2003 Peach Twig Borer Trapping, DD Modeling, and Implications for Management
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Objectives: Refine the approach to peach twig borer (*Anarsia lineatella*) management in northern Utah.

- Trap peach twig borer moths throughout the season while monitoring shoot strikes to track larval activity.
- Quantify harvest damage at each site so that correlations can be made between strike counts and harvest damage.
- Highlight critical elements of twig borer biology.
- Analyze treatment timings relative to moth pressure and harvest damage.
- Assess the validity of the model and its usefulness for timing treatments.

Background

Peach twig borer (PTB) is a small moth that targets the succulent shoot growth of stone fruit trees. It is a major pest of stone fruit in the West, particularly peaches and nectarines. Severe infestations can disfigure young trees by redirecting growth to lateral shoots rather than the dominant shoot on each scaffold. On bearing trees, larval feeding early in the season may cause negligible damage, but as the season progresses and most shoots "harden off" (set terminal buds), the larvae target ripening fruit. Feeding damage to fruit can be confined to tissue right under the skin, or the larva may burrow deeply into the fruit, though the cotyledons are rarely targeted.

Twig borer spends the winter as a larva. Each larva burrows into the tree cambium in the fall, generally at scaffold crotches (2-4 year old wood), leaving a small column of frass that is referred to as a "hibernacula." The larva will emerge on multiple occasions in spring (weather permitting) to feed on young leaves, but if there are no leaves available, the larva is forced to burrow back into the cambium, producing another hibernacula. Looking for the presence of hibernaculae can be a good way to monitoring twig borer activity.

In-season larval monitoring is accomplished by counting shoot strikes. Shoot strike counts are a very straightforward means of determining the size, distribution, and developmental stage of a local twig borer population. When the larva bores down into a new shoot, the leaves and petioles above the shoot wilt, droop downward, and become discolored. Peeling open a strike will often reveal either the live larva or signs of recent feeding. Older, abandoned shoot strikes usually turn dark brown or black, but the older strikes are generally not good indicators of current pest pressure.

Methods

Eight sites (seven peach blocks and one nectarine block) were monitored for PTB in 2003. All sites were commercial operations located in northern Utah. Biofixes were set and weather was tracked so that degree-day accumulations could be used for spray timings. Shoot strikes were counted at all sites on June 15th, again on July 15th, and finally on August 5th. Mean shoot strikes/tree were generated by examining 32 trees per site on each of three sampling occasions. Only new strikes were counted. Harvest damage ratings were made at each site bearing fruit (between late August and early-September).

Results and Discussion

Overwintering PTB. The growing season of 2003 was preceded by a relatively mild Utah winter, which tends to allow a higher percentage of overwintering individuals to survive. In late-winter, examinations of peach trees in Boxelder and Utah county orchards did not reveal any hibernaculae. It had been a mild winter temperature-wise, but there seemed to be weekly cold fronts that dropped considerable rain amidst very windy conditions. After frequent, hard rains, it is understandable that few, if any, hibernaculae would be recognizable in the field. Hibernaculae are loosely held together by starches, undigested cellulose, water, and occasionally, saprophytic fungi. They can be washed away or reduced to an unrecognizable mass. Nevertheless, scouting for hibernaculae in heavily infested orchards can be a good means of assessing the degree of infestation early in spring.

Trapping. Overall trapping patterns were typical of twig borer, notably the bimodal peak in the first flight (Figure 1). The cool and wet spring likely delayed moth-catch at most sites and may have also extended the period during which moths would be flying.

One particular location in Boxelder County produced extraordinarily high numbers of moths. These counts were not excluded from the overall flight pattern, however, because they did follow trends similar to the rest of northern Utah.

The total number of PTB caught in 16 traps in northern Utah was 4,863 (Table 1). Mean moth-catch per site in Boxelder County was 1,976, while Utah County's average was 131 moths/site. All of the trapping done in Boxelder County was along the "Fruitway." It appears there is exceedingly high moth pressure along this bench and that suppression efforts may need to employ mating disruption, better spray timings, and more uniform spray coverage. It should be noted that the high moth counts registered in Boxelder County were largely due to an orchard that was beset by personal tragedy, which lead to orchard neglect.

Trapping by Dr. James Pitts in the "Fruitway" area has revealed that PTB moths were still being caught in late-October. This provides further evidence that overwintering larvae represent multiple (overlapping) generations. Overlapping generations and wide disparities in larval maturity explain the prolonged, bimodal spring peaks.

Figure 1. Mean PTB moth-catch per night over the course of the 2003 growing season in northern Utah.

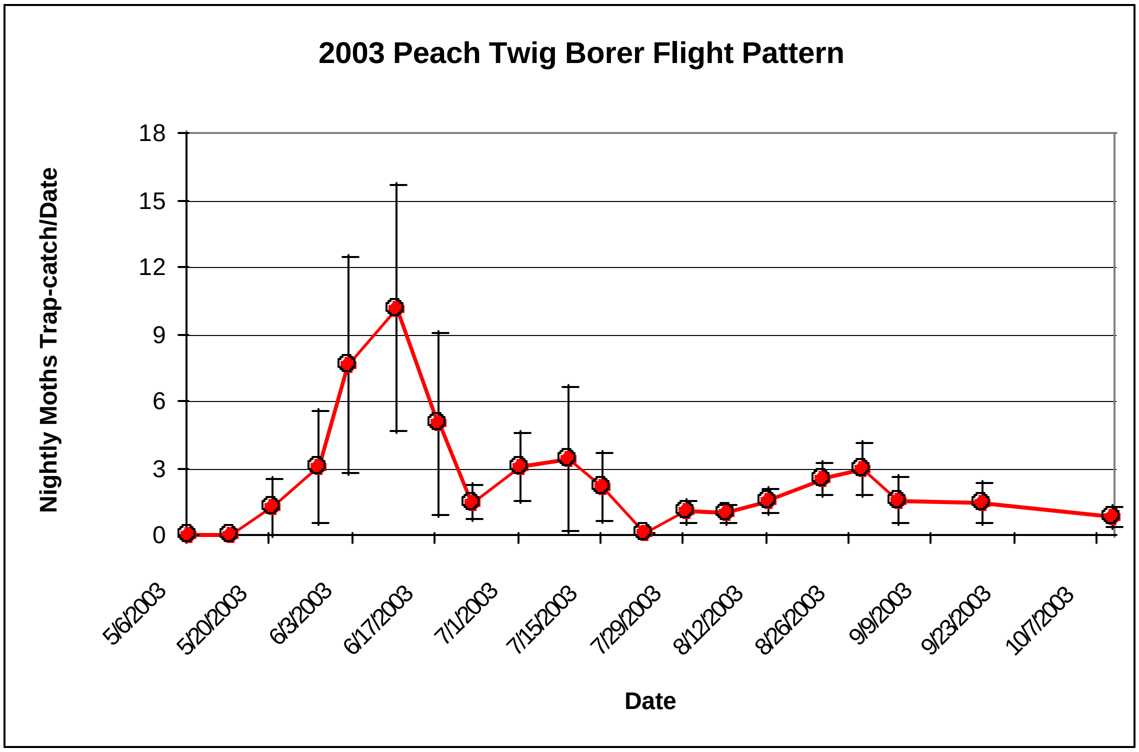


Table 1. Total moths caught at each location, as well as per-trap values and average across all sites.

Site	Total PTB	Per-trap
Perry	3388	1694
Willard	564	282
Kaysville	256	128
Payson	19	9.5
Santaquin	60	30
N. Santaquin	91	91
Genola	83	41.5
Lincoln Pt.	402	201
Overall:	**4863**	
Average:	**608**	**413**

Shoot Strike Counts. Relatively few shoot strikes were found at most of the monitored orchards, with the exception of the Perry area (Table 2). Lincoln Point and Kaysville had fairly high moth trap-counts (Table 1), and this was reflected to a small degree in their respective shoot strike counts. The average number of strikes per tree at Lincoln Point and Kaysville were well below mid-season thresholds of 1-2 strikes per tree. Later in the season, as fruit ripen and shoots set terminal buds, moth pressure becomes more significant and thresholds are lower.

A correlation between mid-season shoot strikes and harvest damage was done to determine if there was any relationship between mid-season twig borer populations and harvest damage. The "*r-squared* value" of the correlation was very high (0.999), indicating that there was a very strong relationship between the two variables. However, only seven data points were available (only seven sites were monitored in 2003), and most points were clustered near zero. Nevertheless, the relationship appears to be tight, and it makes biological sense that the mid-season population would directly affect harvest damage because the progeny of the mid-season moths target fruit. Repeating this work in 2004 will provide more data points and thus greater resolution of the nature of the relationship. Eventually, a mid-season assessment of shoot strikes in Utah orchards may be a good predictor of likely harvest damage.

Table 2. Mean shoot strikes per tree at each site and the corresponding harvest damage (non-bearing orchards excluded).

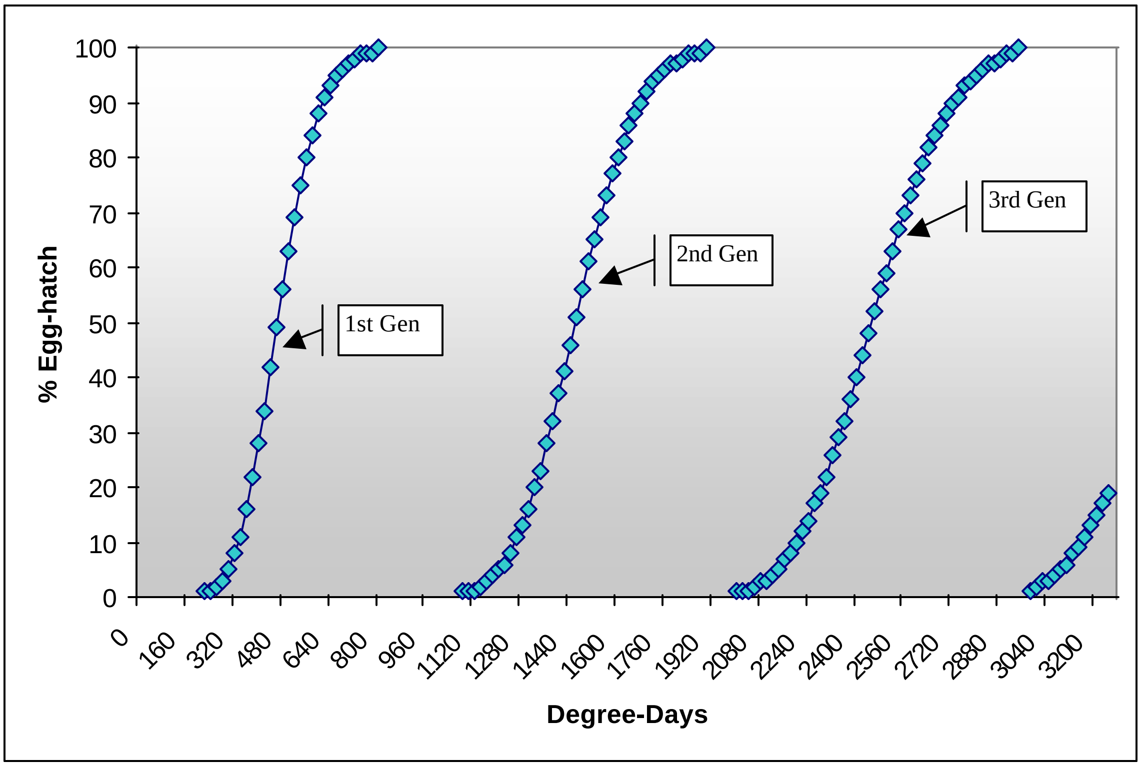
Orchard Site	**Mean Strikes/Tree**	**Harvest Damage (%)**
Payson Peaches	0.00	0.00
Lincoln Pt. Nectarines	0.06	0.50
Perry Peaches	2.30	26.80
Willard Peaches	0.01	0.00
Kaysville Peaches	0.04	0.12
Santaquin Peaches	0.00	0.00
Genola Peaches	0.00	0.00

Important Elements of PTB Biology. Peach twig borers generally live (egg-to-egg) for 1,090 degree-days (DDs), and of that total, approximately 464 DDs are spent as larvae. Each twig borer, therefore, spends about half of its life as a larva. Control tactics can be aimed at adults, eggs, and pupae, but the developmental period in which there must be some degree of fruit protection is the larval period.

The "larval period" can also be referred to as the "egg-hatch period" of each generation. Past research has shown that egg-hatch proceeds in a predictable way (Figure 2.). It is noteworthy that the slope of each curve is steepest between 10% and 90% egg-hatch. This suggests that a greater percentage of the eggs are hatching in each time increment during the 10-90% period. This "peak" in egg-hatch tends to occur between 320 and 620

DDs for the 1st generation. Targeting larvae between 320 and 620 DD will likely provide the greatest degree of suppression. The same approach can be applied to each of the subsequent generations if scouting indicates treatments are necessary. The second generation egg-hatch occurs typically between 1,080 and 1,900 DDs, with a peak occurring between 1,280 and 1,680 DDs.

Figure 2. The percent egg-hatch relative to degree-day accumulation.



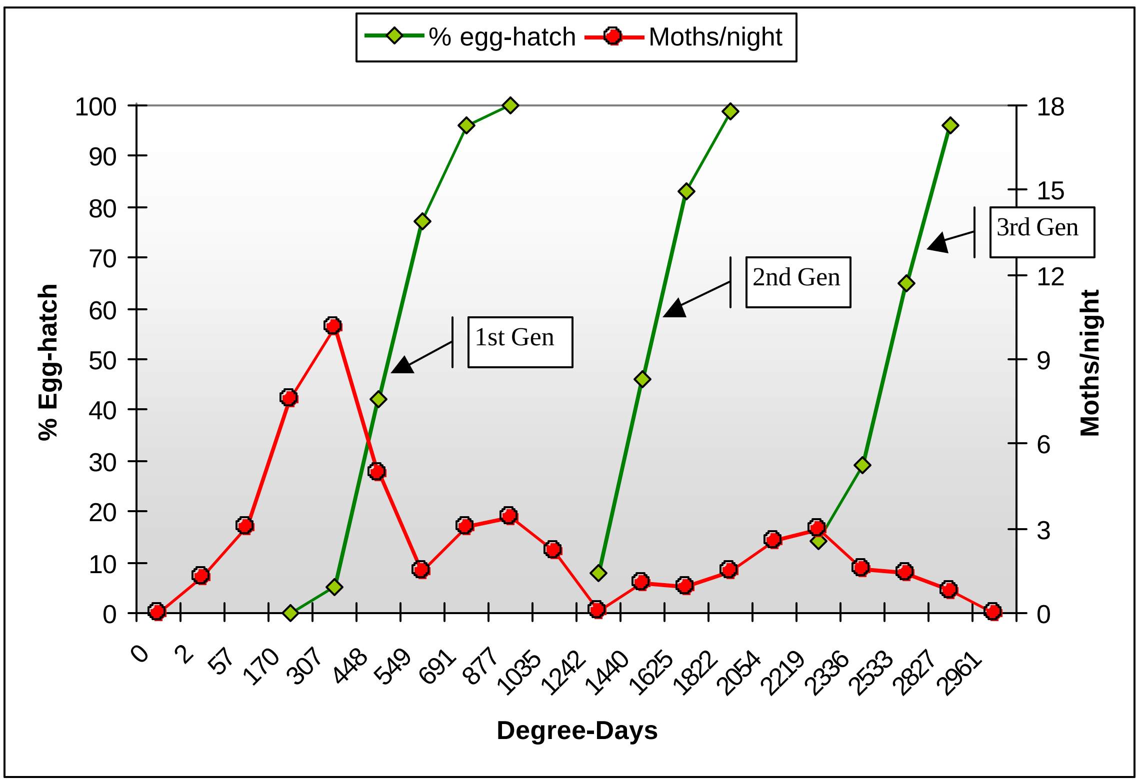
Treatment Timing and Management Approach. Using the developmental model and average DD accumulations, the likely % egg-hatch can be predicted (Fig. 3a). As described earlier, the bulk of the 1st generation egg-hatch occurs between 320 and 620 DDs (counting from biofix). All in-season insecticide treatments, therefore, should be timed to provide active residues during this period. Any larvae that are not killed before entering a shoot will continue to develop well beyond the egg-hatch period. These larvae can still be targeted because they require 3-5 shoots to complete their development, and they must leave one shoot to find another.

An examination of the treatment timings employed by northern Utah growers shows the effect of well-timed sprays. Sites with low fruit damage (Table 2) despite relatively high moth catches (Table 1) were orchards in Lincoln Point and Willard. Each of these sites applied the first treatment early in the 1st generation egg-hatch (226 DDs in Lincoln Pt., 360 DDs in Willard) and then again mid-way through the egg-hatch (514 in Lincoln Pt.; 569 DDs in Willard). Second generation sprays were again well-timed (1,100 and 1,750 in Lincoln Pt.; 1,313 in Willard). Subsequent shoot-strike counts were close to zero.

Other sites, such as the Genola, Santaquin, and Payson orchards, had excellent treatment timings as well, but the moth populations were so low to begin with that the results were not as dramatic. None of the fruit harvested at the sites monitored in Genola, Santaquin, or Payson had any PTB damage. Good harvest numbers that are attributable to good treatment timings suggest the PTB model is accurate and reliable enough to be useful in Utah growing regions.

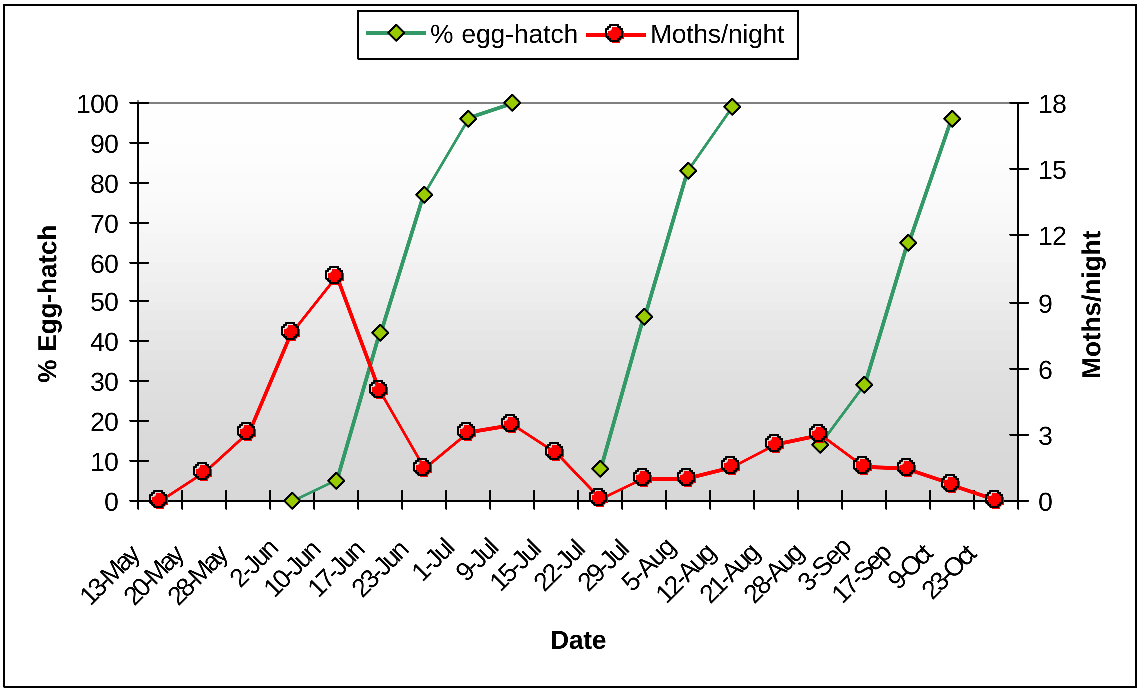
For the model to work, an accurate biofix is paramount. In 2003, the average 1st biofix was 367 DD (+/- 53 DDs), counting from March 1st. This "average biofix" is the average number of DDs accumulated at each site when the site got its first biofix. The significance of this number is that it provides information as to when the first moths are likely to be flying in spring. It is crucial to get an accurate first biofix, and in order to do so, traps need to be out several weeks before the biofix is expected. If the first moths are expected between 350-400 DDs (counting from March 1st), then traps likely need to be set up by 300 DDs.

Figure 3a. Moth flight and predicted egg-hatch in 2003 (relative to degree-days).



The overall flight dynamics of 2003 form the basis of an analysis of the PTB populations in northern Utah (Figure 3a). Figure 3a presents the egg-hatch periods of each generation set against the backdrop of the moth flights (averaged across all monitored sites). The values along the x-axis show how development proceeds relative to degree-days rather than calendar date. The first flight of the adult moths provides the starting point for the PTB development model, and using the mean DD accumulation at each sample date, the season-long progression of PTB development can be generated. There were three complete generations, and possibly part of a fourth. This was not surprising given that it was the warmest June-July period on record.

Figure 3b. Degree-days converted to calendar dates.



When calendar-dates replace DDs in the x-axis, the critical egg-hatch periods are evident as windows in time (Figure 3b). For the 1st generation, the window was early June through mid-July. Mid-July was somewhat beyond the first egg-hatch period, but there will still be larvae crawling from shoot to shoot after egg-hatch has ended. The 2nd generation's egg-hatch period was much shorter because temperatures were substantially warmer (late-July through mid-August). If substantial control has been achieved in the 1st generation, then moth pressure should be much reduced by the 2nd generation.

Counting shoot strikes in mid-June and mid-July of 2003 provided an early and late snapshot of the 1st generation's degree of "escape" from sprays. Counting strikes in early August provided information on the 2nd generation. It is the 2nd generation that targets fruit to a greater degree. The latter part of the 1st generation will also feed on fruit, but the large number of actively growing shoots in the early-season provides a profusion of more desirable feeding sites.

Since larvae require about 464 DDs to finish feeding and initiate pupation, the amount of time spent in each shoot can be approximated by dividing 464 DDs by the number of shoots consumed. As mentioned earlier, a larva generally requires three-to-five shoots reach pupation, which means that each larva spends about 90 to 150 DDs in a shoot. In mid-summer, 90 to 150 DDs translates into 4-7 days (assuming 20-25 DDs per day). It is likely that each larva will spend about four days to a week in a shoot before chewing its way out and finding another shoot. They are vulnerable to weather, predators, and sprays during this period, which is the main reason why it is critical to be aware of when larvae are actively feeding so that control measures can be optimized.

Management for 2004.

In 2003, PTB problems were not widespread, and most growers did not experience much harvest damage. Given the higher moth pressure in the past, there are three potential improvements that can be made for the 2004 growing season. First, mating disruption should be deployed. It is an effective, proven tool for PTB control, and it works primarily by delaying mating. Delaying mating by just 4-6 days results in a large decrease in egg-laying. This is an economical and wise IPM option. Orchard size, shape, and neighboring orchards will determine how the pheromone dispensers should be applied.

The second refinement that might be made to Utah peach production is the use of an effective non-OP insecticide at delayed-dormant. A treatment applied at delayed-dormant is a good opportunity to kill larvae just as they begin to emerge from hibernaculae. A very effective and inexpensive material commonly used in California is esfenvalerate (trade name: Asana). This material is also very resistant to photo-degradation and hydrolysis, and it is almost insoluble in water, which makes it a good match to stick to tree scaffolds and not get washed off during winter storms. It is unlikely to flair mites because it is applied long before they become active in the canopy.

The third element of a good IPM approach is the use of Bt sprays (DiPel, Javelin, Thuricide, Crymax) at bloom. This has been used with success for many years in California stone fruit orchards. Bt is inexpensive, harmless to bees, and is very specific to caterpillars. Two or three applications between full-bloom and petal-fall should suppress the twig borer population substantially.