Decision-Making for Management of Cranberry Tipworm, *Dasineura oxycoccana:* Responses of Tipworm and Parasitoid Populations to Insecticide Applications on Cranberry Farms

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Warren Wong, photographer

Female parasitoid *Aprostocetus* sp. near *Marylandensis* (left) next to female cranberry tipworm *Dasineura oxycoccana* (right).

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Executive Summary

This research report documents the effects of registered insecticides on cranberry tipworms and parasitoids in 2014 on three cranberry farms; compares the effects with those documented in 2013; and describes the prototype of a trap that will be used to study emergence of cranberry tipworm from overwintering sites in the soil.

- Results support the hypothesis that applications of Movento (spirotetramat) in 2013 reduced the overwintering population of cranberry tipworms and consequently reduced the number of egg-laying females in spring 2014. The overwintering populations of the parasitoids *Aprostocetus* and *Platygaster* were also reduced, probably because of the decrease in tipworm hosts.

- Movento, which was used on two of the three farms in 2014, reduced the percentage of shoots infested with immature tipworms and the number of live immatures per shoot. Populations of the parasitoids *Aprostocetus* and *Platygaster* were also reduced, probably because of the decrease in tipworm hosts.

- Diazinon, which was used instead of Movento on one farm in 2014, temporarily reduced the percentage of shoots infested with tipworm immatures, but infestation increased after several weeks because there was no systemic residual effect of Diazinon.

- After the insecticide applications, additional mortality of tipworm immatures was recorded in early August 2014 following several days of intense heat that was apparently lethal to eggs and early instars.

- The final prototype of the tipworm emergence trap was constructed from two white plastic buckets, each 16 cm high. The bottoms were cut off both buckets. One bucket was fitted with pegs made from sturdy wire stakes, which anchored the bucket to the soil, and a groundcloth skirt that prevented light and insects from entering the bucket at soil level. The second bucket was inserted into the first, and fitted with a mesh lid to prevent escape of cranberry tipworm midges but allow water and sunlight to penetrate. A double-sided yellow sticky card was suspended by a foldback clip on a length of dowel within the top bucket. In the field, cranberry vines were carefully parted so that the trap could be seated into the soil without covering vines. Traps were robust for three months in the field.

Introduction

Cranberry growers and integrated pest management consultants in British Columbia have become familiar with the signs of infestation by cranberry tipworm, *Dasineura oxycoccana* (Johnson) (Diptera: Cecidomyiidae). Cupped, puckered, silvery leaves at the tips of cranberry shoots indicate that a second or third instar larva is feeding or has fed on the bud at the apex of the shoot tip. Damaged buds die and the plant often responds by producing side shoots from buds at leaf axils below the apex (Tewari et al. 2013).

Cranberry tipworm is a relatively recent pest in British Columbia (Maurice et al. 2000), so growers and pest management consultants are still learning how to manage it. Detection and monitoring of cranberry tipworm is best done by collecting shoot tips regularly and examining them under magnification to count the numbers of tipworm eggs, larvae and pupae (Fitzpatrick 2012, 2013). Two methods of monitoring for adult tipworms have been tested but the methods are cost-prohibitive (synthetic pheromone) or ineffective (white sticky traps) (Fitzpatrick 2012, 2013).

The decision to apply an insecticide treatment against cranberry tipworm is based on the detection of early stage immatures in 30% of collected shoots and the concurrent absence of pollinators from the field (Fitzpatrick 2013). The 30% threshold is referred to as a working threshold or an action threshold because it is based on experience of growers and pest management consultants in British Columbia. The threshold is usually reached and exceeded during the bloom period when pollinators are in the field and insecticide should not be applied. Therefore, an operational compromise must be made, such that insecticide is applied after bloom when more than 30% of collected shoots contain immature tipworms that can be in early stages (egg and first instar) and later stages (second and third instar, prepupa[1] and pupa) (Fitzpatrick 2013).

Of the insecticides registered in Canada for management of cranberry tipworm, only Movento (spirotetramat) penetrates through the leaf cuticle and is translocated to growing shoots (Brück et al. 2009) where immature tipworms reside and feed. When applied by chemigation, Movento killed the majority of feeding instars (Fitzpatrick 2013). Prepupae and pupae, which do not feed, were not killed (Fitzpatrick 2013).

In 2013, which was the first year of Movento applications to bearing cranberry fields in British Columbia, most of the tipworm populations experienced two distinct phases: an increase during bloom (often to 60% or more of collected shoots), then a radical decline (to 20% or less) as a result of Movento (Fitzpatrick 2013). The reduced population in late summer

[1] In this report, the term prepupa is synonymous with last-instar larva, and refers to a third instar larva that has finished feeding and is preparing to enter the pupal stage.

would have produced fewer overwintering individuals than usual, therefore the population of cranberry tipworm adults emerging the following spring should have been lower than usual.

Two species of parasitoids, known by their genus names *Aprostocetus* and *Platygaster* (Peach et al. 2012), occur naturally on British Columbia cranberry farms. These parasitoids seek and infest tipworm hosts during the bloom period when insecticides cannot be applied, and after bloom when fruit are forming (Fitzpatrick 2013).

The first objective of the present study arose from the need to quantify tipworm populations in the year following Movento application(s). As written in the grant proposal, the first objective is: **to determine if the combined effects of Movento (spirotetramat) and naturally occurring beneficial parasitoids reduce tipworm populations to low and sustainable levels.** To meet this objective, tipworm and parasitoid populations were monitored on a subset of the cooperating farms that used Movento in the 2013 study (Fitzpatrick 2013). Comparisons are drawn between the results of monitoring in 2013 and 2014.

Decision-making for management of cranberry tipworm would benefit from knowledge of the timing of emergence after winter. Cranberry tipworm prepupae (i.e., last-instar larvae) spend the winter in the soil (Tewari et al. 2013), in a state of suspended development called diapause. In spring, adult tipworms emerge from pupation sites in the soil. The duration (weeks, months) of emergence from the soil is not known. Post-diapause emergence of a related insect, swede midge, *Contarinia nasturtii*, occurs in two large peaks, in mid-June and early July, with a third, smaller peak in late August; and a small percentage of swede midges overwinter for two years (Des Marteaux et al. 2014). It is possible that cranberry tipworm emergence after diapause follows a similar pattern.

The second objective of the present study is: **to determine if cranberry tipworm population increases are due to reproduction by successive generations <u>and</u> to different emergence times of overwintered tipworms.** Work on this objective began by designing and testing prototypes of traps for detecting adult tipworms that emerge from overwintering sites in the soil.[2]

[2] The third objective in the grant proposal, regarding voles and cranberry girdler, has been postponed.

Methods

Objective 1: To determine if the combined effects of Movento (spirotetramat) and naturally occurring beneficial parasitoids reduce tipworm populations to low and sustainable levels.

Three of the farms that cooperated in the previous year's study (Fitzpatrick 2013) were chosen as study sites for the 2014 study. These farms, numbered 4, 6 and 7 in the previous study (Fitzpatrick 2013), are in Langley and Pitt Meadows. The cultivar Stevens is grown at each site and the vines are at least 15 years old. Insecticide records were obtained from cooperating growers throughout the growing season. These growers received pest management information and recommendations from private IPM consultants.

The study site on each of the three farms was the same as in the 2013 study (Fitzpatrick 2013). In early May, at each study site, five yellow sticky card traps (10 x 16 cm; purchased from Terralink Horticulture Inc. www.tlhort.com) for trapping parasitoids were attached to small wooden stakes and arranged in a transect across the field. There were 20-30 m between traps in the transect. Yellow traps were placed such that the lower edge was 0-10 cm above cranberry shoot tips.

To provide information on the numbers of tipworm eggs and larvae in cranberry shoots, 10 cranberry shoots were collected each week from within 1 metre of each yellow sticky card trap. When tipworm damage ("cupping") became apparent in the field, five cupped shoots and five uncupped shoots were collected. By collecting a mixture of cupped and uncupped shoots, we maximized the probability of collecting eggs and early instars (found in uncupped shoots) as well as second and third instars and pupae (found in cupped shoots) (per Cook et al. 2012). The collected shoots were placed into labelled containers and transported in a cooler to the laboratory (AAFC-PARC Agassiz). The shoots were viewed through a stereomicroscope at 20X magnification and the numbers of eggs, larvae (first, second, and third instar) and pupae were recorded.

The yellow sticky card traps were collected from the field and replaced with fresh ones each week until late September. Traps were transported to the lab in Agassiz where they were examined through a stereomicroscope at 16X magnification. The numbers of *Aprostocetus* and *Platygaster* parasitoids[3] were recorded.

Counts of tipworms and parasitoids are displayed graphically and presented with graphs from 2013 to compare the populations through the two growing seasons. On all graphs, the data points are averages (means) of the total number sampled on each date. Dates of insecticide application are included. Graphs of daily maximum and minimum temperatures and

[3] Parasitoids belonging to a previously unrecorded species were also counted. See Results.

daily rainfall at the nearby Abbotsford Airport are provided to assist with interpretation of the insect data.

Objective 2: To determine if cranberry tipworm population increases are due to reproduction by successive generations and to different emergence times of overwintered tipworms.

Students Kieryn Matthews and Warren Wong developed successive prototypes of a trap designed to catch adult tipworms as they emerge from overwintering sites in the soil. Two-litre plastic buckets were modified such that they could be fitted with yellow sticky card traps and placed in tipworm-infested areas at the edges of cranberry beds without harming the cranberry plants. Trap development is described and shown in Results.

Results

Objective 1: To determine if the combined effects of Movento (spirotetramat) and naturally occurring beneficial parasitoids reduce tipworm populations to low and sustainable levels.

- The results from Farm 4 in 2014 are illustrated on pages 9 - 10. For comparison, the results from Farm 4 in 2013 are illustrated on pages 11 - 12.

- The results from Farm 6 in 2014 are illustrated on pages 14 - 15. For comparison, the results from Farm 6 in 2013 are illustrated on pages 16 - 17.

- The results from Farm 7 in 2014 are illustrated on pages 19 - 20. For comparison, the results from Farm 7 in 2013 are illustrated on pages 21 - 22.

- On the graphs, arrows above dotted vertical lines indicate insecticide applications by chemigation, as follows:
  = Altacor   = Delegate   = Diazinon   = Movento

- Photos of parasitoids are on pages 23 - 24.

- Graphs of temperature and rainfall in 2014 and 2013 are on pages 31 and 32.

On Farm 4 in 2014, the average percentage of infested shoots containing live immatures rose from zero on May 15 to 20% on June 12, decreased moderately, then increased to about 55% on July 3. During the same period in 2013, the average percentage of infested shoots containing live immatures began at about 40%, declined to 20%, then rose steadily to over 80% on July 4. The insecticide applications in 2013 – in particular the two Movento applications – probably reduced the overwintering population of tipworms and led to a reduced population of tipworms in spring 2014. In 2014, the Diazinon application on July 9 was followed by a decrease in the percentage of shoots containing live immatures. (The grower's decision to use Diazinon instead of Movento was based on economics.)

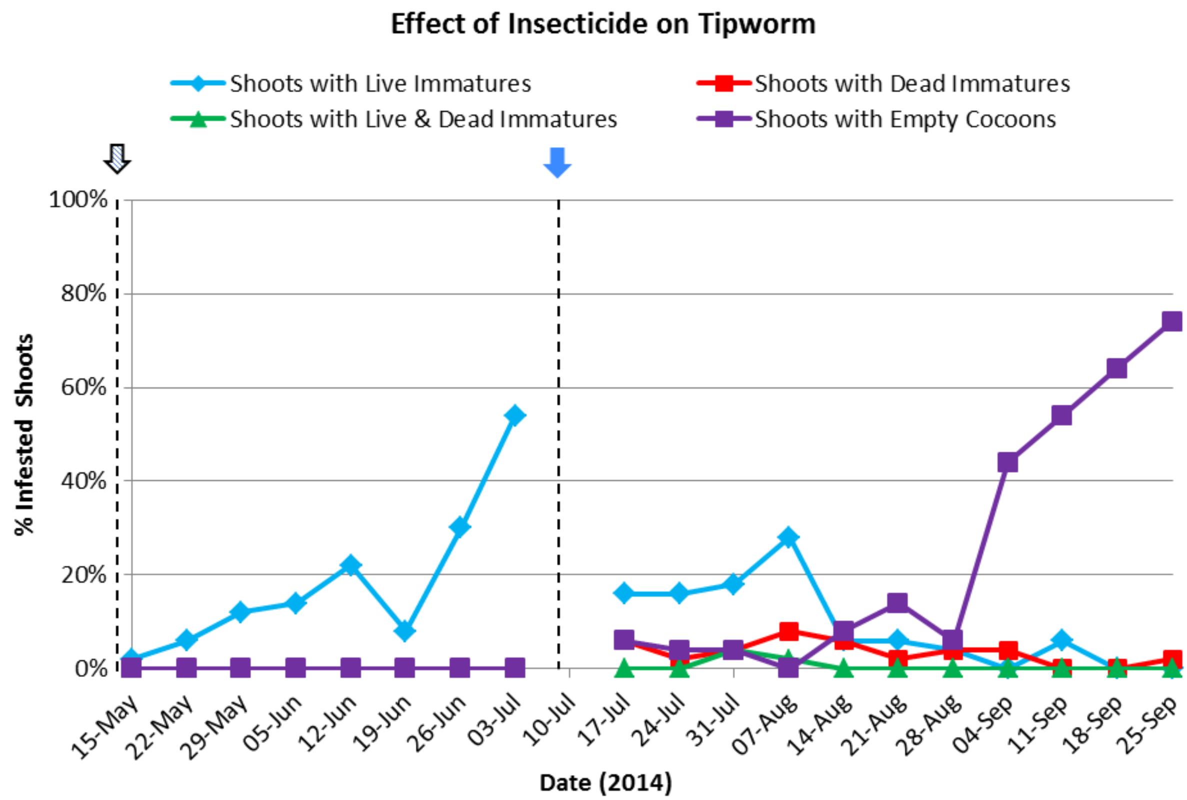
In 2014, the average number of immature tipworms per 10 shoots remained below 5 until July 3, when there were about 8 immatures per 10 shoots. During the same period in 2013, the average number of immatures per 10 shoots rose from 5 on May 23 to a maximum of 30 on July 4. In 2014, the Diazinon application on July 9 was followed by a reduction in the number of immatures to about 2 per 10 shoots. This number increased to a maximum of about 10 on August 7, then decreased to almost zero on August 14, and did not increase again. The marked decrease on August 14 was probably due to extreme heat on August 11 (see Appendix and explanation for Farm 6).

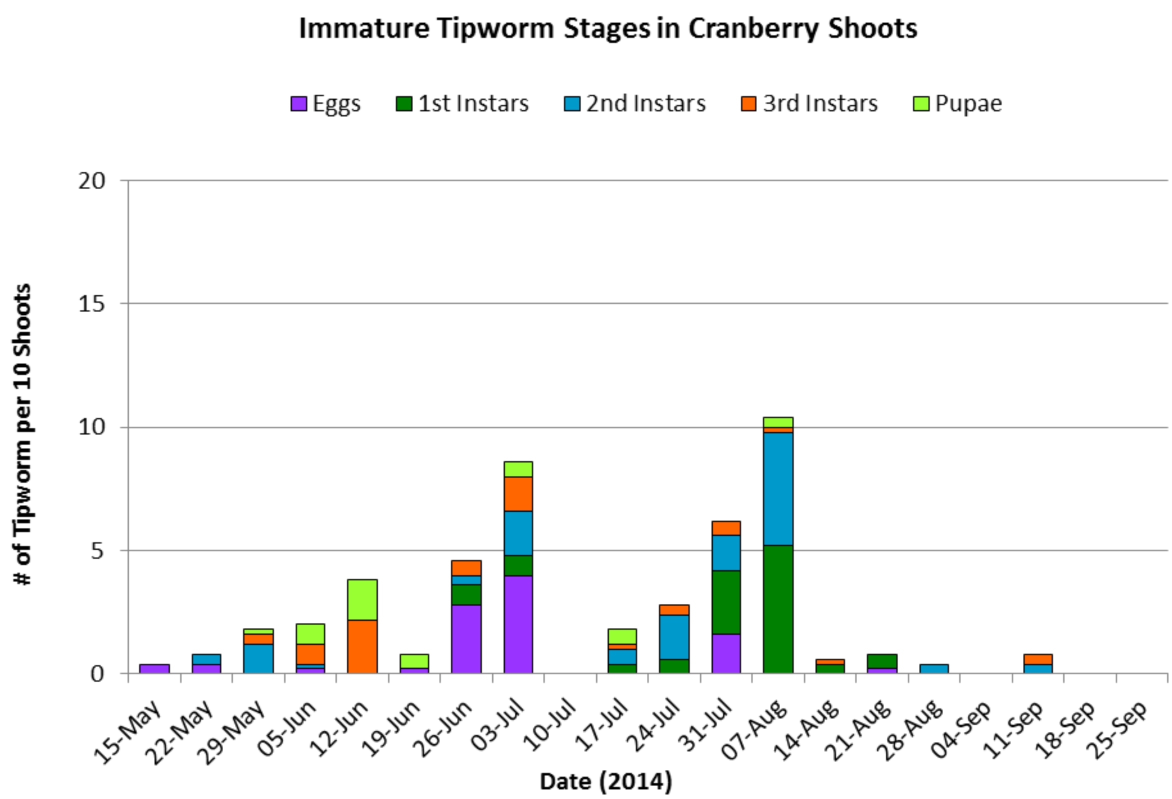
There was a noticeable difference in the stage distribution of immatures following applications of Diazinon or Movento. In 2013, following the Movento spray on July 4, almost all the immatures in shoots were eggs or first instars. In 2014, following the Diazinon spray on July 9, all stages from egg to pupa were found in the shoots. These results suggest that, in 2013, Movento remained in the plants and killed first instars shortly after they began to feed. In 2014, Diazinon killed egg-laying adults but did not prevent first instars from developing into second instars.

In 2014, the average percentage of infested shoots rose in September, when empty cocoons were found in 40 to 80% of shoots. In September, our sampling changed because most shoots had set a bud, and it was difficult to find shoots with vegetative tips. Therefore, 40 to 80% is probably an overestimate. The empty cocoons were found only in vegetative tips. Empty cocoons indicate that a tipworm completed development, pupated and emerged as an adult midge in the preceding weeks. In 2013, we did not sample in September, so it is not possible to compare September 2013 with September 2014.

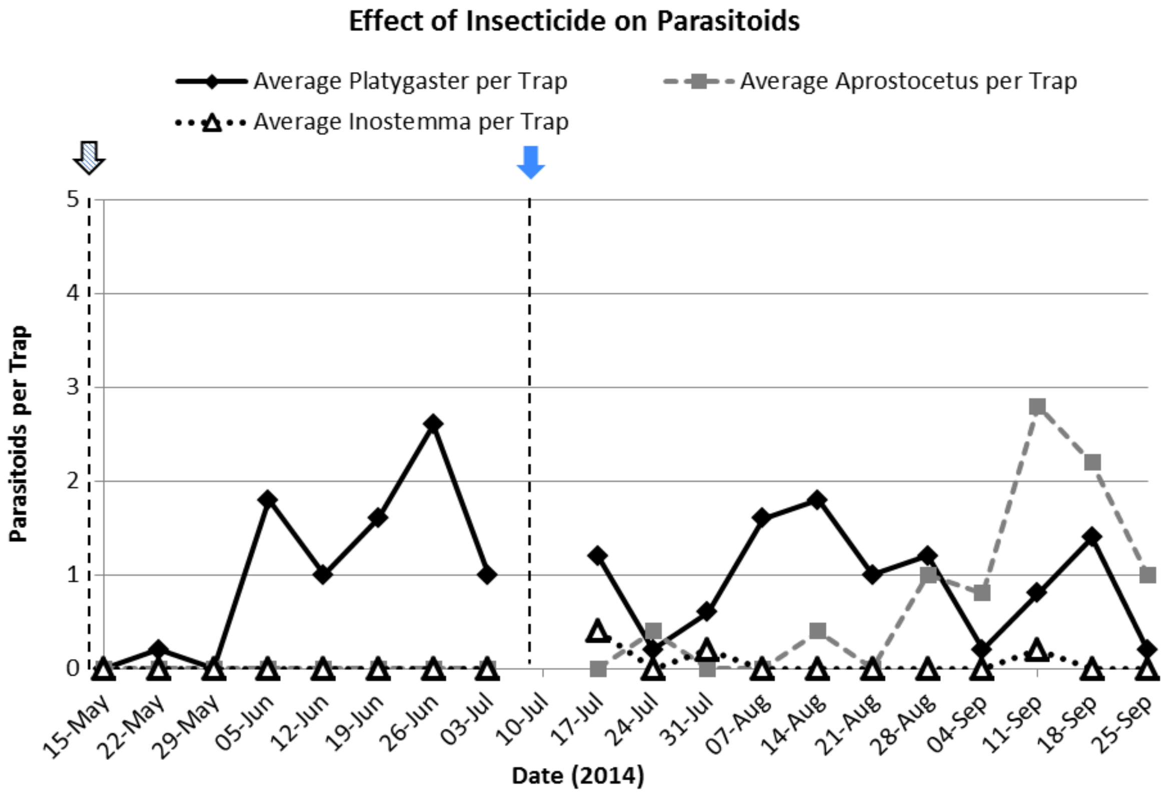
There were five-to ten-fold fewer parasitoids per yellow sticky card trap in 2014 than in 2013. *Platygaster* predominated in June, July and August of both years, while *Aprostocetus* was more numerous in September 2014 (photos page 23). A previously unnoticed parasitoid, *Inostemma* sp., was caught on yellow sticky card traps in July and September 2014 (photo page 24). The reduced number of parasitoids in 2014 is probably due to the reduced number of immature tipworms available for parasitizing. Diazinon probably killed adult parasitoids, whereas Movento is reported to be less lethal to them (see Discussion.)

FARM 4 IN 2014

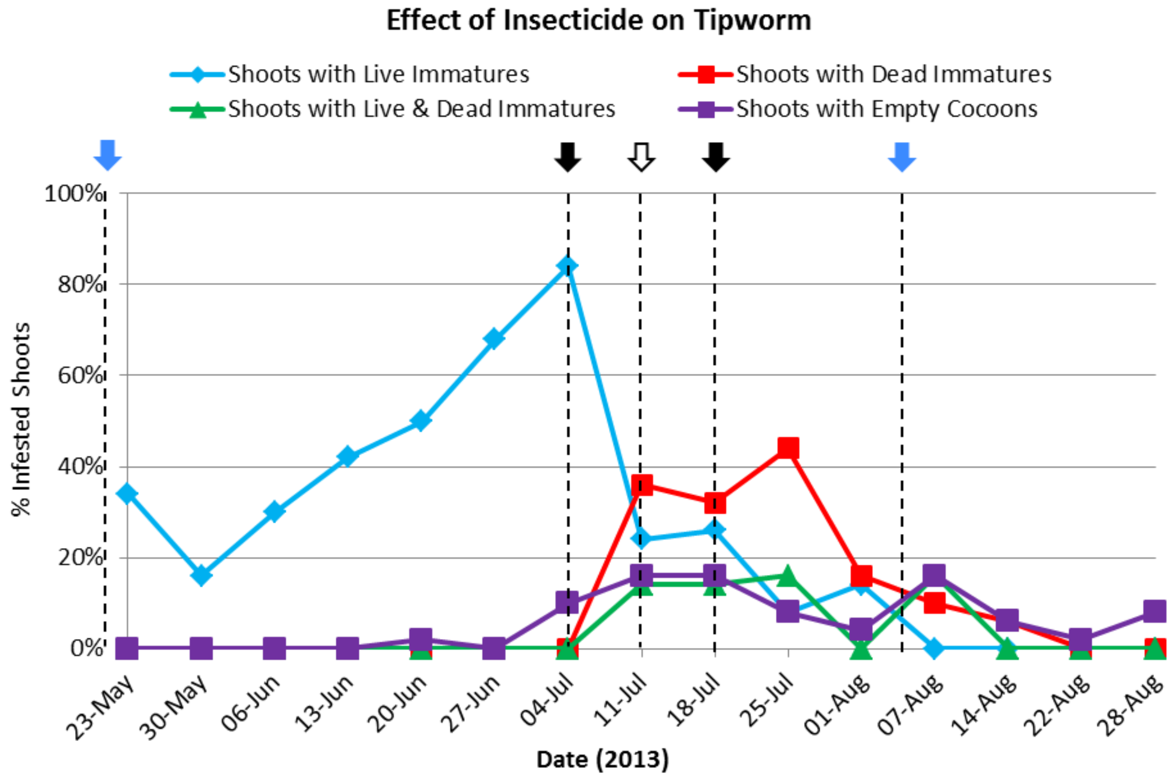


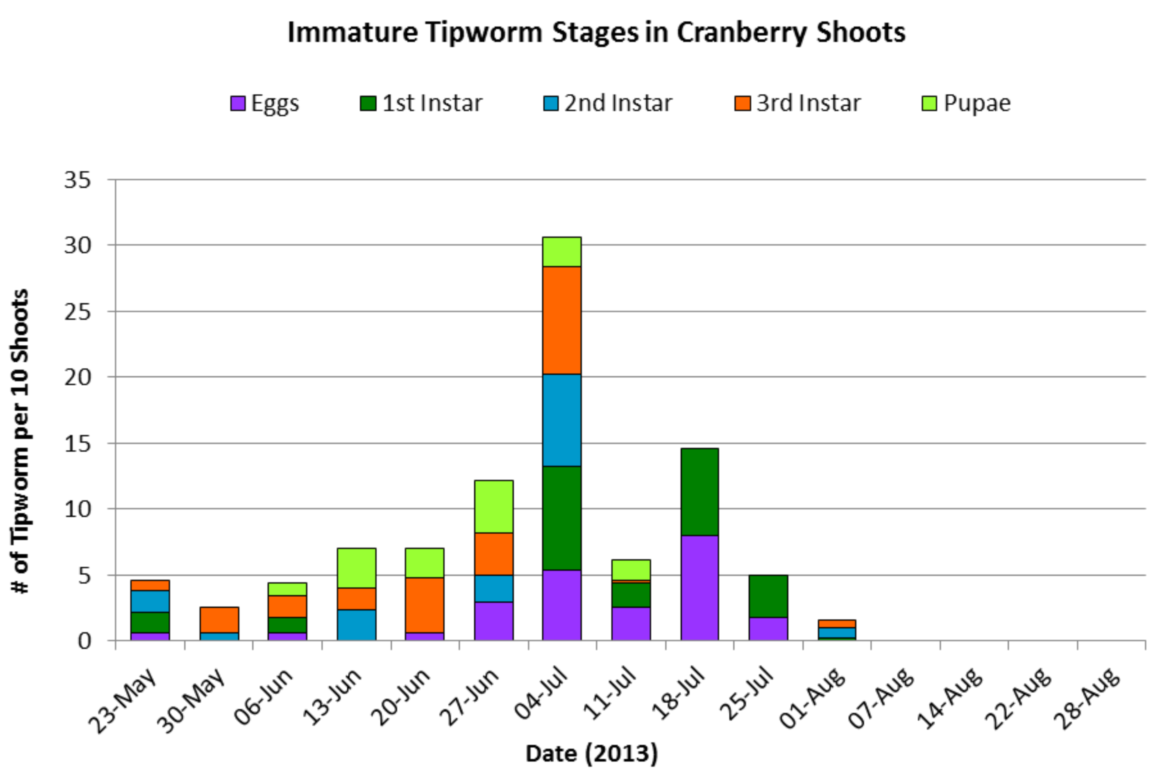


FARM 4 IN 2014

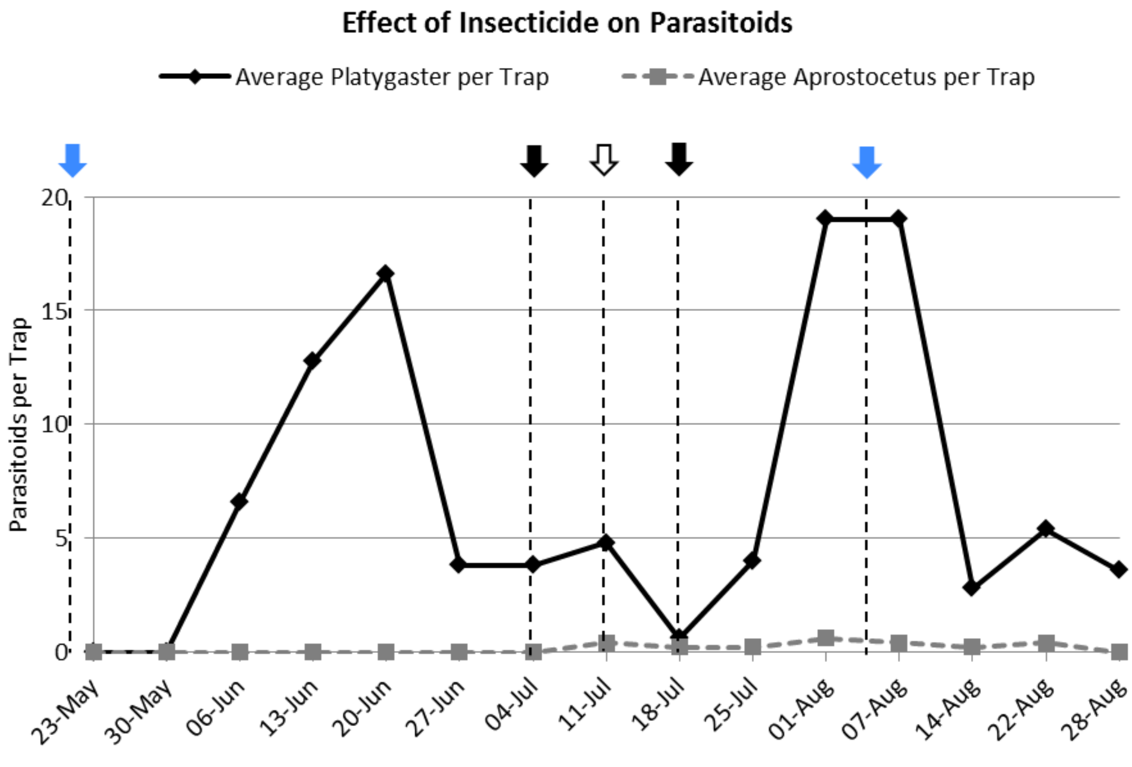


FARM 4 IN 2013





FARM 4 IN 2013



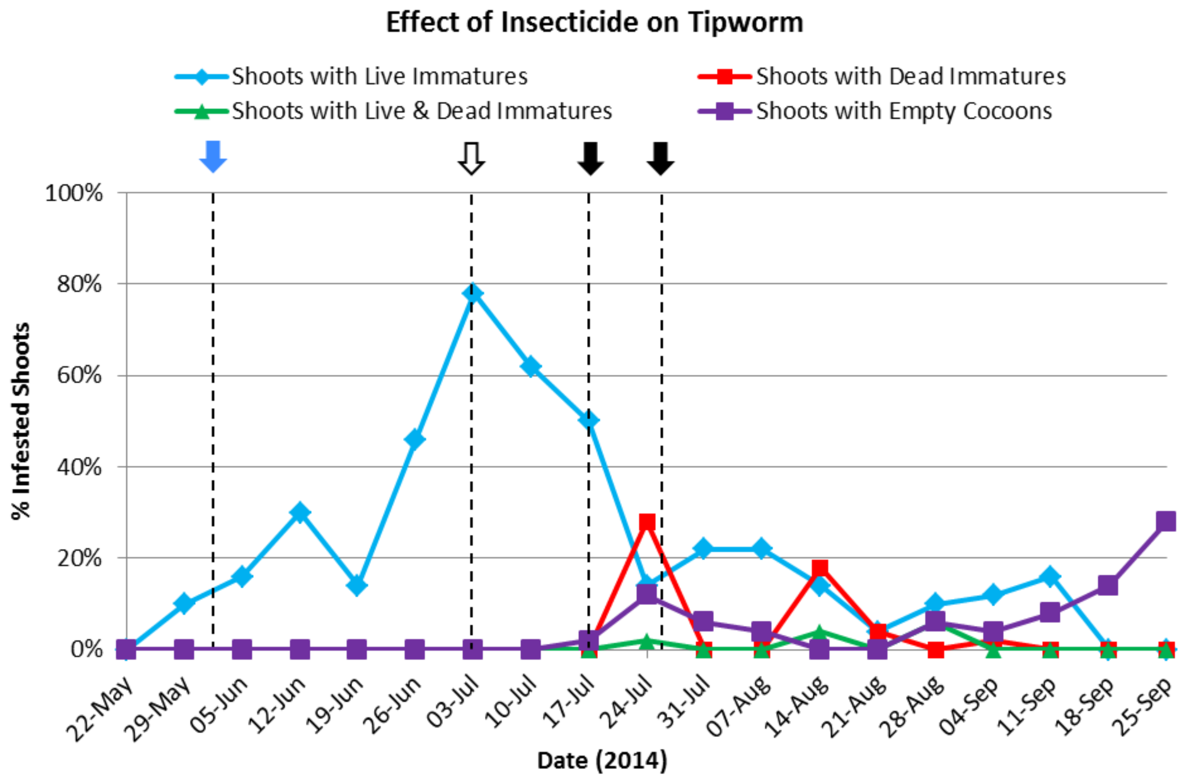
On Farm 6 in 2014, the average percentage of infested shoots containing live immatures rose from zero on May 22 to 30% on June 12, decreased moderately, then increased to about 80% on July 3. The Diazinon application on June 2 would have killed adult tipworms, and might have caused the moderate decrease in infested shoots on June 19. The Delegate application on July 3 appears to have initiated a decrease in the percentage of infested shoots. In 2014, two Movento applications (July 17 and 26) reduced the percentage of shoots containing live immatures to about 20%. In 2013, the average percentage of infested shoots containing live immatures began at about 10% on May 23, then increased steadily to over 80% on June 27 and July 4. The Movento application in 2013 probably reduced the overwintering population of tipworms and led to a lower population of tipworms in spring 2014.

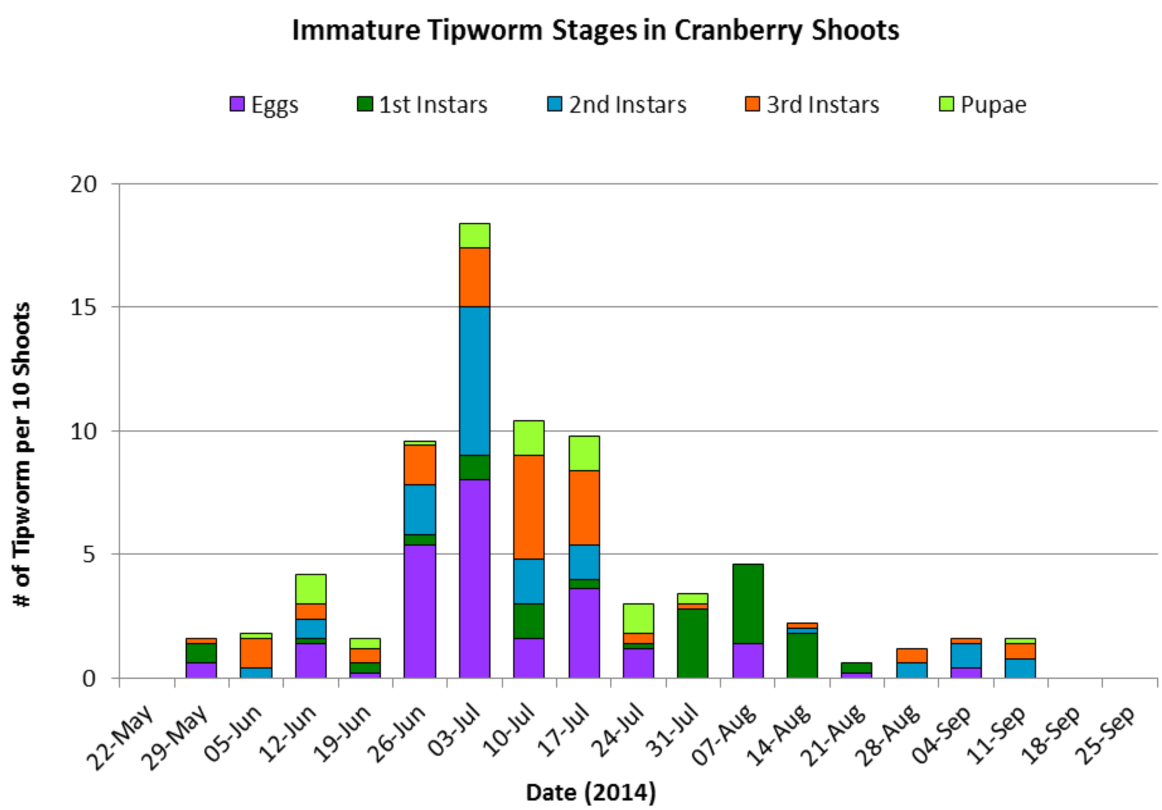
In 2014, the average number of immature tipworms per 10 shoots remained below 5 until June 26, when there were about 10 immatures per 10 shoots. During the same period in 2013, the average number of immatures per 10 shoots rose from about one on May 23 to about 11 on June 13, then to about 13 on June 27. In both years, the number of immatures per 10 shoots at the time of Delegate application was about 20. In 2014, the Delegate application on July 3 was followed by a reduction in the number of immatures per 10 shoots. In 2014, the Movento applications on July 17 and July 26 were followed by further reduction in the number of immatures per 10 shoots, and these immatures were predominantly eggs and first instars. They appeared shrivelled on August 14, 2014, following extreme heat on August 11 (H. van Dokkumburg, personal communication; and see Appendix page 32). The systemic effect of Movento, in combination with the heat, killed most of the feeding instars. The heat may also have prevented eggs from hatching.

In 2014, very few empty cocoons were found in shoots whereas, in 2013, as many as 50% of shoots collected in July contained empty cocoons. Therefore, fewer tipworms completed development, pupated and emerged as adult midges in 2014.

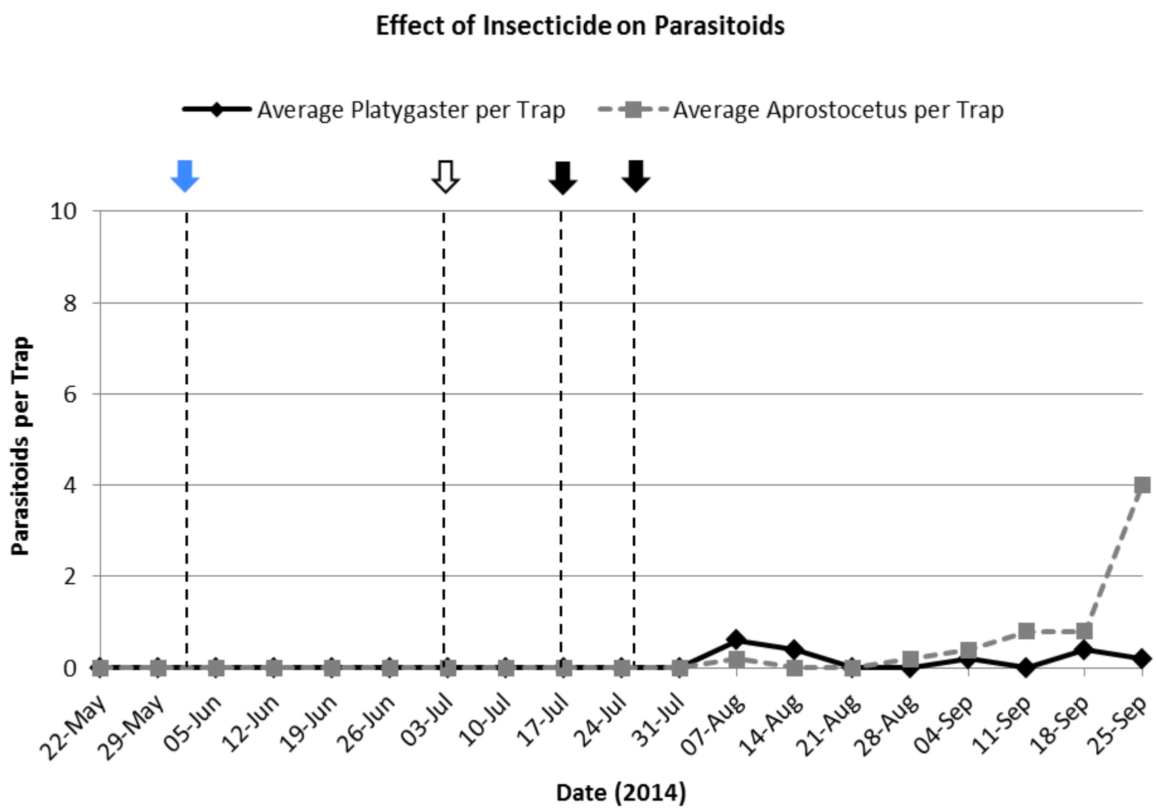
There were no parasitoids on yellow sticky traps during May, June and July of 2014. Through August and September of 2014, the average number of *Platygaster* per trap was less than one, as was the average number of *Aprostocetus* per trap (photos page 23). At the end of September, the average number of *Aprostocetus* per trap increased to four. The reduced number of parasitoids in 2014 compared with 2013 is probably due to the reduced number of immature tipworms available for parasitizing (see Discussion).

FARM 6 IN 2014

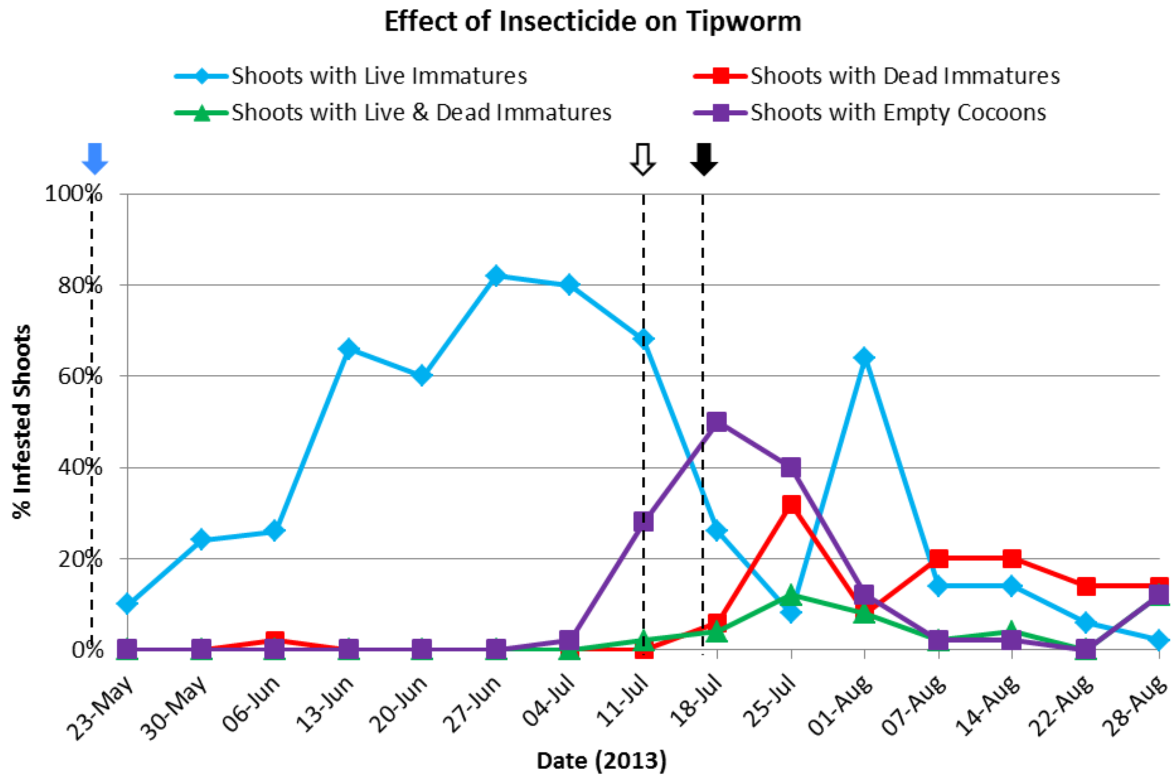


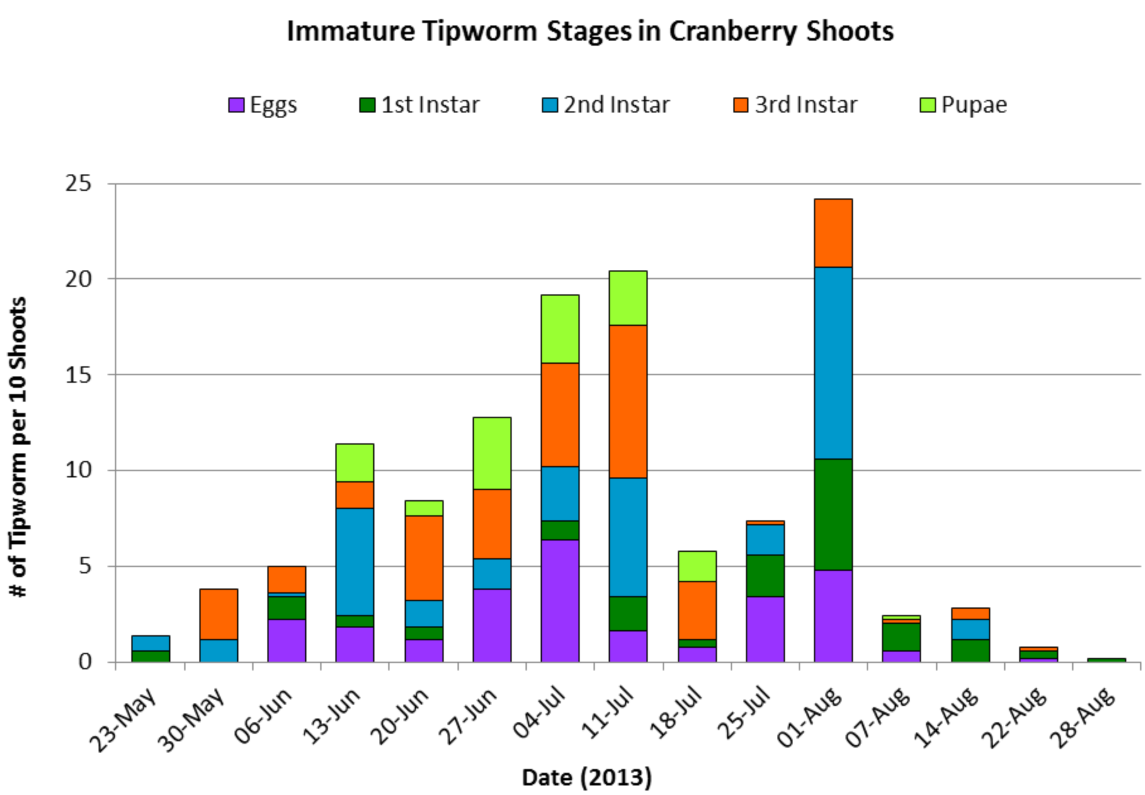


FARM 6 IN 2014

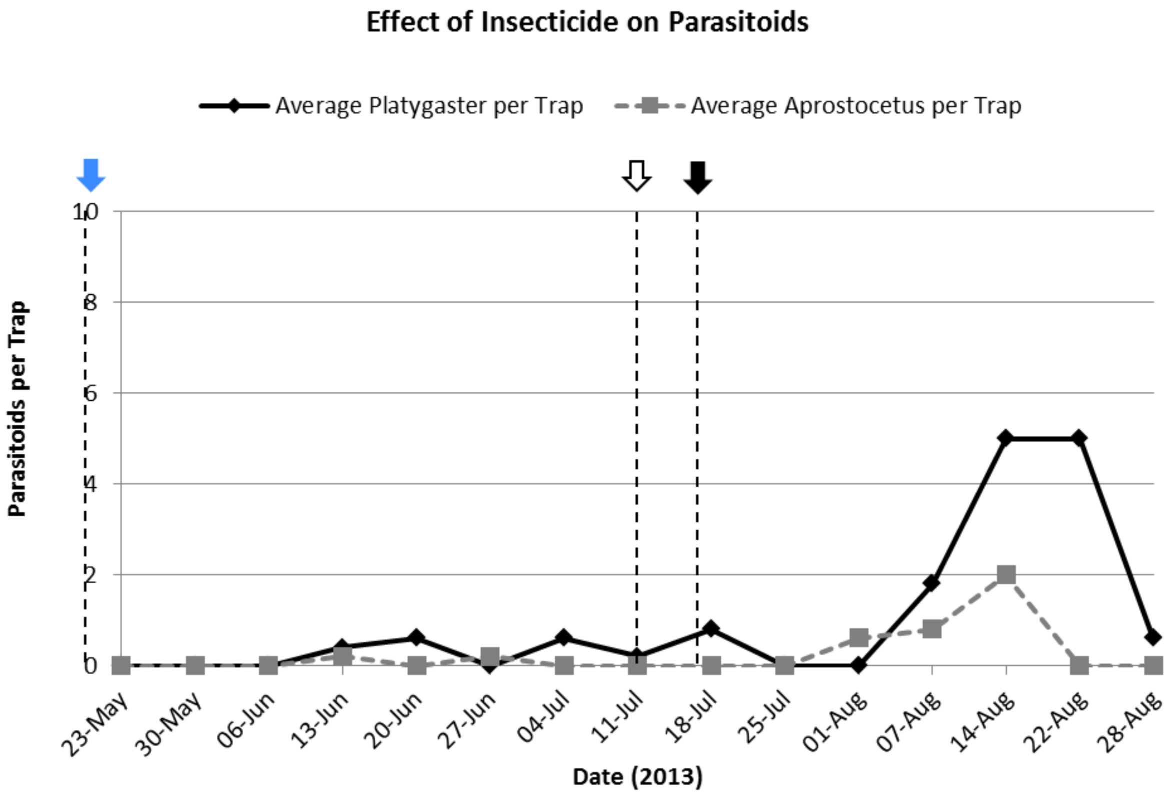


FARM 6 IN 2013





FARM 6 IN 2013



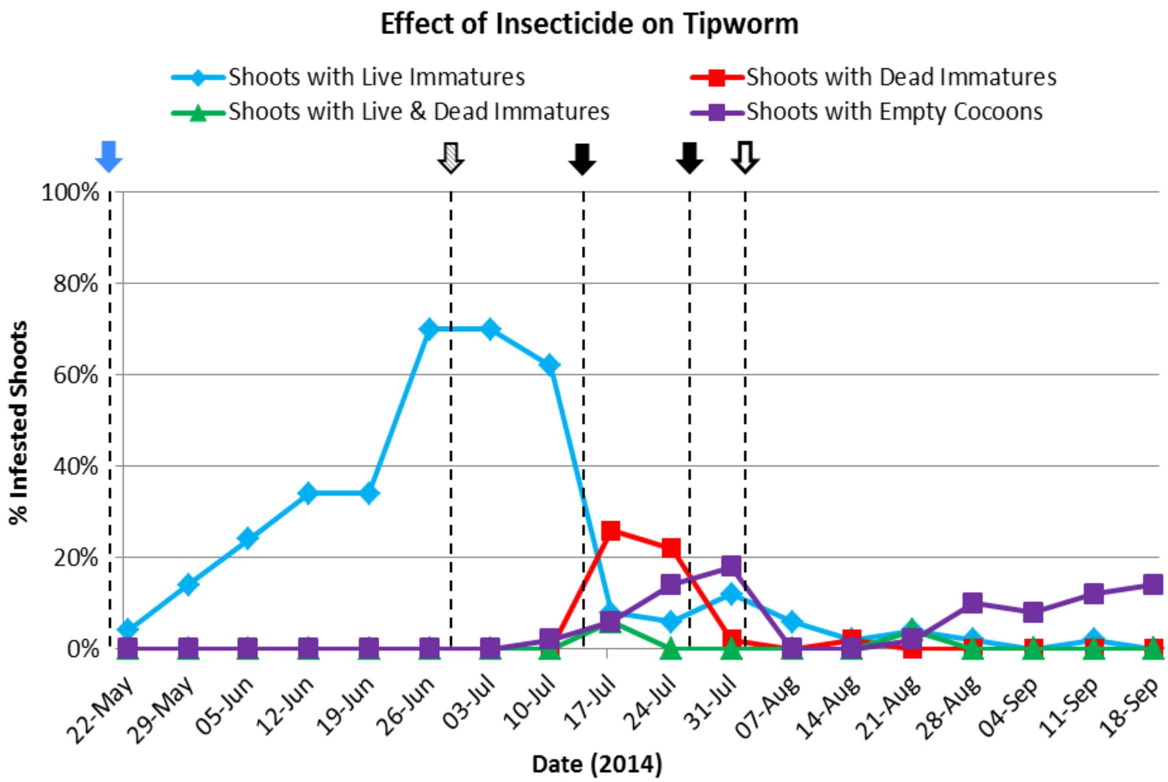
On Farm 7 in 2014, the average percentage of infested shoots containing live immatures increased from about one on May 22 to about 70% on June 26 and July 3. This pattern was similar to that recorded in 2013. The Altacor application on June 29 might have caused the slight decrease in infested shoots on 10 July (but see next paragraph). The most pronounced decrease in percent infested shoots followed the Movento application on July 14. Movento was applied a second time on July 25. Its systemic effect, in addition to the extreme heat on August 11 (see Appendix page 32), prevented resurgence of infested shoots in August and September 2014. The application of Delegate on August 1 targeted other pests.

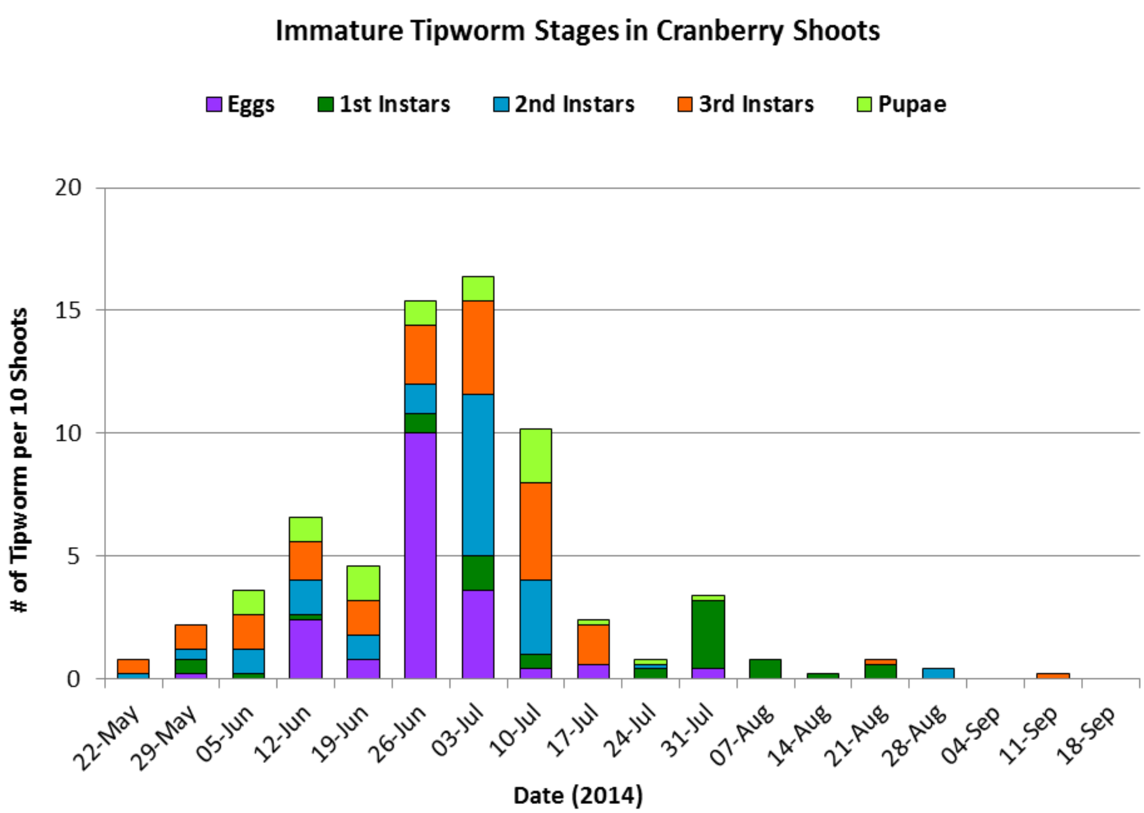
In 2014, the average number of immature tipworms per 10 shoots remained below 7 until June 26, when the number increased to about 15 immatures per 10 shoots. During the same period in 2013, the average number of immatures per 10 shoots remained below 10 until July 4, when the number increased to about 40 immatures per 10 shoots. In 2014, the Altacor application might have caused the decrease in immatures in shoots recorded on July 10. An alternative explanation is that competition between larvae in the shoots caused the decrease. On June 26, most of the immatures were eggs; by July 3, the eggs had hatched and second instars predominated in the shoots; and by July 10, third instars predominated. Cook et al. (2012) found that the space and resources within a shoot tip will only support one or two third instars, even though shoot tips can accommodate many eggs and early instars. In 2014, the Movento applications on July 14 and July 25 further reduced the average number of immatures per 10 shoots to less than five. These immatures were predominantly first instars. The systemic effect of Movento, in combination with the heat on August 11 (see Appendix page 32), killed most of the feeding instars. In late August through September, 2014, the number of immatures in the shoots was virtually zero.

In 2014, few empty cocoons were found in shoots whereas, in 2013, as many as 50% of shoots collected in July contained empty cocoons. Therefore, fewer tipworms completed development, pupated and emerged as adult midges in 2014.

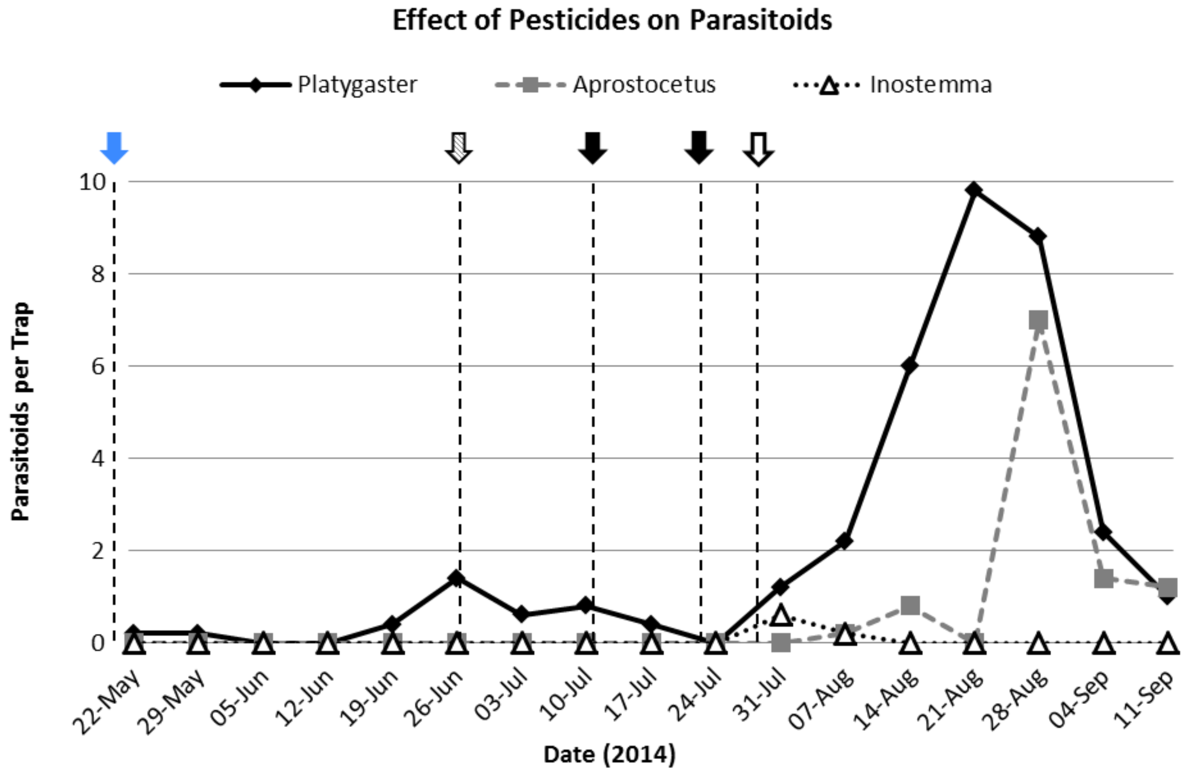
In 2014, Farm 7 had more parasitoids than Farms 4 or 6. Very few *Platygaster* were trapped until August, when average numbers per yellow sticky card trap peaked at 10 on August 21 (photo page 23). The pattern of *Aprostocetus* activity was similar but the peak of 6 parasitoids per trap was reached one week later on August 28 (photo page 23). A previously unnoticed parasitoid, *Inostemma* sp., was caught on yellow sticky traps in July, 2014 (photo page 24). The parasitoids trapped in late summer probably developed inside tipworm larvae that were parasitized during the bloom period (see Discussion). In 2013, a peak of four *Platygaster* per trap was recorded on June 27, then sampling ceased on August 1, so it is not possible to know if catches increased through August and September 2013.

FARM 7 IN 2014

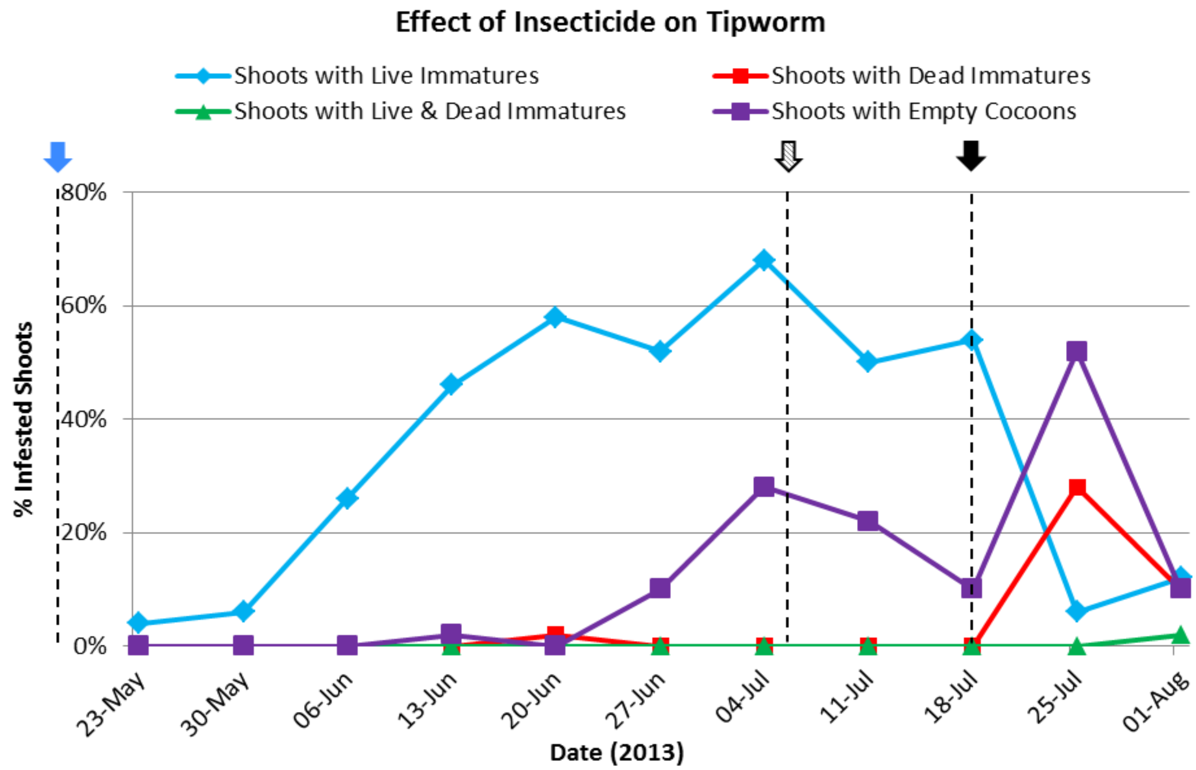


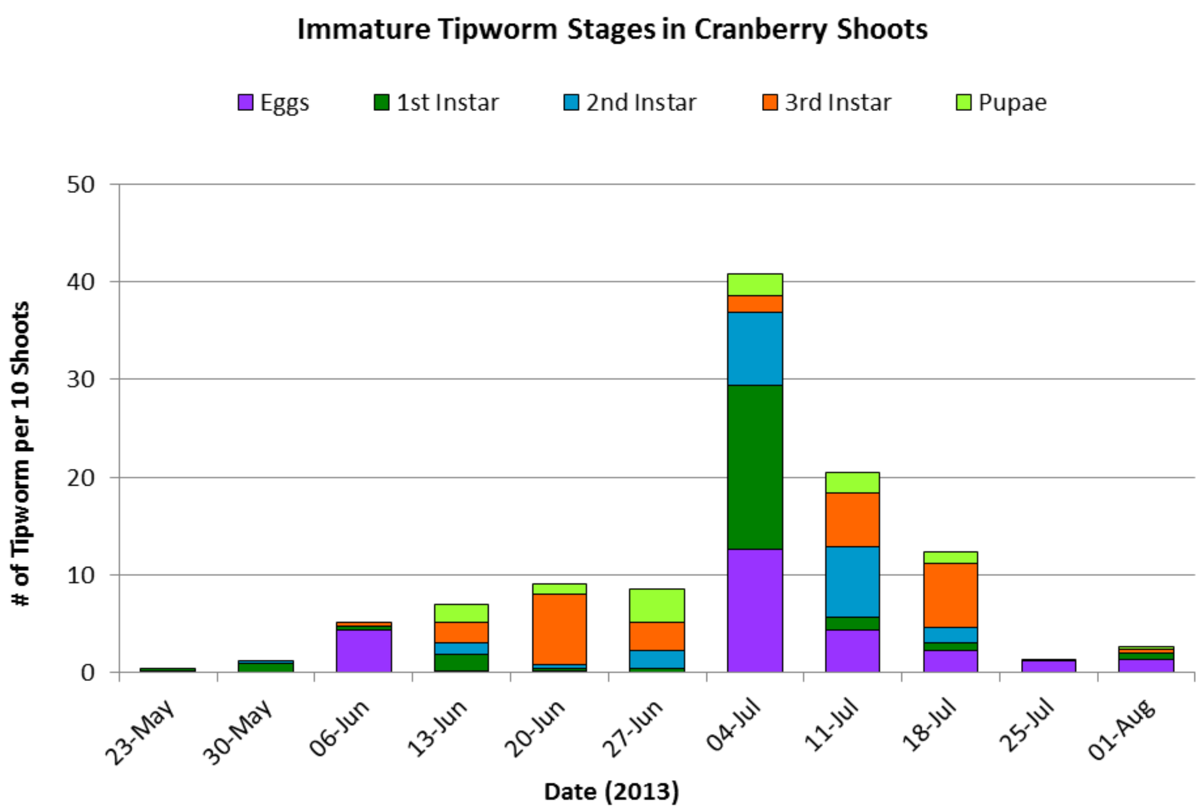


FARM 7 IN 2014

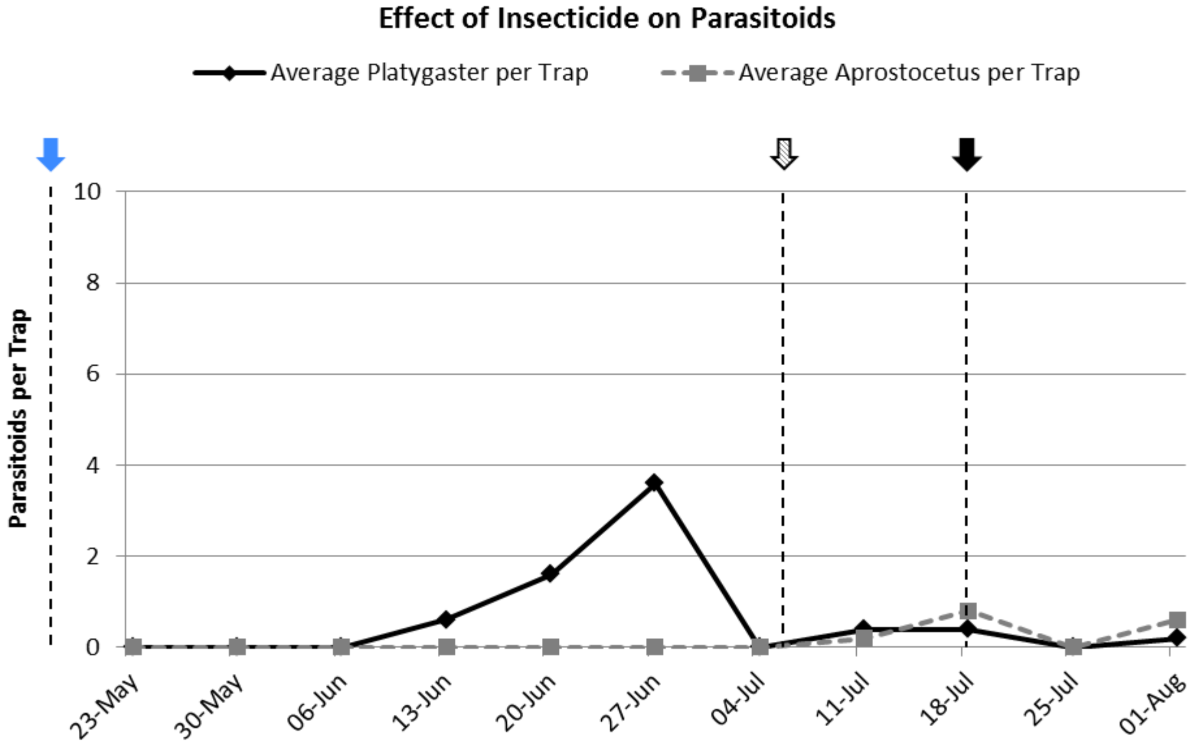


FARM 7 IN 2013





FARM 7 IN 2013



PARASITOIDS OF CRANBERRY TIPWORM

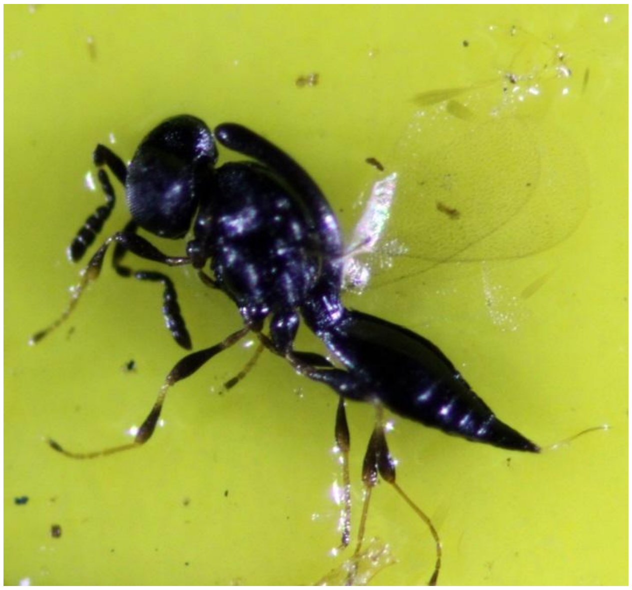
Warren Wong, photographer

Aprostocetus **sp. male (left) and female (right). Length varies from 1.0 – 2.0 mm.**

Warren Wong, photographer

Platygaster **sp. male. Length varies from 0.8 - 1.2 mm.**

PROBABLE PARASITOID OF CRANBERRY TIPWORM



Warren Wong, photographer

Inostemma **female caught on yellow sticky trap (top) and emerged from a blueberry shoot (bottom). Note the sting sheath extending from the abdomen over the thorax (see Discussion). Approximate length of female is 1.0 – 1.5 mm.**

Objective 2: To determine if cranberry tipworm population increases are due to reproduction by successive generations <u>and</u> to different emergence times of overwintered tipworms.

Students Kieryn Matthews and Warren Wong used plastic buckets with detachable lids to construct successive prototypes of traps. The bucket with the lid attached measured 16 cm high, and the lid was 16 cm in diameter. Trap bottoms were cut off, lids were fitted with no-see-um mesh, and a dowel was positioned within the bucket, near the top, so that a yellow sticky card could be attached, by a foldback clip, to the dowel. The earliest prototype was fitted with wooden stakes to hold the trap in place in the cranberry bed.

On May 29, 2014, prototype traps were seated into tipworm-infested areas at field edges. Farm 4 received 5 traps (a sixth was added in late July), and Farms 6 and 7 received one each. After testing different methods of seating the traps, we decided it was best to gently part the cranberry vines and seat the traps directly into the soil over cranberry runners and roots. Thus the traps covered soil that might contain cranberry tipworm pupae. Water from rainfall and irrigation could pass through the mesh at the top of the trap. Sunlight could penetrate the mesh.

Later prototypes of the emergence trap included a skirt of ground cloth taped to the bottom of the bucket, and three firm wire stakes as pegs. The cloth skirting prevented tipworms and other insects from crawling into the trap from the bottom, and also kept sunlight from entering the bottom of the trap. Any tipworms that emerged from pupae in the soil would be guided up and toward the sky, and would encounter the double-sided yellow sticky card. The wire pegs seated the trap firmly without harming the cranberry roots or runners.

The final prototype used one bucket with a mesh lid placed inside another bucket without a lid. The inner bucket, with its lid, dowel, clip and yellow sticky card, could be lifted up out of the second bucket, which was seated into the soil by pegs and cloth skirting. This prototype facilitated replacement of the yellow sticky card without removal of the lid. On earlier prototypes, we found that lids were hard to remove and often cracked after several removals. Photographs of the trap prototypes are shown on page 26.

Our prototype traps remained in place from May 29 until September 18, 2014. The traps stayed intact and did not interfere with farm operations. One or two cranberry tipworm midges were caught on the yellow sticky cards in several of the emergence traps in late June through early August, and in mid September. These results indicate that the emergence traps will be effective for studying emergence of overwintered cranberry tipworms in 2015.

PROTOTYPES OF EMERGENCE TRAP FOR CRANBERRY TIPWORM

Warren Wong, photographer

Top: Early prototype seated into cranberry vines near the edge of a field.
Bottom left: View into top of trap, showing dowel and foldback clip that holds the yellow sticky card.
Bottom right: Final prototype showing top bucket with lid attached, inside support bucket that has cloth skirting and wire pegs.

Discussion

On two of the three farms that were monitored in this study, the percentage of shoots infested with cranberry tipworm was noticeably lower in spring of 2014 than in spring of 2013. On the third farm, the percentage of infested shoots was similar in 2014 and 2013.

On all three farms, the number of tipworm immatures per 10 shoots was lower in spring 2014 than in spring 2013.

These results support the hypothesis that Movento applications in 2013, which caused extensive mortality of feeding stages in shoot tips (Fitzpatrick 2013), reduced the overwintering population of cranberry tipworms and consequently reduced the number of egg-laying females in spring 2014.

Following the bloom period in 2014, which lasted from late May through early July, Movento applications on two of the three farms further reduced the percentage of shoots infested with live immatures and the number of live immatures per 10 shoots. One of the three farms applied Diazinon instead of Movento. The Diazinon application temporarily reduced shoot infestation, but infestation increased three weeks later because there was no residual systemic effect of Diazinon. Similarly, the July application of Delegate on one farm had only a small suppressive effect on cranberry tipworm. On the farms where Movento was applied, very few immatures developed beyond the first instar stage.

In 2014, several days of intense heat that peaked on August 11 appear to have killed all immature stages in the shoots on all three farms. Air temperatures rose to 35^{o}C, so temperatures in the unshaded shoot tips probably exceeded 40^{o}C. The heat killed immatures that survived the application(s) of Movento or Diazinon.

There were noticeably fewer parasitoids (*Aprosotocetus* sp. and *Platygaster* sp.) caught on sticky traps in 2014 than in 2013, particularly during the bloom period. This result suggests that Movento applications in 2013 reduced the number of tipworm hosts available for parasitizing and consequently reduced the overwintering population of parasitoids.

In spring 2014, there were fewer tipworm hosts available for parasitizing and consequently fewer parasitoids developed through to emergence in late summer 2014. These results suggest that Movento applications are indirectly driving down the population of parasitoids.

The Movento label states that the product is toxic to certain beneficial insects. Evaluations under field or semi-field conditions where adult hymenopteran parasitoids were exposed to treated leaf surfaces concluded that the active ingredient spirotetramat was safe to four species of hymenopteran parasitoids (Brück et al. 2009). In laboratory tests where adults of the parasitoid *Encarsia citrana* were confined with treated leaves in test tubes, parasitoid survival was not reduced (Frank 2012). However, field studies or simple exposure tests in the laboratory are not designed to assess sub-lethal or long-term effects of spirotetramat (Movento) such as reduced mobility, fecundity or longevity that may result from direct exposure or from developing in a host that has ingested the product (Frank 2012). In the case of the hymenopteran parasitoids *Aprostocetus* sp. and *Platygaster* sp. in cranberry, sub-lethal or long-term effects of Movento might be partly responsible for the decrease in populations in 2014.

The appearance of *Inostemma* sp. on yellow sticky card traps at Farms 4 and 7 raises the possibility of a third species of parasitoid on cranberry tipworm. *Inostemma* sp. is a parasitoid of blueberry gall midge (Sampson et al. 2006, 2013), which is a cryptic relative of cranberry tipworm. *Inostemma* sp. females are readily distinguished by the unique sting sheath that extends to the top of their heads (Sampson et al. 2013). The long stinger is used to place eggs in a midge larva's brain (Sampson et al. 2013). Males do not possess the sheath (Sampson et al. 2013). *Inostemma* sp. is rare in blueberry fields (Sampson et al. 2013). In British Columbia in 2014, one *Inostemma* female emerged from a blueberry shoot infested with blueberry gall midge (Mathur, unpublished data; photo page 24). To determine if this parasitoid develops within cranberry tipworm larvae, considerable numbers of tipworm-infested shoots would need to be collected from cranberry fields and maintained under controlled conditions until parasitoids emerged.

In response to the first objective of this study: evidence suggests that one or two applications of Movento after bloom reduce tipworm populations in late summer through the following winter and spring. Unfortunately, parasitoid populations are reduced as well. Low populations of cranberry tipworm from mid-July through August should facilitate flower bud development during that time.

The emergence trap designed by students Kieryn Matthews and Warren Wong will be used in 2015 to study the seasonal patterns of cranberry tipworm emergence from overwintering sites in the soil. Preliminary data suggest that some tipworms emerge in September, at a time when there are few vegetative cranberry shoots. Further investigation will reveal more information about the variability in seasonal patterns of emergence of cranberry tipworms and their parasitoids.

In response to the second objective of this study: the emergence trap will be used in 2015 to detect cranberry tipworm midges as they emerge from overwintering sites in the soil. The temporal pattern of tipworm emergence, in conjunction with the temporal pattern of larval development in shoot tips, will provide information about the source of cranberry tipworm infestations throughout the growing season. Management tactics can be adjusted according to the information obtained.

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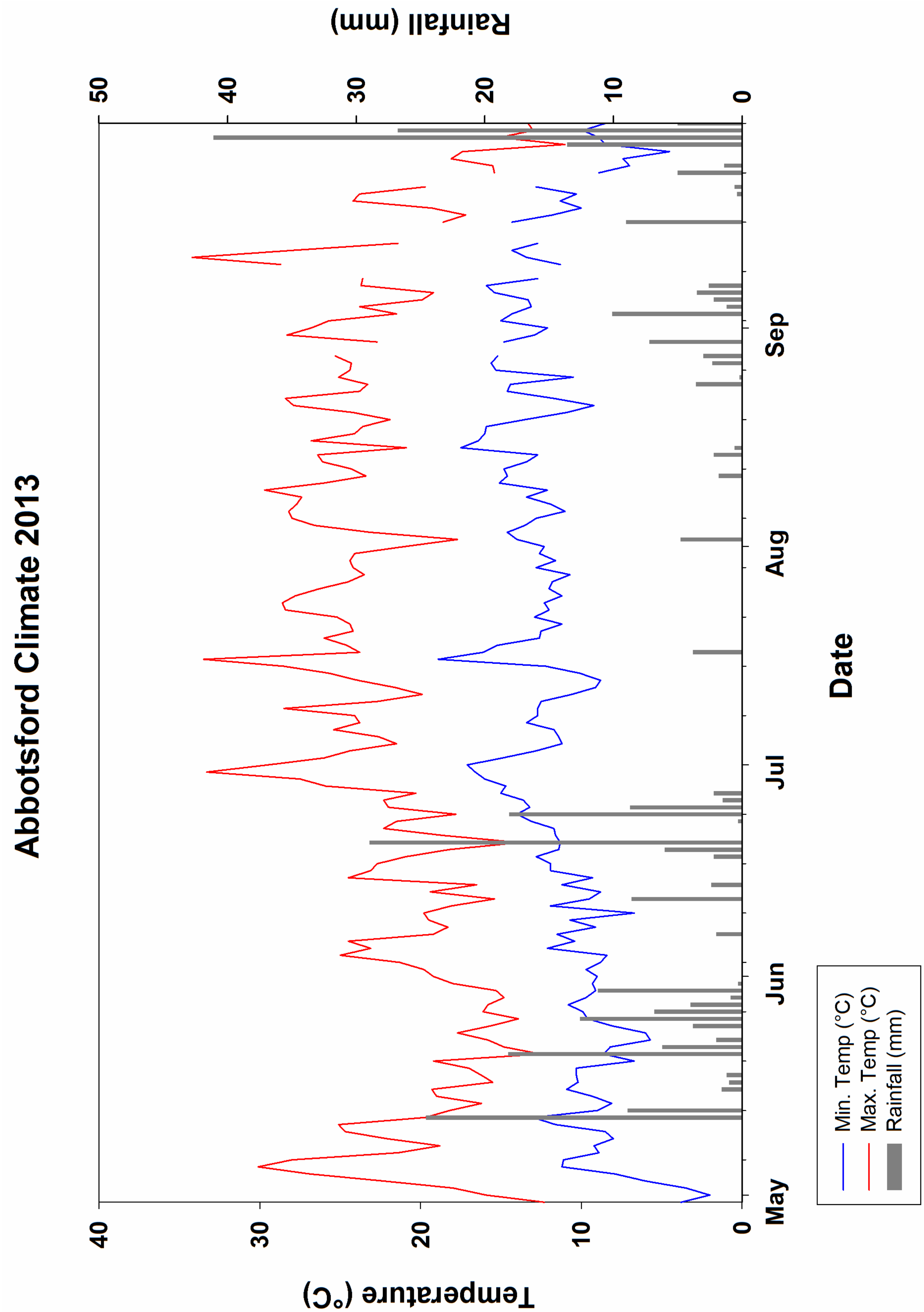
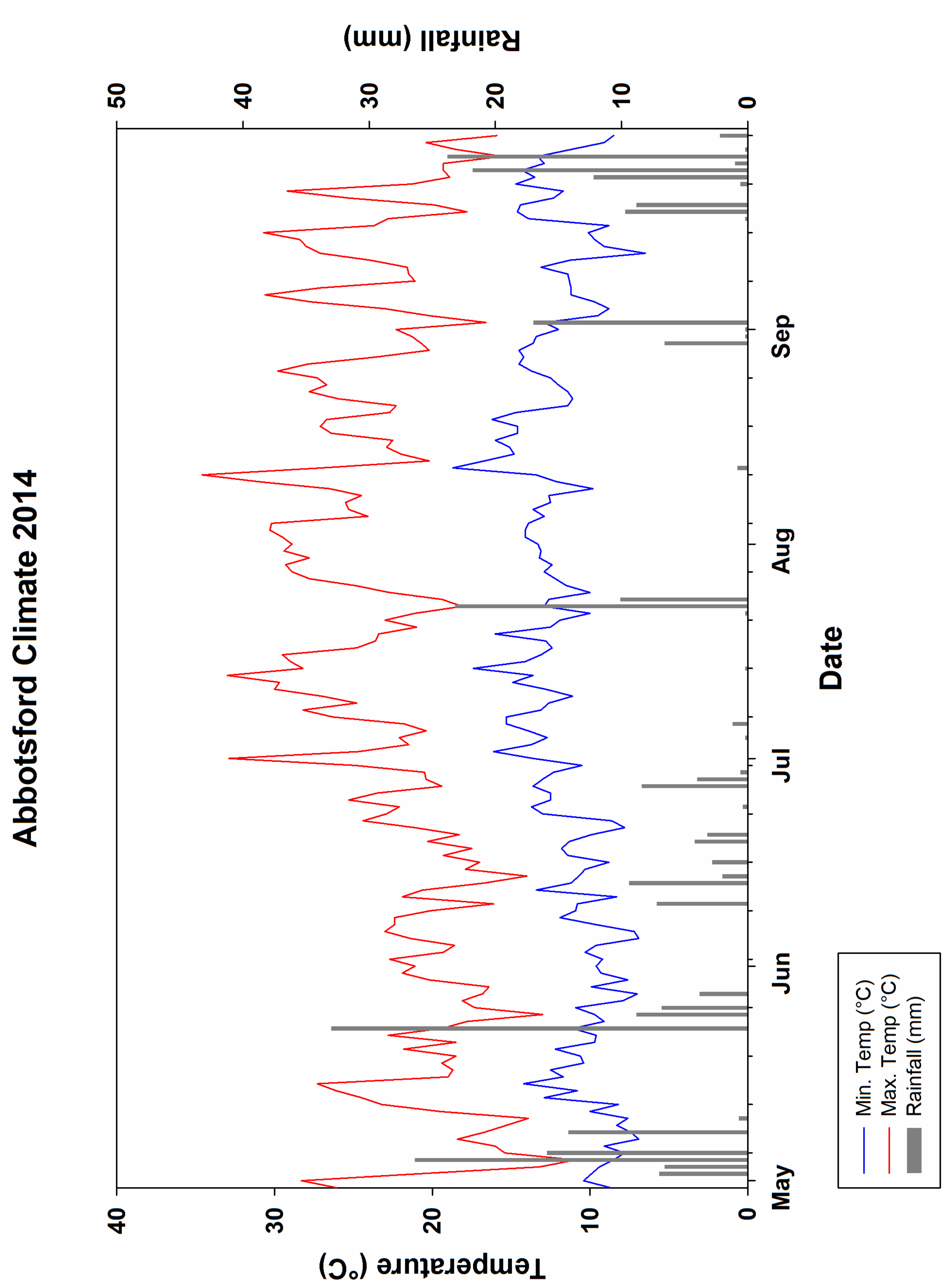
APPENDIX: CLIMATE DATE FROM ABBOTSFORD AIRPORT IN 2013 AND 2014





Abbotsford Climate 2014
Temperature (°C)
Rainfall (mm)
Date
0
10
20
30
40
50
May
Jun
Jul
Aug
Sep
Min. Temp (°C)
Max. Temp (°C)
Rainfall (mm)