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Sampling for Asian citrus psyllid (ACP) in Florida citrus groves[1]

H. A. Arevalo, J. A. Qureshi and P. A. Stansly[2]

The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Homoptera: Psyllidae) vectors *Candidatus* Liberibacter asiaticus, causal agent of citrus greening disease or huanglongbing (HLB), in the U.S and elsewhere. HLB is considered the most devastating disease of citrus worldwide (Gottwald et al. 2006, Halbert & Manjunath 2004). The vector was first found in Florida in 1998 and is now present in all U.S. citrus producing states (Halbert & Manjunath 2004, Halbert 2005, APHIS-USDA 2009). Research efforts to manage HLB and slow its spread have dramatically increased since the disease was detected first in Brazil (2004), then a year later in Florida (Halbert 2005, Sutton et al. 2005). Although bacterium is mainly acquired primarily by actively feeding nymphs, adult psyllids are responsible for its spread. Thus, the objective behind management of adults is to reduce and delay transmission to healthy trees and reduce both re-infestation and re-inoculation of infected trees. As with most agricultural pests, it is advantageous to combine management strategies such as biological control with chemical control that conserves natural enemies in addition to suppressing pests (Qureshi & Stansly 2007, 2010). The cornerstone of any successful IPM program is real-time knowledge of pest and beneficial insect population densities in the field. Hence, an effective and efficient monitoring system to determine when and where pest populations are increasing will allow the grower to make informed management decisions.

One psyllid would be too many if the objective were to eradicate HLB. Unfortunately, the tools are not yet available to eliminate pest or disease. Nevertheless, efficient and economical pest suppression is possible. For example, a single application of broad-spectrum insecticide during winter months when citrus trees are not producing new growth (flush) has provided significant psyllid suppression for 4 to 6 months (Qureshi & Stansly 2010) although a second “dormant” spray is recommended. Good spray penetration can be achieved during winter when the canopy is sparse and spray residues break down slowly. Adults are basically the only stage present and they can contact spray residues by moving within the canopy. In contrast, nymphs are sessile, feeding on and are protected by newly emerged shoots which also harbor their natural enemies such as ladybeetles and

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2. H. A. Arevalo, postdoctoral extension and research associate, J. A.. Qureshi, assistant research professor, and P. A. Stansly, professor, SWFREC, University of Florida, Immokalee, FL

lacewings. During the growing season, adult ACP should be monitored and treated prior to the appearance of new growth when justified by increasing numbers.

Records of population trends on a block-by-block basis will greatly assist effective and efficient ACP management, even though thresholds for ACP control have not yet to been developed. Sampling during the growing season at two-week intervals in concert with ACP generation time is necessary to detect population increases in time to react (Liu & Tsai 2000, Stansly et al. 2009). Three techniques are currently in use to sample adults: stem-tap, sweep-net, and sticky cards. The strengths and weaknesses of each as well as our recommendations for routine monitoring of ACP for management purposes are discussed below.

Stem-tap sampling

All that is needed to conduct a stem-tap sample is a letter size (8.5 x 11 inches) sheet of laminated white paper or transparent clipboard and a 2 ft stick or PVC pipe. The sheet is held about 1 ft below a leafy branch which is struck consecutively three times for each sample, causing psyllids and other insects to fall onto the sheet (Figure 1). The smooth surface of the sheet makes it difficult for psyllids to fly, allowing sufficient time to count and record (Figure 2) (Qureshi & Stansly 2007).

The stem tap is rapid, works under either dry or wet conditions, and has proven to be reliable and consistent (Hall et al. 2007, Qureshi et al. 2009, Hall & Hentz 2010). It can also be used to monitor other pests such as weevils and leafminer adults, as well as beneficial insects such as ladybeetles, lacewings, and spiders. According to Southwood & Henderson (2000), 75% precision is considered adequate for commercial pest management purposes (Table 1). A little more than 100 tap samples would be necessary to detect with confidence 15 psyllids with 75% precision, a reasonable threshold during the growing season.

Sweep-net sampling

A sturdy 15-inch diameter sweep net and a datasheet or data recorder are needed. The net is swung twice making a “figure 8”, being sure that half of the rim is inside the canopy (Figure 3). We compared such a sweep net with 2 stem tap samples at low and high densities and found no difference between two methods. However, if the sweep net is swung multiple times it will accumulate more psyllids but also more debris and other insects that can increase the error. Furthermore, the labor is considerable because of the weight of the net. Wet nets are especially heavy and prone to spread canker.

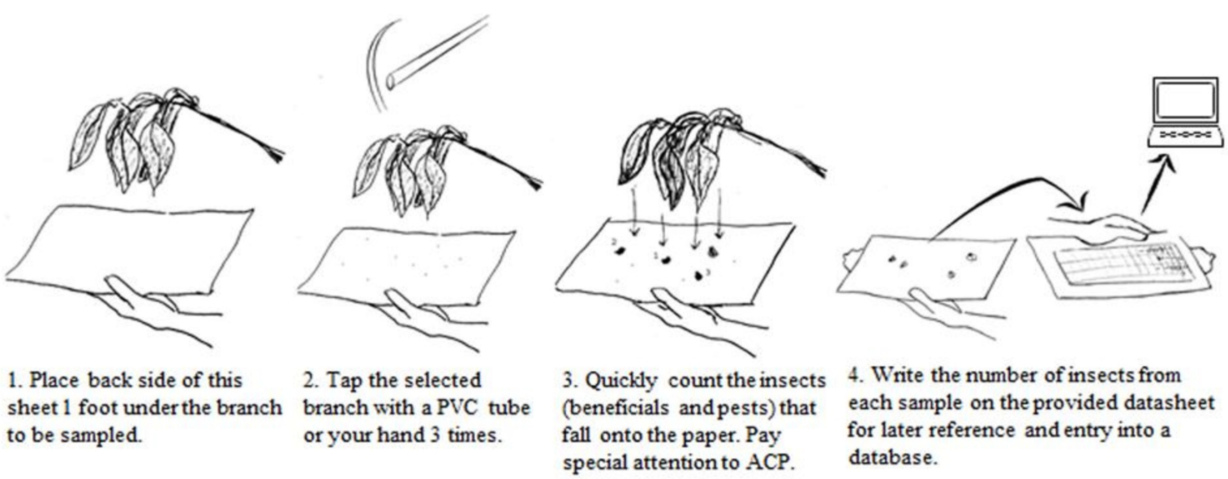

Figure 1. Instructions for conducting a stem-tap sample to monitor Asian citrus psyllid, other foliar pests and some natural enemies such as ladybeetles or spiders.

Figure 2. Stem-tap technique (left). Close up of psyllid adults on a laminated sheet or clipboard (right).

Figure 3. Use of a sweep net describing the figure 8 inside the canopy (left). Inside view of the net after the sample showing debris and ants (right).

Sticky traps

Sticky traps have been used to monitor flying insects in various crops. In citrus, yellow and yellow/green sticky traps have been successfully tested and used to monitor adult ACP for many years (Samways et al. 1986, Van Den Berg & Deacon 1988, Mercado et al. 1991, Hall 2009, Hall & Hentz 2010). They are hung in the canopy for one or two weeks, during which a variety of insects may be captured (Figure 4). The traps must then be taken down, transported to the laboratory, and carefully scanned under a magnifying lamp to identify the psyllids. Sticky traps capture more ACP than stem taps because they are out for a long time. However, they are costly - about $1.00 each – and require about 14 times more labor to deploy, collect, and read than stem-tap samples (Table 2). Another inconvenience is the time delay to obtain information depending on how long the traps are left in the field. Therefore, sticky traps are not recommended for routine monitoring or pest management purposes.

Figure 4. Deployment (left) and close-up (right) of yellow sticky traps used in citrus to monitor adult ACP populations. A psyllid captured in the trap can be seen inside the red circle.

Flush observation

The adult female ACP must feed on emerging shoots to mature eggs in the ovary and two weeks later begin laying eggs in young unexpanded leaves or “feather flush.” The presence of yellow-orange eggs and nymphs on young flush indicates that adult psyllids are present and reproducing, and therefore should be included in the sampling protocol. Feeding of both adults and nymphs causes the young leaves to twist in a characteristic way that is easily differentiated from curling caused by the green citrus aphid, *Aphis spiraecola* (Figure 5). Leaf distortion caused by adult or nymphal feeding is often the first indication of psyllid activity, leaving a permanent record as the leaves mature. Nymphs also excrete spirals of honeydew contained in tubes of white wax often seen on young shoots. It is difficult to accurately count the number of ACP eggs or nymphs in the field. For this reason, a simple presence/absence assessment is recommended. A ratio of infested shoots to number of shoots observed is useful information. However, proper interpretation requires an estimate of flush density in the block because a high percentage of infested shoots when flush is sparse may be of lesser concern than a moderate level of infestation with high flush density.

Figure 5. Damage by two sucking pests in young citrus shoots. Note the curling produced by aphid feeding (left) in contrast to twisting and deformation caused by ACP (right).

Routine monitoring protocol

A protocol for monitoring adult plus immature psyllids has been developed and tested using the stem tap method and flush observation respectively. We recommend 100 samples per block divided into 10 stops, five along the perimeter where ACP tends to congregate, and five inside the block. This scheme could lead to a decision to spray only the block perimeter if necessary. Ten tap samples should be taken at each stop, one per tree. Then 10 young shoots, each containing “feather flush” should be examined with a hand lens to determine if they are infested with psyllids. The search is terminated if 10 young shoots cannot be found after examining 20 trees. A data sheet (annexed) is marked to note the numbers of adults per 10 taps, shoots searched, and shoots infested. The number of trees searched to find the examined shoots is also noted as an indication of flush density. Other information that could be included is the number of pests such as weevils and leafminer adults falling in the tap sample, or of beneficial arthropods such as ladybeetles, lacewings, spiders, etc. (Qureshi & Stansly 2009). The incidence or intensity of other pests and diseases such as leafminers, scales, HLB, or canker can also be recorded. More information on psyllid monitoring can be found at http://swfrec.ifas.ufl.edu/entomology/.

References cited

APHIS-USDA. 2009. Citrus Greening. Animal and Plant Health Inspection Service.

GOTTWALD, T., AUBERT, B., ZHAO, X., BERGAMIN-FILHO, A., BASSANEZI, R., AND AMORIM, L. 2006. Huanglongbing epidemiology: An international perspective. Proceedings of Huanglongbing-greening International Workshop, July 14-21, 2006, Ribeiro Preto, Brazil 35-36.

HALBERT, S. E. 2005. Citrus greening/Huanglongbing. Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL.

HALBERT, S. E., AND MANJUNATH, K. L. 2004. Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: a literature review and assessment of risk in Florida. Florida Entomologist 87 (3): 330-353.

HALL, D. 2009. An assessment of yellow sticky card traps as indicators of the abundance of adult *Diaphorina citri* (Hemiptera: Psyllidae) in Citrus. Journal of Economic Entomology 102 (1): 446-452.

HALL, D. G., AND HENTZ, M. G. 2010. Sticky trap and stem–tap sampling protocols for the Asian citrus psyllid (Hemiptera: Psyllidae). Journal of Economic Entomology 103 (2): 541-549.

HALL, D. G., HENTZ, M. G., AND CIOMPERLIK, M. A. 2007. A comparison of traps and stem tap sampling for monitoring adult Asian citrus psyllid (Hemiptera : Psyllidae) in citrus. Florida Entomologist 90 (2): 327-334.

LIU, Y. H., AND TSAI, J. H. 2000. Effects of temperature on biology and life table parameters of the Asian citrus psyllid, *Diaphorina citri* Kuwayama (Homoptera : Psyllidae). Annals of Applied Biology 137 (3): 201-206.

MERCADO, B. G., ARANO, B., BARAIRO, G. A., GONZALES, C. I., AND GAVARRA, M. 1991. Monitoring the presence and populations of *D. citri* using different traps in the Philippines, pp. 594-597. IN B. Huang and Q. Yang [eds.], Proceedings of the International Citrus Symposium Guangzhou, China, Nov. 5-8, 1990. International Academic Publishers, Beijing.

MURARAO, RP. 2009. Summary of 2008 - 2009 Citrus Budget for the Southwest Florida

Production Region. University of Florida, IFAS, CREC, Lake Alfred, FL [http://www.crec.ifas.ufl.edu/extension/economics/pdf/SW_Budget_Summ_2008-2009.pdf]

QURESHI, J. A., AND STANSLY, P. A. 2007. Integrated approaches for managing the Asian citrus psyllid *Diaphorina citri* (Homoptera: Psyllidae) in Florida. Proceedings of the Florida State Horticultural Society. 120 : 110-115

QURESHI, J. A., AND STANSLY, P. A. 2009. Exclusion techniques reveal significant biotic mortality suffered by Asian citrus psyllidDiaphorina citri (Hemiptera: Psyllidae) populations in Florida citrus. Biological Control 50(2):129-136.

QURESHI, J.A., ROGERS, M.E., HALL, D.G., STANSLY, P.A., 2009. Incidence of invasive *Diaphorina citr*i (Hemiptera: Psyllidae) and its introduced parasitoid *Tamarixia radiata* (Hymenoptera: Eulophidae) in Florida citrus. J. Econ. Entomol. 102, 247-256.

QURESHI, J. A., AND STANSLY, P. A. 2010. Dormant season foliar sprays of broad-spectrum insecticides: An effective component of integrated management for *Diaphorina citri* (Hemiptera: Psyllidae) in citrus orchards. Crop Protection. 29 (8): 860-868.

SAMWAYS, M. J., TATE, B. A., AND MURDOCH, E. 1986. Monitoring the citrus thrips and psylla using fluorescent yellow sticky traps- a practical guide. The Citrus and Subtropical Fruit Journal 629: 9-15.

SOUTHWOOD, R., AND HENDERSON, P. A. 2000. Ecological methods. 3rd edition. Blackwell Pub.

STANSLY, P. A., QURESHI, J. A., AND AREVALO, H. A. 2009. Why, when and how to monitor and manage Asian citrus psyllid. Citrus Industry Magazine 90(3):24-26.

STANSLY, P. A., AREVALO, H. A., AND QURESHI, J. 2010. Monitoring methods for Asian citrus psyllid. Citrus Industry Magazine. 91(4): 20-22.

SUTTON, B. D., DUAN, Y.-P., HALBERT, S., SUN, X.-A., SCHUBERT, T., AND DIXON, W. 2005. Detection and identification of citrus huanglongbing (greening) in Florida, USA, pp. 59. IN T. R. Gottwald, W. N. Dixon, J. H. Graham and P. Berger [eds.], Proc. of the 2nd Intl. Citrus Canker and Huanglongbing Workshop 7-11 November. Florida Citrus Mutual, Orlando, FL USA.

VAN DEN BERG, M., AND DEACON, V. E. 1988. Dispersal of the citrus psylla, *Trioza erytreae* (Hemiptera: Triozidae) in the absence of its host plants. Phytophylactica 20 (4): 361-368.

Table 1. Relationship between hypothetic threshold and number of tap samples needed to obtain 75% precision (100 – standard error / mean) necessary to make informed decisions under commercial conditions according to Southwood & Henderson (2000). This data was calculated based on an average standard deviation (σ) = 0.39 observed from data collected over two years in several commercial and research citrus blocks.

Threshold (ACP adults per 100 taps)	10	15	20	25	30	40	50
Number of tap samples needed	243	108	61	39	27	15	10

Table 2. Cost of sampling and spraying a 50-acre block of citrus for ACP control in 2010 in southwest Florida. Costs are based on $10 per hour salary for a scout and a $10/day depreciation cost for an ATV (HAA and PAS unpublished data).

50 ac. block	**Stem-Tap Sample**	**Sweep Net**	**Sticky Traps**	**Insecticide application @ $24.95/ac [2]**
Cost (materials and labor) [1]	$ 7.40	$ 7.40	$ 203.60	$1,247.50
Vehicle fuel and amortization	$10	$ 10	$ 10	
Total cost / block	$ 17.40	$ 17.40	$ 213.60	$1,247.50
Risks	• Population may be too low to detect	• Spread canker • Knock down fruit • Difficult to record	• Delayed results • Time consuming • Expensive	• Might be a waste of resources if ACP is low

[1] Labor cost based on 1/2 hour of work @ $15.80 per hour. For sticky traps, the value of the traps ($100) is also added.
[2] Assuming an aerial low volume fixed wing @ 5 GPA. For this example, we used Danitol at $19.45/acre

Datasheet to monitor citrus pests and beneficial insects, with an emphasis on Asian citrus psyllid (ACP)
Entomology Group. University of Florida - Southwest Florida Research and Education Center
[http://swfrec.ifas.ufl.edu/entlab/]

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Sampled by ____________________ Grove ____________________
Date ____________________ Block ____________________
Flush (None) (Low) (Moderate) (High) Bloom (None) (Low) (Moderate) (High)

			ACP Adults		ACP in flush			Secondary pests				Diseases			Beneficials [5]			Comments
Stop[1]	Latitude	Longitude	ACP Tally [2]	# Total of ACP per stop *	# of infested flush	# of observed flush	# sampled trees	Citrus leaf miner (0,1,2) [4]	Scales (0,1,2) [4]	Spider mites (0, 1, 2) [4]	Rust mite [3] (5 Fruits x 2 LF)	Tally of tees with HLB symptoms [2]	Total # of trees with HLB symptoms in 10 trees *	Canker (0, 1,2) [4]	Ladybeetles	Spiders	Trash-bugs	
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
Total																		

[1] Make 10 stops per block, 5 around the perimeter and 5 in the inside

[2] Use the spaces "ACP tally" and "Tally of tees with HLB symptoms" in the data sheet to keep a tally of adult ACP or the number of trees with HLB symptoms observed in each sample. Then add them and place the total number per stop in the respective field *

[3] If rust-mite sampling is needed, count the number of rust-mites in 2 lens-fields per fruit in 5 fruits per stop

[4] The scale for secondary pests and canker is (0 = Nothing), (1 = low), (2 = high) in the 10 observed tress

[5] Count the number ladybeetles, spiders and trash-bugs observed during the sampling