Project No. 88-C11-Mite and Insect Research

Project Leader: Dr. Frank Zalom
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Objectives: (1) Provide traps and lures to Cooperative Extension advisors to monitor population levels of navel orangeworm, peach twig borer, and oriental fruit moth on an ongoing basis. This information will be summarized and used to interpret and validate phenology models on those crops. (2) Compare commercailly available traps and lures for peach twig borer and oriental fruit moth. (3) Develop a program to simulate navel orangeworm phenology using the developmental data reported by Dr. John Sanderson.

Additional Work on Almonds: Mass-trapping of peach twig borer to control this insect was attempted in 2 sites, Merced County and San Joaquin County.

Results:

Population Monitoring: Pheromone traps were provided to all Cooperative Extension Farm Advisors who requested them. The data obtained will be summarized using the UC "Trap Counts" program, and will become a part of our database on the phenology of these pests.

Pheromone Lure and Trap Efficiency: Several companies are marketing lures for peach twig borer and oriental fruit moth. Further, several trap designs are being marketed for "small moths". Most growers and PCA's currently use Trece lures and Trece wing-style traps for these insects, and most of the University's research data has been based on these lures.

The results of this years trial showed that the Trece lures performed better than any of the other brands in the spring trial (beginning in April) in terms of numbers caught in the traps. The lures appeared to last for about 6 weeks in comparison to a new Trece lure. The Biolure caught fewer moths than the Trece lures during the first 8 weeks, and then became higher in subsequennt weeks. The Biolure caught the most moths in weeks 9 - 18 of the trial, then appeared to decline in efficiency. The Hercon lure was similar in efficiency to the Trece lure. In the second trial (beginning in late June) the Biolure caught more moths than a new trece lure for all 11 weeks. The Trece lure appeared to perform as well as a new Trece lure for only 2 weeks. It seems likely that the cool spring resulted in better efficiency and longevity of the Trece lure as compared to the Biolure, however the performance of the Biolure was far superior when temperatures were higher.

There was no significant difference in trap catch for the oriental fruit moth Trece lure or Biolure as compared to a new Trece lure for 16 weeks. The Hercon lure appeared to be contaminated as noctuids were caught for the first 10 weeks of the trial, excluding all other moths. After the flight of this noctuid, the traps with Hercon lures began to record oriental fruit moths.

Comparison of traps confirmed the prior years results with the Trece wing style traps being most effective for peach twig borer and the Multipher trap (with Vapona) being best for oriental fruit moth. The Trece wing-style trap was also quite effective. The Pherocon II trap was least effective for both moths.

Navel Orangeworm Model: As reported last year, all methods of simulating navel orangeeworm phenology worked equally well. These included degree-day models with a horizontal developmental cutoff, degree-day models with a vertical cutoff and a nonlinear approach using developmental data from Dr. John Sanderson. The nonlinear approach was developed in a computer program written by Ann Strawn at UC Riverside, and is running on the UC IMPACT computer and on a DOS microcomputer. This program will be available for further validation this season.

# ALMOND BOARD OF CALIFORNIA
# ANNUAL REPORT - 1988

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**Cooperators:** w. Barnett, J. Connell, J. Edstrom, L. Hendricks, W. Krueger, R. Plant, W. Reil, D. Rough

**Objectives:**

1) Provide traps and lures to Cooperative Extension Advisors rto monitor population levels of navel orangeworm peach twig borer, and oriental fruit moth on an ongoing basis. This information will be summarized and used to interpret and validate phenology models on those crops.

2) Compare commercially available lures and traps for peach twig borer and oriental fruit moth.

3) Develop a program to simulate navel orangeworm phenology using the developmental data reported by John Sanderson.

4) Develop a computer program to predict spider mite and predator populations and mite-day guidelines using either a presence-absence or a brush and count monitoring method.

**Additional Work on Almonds:**

1) Mass-trapping for peach twig borer in cooperation with Lonnie Hendricks and Don Rough.

2) Validating low temperatures as a possible cause of the 'twin peaks' observations of peach twig borer flights in cooperation with Bill Barnett.

3). Coordinating development of UC Guidelines for Almond Pests, a new UC publication.

**Results:**

*Population monitoring.* Pheromone traps and lures were provided to all Cooperative Extension Advisors who requested them. Seven Farm Advisors received a total of 78 NOW traps and bait, 51 wing-style traps, 153 trap liners, 578 peach twig borer lures, and 36 oriental fruit moth lures.

The data obtained by the Advisors will be summarized using the UC Trap Counts program, and will become part of our database on the phenology of these pests.

*Pheromone lure and trap efficacy.* Several companies are marketing lures for peach twig borer and oriental fruit moth. Further, several trap designs are being marketed for 'small moths'. Most growers and PCA's currently use the Trece lures and traps which were formerly manufactured by Zoecon. Most of the University's research has been based on these lures.

Tests were conducted in 1986 on peach twig borer and in 1987 and 1988 on both peach twig borer and oriental fruit moth to compare lures and commercially available traps to each other and to the standard Trece (Zoecon) lure and wing trap.

Peach twig borer lures tested in 1988 included commercial ones from Consep Membranes (hereafter referred to as Biolure), Hercon, Scentry, and Trece (hereafter referred to as Zoecon). Each lure was placed in an orchard in a randomized complete block which was replicated 4 times. A second Zoecon lure was placed in each block one week later. The lures were rotated within each block following each sampling date. Once a week, a new Zoecon lure was put in place of the prior weeks Zoecon lure in each block. Actual trap counts were converted to mean proportion of total adults caught per trap to standardize traps across weeks. An arcsin transformation was performed prior to analysis. The lures from the first trial remained in the orchard for 9 weeks. All lures except the Biolure (BiolureI) and the Zoecon lure (Zoecon I) were replaced after the ninth week, and the trial was continued for 11 additional weeks. The original Biolure (Biolure I) and the original Zoecon lure (Zoecon I) were permitted to remain in each block for the entire trial, however a new Biolure (Biolure II) and a new Zoecon lure (Zoecon II) were added after the ninth week.

The results of this years work showed that the Zoecon lures caught more moths than any of the other types for the first 7 weeks of the season (beginning in April). The lures caught as much as a new Zoecon lure for the first 12 weeks of the trial (Figure 1). These aged Zoecon lures continued to catch a low number of moth for all 21 weeks of the trial. There was no significant difference between the new Zoecon lure and any of the other types except the Scentry lure during the first 9 weeks of the trial. The Scentry lure only caught the same level of moths for the first 6 weeks of the trial. The Biolure began to catch more moths than the new Zoecon lure in the ninth week of the trial. The new and aged Biolures caught relatively the same number of moths during the second trial (weeks 10 through 21). During this period they consistently caught more moths than the new Zoecon lure (Figure 2). The Hercon lure in trial 2 performed equally well as the Biolure.

The results of the 2 1988 trials were quite different when compared over the season (Figure 3). The second trial was most similar to that observed in the other 2 years. It seem possible that the cool spring temperatures resulted in greater efficiency of the Zoecon septa as compared to the Biolure or Hercon lures. In the warmer summer conditions, the Biolure and Hercon lures caught many more moths, and the Zoecon lure only appeared to last 2 or 3 weeks. This is consistent with a recent article by Dr. Les McDonough (1988) of the USDA in Yakima who shoed that relaease rates and longevity of rubber septa are greatly influenced by temperature. These results emphasize our prior cautions that pheromone lures are best not used for assessing population levels, but rather are best used for determining biofix and relative seasonal abundance. The Zoecon lures might best be used in the spring under cool conditions, and the Biolure or Hercon lures under warmer conditions. Again, when mixing lures it becomes impossible to relate moth abundance.

When total moth catch was compared for the season, Biolure II caught significantly more moths than the other treatments. Biolure I, Zoecon I, the new Zoecon lure, and the Hercon lures all caught the same number of moths. The Scentry lure and Zoecon II caught significantly fewer toatl moths than the other lures.

There was no significant difference in trap catch for any of the oriental fruit moth lures except Hercon for the first 18 weeks of the trial. The Hercon lure appeared to be contaminated as large noctuids were caught for the first 10 weeks of the trial, neccessitating replacement of trap bottoms each week. Apparently, after the flight of these noctuids ended, the traps with the Hercon lure began to catch oriental fruit moths, becoming dominant after the 15th week.

When total moth catch was compared for the season, all lures except the Hercon lure caught similar numbers of moths, but all were significantly less than a new Zoecon lure.

Comparisons of traps for oriental fruit moth showed that the Zoecon wing-style trap and the Multipher trap with vapona as a killing agent caught significantly more moths than the Multipher trap with water or the Hercon wing-style trap. The Pherocon II trap caught the least moths. This is not inconsistent with prior years results. A description of the experimental design and each trap type was given in my 1987 Annual Report.

*Navel Orangeworm Phenology Models.* In 1987, I compared various phenology models proposed for predicting the development of navel orangeworm. The results presented in my 1987 Annual Report showed no significant difference between methods in their ability to predict the flight of navel orangeworm, although all had considerable spread in the predictions. The best method in terms of least variance in the predicted versus observed dates predicted for flight intervals was a nonlinear model based on the developmental rate data developed by John Sanderson. This year I proposed to develop a program for simulating navel orangeworm flight using this nonlinear method. The program was demonstrated at the 1988 Almond Board Annual Conference in Sacramento. A handout (Figure 5) was developed for the conference which explains how to use the various models and the assumptions unique to each.

A data set independent of that used in the original model validation was obtained in 1988 consisting of 7 orchards from different areas. This data set was used to validate the program. The results showing predicted versus observed dates of the initiation of the third navel orangeworm flight are provided on Figure 6. A slope of 1.00 indicates a perfect fit of predicted versus observed dates. It can be seen that the results are quite good. The other measure of fit, variance about the regression line shows, that predictions are generally within 1 week of the observations. This is good as the data used were only taken once a week and therefore the observations could have easily been a week off.

The program is available to UC Farm Advisors, and will be made available through the University for public distribution after a users manual is written and the program is approved.

*Spider Mite Program.* I proposed to develop a program for predicting development of spider mite and predator populations, and for relating presence-absence or bruch and count monitoring to mite-day thresholds during this fiscal year. The actual project was initiated in September. I am working with Dr. Richard Plant of the Department of Mathematics at UC Davis on this project. Dr. Plant is an expert in the developing area of artificial intelligence, and this program is being written in the CALEX expert system shell. It will be possible to run the program on any DOS compatible microprocessor. We anticipate completion of the program this summer.

**Other Almond Activities:**

*Mass-trapping.* I purchased enough Biolure peach twig borer lures and wing-style traps to attempt mass-trapping of a portion of 2 orchards, one in Manteca and the other in Hilmar. The Manteca orchard did not have enough damage at harvest to show differences between treated and untreated portions of the orchard. The Hilmar orchard, which was conducted by Lonnie Hendricks had 1.9% damage in the untreated portion of the orchard, 0.3% damage in the mass-trapping portion of the orchard, and 0.3% damage in an adjacent orchard which received a dormant spray and a May spray. Because this trial was not replicated, any conclusions drawn are at best tentative. It would be a good idea to treat another portion of the orchard in 1989 with the mass-trapping to see if these results can be duplicated in another part of the orchard. The treated portions of these orchards received one trap per 10 trees. About 4 acres were treated at each site. It is not possible to treat smaller areas successfully, and this severely limits the design of potential experiments. Results from mass-trapping in 5 other orchards with different types of trees were inconclusive. I hope to pursue this technique with Lonnie next year.

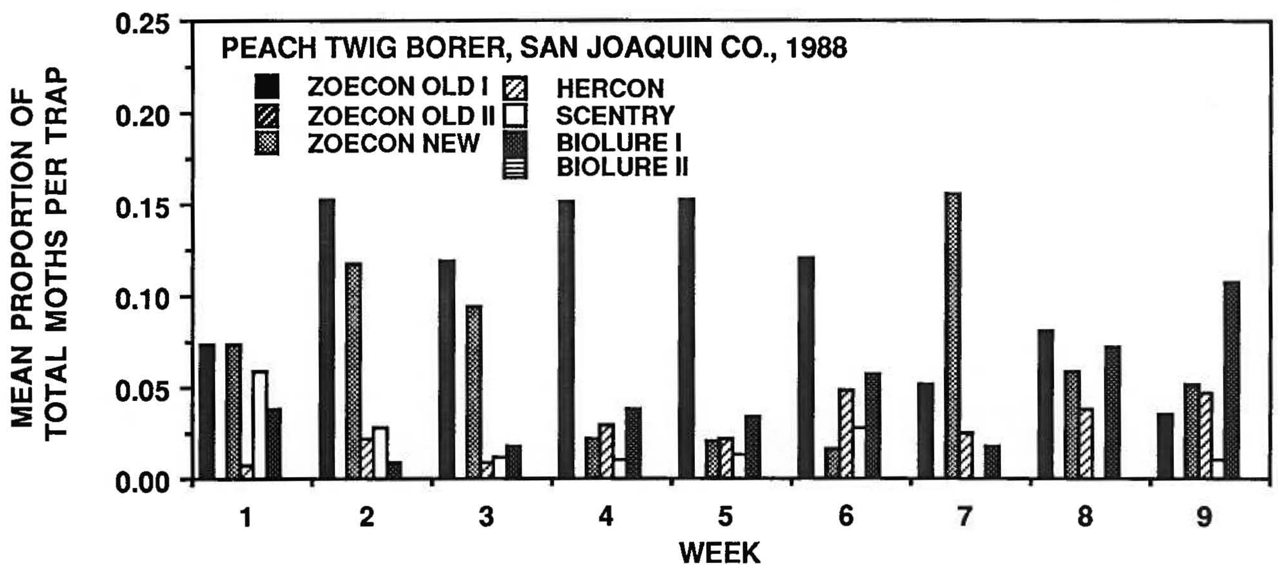
*Peach twig borer emergence and flights.* In 1986, we conducted an analysis which concluded that temperature could explain the occurence of twin peaks of peach twig borer flight. Low temperatures in the spring during peak flight resulting in depressed catches. The analysis was strictly correlative, and was presented in my 1986 Almond Board Annual Report. In 1988, we attempted to obtain data which would support the results of this study with data from other life stages. Bill Barnett banded trees in Snelling to catch peach twig borer pupae. Each week he removed 11 to 15 of the bands (so that at least 100 pupal cases were present), and determined the proportion of pupal cases from which moths had emerged. He also counted eggs per 100 fruit, and ran pheromone traps in the orchard.

The results of this study confirmed our previous observation that the emergence of moths from pupae (our prior work had been emergence of larvae from hibrnaculae) progressed fairly consistently and didn't appear to be impacted by low temperature, even in an orchard where 'twin peaks' were observed in pheromone traps (Figure 7). The pheromone trap catches from this orchard showed the typical 'twin peak' which was well correlated with low nighttime temperatures (Figure 8). What was particularly interesting was that oviposition in this orchard showed 2 distinct peaks well correlated with the timing of the peaks of moth flight.

Our 1986 study showed that the twin peaks appeared to occur in subsequent generations of the peach twig borer following a 'twin peak' observation during the first moth flight. The finding of oviposition occurring in similar fashion is significant as it tends to confirm the original study findings.

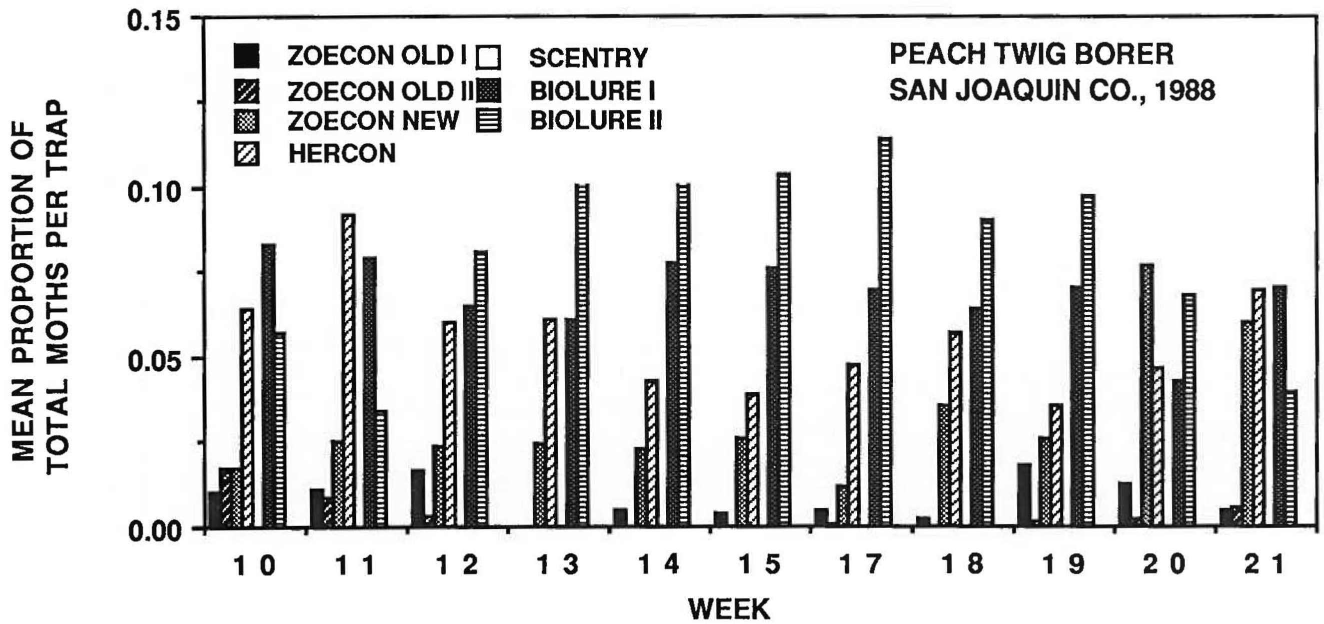
*UC Almond Pest Management Guidelines.* The University is now attempting to update their pest management guidelines by producing them in a standard, easy to update manner. The guidelines are available through the UCIPM IMPACT computer, or in hard copy from county Cooperative Extension offices. They may soon be available through UC Agricultural Sciences Publications. The Almond Pest Management Guidelines were written by many Farm Advisors, Specialists and researchers, and I helped coordinate them. A copy of the guidelines is atteched.

**Discussion:** My research continues to emphasize monitoring, nonchemical pest controls, and the safe and efficient use of pesticides for control of insect pests in almonds. These research and extension efforts rely heavily on the cooperation of the outstanding Cooperative Extension Farm Advisors who work on almonds. Providing them with physical and research tools is the most important long-term objective of my project. Specific recommendations which have resulted from our efforts in 1988 are presented in the results section of this report. Future work should include studies of new chemical and nonchemical controls for insects and mites, and to insure the continued availability of dormant sprays or suitable alternatives. I hope to continue to be a part of this research, and am willing to consider specific projects suggested by Farm Advisors or the Almond Board which fit into these areas.



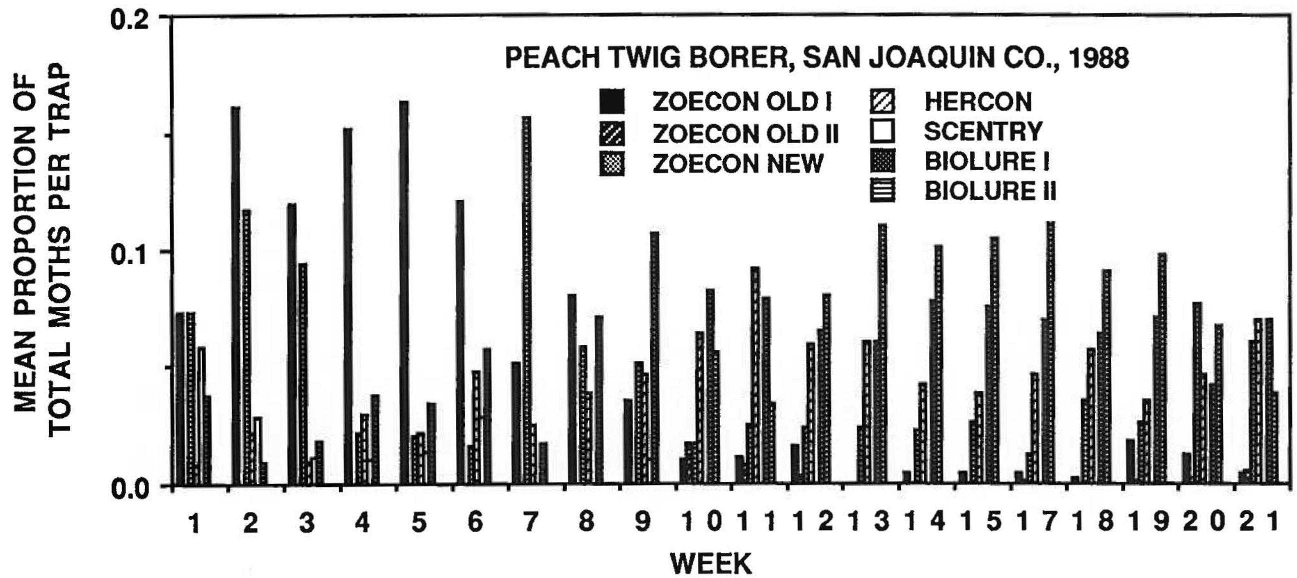
PEACH TWIG BORER, SAN JOAQUIN CO., 1988
ZOECON OLD I
ZOECON OLD II
ZOECON NEW
HERCON
SCENTRY
BIOLURE I
BIOLURE II
MEAN PROPORTION OF TOTAL MOTHS PER TRAP
0.25
0.20
0.15
0.10
0.05
0.00
1
2
3
4
5
6
7
8
9
WEEK


Figure 1



0.15
0.10
0.05
0.00
MEAN PROPORTION OF
TOTAL MOTHS PER TRAP
ZOECON OLD I
ZOECON OLD II
ZOECON NEW
HERCON
SCENTRY
BIOLURE I
BIOLURE II
PEACH TWIG BORER
SAN JOAQUIN CO., 1988
10
11
12
13
14
15
17
18
19
20
21
WEEK


Figure 2



PEACH TWIG BORER, SAN JOAQUIN CO., 1988
ZOECON OLD I
ZOECON OLD II
ZOECON NEW
HERCON
SCENTRY
BIOLURE I
BIOLURE II
MEAN PROPORTION OF TOTAL MOTHS PER TRAP
0.2
0.1
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 21
WEEK


Figure 3

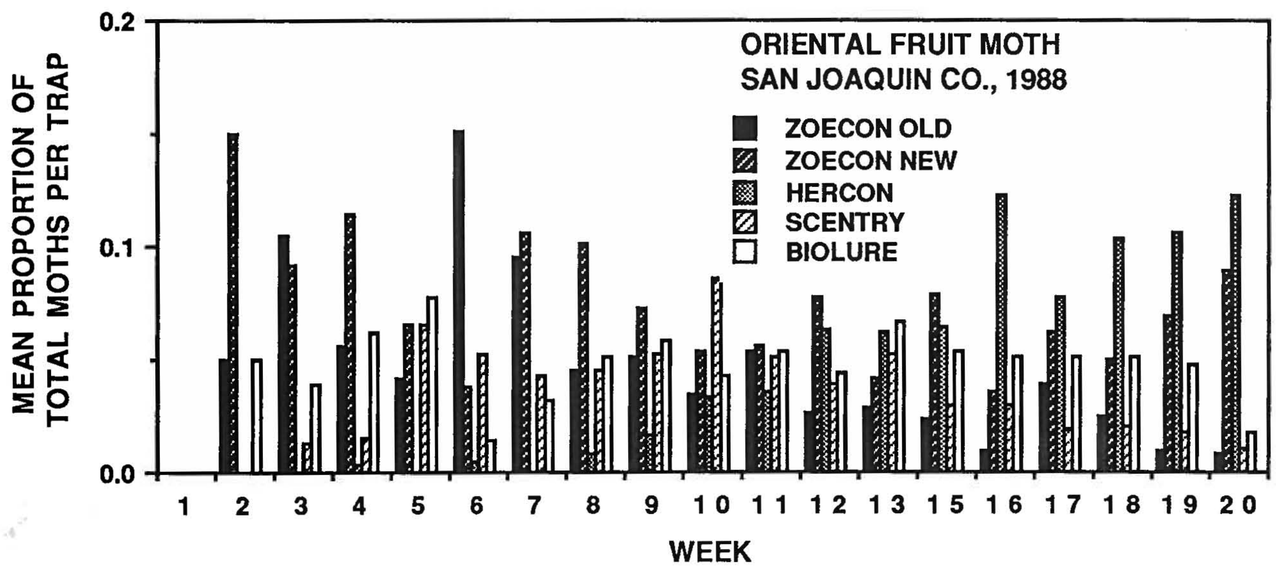

ORIENTAL FRUIT MOTH
SAN JOAQUIN CO., 1988
ZOECON OLD
ZOECON NEW
HERCON
SCENTRY
BIOLURE
MEAN PROPORTION OF TOTAL MOTHS PER TRAP
0.2
0.1
0.0
1
2
3
4
5
6
7
8
9
10
11
12
13
15
16
17
18
19
20
WEEK

Figure 4

Figure 5

# NAVEL ORANGEWORM PHENOLOGY

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A considerable amount of work has been done in the last decade by Dr. Martin Barnes and his students to determine the developmental rate of navel orangeworm, and to develop a degree-day phenology model for the insect. A modelling effort has also been conducted by Dr. Keith Oddson to develop a more detailed simulation. Concurrently, work has been done by several Cooperative Extension Advisors and Specialists to confirm the research. Much of this research has been sponsored by the Almond Board of California and the UC Statewide IPM Project.

In 1985, Dr. Gary Smith of the UC IPM Project began to work with all of these individuals to try to determine which elements of the various efforts could have utility in predicting moth flights and navel orangeworm development.

Three approaches all appear to be valid in predicting navel orangeworm phenology: 1) a simple degree-day model using a horizontal upper developmental cutoff, 2) a simple degree-day model using a vertical upper developmental cutoff, and 3) a nonlinear model using developmental rate data directly. All 3 approaches were tested using egg trap data collected by Farm Advisors in 10 counties (Kern, Tulare, Merced, Madera, Fresno, San Joaquin, Yolo, Colusa, Butte, and Sutter) since 1978. Only data sets which had complete trap records, nearby weather records, and hullsplit date were used. In all, 36 data sets met these criteria. Results presented in last year's report to the Almond Board showed that there was no significant difference in predictions of initiation of first and second generation flight. As expected, however, the variance of the data about the regression line is less in the first generation than in the second generation, probably due to overlap of generations. The variance was less for the nonlinear model than for the two simple phenology models.

Horizontal Method: The horizontal method is most similar to that used for monitoring other insects such as San Jose Scale and Peach Twig Borer. This method uses a lower developmental threshold of 55$^{o}$F and an upper developmental threshold of 94$^{o}$F with a horizontal upper developmental threshold cutoff. The horizontal upper cutoff assumes that development continues at a constant rate at temperatures in excess of the upper threshold (see Figure 1). Mean developmental time for navel orangeworm on mummy nuts is 1025 degree-days, and on new crop nuts 692 degree-days. Mean egg hatch is at 100 degree-days.

Vertical Method: The vertical method is a more recent concept. It makes the assumption that no development occurs above the upper developmental threshold (see Figure 1). This method uses a lower developmental threshold of 55$^{o}$F and an upper developmental threshold of 94$^{o}$F with a vertical upper developmental cutoff. Mean developmental time for navel orangeworm on mummy nuts is 1092 degree-days, and on new crop nuts 738 degree-days. Mean egg hatch is at 100 degree-days.

<u>Nonlinear Method:</u> The nonlinear method uses the navel orangeworm developmental data determined by Dr. John Sanderson for mummy nuts and new crop nuts directly (see Figure 2). By comparing Figures 1 and 2, it can be seen that the horizontal method tends to overestimate development at temperatures over the upper developmental threshold while the vertical method tends to underestimate development over the upper developmental threshold. As mentioned before, our validation studies showed no significant difference in the accuracy of either method, although an article by Sanderson and Barnes (1984) indicated that their original data, which was gathered in Kern County, gave a slightly better fit with the vertical cutoff.

Using the nonlinear method is not as convenient as the two linear methods as it is necessary to estimate development at more frequent intervals than is done using the linear methods. A computer program has been developed which allows this to be done simply. The program uses a sine wave drawn through the maximum and minimum temperature on a given day and divides the wave into 24 hourly increments. The temperature on each hour is related to the percentage development that would occur at that temperature. The percentage development for each hour is summed over the day, and the daily percentage development is summed until 100% development occurs (the length of one navel orangeworm generation). In theory, this method should be accurate assuming the developmental rate curve developed is accurate.

The UC IPM IMPACT Computer System permits the calculation of degree-days using either a vertical or a horizontal cutoff, and either linear method may be used given the parameters for development mentioned earlier. The program for the nonlinear method is on the UC IPM Prime computer, and has also been written for microcomputers with DOS operating systems. We plan to have the DOS version available for distribution after testing and completion of a users manual.

Figure 1

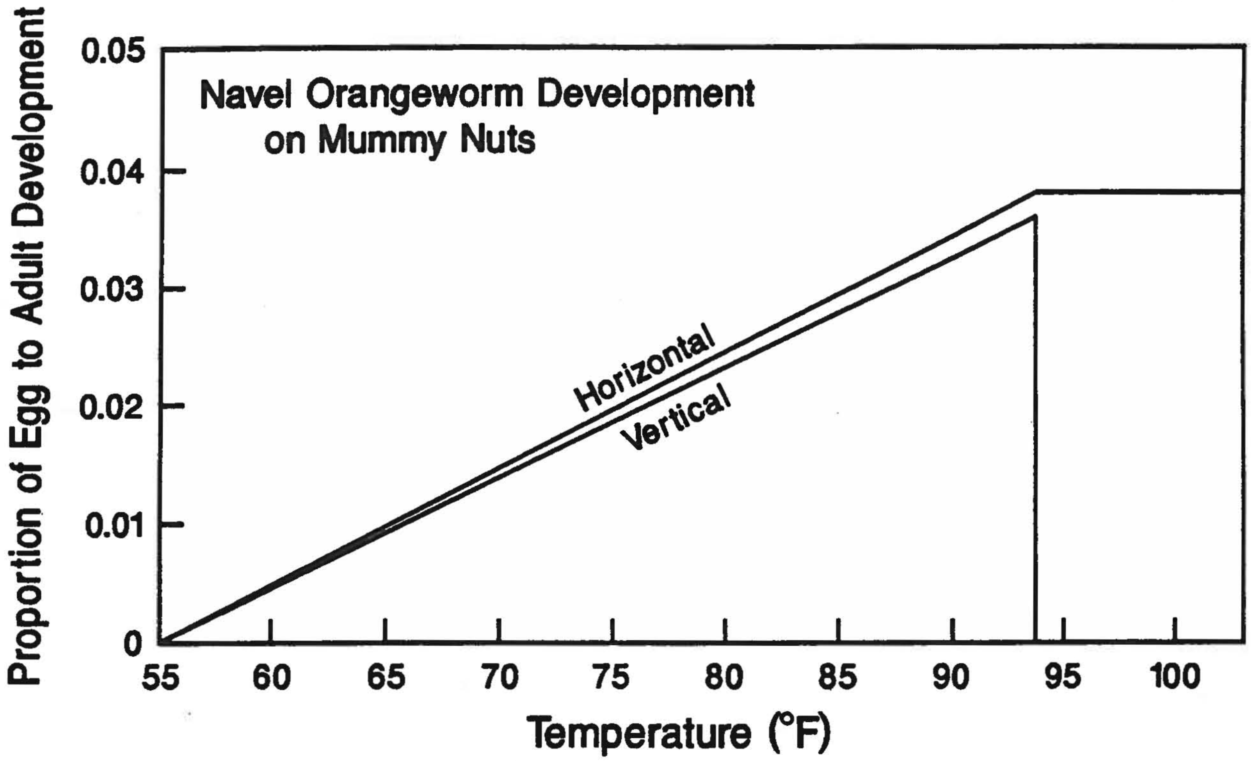



Figure 2

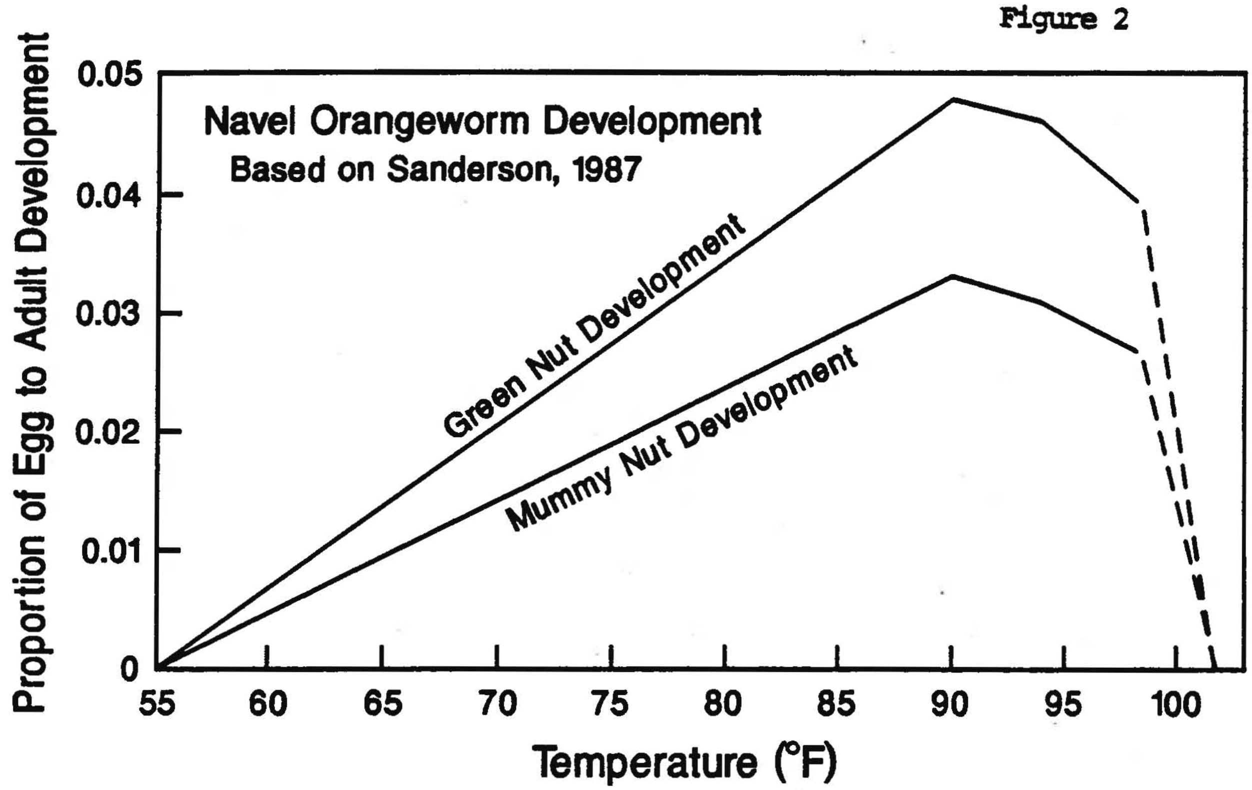
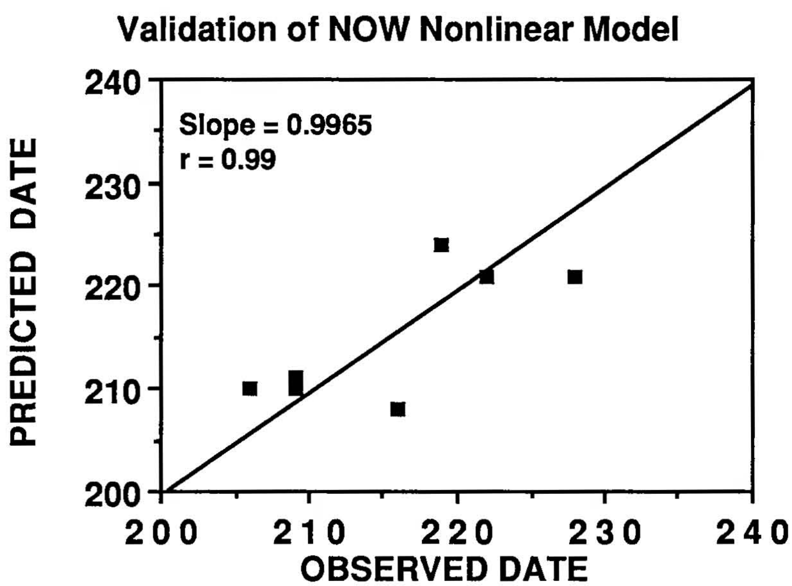


Figure 6


Validation of NOW Nonlinear Model
Slope = 0.9965
r = 0.99
PREDICTED DATE
240
230
220
210
200
200
210
220
230
240
OBSERVED DATE

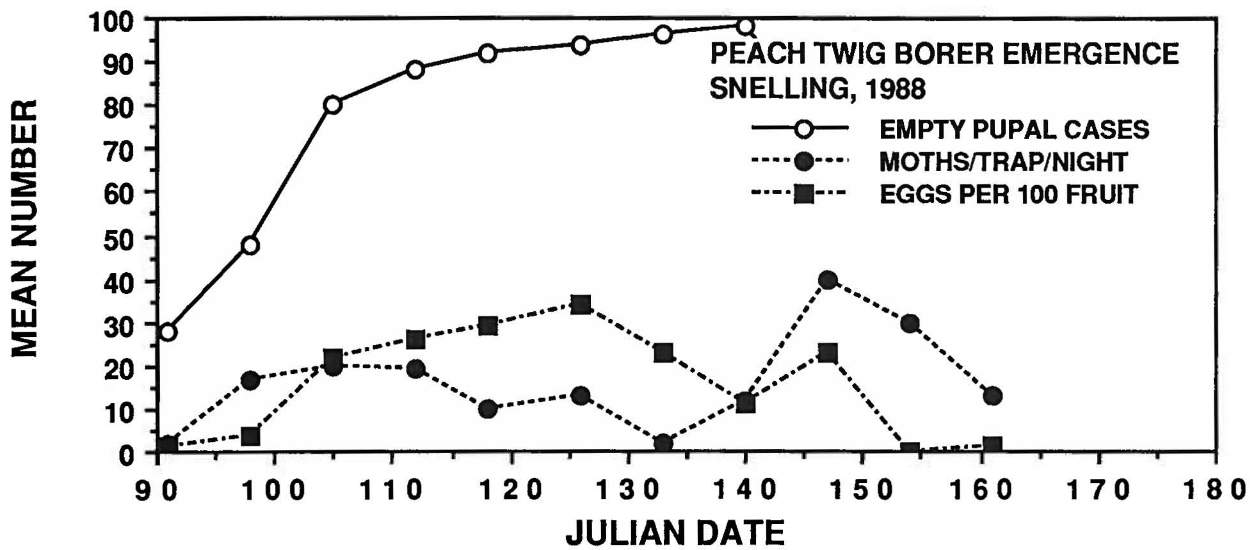

PEACH TWIG BORER EMERGENCE
SNELLING, 1988
EMPTY PUPAL CASES
MOTHS/TRAP/NIGHT
EGGS PER 100 FRUIT
MEAN NUMBER
100
90
80
70
60
50
40
30
20
10
0
90
100
110
120
130
140
150
160
170
180
JULIAN DATE

Figure 7

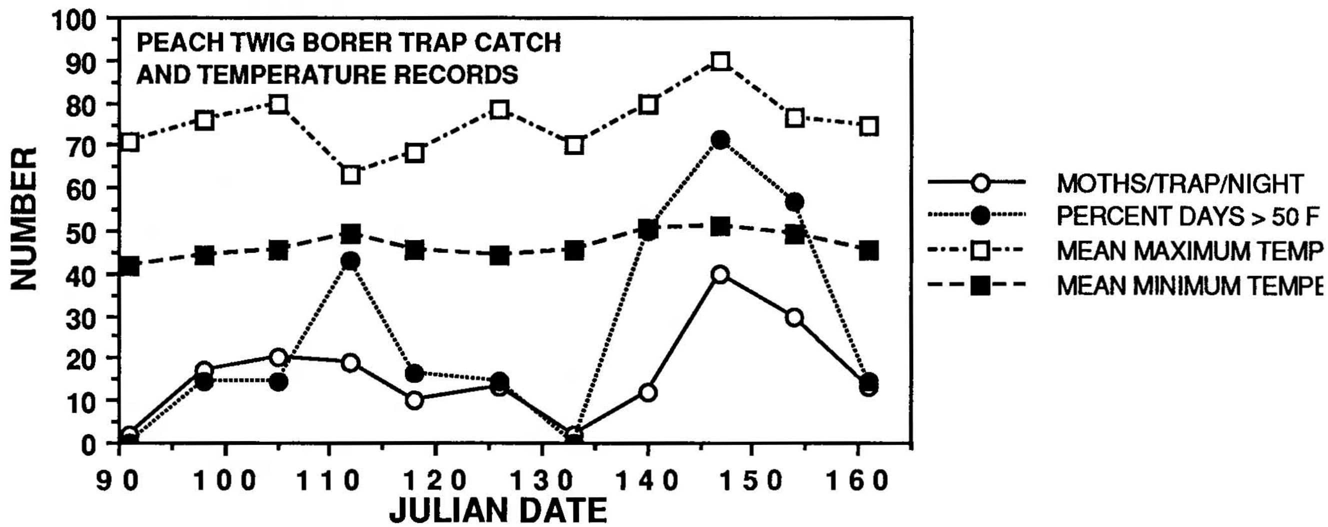

PEACH TWIG BORER TRAP CATCH
AND TEMPERATURE RECORDS
NUMBER
100
90
80
70
60
50
40
30
20
10
0
90
100
110
120
130
140
150
160
JULIAN DATE
MOTHS/TRAP/NIGHT
PERCENT DAYS > 50 F
MEAN MAXIMUM TEMP
MEAN MINIMUM TEMPE

Figure 8