Data Analysis and Tactical Operations Center
Briefing paper

The search for a better trap: a review of Asian citrus psyllid trap technology research

Holly Deniston-Sheets[1]
Monique Rivera[2]
Rick Dunn[1]
Neil McRoberts[3]

[1]Citrus Research Board
2 Department of Entomology, UC Riverside
[3]Quantitative Biology & Epidemiology Lab, Plant Pathology Dept., UC Davis

Summary

In January, the CPDPC Operations Subcommittee asked DATOC to review available methods of trapping ACP and recent research on the subject. After querying the DATOC expert panel and a review of available literature, we cannot recommend any new technology for immediate utilization by the CPDPD. However, there are a few options which we can recommend be tested experimentally, including the use of “no mess” sticky cards.

Background

The Citrus Pest and Disease Prevention Division (CPDPD) is currently exploring the use of 3D traps in Southern California. These traps collect Asian citrus psyllid (ACP) into a preservative, allowing the insect to be tested for *Candidatus* Liberibacter asiaticus (*C*Las). The Operations Subcommittee asked the Data Analysis Tactical Operations Center to explore other trapping methods that the program could potentially use to broaden our understanding of vector dynamics and the vector/pathogen complex in California. We were asked to consider not just the current situation and efficacy, but any potential improvements in labor or processing, and how tools might be used in the future as the California situation changes.

Sticky Panel Traps

Despite a commonly encountered view that yellow sticky traps are a low-tech method of questionable efficacy, a substantial body of research, conducted over more than a decade, supports their use in monitoring Asian citrus psyllid populations. Although by no means a foolproof method, insect catches from sticky traps have been shown to be correlated with the presence or absence of field populations, population trends over time, and are better suited for detecting ACP at low-population densities than visual or stem-tap sampling (Hall, 2009; Monzo et al. 2015; Miranda et al. 2018). For monitoring ACP, sticky traps have been shown to be superior to other trap types, such as the Multi Lure trap for monitoring fruit flies, or the CC Trap (named for one of its inventors, Chang-Chi Chu) for whiteflies (**Figure 1**) (Hall et al., 2007).

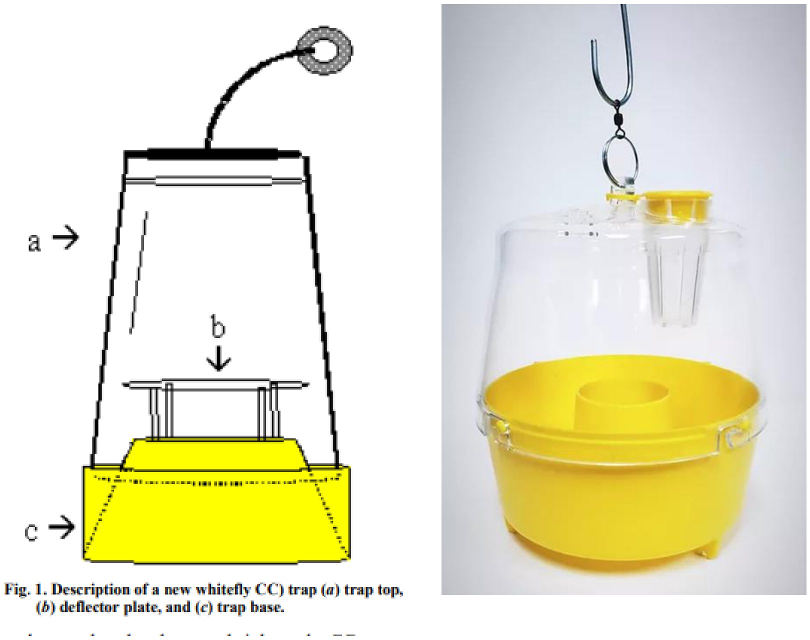

Figure 1. Left: CC Trap from Chu and Henneberry (1998). Right: multi-lure trap from betterworldus.com. https://www.betterworldus.com/products

The type of sticky trap to use has been extensively researched. Various shades of yellow cards have been compared with red, green, blue, white, and purple cards, to name just a few (Miranda et al, 2018. Hall et al., 2007, Sétamou and Czokajlo, 2008). Shades of yellow and lime green have typically performed best in these experiments.

Different types of adhesive have also been tested. Traps with a traditional sticky adhesive have been tested against traps coated with a pressure sensitive adhesive, and there was no difference in the number of trapped adults between the two (Hall et al., 2010). The latter type has the additional benefit of allowing the removal of ACP for *C*Las testing using Histo-clear, an orange-oil based clearing agent. ACP from traps exposed to up to 3 weeks of weathering in Texas have been successfully tested for *C*Las using this method with no apparent degradation in the proportion which test positive (Villegas, 2020). Other research from Brazil utilized ACP collected from yellow sticky traps to monitor the proportion of the population infected with *C*Las (Wulff et al., 2020).

Mesh laid over sticky traps has been explored as a method of reducing non-target bycatch and debris. One type of tested mesh did not significantly reduce ACP catch numbers and did significantly reduce non-target species and debris (**Figure 2**) (Sétamou et al., 2018).

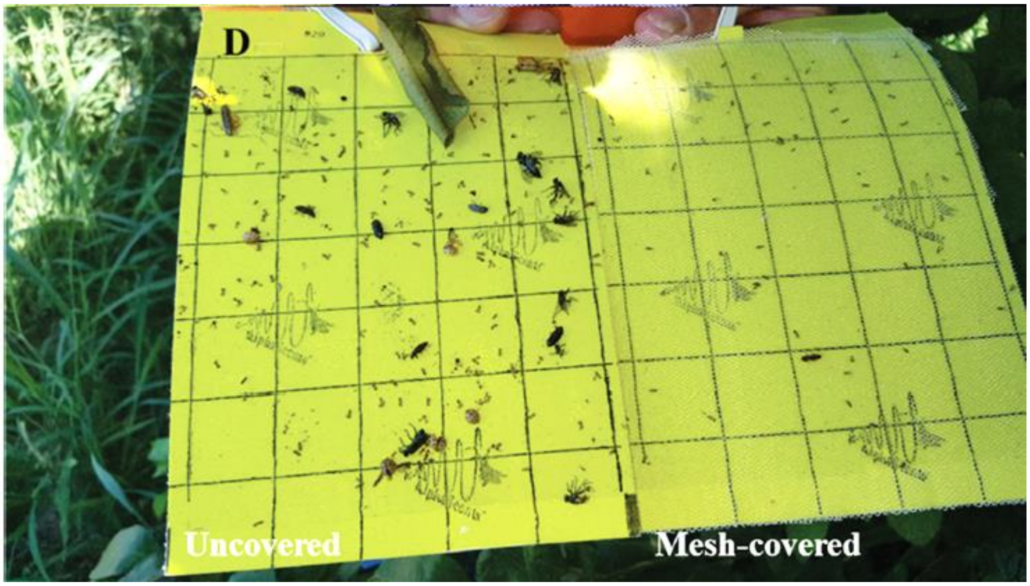

Figure 2. The difference in cleanliness between uncovered traps (left) and mesh-covered traps (right. From Sétamou et al., 2019 with modifications).

Research has also revealed how to optimize the location of sticky cards based on the preferred spatial niche occupation of ACP. Research has shown at what heights ACP commonly fly and documented their prevalence along the borders of groves, thereby indicating that traps should be placed on orchard perimeters (Setamou & Bartels, 2015) at a height of 1 – 2 m (Setamou et al., 2018) (**Figure 3**). Other research has found differing ACP densities based on the direction of the grove edge examined, but this has not yet been shown to be the case in California groves.

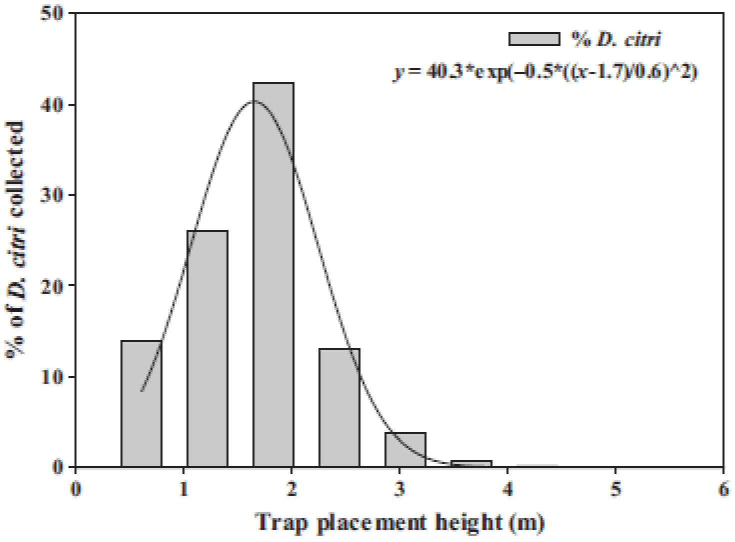

Figure 3. Percentage of ACP caught on traps placed at different heights along the perimeter of an orchard (from Sétamou et al., 2018).

Attractants, lures, and attract-and-kill traps

Much work has gone into research on attractants, both with yellow panel traps and with other types of traps, including attract-and-kill (AK) devices. Formic acid, acetic acid, and propionic acid have all been shown to be dose-dependent male ACP attractants, and traps using these chemicals as lures have been shown to catch significantly more male ACP than unbaited lures in field trials in California. Importantly, in an area of such low ACP density that visual confirmation of ACP infestation was nearly impossible, a slow-release acetic acid lure captured three times the amount of male ACP as a standard yellow trap (Zanardi et al., 2019).

Attract-and-kill devices have been tested with formic acid and acetic acid. Research has shown that these chemicals combined with para-cymene, a naturally-occurring terpene, induce psyllid feeding. This trio can be added with an insecticide to SPLAT (Specialized Pheromone & Lure Application technology), a slow-release wax used in several studies. When used with a three-dimensional trap, this can kill psyllids for 12 weeks (George et al., 2020) (**Figure 4**).

Other AK devices rely on ACP attraction to color. A two-dimensional device, made of plasticized PVC treated with B-cyfluthrin, was tested in Texas and was active for 8 weeks (Chow et al., 2019) (**Figure 4**).

Figure 4. Left: Example of one type of 3D trap covered with SPLAT and an insecticide (from George et al., 2020). Right: A 2D attract-and-kill device, conceived and developed by M. Sétamou and manufactured by Alpha Scents Inc. (West Linn, OR) (from Chow et al., 2019).

Other proprietary blends of host plant volatiles and ACP-produced compounds have been tested as lures in Texas and Florida; results indicated several blends significantly improved trap catches. Although California trials were inconclusive, this research resulted in a commercially available lure (Czokajlo, 2015; Alpha Scents Inc.).

Illumination has also been used to increase the attractiveness of traps to ACP. Setamou et. al (2012) showed that illuminating traps at night increased nighttime catches 5-fold compared with non-illuminated traps. Illumination has also been shown to increase trap catches in indoor environments set up to mimic citrus shipping containers (Mangan & Chapa, 2013).

Propylene glycol, a common food additive generally regarded as safe by the Environmental Protection Agency and the Food and Drug Administration (Thomas, 2008), has been tested in a salt mixture for preserving bacterial DNA in psyllids caught in the field. Research showed the preservative was effective for up to 6 weeks as compared with ACP tested either immediately or after being preserved at -20° C (Hall et al., 2018).

Many different types of 3D traps have been designed, and those that performed well in the lab have been tested in the field using propylene glycol as a preservative. Three trap types were tested in Florida, a "stem trap" and two versions of a "cylinder trap", against yellow sticky traps (**Figure 5**). Although the cylinder trap captured less ACP than sticky cards, they captured more psyllids than the stem trap, eliminate most bycatch, and preserved psyllids for polymerase chain reaction (PCR) testing (Snyder et al., 2019).

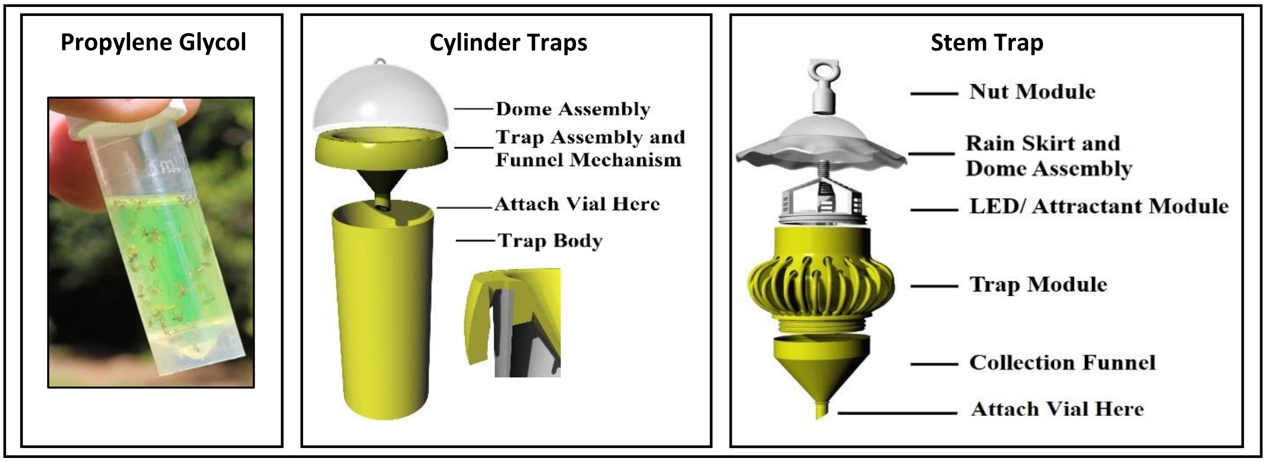

Figure 5. Examples of 3D printed trap designs tested in Florida (from Snyder et al., 2019).

Suction

Sampling using suction devices has generally been shown to be an effective method of insect monitoring. However, it has various drawbacks which could limit its usefulness in large-scale ACP-detection programs; although it is the most sensitive technology for detecting low-density populations, the weight of the device, exhaust fumes from gas-powered devices, and the need for a power source for cabled devices limits its efficiency (Monzo et al., 2015; Thomas, 2012). The labor needed to sort and quantify samples is also a limiting requirement.

Bioaccoustics & Vibration

Some research has explored using bioacoustics or vibrational patterns as attractants or potential mating disruption. However, published research indicates that these are either still in the prototype stage or were not effective (Fernandez, 2020; Hartman, 2017).

Commercially available traps

A panel trap with a pressure-sensitive adhesive ("ACP Trap") is currently available from Alpha Scents. The cost is $1.39/trap for large orders (≥100 traps). Alpha Scents also offers a lure made with a proprietary formulation at the same large-order price (≥100 lures). We are unaware of any 3D or other

AK traps commercially available at this time. The contract price for traps currently used by California Department of Food and Agriculture (CDFA) is $0.28.

Concluding Remarks

At this time, we cannot recommend any new technology for immediate utilization by the CPDPD. However, there are a few options which we can recommend be tested concurrently.

Histo-clear has previously been used by the program to remove ACP from cards with a traditional adhesive, but there were practical limitations: it was labor-intensive, quality-control failures were more common than testing ACP collected into a preservative, and ACP on cards had to be identified by appropriate CDFA entomologists before they could be tested by the lab. However, research results testing ACP off of yellow traps with a "no-mess" adhesive are encouraging. Testing ACP from "no-mess" cards could be evaluated in California to determine if the process is superior to testing off of standard traps. Such an evaluation should include not just PCR results, but also the cost of the cards and the labour and timing involved in identification and removal of insects from the cards. If this method proves adequately suited for detecting *C*Las, but inferior in terms of labour or cost, such a technique could be deployed only where the usefulness of additional information on *C*Las in the vector population would outweigh the additional costs.

Such a trial could be run concurrently with collection methods directly into a preservative, as is the case with 3D traps, and compared with standard yellow sticky traps for monitoring total numbers caught. Likewise, the effectiveness of lures in California could also be evaluated. Lures could be useful in areas of low population density or where early detection of ACP is a priority, like Kern County, where the additional cost could be justified by the need for a more sensitive detection method.

References

Alpha Scents. https://www.alphascents.com/pub/media/Pdf/ACP_New_Lure_and_Trap.pdf

Chow, A., D. Czokajlo, J.M. Patt, and M. Sétamou. 2019. Development and field validation of a beta-cyfluthrin-based ‘attract-and-kill’ device for suppression of Asian citrus psyllid (Hemiptera: Liviidae) on residential citrus. J Econ Entomol. 112(6): 2824–2832. doi: 10.1093/jee/toz221.

Chu, C. and T.J. Henneberry. 1998. Development of a New Whitefly Trap. J. Cotton Sci. 2: 104-109.

Czokajlo, D., L. Stelinski, K. Godfrey and M. Sétamou. 2015. Novel Attractant and Trap for More Sensitive ACP Monitoring and Detection. Citrograph. 6(2).

Fernandez, F. 2020. Bioacoustic trapping methods for the Asian citrus psyllid (Master’s thesis). Available from California Polytechnic University Bronco Scholar. http://hdl.handle.net/10211.3/216031.

George, J., S.L. Lapointe, L.T. Markle, J.M. Patt, S.A. Allan, M. Sétamou, M.J. Rivera, J.A. Qureshi, L.L. Stelinski. 2020. A multimodal AK Device for ACP. Insects. 11(12): 870. doi:10.3390/insects11120870.

Hall, D.G., M.G. Hentz, and M.A. Ciomperlik. 2007. A Comparison of traps and stem tap sampling for monitoring adult Asian citrus psyllid (Hemiptera: Psyllidae) in citrus. Fla. Entomol. 90(2): 327 – 334.

Hall, D.G. 2009. An assessment of yellow sticky card traps as indicators of the abundance of adult *Diaphorina citri* (Hemiptera: Psyllidae) in citrus. J. Econ. Ent. 102(1): 446 - 452.

Hall, D.G., M. Sétamou, R.F. Mizell III. 2010. A comparison of sticky traps for monitoring Asian citrus psyllid (*Diaphorina citri* Kuwayama). Crop Protection. 29:1341-1346. doi:10.1016/j.cropro.2010.06.003.

Hall, D.G., C. Ramadugu, S. Halbert. 2018. Efficiency of propylene glycol and salt for preserving *Ca. Liberibacter asiaticus* in infected adult Asian citrus psyllids captured in outdoor traps [Poster session]. Annual meeting of the Southeastern branch of the Entomological Society of America, Orlando, FL, United States.

Hartman, E., B. Rohde, S. Lujo, M. Dixon, S. McNeill et al. 2017. Behavioral responses of male *Diaphorina citri* (Hemiptera: Liviidae) to mating communication signals from vibration traps in citrus (Sapindales: Rutaceae). Fla. Entomol. 100(4) 767 – 771.

Lapointe, S.L, D.G. Hall and J. George. 2016. A Phagostimulant Blend for the Asian citrus psyllid. J Chem Ecology 42: 941 - 951. DOI 10.1007/s10886-016-0745-4

Mangan, R.L. and D. Chapa. 2013. Evaluation of the effects of light source and plant materials on Asian citrus psyllid (Hemiptera: Psyllidae) trapping levels in the Transtrap for citrus shipping containers. Fla. Entomol. 96(1): 104-111.

Miranda, M.P., F.L. dos Santos, R.B. Bassanezi, L.H. Montesino, J.C. Barbosa, M. Sétamou. 2018. Monitoring methods for *Diaphorina citri* Kuwayama (Hemiptera: Liviidae) on citrus groves with different insecticide application programmes. J. Appl. Entomol. 142: 89 – 96.

Monzo, C., H.A. Arevalo, M.M. Jones, P. Vanaclocha, S.D. Croxton, J.A. Qureshi, and P.A. Stansly. 2015. Sampling methods for detection and monitoring of the Asian Citrus Psyllid (Hemiptera: Psyllidae). Environ. Entomol. 44(3): 780 – 788. DOI: 10.1093/ee/nvv032.

Sétamou, M. and D. Czokajlo. 2008 Detection and monitoring trap for the Asian citrus psyllid, *Diophorina citri* Kuwayama. Manuscript submitted for publication. https://www.alphascents.com/pub/media/Pdf/Monitoring_Trap_for_the_Asian_Citrus_Psyllid.pdf

Sétamou, M., A. Sanchez, J.M. Patt, S.D. Nelson, J. Jifon, E.S. Louzada. 2012. Diurnal patterns of flight activity and effects of light on host finding behavior of the Asian citrus psyllid. J. Insect. Behav. 25: 264 – 276. DOI 10.1007/s10905-011-9295-3

Sétamou, M. and D. Bartels. 2015. Living on the edges: spatial niche occupation of Asian citrus psyllid, Diaphorina citri Kuwayama (Hemiptera: Liviidae), in Citrus Groves. PLoS ONE 10(7): e0131917. doi:10.1371/journal.pone.0131917

Sétamou, M., O.J. Alabi, N. Tofangsazi, and E. Grafton-Cardwell. 2018. COPF: Citrus orchard perimeter fencing as a strategy for reducing Asian citrus psyllid (Hemiptera: Liviidae) infestation. J. Appl. Entomol. 2018;00: 1-8. DOI: 10.1111/jen.12535.

Sétamou, M., R.R. Saldaña, J.M. Hearn, J. Dale, T.P.F. Arroyo, and D. Czokajlo. 2019. Screening sticky cards as a simple method for improving efficiency of *Diaphorina citri* (Hemiptera: Liviidae) monitoring and reducing nontarget organisms. J. Econ. Entomol. 112(3): 1167 – 1174. doi: 10.1093/jee/toz045

Snyder, J., S. Dowling, E. Rohrig, S. Halbert, C. Ramadugu, G. Simmons, R. Mizell, R. Henderson. 2019. Field assays of 3D-printed Asian citrus psyllid (*Diaphorina citri*) trapping systems [Poster session]. International Research Conference on HLB, Riverside, CA, United States. 2019.

Thomas, D.B. 2008. Nontoxic Antifreeze for Insect Traps. Entomol. News. 119(4): 361-365. https://doi.org/10.3157/0013-872X-119.4.361

Thomas, D.B. 2012. Comparison of insect vacuums for sampling Asian citrus psyllid (Homoptera: Psyllidae) on citrus trees. Southwest. Entomol. 37(1):55-60. http://dx.doi.org/10.3958/059.037.0107

Villegas, Cecilia. 2020. Development of a technique for reliable recovery of testable asian citrus psyllid from field deployed sticky cards [Master's thesis]. ProQuest Dissertations Publishing.

Wulff, N.A., B. Daniel, R.S. Sassi, A.S. Moreira, R.B. Bassanezi, I. Sala, D.A.B. Coletti, and J.C. Rodrigues. Incidence of Diaphorina citri carrying Candidatus Liberibacter asiaticus in Brazil's citrus belt. Insects. 11(10):672. doi:10.3390/insects1110067.

Zanardi, O.Z., H.X.L. Volpe, R.A. G. Luvizotto, R.F. Magnani, F. Gonzalez, C. Calvo, C.A. Oehlschlager, B.J. Lehan, V. Esperança, J.Y. Delfino, R. de Freitas, R.I. de Carvalho, T.A. Mulinari, M.P. Miranda, J.M.S. Bento and W.S. Leal. 2019. Laboratory and field evaluation of acetic acid-based lures for male Asian citrus psyllid, *Diaphorina citri.* Sci. Rep. 9, 12920. doi.org/10.1038/s41598-019-49469-3.