



# Biological Control of Codling Moth: Parasitoid Releases in Walnuts, Apples, and Pears

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## INTRODUCTION

CM is the most important pest of apples, pears and walnuts in California. It is not native to the state and our naturally occurring biological control agents are not effective in providing any appreciable control. In a classical biological control effort, Dr. Nick Mills collected CM parasitoids from the wild apple forests of central Asia where CM is thought to originate. He imported them to California and reared them in his quarantine insectary at UCB. *Mastus ridibundus* is one of these parasitoids. It attacks the cocoon stage of the CM lifecycle. If it can be established in California orchards, it may provide significant suppression of codling moth in unsprayed orchards. This poster describes the effort to establish and monitor the establishment of *Mastus ridibundus* in orchards in Eastern Contra Costa County.

## MATERIALS & METHODS

**Releases:** *Mastus ridibundus* were released in a total of 16 apple, pear or walnut orchards over a 6 year period from 1998-2003. Most orchards selected for release were unsprayed in order to be able to track future establishment, although management changed in several orchards the over course of this study. Either single or multiple releases were made in individual orchards each fall (with the exception of the fall of 2001). Release dates varied from 8/26 to 11/20. Release rates varied from 400 to 8000 wasps per orchard or 83-1000 wasps if calculated on a per acre basis. All releases are summarized in Table 1.

**Parasite Recovery:** Corrugated cardboard bands were used to recover *Mastus* from the orchards and to evaluate the rate of establishment and parasitization. In each orchard, fifty 2-3 inch wide cardboard bands with A-flute corrugation were wrapped around tree trunks for several weeks from August through October or November to capture overwintering codling moth. Bands were placed in selected orchards before the first release, the first year following a release, the second year following a release and/or the third year following a release. Bands were then collected and brought back to the Mills lab to determine the number of codling moth captured, the *Mastus* recovery and the rate of parasitization.

**Codling Moth Populations:** Codling moth populations were monitored with standard pheromone traps in 3-4 unsprayed walnut orchards and compared to those in 3 conventional, sprayed walnut orchards over a 5 year period (1999-2003).

**Codling Moth Damage:** Insect damage data from the processor grade sheets reports were available from one unsprayed walnut release site for the season before and 4 seasons after the releases began.

| MASTRUS RELEASES |             |        |            |                   |              |           |      |                 |           |      |              |           |     |           |      |     |
|------------------|-------------|--------|------------|-------------------|--------------|-----------|------|-----------------|-----------|------|--------------|-----------|-----|-----------|------|-----|
| ORCHARD          | CROP        | ACRES  | MANAGEMENT | 1998              |              |           | 1999 |                 |           | 2000 |              |           |     |           |      |     |
|                  |             |        |            | Date              | No./ orchard | No./ acre | Date | No./ orchard    | No./ acre | Date | No./ orchard | No./ acre |     |           |      |     |
| 1                | Christ      | apple  | 3          | unsprayed         | 11/4         | 1500      | 500  | 10/22           | 2000      | 667  |              |           |     |           |      |     |
| 2                | Courchesne  | pears  | 6          | organic           | 11/4         | 1500      | 250  | 10/22           | 2000      | 333  |              |           |     |           |      |     |
| 3                | Birx        | walnut | 6          | unsprayed         | 11/17        | 1200      | 200  | 10/22           | 2000      | 333  |              |           |     |           |      |     |
| 4                | Black       | walnut | 2          | unsprayed         | 11/20        | 1200      | 600  | 10/22           | 2000      | 1000 |              |           |     |           |      |     |
| 5                | Grey        | walnut | 5          | unsprayed         | 10/22        | 1500      | 300  | 10/22           | 2000      | 400  |              |           |     |           |      |     |
| 6                | Mena        | walnut | 5          | unsprayed/Conv    |              |           |      | 8/26, 9/2, 9/15 | 2700      | 540  |              |           |     |           |      |     |
| 7                | Palma       | walnut | 10         | unsprayed         |              |           |      | 8/26, 9/2, 9/15 | 2700      | 270  | 11/7         | 1700      | 340 | 9/1, 9/28 | 6000 | 600 |
| 8                | Tennant     | walnut | 30         | conventional      |              |           |      | 8/26, 9/2, 9/15 | 2700      | 80   |              |           |     |           |      |     |
| 9                | Johnson     | walnut | 9          | unsprayed         |              |           |      | 8/26, 9/2, 9/15 | 2700      | 300  |              |           |     |           |      |     |
| 10               | Coehlo      | walnut | 18         | conventional      |              |           |      | 8/26, 9/2, 9/15 | 2700      | 150  |              |           |     |           |      |     |
| 11               | Delta       | apples | 16         | Mating Disruption |              |           |      | 10/22           | 2000      | 125  |              |           |     |           |      |     |
| 12               | Rosie Hills | apples | 35         | Mating Disruption |              |           |      | 10/22           | 2000      | 57   |              |           |     |           |      |     |
| 13               | Faria       | apples | 60         | organic           |              |           |      |                 |           |      | 10/4, 10/12  | 8000      | 133 |           |      |     |
| 15               | Massoni     | walnut | 50         | conventional      |              |           |      |                 |           |      |              |           |     |           |      |     |
| 16               | Nielson     | apple  | 10         | unsprayed         |              |           |      |                 |           |      |              |           |     |           |      |     |

| MASTRUS RECOVERY IN CODLING MOTH COCOONS |             |        |            |                   |              |           |               |                   |               |           |                   |               |            |
|--|-------------|--------|------------|-------------------|--------------|-----------|---------------|-------------------|---------------|-----------|-------------------|---------------|------------|
| ORCHARD                                  | CROP        | ACRES  | MANAGEMENT | 1998              |              |           | 1999          |                   |               | 2000      |                   |               | CM cocoons |
|  |             |        |            | Date              | No./ orchard | No./ acre | Date          | % Para-sitization | Banding dates | Date      | % Para-sitization | Banding dates |            |
| 1  | Christ      | apple  | 3          | unsprayed         |              |           | 517           | 0.0               | 8/31-10/22    |           |                   |               |            |
| 2  | Courchesne  | pears  | 6          | organic           |              |           | 12            | 0.0               | 8/31-10/22    |           |                   |               |            |
| 3  | Birx        | walnut | 6          | unsprayed         |              |           | 20            | 0.0               | 8/31-10/22    |           |                   |               | 3          |
| 4  | Black       | walnut | 2          | unsprayed         |              |           | 149           | 0.0               | 8/31-10/22    |           |                   |               | 4          |
| 5  | Grey        | walnut | 5          | unsprayed         |              |           | 19            | 0.0               | 8/31-10/22    |           |                   |               | 2          |
| 6  | Mena        | walnut | 5          | unsprayed/Conv    |              |           | 636           | 5.7               | 8/31-11/27    |           |                   |               | 4          |
| 7  | Palma       | walnut | 10         | unsprayed         |              |           | 380           | 5.3               | 8/31-11/27    |           |                   |               | 4          |
| 8  | Tennant     | walnut | 30         | conventional      |              |           | 162           | 10.0              | 8/31-11/27    |           |                   |               |            |
| 9  | Johnson     | walnut | 9          | unsprayed         |              |           | 22            | 12.5              | 8/31-11/27    |           |                   |               |            |
| 10                                       | Coehlo      | walnut | 18         | conventional      |              |           | 305           | 10.9              | 8/31-11/27    |           |                   |               |            |
| 11                                       | Delta       | apples | 16         | Mating Disruption |              |           |               |                   |               |           |                   |               |            |
| 12                                       | Rosie Hills | apples | 35         | Mating Disruption |              |           |               |                   |               |           |                   |               | 59         |
| 13                                       | Faria       | apples | 60         | organic           |              |           |               |                   |               |           |                   |               | 19         |
| 15                                       | Massoni     | walnut | 50         | conventional      |              |           |               |                   |               |           |                   |               |            |
| 16                                       | Nielson     | apple  | 10         | unsprayed         |              |           |               |                   |               |           |                   |               |            |
|  |             |        |            |                   |              |           | orchards 1-5  |                   |               | 7.5 wks   |                   |               |            |
|  |             |        |            |                   |              |           | orchards 6-10 |                   |               | 11-12 wks |                   |               |            |

## RESULTS

**Parasite Recovery:** Band traps placed in orchards just prior to the first release of *Mastus* caught high numbers of overwintering codling moth and resulted in 6-12% parasitization the year of the release. The first, and frequently the second and third season following a release, comparatively few codling moth could be caught in the bands, indicating that *Mastus* had survived in the orchard and was having a significant impact in reducing the overwintering codling moth population. Curiously, the few CM that were caught in the bands had none or a very low rate of parasitism evident at the time the bands were collected in October.

In 2003, releases were again made in orchards that were expected to be relatively free of *Mastus* – they had not had a previous release, had been sprayed after a previous release, or had not had a significant release for 3 years. These orchards were successful in capturing significant numbers of CM in band traps and the parasitization rate from this release ranged between 0 (in a very low pressure walnut orchard) to 34% (in a high pressure apple orchard). [see Table above]

**Codling Moth Populations:** The pheromone traps showed a suppressed overwintering flight in the unsprayed walnut release sites when compared to conventionally sprayed walnut orchards with no parasitoid releases. This suppression of the overwintering generation was evident for at least two to three seasons after the release, again indicating *Mastus* survival. The 2nd and 3rd flights in the unsprayed release sites were similar to or higher than in the conventional comparison orchards. There was little difference in the cumulative seasonal trap counts in the unsprayed release sites and the conventionally sprayed orchards. [see Graphs to right]

**Codling Moth Damage:** The grade sheets from one unsprayed walnut release site show moderate "insect" damage the season prior to the first *Mastus* release. Damage was reduced in the seasons following large releases (2000 and 2001) and increased again following seasons with no (2001) or very small (2002) releases. [see Table to right]

## DISCUSSION

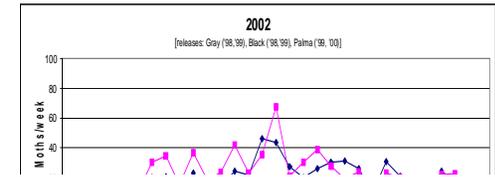
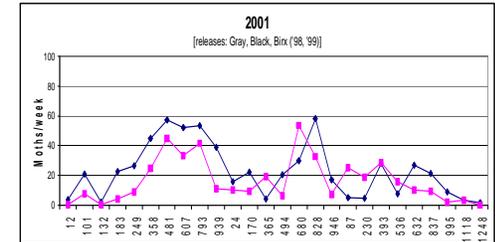
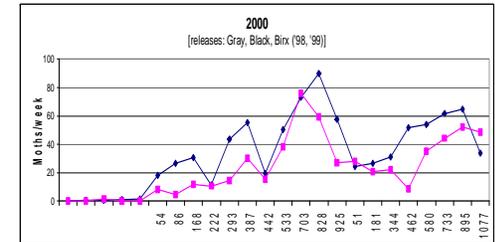
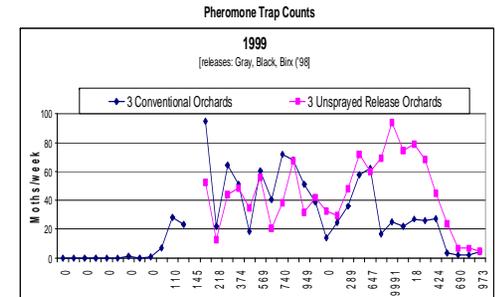
Both the band and pheromone trap counts indicate a suppression of the overwintering codling moth populations for 2 or more years following the release of *Mastus* into an orchard.

We were unable to determine the actual parasitism rate in years following the release due, in part, to the difficulty in recovering enough overwintering codling moth in the band traps for evaluation. The low parasitism rate in the few larva that were caught may have been due, in retrospect, to a premature removal of the bands. Other (unpublished) work indicates that "naturalized" *Mastus* goes through more than one winter generation in California and can continue to attack the overwintering codling moth through the winter and into the spring. This corresponds to the higher rates of parasitism evident in bands left in orchards later in the season.

The unsprayed walnut orchards with *Mastus* releases were able to maintain pheromone trap counts that were similar to the conventional, sprayed comparison orchards.

Orchard 7 was also able to achieve acceptable levels of codling moth control during the years following large *Mastus* releases even in the very susceptible Serr variety. The damage levels following years without significant releases were acceptable in Chandler but not in Serr. This suggests that *Mastus* may be able to "naturalize" and provide satisfactory codling moth control in some of the less susceptible walnut varieties but may require annual augmentation in more susceptible varieties. *Mastus* was not able to provide an acceptable level of control apple orchards.

## CODLING MOTH POPULATIONS



## CODLING MOTH DAMAGE

| Year | Variety  | "Insect" Damage | Notes                       |
|------|----------|-----------------|-----------------------------|
| 1999 | Chandler | 3%              | Prior to any releases       |
|      | Serr     | 7%              |                             |
| 2000 | Chandler | 0%              | 2700 released previous fall |
|      | Serr     | 6%              |                             |
| 2001 | Chandler | 1%              | 6000 released previous fall |
|      | Serr     | 3%              |                             |
| 2002 | Chandler | 0%              | No releases previous fall   |
|      | Serr     | 14%             |                             |
| 2003 | Chandler | 0%              | 500 released previous fall  |
|      | Serr     | 10%             |                             |