EUROPEAN EARWIGS IN CITRUS

Developing IPM Tools

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Small wooden boards placed under citrus trees can be used to easily estimate earwig densities in citrus orchards.

Project Summary

Recent research has shown that European earwigs damage tiny developing citrus fruit, creating scarring damage that is hard to distinguish from scarring generated by worms or katydids. We worked to develop the basic tools needed for an integrated pest management (IPM) program for this pest.

First, we developed a farmer-friendly sampling method. We found that small wooden boards, placed on the ground under the skirt of the trees, created a preferred refuge for earwigs and could be checked easily to estimate earwig densities in commercial citrus. To obtain useful density estimates, it is critical to distinguish between European earwigs (which are damaging) and ring-legged earwigs (which are non-pests, as they do not climb into trees).

Second, to better understand the optimal timing for earwig control measures, we studied when during the year earwigs move from their underground nests up into the citrus tree canopies to begin attacking fruit. We found that this movement starts early, well before petal fall. Thus, when control is needed, it should be applied at least a month before petal fall.

Third, we conducted a survey of 93 commercial citrus blocks to understand how widespread European earwig populations are. We found that this pest is distributed very patchily – most blocks had low to zero earwigs, while only a small minority had high densities.

Finally, we were unable to define the relationship between estimated European earwig densities and the amount of scarring observed on maturing or harvested fruit. This key piece of information requires additional research.

Introduction

It long has been understood that European earwigs can build up high densities in citrus groves, especially in newly planted blocks, where earwigs often aggregate under tree wraps, emerging at night to consume foliage. More recently, however, it has become clear that European earwigs also are potentially damaging in mature citrus blocks. Recent experiments have shown that European earwigs use their chewing mouthparts to attack tiny developing fruit, creating damage that becomes deep, scabby scars at harvest (Kahl et al. 2021). Earwig scars are hard, if not impossible, to distinguish from the scars generated by other insects that have chewing mouthparts – including worms and katydids. Orange and clementine varieties appear to be vulnerable to earwig feeding damage when fruit are very tiny – within the first three weeks after petal fall. True mandarin varieties appear to have very high levels of natural resistance to European earwigs. The goal of our project was to begin developing the basic tools needed for integrated pest management of European earwigs in oranges and clementines.

Sampling European Earwigs

European earwigs are not easy to sample. They spend the late fall, winter and early spring in shallow underground nests, where females lay clutches of eggs, which they guard before and after hatch. Earwigs also produce chemicals that attract other unrelated earwigs, so unrelated individuals often can be found in large aggregations. Sampling methods used by researchers (for example, rolls of cardboard attached to tree branches) are likely too time consuming for use by field scouts in citrus.

Figure 1. Adult European earwig female.
Photo credit: J. Berger.

Figure 2. Adult ring-legged earwig.
Photo credit: N. Vesović.

We found that small, wooden boards (ten-inch square) placed on the ground under the edge of the tree skirt creates a preferred refuge for European earwigs. Earwigs will excavate their nests directly below these boards. Boards can be checked rapidly to count adults, clutches of eggs and aggregations of tiny European earwig nymphs; replacing the boards carefully allows observers to follow the development of the single annual generation of the European earwig. One complication is that scouts need to distinguish between European earwigs (**Figure 1**), which are pests, and ring-legged earwigs (**Figure 2**), which never climb into trees and thus are not pests. European earwigs have large hindwings that they store folded up and hidden underneath small, tan forewings, which are easy to see. Ring-legged earwigs are completely wingless. Ring-legged earwigs also are darker, thinner and shinier than European earwigs. As their name implies, they have bands on their legs and a white segment near the ends of their antennae that can be seen with a hand lens. In some citrus blocks, ring-legged earwigs are more abundant than European earwigs. Another possible complication (which we did not experience but which we suggest could be an issue in some blocks) is that rattlesnakes might use the boards as a refuge, as well; this is one of the reasons why we used very small (ten-inch square) boards instead of larger boards that snakes may prefer. We suggest using 10-20 boards distributed evenly across a citrus block where damaging European earwig populations are suspected to be present.

Survey of Commercial Citrus for European Earwigs

To determine how common it is for commercial citrus blocks to harbor potentially damaging populations of European earwigs, we conducted a survey from April 2022 – November 2023 of 93 commercial citrus blocks grown in Fresno and Tulare counties. We found that European earwigs are distributed very sporadically across blocks: most blocks have extremely low-density populations (less than 0.2 adult earwigs per board) or no European earwigs detected at all (**Figure 3**). It was only a handful of blocks that had moderate to high densities (greater than 0.5 adult earwigs per board, on average).

The four successive surveys also suggested that European earwig populations can fluctuate strongly across seasons and years. Overall, informal observations may suffice to determine that European earwigs are absent or at very low densities in most citrus blocks; additional formal sampling will be more useful in blocks with suspected or known higher density populations.

When Do European Earwigs Move into Citrus Canopies?

Earwig adults and nymphs eventually leave their underground nests and climb up into citrus trees, where they can damage tiny developing fruit. In citrus blocks that harbor potentially damaging European earwig populations, this movement can be blocked either by placing a sticky barrier on the tree trunks or by applying an insecticide to the tree trunks and the surrounding soil surface. We wanted to know when in the spring the movement from the ground up into the trees occurred so that farmers could choose an appropriate time for control measures. We pruned the skirts of all trees in a citrus block growing at the University of California Lindcove Research and Extension Center. This eliminated all walking paths into the tree canopy except for the central trunk (adult European earwigs can fly, but they do so only very rarely). We used video cameras with nighttime infrared illumination to conduct periods of surveillance of citrus tree trunks, with three days of observations conducted every two weeks from March 22 –June 18, 2021.

European earwigs are nocturnal, active only between sundown and sunrise. We found that European earwigs already were moving up and down tree trunks on our first monitoring day (March 22, which is the same as Julian Date 81; **Figure 4**). Petal fall in this district was not declared until April 30, so this movement was occurring more than

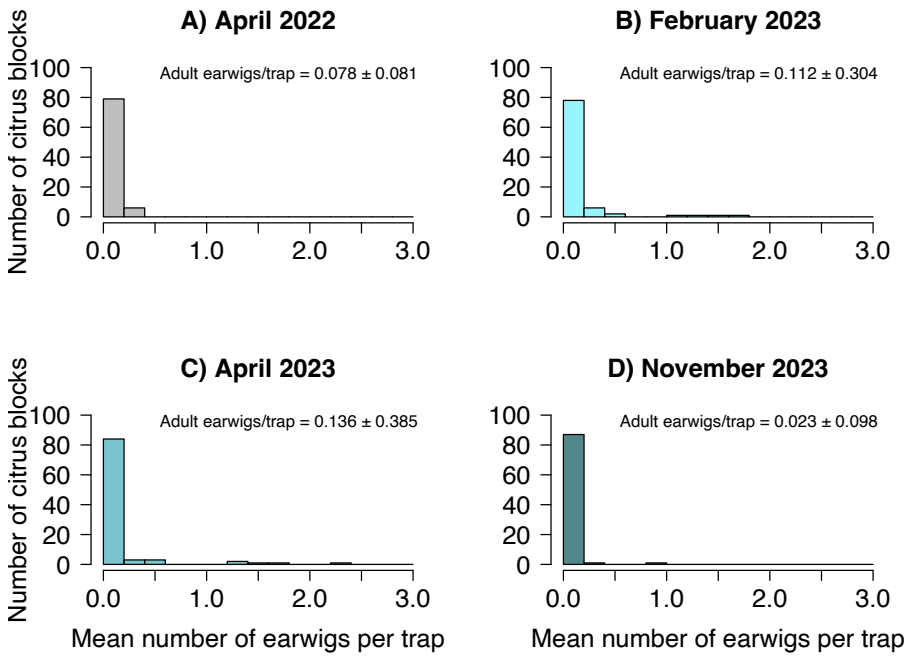

Figure 3. Survey of 93 commercial citrus blocks for densities of European earwigs using small wooden boards (18 boards used per block) as a sampling method. Shown are the mean number of adult earwigs per board.

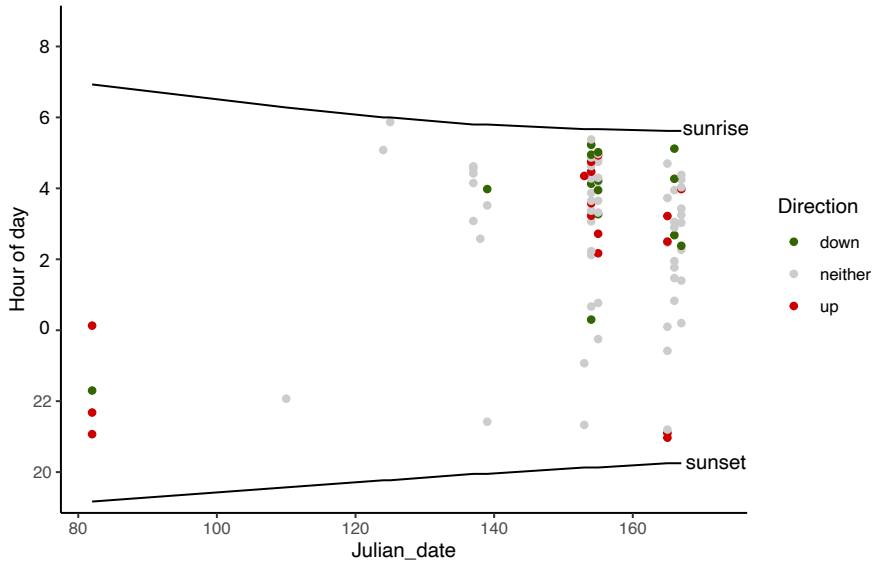

Figure 4. Daily and seasonal movement of European earwigs travelling up, down or horizontally ('neither') on citrus tree trunks. Hour of day 0 corresponds to midnight. Curving lines show the seasonal change in the times of sunset and sunrise. Videography was performed over 24-hour periods for the first four sampling periods (Julian dates 81 – 127 [March 22 –May 7]) and over 12-hour periods starting at sunset for the last three sampling periods (Julian dates 137 – 168 [May 17 –June 17]). No insect activity was seen between 10:00 – 18:00 hours, so those times are not plotted.

five weeks before petal fall. A big increase in the numbers of European earwigs traveling up and down the tree trunks was observed much later in the spring, between June 2-18 (Julian Dates 153-167); but by then, we expect the fruit to have developed beyond their early susceptibility to European earwig damage.

Earwig Density/Damage Relationship

To calculate a critical density of European earwigs at which we expect to see economically important crop damage, we sought to characterize the relationship between European earwig densities and scarring damage on maturing or mature fruit. The usual expectation is that such relationships should be simple and positive: the more pests present, the more we expect to see crop damage. However, for omnivorous arthropods like the European earwig (which eats plant matter but also can act as a predator, consuming a variety of other insects), the relationship between density and damage may be more complicated. Indeed, there have been several published studies that have sought to characterize the density/damage relationship but have failed (Orpet et al. 2019; Quarrell et al. 2021). Thus, we were not altogether surprised when we found a complete absence of any correlation between estimated European earwig densities and fruit scarring on maturing or harvested fruit (**Figure 5**). There could be numerous explanations for this; additional research is needed to determine the critical density threshold for European earwigs beyond which monetary losses become important.

Conclusions

European earwigs have long flown under the radar as damaging pests in mature citrus groves, where they can feed on tiny developing fruit of orange and clementine varieties, generating scarring that causes downgrading at the packinghouse (true mandarins appear to have high levels of natural resistance). In some cases, earwig damage probably has been misdiagnosed as damage caused by worms or, especially, katydids. Because European earwigs are strictly nocturnal, they have remained little studied. Here we introduce a farmer-friendly sampling method based on small wooden boards placed on the ground under the edge of

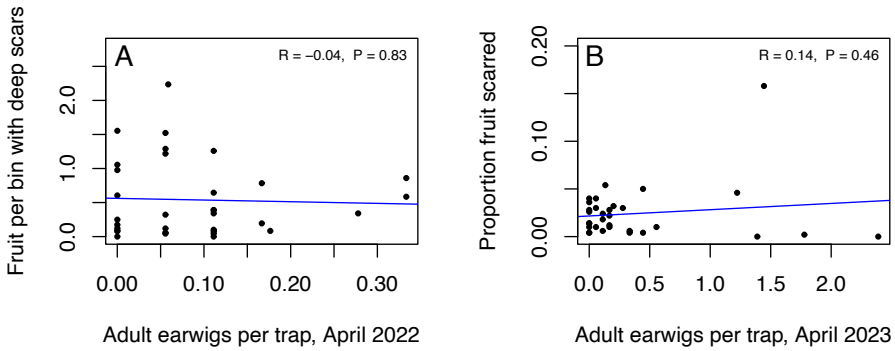

Figure 5. Relationship between the mean number of adult European earwigs per board trap during April sampling and (A) the mean number of fruit bearing deep, scabby scars at harvest per bin (bin samples; 200-300 fruit checked/bin) in 2022; or (B) the mean proportion of fruit bearing deep, scabby scars during September 2023 sampling (fruit still maturing on trees).

the tree skirt. Most of the commercial citrus blocks that we surveyed had few or no European earwigs present; but in some blocks, European earwigs were common. European earwigs moved from their underground nests into citrus tree canopies starting early in the spring, well before petal fall. Additional research is needed to determine at what density European earwigs begin to generate economically significant damage.

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References

Kahl, H.M.; Mueller, T.G.; Cass, B.N.; et al. 2021. Characterizing herbivory by European earwigs (Dermaptera: Forficulidae) on navel orange fruit with comparison to forktailed bush katydid (Orthoptera: Tettigoniidae). *Journal of Economic Entomology* 114(4):1722-1732.

Orpet, R.J.; Crowder, D.W.; Jones,V.P. 2019. Biology and management of European earwig in orchards and vineyards. *Journal of Integrated Pest Management* 10(1):21. *https://doi.org/10.1093/jipm/pmz019*

Quarrell, S.R.; Corkrey, R.; Allen, G.R. 2021. Cherry damage and the spatial distribution of European earwigs, (*Forficula auricularia* L.) in sweet cherry trees. *Pest Management Science* 77(1): 159-167.

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