DETERMINATION WHEN OVERWINTERING GENERATION 
CODLING MOTH (CM) FIRST ATTACKS WALNUTS; 
COMPARE CM PHENOLOGY MODEL TO TRAP CATCHES AND 
ACTUAL EMERGENCE; DETERMINE BEST TREATMENT TIMING 

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ABSTRACT 

Data collected indicates codling moth can successfully damage nuts of any size tested and that the recommended treatment timing of 3/8 - 1/2" nut size is coincidental to codling moth phenology on early varieties. Better treatment timing remains a possibility.

Day degree accumulation to predict 50 percent and/or peak emergence which could be useful in treatment timing is not possible because these events appear to occur at different times each year.

Emergence bands successfully validate trap activity but do not validate the codling moth phenology model. Banding studies strongly suggest the first summer generation begins at 900 D\* while the model recommends 1050.

Oviposition studies do validate the codling moth phenology model and show egg hatch occurs after 200 D\* from emergence.

Female moths clearly emerge over a wider period of time than first suspected.

OBJECTIVES:

1) Determine at what stage of nut growth the overwintering generation of codling moth larvae begin to enter the developing nuts of Ashley and Vina Walnuts - 1990, 1991, 1992. Also determine when most worm damage is encountered by the overwintering generation on these two varieties.

2) Determine when peak and 50 percent codling moth emergence from overwintering sites takes place in terms of day degrees - 1990, 1991, 1992. This will also be done in Stanislaus County in 1991 and 1992. Determine if these are useful parameters in terms of control strategies.
3) Determine which of the above (first entry, peak emergence, or 50% emergence) provides the best timing for control of overwintering codling moth larvae with short residual insecticides.


5) Determine if female moths emerge throughout the emergence period and if late emerging females are as productive as early females.

PLANS AND PROCEDURES:

1) Use native, wild, codling moths reared on walnuts and place 20 pairs in branch cages over nuts and leaves on Ashley and Vina walnuts. Do this beginning at 200 day degrees on nuts as they develop from less than 1/4" diameter; 3/8-1/2" diameter, 1/2-3/4" diameter and 1" diameter. Replicate as often as possible depending on the quantity of moths available. Evaluate percent infested walnuts per nut size exposure to codling moth.

2) Place overwintering pupae housed in cardboard band pieces in emergence cages and collect and sex moths as they emerge. Record moth emergence and determine the day degrees accumulation for peak emergence and 50 percent emergence. Compare pheromone trap catches with emergence from pupation bands from the same orchard. Butte and Stanislaus Counties in 1991, 1992. Use these emerged moths in oviposition studies.

3) Place pupation site cardboard bands around walnut trunks before each generation pupates at 600 day degrees. Collect a percentage of the bands each week as emergence approaches and throughout emergence. Determine beginning of emergence and percent emergence. Compare with trap catches and phenology model predictions. Determine peak emergence and 50 percent emergence from pupation sites, 1990, 91, 92. Stanislaus County 1991, 1992.
4) After determining when overwintering codling moths enter nuts apply treatments; when nuts are first susceptible; at peak emergence, and at 50% emergence from overwintering sites, with a short residual insecticide to determine best treatment timing. Set up these timing treatments in a randomized block design with 10 replicates. Tag nut for evaluation and summarize worm damaged nuts by analysis of variance.

RESULTS OF DISCUSSION

The objective of determining when codling moth larvae enter and damage nuts of various sizes (objective 1) is still in progress. Studies have not been conducted on nuts less than .64" in diameter at egg hatch because moths have not been available during this early rapid nut growth period. Never the less 12 cases have been studied so far.

Most eggs are laid on leaves, with some eggs being laid on nuts generally when they become larger than .75" in diameter and are shiny, Table 1, A and B.

Nut damage in the 12 studies ranged from 14-95 percent. There is no relationship between nut size and damage, that is, the smallest nuts at egg laying (.26-.38") had as much damage as the largest nuts at egg laying (1.01-1.75") Table 1 A and B.

This study indicates that: 1) eggs do not need to be laid on nuts to cause damage and that larvae migrating from leaf to nut can cause sufficient nut damage. 2) Nuts of all sizes evaluated are susceptible to damage if codling moth are present. Hartley walnuts will be used in 1992 to evaluate walnuts sizes in the smallest category.

Two years of evaluations of 50 percent codling moth emergence and/or peak emergence (Objective 2) from overwintering sites revealed that these events do not occur at or near the same day degree accumulation each year, Table 2. Using day degrees to predict these events and to determine best spray timing does not appear to be possible.

Test to evaluate best timing for overwintering generation codling moth control based on day degrees (objective 3) has not been attempted due to time commitment and re-evaluation of best treatment timings. A treatment trial using 200, 300, 400, etc. day degrees as timing intervals will be evaluated under a new project.
Validation of the codling moth phenology model (objective 4):
1) Oviposition Studies. Sixteen cases have been evaluated to
determine the day degree interval between emergence and first
oviposition, and emergence and egg hatch using mature moths.
The average accumulated day degrees, using 50/88 °F. thresholds
is 56 D° for first oviposition (range 30-77 D°) and 205 D°
(range 160-249 D°) between emergence and egg hatch. These
cases validate the day degree model which indicates 50 D°
between emergence and first oviposition and 210 D° between
emergence and egg hatch.
2) Emergence Bands. Using emergence bands appears to be an
accurate way of validating trap catch and confirming the day
degree intervals between events. Table 3 summarized the date
first moth emerged, the day degree to second flight beginning
and third flight beginning. The trap catch and band emergence
essentially agree. There could be experimental error at the
beginning of third flight due to overlap between generations.
There is no error due to overlap in generations at the
beginning of the second flight because of the different way
the bands were handled. Trap catch and band emergence do not
agree with the current phenology model. Data from this trial
suggest the second flight begins after about 900 D° (model
suggest 1050) and the 3rd flight begins after 1125. D° (model
suggest 1050).
Figures 1A and 1B and 2A and 2B show the trap catch and actual
emergence of overwintering codling moth in 1990 and 1991.
These data illustrate that:
1) Female moths emerge throughout the entire emergence period.
2) In general, females emerge at the same rate as male moths.
3) There is a clear break between overwintered emerged males
and first generation emerged males.
4) The first generation emergence and trap catch begins after
900 D°
5) Although the period of emergence and moth catch in traps
are virtually identical the percent emergence on any one
date have little relationship with moth catch on that date,
indicating that the number of moths caught on one date has
little significance.
6) 1990 had a bimodel trap catch between 500-800 D° and this
is reflected in the male emergence to a slight degree.
Figures 3A and B and 4A and B show the trap catch and emergence
as determined from empty pupal cases in the pupation bands of
These data indicate that:
1) The actual emergence corresponds well with trap catch but
the percent emergence at any one time has little
relationship to trap catch at that time.
2) The overlap between the end of the second and beginning of the third generations around 1900 D' in 1990 and 2100 D' in 1991 (fig. 3B and 4B) makes it impossible to separate the generations completely.

3) The third generation began around 1125 D'.

CONCLUSIONS

Although another season of data is needed to evaluate nuts of the smallest size category it appears clear that codling moth can damage nuts of any size and the traditional recommendation that 3/8-1/2" nut size is when to treat for codling moth is coincidental. Coincidental to the fact that 3/8 - 1/2" nut size is approximately the size nuts are when eggs from first emerged moths begin to hatch on the earliest varieties (Ashley, Payne). The same nut size spray timing recommendation on cultivars with different leafing dates would not be useful since codling moths generally first emerge about the same time regardless of cultivar. Better treatment timing would probably be at first egg hatch after emergence which is at 200 D'. This however is yet to be tested. Test on this subject will be conducted under a new project.

Using D' to predict 50 percent or peak emergence and spray timing is not useful since this does not occur at the same time each year.

Emergence from bands validates trap activity fairly well but does not validate the codling moth phenology model. Another year of similar results will suggest reducing the day-degree interval between first moth and first summer generation to 900 D' rather than the current 1050.

Females clearly emerge over a wider period of time than first thought. However it has not yet been determined whether late emerging moths are as reproductive as early moths. This will be evaluated in 1992. If they are additional control efforts may be needed when using short residual materials. This project does not address the spread in emergence of second generation female moths. An attempt to evaluate this will be conducted in 1992.
### Table 1A

<table>
<thead>
<tr>
<th>CASE #</th>
<th>EGG LAYING</th>
<th>% EGGS NL/F.</th>
<th>EGG HITCH</th>
<th>% DAMAGE</th>
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<tbody>
<tr>
<td>0.25&quot;</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>1</td>
<td>.26-.38&quot; F. H.</td>
<td>0/100</td>
<td>.79&quot;-D.</td>
<td>92</td>
</tr>
<tr>
<td>2</td>
<td>V.</td>
<td>0/100</td>
<td>.81&quot;-D.</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>A.</td>
<td>0/100</td>
<td>.64&quot;-F.</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>A.</td>
<td>0/100</td>
<td>.73&quot;-F.</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>.39-.50&quot; F. A.</td>
<td>0/100</td>
<td>.93&quot;-D.</td>
<td>95</td>
</tr>
</tbody>
</table>

F. = FUZZY; D. = DUSTY; H. = HARTLEY; V. = VINA; A. = ASHLEY

F = FUZZY; D = DUSTY; H = HARTLEY; V = VINA; A = ASHLEY

### Table 2

<table>
<thead>
<tr>
<th>YEAR</th>
<th>PK. EMERG.-DD.</th>
<th>50 % EMERG.-DD.</th>
<th>2ND FLT.-DD.</th>
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<tbody>
<tr>
<td>1990</td>
<td>354 449</td>
<td>390 449</td>
<td>870</td>
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<tr>
<td>1991</td>
<td>248 248</td>
<td>190 190</td>
<td>933</td>
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THRESHOLDS: 50/88 D.F.

### Table 1B

<table>
<thead>
<tr>
<th>CASE #</th>
<th>EGG LAYING</th>
<th>% EGGS NL/F.</th>
<th>EGG HITCH</th>
<th>% DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>.51-.75&quot; F. A.</td>
<td>2/98</td>
<td>1.00&quot;-D.</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>A.</td>
<td>0/100</td>
<td>.92&quot;-D.</td>
<td>39</td>
</tr>
<tr>
<td>8</td>
<td>V.</td>
<td>3/97</td>
<td>.98&quot;-D.</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>.76-1.00&quot; D. A.</td>
<td>0/100</td>
<td>1.20&quot;-S.</td>
<td>69</td>
</tr>
<tr>
<td>10</td>
<td>1.01-1.25&quot; S. V.</td>
<td>0/100</td>
<td>1.22&quot;-S.</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>A.</td>
<td>15/85</td>
<td>1.40&quot;-S.</td>
<td>16</td>
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<td>12</td>
<td>A.</td>
<td>4/96</td>
<td>1.30&quot;-S.</td>
<td>86</td>
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</table>

F. = FUZZY; D. = DUSTY; S. = SHINLEY; A. = ASHLEY; V. = VINA

F = FUZZY; D = DUSTY; S = SHINLEY; A = ASHLEY; V = VINA

### Table 3

<p>| VALIDATION OF CODLING MOTH ACTIVITY-BUTTE CO. |
|-----------------------------------------------|-----------------------------------------------|</p>
<table>
<thead>
<tr>
<th>INDEX</th>
<th>DATE 1ST. MOTH</th>
<th>2ND. FLIGHT</th>
<th>3RD. FLIGHT</th>
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<tbody>
<tr>
<td>MODEL</td>
<td>N.A. N.A.</td>
<td>N.A.</td>
<td>1050</td>
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THRESHOLDS = 50/88 D. F.