California Tree Fruit Agreement Project Report - 1979

Stonefruit Pest Management

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Introduction: The use of predictive techniques in forming pest management strategies and decisions is now feasible. By incorporating weather data and certain observations of pest development into simple computer models, predictions can be made when certain subsequent life stages of a given pest will occur. The stonefruit pest management project supported by CTFA in 1979 was to gather and analyze pheromone trapping data for several major tree fruit pests, and to use these data to help develop and validate predictive (or phenological) models for each of these pests. Assisting in this project were Cooperative Extension Farm Advisors W. Barnett, Fresno County; W. Bentley, Kern County; and D. Flaherty, Tulare County. Cooperating in the analysis of data and development of the computer models have been C. Jorgensen and B. Croft, Michigan State University, and J. Brunner and S. Hoyt, Washington State University, Wenatchee. A summary and discussion of progress for each pest follows.

I. Oriental Fruit Moth, *Grapholitha molesta* (Busck)

The predictive phenology model for oriental fruit moth is being developed by Brian Croft at Michigan State University as part of an over-all modeling effort for pome and stonefruit pests. The model is based on the use of maximum and minimum field temperatures, lower and upper thresholds of OFM development, and calculated day-degree (D^{o}) accumulations for various life stages of the insect (Table 1).

Of nine orchards trapped for OFM through the 1979 season, data from six orchards have been evaluated for accuracy and comparison to the model (= validation). These comparisons (Table 2) show relatively good accuracy

Table 1. Temperature thresholds and day-degree requirements for oriental fruit moth.

Lower threshold	: $45^{o}F$
Upper threshold	: $90^{o}F$
Pre-oviposition ♀	: 50 D^{o}
Egg development	: 143 D^{o}
1st moth to egg hatch	: ca. 193 D^{o}
Larvae (total)	: 387
Pupae	: 383
D^{o}/generation	: ca. 1000 @ 45^{o}
Total D^{o}/season	: ca. 5996
Day-degree calculation	: $\frac{\text{Max. temp.} + \text{Min. temp.}}{2} - 45^{o}F = D^{o}$ for each 24 hr. period.

Table 2. Analysis of 1979 oriental fruit moth phenology data using a predictive model based on 45^{o}-$90^{o}F$ thresholds.

Orchard No.	Day-degrees calculated from 1st moth: 1st - 2nd flt.	2nd - 3rd flt.	3rd - 4th flt.	4th - 5th flt.	$\bar{X}$
1	1009	986	955	1035	996
2	732	1027	1084	1164	1002
3	959	953	926	1036	969
4	923	925	1003	1019	968
5	992	1016	1058	982	1012
6	906	1086	1050	895	984
$\bar{X}$	920	999	1013	1022	989

in terms of D^o required for each generation. Generation times are based on collections of first moths in one flight to first moths in the next flight. By knowing that it requires ca. 1000 D^o for each generation of OFM to develop, and by keeping accurate daily or weekly totals of accumulated day degrees, it is possible to tell if fluctuations in moth counts are actually due to OFM population trends (Fig. 1), or are caused instead by weather conditions, poor trap maintenance, spray applications, etc. The calculations in Table 2 are based on desk-top calculator analyses; these data will also be analyzed by computer as soon as computer time can be obtained to enter the data and run the computer.

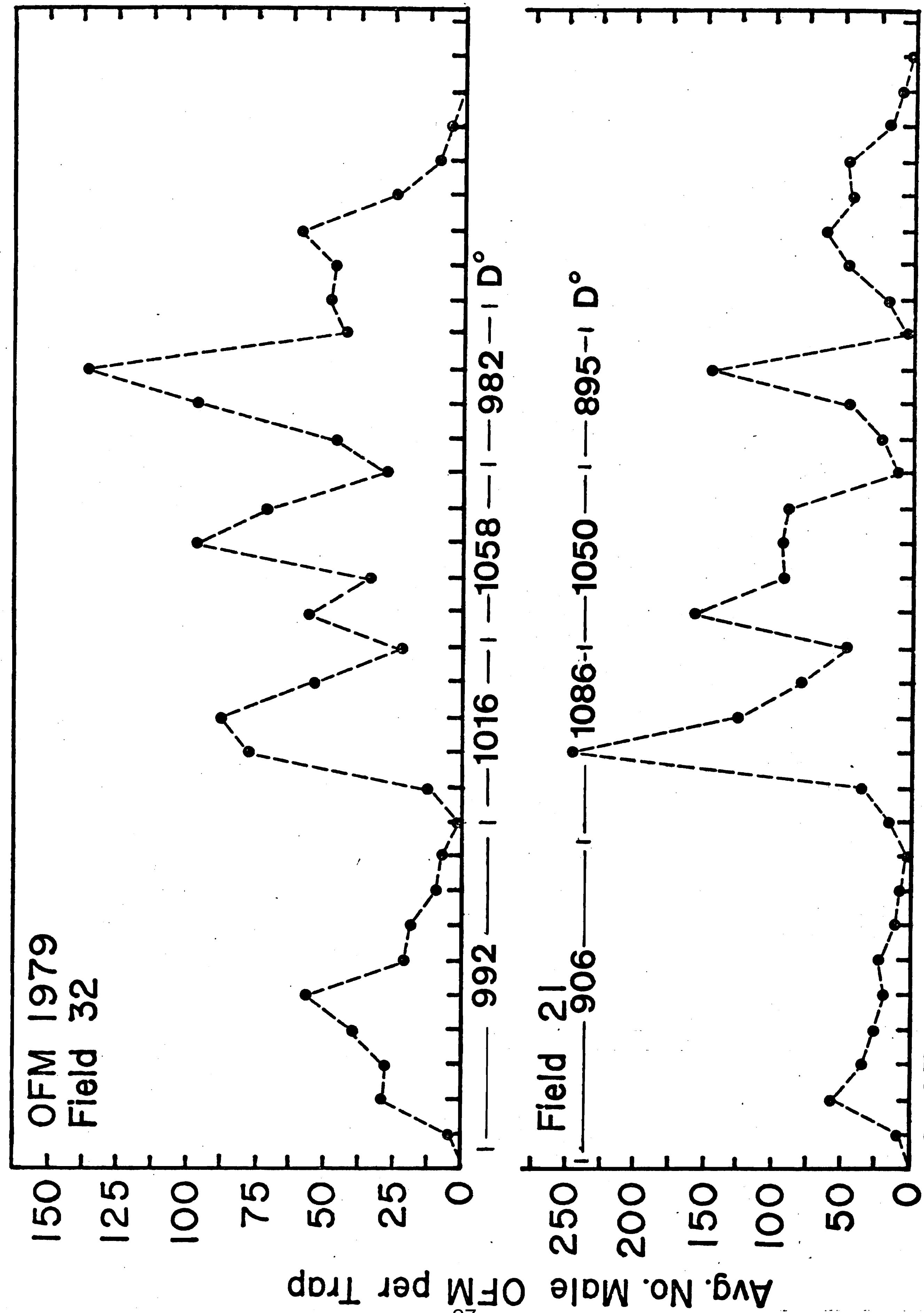
The results of these analyses show that the OFM model is acceptably accurate in showing when a given event is occuring in the development or life cycle of OFM (e.g. - time for each generation to develop). The accumulated D^o for each generation, based on observed moth collections in pheromone traps, is quite close to the model prediction of ca. 1000 D^o. Even the average of 920 D^o during the first flight is within the 10% variation normally accepted for field data of this type.

Because the model appears to be accurate in calculating total D^o values per generation, we can assume that calculated values for different life stages (e.g. - eggs) are also reasonably accurate. Thus, after 1st moth flight occurs we can determine just when first eggs will hatch, when larvae are pupating, and when first moths of the next generation should appear (Table 1). Pending completion of 1979 data analysis, it is anticipated that the OFM model will be ready for grower use by early 1980.

Some of the practical applications of this information would be:

1). After 1st moths are trapped in the spring flight (March), we can determine when to expect the beginning of the May moth flight by using only temperature data. Pheromone traps would not need to be

Figure 1.


OFM 1979
Field 32
Field 21
992
1016
1058
982
D°
906
1086
1050
895
D°
150
125
100
75
50
25
0
250
200
150
100
50
0
Avg. No. Male OFM per Trap
9 23 6 20 4 18 1 15 29 13 27 10 24 7 21 5 19
Mar Apr May June July Aug Sept Oct

used during most of March and April, and would be placed back in the orchards just prior to the expected May flight (e.g. - at ca. 900 D^o after 1st moth in March).

2). Upon trapping 1st moths in the May flight, D^o calculations will tell us when 1st eggs are hatching, and help us to anticipate optimum spray timing for the May treatment - e.g. - ca. 225-250 D^o after 1st May flight moths. Better predictions of optimum spray timing should enable growers to plan other orchard activities in a logical sequence.

3). Accurate calculations of each generation time development should lead to better timing of late season sprays on later maturing varieties; e.g. - optimum timing on June or July OFM flights.

4). Use of the OFM model throughout the season should enable growers and field men to reduce the total amount of time spent in servicing pheromone traps during the season. In other words, "spot-trapping" for ca. 2 weeks at pre-determined times during each moth flight should be enough to update the model for each generation. A trade-off in time will be required to read temperature recorders at daily or weekly intervals, but a net gain in time, labor, and expense should be realized.

II. Peach Twig Borer, *Anarsia lineatella* Zeller.

A predictive phenology model for peach twig borer (PTB) is being developed by J. Brunner at Wenatchee, Washington. The major sources of pheromone trapping data and temperatures for validating this model will be from California, so it is believed the model will be reasonably accurate for California conditions once the model is perfected. A total of thirteen orchards were trapped for PTB in 1979; eight of these provided data good enough for preliminary evaluation in the model. At this time it has not been determined which precise temperature value should be used for the lower threshold of PTB development. However, it appears that either 50^{o} or 52^{o}F will eventually be the figure used.

Using a 52^{o}F threshold, calculations of developmental times between first moths of each flight in 1979 (Table 3) showed fairly good correlations between flights (generations), and also between different orchard locations. Studies on PTB egg development under both field and laboratory conditions have shown D^{o} values of ca. 160-180 D^{o} between oviposition and hatch. These data, along with data on larval and pupal development, will be incorporated into the PTB model in the same manner as the OFM model was constructed. Preliminary evaluation of pupation data from Wenatchee also shows generation requirements of ca. 1000 D^{o}, which agrees fairly well with generation values based on moth activity (Table 3). With additional trapping data from various locations in 1980, it is hoped that the PTB model will be operational by 1981.

Table 3. Preliminary comparisons of developmental times for successive generations of peach twig borer, using a lower developmental threshold of 52^{o}F.

Orchard	Day-degrees calculated from 1st moth			
No.	1st - 2nd flt.	2nd - 3rd flt.	3rd - 4th flt.	$\bar{X}$
1	980	986	-	983
2	980	986	-	983
3	1084	1085	796	988
4	926	919	886	910
5	924	1002	1046	991
6	995	1014	1003	1004
7	924	1029	1020	991
8	1007	905	1033	1008
$\bar{X}$	978	[illegible]	964	981

III. Codling Moth, *Laspeyresia pomonella* (L.)

A predictive phenological model for codling moth has been used commercially for several years in California. Because this model was initially developed from data collected in pome fruits and walnuts, we thought it worthwhile to challenge the model with pheromone trapping data from plums. Therefore, seven plum orchards were monitored in 1979 for codling moth flight activity. Unfortunately (fortunately for the growers), codling moth populations in all of these orchards were so low that good, consistent data on moth population trends could not be obtained. These low populations of codling moth in plums probably are a result of two things; 1) good grower surviellance and control of CM; and 2) the cyclic nature of codling moth in plums, with populations for the past several years generally in a down trend.

Consequently, we were not able to challenge the codling moth model in 1979 with data from plums. In the absence of this however, I think we could assume that the existing CM model parameters could be used by growers to at least give them some idea of codling moth population development in plums. The D^o values used successfully for codling moth in apples, pears, and walnuts are given in Table 4.

Table 4. Temperature thresholds and day-degree requirements for codling moth.

Lower threshold	52^oF
Upper threshold	94^oF
Pre-oviposition female	ca. 50 D^o
Egg development	160 D^o
1st moth to egg hatch	ca. 210 D^o
Larval development (total)	450
Pupal development	380
D^o/generation	ca. 1030 D^o

IV. San Jose Scale, *Quadraspidiotus perniciosus* (Comst.)

Although San Jose scale (SJS) was not initially included in the 1979 pest management research proposal to CTFA, opportunities developed during the season that enabled us to include San Jose scale in the over-all trapping and modeling program. Partly as a result of CTFA support in 1976, the sex pheromone of San Jose scale has been isolated, identified and synthesized. Quantities of the synthetic pheromone became available in 1979 that allowed us to trap scale in several orchards at Parlier, as well as at locations in Oregon and Washington. Concurrent with the field development of SJS trapping techniques and systems in 1979, interest was expressed by modelers at Michigan State University (B. Croft, C. Jorgensen) in developing a scale model for inclusion in their modeling system for deciduous fruit.

As a result of our joint interests, we provided considerable field and laboratory data to MSU on scale biology, pheromone trapping, and temperatures. These data were worked into a prototype model for San Jose scale that looks quite promising in terms of accuracy and value to pest management programs. As with the models developed for OFM, PTB, and codling moth, the scale model uses lower and upper temperature thresholds for scale development. These values have initially been set at 51^{o}F and 90^{o}F respectively. There has been some discussion about the possibility of using either 50^{o}F or 52^{o}F as the lower threshold so that calculations for both PTB and scale could be made at the same time.

Using the 51^{o}F threshold, computer projections of scale population development agree quite well with observed scale flights at Parlier (Fig. 2). These data show that it takes ca. 1000 D^{o} for a generation of scale to complete its development; it is interesting to note how similar the D^{o}/generation requirements are for all of the four species included in this report. Following first male flight in each generation, initial calculations indicate ca. 350-400 D^o are required for first crawlers to appear. From 50% male flight to 5% crawler emergence requires ca. 370 D^o. Using these figures, it could thus be projected that optimum spray timing for crawler treatments (e.g. - "May spray") could be timed to ca. 400-450 D^o after first male flight. It should be noted that these D^o values are the first developed for San Jose scale, and will be subject to extensive continued validation before they can be used with confidence. However, we believe that the model can be refined to a considerable degree, and will prove to be an extremely valuable tool to use along with the scale pheromone trapping system in deciduous fruit pest management programs.

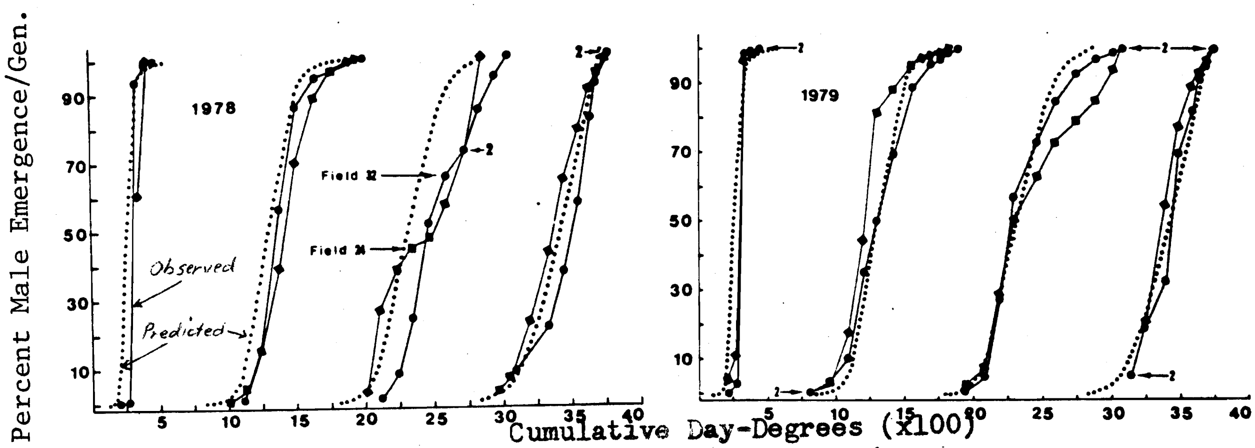


Figure 2. Cumulative development curves for emerging San Jose scale males in central California, 1978-79.