Navel Orangeworm Monitoring: An Intractable Problem?

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By the early 1970s it became very evident that navel orangeworm (NOW) had become a primary pest on almond. In 1973, about 25 years after it was first described on almond, the moth pest caused an estimated 12-million-dollar loss to the crop produced on approximately 213 thousand acres. By the mid-1970s, Rice (1975) published his work on comparison of different NOW monitoring techniques. Not only did his work establish the foundation on which much of our current understanding of NOW flight patterns in almond are based, but gave us the egg trap. I can imagine that Dr. Rice thought - if NOW lays eggs on mummy nuts, why not devise a trap that mimics mummies. As an entomology researcher that has worked on developing monitoring tools, I admire Dr. Rice’s insight.

Egg traps have played and continue to play an important role in monitoring NOW in almond as well as pistachio. The University of California, Statewide IPM Program, Pest Management Guidelines instruct in the use of egg traps. And moreover, provide treatment timing recommendations based on a NOW developmental model (Fig. 1). The principal value of egg traps as a monitoring tool stands out in that they can detect the initiation of egg deposition, in other words, a biofix (Fig. 1), which occurs from mid-March to about mid-April. However, subsequent egg capture typically decreases considerably during the second NOW flight (late June–August) and sometimes third flight (August–September) and therefore their utility as a season-long monitoring tool is limited. Moreover, egg traps may not detect egg-laying activity in low-population orchards.

In 2010 Kuenen of the USDA, ARS and two University of California, Riverside researchers, McElfresh and Millar, published their findings of a navel orangeworm four-component sex pheromone blend. It took a couple of years but USDA ARS researchers Higbee and Burks developed a stable delivery system and the NOW monitoring lure became commercially available in 2012. An advantage of pheromone-baited traps lies in that the tool has a much greater resolution than egg traps and reliably detects peaks in second and third flight activity; and moreover, can detect flight activity in orchards with a very low population.

This advantage makes pheromone traps attractive as an NOW monitoring tool, and it’s safe to say that the great majority of PCAs working in almond, as well as pistachio employ the relatively new tool. The use of pheromone lures, however, have not completely foregone the use of egg traps.

This could be due to PCAs with years of experience using egg traps feeling more confident making management decisions based on egg capture data. Moreover, a primary limitation of pheromone traps is that they cannot reliably establish an NOW biofix. Unlike other lepidopterous pests such as codling moth and Oriental fruit moth, NOW does not have a synchronized spring emergence following a winter diapause period. Male NOW moths can emerge and fly as early as January given warm enough temperatures and therefore establishing a biofix is not possible.

The UC Pest Management Guidelines recommends deploying one NOW egg trap per 10 acres or at least four traps per orchard and one pheromone-baited wing or delta trap per 50 acres or at least two per orchard. Although a few additional traps may be required, egg and pheromone traps can be deployed in sets consisting of a single pheromone trap and two egg traps deployed in the same

![Figure 1. Mean male and egg capture at an orchard in the San Joaquin Valley (Merced County). Bottom figure shows the accumulated degree days from egg biofix indicating the date at which the second (1056) and third (2112) flight periods are predicted respectively.](image)
Another level of complexity in NOW monitoring has developed with the arrival and rapidly expanding use of mating disruption. When working properly, mating disruption shuts down pheromone traps; the absence of males provides a strong indicator that males likely cannot effectively locate females as well. That raises the question, “if pheromone traps are not capturing male moths, how can management decisions be made?” Of course, egg traps function well and provide the needed information to make insecticide application decisions if a treatment becomes necessary. Although not yet available, monitoring lures for use in orchards under mating disruption should become commercially available by 2018.

Additional monitoring options do exist for orchards under mating disruption but require a little more time to implement. About a decade ago, the USDA funded an NOW Areawide Control Project that included Federal, UC, and private researchers conducting multiple projects. At the Santa Fe Areawide site (Wonderful Orchards), led by Higbee, a monitoring program that allows a spray decision (spray or no spray) with a high degree of confidence for orchards under mating disruption was developed. It involves monitoring of at least six sites (four around the orchard edges and two-four in the orchard interior). Each set has an egg trap, a pheromone trap, an oviposition attractant as a lure in a sticky trap and an area in which samples are taken to determine preharvest infestation levels. That level of intensive monitoring provides the needed information for making highly confident no-treat decisions.

Stern, one of the founding fathers of IPM defined economic threshold (ET) as “the amount of injury which will justify the cost of artificial control measures.” Commonly, researchers get asked, what number of male NOW moths and/or eggs per week constitutes an ET in almond and pistachio? Developing such a predictive model requires a keen understanding of host-plant and pest physiology and depends on estimating and predicting several difficult parameters. The ET, or sometimes termed an action threshold, exists for very few crops. The majority of ET values are subjective, in other words, based on a practitioner’s experiences. University of California researchers are working to develop an ET model for almond and pistachio, however the complexity of developing such a model, large acreages, and number of host crops presents considerable challenges.

So yes, effectively monitoring navel orangeworm for making sound management decisions is challenging. Symmes in the June 2017 issue of the CAPCA Adviser discusses some of the recent developments for monitoring NOW in almond and pistachio as well as codling moth in walnut. However, until these new tools become commercially available for monitoring orchards both under mating disruption and not, PCAs and growers will have to rely on the host of available monitoring tools.