Assessing distribution, lifecycle, damage, and potential plant hosts of Sparganothis Fruitworm in BC cranberry bogs

To
BC Cranberry Commission

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Executive Summary
Season long monitoring of Sparganothis fruitworm *(Sparganothis sulphureana)* larvae and moths was carried out in Langley and Pitt Meadows, B.C. Sweep net sampling was used in May and June to detect Sparganothis larvae in cranberry fields but no larvae were caught with this method. Visual sampling was successfully used from May to September to detect larval presence in fields, indicating that visual sampling is better suited for Sparganothis monitoring in B.C. While larval levels remained generally low there were two noticeable peaks in adult activity, which may imply the existence of a native Sparganothis population outside of cranberry farms. Sparganothis fruitworm has a wide range of host plants so vegetation surrounding cranberry farms was sampled. Through visual sampling of alternative host plants we found one larva in Western Dock *(Rumex occidentalis)*, and pheromone traps outside of cranberry fields showed two peak in Sparganothis moth activity in the growing season. Finally, a damage assessment was carried out in two different sites for three consecutive weeks. Cranberries were collected from 0.5 m^2 plots which had had different levels of Sparganothis presence throughout the season. Berries were inspected for signs of Sparganothis damage. We did not see a strong correlation between the density of Sparganothis fruitworm larvae and the levels of berry damage on a per hotspot basis in either site. The amount of berry damage caused by Sparganothis ranged from 1.8 to 4.8% in the two fields examined. However, it was sometimes impossible to distinguish damage caused by Blackheaded fireworm and Sparganothis fruitworm. Future work should include direct observation and comparison of fireworm and Sparganothis feeding on berries so that the cause of berry damage can be distinguished in the field. Understanding the potential amount and severity of Sparganothis damage may aid in the development of an action threshold for this insect in B.C.

Introduction
Sparganothis fruitworm *(Sparganothis sulphureana)* is a primary pest in Wisconsin and the East Coast of the United States, and a secondary pest in Eastern Canada (LeDuc & Turcotte, 2004). Although, Sparganothis presence has been rare in British Columbia cranberry bogs, late in the 2007 growing season Sparganothis fruitworm was identified in cranberry fields in Pitt Meadows and Langley. Sparganothis fruitworm can cause berry damage and direct yield loss (Teixeira & Averill, 2006). Therefore acquiring knowledge about its lifecycle, distribution within fields, and the damage it is currently causing under our climatic conditions is an important first step towards minimizing its possible negative impact on local cranberry production.

Sparganothis fruitworm overwinters as a first instar larva (Mahr, 2005) and there are two generations each year (Polavarapu *et al*. 2001). Overwintering Sparganothis larvae develop from bud break until June, when they pupate. Adults emerge between late June and mid-July and lay eggs. Second generation larvae

emerge from eggs 9 – 12 days after they are laid (LeDuc & Turcotte, 2004) and pupate after 50 – 60 days of development (Turner & Liburd). Adults emerge in late August and remain active until late September. They lay eggs which hatch 9 – 10 days later and the newly emerged larvae hibernate in the trash layer (LeDuc & Turcotte, 2004).

First generation larvae feed on developing blossoms and foliage, turning them brown and sometimes "skeletonizing" the leaves (similar to the damage caused by fireworm). Second generation larvae cause the most damage as they directly feed on the cranberries. Each larva attacks 3-5 berries and scars the surface of several others (Teerink & Carlson, 1988). This generation of larvae pupates either inside a fruit or a webbed tent. Action thresholds for Sparganothis fruitworm are loosely established and are only available for sweep net sampling. According to Averill and Sylvia (2007), if the number of larvae found in several sweep net samples (each one consisting of 25 sweeps) exceeds an average of 1-2 larvae, it is an indication that the pest is present in levels considered high and worthy of attention. However these numbers should not necessarily trigger a control measure (Averill and Sylvia 2007). Sparganothis fruitworm is known to have several plant hosts in addition to cranberry. Therefore monitoring plants that occur in and around cranberry bogs may provide some insights into other plants that may harbor this insect.

The purpose of this study was to:

1. Study the lifecycle and within field distribution of Sparganothis fruitworm in B.C.
2. Conduct a survey of potential host plants for Sparganothis fruitworm in areas surrounding bogs.
3. Assess the damage inflicted on cranberry fruit by Sparganothis fruitworm.

Materials and Methods

All of the field work for this study was conducted on two farms with Sparganothis presence in 2007, one in Langley and the other in Pitt Meadows. Two fields from each farm were selected to monitor the pest's field distribution and lifecycle. Native vegetation surrounding all four fields was checked for Sparganothis larvae. One field from each farm was used to assess berry damage.

<u>Lifecycle and within field distribution</u>

In order to determine the timing of Sparganothis life stages and the distribution of larvae within fields, we monitored for eggs, larvae, and adults using a variety of approaches.

Larvae: Weekly sweep net samples were taken every week from bud break until blossom. Samples were taken with a 15" diameter rim net and a single sample consisted of 20 continuous sweeps following a "W" pattern. The University of Wisconsin scouting

protocol suggests taking six samples in fields larger than 6 acres. All four fields were approximately 4 acres so we did 5 samples/field – 3 edge and 2 interior. The number of larvae caught in the sweep net, their development stage, and a diagram with the location of the samples were recorded. In addition to sweep net sampling, we also did visual monitoring for Sparganothis on a weekly basis, at the same time that fireworm larvae were being monitored from May to September. Samples were taken in every corner and every 5-8 metres along the edge of the field. A sample consisted of a visual scan for webbed uprights ("tents") over 2 ft^2 (0.19 m^2), with15 uprights/plot directly inspected for larvae. A hot spot map was made for each field marking the location of plots where Sparaganothis larvae were found.

Adults: Sparganothis moth activity was also tracked in these fields with two pheromone traps/field placed in spots where Sparganothis larvae were observed in the summer of 2007. Traps were used from June 10th to September 10th, and were checked weekly.

Eggs: During the visual monitoring for larvae we also checked plots for eggs on the upper leaf surface near the top of the upright. A more intensive search for Sparganothis eggs was conducted in the same week as the second peak in moth captures in pheromone traps. All of the Sparganothis hot spot in each field were visually scanned for eggs, after which 20 uprights from the plot were randomly selected and closely examined for eggs.

Monitoring potential host plants

When medium and large larvae from the second generation were observed in the cranberry fields, the vegetation in the areas surrounding the fields was visually inspected for Sparganothis. We followed a protocol similar to the one used for finding Sparganothis in the field. A sample consisted of visually inspecting 15 shoots, leaf tips, blossoms and crevices of all the different plant species present in 2 ft^2 plots for Sparganothis larvae, webbing and the tents. Samples were taken every 30 paces along the perimeter of the field but all plants were closely observed in between samples as well. A total of 36 samples were taken around the Pitt Meadows field and 32 in Langley. A list of all plant species that were sampled is presented in Appendix A. The number of Sparganothis larvae, name of the host plant and its location were recorded.

Sparganothis moth activity was also monitored in the surrounding vegetation around each field. Four Sparganothis pheromone traps were placed throughout the vegetation areas surrounding the farms. Traps to monitor the first seasonal flight were placed in early June; lures were replaced with new ones in early July to monitor the second generation moths. The number of moths caught in the trap was recorded weekly until the second week of September when traps were removed.

Cranberry damage

Using the hotspot maps created through the season long visual scouting of Sparganothis larvae, we identified four types of plots for assessing cranberry damage due to this pest.

Plots were classified based on the total number of Sparganothis larvae observed over the season (Table 1). Hotspots throughout the farm were used for the berry damage assessment and there were a different number of plots in each category in each farm (Table 1).

Table 1. Classification of berry damage assessment plots based on season long observations of Sparganothis larvae; and summary of the number of plots in each category in each field used for the berry damage assessment.

Plot categories and season long Sparganothis counts/ plot	**Number of plots in each category in Pitt Meadows farm**	**Number of plots in each category in Langley farm**
Control plots (with no Sparganothis activity over the season)	4	4
Low (1-2 larvae observed through the season)	9	9
Moderate (3-5 larvae)	8	9
High (5+ larvae)	3	2

Plots measuring 0.5m² were flagged within the various hotspots. Ten cranberries were collected at random from each plot for three consecutive weeks (last week of August and two first weeks of September). Fruits were then visually examined for bruising, scarring and larvae entry holes. Damaged berries were cut in half to inspect for larvae or pupae. Damage data was plotted against Sparganothis infestation levels of the hotspot to see the relationship between pest density and berry damage.

Results and Discussion

Lifecycle and within field distribution

Sweep net sampling is often used in Eastern cranberry production areas to detect the presence of Sparganothis fruitworm (Mahr et al. 2001). Scouting protocols from Wisconsin and Quebec recommend that weekly sweep sampling should continue as berries continue to grow. We began using this method to monitor for overwintering Sparganothis larvae in the spring as they first become active after bud break. We did not see any Sparganothis larvae in any of the sweep samples taken. Visual sampling was the only method through which Sparganothis was detected in these fields (Table 2). There are several important differences between Eastern and Western growing conditions that could account for the poor efficacy of sweep sampling. Firstly, precipitation in Langley and Pitt Meadows made it impossible to take sweep samples in three of the eight weeks that we attempted sweeping. This could possibly explain why we did not see any

larvae in the fields at bud break. Secondly, plant canopy is denser and lusher in the West (B. Mauza personal communication) making it difficult to sweep without knocking blossoms and fruit off of vines. We therefore did not use this sampling technique after June. Overall, sweep net sampling does not appear to be a suitable method for monitoring Sparganothis fruitworm in B.C. Visual sampling was a more effective detection tool and it can be easily incorporated into the protocol that is used for monitoring Blackheaded fireworm. Visual sampling was also used to find Sparganothis fruitworm eggs on cranberry uprights but none were seen.

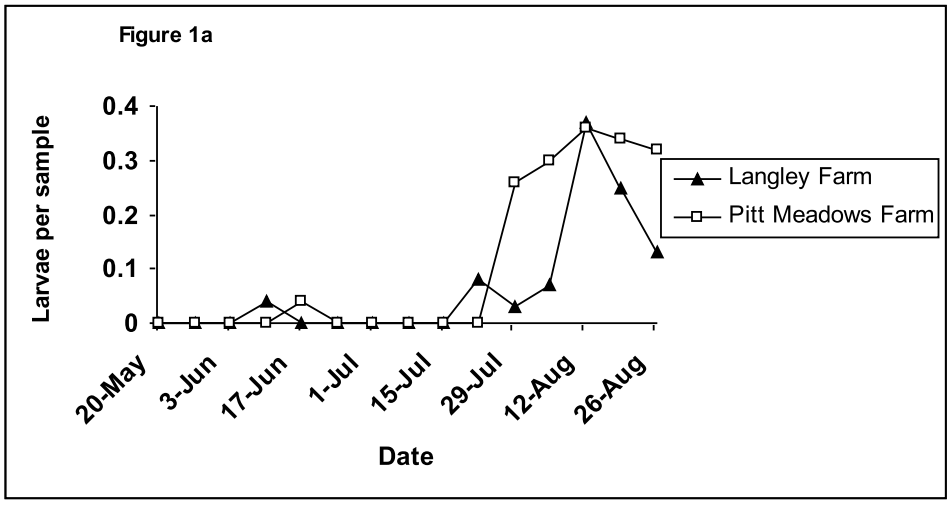
Table 2. Summary of sampling methods used to detect Sparganothis fruitworm larvae.

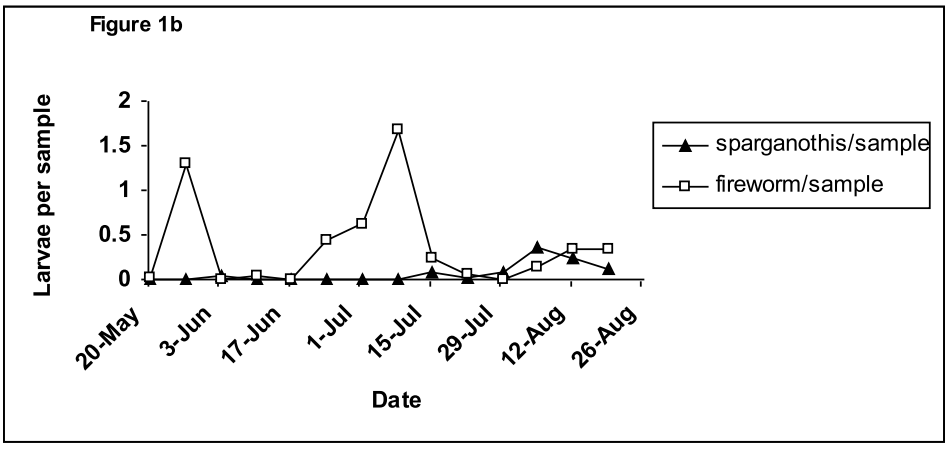
Sampling duration	**Location**	**Sampling method**	**Larvae observed**
May-June	edge	sweep net	no larvae
May-June	within field	sweep net	no larvae
May-June	within field	visual	larvae starting June 10th – Langley
			larvae starting June 24th – Pitt Meadows
May-August	edge	visual	larvae starting June 3rd - Langley
			larvae starting June 24th – Pitt Meadows
May-June	weedy areas	sweep net	no larvae
May-August	weedy areas	visual	no larvae

In terms of within field distribution, Sparganothis larvae were first detected along the edge and then within the field a week later, in Langley (Table 2). In the Pitt Meadows fields larvae were observed along the edge and within the field during the same week. We did not find any larvae adjacent to or within the weedy areas of any of the fields. Sparganothis larval levels in all fields were extremely low during May and June (Fig. 1A). Sparganothis larvae were first seen on the week of June 3rd in Langley and on the week of June 24th in Pitt Meadows (Fig. 1A). In spite of the low number of larvae detected in fields there was a peak moth flight on the first week of July in Langley and Pitt Meadows (Fig. 2A and 2B). In both farms, second generation Sparganothis larvae numbers peaked during the week of August 19th (Fig. 1A). Moth levels peaked for the second time on the week of September 2nd; larvae produced by these moths will be the overwintering generation.

It is possible that because fireworm resemble Sparganothis larvae when they are in their first instars, we were not properly identifying the latter insect when taking visual samples and we missed detecting the overwintering generation of larvae. Another possibility is that

Sparganothis levels were kept low due to fireworm treatments. Fireworm larval populations peaked in late May in both Langley (Fig. 1B) and Pitt Meadows (Fig. 1C). They peaked for the second time on the first week of July. The farm in Pitt Meadows had a third peak on the third week of July. Both farms treated for fireworm with a chemical that also targets Sparganothis fruitworm, which could explain why Sparganothis larvae were practically undetectable when fireworm levels were above the action threshold, between May and July. Thus, one possibility is that Sparganothis moths from the first peak came from outside the cranberry fields. Both farms are surrounded by native vegetation and blueberries are grown in the vicinity of the Pitt Meadows farm. Sparganothis fruitworm has a wide host range, so there is a great potential for alternative hosts, (see below).





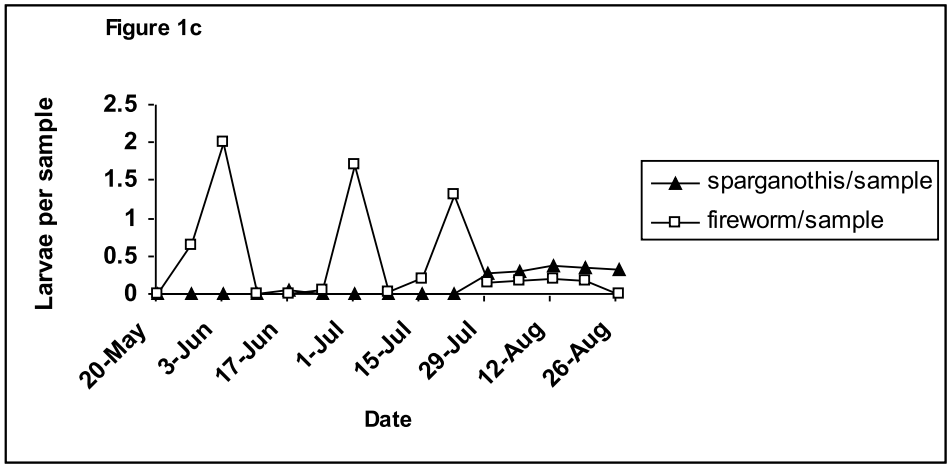
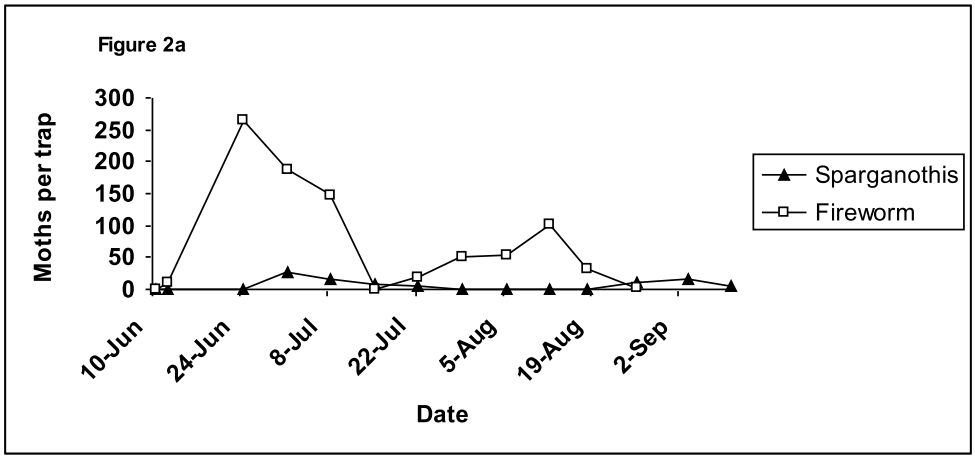


Figure 1. Larval activity in two cranberry farms during 2008 field season. A) Season long trends in Sparganothis activity in Langley and Pitt Meadows. Comparison of Sparganothis and fireworm larval peaks in Langley (B) and Pitt Meadows (C). Data points on the graph show the average number of larvae found per sample taken in the entire farm.



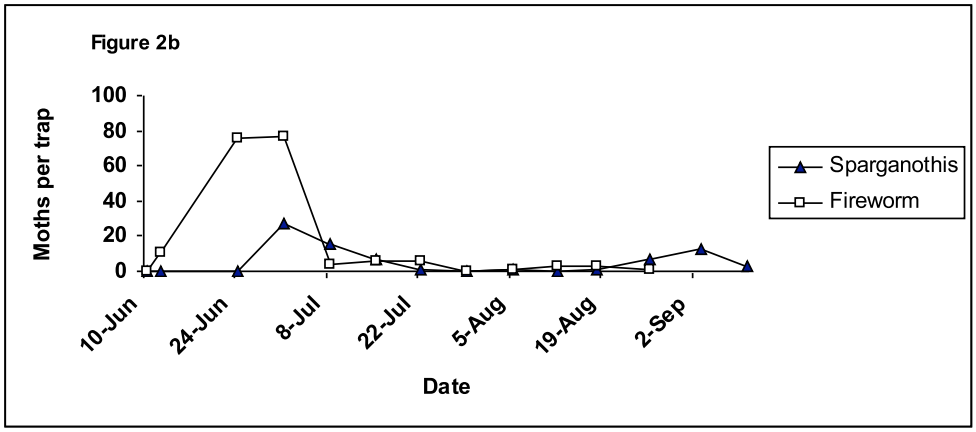


Figure 2. Seasonal patterns in Sparganothis and fireworm male moth captures in pheromone traps in A) Langley and B) Pitt Meadows. Data points on the graph show the average number of moths caught in two traps placed in trial fields.

Monitoring potential host plants

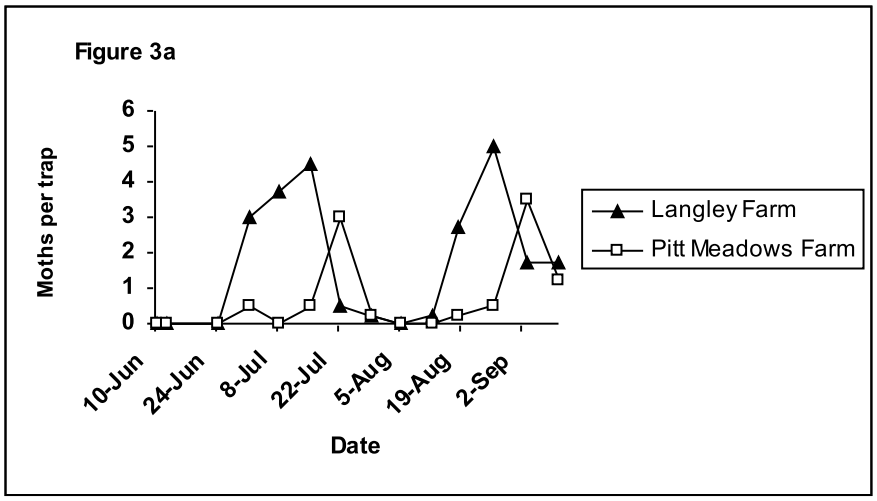
In addition to the cranberry plant Sparganothis fruitworm may also feed on blueberry, apple, celery, corn, red cedar, jack pine, Scotch pine, strawberry, willow, elm, alfalfa, (Teerink & Carlson, 1988) and several common weed species such as sweetfern (Polavarapu *et al*. 2001). Yellow loosestrife *(Lysimachia terrestris)* is a common weed in cranberry bogs and is a known host of Sparganothis fruitworm (Marucci, 1977). Yellow loosestrife was widespread in and around our two sampling bogs in Langley. Twenty-three different plant species were sampled (Appendix A). Only one large Sparganothis fruitworm was found in Western Dock *(Rumex occidentalis)* in Pitt Meadows (Table 3).

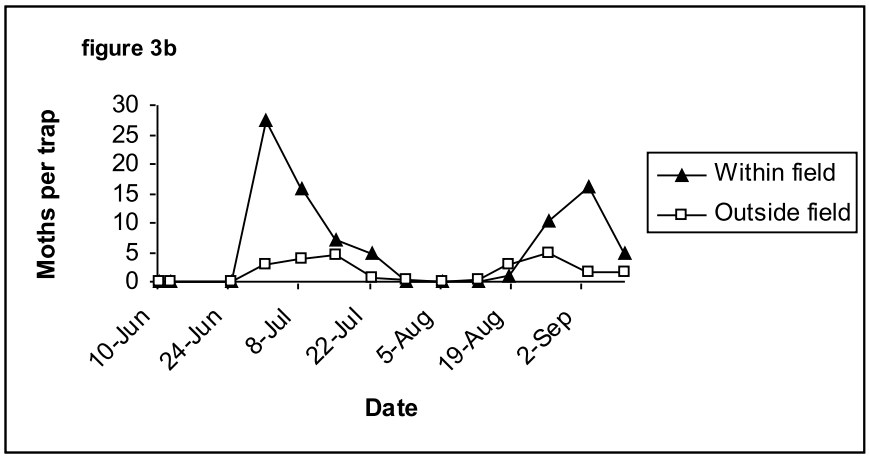
There were two clearly marked peaks in the number of moths caught in the pheromone traps placed in the vegetation surrounding the cranberry fields (Fig. 3A). Moth levels peaked on the weeks of July 13th and again on August 26th in Langley. Neither of the outside field peaks occurred in the same week as the peaks in pheromone trap catches inside the field (Fig. 3B). In Pitt Meadows trap catches peaked on the weeks of July 22nd and again on September 2nd; the first peak did not occur at the same time inside and outside the field however the second peaks were in the same week (Fig. 3C). In addition to differences in the timing of peak moth captures, the overall number of moths caught was noticeably lower outside the field than inside, at both farms (Fig. 3B and 3C). However, the vegetation area that the pheromone traps, placed inside fields, covered is quite small in relation to the large vegetation expanses that surround both farms. Lower trap counts from traps located in surrounding vegetation therefore do not rule out the possibility that Sparganothis moths could be entering cranberry fields from an outside source.

A Sparganothis fruitworm population existing outside of cranberry fields could have a negative impact on cranberry production. The large vegetation areas and agricultural land nearby the farms could include a large number of Sparganothis host plants. Thus areas outside the field could potentially harbor significant populations of this insect. If this outside-field population is not synchronized with the internal one, as suggested by the differences in timing of peak trap catches, there could be an influx of Sparganothis into the field that could be unaffected by treatments targeted for fireworm or the within-field Sparganothis population.

Table 3. Summary of occurrence of Sparganothis larvae on alternative host plants around cranberry farms.

Farm	Sampling Date	Sparganothis larvae found
Pitt Meadows	July 25th	1 larva in Western Dock
Langley	July 31st	none





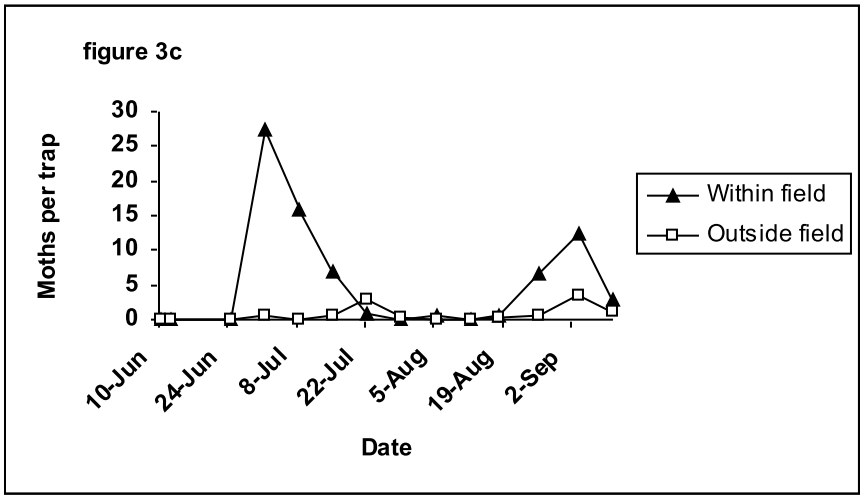


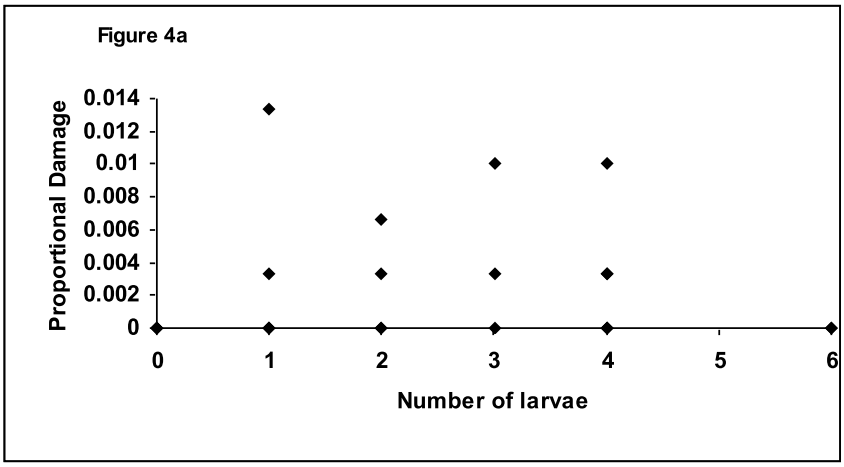
Figure 3. Seasonal patterns in Sparganothis male moth captures in pheromone traps. A) Traps placed outside fields Langley and Pitt Meadows. Comparison between traps within and outside fields in Langley (B) and Pitt Meadows (C). Data points on the graph show the average number of moths caught in four traps placed in each farm.

Cranberry damage

We did not see a strong correlation between the density of Sparganothis fruitworm larvae and the levels of berry damage on a per hotspot basis in either Langley (Fig. 4A; R^2 = 0.0016) or Pitt Meadows (Fig. 4B; R^2 = 0.086). The highest levels of berry damage did not correspond to the hotspots with the highest season-long Sparganothis density.

Fireworm and Sparganothis fruitworm cause similar damage to cranberries. At times it was impossible to know for certain which of the two insects had bruised or burrowed into a berry. As such, berries were divided into the following categories after they were assessed: no damage, Sparganothis, fireworm, and Sparganothis or fireworm. In Langley 87 percent of berries did not show damage, 1.8 percent were damaged by Sparganothis, 1.2 percent by fireworm, and 10 percent had indistinguishable damage (Fig. 5A). In Pitt Meadows 92 percent of berries did not show damage, 4.8 percent were damaged by Sparganothis, 0.1 by fireworm and 3.1 percent had indistinguishable damage (Fig. 5B). Both farms had less than 20 percent damaged berries. A future assessment may show clearer trends if comparisons are between fields with both Sparganothis and fireworm and fields with a similar fireworm population but no Sparganothis.

The damage assessment was carried out over a three week period to determine whether the number of damaged berries increased with time. The average proportional damage seen in Langley was highest in week 1 and decreased in weeks 2 and 3 (Fig. 6A). In Pitt Meadows, berry damage increased each week in most hotspots (Fig. 6B). Second generation larvae feed on berries until they pupate, therefore future damage assessments should be carried out after no more larval activity is seen in the field.



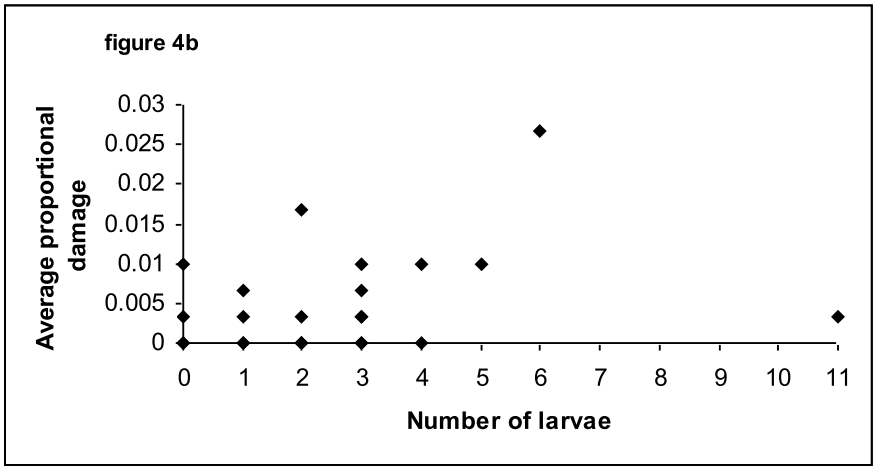
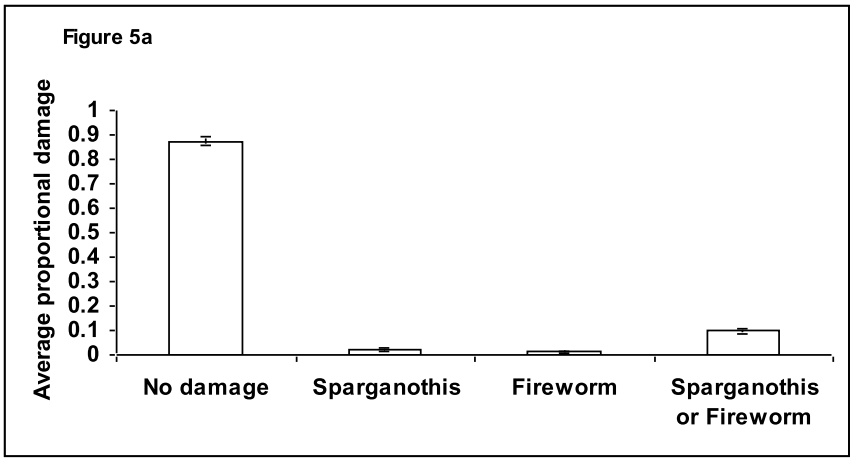


Figure 4. Relationship between number of larvae and average number of damaged berries in hotspots in A) Langley and B) Pitt Meadows.



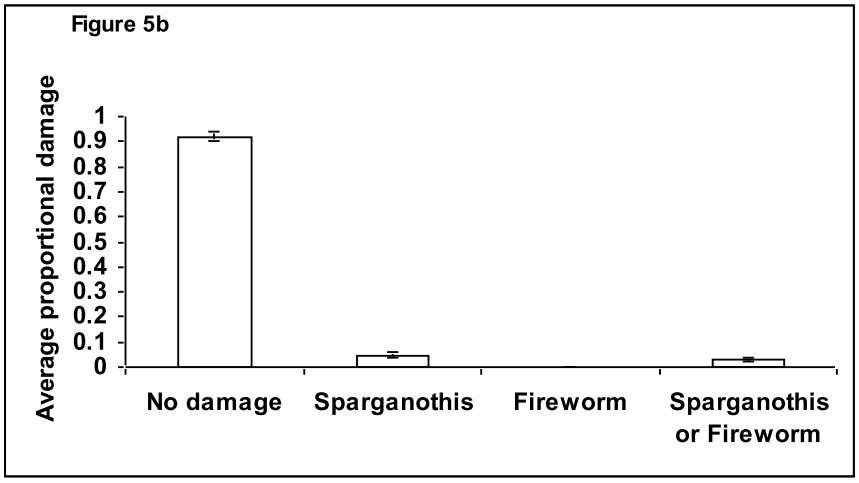
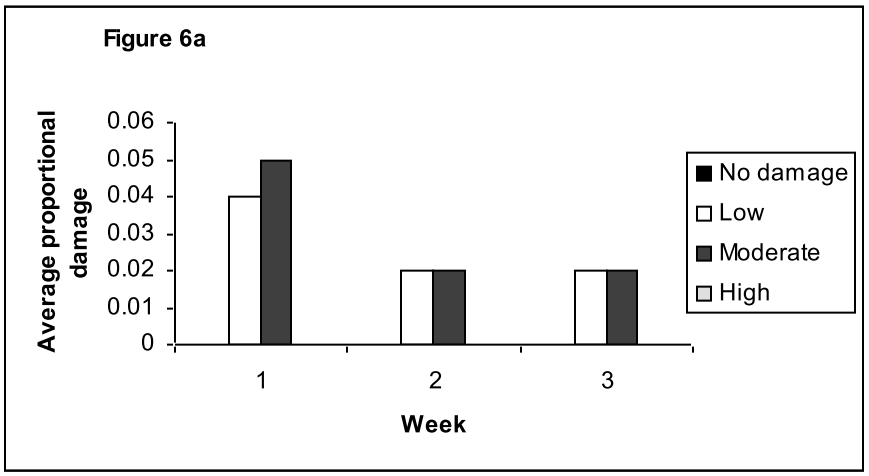


Figure 5. Categories for berry damage assessment and mean (± s.e.) damage found in A) Langley and B) Pitt Meadows



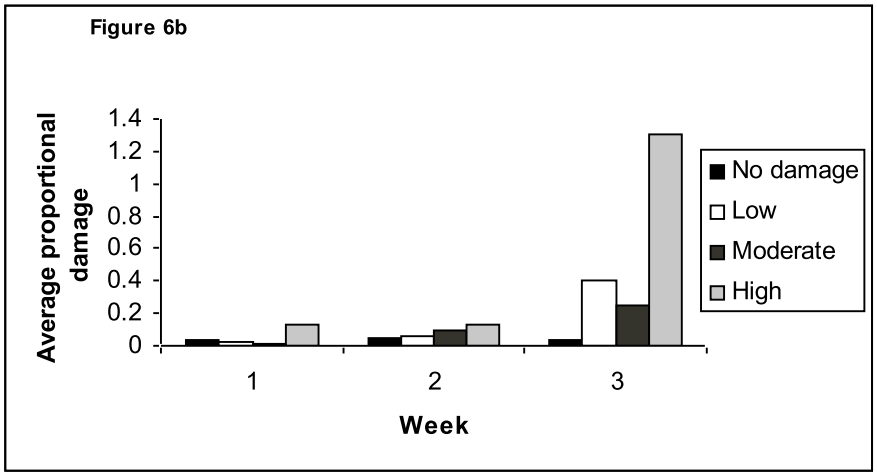


Figure 6. Average berry damage seen each assessment week in A) Langley and B) Pitt Meadows.

Summary and Future Work

This study demonstrated that visual sampling is the most effective way to monitor for Sparganothis larvae. Within field larval counts were generally low until August. Pheromone trap catches reveal two peaks in moth flight. While larval and moth activity was detected at low levels in the vegetation surrounding the fields, it is most likely that the outside field vegetation is the source for the cranberry populations. Therefore additional effort should be made to trap more intensively in the native vegetation. The primary advantage of this additional survey would be to determine what areas are likely to see Sparganothis moving into cranberries from surrounding habitat. Although not a major pest in BC, the economic damage that this insect can cause is significant (Mahr, 2005). In New Jersey, Sparganothis is the most important insect pest of cranberries and is the primary target for the majority of insecticide sprays (Polavarapu *et al*. 2001). Thus documenting the occurrence and potential risk of Sparganothis can help ensure that future pesticide registrations, through the minor use program, are proactive with broad labels.

It is important to note that Sparganothis becomes more of a problem in areas where broad-spectrum organophosphate pesticides are routinely used due to the effect that these products have on their natural enemies (Hastings, 2003). Sparganothis fruitworm is susceptible to naturally-occurring predators and parasites, especially egg parasites (*Trichogramma* spp.) and the parasitic tachinid fly, *Erynnia tortricis* (Mahr, 2005). Future work examining natural enemies of Sparganothis, in both surrounding vegetation and within fields, may help to determine why in some areas Sparganothis moves into field and becomes a pest. A natural enemy survey could also help to identify future biological control agents for this pest.

Finally, berry damage assessment indicated that at the level of individual hot spots there was no correlation between season long larval activity in a hot spot and berry damage. Damage due to Sparganothis alone ranged from 1.2 to 4.8% in the two fields. It was also difficult to distinguish between fireworm and Sparganothis damage in some berries. To better understand the potential impact of Sparganothis future work should include direct observation and comparison of fireworm and Sparganothis feeding on berries so that the cause of berry damage can be distinguished in the field.

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Appendix A

Shrubs
Red Elderberry (*Sambucus racemosa spp. Pubens)*
Common Snow Berry (*Symphoricarpos albus)*
Salmon Berry (*Rubus spectabilis)*
Himalayan Blackberry (*Rubus discolor)*
Trailing Blackberry (*Rubus ursinus)*
Black Raspberry *(Rubus leucodermis)*
Hardhack *(Spiraea douglasii)*
Red-osier Dogwood *(Cornus stolonifera)*

Buckwheat

Sheep Sorrel *(Rumex acetosella)*
Western Dock *(Rumex occidentalis)*

Buttercup

Creeping Buttercup *(Ranunculus repens)*
Western Buttercup *(Ranunculus occidentalis)*

Rose

Sliverweed *(Potentilla anserine ssp. pacifica)*

Evening Primrose

Fireweed *(Epiliobium angustifolium)*
Purple-leaved willowherb *(Epiliobium ciliatum)*

Aster

Smooth Hawksbeard *(Crepis capillaries)*
Nipplewort *(Lapsana communis)*
Great Northern Aster *(Aster modestus)*

Loosestrife

Purple loosestrife *(Lythrum salicaria)*
Yellow loosestrife *(Lysimachia terrestris)*

Grass

Large Barnyard Grass *(Echinochloa crusgalli)*
Hairy Crabgrass *(Digitaria sanguinalis)*

Ferns

Bracken Fern (*Pteridium aquilinum*)