- 0	32- 0	18- 0
858	16	3	00	SWPS	150	582	0- 0	0- 0	13- 0	37- 1
858	16	3	00	SQFT	30	180	1- 0	3- 0	28- 0	26- 0
924	17	1	04	SWPS	150	600	0- 0	3- 0	20- 1	77- 0
924	17	1	04	SQFT	30	84	0- 0	2- 0	9- 0	45- 0
1015	22	1	03	SWPS	150	81	0- 0	8- 6	20-16	53-40
1015	22	1	03	SQFT	30	21	0- 0	0- 0	7- 1	12- 0

FIELD: 1403

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	01	1	06	SQFT	30	0				
621	04	1	05	SQFT	30	0				
663	04	1	10	SQFT	20	16				
725	06	1	15	SWPS	250	17	0- 0	3- 0	14- 0	0- 0
725	06	1	15	SQFT	30	31	4- 0	16- 0	9- 1	2- 0
804	13	1	08	SWPS	150	101	3- 0	14- 0	48- 0	36- 2
804	13	1	08	SQFT	30	36	2- 0	3- 0	24- 0	6- 0
858	11	3	03	SWPS	150	70	0- 0	1- 0	16- 0	52- 2
858	11	3	03	SQFT	30	10	0- 0	0- 0	2- 0	7- 0
924	13	1	02	SWPS	150	138	0- 0	2- 2	10- 7	88- 0
924	13	1	02	SQFT	30	9	0- 0	0- 0	1- 0	8- 0
1015	11	1	04	SWPS	250	38	0- 0	5- 2	9- 8	24-20
1015	11	1	04	SQFT	30	8	0- 0	1- 0	3- 0	6- 0

FIELD: 2103

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	03	1	05	SQFT	30	2	1- 0	1- 0	0- 0	0- 0
565	06	3	04	SQFT	30	9	7- 0	1- 0	0- 0	0- 0
621	09	1	07	SWPS	150	168	0- 0	0- 0	24- 0	26- 0
621	09	1	07	SQFT	30	21				
663	09	2	09	SQFT	20	311				
725	08	1	15	SWPS	150	24	0- 0	1- 0	15- 0	8- 0
725	08	1	15	SQFT	30	360	3- 0	17- 0	36- 0	0- 0
804	14	1	05	SWPS	150	1471	0- 0	6- 0	51- 2	43- 2
804	14	1	05	SQFT	30	179	2- 0	7- 0	33- 0	13- 0
858	11	3	03	SWPS	150	971	0- 0	0- 0	8- 0	37- 0
858	11	3	03	SQFT	30	194	0- 0	4- 0	18- 0	37- 0
924	15	1	03	SWPS	150	1320	0- 0	2- 0	25- 0	73- 0
924	15	1	03	SQFT	30	196	0- 0	0- 0	12- 0	53- 0
1015	18	1	05	SWPS	150	333	0- 0	1- 0	61-42	88-42
1015	18	1	05	SQFT	30	34	0- 0	2- 0	8- 2	23- 0

FIELD: 2401

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
725	07	1	15	SWPS	150	23	0- 0	5- 0	15- 0	3- 0
725	07	1	15	SQFT	30	138	2- 0	27- 0	23- 0	5- 0
804	14	1	05	SWPS	150	497	0- 0	2- 0	72- 0	29- 1
804	14	1	05	SQFT	30	97	1- 0	7- 0	31- 0	16- 0
858	12	3	03	SWPS	150	1110	0- 0	1- 0	17- 0	32- 0
858	12	3	03	SQFT	30	106	2- 0	1- 0	8- 0	44- 1
924	13	3	03	SWPS	150	980	0- 0	0- 0	24- 2	76-15
924	13	3	03	SQFT	30	63	0- 0	2- 0	21- 0	31- 0
1015	14	1	05	SWPS	150	144	0- 0	0- 0	5- 5	95-46
1015	14	1	05	SQFT	30	18	0- 0	0- 0	0- 0	18- 0

FIELD: 3403

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
637	05	1	05	SQFT	30	46	19- 0	27- 0	0- 0	0- 0
663	06	2	06	SQFT	20	72				
725	06	1	05	SQFT	30	29	28- 0	33- 0	14- 0	0- 0
725	07	1	10	SWPS	150	46	0- 0	3- 0	26- 2	17- 2
725	07	1	10	SQFT	30	61	4- 0	18- 0	27- 0	2- 0
804	10	1	03	SWPS	150	278	0- 0	5- 0	21- 0	24- 0
804	10	1	03	SQFT	30	46	2- 0	4- 0	33- 0	12- 0
858	13	1	03	SWPS	150	1129	0- 0	3- 0	57- 1	46- 0
858	13	1	03	SQFT	30	80	1- 0	8- 0	23- 0	22- 0
924	13	3	00	SWPS	150	717	2- 0	3- 0	30- 5	65- 6
924	13	3	00	SQFT	30	173	0- 0	13- 0	21- 0	24- 0
1015	14	3	08	SWPS	250	537	0- 0	0- 0	19-14	81-41
1015	14	3	08	SQFT	30	74	1- 1	1- 0	7- 2	41- 3

FIELD: 6101

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
565	06	3	02	SQFT	30	10	1- 0	3- 0	5- 0	1- 0
637	09	1	03	SWPS	150	42	0- 0	0- 0	7- 0	35- 8
637	09	1	03	SQFT	30	19	2- 0	2- 0	12- 0	2- 0
663	10	2	07	SWPS	150	180	0- 0	0- 0	5- 0	45- 6
663	10	2	07	SQFT	20	15				
725	10	1	04	SWPS	150	148	0- 0	0- 0	15- 1	35- 2
725	10	1	04	SQFT	30	39	9- 0	20- 0	11- 0	8- 0
804	15	1	04	SWPS	150	46	0- 0	0- 0	17- 0	28- 2
804	15	1	04	SQFT	30	37	3- 0	17- 0	27- 0	5- 0
858	18	1	04	SWPS	150	1176	0- 0	1- 0	21- 2	28- 2
858	18	1	04	SQFT	30	71	3- 0	2- 0	27- 1	18- 0
924	24	2	03	SWPS	150	252	0- 0	13- 3	54- 6	83- 3
924	24	2	03	SQFT	30	78	0- 0	1- 0	20- 0	30- 0
1015	20	1	04	SWPS	150	258	0- 0	11- 2	29-14	58-31
1015	20	1	04	SQFT	30	21	0- 0	0- 0	12- 1	43- 6

FIELD: 7203

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	07	1	04	SQFT	30	40				
599				SWPS	0	-1				
621	16	1	04	SQFT	30	0				
643	18	3	04	SWPS	150	2	0- 0	1- 0	1- 0	0- 0
643	18	3	04	SQFT	20	72				

FIELD: 7203

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
663	20	3	00	SWPS	250	2	0- 0	0- 0	1- 0	1- 0
663	20	3	00	SQFT	20	2				
725	20	1	10	SWPS	250	2	0- 0	1- 0	1- 0	0- 0
725	20	1	10	SQFT	30	1	0- 0	1- 0	0- 0	0- 0
804	24	1	05	SWPS	250	4	3- 0	1- 0	0- 0	0- 0
804	24	1	05	SQFT	30	0				
858	19	3	00	SWPS	250	3	0- 0	2- 0	1- 0	0- 0
858	19	3	00	SQFT	30	0				
924	19	3	02	SWPS	250	6	0- 0	1- 0	0- 0	5- 0
924	19	3	02	SQFT	30	0				
1015	28	3	05	SWPS	250	6	6- 0	0- 0	0- 0	0- 0
1015	28	3	05	SQFT	30	0				

FIELD:10203

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	05	1	00	SQFT	20	99				
533	08	3	05	SWPS	250	0				
533	08	3	05	SQFT	30	0				
565	03	3	05	SQFT	30	6	0- 0	4- 0	2- 0	0- 0
663	09	3	06	SQFT	20	26				
725	12	1	09	SWPS	150	156	0- 0	34- 2	49-13	17- 9
725	12	1	09	SQFT	30	130	2- 0	35- 0	15- 1	1- 1
804	15	1	05	SWPS	150	497	0- 0	17- 1	46- 2	32-10
804	15	1	05	SQFT	30	10	0- 0	0- 0	6- 0	4- 1
858	11	2	00	SWPS	150	405	0- 0	6- 0	49-12	43- 7
858	11	2	00	SQFT	30	69	0- 0	0- 0	6- 0	64- 0
924	14	3	00	SWPS	150	151	0- 0	2- 1	4- 2	94-26
924	14	3	00	SQFT	30	17	0- 0	0- 0	1- 0	16- 1
1015	20	3	05	SWPS	250	6	0- 0	0- 0	0- 0	6- 6
1015	20	3	05	SQFT	30	1	0- 0	0- 0	0- 0	1- 0

FIELD:12205

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	10	1	07	SWPS	150	1216	1- 0	16- 0	27- 4	6- 1
478	10	1	07	SQFT	20	419				
853	28	1	02	SWPS	150	187	0- 0	1- 0	24- 1	25- 2
853	28	1	02	SQFT	30	5	1- 0	0- 0	21- 0	28- 1
924	30	2	03	SWPS	150	0				
924	30	2	03	SQFT	30	3	0- 0	0- 0	3- 0	52- 1
1015	25	1	03	SWPS	150	2	0- 0	0- 0	1- 0	0- 0
1015	25	1	03	SQFT	30	0	0- 0	0- 0	0- 0	4- 0

FIELD:12206

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
478	08	1	07	SWPS	150	27	5- 0	15- 4	7- 2	0- 0
478	08	1	07	SQFT	20	620	7- 0	21- 0	17- 0	0- 0
853	24	1	02	SWPS	150	764	0- 0	8- 0	42- 0	51- 1
853	24	1	02	SQFT	30	19	0- 0	0- 0	25- 0	19- 1
924	27	2	03	SWPS	150	94	0- 0	1- 0	1- 1	92-29
924	27	2	03	SQFT	30	17	0- 0	0- 0	5- 1	43- 3
1015	25	1	03	SWPS	150	3	0- 0	0- 0	1- 0	2- 2
1015	25	1	03	SQFT	30	0	0- 0	0- 0	1- 0	8- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:12207										
478	08	1	06	SWPS	150	43	0- 0	28- 4	15- 5	0- 0
478	08	1	06	SQFT	20	261				
458	24	1	02	SWPS	150	18	0- 0	2- 0	10- 0	6- 1
858	24	1	02	SQFT	30	1	0- 0	0- 0	35- 1	20- 1
924	27	2	03	SWPS	150	74	0- 0	0- 0	5- 2	68- 8
924	27	2	03	SQFT	30	9	0- 0	1- 0	4- 1	45- 3
1015	28	2	03	SWPS	150	0				
1015	28	2	03	SQFT	30	1				
FIELD:91101										
533	13	3	05	SWPS	150	89	0- 0	5- 0	52-10	31-12
533	13	3	05	SQFT	30	14	2- 0	2- 0	7- 0	3- 1
599				SWPS	150	58	0- 0	0- 0	14- 2	36-18
637	22	1	07	SWPS	150	42	0- 0	0- 0	6- 0	36- 7
637	22	1	07	SQFT	30	8				
663	18	2	06	SWPS	300	636	0- 0	9- 0	30- 1	61-19
663	18	2	06	SQFT	20	17				
725	30	1	10	SWPS	150	108	1- 0	21- 0	47- 1	31- 0
725	30	1	10	SQFT	20	13	1- 0	7- 0	2- 0	3- 0
804	27	1	10	SWPS	150	86	1- 0	4- 1	53- 2	28- 1
804	27	1	10	SQFT	20	5	0- 0	0- 0	2- 0	0- 0
858	27	3	00	SQFT	20	7	1- 0	4- 0	0- 0	2- 0
891	27	1	07	SWPS	150	43	0- 0	4- 0	13- 1	26- 4
924	27	1	03	SWPS	150	60	0- 0	6- 1	21- 4	33- 8
924	27	3	00	SQFT	30	10	1- 0	3- 0	3- 0	3- 0
1015	33	2	05	SWPS	150	17	0- 0	4- 0	9- 0	4- 0
1015	33	3	02	SQFT	30	8	0- 0	5- 0	1- 0	1- 0
FIELD:91102										
533	15	3	04	SQFT	30	17	3- 0	9- 0	3- 0	2- 1
599				SWPS	150	261	0- 0	1- 0	17- 3	32-12
637	23	1	06	SWPS	150	198	0- 0	4- 0	22- 5	24-13
637	23	1	06	SQFT	30	25				
663	20	2	07	SWPS	150	62	0- 0	11- 0	15- 5	24-14
663	20	2	07	SQFT	20	27				
725	27	1	10	SWPS	150	136	0- 0	15- 0	33- 0	52- 9
725	27	1	10	SQFT	20	17	5- 0	5- 0	5- 0	2- 0
804	30	1	07	SWPS	150	80	4- 0	9- 0	32- 1	35- 1
804	30	1	07	SQFT	20	10	2- 0	2- 0	2- 0	4- 0
858	27	3	00	SWPS	150	37	0- 0	4- 0	19- 0	12- 0
858	27	3	00	SQFT	20	3	0- 0	1- 0	0- 0	2- 0
924	30	1	03	SWPS	150	43	0- 0	3- 2	27-14	13- 7
924	30	3	00	SQFT	30	12	0- 0	1- 0	4- 0	7- 0
1015	33	2	05	SWPS	150	15	0- 0	3- 0	2- 0	11- 0
1015	33	3	03	SQFT	30	5	0- 0	0- 0	1- 0	3- 1

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:91103										
533	13	3	05	SQFT	30	4	0- 0	1- 0	1- 0	2- 0
599				SWPS	150	186	0- 0	1- 0	10- 0	39- 2
637	22	1	08	SWPS	150	49	0- 0	6- 0	20- 6	23-11
637	22	1	08	SQFT	30	6				
663	20	2	06	SWPS	150	3	1- 0	0- 0	0- 0	2- 1
663	20	2	06	SQFT	20	2				
725	33	1	12	SWPS	150	7	1- 0	4- 0	0- 0	2- 0
725	33	1	12	SQFT	20	2	0- 0	1- 0	0- 0	0- 0
804	30	1	07	SWPS	150	13	0- 0	2- 0	3- 1	7- 1
804	30	1	07	SQFT	20	4	0- 0	2- 0	2- 0	0- 0
858	27	3	00	SQFT	20	2	0- 0	1- 0	1- 0	0- 0
891	27	1	03	SWPS	150	18	0- 0	0- 0	6- 5	12-11
924	27	1	03	SWPS	150	25	0- 0	2- 1	2- 1	21-12
924	27	2	00	SQFT	30	2	0- 0	0- 0	0- 0	2- 0
1015	30	2	05	SWPS	250	2	0- 0	1- 0	0- 0	1- 0
1015	30	2	05	SQFT	30	0				
FIELD:91104										
533	13	3	04	SWPS	150	206	0- 0	1- 0	39-20	10-10
533	13	3	04	SQFT	30	21	0- 0	10- 1	11- 4	0- 0
599				SWPS	150	181	0- 0	0- 0	13- 8	37-20
637	21	1	06	SWPS	150	135	0- 0	3- 0	24-12	23-14
637	21	1	06	SQFT	30	37				
663	20	1	07	SWPS	150	24	0- 0	3- 0	8- 2	13- 7
663	20	1	07	SQFT	20	16				
725	26	2	08	SWPS	150	124	0- 0	15- 0	51- 4	58-19
725	26	2	08	SQFT	20	24	7- 0	5- 0	5- 0	5- 0
804	28	1	07	SWPS	150	54	6- 1	17- 2	17- 5	10- 4
804	28	1	07	SQFT	20	12	2- 0	3- 0	3- 0	5- 0
858	27	3	00	SWPS	150	113	0- 0	13- 1	55- 7	32- 5
858	27	3	00	SQFT	20	6	0- 0	1- 0	2- 0	3- 0
924	30	1	03	SWPS	150	87	3- 0	5- 1	30-15	49-18
924	30	3	00	SQFT	30	16	0- 0	1- 0	5- 0	10- 0
1015	33	2	05	SWPS	150	15	0- 0	4- 0	2- 0	9- 0
1015	33	3	03	SQFT	30	4	0- 0	1- 0	0- 0	3- 1
FIELD:92101										
533	12	3	05	SQFT	30	9	3- 0	3- 0	2- 0	0- 0
565	12	3	00	SQFT	30	19	8- 0	5- 0	5- 0	1- 0
599			00	SWPS	150	134	2- 0	12- 0	20- 8	16-10
637	22	1	07	SWPS	150	119	0- 0	11- 0	25- 0	14- 7
637	22	1	07	SQFT	30	42				
663	15	2	08	SWPS	150	86	0- 0	10- 0	23-11	17-11
663	15	2	08	SQFT	20	34				
725	33	1	15	SWPS	150	113	3- 0	25- 1	40- 1	55-12
725	33	1	15	SQFT	20	26	5- 0	6- 0	11- 0	6- 0
804	27	2	07	SWPS	150	168	3- 0	9- 0	54- 1	34- 1
804	27	2	07	SQFT	20	33	7- 0	9- 0	14- 1	3- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:92101										
858	27	3	00	SQFT	20	23	2- 0	6- 0	10- 0	5- 0
891	27	2	07	SWPS	150	133	0- 0	3- 0	8- 0	30- 4
924	27	1	03	SWPS	150	84	1- 0	2- 0	17- 3	54-12
924	27	1	03	SQFT	30	9	0- 0	2- 0	2- 0	5- 0
1015	31	2	05	SWPS	150	40	0- 0	0- 0	4- 0	36- 3
1015	31	2	05	SQFT	30	4				
FIELD:92102										
533	12	3	04	SQFT	30	27	6- 0	12- 2	9- 1	0- 0
565	12	3	00	SQFT	30	29	7- 0	11- 0	4- 0	6- 0
599				SWPS	150	200	0- 0	9- 0	26-11	15-11
637	18	1	08	SWPS	150	146	0- 0	8- 0	23- 8	19-12
637	18	1	08	SQFT	30	35				
663	15	2	08	SWPS	150	154	0- 0	2- 0	11- 0	37- 7
663	15	2	08	SQFT	20	25				
725	33	1	15	SWPS	150	55	0- 0	6- 0	33- 0	16- 0
725	33	1	15	SQFT	20	15	2- 0	3- 0	8- 0	2- 0
804	27	2	07	SWPS	150	307	0- 0	0- 0	18- 1	32- 4
804	27	2	07	SQFT	20	39	5- 1	7- 0	16- 1	11- 1
858	27	3	00	SWPS	150	0				
858	27	3	00	SQFT	20	16	1- 0	6- 0	5- 0	5- 0
891	27	2	07	SWPS	150	401	0- 0	2- 0	15- 0	24- 6
924	27	1	03	SWPS	150	120	0- 0	9- 4	30-10	61-25
924	27	2	00	SQFT	30	10	0- 0	1- 0	3- 0	6- 0
1015	29	2	05	SWPS	150	38	0- 0	0- 0	4- 1	34- 6
1015	29	2	05	SQFT	30	3				
FIELD:93101										
565	18	3	02	SQFT	30	16	1- 0	3- 0	6- 0	7- 0
579		3	02	SWPS	150	131	4- 0	9- 2	19-17	18-12
FIELD:93102										
565	17	3	02	SQFT	30	10	1- 0	2- 0	6- 0	2- 0
579		3	02	SWPS	150	47	0- 0	8- 3	31-12	8- 4
FIELD:93103										
565	19	3	02	SQFT	30	4	1- 0	1- 0	1- 0	1- 0
579	19	3	02	SWPS	150	33	0- 0	7- 1	22-13	4- 3
579	19	3	02	SQFT	30	4				
FIELD:94101										
663	20	1	07	SWPS	150	658	0- 0	3- 0	16- 3	31- 9
663	20	1	07	SQFT	20	54				
725	15	1	07	SWPS	150	63	0- 0	5- 0	24- 1	21- 3
725	15	1	07	SQFT	30	89	0- 0	3- 0	7- 2	25- 5
804	23	1	05	SWPS	150	196	0- 0	2- 0	65- 1	36- 5
804	23	1	05	SQFT	30	15	1- 0	14- 0	18- 0	17- 0
858	29	3	03	SWPS	150	60	0- 0	1- 0	20- 1	39- 5
858	29	3	03	SQFT	30	11	1- 0	9- 0	18- 0	18- 0
924	30	1	02	SWPS	150	46	0- 0	2- 0	16- 0	28- 2
924	30	1	02	SQFT	30	21	0- 0	1- 0	15- 1	30- 5

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:94101										
1015	38	3	04	SWPS	150	12	0- 0	1- 1	6- 5	5- 4
1015	38	3	04	SQFT	30	3	0- 0	3- 0	13- 0	32- 2
FIELD:95101										
565	21	3	03	SQFT	30	12	1- 0	6- 0	3- 0	4- 1
579		3	03	SWPS	150	86	0- 0	3- 1	40-33	7- 5
637	18	1	05	SWPS	150	158	4- 0	28- 2	64-27	62-32
637	18	1	05	SQFT	30	21	8- 0	7- 0	3- 0	1- 0
663	20	2	08	SWPS	150	93	2- 0	14- 1	14- 0	20- 2
663	20	2	08	SQFT	20	27				
725	22	1	11	SWPS	150	10	2- 0	1- 0	4- 0	3- 0
725	22	1	11	SQFT	30	37	2- 0	5- 0	16- 1	6- 0
804	30	2	03	SWPS	150	122	0- 0	7- 0	47- 7	56-10
804	30	2	03	SQFT	30	10	1- 0	10- 1	27- 3	13- 1
858	30	3	04	SWPS	150	156	0- 0	10- 0	57- 0	34- 0
858	30	3	04	SQFT	30	19	1- 0	9- 0	18- 0	21- 0
924	35	1	0	SWPS	150	88	0- 0	4- 1	22- 3	62- 8
924	35	1	0	SQFT	30	11	0- 0	4- 0	13- 0	33- 0
1015	40	3	04	SWPS	150	7	0- 0	0- 0	0- 0	7- 1
1015	40	3	04	SQFT	30	6	0- 0	1- 0	7- 0	45- 0
FIELD:95102										
565	20	3	03	SQFT	30	19	3- 0	3- 0	7- 0	5- 1
579	20	3	03	SWPS	150	134	0- 0	4- 0	26-20	20-16
637	18	1	05	SWPS	150	89	0- 0	10- 0	35-14	44-24
637	18	1	05	SQFT	30	31	3- 0	5- 1	11- 0	16- 1
663	20	2	08	SWPS	150	121	0- 0	10- 0	13- 6	27-16
663	20	2	08	SQFT	20	25				
725	22	1	13	SWPS	150	18	0- 0	4- 0	6- 0	8- 3
725	22	1	13	SQFT	30	32	0- 0	0- 0	10- 0	19- 0
804	30	2	04	SWPS	150	32	1- 1	1- 0	12- 1	18- 4
804	30	2	04	SQFT	30	12	1- 0	16- 0	17- 0	20- 0
858	30	3	03	SWPS	150	23	0- 0	3- 0	7- 0	13- 0
858	30	3	03	SQFT	30	14	0- 0	5- 0	23- 1	19- 0
924	35	1	03	SWPS	150	7	0- 0	1- 1	2- 1	4- 1
924	35	1	03	SQFT	30	18	2- 0	6- 0	26- 0	22- 1
1015	40	3	05	SWPS	150	4	0- 0	0- 0	1- 0	3- 0
1015	40	3	05	SQFT	30	3	0- 0	2- 0	15- 1	32- 1
FIELD:95103										
565	19	3	02	SQFT	30	36	2- 0	10- 0	13- 0	7- 0
579		3	02	SWPS	150	431	0- 0	5- 2	21-19	24-17
637	20	1	05	SWPS	150	100	1- 0	15- 0	43- 1	41- 2
637	20	1	05	SQFT	30	27	0- 0	6- 0	4- 0	15- 1
663	25	2	06	SWPS	150	149	0- 0	4- 0	23- 0	23- 0
663	25	2	06	SQFT	20	36				
725	25	1	14	SWPS	150	7	1- 0	0- 0	2- 0	4- 1
725	25	1	14	SQFT	30	38	0- 0	6- 0	9- 1	35- 0
804	25	2	04	SWPS	150	940	0- 0	10- 0	65- 1	31- 1
804	25	2	04	SQFT	30	12	2- 0	4- 0	10- 0	34- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:95103										
858	27	3	02	SWPS	150	147	1- 0	19- 2	50- 1	39- 0
858	27	3	02	SQFT	30	27	0- 0	6- 0	11- 0	33- 0
924	35	1	03	SWPS	150	154	2- 0	1- 0	36-11	61-10
924	35	1	03	SQFT	30	25	0- 0	2- 0	25- 0	28- 0
1015	35	3	04	SWPS	150	5	0- 0	0- 0	1- 0	4- 0
1015	35	3	04	SQFT	30	4	0- 0	0- 0	6- 0	45- 1
FIELD: 1201										
320	22	1	04	SQFT	20	1				
492	33	1	05	SWPS	150	70	0- 0	14- 1	36- 3	0- 0
492	33	1	05	SQFT	30	14				
621				SWPS	150	56	0- 0	2- 0	14- 1	34- 1
FIELD: 1301										
320	20	1	10	SQFT	20	6				
492	35	1	04	SWPS	150	203	0- 0	31- 0	63- 0	9- 1
492	35	1	04	SQFT	30	57	4- 0	24- 0	24- 0	2- 0
533	35	1	09	SWPS	150	116	1- 0	24- 2	55- 3	30- 2
533	35	1	09	SQFT	20	63	2- 0	5- 0	31- 0	9- 1
599				SWPS	150	154	0- 0	0- 0	14- 0	36- 2
FIELD: 1302										
320	19	1	03	SQFT	20	5				
492	25	1	00	SWPS	150	90	0- 0	10- 0	56- 2	24- 0
492	25	1	00	SQFT	30	29	1- 0	4- 0	19- 0	4- 0
599				SWPS	150	28	0- 0	1- 0	9- 0	18- 0
FIELD: 1402										
220	11	2	03	SQFT	20	0				
320	13	1	04	SQFT	20	3				
492	21	1	03	SWPS	150	52	0- 0	3- 0	48- 5	1- 0
492	21	1	03	SQFT	30	10	4- 0	2- 0	4- 0	0- 0
599				SWPS	150	112	0- 0	6- 0	17- 0	27- 0
FIELD: 2101										
320	15	2	04	SQFT	20	3				
492	33	1	03	SWPS	150	67	0- 0	24- 0	39- 4	4- 0
492	33	1	03	SQFT	30	9	3- 0	2- 0	3- 0	1- 0
FIELD: 2102										
320	25	1	06	SQFT	20	5				
512	33	1	03	SWPS	150	251	0- 0	15- 0	27- 0	8- 0
512	33	1	03	SQFT	20	51	6- 0	15- 0	26- 1	1- 0
621				SWPS	150	412	0- 0	0- 0	25- 0	25- 0
FIELD: 2201										
320	15	1	03	SQFT	20	19				
386	20	1	03	SWPS	150	163	11- 0	39- 6	0- 0	0- 0
512	27	1	03	SWPS	150	807	4- 0	35- 1	49- 5	12- 2
512	27	1	03	SQFT	20	109	19- 0	21- 0	8- 0	1- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD: 2201										
621				SWPS	150	1104	0- 0	0- 0	20- 0	30- 3
FIELD: 2301										
320	13	1	07	SQFT	20	3				
386	17	1	00	SWPS	150	88	19- 0	31- 3	0- 0	0- 0
386	17	1	00	SQFT	20	22				
621				SWPS	150	804	0- 0	0- 0	25- 2	25- 0
FIELD: 2402										
320	16	1	06	SQFT	20	1				
512	21	1	08	SWPS	150	85	3- 0	19- 0	52- 6	12- 3
512	21	1	08	SQFT	30	31	5- 0	7- 0	13- 0	0- 0
621				SWPS	150	97	0- 0	0- 0	29-13	21-12
FIELD: 3101										
320	17	1	02	SQFT	20	14				
492	19	1	04	SWPS	150	387	1- 0	33- 2	53- 6	13- 3
492	19	1	04	SQFT	20	70	5- 0	21- 1	26- 0	2- 0
533	24	2	05	SQFT	20	79	7- 0	6- 0	31- 0	5- 0
599	25	3	08	SWPS	150	91	0- 0	5- 0	22- 0	23- 1
FIELD: 3102										
320	14	1	03	SQFT	20	25				
492	24	1	04	SWPS	150	125	1- 0	23- 0	82- 4	11- 0
492	24	1	04	SQFT	20	42	2- 0	11- 0	27- 0	2- 0
533	24	2	04	SQFT	20	51	3- 0	11- 0	28- 3	8- 1
599	30	2	13	SWPS	150	115	0- 0	1- 0	9- 0	40- 3
FIELD: 3301										
320	13	1	03	SQFT	20	39				
478	15	1	05	SWPS	150	78	7- 0	16- 0	30- 4	25- 5
478	15	1	05	SQFT	20	204	26- 0	21- 0	9- 0	1- 0
533	24	2	05	SWPS	150	0				
533	24	2	05	SQFT	20	263	2- 0	17- 0	29- 1	3- 0
599				SWPS	150	285	0- 0	6- 0	24- 1	20- 0
FIELD: 3401										
320	21	1	03	SQFT	20	6				
492	26	1	02	SWPS	150	376	0- 0	8- 0	32- 2	10- 1
492	26	1	02	SQFT	20	120	13- 0	11- 0	19- 0	0- 0
533	27	2	03	SQFT	20	62	1- 0	21- 0	12- 0	7- 0
599	25	2	09	SWPS	150	28	0- 0	2- 0	7- 0	19- 3
FIELD: 3402										
320	17	1	04	SQFT	20	4				
492	30	1	02	SWPS	150	72	10- 0	20- 0	42- 4	0- 0
492	30	1	02	SQFT	20	69	3- 0	17- 0	32- 1	2- 0
533	28	2	03	SQFT	20	73	1- 0	5- 0	32- 0	10- 0
599	30	3	09	SWPS	150	63	0- 0	0- 0	5- 0	45- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD: 5303										
320	10	1	05	SQFT	20	81				
492	20	1	03	SWPS	150	158	0- 0	13- 2	63-17	24-10
492	20	1	03	SQFT	20	72	0- 0	2- 0	36- 0	3- 0
533	16	2	07	SQFT	20	79	2- 0	12- 0	29- 0	11- 0
599	11	3	04	SWPS	150	308	0- 0	0- 0	10- 0	40- 4
FIELD: 5401										
320	10	1	04	SQFT	20	18				
478	18	1	06	SWPS	150	66	1- 0	21- 0	28- 2	0- 0
478	18	1	06	SQFT	20	103				
533	21	2	05	SQFT	20	52	7- 0	15- 0	20- 0	7- 0
599	15	3	03	SWPS	150	194	0- 0	0- 0	11- 0	39- 3
FIELD: 6201										
320	17	1	04	SQFT	20	15				
345	21	2	05	SQFT	30	6				
478	23	1	04	SWPS	150	18	0- 0	1- 0	16- 0	1- 0
478	23	1	04	SQFT	20	93	14- 0	11- 1	5- 0	0- 0
533	25	2	04	SQFT	20	110	17- 0	8- 0	12- 0	11- 0
565	30	2	03	SQFT	20	69	4- 0	7- 0	16- 0	25- 0
579	30	2	03	SWPS	150	124	0- 0	2- 0	8- 2	40- 8
637	35	1	03	SWPS	150	103	0- 0	13- 0	41- 0	46- 0
637	35	1	03	SQFT	20	62	1- 0	18- 0	17- 0	11- 0
663	27	1	05	SWPS	150	112	1- 0	11- 0	15- 0	23- 0
858	36	1	03	SWPS	150	168	0- 0	3- 0	6- 0	41- 2
FIELD: 6301										
320	19	1	04	SQFT	20	9				
345	17	3	03	SQFT	30	22				
478	29	1	04	SWPS	150	53	5- 0	23- 1	22- 0	0- 0
478	29	1	04	SQFT	20	100	3- 0	19- 0	12- 0	0- 0
533	26	2	03	SQFT	20	84	4- 0	14- 0	23- 0	11- 1
565	30	2	04	SQFT	20	62	5- 0	10- 0	18- 0	18- 0
579		2	04	SWPS	150	78	0- 0	2- 0	15- 0	33- 5
637	35	1	03	SWPS	150	37	0- 0	5- 0	17- 4	15- 1
643	35	1	03	SWPS	150	0				
643	35	1	03	SQFT	30	42	0- 0	6- 0	15- 0	21- 0
663	32	1	08	SWPS	150	248	0- 0	9- 0	20- 0	21- 2
858	37	1	03	SWPS	150	51	0- 0	0- 0	7- 1	42- 5
FIELD: 7101										
345	21	1	00	SQFT	30	2				
478	27	1	07	SWPS	150	102	0- 0	1- 0	46- 5	3- 1
478	27	1	07	SQFT	30	29	8- 0	3- 0	12- 0	1- 0
533	30	1	08	SWPS	150	46	0- 0	1- 0	28- 0	17- 1
533	30	1	08	SQFT	30	17	2- 0	5- 0	4- 0	6- 1
599				SWPS	150	138	0- 0	2- 0	12- 0	36- 3
637	28	1	06	SWPS	150	16	0- 0	0- 0	2- 0	14- 0
637	28	1	06	SQFT	30	8				

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD: 4101										
320	14	1	06	SQFT	20	60				
492	23	1	02	SWPS	150	487	13- 0	71- 3	45- 6	21- 5
492	23	1	02	SQFT	20	169	35- 0	9- 0	6- 0	0- 0
533	25	2	02	SQFT	20	203	6- 0	32- 0	13- 0	1- 0
599	25	2	10	SWPS	150	467	0- 0	3- 0	19- 0	28- 0
FIELD: 4201										
320	15	1	03	SQFT	20	47				
386	20	1	04	SWPS	150	229	13- 0	37- 4	0- 0	0- 0
386	20	1	04	SQFT	20	84	36- 0	12- 0	1- 0	0- 0
533	28	3	03	SQFT	20	178	9- 0	12- 0	24- 0	7- 0
599	30	2	10	SWPS	150	210	0- 0	3- 0	19- 0	28- 0
FIELD: 4202										
320	15	1	03	SQFT	20	47				
386	19	1	04	SWPS	150	36	9- 0	27- 3	0- 0	0- 0
386	19	1	04	SQFT	20	64	19- 0	25- 0	7- 0	0- 0
533	28	3	03	SQFT	20	106	3- 0	18- 0	21- 2	6- 0
599	30	3	08	SWPS	150	293	0- 0	4- 0	25- 0	21- 0
FIELD: 4301										
320	20	1	03	SQFT	20	56				
492	30	1	03	SWPS	150	1553	0- 0	7- 0	35- 0	8- 0
492	30	1	03	SQFT	20	497	3- 0	15- 0	29- 1	1- 0
533	33	2	03	SQFT	20	431	2- 0	4- 0	40- 0	9- 0
599	30	2	06	SWPS	150	970	0- 0	1- 0	10- 0	39- 1
FIELD: 4302										
320	22	1	03	SQFT	20	29				
492	33	1	02	SWPS	150	1250	1- 0	12- 1	18- 1	19- 2
492	33	1	02	SQFT	20	362	14- 0	14- 0	27- 0	0- 0
533	33	2	04	SQFT	20	426	5- 0	10- 0	25- 0	10- 0
599	30	2	07	SWPS	150	1711	0- 0	2- 0	25- 1	23- 0
FIELD: 5101										
FIELD: 5201										
345	12	3	02	SQFT	20	13				
FIELD: 5302										
320	17	1	03	SQFT	20	26				
492	25	1	02	SWPS	150	60	0- 0	9- 0	46- 4	5- 0
492	25	1	02	SQFT	20	83	6- 0	27- 1	14- 0	1- 0
533	21	2	04	SQFT	20	67	7- 0	14- 0	21- 0	9- 0
599	30	2	07	SWPS	150	230	0- 0	6- 0	26- 0	18- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD: 7101										
663	32	1	09	SWPS	250	27	0- 0	0- 0	11- 0	16- 0
858	30	1	04	SWPS	150	9	0- 0	0- 0	1- 0	8- 0
FIELD: 7102										
345	18	3	00	SQFT	30	4				
478	25	1	07	SWPS	150	70	1- 0	38- 0	31- 3	0- 0
478	25	1	07	SQFT	30	50				
533	24	1	06	SWPS	150	121	0- 0	11- 0	24- 2	15- 2
533	24	1	06	SQFT	30	28				
599				SWPS	150	247	0- 0	5- 0	20- 0	25- 3
637	38	1	05	SWPS	150	138	0- 0	1- 0	17- 0	32- 2
637	38	1	05	SQFT	20	103				
663	35	1	09	SWPS	150	95	0- 0	0- 0	18- 0	32- 2
858	39	1	04	SWPS	150	32	0- 0	0- 0	7- 0	25- 0
FIELD: 7201										
345	13	1	00	SQFT	30	43				
478	18	1	07	SWPS	150	1928	0- 0	35- 1	42- 5	22- 6
478	18	1	07	SQFT	20	283	18- 0	13- 0	9- 0	2- 0
533	18	1	06	SWPS	150	4281	1- 0	7- 0	63- 2	29- 4
533	18	1	06	SQFT	30	277	10- 0	29- 0	40- 0	1- 0
599				SWPS	150	1324	0- 0	2- 0	14- 0	34- 2
621	25	2	06	SQFT	30	164				
643	27	2	08	SWPS	300	1608	0- 0	0- 0	42-13	58-13
643	27	2	08	SQFT	20	109				
663	31	1	08	SWPS	150	500	0- 0	3- 0	18- 2	29- 1
858	32	1	08	SWPS	150	37	0- 0	0- 0	6- 0	31- 0
FIELD: 7202										
345	24	1	06	SQFT	30	16				
478	27	1	08	SWPS	150	361	0- 0	12- 0	22- 3	16- 1
478	27	1	08	SQFT	20	62	27- 0	36- 1	39- 0	0- 0
533	30	1	07	SWPS	150	181	1- 0	20- 2	65- 3	22- 0
533	30	1	07	SQFT	20	60	1- 0	3- 0	21- 0	1- 0
599				SWPS	150	380	0- 0	0- 0	2- 0	48- 2
637	30	1	02	SWPS	150	105	0- 0	0- 0	5- 0	45- 0
637	30	1	02	SQFT	30	75				
663	37	1	08	SWPS	150	83	0- 0	1- 0	10- 0	39- 0
858	42	1	08	SWPS	150	9	0- 0	0- 0	2- 0	7- 1
FIELD: 7302										
345	16	3	00	SQFT	30	39				
478	23	1	09	SWPS	150	616	1- 0	18- 1	27- 3	4- 0
478	23	1	09	SQFT	20	65				
533	24	1	09	SWPS	150	910	0- 0	4- 0	31- 3	15- 4
533	24	1	09	SQFT	20	115	2- 0	2- 0	28- 1	17- 0
599				SWPS	150	340	0- 0	1- 0	17- 0	32- 0
621	28	2	08	SQFT	30	42				
643	30	1	09	SWPS	150	87	0- 0	0- 0	28- 7	22- 4
643	30	1	09	SQFT	20	87				

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD: 7302										
663	30	1	06	SWPS	150	403	2- 0	17- 0	18- 0	13- 0
858	42	1	08	SWPS	150	135	0- 0	4- 0	15- 1	30- 2
FIELD: 7401										
345	12	3	00	SQFT	30	7				
478	21	1	07	SWPS	150	489	0- 0	7- 0	24- 5	19- 4
478	21	1	07	SQFT	30	22	1- 0	6- 0	14- 0	1- 0
533	22	1	04	SWPS	150	171	0- 0	0- 0	22- 2	28- 5
533	22	1	04	SQFT	30	26	4- 0	1- 0	13- 0	14- 1
599				SWPS	150	242	0- 0	0- 0	7- 0	43- 2
621	24	2	07	SQFT	30	18				
643	31	1	08	SWPS	150	63	0- 0	0- 0	18- 4	32- 1
643	31	1	08	SQFT	20	96				
663	29	1	08	SWPS	150	59	0- 0	5- 0	17- 1	28- 2
858	27	1	06	SWPS	150	3	1- 0	0- 0	0- 0	2- 1
FIELD: 7402										
345	15	3	00	SQFT	30	2				
478	16	1	05	SWPS	150	45	0- 0	9- 0	34- 0	2- 0
478	16	1	05	SQFT	30	13				
533	23	1	03	SWPS	150	20	1- 0	4- 0	10- 0	5- 0
533	23	1	03	SQFT	30	7	0- 0	4- 0	1- 0	2- 0
599				SWPS	150	28	0- 0	1- 0	12- 0	15- 0
621	32	1	03	SQFT	30	10				
643	30	1	02	SWPS	250	33	3- 0	7- 0	9- 1	14- 2
643	30	1	02	SQFT	20	21				
663	30	1	07	SWPS	150	75	0- 0	1- 0	22- 0	27- 1
858	30	1	04	SWPS	150	13	0- 0	2- 0	3- 0	8- 0
FIELD: 8101										
FIELD: 8102										
FIELD: 8103										
320	07	1	08	SQFT	20	1				
492	10	3	04	SWPS	150	89	3- 0	45- 1	45- 4	2- 0
492	10	3	04	SQFT	30	24	4- 0	16- 0	4- 0	0- 0
599				SWPS	150	29	0- 0	1- 0	12- 0	16- 0
FIELD: 8104										
320	18	1	06	SQFT	20	8				
492	26	2	02	SWPS	150	83	0- 0	13- 0	58- 4	12- 0
492	26	2	02	SQFT	30	16	2- 0	3- 0	7- 0	4- 0
599				SWPS	150	32	0- 0	0- 0	8- 0	24- 1
FIELD: 8201										
320	18	1	08	SQFT	24	2				
492	28	1	02	SWPS	150	74	4- 0	36- 0	34- 2	0- 0
492	28	1	02	SQFT	30	24	9- 0	4- 0	8- 0	1- 0
599				SWPS	150	70	0- 0	4- 0	17- 1	29- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD: 8202										
320	14	1	07	SQFT	20	2				
492	19	2	03	SWPS	150	47	2- 0	16- 0	28- 0	1- 0
492	19	2	03	SQFT	30	15	5- 0	3- 0	7- 0	0- 0
599				SWPS	150	233	0- 0	0- 0	6- 0	44- 1
FIELD: 8301										
320	17	1	07	SQFT	20	3				
492	27	2	04	SWPS	150	85	0- 0	26- 0	54- 3	5- 0
492	27	2	04	SQFT	30	14	0- 0	3- 0	11- 0	0- 0
621				SWPS	150	21	0- 0	0- 0	5- 0	16- 0
FIELD: 8302										
320	19	1	05	SQFT	20	3				
FIELD: 8303										
320	17	1	07	SQFT	20	13				
492	28	2	03	SWPS	150	71	0- 0	14- 0	52- 2	5- 1
492	28	2	03	SQFT	30	29	1- 0	10- 0	22- 0	0- 0
599				SWPS	150	62	0- 0	0- 0	31- 0	19- 0
FIELD:10101										
345	16	3	02	SQFT	30	30				
478	18	1	05	SWPS	150	324	10- 0	28- 4	28- 2	3- 0
478	18	1	05	SQFT	20	59				
533	25	1	07	SWPS	150	438	0- 0	3- 0	24- 2	23- 3
533	25	1	07	SQFT	20	142	5- 0	15- 0	23- 0	7- 0
565	25	3	00	SQFT	20	187	3- 0	6- 0	41- 0	2- 0
599	28	1	05	SWPS	150	362	0- 0	2- 0	23- 0	25- 1
637	28	1	07	SWPS	150	172	0- 0	1- 0	9- 0	40- 0
637	28	1	07	SQFT	20	158				
663	30	1	08	SWPS	150	1070	0- 0	0- 0	14- 0	36- 0
858	32	2	00	SWPS	150	7	0- 0	0- 0	2- 0	5- 0
FIELD:10201										
345	18	3	03	SQFT	30	11				
478	20	1	04	SWPS	150	112	2- 0	12- 1	35- 2	1- 0
478	20	1	04	SQFT	20	58	31- 0	14- 0	0- 0	0- 0
533	25	1	08	SWPS	150	106	5- 0	9- 0	26- 0	10- 0
533	25	1	08	SQFT	20	87	16- 0	19- 0	12- 1	5- 0
565	25	3	04	SQFT	20	167	13- 0	18- 0	15- 0	5- 1
599	28	1	05	SWPS	150	160	0- 0	2- 0	15- 1	33- 7
637	29	1	07	SWPS	150	180	0- 0	2- 0	10- 0	38- 1
637	29	1	07	SQFT	20	172				
663	40	1	06	SWPS	150	65	0- 0	4- 0	13- 0	33- 5
858	27	1	00	SWPS	250	10	0- 0	1- 0	4- 0	5- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:10202										
345	17	3	02	SQFT	30	13				
478	20	1	05	SWPS	150	179	1- 0	17- 1	25- 1	7- 0
478	20	1	05	SQFT	20	106	13- 0	26- 0	22- 0	2- 0
533	24	1	06	SWPS	150	72	0- 0	3- 0	16- 1	53- 7
533	24	1	06	SQFT	20	101	2- 0	11- 0	27- 0	5- 0
599	29	1	05	SWPS	150	30	0- 0	7- 0	17- 0	6- 0
637	31	1	07	SWPS	150	28	0- 0	6- 0	12- 0	10- 0
637	31	1	07	SQFT	20	40				
663	25	1	10	SWPS	150	322	0- 0	6- 0	12- 0	32- 0
858	30	1	05	SWPS	250	11	0- 0	0- 0	4- 0	7- 0
FIELD:10401										
345	15	3	00	SQFT	30	10				
478	21	1	08	SWPS	150	45	7- 0	18- 1	14- 1	6- 1
478	21	1	08	SQFT	20	127	38- 0	13- 0	5- 0	0- 0
533	21	1	07	SWPS	150	121	0- 0	6- 0	25- 2	19- 2
533	21	1	07	SQFT	20	161	14- 0	27- 0	5- 0	3- 0
565	21	3	00	SQFT	20	198	11- 0	34- 0	21- 0	4- 0
599	29	1	02	SWPS	150	70	1- 0	10- 0	27- 0	12- 0
637	31	1	08	SWPS	150	171	0- 0	2- 0	33- 0	15- 0
637	31	1	08	SQFT	20	203				
663	38	1	10	SWPS	150	140	0- 0	4- 0	22- 0	24- 0
858	30	1	03	SWPS	150	84	0- 0	2- 0	19- 0	29- 0
FIELD:11101										
345	16	3	05	SQFT	30	6				
386	18	1	00	SWPS	250	112	19- 0	31- 4	0- 0	0- 0
386	18	1	00	SQFT	22	50				
533	19	1	06	SWPS	150	356	0- 0	6- 0	34- 0	60-15
533	19	1	06	SQFT	20	112	12- 0	15- 0	27- 1	4- 0
599	24	1	04	SWPS	150	282	0- 0	4- 0	24- 0	22- 0
637	27	1	08	SWPS	150	204	0- 0	2- 0	24- 0	24- 0
637	27	1	08	SQFT	20	158				
663	29	1	10	SWPS	150	478	0- 0	7- 0	19- 0	24- 0
858	28	1	03	SWPS	150	207	0- 0	0- 0	6- 0	44- 0
FIELD:11102										
345	16	3	05	SQFT	30	1				
386	18	1	03	SWPS	250	62	13- 0	31- 0	6- 0	0- 0
386	18	1	03	SQFT	20	1				
533	20	1	07	SQFT	20	102	9- 0	9- 0	25- 0	7- 1
599	24	1	04	SWPS	150	251	0- 0	0- 0	16- 0	34- 2
637	25	1	08	SWPS	150	162	0- 0	0- 0	15- 0	35- 0
637	25	1	09	SQFT	20	191				
663	24	1	10	SWPS	150	789	0- 0	1- 0	27- 0	22- 0
858	28	1	03	SWPS	150	134	0- 0	0- 0	3- 0	47- 0

DD	CH	M	WI	UNIT	NSU	TOTC	1	2	3	4
FIELD:12204										
345	15	3	04	SQFT	20	24				
492	30	1	02	SWPS	150	61	1- 0	7- 0	36- 3	17- 2
492	30	1	02	SQFT	20	19	3- 0	7- 0	8- 0	1- 0
533	21	2	05	SQFT	30	28	4- 0	1- 0	4- 0	20- 1
599	25	2	06	SWPS	150	52	0- 0	4- 0	19- 0	27- 1
FIELD:13101										
320	16	1	06	SQFT	20	3				
492	28	1	04	SWPS	150	31	2- 0	11- 0	15- 0	3- 0
492	28	1	04	SQFT	30	19	4- 0	8- 0	8- 0	0- 0
544	24	3	03	SQFT	30	16	5- 0	3- 0	6- 0	0- 0
556	24	1	05	SWPS	250	39	0- 0	4- 0	21- 0	14- 5
599	28	1	03	SWPS	250	51	1- 0	10- 0	22- 1	17- 1
FIELD:14401										
320	20	1	00	SQFT	20	0				
492	24	1	02	SWPS	150	21	3- 0	17- 0	1- 0	0- 0
492	24	1	02	SQFT	30	27	10- 0	11- 0	6- 0	0- 0
533	25	3	05	SQFT	30	6				
556	25	1	05	SWPS	250	27	2- 0	15- 1	9- 0	1- 1
599	30	1	07	SWPS	150	61	2- 0	12- 0	25- 1	11- 0
FIELD:14402										
320	11	1	03	SQFT	20	0				
492	15	1	00	SWPS	150	124	10- 0	40- 0	68- 6	6- 0
492	15	1	00	SQFT	30	25	2- 0	2- 0	17- 0	2- 0
533	21	3	06	SWPS	150	42	0- 0	6- 0	18- 1	18- 3
533	21	3	06	SQFT	30	24	7- 0	28- 0	24- 0	14- 0
599	26	1	07	SWPS	150	83	0- 0	2- 0	12- 0	36- 1
FIELD:15301										
320	17	1	03	SQFT	20	1				
492	21	1	06	SWPS	150	2275	0- 0	7- 0	26- 2	17- 2
492	21	1	06	SQFT	30	153	1- 0	16- 0	31- 0	2- 0
544	22	1	06	SQFT	20	104	0- 0	2- 0	27- 0	24- 0
556	22	1	05	SWPS	150	941	0- 0	7- 0	21- 0	22- 0
599	23	1	15	SWPS	150	1014	0- 0	0- 0	2- 0	48- 0
FIELD:15401										
512	27	1	04	SWPS	250	30	10- 0	5- 0	6- 0	0- 0
512	27	1	04	SQFT	30	45	11- 0	17- 0	15- 0	0- 0
544	26	3	05	SQFT	20	1	0- 0	0- 0	1- 0	0- 0
556	26	1	02	SWPS	250	6	1- 0	2- 0	3- 0	0- 0
599	31	1	10	SWPS	250	10	4- 0	3- 0	2- 0	1- 0
FIELD:15402										
320	17	1	10	SQFT	20	1				
492	22	1	05	SWPS	150	202	3- 0	15- 0	32- 0	0- 0
492	22	1	05	SQFT	30	127	9- 0	20- 0	15- 0	2- 0
FIELD:11201										
478	20	1	03	SWPS	150	116	3- 0	31- 2	14- 0	2- 0
478	20	1	03	SQFT	20	152	30- 0	17- 0	4- 0	0- 0
533	22	1	07	SWPS	150	118	5- 0	40- 0	57-12	16- 4
533	22	1	07	SQFT	20	313	8- 0	26- 0	14- 0	2- 0
599	29	1	05	SWPS	150	489	0- 0	3- 0	19- 0	28- 9
637	24	1	06	SWPS	150	607	0- 0	2- 0	23- 0	25- 0
637	24	1	06	SQFT	20	323				
663	32	1	08	SWPS	150	739	0- 0	3- 0	13- 0	34- 0
858	28	1	06	SWPS	150	35	0- 0	1- 0	16- 3	17- 2
FIELD:11202										
599	29	1	05	SWPS	0	-1				
FIELD:11203										
478	20	1	03	SWPS	150	64	0- 0	15- 0	35- 4	0- 0
478	20	1	03	SQFT	20	78	2- 0	27- 0	16- 0	0- 0
533	22	3	06	SQFT	20	52	7- 0	14- 0	11- 0	19- 0
556	28	1	07	SWPS	150	50	0- 0	2- 0	25- 0	23- 0
599	30	1	05	SWPS	150	44	0- 0	0- 0	2- 0	42- 0
637	26	1	08	SWPS	150	29	0- 0	0- 0	1- 0	28- 0
637	26	1	08	SQFT	20	43				
663	33	1	07	SWPS	150	107	0- 0	2- 0	8- 0	40- 4
858	28	1	06	SWPS	250	20	0- 0	0- 0	4- 0	16- 0
FIELD:12101										
533	21	2	07	SQFT	30	33	2- 0	6- 0	22- 0	2- 0
FIELD:12102										
320	07	1	06	SQFT	20	7				
478	15	1	05	SWPS	150	291	2- 0	19- 2	29- 6	0- 0
478	15	1	05	SQFT	20	159				
599	20	2	03	SWPS	150	974	0- 0	1- 0	15- 0	34- 1
FIELD:12201										
320	12	1	04	SQFT	20	9				
478	18	1	07	SWPS	150	53	1- 0	17- 0	30- 0	2- 0
478	18	1	07	SQFT	20	41	7- 0	14- 0	14- 0	1- 0
533	23	2	03	SQFT	20	55	0- 0	8- 0	34- 0	8- 0
599	25	2	03	SWPS	150	118	0- 0	0- 0	13- 0	37- 5
FIELD:12202										
320	13	1	06	SQFT	20	13				
492	23	1	02	SWPS	150	69	0- 0	5- 0	51- 2	13- 0
492	23	1	02	SQFT	20	47	2- 0	26- 0	18- 0	2- 0
533	24	2	05	SQFT	30	42	4- 0	7- 0	16- 0	17- 0
599	25	3	04	SWPS	150	361	0- 0	4- 0	23- 0	23- 0
FIELD:15402										
533	22	1	05	SWPS	150	0				
533	22	1	05	SQFT	20	97	2- 0	20- 0	39- 0	5- 0
556	20	1	05	SWPS	150	273	0- 0	14- 0	19- 0	17- 2
599	31	1	10	SWPS	150	207	0- 0	0- 0	14- 0	36- 2
FIELD:15404										
512	24	1	03	SWPS	150	57	0- 0	11- 0	41- 2	5- 0
512	24	1	03	SQFT	20	106	3- 0	10- 0	33- 0	4- 1
544	33	1	02	SQFT	20	55	3- 0	8- 0	31- 0	11- 0
556	33	1	02	SWPS	150	55	0- 0	7- 0	24- 0	19- 0
599	32	1	10	SWPS	150	52	0- 0	4- 0	21- 0	25- 0
FIELD:16301										
512	31	1	04	SWPS	150	362	0- 0	0- 0	3- 0	47- 3
512	31	1	04	SQFT	20	72	2- 0	1- 1	52- 2	10- 3
544	27	1	02	SQFT	20	63	0- 0	7- 0	11- 0	35- 0
556	27	1	02	SWPS	150	265	0- 0	0- 0	2- 0	48- 4
599	30	1	10	SWPS	150	54	0- 0	0- 0	2- 0	48- 1
FIELD: 7403										
FIELD: 1401										
320	13	1	00	SQFT	20	0				
492	16	1	04	SWPS	150	87	0- 0	6- 0	18- 2	26- 7
492	16	1	04	SQFT	30	13	2- 0	1- 0	7- 1	3- 0
599				SWPS	150	66	0- 0	0- 0	8- 0	42- 3

Appendix 6c. PWS adult count data.

DD = degree days base 48°F

CH = crop height (inches)

M = field wetness (1=dry; 2=damp; 3=wet)

WI = wind speed (mph)

SWP = number of sweeps

ASWP = number of adults in SWP

SQ = number of linear feet

ASQ = number of adults in SQ

DD	CH	M	WI	SWP	ASWP
FIELD: 1303					
512				300	35
599				150	73
663	12	2	12	150	63
725	07	1	10	150	22
829	12	1	05	150	18
858	16	3	00	150	46
924	17	1	04	150	14
1015	22	1	03	150	2
FIELD: 1403					
725	06	1	15	250	2
804	13	1	08	150	3
858	11	3	03	150	3
924	13	1	02	150	12
1015	11	1	04	250	12
FIELD: 2103					
621	09	1	07	150	6
725	08	1	15	150	3
804	14	1	05	150	30
858	11	3	03	150	31
924	15	1	03	150	15
1015	18	1	05	150	11
FIELD: 2401					
725	07	1	15	150	4
804	14	1	05	150	13
858	12	3	03	150	24
924	13	3	03	150	17
1015	14	1	05	150	18
FIELD: 3403					
725	07	1	10	150	4
804	10	1	03	150	64
858	13	1	03	150	11
924	13	3	00	150	9
1015	14	3	08	250	8
FIELD: 6101					
637	09	1	03	150	26
663	10	2	07	150	45
725	10	1	04	150	21
804	15	1	04	150	1
858	18	1	04	150	60
924	24	2	03	150	56
1015	20	1	04	150	6

DD	CH	M	WI	SWP	ASWP
FIELD: 7203					
599				250	0
643	18	3	04	150	0
663	20	3	00	250	0
725	20	1	10	250	2
804	24	1	05	250	0
858	19	3	00	250	4
924	19	3	02	250	0
1015	28	3	05	250	0
FIELD:10203					
533	08	3	05	250	0
725	12	1	09	150	2
804	15	1	05	150	3
858	11	2	00	150	2
924	14	3	00	150	4
1015	20	3	05	250	8
FIELD:12205					
478	10	1	07	150	45
858	28	1	02	150	0
924	30	2	03	150	2
1015	25	1	03	150	0
FIELD:12206					
478	08	1	07	150	5
858	24	1	02	150	13
924	27	2	03	150	0
1015	25	1	03	150	1
FIELD:12207					
478	08	1	06	150	48
858	24	1	02	150	3
924	27	2	03	150	5
1015	28	2	03	150	0
FIELD:91101					
533	13	3	05	150	13
599				150	14
637	22	1	07	150	15
663	18	2	06	300	64
725	30	1	10	150	56
804	27	1	10	150	26
891	27	1	07	150	11
924	27	1	03	150	3
1015	33	2	05	150	1

DD	CH	M	WI	SWP	ASWP
FIELD:91102					
599				150	10
637	23	1	06	150	3
663	20	2	07	150	4
725	27	1	10	150	8
804	30	1	07	150	1
858	27	3	00	150	2
924	30	1	03	150	0
1015	33	2	05	150	0
FIELD:91103					
599				150	6
637	22	1	08	150	0
663	20	2	06	150	2
725	33	1	12	150	0
804	30	1	07	150	2
891	27	1	03	150	0
924	27	1	03	150	0
1015	30	2	05	250	0
FIELD:91104					
533	13	3	04	150	34
599				150	16
637	21	1	06	150	7
663	20	1	07	150	5
725	26	2	08	150	6
804	28	1	07	150	5
858	27	3	00	150	5
924	30	1	03	150	0
1015	33	2	05	150	0
FIELD:92101					
599			00	150	8
637	22	1	07	150	21
663	15	2	08	150	0
725	33	1	15	150	0
804	27	2	07	150	3
891	27	2	07	150	0
924	27	1	03	150	0
1015	31	2	05	150	0
FIELD:92102					
599				150	9
637	18	1	08	150	3
663	15	2	08	150	4
725	33	1	15	150	5
804	27	2	07	150	7
858	27	3	00	150	0

DD	CH	M	WI	SWP	ASWP
FIELD:92102					
891	27	2	07	150	0
924	27	1	03	150	0
1015	29	2	05	150	0
FIELD:93101					
579		3	02	150	26
FIELD:93102					
579		3	02	150	19
FIELD:93103					
579	19	3	02	150	7
FIELD:94101					
663	20	1	07	150	35
725	15	1	07	150	5
804	23	1	05	150	2
858	29	3	03	150	3
924	30	1	02	150	3
1015	38	3	04	150	0
FIELD:95101					
579		3	03	150	23
637	18	1	05	150	12
663	20	2	08	150	8
725	22	1	11	150	0
804	30	2	03	150	2
858	30	3	04	150	1
924	35	1	0	150	1
1015	40	3	04	150	0
FIELD:95102					
579	20	3	03	150	13
637	18	1	05	150	6
663	20	2	08	150	7
725	22	1	13	150	3
804	30	2	04	150	7
858	30	3	03	150	2
924	35	1	03	150	0
1015	40	3	05	150	0
FIELD:95103					
579		3	02	150	7
637	20	1	05	150	3
663	25	2	06	150	2
725	25	1	14	150	0
804	25	2	04	150	107
858	27	3	02	150	3
924	35	1	03	150	0
1015	35	3	04	150	4

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
FIELD: 1201							
91	8	1	6			100	0
101	8	1	5			100	0
121	9	1	5			100	0
132	10	3	7	150	26		
154	10	1	5	150	88	60	13
210	15	3	0	150	51	80	1
231	16	3	5	150	59	60	7
290	22	1	5	120	66	80	17
492	33	1	05	150	19		
621				150	3		
FIELD: 1301							
91	6	1	5			100	0
101	6	2	7			100	0
121	8	1	5			60	12
132	10	3	7	150	75		
154	12	1	6	150	83	60	16
210	14	3	3	150	132	60	11
225	17	1	10	150	94	56	33
290	20	1	12	150	46	60	5
492	35	1	04	150	20		
533	35	1	09	150	5		
599				150	6		
FIELD: 1302							
91	8	1	5			100	0
101	8	3	2			80	1
121	9	1	3			100	0
154	10	3	6	150	27	100	0
210	16	3	0	150	6	100	0
225	16	1	8	150	5	100	0
290	19	1	12	150	3	100	0
492	25	1	00	150	9		
599				150	1		
FIELD: 1402							
91	6	1	5			100	0
101	6	1	4			100	0
121	6	1	2			100	0
154	7	1	7			80	2
201	8	2	8			80	3
225	10	1	10	150	44	60	4
290	13	1	12	150	63	60	13
492	21	1	03	150	8		
599				150	5		

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
FIELD: 2101							
91	7	1	7			60	6
101	5	1	3			60	3
121	6	1	4			60	8
154	7	1	6			60	3
201	11	3	4			60	6
210	11	2	6	150	53		
225	12	1	8	150	74	60	31
290	15	1	5	105	110	60	47
492	33	1	03	150	68		
FIELD: 2102							
91	8	1	7			60	6
101	10	1	5			60	5
121	11	2	6			60	44
132	13	3	4	150	152		
154	16	1	8	150	185	60	21
201	18	3	5			60	8
210	19	1	7	150	52		
225	15	1	10	150	25	60	3
290	25	1	7	150	13	80	4
512	33	1	03	150	8		
621				150	6		
FIELD: 2201							
91	5	1	5			60	7
101	8	1	5			60	10
121	8	1	4			60	28
154	10	1	8	150	265	60	48
210	13	1	7	105	157	56	43
225	13	1	7	150	136	60	35
290	15	1	8	150	71	60	11
386	20	1	03	150	231		
512	27	1	03	150	7		
621				150	4		
FIELD: 2301							
91	3	1	10			100	0
101	3	1	6			100	0
121	5	2	7			80	3
154	6	1	10			80	2
201	8	2	7			60	23
231	9	1	5			60	11
290	13	1	10	150	160	60	36
386	17	1	00	150	175		
621				150	22		

FIELD: 2402

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	5	1	3			80	1
101	5	1	5			60	2
121	8	2	6			80	2
154	10	1	7	150	14	80	1
201	14	3	5			60	5
210	13	2	5	150	49		
225	10	1	10	150	27	60	8
290	16	1	7	150	60	60	12
512	21	1	08	150	8		
621				150	7		

FIELD: 3101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	2	6			80	3
101	5	1	3			80	1
121	6	3	7			60	1
154	8	1	7	150	92	60	13
201	9	2	5	150	169	54	34
231	8	2	5	150	133	60	13
290	10	1	7	150	242	60	8
492	19	1	04	150	66		
599	25	3	08	150	7		

FIELD: 3102

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	3	8			100	2
101	3	2	5			80	4
121	7	3	4			60	3
154	10	1	8	150	151	60	12
201	10	2	5	150	112	60	14
231	11	2	3	150	156	60	10
290	14	1	9	150	199	60	18
492	24	1	04	150	45		
599	30	2	13	150	1		

FIELD: 3301

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	2	2	2			100	0
101	3	1	5			100	1
121	5	3	5			100	0
154	5	1	8			60	24
201	9	3	3	150	117	60	23
231	9	1	3	150	293	50	39
290	14	1	4	150	358	60	28
478	15	1	05	150	5		
533	24	2	05	150	0		
599				150	8		

FIELD: 3401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	2	3			80	3
101	5	3	6			80	4
121	7	3	7			80	1
154	12	1	8	150	192	60	9
201	14	3	6	150	285	60	7
231	20	1	5	150	297	60	12
290	16	1	8	150	131	60	16
492	26	1	02	150	17		
599	25	2	09	150	7		

FIELD: 3402

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	2	0			80	6
101	7	2	2			80	2
121	8	3	6	150	21	60	4
132	10	1	6	150	40	60	5
154	10	1	15	150	39	60	8
201	12	2	4	150	52	60	5
231	17	1	4	150	43	60	4
290	20	1	7	150	44	60	5
492	30	1	02	150	21		
599	30	3	09	150	5		

FIELD: 4101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	6	1	3			60	6
101	5	1	7			60	18
121	7	3	8			60	4
154	8	1	6	150	156	60	32
201	11	2	4	150	193	60	33
231	12	2	3	150	248	60	29
290	14	1	5	150	360	60	33
492	23	1	02	150	22		
599	25	2	10	150	15		

FIELD: 4201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	5	1	4			60	8
101	6	1	6			60	4
121	7	3	5			60	13
154	9	1	6	150	169	56	28
201	11	2	5	150	462	58	25
231	15	3	3	150	253	60	22
290	18	1	8	150	171	60	12
386	20	1	04	150	57		
599	30	2	10	150	5		

FIELD: 4202

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	1	4			60	8
101	4	1	6			60	9
121	7	3	5			60	11
154	9	1	6	150	350	48	48
201	11	3	4	150	272	50	64
231	15	3	3	150	236	58	22
290	20	1	8	150	298	60	11
386	19	1	04	150	83		
599	30	3	08	150	9		

FIELD: 4301

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	1	4			60	7
101	4	2	4			60	10
121	10	3	7	150	83	60	17
132	9	1	4	150	87	56	53
154	12	1	6	150	884	30	77
201	13	3	4	150	587	40	44
231	17	1	6	150	654	46	67
290	22	1	6	150	250	50	34
492	30	1	03	150	28		
599	30	2	06	150	1		

FIELD: 4302

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	5	1	6			54	41
101	4	0	7			60	10
121	7	3	3	150	78	60	21
132	9	1	2	150	119	54	32
154	12	1	5	150	741	44	69
201	13	3	3	150	703	48	58
231	17	1	4	150	546	42	63
290	20	1	6	90	446	52	32
492	33	1	02	150	58		
599	30	2	07	150	20		

FIELD: 5101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
101	3	2	9			80	2

FIELD: 5201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	2	4			60	15
101	4	2	4			60	11
121	6	3	3			100	0
154	8	1	4	150	140	56	26
201	11	2	4	150	159	60	18
290	15	1	7	150	172	60	15

FIELD: 5302

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	2	0			80	14
101	4	2	5			80	2
121	4	3	2			60	1
154	9	1	6	150	155	60	23
201	12	3	3	150	139	60	13
231	12	1	5	150	193	60	5
290	10	1	8	150	139	60	7
492	25	1	02	150	13		
599	30	2	07	150	9		

FIELD: 5303

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	2	2	4			80	2
101	3	2	5			100	1
121	5	3	2			60	2
154	4	1	2			60	16
201	9	3	3	150	126	60	21
231	7	1	3	150	129	60	14
290	10	1	8	150	75	60	4
492	20	1	03	150	220		
599	11	3	04	150	72		

FIELD: 5401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	2	3			80	4
121	6	3	5			60	1
154	6	1	5			60	6
201	7	3	7	150	74	60	5
231	6	1	5	150	67	60	5
290	10	1	9	150	73	60	12
478	18	1	06	150	13		
599	15	3	03	150	18		

FIELD: 6201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	2	4			80	10
101	5	2	4			60	4
121	7	3	5			60	1
154	10	1	6	150	88	60	10
201	14	3	4	150	60	58	18
231	20	1	5	150	104	60	16
290	17	1	10	150	208	60	24
478	23	1	04	150	15		
579	30	2	03	150	22		
637	35	1	03	150	8		
663	27	1	05	150	15		
858	36	1	03	150	2		

FIELD: 6301

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	6	2	5			60	3
101	7	2	8			80	2
121	9	3	4	150	69	60	1
132	9	1	6	150	38	60	1
154	11	1	6	150	146	60	28
201	15	3	6	150	44	60	3
231	15	1	6	150	189	60	3
290	20	1	9	150	69	60	7
478	29	1	04	150	3		
579		2	04	150	10		
637	35	1	03	150	4		
643	35	1	03	150	0		
663	32	1	08	150	5		
858	37	1	03	150	3		

FIELD: 7101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	1	2			60	5
101	8	2	6			80	2
121	8	1	4			60	2
132	10	3	3	150	21		
154	10	1	6	150	44	60	5
210	11	3	6	150	6	100	0
225	16	1	9	150	4	100	0
290	21	1	9	150	11	100	0
478	27	1	07	150	7		
533	30	1	08	150	5		
599				150	1		
637	28	1	06	150	7		
663	32	1	09	250	3		
858	30	1	04	150	0		

FIELD: 7102

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	1	6			100	1
101	8	2	6			60	5
121	8	2	4			80	9
132	10	3	8	150	37		
154	11	1	2	150	79	60	15
201	11	3	7			60	6
210	15	3	6	150	41		
225	18	1	10	150	43	60	17
290	18	1	9	150	106	60	12
478	25	1	07	150	39		
533	24	1	06	150	31		
599				150	23		
637	38	1	05	150	13		
663	35	1	09	150	4		
858	39	1	04	150	0		

FIELD: 7201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	1	10			80	1
101	4	1	4			100	3
121	7	2	6			80	3
154	7	1	8			60	36
201	11	2	8	150	190	60	54
231	12	1	3	150	171	60	21
290	13	1	8	150	81	60	14
478	18	1	07	150	8		
533	18	1	06	150	91		
599				150	7		
643	27	2	08	300	35		
663	31	1	08	150	2		
858	32	1	08	150	7		

FIELD: 7202

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	9	1	6			80	4
101	6	1	4			60	4
121	8	3	6			80	2
132	12	2	4	150	73		
154	10	1	6	150	33	80	10
201	15	2	5	150	48	60	3
231	17	3	3	150	33	60	3
290	24	1	7	150	16	60	2
478	27	1	08	150	7		
533	30	1	07	150	8		
599				150	2		
637	30	1	02	150	2		
663	37	1	08	150	4		
858	42	1	08	150	0		

FIELD: 7302

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	3	4			100	0
101	7	1	5			60	3
121	7	2	5			80	6
154	8	1	3			60	23
201	12	2	7	150	18	80	1
231	13	3	7	150	137	60	36
290	16	1	9	150	76	60	3
478	23	1	09	150	18		
533	24	1	09	150	6		
599				150	6		
643	30	1	09	150	0		
663	30	1	06	150	4		
858	42	1	08	150	0		

FIELD: 7401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	8	1	7			60	4
101	12	1	7			100	0
121	7	2	5			80	5
154	6	2	2			60	8
201	10	3	6			60	5
210	10	3	6	150	3		
231	12	3	6	150	9	60	7
290	12	1	7	150	7	60	2
478	21	1	07	150	9		
533	22	1	04	150	24		
599				150	18		
643	31	1	08	150	1		
663	29	1	08	150	1		
858	27	1	06	150	0		

FIELD: 7402

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	18	3	10			80	1
101	7	1	6			80	1
121	8	1	2			100	0
154	8	1	2			100	0
201	9	3	5			100	0
210	10	3	6	150	4		
231	14	3	5	150	14	100	1
290	15	1	8	150	15	100	0
478	16	1	05	150	19		
533	23	1	03	150	10		
599				150	5		
643	30	1	02	250	14		
663	30	1	07	150	6		
858	30	1	04	150	2		

FIELD: 8101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	4	1	8			80	1

FIELD: 8102

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	3	1	8			100	0

FIELD: 8103

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	3	1	5			60	2
101	3	1	5			100	0
121	3	1	3			80	2
154	5	1	7			100	0
201	6	2	7			100	0
225	7	1	10			60	5
290	7	1	12			100	0
492	10	3	04	150	37		
599				150	7		

FIELD: 8104

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	5	1	8			60	2
101	5	1	5			60	3
121	6	1	3			80	2
154	11	1	6	150	40	60	3
201	13	3	7			60	4
210	13	2	6	150	45		
225	14	1	10	150	67	60	7
290	18	1	12	150	19	60	3
492	26	2	02	150	4.		
599				150	3		

FIELD: 8201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	6	1	7			80	1
101	6	1	4			100	0

FIELD: 8201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
121	6	1	5			100	0
154	9	1	6	150	82	60	8
201	13	3	4			60	4
210	13	2	5	150	116		
225	17	1	10	150	89	60	27
290	18	1	12	150	62	60	10
492	28	1	02	150	102		
599				150	17		

FIELD: 8202

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	5	1	5			100	0
101	6	1	3			100	0
121	7	1	3			60	10
154	8	1	6			100	3
201	11	3	5			60	16
210	10	2	5	150	80		
231	12	3	5	150	38	60	6
290	14	1	12	150	7	60	2
492	19	2	03	150	5		
599				150	10		

FIELD: 8301

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	5	1	8			100	0
101	6	1	3			80	1
121	7	1	4			60	2
154	9	1	4			80	5
201	12	3	6			100	0
210	11	3	4	150	3		
231	12	3	5	150	19	60	4
290	17	1	14	150	0	100	0
492	27	2	04	150	0		
621				150	0		

FIELD: 8302

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	8	2	4			100	0
101	4	2	5			100	10
121	9	1	2			100	0
154	13	1	5	150	35	60	6
201	16	3	4			100	1
210	19	3	4	150	5		
231	19	3	5	150	6	60	4
290	19	1	14	150	0	100	0

FIELD: 8303

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
101	12	1	4			60	4
154	8	1	5			60	21
201	14	2	7	150	20	80	4
231	11	3	3	150	58	60	10
290	17	1	14	150	3	80	1
492	28	2	03	150	11		
599				150	18		

FIELD:10101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	5	1	0			60	1
101	6	1	3			60	4
121	10	2	6	150	31	60	2
154	10	1	7	150	38	60	6
201	12	3	5	150	263	60	92
225	14	1	6	150	101	60	27
290	17	1	13	150	113		
478	18	1	05	150	8		
533	25	1	07	150	3		
599	28	1	05	150	6		
637	28	1	07	150	2		
663	30	1	08	150	11		
858	32	2	00	150	1		

FIELD:10201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	7	1	2			60	3
101	6	1	8			60	7
121	7	2	7			60	3
154	10	1	6	150	53	60	17
201	10	3	10	150	34	60	6
225	13	1	10	150	9	60	3
290	16	1	13	150	44		
478	20	1	04	150	8		
533	25	1	08	150	1		
599	28	1	05	150	0		
637	29	1	07	150	2		
663	40	1	06	150	1		
858	27	1	00	250	1		

FIELD:10202

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	5	2	2			60	6
101	4	1	8			60	7
121	7	2	7			60	2
154	10	1	5	150	42	60	9
201	10	3	5	150	97	60	29
225	15	1	6	150	41	60	4
290	16	1	14	150	24		
478	20	1	05	150	2		
533	24	1	06	150	0		
599	29	1	05	150	10		
637	31	1	07	150	2		
663	25	1	10	150	2		
858	30	1	05	250	0		

FIELD:10401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	6	2	7			80	1
110	7	1	6			60	6
132	8	2	6			60	12
170	10	1	3	150	167	60	16
201	12	1	10	150	64	60	22
231	17	1	6	150	446	60	20
290	19	1	13	60	144		
478	21	1	08	150	177		
533	21	1	07	150	53		
599	29	1	02	150	31		
637	31	1	08	150	28		
663	38	1	10	150	7		
858	30	1	03	150	1		

FIELD:11101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	3	2			60	3
101	4	1	6			80	2
121	7	1	4			60	7
154	9	1	5	150	73	60	23
201	13	3	5	150	135	60	27
225	12	1	10	150	64	60	7
290	18	1	12	150	204		
386	18	1	00	250	439		
533	19	1	06	150	27		
599	24	1	04	150	7		
637	27	1	08	150	6		
663	29	1	10	150	2		
858	28	1	03	150	0		

FIELD:11102

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	6	2	2			80	2
101	5	1	8			80	1
121	6	1	4			60	11
154	8	1	5	150	20	60	5
201	10	3	10	150	90	60	10
225	12	1	10	150	134	60	17
290	13	1	12	150	162		
386	18	1	03	250	896		
599	24	1	04	150	23		
637	25	1	08	150	15		
663	24	1	10	150	42		
858	28	1	03	150	5		

FIELD:11201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	1	6			80	6
101	5	1	8			100	6
132	4	3	0			60	3
154	10	1	6	150	24	60	12
201	11	3	10	150	210	60	66
225	10	1	8	150	141	60	17
290	13	1	12	150	262		
290	11	1	14	150	432		

FIELD:11201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
478	20	1	03	150	7		
533	22	1	07	150	11		
599	29	1	05	150	9		
637	24	1	06	150	3		
663	32	1	08	150	4		
858	28	1	06	150	0		

FIELD:11202

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	1	7			60	2
599	29	1	05	150	9		

FIELD:11203

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
101	6	1	6			60	4
132	11	3	4			60	12
154	11	1	10	150	37	60	10
201	14	2	10	150	15	60	1
225	20	1	6	150	26	60	2
290	18	1	11	150	77		
478	20	1	03	150	12		
556	28	1	07	150	4		
599	30	1	05	150	0		
637	26	1	08	150	2		
663	33	1	07	150	6		
858	28	1	06	250	0		

FIELD:12101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	1	2			60	8
101	8	1	8			90	2
121	8	1	6			60	2
154	12	1	5	150	26	80	6
201	14	3	6	150	5	60	3
225	17	1	10	150	7	80	1

FIELD:12102

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	2	3	2			80	1
101	5	1	8			100	1
121	3	1	5			60	4
154	7	1	5	150	32	60	3
201	7	3	7	150	18	60	4
225	12	1	10	150	67	60	41
290	11	1	10	150	187	60	19
478	15	1	05	150	16		
599	20	2	03	150	30		

FIELD:12201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	7	2	4			60	0
101	6	1	8			80	4
121	7	1	8	150	55	60	14
154	10	1	5	150	36	60	7
201	11	3	8	150	30	60	5

FIELD:12201

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
225	19	1	10	150	12	80	2
290	20	1	12	150	19		
478	18	1	07	150	3		
599	25	2	03	150	4		

FIELD:12202

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	6	1	5			80	1
101	5	1	8			60	1
121	6	1	6	75	64	80	2
154	9	2	3	150	89	60	43
201	11	3	9	150	168	60	41
225	14	1	8	150	95	60	5
290	17	1	10	150	85		
492	23	1	02	150	15		
599	25	3	04	150	9		

FIELD:12204

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	1	5			80	2
101	7	1	7			60	4
121	9	1	8	75	20	60	10
154	13	2	4	150	5	60	6
201	14	3	8	150	9	60	2
225	16	1	9	150	3	60	2
492	30	1	02	150	2		
599	25	2	06	150	6		

FIELD:13101

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	3	1	2			60	2
101	4	1	6			90	0
132	5	3	3			80	1
154	10	1	10	150	3	100	0
201	14	1	10	150	5	80	1
225	13	2	6	150	3	80	2
290	14	1	12	150	53		
492	28	1	04	150	2		
556	24	1	05	250	5		
599	28	1	03	250	11		

FIELD:14401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	4	1	15			100	0
110	7	1	0			80	3
132	6	3	4			100	1
154	8	1	5	150	44	60	8
210	11	2	7	150	52	80	5
225	15	1	6	150	57	60	4
290	20	1	8	150	80		
492	24	1	02	150	61		
556	25	1	05	250	13		
599	30	1	07	150	75		

FIELD:14402

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	4	1	2			100	0
110	4	2	4			100	0
132	4	3	5			100	0
154	6	1	10			60	1
210	10	2	7	150	5	80	2
225	9	1	8	150	7	100	0
290	11	1	10	150	20		
492	15	1	00	150	39		
533	21	3	06	150	5		
599	26	1	07	150	5		

FIELD:15301

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	3	2	6			80	1
110	6	2	6			60	6
132	7	3	4			80	4
154	8	1	10	150	108	60	23
210	11	1	5	150	200	60	16
290	14	1	13	105	91		
492	21	1	06	150	6		
556	22	1	05	150	12		
599	23	1	15	150	8		

FIELD:15401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	7	2	7			100	0
110	8	2	8			80	1
132	10	2	6			60	17
170	11	1	3	150	160	60	11
210	15	1	4	150	25	60	1
290	17	1	5	150	18	60	1
512	27	1	04	250	11		
556	26	1	02	250	9		
599	31	1	10	250	1		

FIELD:15402

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	7	3	5			100	0
110	6	2	7			80	2
132	9	3	4			80	14
154	10	1	10	150	91	60	15
210	11	1	10	150	212	60	37
231	14	1	8	150	116	60	11
290	17	1	7	150	418	60	42
492	22	1	05	150	12		
533	22	1	05	150	0		
556	20	1	05	150	7		
599	31	1	10	150	6		

FIELD:15404

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	2	4			60	7
110	8	2	8			60	3
132	12	2	5			60	23
154	12	1	7	150	108	60	15
210	15	1	4	150	92	60	6
231	8	1	7	150	31	60	6
290	16	1	9	150	221	60	3
512	24	1	03	150	18		
556	33	1	02	150	14		
599	32	1	10	150	3		

FIELD:16301

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
87	8	1	2			80	1
110	8	2	8			80	1
132	10	2	6			60	5
170	11	1	03	150	163	60	14
170	11	1	03	150	163	60	14
210	13	1	7	150	19	80	1
290	17	1	7	150	8	80	1
512	31	1	04	150	5		
556	27	1	02	150	4		
599	30	1	10	150	0		

FIELD: 7403

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	5	2	10			80	0
101	5	1	6			60	9

FIELD: 1401

DD	CH	M	WI	SWP	ASWP	SQ	ASQ
91	6	1	5			100	0
101	6	1	4			100	3
121	5	1	2			80	1
154	6	1	6			60	4
201	11	2	6			100	0
225	9	1	10	150	1	100	0
290	13	1	12	150	0	100	0
492	16	1	04	150	30		
599				150	0		

Appendix 7. Pubescent wheat study individual egg, larval, and adult count data.

Appendix 7a. Adult count data. There are 6 sample repititions for sweepnet and 6-10 for linear foot counts. A "30-0" in a linear foot count is a combination of 3, 10 foot samples with no insects found.

DD = degree days base 48°F

CH = crop height (inches)

M = field wetness (1=dry; 2=damp; 3=wet)

WI = wind speed (mph)

SQ = number of linear feet

SW = number of sweeps

KNT = count per SQ or SW

FIELD: 1201

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	08	1	06	30-00	10-00	10-00	30-00	10-00	10-00
101	08	1	05	30-00	10-00	10-00	30-00	10-00	10-00
121	09	1	05	30-00	10-00	10-00	30-00	10-00	10-00
154	10	1	05	10-03	10-01	10-04	10-02	10-00	10-03
210	15	3	00	10-00	10-01	10-00	30-00	10-00	10-00
231	16	3	05	10-00	10-00	10-01	10-01	10-00	10-05
290	22	1	05	30-00	10-03	10-02	10-01	10-00	10-11

FIELD: 1301

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	06	1	05	30-00	10-00	10-00	30-00	10-00	10-00
101	06	2	07	30-00	10-00	10-00	30-00	10-00	10-00
121	08	1	05	10-04	10-00	10-02	10-01	10-02	10-03
154	12	1	06	10-02	10-05	10-00	10-00	10-02	10-07
210	14	3	03	10-03	10-00	10-00	10-03	10-03	10-02
225	17	1	10	10-05	10-03	10-01	6-11	10-06	10-07
290	20	1	12	10-01	10-00	10-01	10-02	10-01	10-00

FIELD: 1302

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	08	1	05	30-00	10-00	10-00	30-00	10-00	10-00
101	08	3	02	30-00	10-00	10-00	10-01	10-00	10-00
121	09	1	03	30-00	10-00	10-00	30-00	10-00	10-00
154	10	3	06	30-00	10-00	10-00	30-00	10-00	10-00
210	16	3	00	30-00	10-00	10-00	30-00	10-00	10-00
225	16	1	08	30-00	10-00	10-00	30-00	10-00	10-00
290	19	1	12	30-00	10-00	10-00	30-00	10-00	10-00

FIELD: 1402

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	06	1	05	30-00	10-00	10-00	30-00	10-00	10-00
101	06	1	04	30-00	10-00	10-00	30-00	10-00	10-00
121	06	1	02	30-00	10-00	10-00	30-00	10-00	10-00
154	07	1	07	30-00	10-00	10-01	10-01	10-00	10-00
201	08	2	08	30-00	10-01	10-01	10-01	10-00	10-00
225	10	1	10	10-03	10-00	10-00	10-00	10-00	10-01
290	13	1	12	10-00	10-03	10-00	10-04	10-05	10-01

FIELD: 2101

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	07	1	07	10-02	10-00	10-00	10-02	10-02	10-00
101	05	1	03	10-02	10-00	10-00	10-01	10-00	10-00
121	06	1	04	10-01	10-01	10-01	10-03	10-02	10-00
154	07	1	06	10-01	10-00	10-00	10-00	10-00	10-02
201	11	3	04	10-01	10-01	10-01	10-01	10-02	10-00
225	12	1	08	10-01	10-03	10-02	10-07	10-07	10-11
290	15	1	05	10-05	10-05	10-06	10-14	10-11	10-06

FIELD: 2102

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	08	1	07	10-04	10-01	10-00	10-01	10-00	10-00
101	10	1	05	10-02	10-01	10-00	10-01	10-00	10-01
121	11	2	06	10-13	10-12	10-13	10-02	10-02	10-01

FIELD: 2102

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
154	16	1	08	10-02	10-02	10-04	10-02	10-05	10-06
201	18	3	05	10-02	10-00	10-01	10-01	10-02	10-02
225	15	1	10	10-02	10-00	10-00	10-01	10-00	10-00
290	25	1	07	10-03	10-00	10-01	30-00	10-00	10-00

FIELD: 2201

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	05	1	05	10-02	10-02	10-01	10-01	10-01	10-00
101	08	1	05	10-03	10-01	10-01	10-02	10-01	10-02
121	08	1	04	10-06	10-08	10-00	10-06	10-06	10-02
154	10	1	08	10-03	10-09	10-06	10-08	10-09	10-13
210	13	1	07	10-06	10-07	6-17	10-04	10-07	10-02
225	13	1	07	10-06	10-07	10-03	10-07	10-04	10-08
290	15	1	08	10-04	10-00	10-03	10-03	10-00	10-01

FIELD: 2301

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	03	1	10	30-00	10-00	10-00	30-00	10-00	10-00
101	03	1	06	30-00	10-00	10-00	30-00	10-00	10-00
121	05	2	07	30-00	10-00	10-00	10-02	10-01	10-00
154	06	1	10	10-00	10-00	10-02	30-00	10-00	10-00
201	08	2	07	10-05	10-02	10-03	10-02	10-08	10-03
231	09	1	05	10-00	10-00	10-03	10-00	10-03	10-05
290	13	1	10	10-06	10-11	10-08	10-02	10-04	10-05

FIELD: 2402

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
91	05	1	03	30-00	10-00	10-00	10-01	10-00	10-00
101	05	1	05	10-00	10-01	10-00	10-01	10-00	10-00
121	08	2	06	10-00	10-02	10-00	30-00	10-00	10-00
154	10	1	07	10-00	10-01	10-00	30-00	10-00	10-00
201	14	3	05	10-00	10-02	10-02	10-00	10-00	10-01
225	10	1	10	10-00	10-00	10-04	10-00	10-00	10-01
290	16	1	07	10-01	10-00	10-04	10-03	10-00	10-04

FIELD: 3101

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
87	03	2	06	10-00	10-02	10-01	30-00	10-00	10-00
101	05	1	03	30-00	10-00	10-00	10-00	10-01	10-00
121	06	3	07	10-00	10-01	10-00	10-00	10-00	10-00
154	08	1	07	10-02	10-01	10-00	10-00	10-04	10-06
201	09	2	05	10-04	10-00	10-01	8-10	10-06	6-13
231	08	2	05	10-00	10-03	10-00	10-00	10-06	10-04
290	10	1	07	10-00	10-02	10-00	10-04	10-02	10-00

FIELD: 3102

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
87	03	3	08	30-00	10-00	10-02	30-00	10-00	10-00
101	03	2	05	30-00	10-00	10-01	10-00	10-02	10-01
121	07	3	04	10-00	10-01	10-01	10-00	10-00	10-01
154	10	1	08	10-00	10-02	10-03	10-04	10-03	10-00
201	10	2	05	10-05	10-05	10-01	10-00	10-02	10-01
231	11	2	03	10-03	10-02	10-02	10-00	10-02	10-01

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
FIELD: 3102									
290	14	1	09	10-03	10-04	10-02	10-01	10-07	10-01
FIELD: 3301									
87	02	2	02	30-00	10-00	10-00	30-00	10-00	10-00
101	03	1	05	30-00	10-00	10-01	30-00	10-00	10-00
121	05	3	05	30-00	10-00	10-00	30-00	10-00	10-00
154	05	1	08	10-01	10-05	10-06	10-02	10-09	10-01
201	09	3	03	10-04	10-07	10-01	10-09	10-00	10-02
231	09	1	03	10-01	10-06	10-00	6-12	4-14	10-06
290	14	1	04	10-06	10-01	10-09	10-01	10-06	10-05
FIELD: 3401									
87	03	2	03	10-01	10-01	10-00	30-00	10-01	10-00
101	05	3	06	30-00	10-00	10-00	10-01	10-01	10-02
121	07	3	07	30-00	10-00	10-00	10-00	10-01	10-00
154	12	1	08	10-02	10-03	10-00	10-04	10-00	10-00
201	14	3	06	10-04	10-01	10-00	10-00	10-02	10-00
231	20	1	05	10-03	10-01	10-01	10-02	10-05	10-00
290	16	1	08	10-06	10-02	10-04	10-03	10-00	10-01
FIELD: 3402									
87	03	2	00	10-02	10-03	10-01	30-00	10-00	10-00
101	07	2	02	10-01	10-01	10-00	10-00	30-00	10-00
121	08	3	06	10-00	10-02	10-00	10-00	10-00	10-02
132	10	1	06	10-00	10-00	10-00	10-01	10-02	10-02
154	10	1	15	10-01	10-02	10-04	10-00	10-00	10-01
201	12	2	04	10-01	10-00	10-00	10-01	10-03	10-00
231	17	1	04	10-00	10-02	10-01	10-00	10-00	10-01
290	20	1	07	10-00	10-01	10-00	10-01	10-01	10-02
FIELD: 4101									
87	06	1	03	10-01	10-02	10-00	10-02	10-01	10-00
101	05	1	07	10-01	10-04	10-06	10-00	10-04	10-03
121	07	3	08	10-00	10-03	10-01	10-00	10-00	10-00
154	08	1	06	10-04	10-07	10-00	10-10	10-09	10-02
201	11	2	04	10-08	10-05	10-03	10-07	10-08	10-02
231	12	2	03	10-07	10-04	10-07	10-01	10-01	10-09
290	14	1	05	10-05	10-02	10-05	10-04	10-06	10-11
FIELD: 4201									
87	05	1	04	10-02	10-02	10-01	10-02	10-00	10-01
101	06	1	06	10-00	10-02	10-00	10-00	10-02	10-00
121	07	3	05	10-01	10-00	10-04	10-00	10-02	10-06
154	09	1	06	10-02	10-02	10-00	10-06	6-14	10-04
201	11	2	05	10-00	10-02	10-02	10-07	10-03	8-11
231	15	3	03	10-00	10-01	10-06	10-01	10-05	10-09
290	18	1	08	10-02	10-00	10-02	10-00	10-04	10-04

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
FIELD: 4202									
87	04	1	04	10-03	10-02	10-00	10-01	10-01	10-01
101	04	1	06	10-04	10-02	10-00	10-03	10-00	10-00
121	07	3	05	10-01	10-07	10-02	10-00	10-00	10-01
154	09	1	06	6-10	4-13	10-03	10-05	10-06	8-11
201	11	3	04	10-04	8-11	10-04	10-14	6-19	6-12
231	15	3	03	8-12	10-00	10-00	10-03	10-04	10-03
290	20	1	08	10-03	10-00	10-02	10-01	10-03	10-02
FIELD: 4301									
87	04	1	04	10-04	10-01	10-01	10-01	10-00	10-00
101	04	2	04	10-00	10-01	10-00	10-00	10-02	10-07
121	10	3	07	10-01	10-00	10-12	10-02	10-00	10-02
132	09	1	04	10-12	10-09	10-14	10-04	10-04	6-10
154	12	1	06	4-10	2-16	4-13	10-09	6-13	4-16
201	13	3	04	10-02	2-10	10-06	6-10	2-12	10-04
231	17	1	06	10-02	10-03	8-11	2-13	6-17	10-21
290	22	1	06	10-06	10-01	2-11	10-04	8-11	10-01
FIELD: 4302									
87	05	1	06	4-20	10-12	10-06	10-00	10-00	10-03
101	04	0	07	10-10	0-	0-	30-00	10-00	10-00
121	07	3	03	10-02	10-09	10-01	10-02	10-00	10-07
132	09	1	02	10-04	10-04	10-04	10-02	10-07	4-11
154	12	1	05	10-11	6-13	6-16	10-05	10-05	2-19
201	13	3	03	8-12	4-12	10-05	6-14	10-09	10-06
231	17	1	04	10-00	8-12	10-09	2-14	2-19	10-09
290	20	1	06	10-09	10-05	2-10	10-01	10-04	10-03
FIELD: 5101									
101	03	2	09	30-00	10-00	10-00	10-01	10-01	10-00
FIELD: 5201									
87	04	2	04	10-06	10-05	10-00	10-03	10-01	10-00
101	04	2	04	10-00	10-03	10-04	10-00	10-02	10-02
121	06	3	03	30-00	10-00	10-00	30-00	10-00	10-00
154	08	1	04	10-04	10-07	6-12	10-00	10-03	10-00
201	11	2	04	10-02	10-01	10-05	10-00	10-03	10-07
290	15	1	07	10-05	10-03	10-03	10-01	10-00	10-03
FIELD: 5302									
87	04	2	00	10-07	10-03	10-04	30-00	10-00	10-00
101	04	2	05	30-00	10-00	10-01	10-01	10-00	10-00
121	04	3	02	10-00	10-00	10-01	10-00	10-00	10-00
154	09	1	06	10-07	10-07	10-00	10-00	10-00	10-09
201	12	3	03	10-00	10-04	10-03	10-01	10-00	10-05
231	12	1	05	10-01	10-02	10-00	10-00	10-01	10-01
290	10	1	08	10-01	10-01	10-00	10-02	10-02	10-01

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
				FIELD: 5303					
87	02	2	04	10-02	10-00	10-00	30-00	10-00	10-00
101	03	2	05	30-00	10-00	10-00	30-00	10-01	10-00
121	05	3	02	10-00	10-02	10-00	10-00	10-00	10-00
154	04	1	02	10-02	10-03	10-08	10-00	10-03	10-00
201	09	3	03	10-08	10-05	10-00	10-00	10-06	10-02
231	07	1	03	10-01	10-03	10-06	10-01	10-00	10-03
290	10	1	08	10-00	10-01	10-00	10-01	10-02	10-00
				FIELD: 5401					
87	03	2	03	10-01	10-02	10-01	30-00	10-00	10-00
121	06	3	05	10-00	10-01	10-00	10-00	10-00	10-00
154	06	1	05	10-00	10-05	10-00	10-00	10-01	10-00
201	07	3	07	10-01	10-01	10-00	10-02	10-01	10-00
231	06	1	05	10-01	10-03	10-00	10-01	10-00	10-00
290	10	1	09	10-03	10-05	10-03	10-00	10-00	10-01
				FIELD: 6201					
87	04	2	04	10-06	10-04	10-00	30-00	10-00	10-00
101	05	2	04	10-00	10-00	10-01	10-02	10-01	10-00
121	07	3	05	10-01	10-00	10-00	10-00	10-00	10-00
154	10	1	06	10-04	10-00	10-00	10-01	10-03	10-02
201	14	3	04	10-00	10-00	8-12	10-02	10-03	10-01
231	20	1	05	10-05	10-00	10-05	10-01	10-04	10-01
290	17	1	10	10-04	10-04	10-00	10-04	10-11	10-01
				FIELD: 6301					
87	06	2	05	10-01	10-00	10-00	10-02	10-00	10-00
101	07	2	08	30-00	10-00	10-00	10-00	10-02	10-00
121	09	3	04	10-00	10-00	10-01	10-00	10-00	10-00
132	09	1	06	10-00	10-00	10-00	10-00	10-00	10-01
154	11	1	06	10-02	10-00	10-03	10-00	10-09	10-14
201	15	3	06	10-00	10-00	10-02	10-00	10-00	10-01
231	15	1	06	10-00	10-00	10-01	10-01	10-01	10-00
290	20	1	09	10-00	10-01	10-03	10-02	10-00	10-01
				FIELD: 7101					
87	08	1	02	10-03	10-00	10-00	10-01	10-01	10-00
101	08	2	06	10-01	10-00	10-00	30-00	10-01	10-00
121	08	1	04	10-00	10-00	10-01	10-01	10-00	10-00
154	10	1	06	10-01	10-00	10-02	10-00	10-01	10-01
210	11	3	06	30-00	10-00	10-00	30-00	10-00	10-00
225	16	1	09	30-00	10-00	10-00	30-00	10-00	10-00
290	21	1	09	30-00	10-00	10-00	30-00	10-00	10-00
				FIELD: 7102					
87	08	1	06	30-00	10-00	10-00	30-00	10-00	10-01
101	08	2	06	10-01	10-01	10-00	10-00	10-02	10-01
121	08	2	04	30-00	10-00	10-00	10-04	10-03	10-02

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
				FIELD: 7102					
154	11	1	02	10-00	10-04	10-03	10-06	10-01	10-01
201	11	3	07	10-00	10-00	10-03	10-01	10-00	10-02
225	18	1	10	10-03	10-01	10-05	10-06	10-00	10-02
290	18	1	09	10-02	10-04	10-01	10-01	10-00	10-04
				FIELD: 7201					
87	04	1	10	10-01	10-00	10-00	30-00	10-00	10-00
101	04	1	04	30-00	10-00	10-03	30-00	10-00	10-00
121	07	2	06	30-00	10-00	10-00	10-02	10-01	10-00
154	07	1	08	10-02	10-10	10-02	10-02	10-08	10-12
201	11	2	08	10-04	10-12	10-19	10-05	10-07	10-07
231	12	1	03	10-01	10-04	10-05	10-04	10-05	10-02
290	13	1	08	10-03	10-00	10-01	10-02	10-02	10-06
				FIELD: 7202					
87	09	1	06	30-00	10-00	10-00	10-02	10-00	10-02
101	06	1	04	10-00	10-00	10-01	10-00	10-01	10-02
121	08	3	06	10-01	10-00	10-01	30-00	10-00	10-00
154	10	1	06	10-00	10-00	10-01	30-00	10-05	10-04
201	15	2	05	10-00	10-02	10-00	10-01	10-00	10-00
231	17	3	03	10-00	10-01	10-00	10-00	10-00	10-02
290	24	1	07	10-00	10-00	10-01	10-01	10-00	10-00
				FIELD: 7302					
87	04	3	04	30-00	10-00	10-00	30-00	10-00	10-00
101	07	1	05	10-01	10-00	10-00	10-00	10-02	10-00
121	07	2	05	30-00	10-00	10-02	10-03	10-01	10-00
154	08	1	03	10-03	10-11	10-02	10-02	10-04	10-01
201	12	2	07	30-00	10-00	10-00	10-01	10-00	10-00
231	13	3	07	10-07	10-10	10-06	10-04	10-06	10-03
290	16	1	09	10-00	10-02	10-00	10-01	10-00	10-00
				FIELD: 7401					
91	08	1	07	10-01	10-00	10-01	10-01	10-01	10-00
101	12	1	07	30-00	10-00	10-00	30-00	10-00	10-00
121	07	2	05	30-00	10-00	10-00	10-04	10-01	10-00
154	06	2	02	10-01	10-02	10-00	10-01	10-03	10-01
201	10	3	06	10-01	10-01	10-02	10-00	10-01	10-00
231	12	3	06	10-00	10-03	10-02	10-00	10-00	10-02
290	12	1	07	10-01	10-00	10-00	10-00	10-01	10-00
				FIELD: 7402					
91	18	3	10	30-00	10-00	10-00	10-01	10-00	10-00
101	07	1	06	10-01	10-00	10-00	30-00	10-00	10-00
121	08	1	02	30-00	10-00	10-00	30-00	10-00	10-00
154	08	1	02	30-00	10-00	10-00	30-00	10-00	10-00
201	09	3	05	30-00	10-00	10-00	30-00	10-00	10-00
231	14	3	05	30-00	10-01	10-00	30-00	10-00	10-00

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
FIELD: 7402									
290	15	1	08	30-00	10-00	10-00	30-00	10-00	10-00
FIELD: 8101									
91	04	1	08	30-00	10-00	10-00	10-01	10-00	10-00
FIELD: 8102									
91	03	1	08	30-00	10-00	10-00	30-00	10-00	10-00
FIELD: 8103									
91	03	1	05	10-00	10-00	10-01	10-01	10-00	10-00
101	03	1	05	30-00	10-00	10-00	30-00	10-00	10-00
121	03	1	03	10-01	10-00	10-01	30-00	10-00	10-00
154	05	1	07	30-00	10-00	10-00	30-00	10-00	10-00
201	06	2	07	30-00	10-00	10-00	30-00	10-00	10-00
225	07	1	10	10-01	10-00	10-01	10-02	10-00	10-01
290	07	1	12	30-00	10-00	10-00	30-00	10-00	10-00
FIELD: 8104									
91	05	1	08	10-01	10-00	10-00	10-00	10-01	10-00
101	05	1	05	10-02	10-00	10-00	10-01	10-00	10-00
121	06	1	03	10-01	10-00	10-01	30-00	10-00	10-00
154	11	1	06	10-00	10-01	10-00	10-01	10-00	10-01
201	13	3	07	10-01	10-01	10-01	10-01	10-00	10-00
225	14	1	10	10-02	10-01	10-00	10-03	10-00	10-01
290	18	1	12	10-00	10-01	10-00	10-00	10-00	10-02
FIELD: 8201									
91	06	1	07	30-00	10-00	10-00	10-01	10-00	10-00
101	06	1	04	30-00	10-00	10-00	30-00	10-00	10-00
121	06	1	05	30-00	10-00	10-00	30-00	10-00	10-00
154	09	1	06	10-00	10-00	10-02	10-03	10-03	10-00
201	13	3	04	10-00	10-00	10-01	10-02	10-01	10-00
225	17	1	10	10-00	10-00	10-02	10-11	10-09	10-05
290	18	1	12	10-01	10-00	10-03	10-04	10-02	10-00
FIELD: 8202									
91	05	1	05	30-00	10-00	10-00	30-00	10-00	10-00
101	06	1	03	30-00	10-00	10-00	10-00	30-00	10-00
121	07	1	03	10-03	10-00	10-00	10-04	10-01	10-02
154	08	1	06	30-00	10-00	10-01	30-00	10-02	10-00
201	11	3	05	10-06	10-02	10-04	10-00	10-02	10-02
231	12	3	05	10-01	10-00	10-00	10-02	10-01	10-02
290	14	1	12	10-00	10-00	10-01	10-00	10-01	10-00
FIELD: 8301									
91	05	1	08	30-00	10-00	10-00	30-00	10-00	10-00
101	06	1	03	30-00	10-00	10-00	10-01	10-00	10-00
121	07	1	04	10-01	10-00	10-00	10-01	10-00	10-00

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
FIELD: 8301									
154	09	1	04	10-02	10-01	10-00	30-00	10-01	10-01
201	12	3	06	30-00	10-00	10-00	30-00	10-00	10-00
231	12	3	05	10-01	10-00	10-00	10-01	10-02	10-00
290	17	1	14	30-00	10-00	10-00	30-00	10-00	10-00
FIELD: 8302									
91	08	2	04	30-00	10-00	10-00	30-00	10-00	10-00
101	04	2	05	30-10	10-00	10-00	30-00	10-00	10-00
121	09	1	02	30-00	10-00	10-00	30-00	10-00	10-00
154	13	1	05	10-02	10-00	10-02	10-00	10-02	10-00
201	16	3	04	30-00	10-01	10-00	30-00	10-00	10-00
231	19	3	05	10-00	10-01	10-00	10-01	10-01	10-01
290	19	1	14	30-00	10-00	10-00	30-00	10-00	10-00
FIELD: 8303									
101	12	1	04	10-00	10-00	10-03	10-01	10-00	10-00
154	08	1	05	10-00	10-01	10-02	10-09	10-02	10-07
201	14	2	07	10-00	10-00	10-04	30-00	10-00	10-00
231	11	3	03	10-02	10-01	10-01	10-03	10-02	10-01
290	17	1	14	30-00	10-00	10-00	10-01	10-00	10-00
FIELD:10101									
87	05	1	00	10-00	10-00	10-00	10-00	10-01	10-00
101	06	1	03	10-01	10-01	10-00	10-00	10-01	10-01
121	10	2	06	10-00	10-01	10-00	10-00	10-01	10-00
154	10	1	07	10-01	10-03	10-00	10-00	10-02	10-00
201	12	3	05	10-11	10-12	10-14	10-18	10-11	10-26
225	14	1	06	10-00	10-00	10-01	10-03	10-13	10-10
FIELD:10201									
87	07	1	02	10-00	10-00	10-00	10-01	10-01	10-01
101	06	1	08	10-00	10-01	10-02	10-02	10-02	10-00
121	07	2	07	10-02	10-00	10-00	10-00	10-01	10-00
154	10	1	06	10-08	10-06	10-01	10-01	10-01	10-00
201	10	3	10	10-02	10-03	10-01	10-00	10-00	10-00
225	13	1	10	10-00	10-01	10-00	10-01	10-01	10-00
FIELD:10202									
87	05	2	02	10-00	10-01	10-02	10-02	10-01	10-00
101	04	1	08	10-00	10-01	10-01	10-01	10-01	10-03
121	07	2	07	10-00	10-01	10-00	10-00	10-00	10-01
154	10	1	05	10-00	10-04	10-00	10-02	10-03	10-00
201	10	3	05	10-06	10-07	10-10	10-00	10-02	10-04
225	15	1	06	10-00	10-01	10-00	10-00	10-00	10-03
FIELD:10401									
91	06	2	07	30-00	10-00	10-00	10-00	10-00	10-01
110	07	1	06	10-02	10-02	10-00	10-02	10-00	10-00

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
				FIELD:10401					
132	08	2	06	10-02	10-00	10-00	10-08	10-00	10-02
170	10	1	03	10-02	10-03	10-00	10-07	10-02	10-02
201	12	1	10	10-02	10-02	10-05	10-03	10-07	10-03
231	17	1	06	10-04	10-03	10-05	10-00	10-06	10-02
				FIELD:11101					
87	04	3	02	10-00	10-01	10-00	10-02	10-00	10-00
101	04	1	06	30-00	10-00	10-00	10-00	10-02	10-00
121	07	1	04	10-01	10%01	10-00	10-01	10-02	10-02
154	09	1	05	10-02	10-00	10-04	10-10	10-07	10-00
201	13	3	05	10-00	10-02	10-02	10-15	10-04	10-04
225	12	1	10	10-01	10-00	10-00	10-00	10-02	10-04
				FIELD:11102					
87	06	2	02	30-00	10-00	10-01	10-00	10-00	10-01
101	05	1	08	30-00	10-00	10-00	10-00	10-01	10-00
121	06	1	04	10-04	10-01	10-01	10-00	10-01	10-04
154	08	1	05	10-00	10-01	10-01	10-00	10-02	10-01
201	10	3	10	10-00	10-01	10-01	10-00	10-03	10-05
225	12	1	10	10-01	10-03	10-04	10-02	10-04	10-03
				FIELD:11201					
87	03	1	06	30-00	10-00	10-01	10-00	10-03	10-02
101	05	1	08	30-00	10-00	10-00	30-01	10-04	10-01
132	04	3	00	30-00	10-00	10-01	10-01	10-01	10-00
154	10	1	06	10-05	10-02	10-01	10-00	10-00	10-04
201	11	3	10	10-12	10-06	10-07	10-20	10-20	10-01
225	10	1	08	10-04	10-02	10-01	10-02	10-06	10-02
				FIELD:11202					
87	08	1	07	10-01	10-00	10-00	10-00	10-01	10-00
				FIELD:11203					
101	06	1	06	10-00	10-01	10-01	10-00	10-02	10-00
132	11	3	04	10-01	10-03	10-00	10-08	10-00	10-00
154	11	1	10	10-00	10-02	10-00	10-00	10-05	10-03
201	14	2	10	10-00	10-01	10-00	10-00	10-00	10-00
225	20	1	06	10-00	10-00	10-01	10-01	10-00	10-00
				FIELD:12101					
87	08	1	02	10-00	10-01	10-00	10-07	10-00	10-00
101	06	1	08	10-01	10-00	10-01	30-00	10-00	10-00
121	08	1	06	10-00	10-01	10-00	10-00	10-00	10-01
154	12	1	05	10-03	10-01	10-00	30-00	10-01	10-01
201	14	3	06	10-01	10-00	10-00	10-00	10-01	10-01
225	17	1	10	30-00	10-01	10-00	10-00	10-00	10-00

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
				FIELD:12102					
87	02	3	02	10-00	10-01	10-00	30-00	10-00	10-00
101	05	1	08	30-00	10-00	10-00	30-00	10-01	10-00
121	03	1	05	10-01	10-01	10-00	10-00	10-00	10-02
154	07	1	05	10-01	10-02	10-00	10-00	10-00	10-00
201	07	3	07	10-01	10-00	10-00	10-00	10-01	10-02
225	12	1	10	10-10	10-04	10-02	10-03	10-06	10-16
290	11	1	10	10-06	10-03	10-03	10-03	10-02	10-02
				FIELD:12201					
87	07	2	04	10-00	10-00	10-00	10-00	10-00	10-00
101	06	1	08	10-00	10-04	10-00	30-00	10-00	10-00
121	07	1	08	10-00	10-04	10-00	10-01	10-04	10-05
154	10	1	05	10-01	10-00	10-03	10-02	10-01	10-00
201	11	3	08	10-01	10-01	10-01	10-01	10-01	10-00
225	19	1	10	30-00	10-00	10-01	10-00	10-01	10-00
				FIELD:12202					
87	06	1	05	30-00	10-00	10-00	10-00	10-01	10-00
101	05	1	08	10-00	10-01	10-00	10-00	10-00	10-00
121	06	1	06	10-00	10-01	10-01	30-00	10-00	10-00
154	09	2	03	10-02	10-00	10-06	10-17	10-13	10-05
201	11	3	09	10-11	10-03	10-07	10-04	10-01	10-15
225	14	1	08	10-01	10-01	10-01	10-00	10-02	10-00
				FIELD:12204					
87	08	1	05	30-00	10-00	10-00	10-01	10-01	10-00
101	07	1	07	10-01	10-02	10-00	10-00	10-00	10-01
121	09	1	08	10-00	10-07	10-02	10-01	10-00	10-00
154	13	2	04	10-00	10-01	10-00	10-02	10-00	10-03
201	14	3	08	10-00	10-01	10-00	10-00	10-00	10-01
225	16	1	09	10-00	10-00	10-00	10-00	10-00	10-02
				FIELD:13101					
87	03	1	02	10-01	10-00	10-00	10-00	10-00	10-01
101	04	1	06	30-00	10-00	10-00	20-00	10-00	10-00
132	05	3	03	10-00	10-01	10-00	30-00	10-00	10-00
154	10	1	10	30-00	10-00	10-00	30-00	10-00	10-00
201	14	1	10	30-00	10-01	10-00	10-00	10-00	10-00
225	13	2	06	30-00	10-00	10-01	10-00	10-00	10-01
				FIELD:14401					
91	04	1	15	30-00	10-00	10-00	30-00	10-00	10-00
110	07	1	00	10-03	10-00	10-00	30-00	10-00	10-00
132	06	3	04	30-00	10-00	10-00	30-00	10-01	10-00
154	08	1	05	10-01	10-00	10-01	10-05	10-00	10-01
210	11	2	07	10-00	10-02	10-01	30-00	10-02	10-00
225	15	1	06	10-01	10-00	10-00	10-01	10-00	10-02

DD	CH	M	WI	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT	SQ-KNT
FIELD:14402									
87	04	1	02	30-00	10-00	10-00	30-00	10-00	10-00
110	04	2	04	30-00	10-00	10-00	30-00	10-00	10-00
132	04	3	05	30-00	10-00	10-00	30-00	10-00	10-00
154	06	1	10	10-00	10-01	10-00	10-00	10-00	10-00
210	10	2	07	10-00	10-01	10-00	30-00	10-00	10-01
225	09	1	08	30-00	10-00	10-00	30-00	10-00	10-00
FIELD:15301									
91	03	2	06	30-00	10-00	10-00	10-01	10-00	10-00
110	06	2	06	10-00	10-03	10-00	10-00	10-03	10-00
132	07	3	04	30-00	10-01	10-00	10-01	10-02	10-00
154	08	1	10	10-04	10-06	10-01	10-02	10-04	10-06
210	11	1	05	10-00	10-02	10-01	10-04	10-03	10-06
FIELD:15401									
87	07	2	07	30-00	10-00	10-00	30-00	10-00	10-00
110	08	2	08	10-01	10-00	10-00	30-00	10-00	10-00
132	10	2	06	10-06	10-04	10-01	10-01	10-01	10-04
170	11	1	03	10-01	10-00	10-02	10-01	10-05	10-02
210	15	1	04	10-00	10-01	10-00	10-00	10-00	10-00
290	17	1	05	10-00	10-00	10-00	10-00	10-00	10-01
FIELD:15402									
87	07	3	05	30-00	10-00	10-00	30-00	10-00	10-00
110	06	2	07	10-01	10-01	10-00	30-00	10-00	10-00
132	09	3	04	10-00	10-04	10-08	30-00	10-01	10-01
154	10	1	10	10-03	10-00	10-02	10-06	10-03	10-01
210	11	1	10	10-06	10-04	10-01	10-09	10-10	10-07
231	14	1	08	10-02	10-01	10-00	10-05	10-02	10-01
290	17	1	07	10-02	10-05	10-04	10-04	10-21	10-06
FIELD:15404									
87	08	2	04	10-00	10-01	10-00	10-04	10-02	10-00
110	08	2	08	10-01	10-01	10-00	10-01	10-00	10-00
132	12	2	05	10-05	10-05	10-02	10-06	10-04	10-01
154	12	1	07	10-01	10-01	10-02	10-05	10-04	10-02
210	15	1	04	10-00	10-02	10-01	10-00	10-01	10-02
231	08	1	07	10-00	10-02	10-02	10-00	10-01	10-01
290	16	1	09	10-03	10-00	10-00	10-02	10-01	10-00
FIELD:16301									
87	08	1	02	30-00	10-00	10-00	10-01	10-00	10-00
110	08	2	08	10-01	10-00	10-00	30-00	10-00	10-00
132	10	2	06	10-01	10-00	10-03	10-00	10-01	10-00
170	11	1	03	10-02	10-02	10-03	10-05	10-00	10-02
210	13	1	07	10-00	10-00	10-01	30-00	10-00	10-00
290	17	1	07	30-00	10-00	10-00	10-00	10-01	10-00

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
FIELD: 1201									
132	10	3	07	25-003	25-004	25-000	25-002	25-004	25-013
154	10	1	05	25-006	25-016	25-009	25-019	25-023	25-015
210	15	3	00	25-001	25-013	25-028	25-004	25-005	25-000
231	16	3	05	25-003	25-008	25-028	25-001	25-002	25-017
290	22	1	05	25-001	25-003	25-013	25-022	10-016	10-011
FIELD: 1301									
132	10	3	07	25-001	25-013	25-013	25-007	25-014	25-027
154	12	1	06	25-008	25-022	25-021	25-009	25-019	25-004
210	14	3	03	25-002	25-006	25-005	25-023	25-028	25-068
225	17	1	10	25-006	25-003	25-007	25-017	25-036	25-025
290	20	1	12	25-003	25-004	25-007	25-012	25-008	25-012
FIELD: 1302									
154	10	3	06	25-000	25-002	25-003	25-005	25-006	25-011
210	16	3	00	25-000	25-000	25-000	25-000	25-003	25-003
225	16	1	08	25-001	25-000	25-001	25-000	25-000	25-003
290	19	1	12	25-000	25-000	25-002	25-001	25-000	25-000
FIELD: 1402									
154	07	1	07	25-000	25-000	25-000	25-000	25-000	25-000
225	10	1	10	25-007	25-003	25-002	25-013	25-005	25-014
290	13	1	12	25-010	25-021	25-010	25-003	25-010	25-009
FIELD: 2101									
154	07	1	06	25-000	25-000	25-000	25-000	25-000	25-000
210	11	2	06	25-011	25-017	25-003	25-012	25-003	25-007
225	12	1	08	25-003	25-003	25-008	25-010	25-021	25-029
290	15	1	05	25-026	25-013	25-020	10-013	10-021	10-017
FIELD: 2102									
132	13	3	04	25-018	25-037	25-021	25-020	25-022	25-034
154	16	1	08	25-017	25-023	25-016	25-024	25-022	25-083
210	19	1	07	25-008	25-008	25-009	25-009	25-011	25-007
225	15	1	10	25-000	25-004	25-003	25-010	25-004	25-004
290	25	1	07	25-000	25-000	25-003	25-004	25-005	25-001
FIELD: 2201									
154	10	1	08	25-024	25-051	25-069	25-047	25-039	25-035
210	13	1	07	10-030	10-043	10-024	25-019	25-017	25-024
225	13	1	07	25-014	25-021	25-033	25-009	25-030	25-029
290	15	1	08	25-017	25-011	25-012	25-011	25-012	25-008
FIELD: 2301									
290	13	1	10	25-027	25-043	25-014	25-016	25-029	25-031
FIELD: 2402									
154	10	1	07	25-002	25-002	25-002	25-001	25-006	25-001

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
FIELD: 2402									
210	13	2	05	25-008	25-011	25-017	25-005	25-006	25-002
225	10	1	10	25-001	25-002	25-002	25-010	25-006	25-006
290	16	1	07	25-009	25-001	25-005	25-012	25-019	25-014
FIELD: 3101									
154	08	1	07	25-035	25-022	25-008	25-008	25-001	25-018
201	09	2	05	25-022	25-041	25-028	25-022	25-024	25-032
231	08	2	05	25-008	25-035	25-011	25-017	25-025	25-037
290	10	1	07	25-045	25-042	25-044	25-063	25-032	25-016
FIELD: 3102									
154	10	1	08	25-042	25-013	25-048	25-017	25-023	25-008
201	10	2	05	25-035	25-002	25-024	25-002	25-018	25-031
231	11	2	03	25-044	25-020	25-051	25-003	25-021	25-017
290	14	1	09	25-047	25-042	25-054	25-007	25-031	25-018
FIELD: 3301									
201	09	3	03	25-014	25-011	25-019	25-030	25-021	25-022
231	09	1	03	25-081	25-031	25-072	25-038	25-057	25-014
290	14	1	04	25-131	25-057	25-060	25-033	25-046	25-031
FIELD: 3401									
154	12	1	08	25-015	25-058	25-050	25-011	25-031	25-027
201	14	3	06	25-001	25-256	25-011	25-006	25-008	25-003
231	20	1	05	25-062	25-046	25-079	25-040	25-053	25-017
290	16	1	08	25-026	25-025	25-020	25-015	25-017	25-028
FIELD: 3402									
121	08	3	06	25-003	25-005	25-008	25-000	25-002	25-003
132	10	1	06	25-000	25-000	25-000	25-011	25-012	25-017
154	10	1	15	25-012	25-002	25-005	25-004	25-009	25-007
201	12	2	04	25-011	25-009	25-018	25-003	25-006	25-005
231	17	1	04	25-001	25-013	25-005	25-006	25-011	25-007
290	20	1	07	25-012	25-003	25-005	25-011	25-009	25-004
FIELD: 4101									
154	08	1	06	25-008	25-047	25-061	25-013	25-014	25-013
201	11	2	04	25-033	25-067	25-029	25-008	25-032	25-024
231	12	2	03	25-052	25-036	25-070	25-008	25-059	25-023
290	14	1	05	25-083	25-102	25-030	25-016	25-083	25-046
FIELD: 4201									
154	09	1	06	25-005	25-009	25-038	25-037	25-052	25-028
201	11	2	05	25-040	25-214	25-083	25-023	25-037	25-065
231	15	3	03	25-021	25-043	25-113	25-022	25-013	25-041
290	18	1	08	25-051	25-021	25-024	25-048	25-015	25-012

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
			FIELD: 4202						
154	09	1	06	25-015	25-047	25-159	25-057	25-039	25-033
201	11	3	04	25-034	25-106	25-072	25-008	25-027	25-025
231	15	3	03	25-031	25-047	25-083	25-014	25-036	25-025
290	20	1	08	25-115	25-068	25-032	25-026	25-016	25-041
			FIELD: 4301						
121	10	3	07	25-007	25-029	25-037	25-002	25-004	25-004
132	09	1	04	25-004	25-010	25-029	25-011	25-019	25-014
154	12	1	06	25-356	25-178	25-143	25-047	25-078	25-082
201	13	3	04	25-022	25-161	25-146	25-067	25-088	25-103
231	17	1	06	25-015	25-087	25-098	25-102	25-135	25-217
290	22	1	06	25-033	25-027	25-044	25-084	25-037	25-025
			FIELD: 4302						
121	07	3	03	25-012	25-014	25-005	25-007	25-023	25-017
132	09	1	02	25-031	25-026	25-010	25-014	25-027	25-011
154	12	1	05	25-180	25-056	25-210	25-121	25-098	25-076
201	13	3	03	25-047	25-124	25-217	25-187	25-081	25-047
231	17	1	04	25-121	25-079	25-092	25-068	25-073	25-113
290	20	1	06	25-141	10-047	10-044	25-134	10-046	10-034
			FIELD: 5201						
154	08	1	04	25-036	25-037	25-043	25-011	25-007	25-006
201	11	2	04	25-017	25-032	25-023	25-019	25-041	25-027
290	15	1	07	25-051	25-024	25-074	25-002	25-002	25-019
			FIELD: 5302						
154	09	1	06	25-018	25-038	25-044	25-004	25-024	25-027
201	12	3	03	25-046	25-025	25-011	25-022	25-027	25-008
231	12	1	05	25-047	25-054	25-076	25-005	25-007	25-004
290	10	1	08	25-030	25-019	25-042	25-012	25-021	25-015
			FIELD: 5303						
201	09	3	03	25-022	25-056	25-015	25-007	25-018	25-008
231	07	1	03	25-018	25-012	25-031	25-021	25-025	25-022
290	10	1	08	25-028	25-018	25-011	25-009	25-007	25-002
			FIELD: 5401						
201	07	3	07	25-006	25-015	25-011	25-003	25-012	25-027
231	06	1	05	25-005	25-008	25-028	25-001	25-004	25-021
290	10	1	09	25-005	25-027	25-025	25-001	25-006	25-009
			FIELD: 6201						
154	10	1	06	25-003	25-010	25-025	25-012	25-013	25-025
201	14	3	04	25-002	25-015	25-035	25-002	25-003	25-003
231	20	1	05	25-002	25-018	25-027	25-005	25-032	25-020
290	17	1	10	25-016	25-031	25-105	25-007	25-014	25-035

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
			FIELD: 6301						
121	09	3	04	25-027	25-012	25-025	25-001	25-002	25-002
132	09	1	06	25-007	25-013	25-000	25-007	25-005	25-006
154	11	1	06	25-005	25-059	25-050	25-009	25-004	25-019
201	15	3	06	25-005	25-008	25-011	25-001	25-004	25-015
231	15	1	06	25-002	25-008	25-031	25-005	25-011	25-132
290	20	1	09	25-013	25-027	25-010	25-006	25-005	25-008
			FIELD: 7101						
132	10	3	03	25-002	25-003	25-004	25-003	25-005	25-004
154	10	1	06	25-003	25-008	25-004	25-006	25-008	25-015
210	11	3	06	25-000	25-000	25-000	25-000	25-003	25-003
225	16	1	09	25-000	25-001	25-000	25-002	25-000	25-001
290	21	1	09	25-000	25-002	25-004	25-002	25-003	25-000
			FIELD: 7102						
132	10	3	08	25-006	25-010	25-003	25-010	25-006	25-002
154	11	1	02	25-006	25-006	25-007	25-018	25-016	25-026
210	15	3	06	25-011	25-008	25-002	25-003	25-002	25-015
225	18	1	10	25-006	25-006	25-006	25-005	25-012	25-008
290	18	1	09	25-011	25-012	25-025	25-020	25-018	25-020
			FIELD: 7201						
201	11	2	08	25-027	25-035	25-052	25-020	25-029	25-027
231	12	1	03	25-031	25-041	25-045	25-005	25-027	25-022
290	13	1	08	25-021	25-001	25-007	25-019	25-012	25-021
			FIELD: 7202						
132	12	2	04	25-012	25-005	25-003	25-020	25-022	25-011
154	10	1	06	25-002	25-004	25-000	25-006	25-010	25-011
201	15	2	05	25-020	25-022	25-004	25-000	25-000	25-002
231	17	3	03	25-005	25-003	25-001	25-005	25-007	25-012
290	24	1	07	25-000	25-000	25-004	25-006	25-005	25-001
			FIELD: 7302						
201	12	2	07	25-002	25-006	25-004	25-001	25-001	25-004
231	13	3	07	25-033	25-039	25-024	25-008	25-025	25-008
290	16	1	09	25-004	25-010	25-020	25-012	25-013	25-017
			FIELD: 7401						
210	10	3	06	25-000	25-000	25-002	25-001	25-000	25-000
231	12	3	06	25-002	25-002	25-001	25-001	25-002	25-001
290	12	1	07	25-003	25-002	25-001	25-000	25-001	25-000
			FIELD: 7402						
210	10	3	06	25-001	25-000	25-001	25-000	25-000	25-002
231	14	3	05	25-001	25-001	25-005	25-001	25-001	25-005
290	15	1	08	25-003	25-000	25-002	25-003	25-004	25-003

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
				FIELD: 8104					
154	11	1	06	25-003	25-005	25-003	25-005	25-009	25-015
210	13	2	06	25-002	25-007	25-007	25-001	25-007	25-021
225	14	1	10	25-006	25-009	25-014	25-007	25-014	25-017
290	18	1	12	25-000	25-008	25-002	25-003	25-004	25-002
				FIELD: 8201					
154	09	1	06	25-003	25-011	25-017	25-013	25-014	25-024
210	13	2	05	25-005	25-005	25-002	25-013	25-042	25-049
225	17	1	10	25-002	25-003	25-008	25-022	25-024	25-030
290	18	1	12	25-001	25-004	25-020	25-016	25-012	25-009
				FIELD: 8202					
210	10	2	05	25-003	25-003	25-002	25-015	25-014	25-043
231	12	3	05	25-008	25-015	25-004	25-003	25-004	25-004
290	14	1	12	25-003	25-002	25-000	25-002	25-000	25-000
				FIELD: 8301					
210	11	3	04	25-001	25-000	25-002	25-000	25-000	25-000
231	12	3	05	25-003	25-001	25-002	25-005	25-002	25-006
290	17	1	14	25-000	25-000	25-000	25-000	25-000	25-000
				FIELD: 8302					
154	13	1	05	25-005	25-006	25-014	25-001	25-006	25-003
210	19	3	04	25-000	25-001	25-001	25-002	25-000	25-001
231	19	3	05	25-000	25-000	25-002	25-003	25-001	25-000
290	19	1	14	25-000	25-000	25-000	25-000	25-000	25-000
				FIELD: 8303					
201	14	2	07	25-008	25-004	25-001	25-001	25-005	25-001
231	11	3	03	25-011	25-016	25-012	25-006	25-004	25-009
290	17	1	14	25-000	25-000	25-000	25-002	25-001	25-000
				FIELD:10101					
121	10	2	06	25-001	25-008	25-010	25-001	25-004	25-007
154	10	1	07	25-011	25-014	25-003	25-001	25-004	25-005
201	12	3	05	25-005	25-015	25-055	25-016	25-101	25-071
225	14	1	06	25-008	25-007	25-007	25-027	25-019	25-033
290	17	1	13	25-003	25-018	25-004	25-028	25-034	25-026
				FIELD:10201					
154	10	1	06	25-006	25-022	25-013	25-001	25-011	25-000
201	10	3	10	25-010	25-008	25-014	25-001	25-000	25-001
225	13	1	10	25-003	25-002	25-000	25-002	25-002	25-000
290	16	1	13	25-010	25-017	25-005	25-002	25-002	25-008
				FIELD:10202					
154	10	1	05	25-004	25-003	25-015	25-001	25-008	25-011
201	10	3	05	25-026	25-024	25-031	25-000	25-005	25-011

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
				FIELD:10202					
225	15	1	06	25-007	25-007	25-006	25-004	25-004	25-013
				FIELD:10401					
170	10	1	03	25-030	25-027	25-041	25-011	25-022	25-036
201	12	1	10	25-000	25-012	25-033	25-003	25-010	25-006
231	17	1	06	25-050	25-061	25-075	25-105	25-065	25-090
290	19	1	13	10-020	10-034	10-059	10-008	10-012	10-011
				FIELD:11101					
154	09	1	05	25-002	25-010	25-014	25-013	25-025	25-009
201	13	3	05	25-005	25-012	25-007	25-026	25-037	25-048
225	12	1	10	25-008	25-007	25-003	25-023	25-018	25-005
290	18	1	12	25-046	25-034	25-059	25-015	25-017	25-033
				FIELD:11102					
154	08	1	05	25-011	25-002	25-005	25-000	25-001	25-001
201	10	3	10	25-008	25-003	25-015	25-010	25-018	25-036
225	12	1	10	25-007	25-025	25-020	25-016	25-010	25-056
290	13	1	12	25-026	25-011	25-051	25-021	25-017	25-036
				FIELD:11201					
154	10	1	06	25-004	25-008	25-010	25-000	25-001	25-001
201	11	3	10	25-006	25-030	25-045	25-036	25-050	25-043
225	10	1	08	25-023	25-015	25-045	25-004	25-032	25-022
290	11	1	14	25-089	25-112	25-156	25-032	25-022	25-021
				FIELD:11203					
154	11	1	10	25-008	25-011	25-008	25-001	25-002	25-007
201	14	2	10	25-004	25-000	25-008	25-001	25-002	25-000
225	20	1	06	25-004	25-007	25-006	25-003	25-003	25-003
290	18	1	11	25-003	25-011	25-016	25-008	25-021	25-018
				FIELD:12101					
154	12	1	05	25-004	25-010	25-008	25-003	25-001	25-000
201	14	3	06	25-000	25-004	25-001	25-000	25-000	25-000
225	17	1	10	25-003	25-001	25-001	25-000	25-002	25-000
				FIELD:12102					
154	07	1	05	25-007	25-002	25-012	25-005	25-002	25-004
201	07	3	07	25-000	25-005	25-000	25-001	25-000	25-012
225	12	1	10	25-009	25-006	25-001	25-008	25-014	25-029
290	11	1	10	25-018	25-036	25-080	25-014	25-024	25-015
				FIELD:12201					
121	07	1	08	25-001	25-011	25-021	25-002	25-002	25-018
154	10	1	05	25-005	25-012	25-007	25-005	25-005	25-002
201	11	3	08	25-003	25-007	25-004	25-002	25-008	25-006
225	19	1	10	25-001	25-002	25-004	25-001	25-002	25-002

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
			FIELD:12201						
290	20	1	12	25-001	25-002	25-002	25-001	25-004	25-009
			FIELD:12202						
154	09	2	03	25-008	25-008	25-013	25-016	25-027	25-017
201	11	3	09	25-007	25-022	25-045	25-020	25-027	25-047
225	14	1	08	25-001	25-016	25-022	25-014	25-026	25-016
290	17	1	10	25-019	25-024	25-020	25-012	25-002	25-008
			FIELD:12204						
154	13	2	04	25-000	25-000	25-002	25-000	25-001	25-002
201	14	3	08	25-001	25-000	25-003	25-003	25-002	25-000
225	16	1	09	25-002	25-000	25-000	25-001	25-000	25-000
			FIELD:13101						
154	10	1	10	25-000	25-003	25-000	25-000	25-000	25-000
201	14	1	10	25-001	25-000	25-001	25-001	25-001	25-001
225	13	2	06	25-001	25-001	25-001	25-000	25-000	25-000
290	14	1	12	25-010	25-016	25-003	25-004	25-007	25-013
			FIELD:14401						
154	08	1	05	25-008	25-000	25-010	25-008	25-004	25-014
210	11	2	07	25-017	25-005	25-016	25-008	25-002	25-004
225	15	1	06	25-026	25-006	25-015	25-001	25-000	25-009
290	20	1	08	25-024	25-010	25-017	25-024	25-002	25-003
			FIELD:14402						
210	10	2	07	25-000	25-001	25-001	25-001	25-002	25-000
225	09	1	08	25-002	25-001	25-003	25-001	25-000	25-000
290	11	1	10	25-005	25-001	25-004	25-004	25-003	25-003
			FIELD:15301						
154	08	1	10	25-035	25-022	25-029	25-010	25-009	25-003
210	11	1	05	25-016	25-022	25-014	25-112	25-027	25-009
290	14	1	13	10-020	10-019	10-029	25-008	25-009	25-006
			FIELD:15401						
170	11	1	03	25-031	25-060	25-021	25-016	25-028	25-004
210	15	1	04	25-001	25-002	25-001	25-001	25-014	25-006
290	17	1	05	25-003	25-005	25-001	25-002	25-002	25-005
			FIELD:15402						
154	10	1	10	25-021	25-017	25-020	25-010	25-006	25-017
210	11	1	10	25-004	25-029	25-035	25-068	25-031	25-045
231	14	1	08	25-008	25-013	25-011	25-012	25-031	25-041
290	17	1	07	25-065	25-086	25-052	25-032	25-099	25-084
			FIELD:15404						
154	12	1	07	25-009	25-006	25-016	25-017	25-041	25-019

DD	CH	M	WI	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT	SW-KNT
			FIELD:15404						
210	15	1	04	25-010	25-016	25-045	25-005	25-008	25-008
231	08	1	07	25-007	25-004	25-006	25-003	25-009	25-002
290	16	1	09	25-016	25-035	25-060	25-025	25-055	25-030
			FIELD:16301						
170	11	1	03	25-045	25-031	25-033	25-006	25-015	25-033
210	13	1	07	25-006	25-006	25-003	25-001	25-000	25-003
290	17	1	07	25-000	25-000	25-001	25-004	25-000	25-003
			FIELD: 1401						
154	06	1	06	25-000	25-000	25-000	25-000	25-000	25-000
225	09	1	10	25-000	25-000	25-000	25-000	25-001	25-000
290	13	1	12	25-000	25-000	25-000	25-000	25-000	25-000

Appendix 7b. Egg and larval count data. Each number is the number of insects found in 2 linear feet of row (= 1 square foot).

FIELD/CH ------------------ EGGS / SQ.FT. ------------------------

DEGREE DAYS: 621 DATE: JUNE 5

7281	25	0	0	9	2	2	5	1	3	1	4	4	3	3	1	2
1303	11	19	11	24	9	16	16	7	12	27	9	14	8	11	21	15
1403	4	5	3	9	6	5	2	3	8	2	3	2	4	7	5	3
7203	16	25	16	5	13	12	8	9	9	18	11	8	4	10	11	4
7302	28	0	0	0	0	3	1	0	0	0	2	0	1	0	0	0
7401	24	0	5	1	0	2	3	1	0	0	4	2	0	0	0	0
7402	32	0	0	1	2	0	0	0	0	0	1	0	1	2	1	2

DEGREE DAYS: 725 DATE: JUNE 12

1303	7	8	5	10	16	7	10	17	5	4	2	0	0	0	2	3
1403	6	9	1	3	3	0	1	1	0	2	1	1	3	2	5	6
2103	8	4	11	11	3	22	10	13	7	6	11	5	2	5	2	2
2401	7	8	17	17	21	19	0	0	1	2	3	0	0	2	0	6
3403	7	0	5	13	30	12	9	28	20	24	5	16	11	2	6	2
3403	6	7	2	3	2	2	7	5	3	1	1	6	7	3	1	7
6101	10	0	0	0	2	1	1	1	1	2	2	0	2	4	0	2
7203	20	0	0	0	0	0	0	3	5	6	4	4	5	1	10	14
10203	12	0	0	2	0	1	0	0	0	0	0	3	0	0	0	2
91101	30	0	0	0	1	1	0	3	0	1	2					
91102	27	1	0	0	1	1	0	1	4	2	3					
91103	33	0	0	0	0	1	0	0	1	0	0					
91104	26	1	0	0	1	0	1	1	0	0	3					
92101	33	0	2	3	2	2	3	4	2	2	5					
94101	15	2	3	5	2	1	2	0	3	4	2	5	3	3	1	2
95101	22	1	0	0	1	2	1	3	0	1	1	3	2	4	0	0
95102	22	2	1	1	2	0	3	1	4	0	0	1	2	3	4	1
95103	25	2	1	0	2	2	1	3	2	0	0	1	4	1	3	1

DEGREE DAYS: 804 DATE: JUNE 16

1403	13	1	3	1	2	2	0	0	2	1	2	2	4	1	4	1
2103	14	0	3	1	9	4	16	4	10	9	21	21	18	29	5	25
2401	14	15	4	0	70	1	0	4	0	2	4	1	0	6	1	7
3402	10	2	1	3	6	5	4	5	5	6	2	4	2	7	4	2
6101	15	2	1	1	2	7	8	4	5	6	5	2	4	6	3	1
7203	23	1	11	15	5	8	5	8	7	1	8	6	3	2	0	2
10203	15	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1
91101	27	0	8	5	1	4	4	2	2	2	3					
91102	29	1	1	2	0	0	1	0	1	1	6					
91103	30	1	0	0	0	0	0	0	1	0	0					
91104	28	0	1	2	2	0	2	0	1	2	0					
92101	27	3	1	6	4	5	5	7	5	4	1					
92102	27	0	1	1	0	0	0	3	7	2	1					

DEGREE DAYS: 804 DATE: JUNE 16 (CONT.)

94101	23	2	2	0	2	1	0	3	2	0	0	1	1	0	1	1
95101	30	0	1	2	0	1	0	0	0	1	0	1	0	0	4	0
95102	30	0	1	0	0	0	0	0	2	1	0	0	0	0	1	2
95103	25	0	0	0	1	0	0	0	1	2	0	0	1	0	0	0
1303	11	5	9	4	6	10	6	7	1	0	0	2	3	3	1	4

DEGREE DAYS: 858 DATE: JUNE 18

1303	16	4	2	2	4	2	0	1	0	0	1	1	0	6	3	2
1403	11	1	0	0	0	0	0	1	1	0	2	2	0	1	0	0
2103	11	4	3	5	17	12	2	5	3	2	1	4	8	6	4	8
2401	12	1	0	0	1	2	0	2	0	0	0	0	6	3	1	0
3403	13	0	1	0	2	0	0	0	0	0	1	2	1	1	0	1
6101	18	0	2	3	1	2	2	1	3	4	1	1	0	3	1	1
7203	19	3	4	3	4	6	14	7	4	9	16	5	4	4	3	1
10203	11	1	1	0	0	4	0	2	3	0	0	1	0	0	2	2
12202	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12206	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12301	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91101	27	2	1	3	1	1	2	1	3	6	2					
91103	27	0	0	1	0	0	0	0	0	0	0					
91104	27	0	0	0	0	0	1	0	1	0	0					
92101	27	2	0	1	2	0	2	1	0	0	2					
92102	27	2	3	1	1	2	2	3	2	2	0					
94101	29	0	0	0	0	0	0	0	2	5	1	1	0	0	0	0
95101	30	0	0	0	1	0	0	0	0	1	0	0	0	1	0	3
95102	30	0	0	0	1	0	1	0	1	0	4	0	0	0	0	0
95103	27	1	1	0	0	0	0	0	0	1	0	1	0	1	1	0

DEGREE DAYS: 924 DATE: JUNE 20

1303	17	6	12	4	3	3	1	0	0	1	0	0	0	2	1	0
1403	13	0	1	0	3	6	1	4	1	0	0	1	0	0	0	0
2103	15	9	5	9	4	2	0	0	2	3	1	2	1	0	2	1
2401	13	10	6	11	7	8	9	3	4	4	17	0	0	0	2	2
3403	13	1	1	12	8	17	7	0	0	0	0	0	1	2	0	1
6101	24	4	6	0	2	1	4	1	2	3	1	5	4	1	3	2
7203	19	8	7	6	10	0	2	3	0	5	0	0	0	0	0	1
10203	14	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
12202	27	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
12205	30	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0
12206	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91101	27	6	5	7	3	4	5	6	4	2	2	3	1	6	4	3
91102	30	0	3	1	0	0	3	0	3	0	2	0	0	0	2	0
91103	27	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0
91104	30	0	0	0	1	0	0	0	1	2	1	0	0	0	1	0
92101	27	0	0	2	1	0	1	0	1	0	0	0	0	0	1	1
92102	27	0	1	1	0	2	2	1	3	2	3	1	3	4	1	2
94101	30	0	1	0	2	0	0	0	0	0	2	0	0	0	0	0
95101	35	0	0	0	0	0	1	0	1	0	0	0	2	0	0	1
95102	35	0	0	1	0	2	0	0	0	1	1	0	2	1	0	2
95103	35	0	0	6	0	0	0	0	0	0	0	1	0	0	0	0

DEGREE DAYS: 1015 DATE: JUNE 23

1303	22	9	9	4	1	0	1	0	0	0	0	0	0	1	1	2
1403	11	4	3	1	4	0	2	1	0	3	0	1	1	0	0	0
2103	18	4	0	1	4	1	0	3	1	5	1	5	0	0	0	0
2401	14	1	0	0	5	11	2	0	0	0	0	0	0	0	1	4
3403	14	1	4	3	0	0	1	0	0	9	5	5	11	0	3	0
6101	20	0	1	1	0	3	1	1	0	1	0	0	1	1	2	0
7203	28	4	17	0	1	6	1	5	1	10	14	1	0	6	0	0
10203	20	0	0	3	2	1	0	2	0	0	0	0	0	0	0	0
12301	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91101	33	2	5	2	3	1	3	4	1	3	4	5	4	3	2	4
91102	33	2	3	2	1	2	1	0	1	0	2	0	0	1	0	1
91103	30	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0
91104	33	1	0	1	1	0	0	0	1	0	0	1	1	0	0	1
92101	31	1	5	4	0	2	0	2	2	1	5	3	0	1	1	0
92102	29	1	1	3	0	2	1	2	0	1	1	3	1	1	2	2
94101	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95101	40	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
95102	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95103	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FIELD/CH ---------------------- LARVAE / SQ.FT. ------------------

DEGREE DAYS: 621 DATE: JUNE 5

FIELD/CH															
7201	8	24	12	6	9	7	5	15	8	29	3	12	8	14	3
1303	2	1	2	2	3	0	1	2	4	3	1	4	4	0	2
1403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7302	2	0	5	1	4	3	4	2	5	6	1	3	3	1	2
7401	1	1	2	0	0	0	5	0	2	1	1	1	1	1	1
7402	0	1	1	2	0	1	0	0	0	0	0	2	0	1	2

DEGREE DAYS: 725 DATE: JUNE 12

FIELD/CH															
1303	5	3	6	3	21	10	11	23	14	12	10	9	14	5	14
1403	0	0	4	1	0	0	3	0	3	15	0	0	0	2	3
2103	50	26	5	20	21	26	5	19	81	44	9	7	27	8	12
2401	28	17	10	3	8	5	4	11	0	5	12	11	10	7	7
3403	2	0	8	18	8	5	4	5	0	0	0	0	10	1	0
3403	12	1	0	4	11	0	1	0	0	0	0	0	0	0	0
6101	4	5	1	0	3	3	4	3	1	3	2	2	4	2	2
7203	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10203	4	8	15	2	1	0	3	0	2	12	4	12	24	20	23
91101	2	0	0	0	1	2	0	6	1	1					
91102	0	2	0	0	2	0	4	4	2	3					
91103	0	0	0	0	0	1	1	0	0	0					
91104	1	0	2	1	3	2	3	4	3	5					
92101	1	1	0	5	1	3	5	6	4	2					
92102	1	3	4	1	0	1	1	2	0	2					
94101	5	3	4	7	5	6	3	9	4	7	9	10	7	6	4
95101	2	1	3	4	2	1	6	3	2	1	7	4	1	2	3
95102	1	0	0	3	1	2	4	6	5	0	1	2	3	3	1
95103	3	5	1	4	2	1	5	5	1	1	2	3	4	0	0

DEGREE DAYS: 804 DATE: JUNE 16

FIELD/CH															
1403	5	0	6	5	3	2	0	2	4	6	1	0	0	0	2
2103	53	33	17	5	2	1	0	2	6	2	11	7	3	23	13
2401	14	0	0	8	15	14	10	0	0	0	14	5	12	5	0
3402	9	6	7	3	4	3	4	0	2	4	0	1	0	3	0
6101	5	7	4	3	0	1	0	1	2	1	7	2	2	0	2
7203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10203	0	2	2	0	0	0	2	1	0	0	0	2	0	0	1
91101	2	0	0	2	0	0	1	0	0	0					
91102	3	0	0	1	0	2	1	0	1	2					
91103	0	1	1	0	1	0	1	0	0	0					
91104	1	1	1	2	1	0	3	0	1	2					
92101	0	3	3	6	0	8	2	4	4	3					
92102	4	7	2	5	4	2	3	3	4	5					
94101	1	0	0	0	0	0	0	1	1	0	1	3	1	3	4
95101	0	0	0	1	0	0	1	2	0	1	0	1	2	1	0
95102	0	0	1	4	0	0	0	1	0	0	0	2	1	2	1
95103	0	2	1	1	0	1	0	0	0	0	1	2	3	0	1
1303	2	39	7	11	8	5	8	15	5	10	17	18	9	6	7

DEGREE DAYS: 858 DATE: JUNE 18

1303	12	8	10	12	9	21	23	5	19	12	11	17	2	5	9
1403	0	0	0	1	0	2	0	1	1	2	1	2	0	0	0
2103	19	18	49	3	7	13	9	11	7	12	8	15	14	7	2
2401	1	2	5	10	9	9	7	9	7	11	8	10	6	8	4
3403	21	17	11	5	2	0	0	0	0	0	0	0	8	5	11
6101	3	4	4	4	3	5	7	6	12	2	10	4	4	1	2
7203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10203	0	3	0	0	0	3	12	14	5	11	0	10	3	0	8
12202	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
12206	1	2	1	3	3	1	2	0	0	2	1	0	0	2	1
12301	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0
91101	0	1	0	1	0	1	1	1	2	0					
91103	1	0	1	0	0	0	0	0	0	0					
91104	0	0	2	0	0	2	0	1	0	1					
92101	2	2	2	1	0	5	3	3	1	4					
92102	0	0	3	4	0	1	1	2	5	0					
94101	1	0	0	0	2	2	1	0	1	0	1	1	0	2	0
95101	0	0	1	0	2	1	5	2	0	3	1	0	2	1	1
95102	0	0	0	0	1	0	1	1	3	1	3	1	1	0	2
95103	2	4	1	1	0	1	1	0	3	3	2	3	1	4	1

DEGREE DAYS: 924 DATE: JUNE 20

1303	9	4	16	2	5	2	4	4	5	3	7	9	3	5	6
1403	1	0	0	0	1	0	1	0	0	0	0	6	0	0	0
2103	6	10	5	13	25	10	11	20	15	12	14	19	9	7	20
2401	2	4	0	1	0	0	0	0	2	1	20	21	2	2	5
3403	5	15	9	25	27	13	5	4	3	6	15	13	11	10	12
6101	13	15	4	8	5	1	0	5	8	5	8	2	3	0	1
7203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10203	1	3	1	2	1	8	0	0	0	0	1	0	0	0	0
12202	1	0	2	0	0	0	1	0	0	1	1	0	2	0	1
12205	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
12206	1	0	0	1	2	1	1	2	5	1	0	0	2	1	0
91101	0	1	2	1	2	0	1	0	0	0	0	0	0	2	1
91102	4	1	0	1	1	0	0	0	0	2	0	1	1	0	0
91103	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
91104	2	0	1	1	1	0	0	1	1	1	1	3	0	1	2
92101	0	1	0	2	0	2	1	1	0	0	0	0	1	0	1
92102	0	1	1	1	2	0	1	0	0	1	0	0	0	2	1
94101	2	1	3	0	0	2	3	0	5	0	1	2	2	0	0
95101	1	0	0	2	1	0	0	0	0	3	0	0	1	2	1
95102	2	0	3	1	1	0	2	0	1	1	1	3	0	2	1
95103	3	1	2	1	1	0	0	2	1	0	3	3	2	2	1

DEGREE DAYS: 1015 DATE: JUNE 23

1303	0	3	2	0	2	0	1	0	1	1	0	1	4	3	3
1403	0	0	0	1	0	0	1	0	0	0	0	0	0	3	3
2103	1	1	0	0	1	0	3	2	9	4	2	2	2	4	3
2401	2	0	1	0	0	2	0	0	2	1	3	1	2	2	2
3403	1	0	0	7	5	9	5	13	14	3	6	7	2	2	0
6101	1	1	1	3	1	1	1	1	0	2	3	0	2	2	2
7203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10203	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
12301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91101	1	0	0	2	1	0	0	1	0	1	0	1	0	0	1
91102	1	0	0	1	0	0	0	1	0	0	0	2	0	0	0
91103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91104	0	0	0	1	0	0	0	0	0	1	0	0	2	0	0
92101	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0
92102	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
94101	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
95101	0	1	0	1	0	0	0	0	1	0	1	1	0	1	0
95102	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
95103	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0

Appendix 7-C. Data for between + within-field log s^2 x log $\bar{x}$ regression analysis (Table 9).

A. Adults

Degree Days		Sweepnet			Square Foot	
> 48°F[a]	#Fields[b]	log s^2	log $\bar{x}$	#Fields[c]	log s^2	log $\bar{x}$
87				39	- .9927	-1.1269
91				24	-2.6076	-1.7868
101				54	-1.9663	-1.3426
110				8	-2.1918	-1.4357
121	6*	-.8463	-.4266	49	-1.4553	-1.1000
132	10*	-.8582	-.3513	15	- .8103	- .7111
154	42	.3127	-.0912	58	- .2066	- .5139
170	3*	-.5006	.0370	3*	-1.4699	- .6425
201	34	.3599	-.0110	49	- .3783	- .5068
210	23	-.2477	-.3465	12	- .8767	- .8163
225	27	-.7844	-.4688	28	-1.0590	- .7897
231	28	.2580	.0468	29	.0610	- .4028
290	57	.0947	-.0688	45	- .6174	- .6963

B. Larvae & Eggs - Square Foot Counts

Degree Days	Larval			Eggs	
> 48°F[a]	#Fields[d]	log s^2	log $\bar{x}$	log s^2	log $\bar{x}$
621	7	1.3227	.4021	1.5777	.6981
725	19	1.8370	.6900	1.3733	.5099
804	18	1.5353	.4783	1.5548	.4819
858	20	1.4442	.4926	.7371	.1133
924	21	1.3169	.3910	.8290	.1616
1015	21	.4341	-.1599	.6787	.0445

[a] Accumulated since 1 April.

[b] 6 x 10-25 sweep samples/field. See Sect. 3.3.1.

[c] 6-10 Samples of up to 10 linear feet/field. See Sect. 3.3.1.

[d] 10-15 Square feet/sample. See Sect. 2.2.1.

* Excluded in Table 9 as being two small a sample.

Appendix 8--Pubescent Wheat Study Weather Data.

Temperature records for three locations near the study area with accumulated degree days (base 48°F) for each site and mean accumulated degree days for all three sites. R24 = rainfall during the previous 24 hours (inches/hours).

April, 1975

	-New Carlisle--			--South Bend---			----Site Center-----				Mean
Day	Max	Min	d-Day	Max	Min	d-Day	Max	Min	d-Day	R24	d-Day
1	33	24	--	46	30	--					--
2	29	18	--	38	25	--					--
3	25	18	--	33	25	--					--
4	27	16	--	35	23	--					--
5	29	16	--	38	23	--					--
6	30	18	--	40	24	--					--
7	39	18	--	49	23	--					--
8	50	18	--	52	25	1					1
9	43	34	--	47	34	1					1
10	49	30	--	50	30	1					1
11	41	26	--	43	28	1					1
12	48	24	--	50	23	1					1
13	52	22	1	54	23	2					2
14	46	33	1	48	33	2					2
15	52	33	2	53	32	3					3
16	55	34	4	57	34	5					5
17	68	34	11	69	35	13				Installed	12
18	67	62	27	69	57	28				.5/5	28
19	56	42	30	57	43	31				--	31
20	47	40	30	49	36	31	Installed			--	31
21	47	29	30	48	30	31				.1/.5	31
22	64	42	36	65	42	38				.1/1.5	37
23	70	50	48	68	53	50				.1/2	49
24	58	40	51	58	42	54				--	53
25	54	38	53	59	43	58	Calibrated			--	56
26	61	33	57	62	35	63	62	32(4+est60)		--	61
27	49	41	57	51	42	64	48	40	64	.9/10	62
28	49	42	57	50	44	65	48	41	64	.4/2	62
29	76	40	69	75	41	76	76	40	76	--	74
30	68	52	81	71	55	91	68	52	88	.1/.5	87

May, 1975

	-New Carlisle--			--South Bend---			----Site Center------				Mean
Day	Max	Min	d-Day	Max	Min	d-Day	Max	Min	d-Day	R24	d-Day
1	60	44	86	61	45	97	60	42	91	--	91
2	70	42	95	71	42	107	73	40	101	--	101
3	62	51	103	65	53	118	61	49	108	.1/.5	110
4	56	44	106	57	43	121	55	41	110	--	112
5	70	40	115	70	41	130	70	38	118	--	121
6	65	52	127	68	51	142	65	50	128	.15/.5	132
7	66	45	137	68	47	152	66	44	136	--	142
8	66	50	150	68	54	165	68	51	148	--	154
9	75	52	166	75	53	181	76	50	163	--	170
10			est180	76	47	195	73	48	175	--	183
11			est194	77	46	209	78	42	188	--	197
12	58	40	197	64	43	216	58	37	191	.1/.5	201
13	70	36	205	70	39	225	69	35	199	--	210
14	72	41	215	72	47	237	72	42	209	--	220
15	60	44	220	59	45	242	57	40	212	--	225
16	64	40	226	69	41	251	63	36	217	--	231
17	78	40	239	75	40	262	80	40	231	--	244
18	88	44	258	85	50	282	87	45	249	--	263
19	92	57	284	91	62	310	90	60	276	(out for	290
20	94	63	314	91	67	341	94	62	306	repairs)	320
21	82	62	338	87	63	368	85	60	330	--	345
22	72	60	356	73	61	387	70	56	345	--	363
23	87	56	380	85	57	410	88	54	368	--	386
24	90	66	410	88	67	440	90	64	397	.05/2.0	416
25	88	63	438	86	65	468	87	62	423	.85/1.5	443
26	77	64	460	77	65	491	79	62	445	--	465
27	70	50	472	72	54	506	71	46	456	--	478
28	81	45	487	77	47	520	79	42	470	--	492
29	79	57	507	80	58	541	78	55	488	--	512
30	80	60	529	78	62	563	80	56	508	.4/3.0	533
31	68	52	541	68	53	575	68	46	517	--	544

June, 1975

	-New Carlisle--			--South Bend---			----Site Center-----				Mean
Day	Max	Min	d-Day	Max	Min	d-Day	Max	Min	d-Day	R24	d-Day
1	71	47	552	72	48	587	72	45	528	--	556
2	70	46	562	65	49	596	68	44	537	--	565
3	74	49	576	74	51	610	76	48	551	.5/3.0	579
4	83	52	596	82	55	630	82	52	570	.05/.5	599
5	80	62	619	79	61	652	81	60	592	--	621
6	70	56	634	71	58	668	73	59	610	--	637
7	60	45	639	60	49	674	58	48	615	--	643
8	68	44	648	68	45	683	68	42	623	--	651
9	72	45	659	73	48	695	73	42	634	--	663
10	80	52	677	80	55	715	82	50	652	--	681
11	84	63	703	80	64	739	83	64	678	.35/3.5	707
12	76	56	721	76	59	759	75	55	695	--	725
13	88	57	745	83	58	781	86	56	718	.4/2.0	748
14	82	58	767	81	60	803	84	56	740	.6/4.0	770
15	71	60	785	71	59	820	71	57	756	.5/2.0	787
16	78	52	802	77	56	838	76	52	772	--	804
17	80	69	828	80	69	864	78	66	796	.4/1.5	829
18	91	64	858	88	66	893	88	62	823	--	858
19	90	72	891	87	73	925	92	70	856	--	891
20	93	70	925	90	71	957	96	68	890	--	924
21	92	66	956	88	60	983	92	64	920	--	953
22	94	68	989	91	71	1016	92	68	952	--	986
23	86	68	1018	84	69	1044	88	67	982	--	1015
24	84	67	1046	84	68	1072	86	66	1010	--	1043
25	79	68	1072	77	68	1096	79	66	1034	.2/.5	1067
26	85	65	1099	82	66	1122	89	62	1062	--	1094
27	90	64	1128	86	64	1149	91	62	1090	--	1122
28	92	66	1159	89	67	1179	93	62	1120	--	1153
29	90	66	1189	87	65	1207	92	63	1150	--	1182
30	91	62	1217	88	63	1235	91	60	1178	--	1210

Niles precipitation, 1975, in inches. Source: NOAA.

Day	April	May	June
1	t	.01	
2	.77		t
3	.21	.14	.29
4			.05
5		.01	.12
6		.46	
7			
8		t	
9	t		
10			
11		.01	.50
12		.18	t
13			.36
14	t	t	.62
15		.05	.88
16	t		
17			.42
18	1.40		
19	t		
20		.14	t
21	.21	.30	
22	.06	.05	t
23	.38		.08
24	.05	.22	.01
25	t	.42	.04
26		t	
27	.87	t	
28	.49		
29	.05	.12	
30	.48	.35	

Appendix 9. Examples of Filter Operation.

Appendix 9a. Application of filtering technique to 1974 Gull Lake data (Sawyer 1976).

	CROP HEIGHT		--LARVAL DENSITY--		
DD	O(Y)	E(Y)	O(Y)	E(Y)	F(Y)
FIELD: 911.					
313	3.43		0.00		
378	4.49	3.45	0.00	0.00	0.00
440	6.54	3.99	0.00	0.00	0.00
488	8.07	5.28	.06	0.00	.06
567	10.51	11.62	.15	.71	.43
663	13.50	16.71	.91	1.49	1.20
760	16.81	20.53	.74	1.89	1.31
835	16.18	22.68	.60	1.20	.90
926	18.58	24.18	.09	.48	.28
985	21.65	24.40	.03	.09	.06
1043	23.50	24.27	0.00	0.00	0.00
1157	29.65	23.93	.06	0.00	.06
1249	30.12	27.46	0.00	0.00	0.00
FIELD: 916.					
313	8.10		0.00		
378	3.98	8.11	0.00	0.00	0.00
440	5.71	6.08	.03	0.00	.03
488	7.32	8.96	.06	.39	.22
567	9.21	12.97	1.40	1.28	1.34
663	12.56	16.74	3.29	3.98	3.63
760	14.25	20.09	4.56	5.64	5.10
835	10.83	21.28	3.47	4.87	4.17
926	15.47	21.06	1.61	2.71	2.16
985	17.40	21.47	1.03	1.21	1.12
1043	18.94	22.51	1.06	.47	.76
1157	24.13	26.00	.11	0.00	.06
1249	26.06	25.73	.06	0.00	.03
FIELD: 917.					
313	9.00		0.00		
378	4.13	9.01	0.00	0.00	0.00
440	5.71	6.62	0.00	0.00	0.00
488	7.99	6.21	.15	0.00	.15
567	10.12	12.03	1.72	1.04	1.38
663	12.09	16.72	8.26	4.10	6.18
760	15.08	19.85	8.02	9.61	8.81
835	14.49	21.56	3.16	8.36	5.76
926	17.17	22.90	2.64	3.55	3.10
985	19.76	23.12	1.29	1.71	1.50
1043	20.63	24.41	.71	.63	.67
1157	27.32	27.27	.06	0.00	.03
1249	28.03	27.65	0.00	0.00	0.00

Appendix 9b. Application of filtering technique to 1976 PWS data (Sawyer, unpublished data).

DD	CROP HEIGHT O(Y)	CROP HEIGHT E(Y)	--LARVAL DENSITY-- O(Y)	--LARVAL DENSITY-- E(Y)	--LARVAL DENSITY-- F(Y)
FIELD: 136.					
282	4.00		0.00		
330	6.00	4.02	0.00	0.00	0.00
354	5.00	5.01	.40	0.00	.40
380	8.00	6.68	.30	1.00	.65
399	10.00	8.58	.50	1.18	.84
499	16.00	15.28	9.10	7.13	8.11
570	22.00	19.62	17.20	21.12	19.16
640	22.00	24.41	43.10	33.13	38.12
756	25.00	28.83	2.10	47.71	24.90
815	24.00	29.64	1.10	20.73	10.92
879	28.00	29.78	2.30	7.36	4.83
931	34.00	31.20	.30	2.89	1.60
1025	33.00	36.34	0.00	.31	.16
FIELD: 236.					
264	3.00		0.00		
282	3.00	3.03	0.00	0.00	0.00
330	4.00	3.05	0.00	0.00	0.00
338	4.00	3.55	0.00	0.00	0.00
354	4.00	3.80	0.00	0.00	0.00
374	6.00	3.92	.10	0.00	.10
399	7.00	6.58	0.00	.36	.18
499	12.00	12.99	4.70	2.62	3.66
570	22.00	16.64	6.50	10.58	8.54
640	20.00	23.02	10.90	15.45	13.17
756	22.00	27.28	.80	17.69	9.24
815	18.00	27.52	.60	8.03	4.31
879	29.00	25.97	2.20	3.13	2.67
931	32.00	29.89	.40	1.61	1.00
1025	30.00	34.83	0.00	.16	.08
FIELD: 246.					
330	5.00		0.00		
354	4.00	5.00	0.00	0.00	0.00
374	4.00	4.51	0.00	0.00	0.00
399	4.00	4.27	.10	0.00	.10
499	12.00	10.49	6.00	2.23	4.12
570	16.00	15.47	12.40	12.29	12.34
640	18.00	19.65	20.50	24.49	22.49
756	15.00	24.88	5.20	33.53	19.36
815	14.00	23.03	4.20	18.50	11.35
879	24.00	21.97	5.30	9.07	7.19
931	28.00	25.61	2.80	4.77	3.78
1025	28.00	31.08	0.00	1.07	.53

	CROP HEIGHT		--LARVAL DENSITY--		
DD	O(Y)	E(Y)	O(Y)	E(Y)	F(Y)

FIELD: 337.

DD	O(Y)	E(Y)	O(Y)	E(Y)	F(Y)
282	6.00		.60		
330	5.00	9.07	2.10	3.06	2.10
354	8.00	8.60	4.10	4.33	4.22
374	11.00	9.55	4.60	7.34	5.97
387	14.00	11.12	11.60	8.44	10.02
487	15.00	18.32	8.50	68.37	38.43
570	19.00	21.21	24.501	13.54	69.02
640	24.00	23.74	26.901	21.29	74.10
756	24.00	29.43	22.70	90.26	56.48
815	28.00	29.46	3.80	47.24	25.52
879	26.00	31.57	.50	16.64	8.57
931	26.00	31.11	0.00	5.19	2.59
1025	30.00	32.68	.10	.66	.38

FIELD: 346.

DD	O(Y)	E(Y)	O(Y)	E(Y)	F(Y)
338	5.00		0.00		
354	8.00	5.00	.30	0.00	.30
380	12.00	8.20	.80	.78	.79
399	12.00	11.31	3.40	1.37	2.39
487	15.00	16.83	1.00	13.84	7.42
570	20.00	20.51	8.00	22.73	15.36
640	24.00	23.88	8.20	26.99	17.60
815	28.00	32.06	.50	17.23	8.87
879	25.00	32.81	0.00	5.59	2.79
931	26.00	31.22	0.00	1.64	.82
1025	29.00	32.73	0.00	.13	.06

FIELD: 524.

DD	O(Y)	E(Y)	O(Y)	E(Y)	F(Y)
262	2.00		0.00		
282	3.00	2.03	0.00	0.00	0.00
338	6.00	2.55	0.00	0.00	0.00
354	6.00	4.29	0.00	0.00	0.00
374	6.00	5.15	.10	0.00	.10
387	6.00	6.44	0.00	.22	.11
487	11.00	12.45	.50	2.27	1.39
570	13.00	16.61	3.80	5.21	4.51
640	12.00	18.78	12.10	9.27	10.69
756	18.00	21.78	3.30	18.31	10.80
815	22.00	22.98	8.90	10.33	9.61
879	26.00	25.71	.30	7.08	3.69
931	27.00	28.32	.10	2.31	1.20
1025	24.00	31.88	.10	.25	.18

	CROP HEIGHT		--LARVAL DENSITY--		
DD	O(Y)	E(Y)	O(Y)	E(Y)	F(Y)

FIELD: 612.

380	8.00		0.00		
399	7.00	8.01	.20	0.00	.20
487	13.00	12.93	.20	2.18	1.19
570	17.00	17.73	1.00	4.35	2.68
640	18.00	21.20	1.60	5.20	3.40
756	20.00	25.56	.30	4.98	2.64
815	20.00	25.75	0.00	2.37	1.18
879	27.00	26.08	0.00	.83	.41
931	28.00	28.98	0.00	.20	.10
1025	32.00	30.36	0.00	0.00	0.00

FIELD: 1024.

262	3.00		0.00		
282	4.00	3.03	0.00	0.00	0.00
330	6.00	3.54	0.00	0.00	0.00
354	6.00	4.78	0.00	0.00	0.00
374	12.00	5.41	0.00	0.00	0.00
387	12.00	8.71	.40	0.00	.40
487	10.00	16.29	1.30	4.03	2.67
570	13.00	17.90	3.50	9.19	6.35
640	17.00	19.39	9.60	12.76	11.18
756	22.00	24.32	4.80	17.13	10.97
815	28.00	26.11	1.70	9.82	5.76
879	28.00	30.00	.30	3.84	2.07
931	29.00	31.30	.10	1.20	.65
1025	36.00	34.14	0.00	.07	.03

FIELD: 1135.

330	6.00		0.00		
354	6.00	6.04	.30	0.00	.30
380	6.00	7.71	.90	.79	.84
399	8.00	8.11	.60	1.50	1.05
499	3.00	14.12	.50	9.10	4.80
591	12.00	14.13	.50	19.91	10.20

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