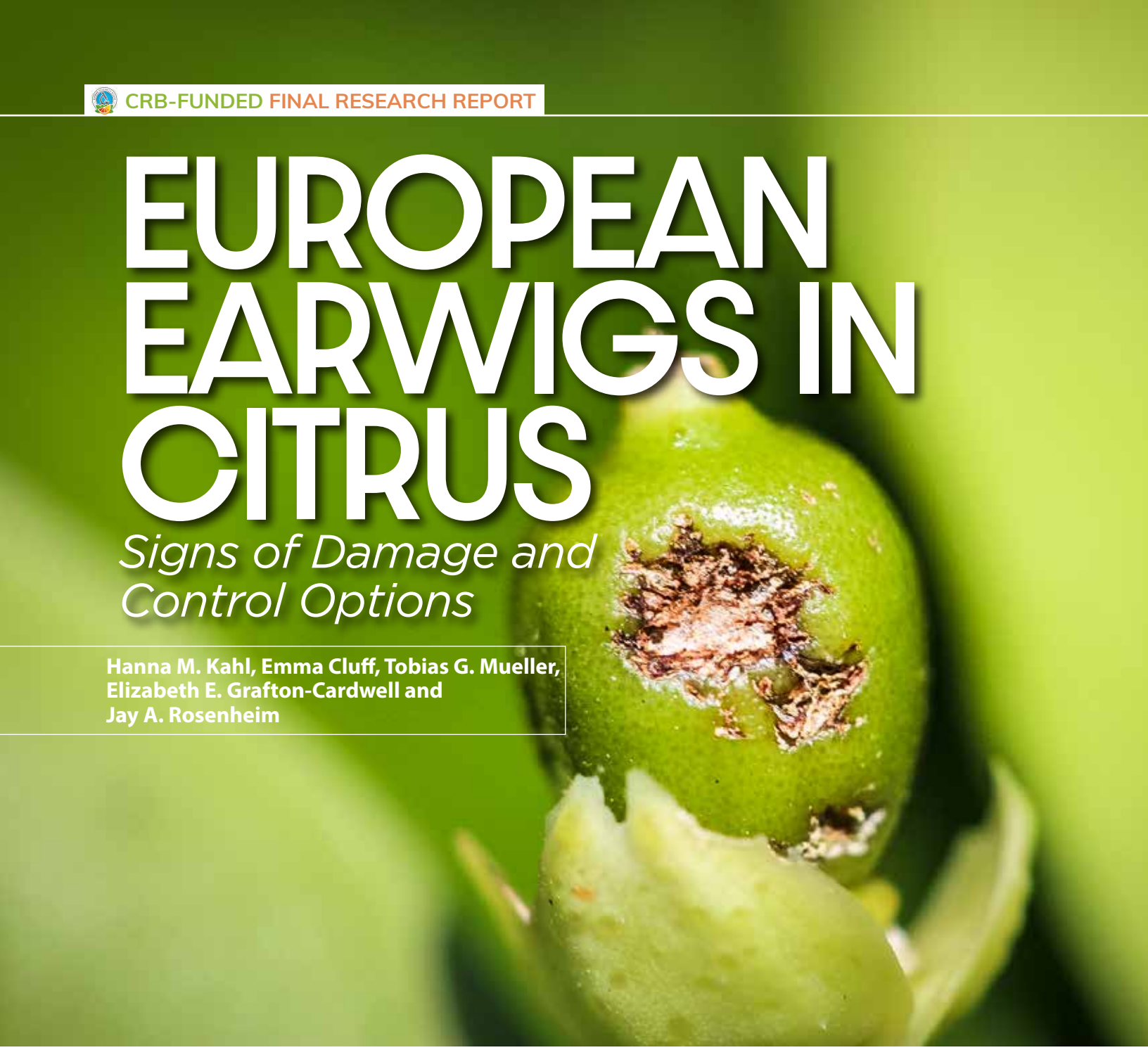
EUROPEAN EARWIGS IN CITRUS

Signs of Damage and Control Options



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Project Summary

Although it has been suggested that earwigs are capable of damaging citrus fruit, very little research has been conducted to characterize this damage. In this project, our experiments investigated the nature of earwig damage to the fruit of sweet oranges, clementines and 'true mandarins.' We also tested the efficacy of bifenthrin treatments to tree trunks and barriers of sticky materials for reducing the numbers of earwigs, Fuller rose beetles and ants in citrus tree canopies. We found that earwigs chew holes into young orange and clementine fruit, which develop into large scars as the fruit matures. True mandarins, in contrast, are largely naturally resistant to earwig attack. Earwigs are early season pests; they move into the canopy in early spring and stop feeding on fruit at around four weeks post-petal fall. Sticky barriers and bifenthrin trunk treatments successfully reduced movement of earwigs, Fuller rose beetles and ants into tree canopies. Sticky barriers reduced fruit scarring and the proportion of fruit infested with Fuller rose beetle eggs.

A young navel orange fruit damaged by a European earwig.

Introduction

The role of European earwigs in citrus has been enigmatic. Earwigs are nocturnal, so it is difficult to observe their behavior. Previous research conducted in Europe has identified earwigs as effective predators of aphids in citrus (Piñol et al. 2009), and earwigs have been reported to feed on California red scale (Romeu-Dalmau et al. 2012). However, growers and pest control advisors have observed that earwigs also consume citrus leaves, flowers and fruit (Kallsen 2006). If earwigs chew extensively on fruit, it is plausible that the resulting damage could lead to fruit scarring and downgrading of the fruit at the packinghouse, with significant loss of fruit value and, in turn, profit loss for citrus growers. Yet, little was known previously about earwig damage to citrus fruit, and there had been no comparisons made between earwig damage and that of more well-known chewing herbivores of citrus, such as fork-tailed bush katydids.

We also know very little about earwig movement. Earwigs dig nests in the ground during the winter, and older nymphs and adults are thought to move into the trees in the spring by crawling, as the winged adults are rarely observed to fly. However, the timing of earwig invasion of the citrus canopy has not been studied. We also explored whether citrus species vary in their susceptibility to earwig damage, as has been observed with other citrus herbivores (Cass et al. 2019; Mueller et al. 2019).

Through this research, we:

1. characterized earwig damage to citrus fruit,
2. assessed differences in earwig damage on various citrus species,
3. identified the period of time during which fruit are vulnerable to earwig damage and
4. identified whether treatments to citrus tree trunks can be used to manage earwigs, Fuller rose beetles and ants.

Earwig Damage to Citrus

We conducted field experiments caging European earwigs (2nd to 4th instar nymphs and adults) and fork-tailed bush katydid nymphs onto citrus branch terminals containing young developing fruit at the University of California Lindcove Research and Extension Center (LREC) in May 2019. First, we found that earwig nymphs and adults could chew deep holes into young sweet orange (*Citrus sinensis* cv. 'Washington') fruit or chew the surface of the fruit extensively (**Figure 1A**, **B**, **Figure 2**; Kahl et al. 2021). The damage caused by earwig feeding was variable in appearance and easily could be mistaken for damage caused by katydid feeding. We suspect that earwig damage commonly may be misdiagnosed as katydid damage (**Figure 1C**, **D**). Whereas earwigs readily chewed

Figure 1. Examples of initial damage on young sweet orange fruit by earwigs. (A) surface chewed by earwigs. (B) Deep holes and small cuts chewed by earwigs. The arrows point at examples of small cuts. (C) Surface chewed by katydids. (D) Deep hole chewed by katydids. Credit: Kahl H.M.; Mueller, T.G.; Cass, B.N.; et al., Characterizing herbivory by European earwigs (Dermaptera: Forficulidae) on navel orange fruit with comparison to forktailed bush katydid (Orthoptera: Tettigoniidae) herbivory, *Journal of Economic Entomology*, 2021, 114(4):1722-1732, by permission of Oxford University Press.

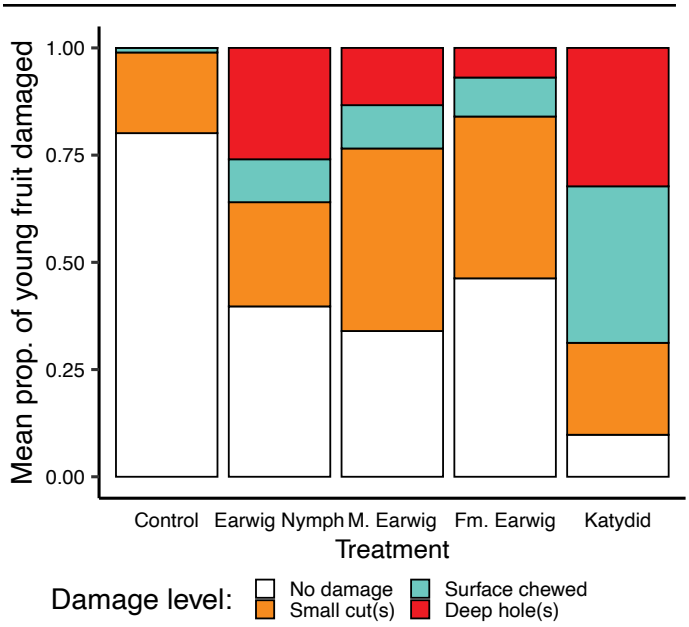


Figure 2. Mean proportion of fruit that had each damage level (no damage, small cut[s], surface chewed and deep hole[s]) across insect treatments (control, earwig nymph, male [M.] earwig adult, female [Fm.] earwig adult and katydid nymph). Credit: Kahl H.M.; Mueller, T.G.; Cass, B.N.; et al., Characterizing herbivory by European earwigs (Dermaptera: Forficulidae) on navel orange fruit with comparison to forktailed bush katydid (Orthoptera: Tettigoniidae) herbivory, *Journal of Economic Entomology*, 2021, 114(4):1722-1732, by permission of Oxford University Press.

on sweet orange fruit when fruit were small, earwigs stopped chewing holes into sweet orange fruit at around four weeks post-petal fall (Kahl et al. 2021).

Many young citrus fruit abscise naturally; but for fruit that did not abscise, earwig damage developed into large scars as the fruit matured. The scars caused by earwig feeding varied in size and shape, but they often were irregular-shaped with some jagged edges (**Figure 3A-E**). The scars on the mature fruit that resulted from early season earwig damage looked similar to scars on the fruit caused by katydids (**Figure 3F-G**; Kahl et al. 2021). Many of the fruit seriously damaged by earwigs would be downgraded at the packinghouse, losing most or all of their value.

We also discovered that earwig damage varied across citrus species. Earwigs caused serious damage in sweet oranges and clementines (*C. clementina* cv. 'de Nules' and 'Fina Sodea'), but true mandarins (*C. reticulata* cv. 'Tango') showed nearly complete resistance to extensive earwig feeding (**Figure 4**; Kahl et al. 2022). True mandarin fruit exposed to earwigs rarely received more than small cuts. It seems that earwigs may avoid feeding on true mandarin fruit after taking small "tastes." Previous research established that fork-tailed bush katydids also cause intensive damage to sweet orange and clementine fruit, but almost no discernable damage to true mandarin fruit (Cass et al. 2019).

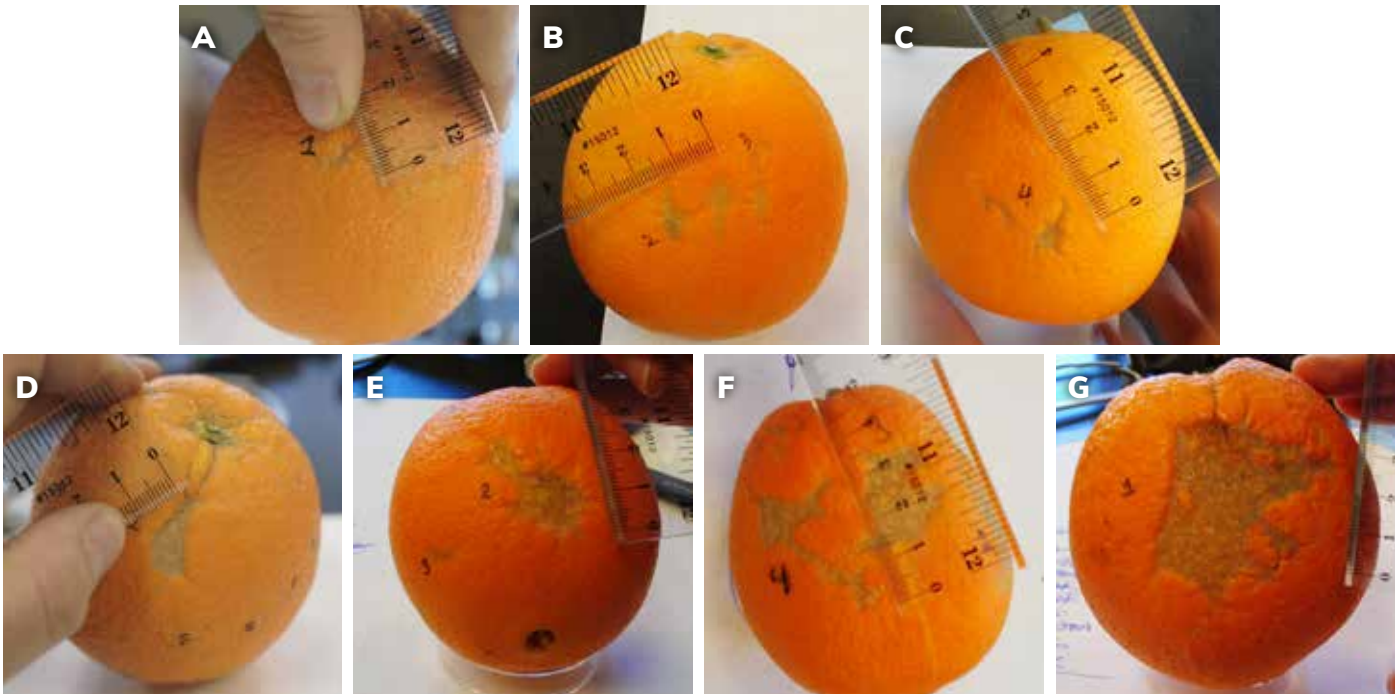


Figure 3. Examples of scars on sweet orange fruit at harvest that were caused by (A-E) earwigs and (F-G) fork-tailed bush katydids. Credit: Kahl H.M.; Mueller, T.G.; Cass, B.N.; et al., Characterizing herbivory by European earwigs (Dermaptera: Forficulidae) on navel orange fruit with comparison to forktailed bush katydid (Orthoptera: Tettigoniidae) herbivory, *Journal of Economic Entomology*, 2021, 114(4):1722-1732 by permission of Oxford University Press.

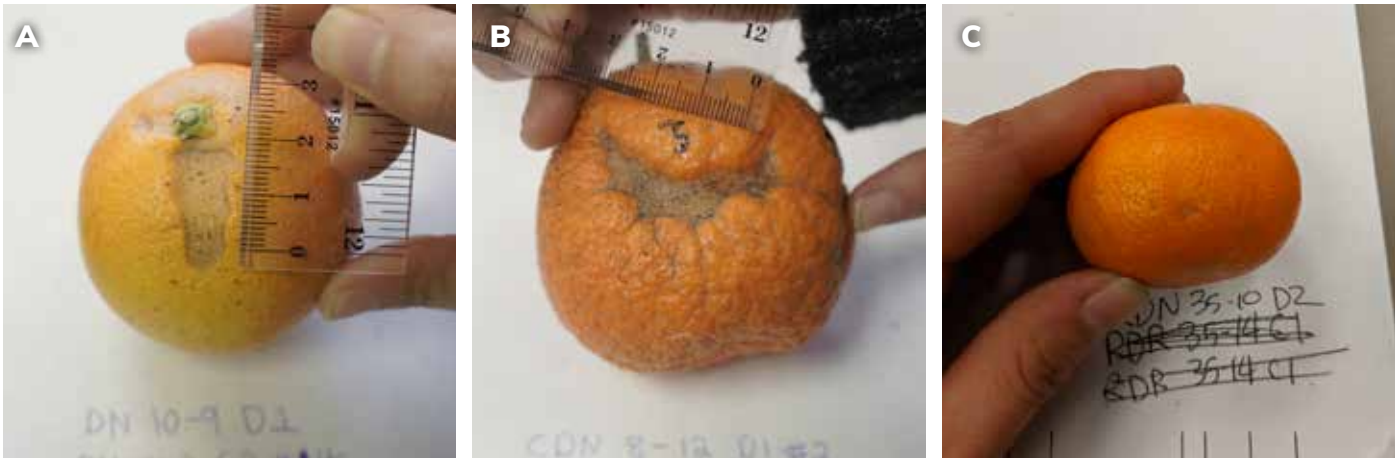


Figure 4. Examples of earwig damage at harvest on (A) sweet orange, (B) clementine and (C) true mandarins. Kahl H.M.; Mueller, T.G.; Cass, B.N.; et al., Herbivory by European earwigs (*Forficula auricularia*; Dermaptera: Forficulidae) on citrus species commonly cultivated in California. *Journal of Economic Entomology*, 2022, 115(3):852-862, by permission of Oxford University Press.

Influence of Trunk Barriers

We tested the efficacy of barriers placed on citrus tree trunks to block the movement of earwigs, Fuller rose beetles and ants into citrus canopies. At the LREC, we skirt-pruned 90 experimental sweet orange (cv. 'Washington') trees and weeded under the trees, making the trunk the only way to access the canopy on March 25, 2020. On March 31, 2020, we established three treatments:

1. trees were left without barriers (control),
2. a roughly 18-centimeter wide sticky barrier (Sticky Stuff Coating, Olson Products Inc., Medina, Ohio) was added to the trunk of each tree and
3. an insecticide (bifenthrin, Brigade®, FMC Corporation) was sprayed on the soil and the trunk of each tree.

Foliage beating was used to sample Fuller rose beetles and ants, and earwigs were sampled by placing cardboard roll traps in the tree canopies. We also used video cameras to monitor arthropods climbing tree trunks and the efficacy of sticky barriers.

We found that both chemical and sticky barriers reduced densities of earwigs (**Figure 5A**), Fuller rose beetles (**Figure 5B**) and ants (**Figure 5C**) in the tree canopies, particularly from April to June. If applied to an entire block rather than to individual trees as in our study, bifenthrin may show greater efficacy than

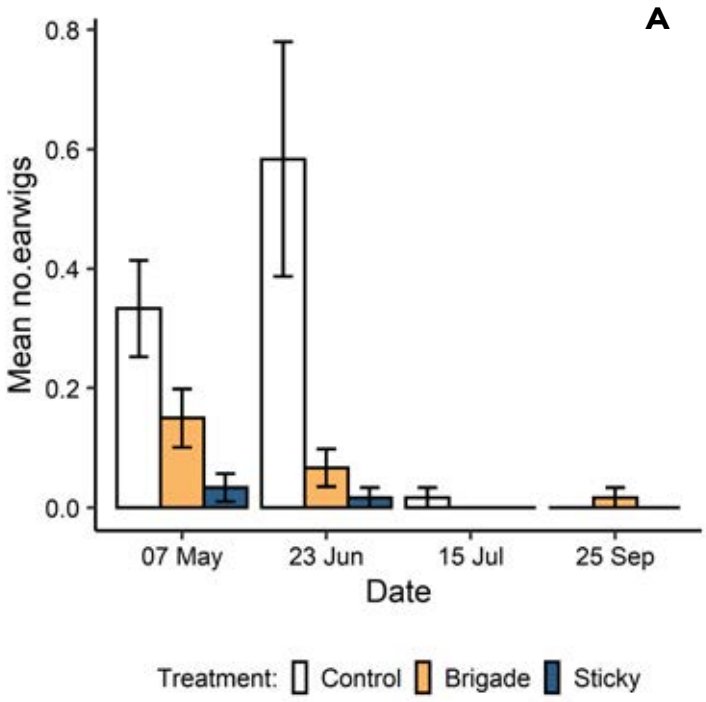
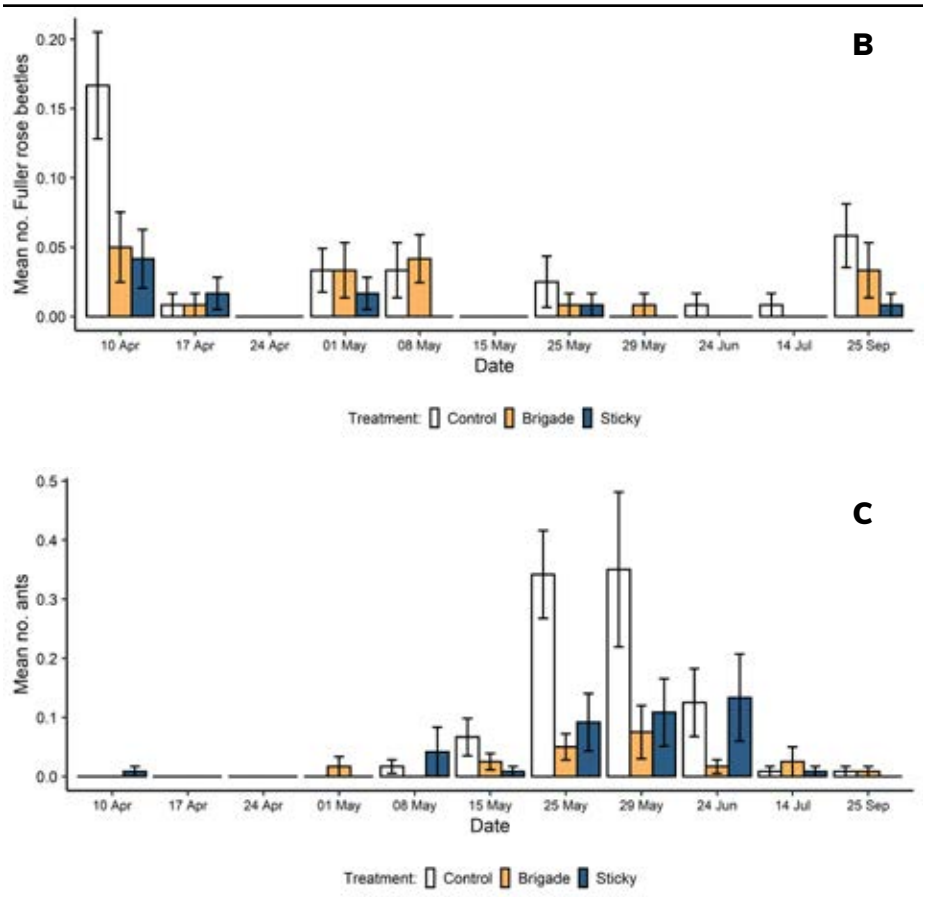


Figure 5. Mean numbers of (A) European earwigs (means ± standard error [SE]) from cardboard rolls across dates, (B) Fuller rose beetles from foliage beat samples (means ± SE), and (C) ants from foliage beat samples (means ± SE). Means were calculated by averaging first by tree and then by treatment per each date. Standard errors were calculated from mean counts by tree, date and treatment. Treatments were applied on March 31, 2020. Sampling timing and frequency differed with the different sampling methods (cardboard rolls used in graph A and foliage beat samples used in B and C). *See next page for figures B and C.*



it did in our study. Video monitoring confirmed that both earwigs and Fuller rose beetles were unable to cross sticky barriers. Sticky barriers reduced the incidence of scarred fruit at harvest and decreased the proportion of harvested fruit infested with Fuller rose beetle eggs.

Conclusions

This research highlights that earwigs can cause serious damage to sweet orange and clementine fruit, but that true mandarins (cv. 'Tango') are naturally resistant. Earwig damage easily can be mistaken for damage caused by katydids. This suggests that monitoring and management of earwigs, when needed, should be considered in citrus pest management planning. Future work will focus on developing sampling methods that easily can be adapted by pest control advisors and an economic density threshold for earwigs.

These results also suggest that chemical or sticky trunk barriers, particularly sticky barriers, show promise for reducing the densities of pests such as earwigs, Fuller rose beetles and ants that access the tree canopy by crawling. However, applying sticky barriers is very time-intensive and painstaking. Future work identifying better ways to better apply sticky barriers to tree trunks is needed.

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References

Cass B.N.; Hack, L.M.; Grafton-Cardwell, E.; et al. 2019. Impacts of fruit-feeding arthropod pests on oranges and mandarins in California. *Journal of Economic Entomology* 112(5):2268–2277.

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) herbivory. *Journal of Economic Entomology* 114(4):1722–1732.

Kahl H.M.; Mueller, T.G.; Cass, B.N.; et al. 2022. Herbivory by European earwigs (*Forficula auricularia*; Dermaptera: Forficulidae) on citrus species commonly cultivated in California. *Journal of Economic Entomology* 115(3):852–862.

Kallsen C. 2006 Earwigs flying under the radar of many citrus pest control advisors. *Western Farm* Press:1–3.

Mueller T.G.; Kahl, H.M.; Cass, B.N.; et al. 2019. Differential impacts of citrus thrips across sweet orange and mandarin species. *Journal of Economic Entomology* 112(6):2767–2773.

Piñol J.; Espadaler, X.; Cañellas, N.; et al. 2009. Effects of the concurrent exclusion of ants and earwigs on aphid abundance in an organic citrus grove. *BioControl* 54:515–527.

Romeu-Dalmau C.; Gu, P.; Scott, S.; et al. 2012. Earwigs: pests or beneficials in California citrus orchards? *Citrograph* 3(1):18–22.

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