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Surveys and Needs Assessments

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Surveys and Needs Assessments

Residents' contribution to Asian citrus psyllid and citrus greening management in Florida residential habitats

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The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), is the world's most damaging citrus pest that transmits the bacteria that cause huanglongbing (HLB). In the fall of 2022, we investigated residents' attitudes to ACP and HLB using online surveys over a 9-month period. The survey gathered information on citrus grown in backyards and on the detection of ACP and HLB, as well as the management strategies used (or ready to be implemented) to control them. We recorded 529 responses, 218 from areas where HLB is endemic (South and Central Florida) and 311 from areas where HLB and ACP are still rare (North Florida). In the HLB area, the number of citrus grown was significantly reduced, and residents were more active in controlling ACP and HLB. Most residents were able to identify an adult psyllid from a photo, but only 5% reported having seen it on their trees, in most cases in areas with high HLB incidence. The results also revealed residents' interest in managing ACP and HLB, as well as their willingness to participate in the search for integrated solutions to tackle ACP and HLB in urban habitats. Interestingly, 76% of responders agreed to remove HLB trees from their backyard; this went up to 82% if compensation was offered. This study provides valuable insights for improving backyard Extension strategies tailored to the needs and willingness of residents to manage ACP and HLB.

Key words: Asian citrus psyllid, citrus greening, resident, management, audience research

Résumé

Le psylle asiatique des agrumes (ACP), Diaphorina citri Kuwayama (Hemiptera: Psyllidae), est le ravageur des agrumes le plus dommageable au monde, servant de vecteur à la maladie bactérienne des agrumes, huanglongbing (HLB). Durant l'automne 2022 et le printemps 2023, nous avons étudié l'attitude des résidents de l'état de Floride face à l'ACP et la maladie HLB en utilisant une enquête en ligne sur une période de 9 mois. L'enquête a recueilli des informations sur les agrumes cultivés dans les arrière-cours des zones résidentielles et sur la détection de l'ACP et de la maladie HLB, ainsi que sur les stratégies de gestion utilisées (ou prêtes à être mises en œuvre) pour les contrôler. Au total, nous avons enregistré 529 réponses; 218 provenaient de régions où la maladie HLB est endémique (sud et centre de la Floride) et 311 de régions où elle est encore rare (nord de la Floride). La présence de la maladie a considérablement réduit le nombre d'agrumes cultivés par les résidents. En général, les résidents des régions où la maladie est répandue ont été plus actifs dans la lutte contre l'ACP et la maladie HLB en utilisant différentes tactiques. La plupart des résidents étaient capables d'identifier une photo de psylles adultes et de nymphes, mais lorsqu'on leur a demandé s'ils avaient détecté ce ravageur, seuls 5 % ont déclaré l'avoir vu sur leurs arbres, la plupart des cas se trouvant dans les zones où la maladie est prévalente. Les résultats ont également révélé l'intérêt des résidents pour la gestion de l'ACP et de l'HLB, ainsi que leur volonté de participer à la recherche de solutions intégrées pour lutter contre l'ACP et l'HLB dans les habitats urbains. Il est intéressant de noter que 76 % des résidents ont accepté d'enlever les arbres infectés par la bacterie de leur jardin; ce chiffre passe à 82 % si une compensation leur est offerte. Cette étude fournit des informations utiles pour améliorer les stratégies de vulgarisation dans les zones résidentielles, en les adaptant aux besoins des habitants de gérer l'ACP et l'HLB.

Introduction

Florida is one of the world's largest citrus-producing regions (Crist 1955, Bové 2006, Gottwald and Graham 2014). However, in recent decades the Florida citrus landscape has been under assault from the Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Sternorryncha: Psyllidae), which is a vector of the endogenous, sieve tube-restricted bacterium Candidatus *Liberibacter asiaticus* (C*Las*), causing the deadly citrus greening disease or huanglongbing (HLB) (Bové 2006). This disease is currently a major threat to Florida's citrus industry, decimating yields and ruining the citrus industry statewide (Bové 2006, Feely 2016, Kadyampakeni and Chinyukwi 2021) by causing an 80% decline in Florida citrus groves for over a decade (LOCUS/AG 2022). Citrus greening causes serious economic losses and reduces fruit quality and the lifespan of affected trees (Bové 2006). Trees infected with C*Las* exhibit an appearance of leaf yellowing, asymmetrical chlorosis (blotchy mottle) similar to zinc deficiency (symmetrical chlorosis), gradual twig dieback, and decline in vigor, ultimately followed by plant deterioration (Li et al. 2012, 2021). Fruit size decreases, and heavy fruit drops occur as the disease becomes severe (Aubert 1993, Halbert and Manjunath 2004).

In the United States, the first case of citrus greening was reported in residential habitats of South Florida (Bové 2006, Manjunath et al. 2008). The infection spread rapidly across Florida with the movement of citrus and of the ornamental orange jasmine, *Murraya paniculata* (L.) Jack (Singerman and Rogers 2020). By 2018, ACP and HLB had spread in Central and South Florida (McLean 2016). Recently, the disease and vector have been detected in residential habitats in the northwestern part of the state on the Mexican Gulf Coast, particularly in Franklin County (29°48′0.00″ N/ −84°49′12.00″ W); however, the incidence of the disease and the vector remains low in this region (Martini et al. 2020).

There is currently neither a cure for this disease nor HLB-resistant varieties (Bové 2006, Folimonova et al. 2009, Singerman and Rogers 2020). Therefore, the management of HLB relies on the production and planting of disease-free nursery stock, regular inspection of individual trees, application of slow-release nutrients (Qureshi and Stansly 2007, Gottwald et al. 2012), suppression of vector populations through intensive insecticide applications (Qureshi and Stansly 2007, 2010, Barr et al. 2009, Bové 2012, Alvarez et al. 2016, Khan et al. 2020, Li et al. 2020), and removal of HLB-infected trees (Bové 2006, Polek et al. 2007, Bassanezi et al. 2013). The decision to remove infected trees is the sole responsibility of tree owners, as no legal regulations have been imposed. Tree removal remains controversial due to the precedent established by the Florida Supreme Court regarding an earlier citrus canker eradication program. In 1995, the Florida legislature passed a prescription to eradicate the disease by destroying and incinerating all trees within 1,900 ft (initially 125 ft) of an infected tree (Florida Statutes 2005, Adams et al. 2007). Although it was shown that the disease would significantly reduce citrus production in backyards, residents sued the state for the full value of the trees destroyed (Centner and Ferreira 2012). To this day, residents continue to file lawsuits seeking more compensation for the damage caused by the loss of the trees. This situation has set a challenging precedent for disease control efforts in the state, impacting the Florida legislature's response to HLB. It highlights the state's limited powers to combat citrus diseases that may require tree removal (Florida Statutes 2005, Adams et al. 2007, Centner and Ferreira 2012).

In recent years, progress has been made in the development and implementation of ACP control strategies for backyard citrus. However, questions remain as to the ability and interest of residents in tackling this pest. Since HLB was first detected in the United States, residents' responses in areas where the disease is prevalent and those where it is sporadic have not been thoroughly evaluated. The aim of this research was to assess current strategies used to combat HLB in residential habitats and their successes and challenges. We sought to determine residents' level of contribution to ACP and HLB control and their willingness to implement new strategies to limit their spread depending on the prevalence of HLB in the studied area. The survey data highlights residents' interest in participating in the search for an integrated solution against ACP and HLB.

Florida uniquely possesses a southern and central region with a high prevalence of HLB, whereas in the northern region, HLB is still rare. Therefore, Florida is particularly suited to study the response of residents depending on the prevalence of HLB in an area. Our results will help develop adequate Extension strategies for residents nationwide depending on their need and their willingness to control ACP and HLB.

Survey Methods

Questionnaire Design

A 42-question survey (Supplementary material S1) was structured to investigate perceptions surrounding citrus pests in residential areas, wherein Florida residents were asked to respond to pests found on their citrus trees and management strategies they would be willing to implement to control the infestations of citrus on their properties.

This survey was designated uniquely for residents who grow citrus on their property for noncommercial purposes. The survey was designed to be completed in under 20 minutes, and the questions were split into 3 sections: 12 regarding citrus varieties cultivated and residents' maintenance, 21 focusing on the detection and identification of citrus pests as well as the management of ACP, and 9 on demographic information. A consent form was added on the front page of the questionnaire as an invitation to participate in the survey, and the confidentiality of survey respondents was ensured. No compensation was provided to residents who completed the survey.

Survey questions were presented in 4 different formats: (i) multiple choices questions with single and multiple-answer options and open-text write-in responses; (ii) dichotomous questions (yes/no); (iii) imported choices questions where respondents selected the correct answers; and (iv) matrix table questions (5-point Likert scales) allowing 1 answer, with 5 statements. Pictures of pests were displayed in 4 questions to assess respondents' visual ability to identify citrus pests and to obtain appropriate responses to questions related to the pest detection and identification section.

Survey Implementation Plan

The survey was web-based only. A digital questionnaire was developed and hosted by web-based provider Qualtrics (Seattle, WA, USA) to be compatible with respondents' mobile devices. Because our research involved human subjects, our research protocols and data collection and storage methods were first reviewed and approved by the University of Florida's Institutional Review Board (IRB) (IRB Study # IRB202200230). Responses to the survey were anonymous, and personal information that could lead to identifying respondents was not collected.

Survey Distribution

The survey was conducted across Florida (Fig. 1) from August 2022 to May 2023. The sampling method used to reach the population of interest was purposive sampling (Palinkas et al. 2015), a nonprobabilistic sampling method in which we intentionally selected participants based on predefined characteristics. Our participants were chosen on 3 criteria: age (respondents must be at least 18 years old), residency status (respondents must reside in Florida), and presence of citrus tree on the respondents' property (at least 1 citrus tree). Therefore, individuals with characteristics not corresponding to our selection criteria were excluded from the study. We used 3 networks to connect with potential respondents who presumably live in Florida and are involved in citrus cultivation. First, we used the Extension agent network of the Institute of Food and Agricultural Sciences (IFAS/Extension) of the University of Florida (UF), which employs IFAS Extension agents across Florida to work with homeowners and Master Gardeners Volunteers. Given their close interactions with homeowners, extension agents were provided with the survey link and instructed to send it to residents via their smartphones or email addresses using a contact list. Second, we reached out to Florida A&M's Extension Service to diffuse the survey to individuals on their residential contact. This service is recognized for providing information on educational research to residents with limited resources. Third, we enlisted individuals from local communities (religious, gardening, and sports clubs) and other personal contacts who might have connections with local people growing citrus trees in their backyards. Finally, the survey was promoted broadly through 3 social networks: Facebook, Instagram (Meta Platforms, Menlo Park, CA, USA), and Twitter (Twitter, Inc. San Francisco, CA, USA). Residents who received the link were encouraged to share it with others who might not be targeted.

Descriptive statistics were computed for the studied population. Cross-tabulation was used as a statistical tool to process data. The Qualtrics software was used to cross-tabulate each question answered by respondents. We calculated the frequency for categorical measures, and Chi-Square tests were conducted to analyze the differences in variables of interest across the data using the RStudio, version 4.2.1 (RStudio software Inc., Boston, MA, USA).

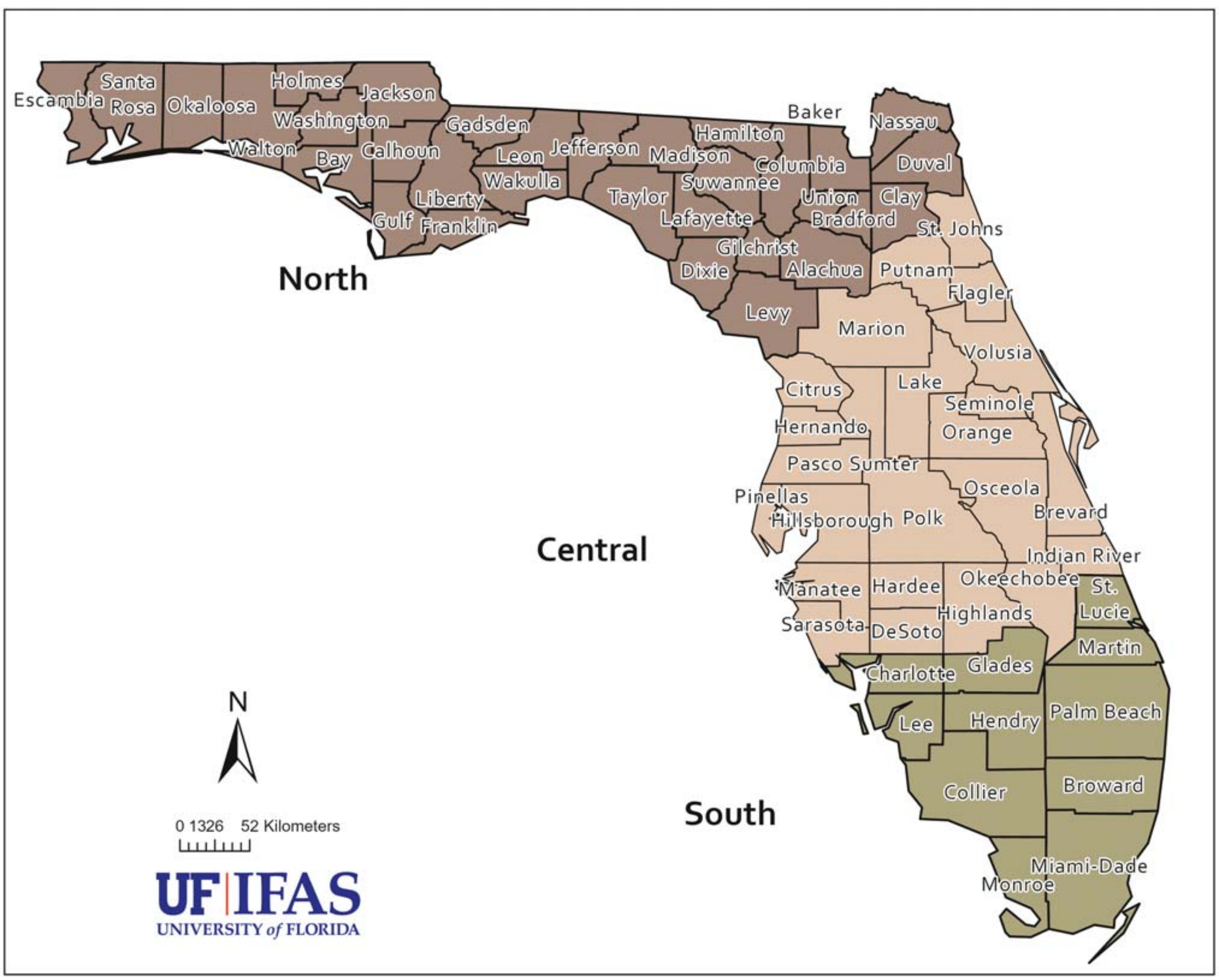

Fig. 1. Map of major regions of the State of Florida. The northern region (33 counties) is the least affected by HLB, and the central and southern regions (34 counties) are the most affected.

Survey Results

Respondents

We gathered a total of 529 responses from Florida residents who currently grow citrus in their backyards. Of these, 58.79% live in North Florida, an area with a low incidence of HLB (hereinafter referred to as "Low-HLB region"), and 41.21% in Central and South Florida where HLB is prevalent (hereinafter referred to as "High-HLB region") (Fig. 1).

Demographic Characteristics

Almost 63% of respondents were aged between 50 and 75, and less than 1% were between 18 and 25. Of the 507 respondents who provided their marital status, 84.84% were either married or cohabiting. Furthermore, 70.83% of respondents were female, 28.60% were male, and 0.57% identified as nonbinary. The survey population was mainly composed of white ethnic groups (88.69%), followed by Hispanics and Latin Americans (4.24%). Black Americans, Asians, and other ethnic groups accounted for only 6.67%. The majority of respondents had at least a high school diploma or equivalent, and over half (67%) had a bachelor's or master's degree. Around 57% of respondents were retired, 24.66% were working full-time, and 18.40% belonged to groups consisting of the unemployed, students, homemakers, and self-employed, as well as those unable to work. The annual income of 95.38% of residents was over $25,000. Except for 3.05% who were tenants, 95.73% of respondents were recognized as owners, while 1.22% lived with their parents and/or children (Table 1).

Table 1. Survey population demographics in all regions combined

Characteristic of respondents	Count	Percent
Age	*n (525)*	
18–25	2	0.38
25–50	99	18.86
50–75	330	62.86
>75	94	17.90
Sex	*n (528)*	
Male	151	28.60
Female	374	70.83
Nonbinary	3	0.57
Ethnicity	*n (495)*	
White	439	88.69
Black or African American	8	1.62
American Indian or Alaska Native	2	0.40
Asian	9	1.82
Native Hawaiian or Pacific Islander	0	0.00
Hispanic and Latino Americans	21	4.24
Other	16	3.23
Education	*n (525)*	
Less than a high school diploma	0	0.00
High school degree or equivalent (e.g., GED)	13	2.48
Some college, no degree	60	11.43
Associate degree (e.g., AA, AS)	47	8.95
Bachelor's degree (e.g., BA, BS)	188	35.81
Master's degree (e.g., MA, MS, MEd)	166	31.62
Doctorate or professional degree (e.g., MD, DDS, PhD)	51	9.71
Marital Status	*n (507)*	
Single (never married)	23	4.54
Married, or in a domestic partnership	420	82.84
Widowed	28	5.52
Divorced	35	6.90
Separated	1	0.20
Employment	*n (511)*	
Employed full-time (40 or more hours per week)	126	24.66
Employed part-time (up to 39 h per week)	28	5.48
Unemployed and currently looking for work	3	0.59
Unemployed not currently looking for work	4	0.78
Student	4	0.78
Retired	291	56.95
Homemaker	23	4.50
Self-employed	30	5.87
Unable to work	2	0.39
Income	*n (356)*	
<$25,000	20	5.62
$25,000–$50,000	61	17.13
$50,000–$75,000	66	18.54
$75,000–$100,000	81	22.75
$100,000–$125,000	43	12.08
$125,000–$150,000	28	7.87
$150,000–$175,000	24	6.74
$175,000–$200,000	12	3.37
>$200,000	21	5.90
Property	*n (492)*	
Owner	471	95.73
Tenant	15	3.05
Other	6	1.22

Citrus Grown in Backyards

Over half of residents grew 1–3 cultivars in their backyards, followed by around a quarter who grew 4–6 cultivars (Table 2, section 1). However, only a few reported growing 7 or more cultivars. The regional comparison shows that residents in high-HLB areas grew fewer (1–3) trees on their property than those in low-HLB areas who had 4–6 trees. Regarding citrus age, no significant differences were found between citrus grown in both regions (Table 2, section 2). Most residents (64.43%) grew citrus aged 5 years or more, followed by 28.97% with trees aged 2 to 4 years. In contrast, only 6.54% had trees aged 1 year or less on their properties.

Citrus Species Grown in Backyards, Origin, and Care

Residents across Florida cultivated a variety of species in their backyards; the most reported in this survey were oranges, tangerines (or satsuma), limes, lemons, and grapefruit. Of these species, lemon was listed first in respondents' answers, followed by oranges, mandarins, limes, and grapefruit (Table 2, section 3). In regions with both low- and high-HLB incidence, lemon was also the species most frequently reported by residents. In contrast, lime production was higher where HLB is prevalent (Table 2, section 3). Other species cited included calamondin, kumquat, limequat, and pomelo, with kumquat and limequat representing 44.5% (n = 153) of the respondent-provided varieties.

In both regions, respondents reported obtaining citrus trees from nurseries (78.98%), donations (12.88%), or growing them from seeds (11.74%). At 64.78% (n = 531), a majority of survey responders indicated that the trees acquired were inspected for pests and diseases before being planted.

The majority of residents, whether in areas with low or high HLB, properly maintained their citrus trees by ensuring watering, weeding, pruning, and fertilization. However, significantly fewer provided protection for citrus against pests and diseases (χ^2 = 60.35, df = 4, P < 0.001) (Table 2, section 4). Residents received training in citrus care and maintenance from various sources: 78.65% reported attending training sessions provided by the UF via IFAS/Extension, while fewer reported using social media (22.5%) and specialist blogs

(18.65%) to gain knowledge about citrus care (Table 2, section 5). Residents also indicated that they had acquired knowledge about citrus care from nurseries or from manuals and books covering the subject.

Backyard Citrus Production Trends

Residents provided their perception of the change in their citrus fruit production over time (Table 3). Whereas 44.50% of respondents living in areas with high-HLB incidence perceived a decrease in their citrus production over the years, there were only 21.36% in low-HLB areas ($\chi^2 = 33.278$, $df = 1$, $P < 0.001$). Residents in the high-HLB area estimated that pests and diseases were the main culprits behind the yield decline, as opposed to other factors ($\chi^2 = 41.346$, $df = 4$, $P < 0.001$) (Table 3).

Detection and Identification of Citrus Pests

Residents were asked which of the pests listed in Table 4 (citrus mealybug, leafminer damage, rust mite damage, ACP) they found on their citrus trees—only pictures were provided, not names (Fig. 2). Compared to other citrus pests, citrus leafminers were

Table 2. Citrus cultivation and care in residential areas

Section	Region		Chi-square	*P*-value
	Low-HLB incidence (%)	High-HLB incidence (%)		
1. # citrus trees	**(*n* = 311)**	**(*n* = 218)**		
≤3	53.38	66.51	8.596	0.003*
4–6	29.90	21.56	4.166	0.041*
>7	16.72	11.93	1.977	0.159
2. Citrus age	**(*n* = 287)**	**(*n* = 217)**		
<1	4.87	8.75	2.435	0.118
2–4	28.92	29.03	1.126e–29	1
≥5	62.20	62.21	0.693	0.404
3. Species cultivated	**(*n* = 312)**	**(*n* = 219)**		
Orange	48.72	54.34	1.409	0.235
Tangerine/satsuma	58.65	30.59	39.547	0.001*
Limes	33.33	46.12	8.343	0.003*
Lemons	67.31	63.01	0.868	0.351
Grapefruits	28.53	27.85	0.005	0.943
Others	32.37	23.74	–	–
4. Citrus care	**(*n* = 301)**	**(*n* = 214)**		
Pest management	51.83	56.54	0.936	0.333
Watering	89.70	89.72	9.174e–31	1
Fertilizing	93.36	88.32	3.373	0.066
Weeding	73.09	77.57	1.109	0.292
Pruning	82.72	77.10	2.163	0.141
5. Training	**(*n* = 305)**	**(*n* = 215)**		
Social media	25.90	17.67	4.434	0.035*
Specialized blogs	21.64	14.42	3.870	0.049*
UF/IFAS Extension	76.39	81.86	1.931	0.164
Others	30.49	20.47	6.026	–

An asterisk (*) indicates significance difference between region ($P < 0.05$).

Table 3. Trend of citrus production on residents' properties and perceived factors responsible for the decline of citrus yield in backyards

Region	Trend (%)			
	Increased	Similar	Declined	Not sure
Low-HLB	33.01	30.77	21.36	14.89
High-HLB	15.14	23.39	44.50	16.97
Chi-square	20.499	3.09	30.953	0.276
P-value	5.96e–06*	0.078	2.64e–08*	0.598
	Perceived factors (%)			
	Pests and diseases	Climate change	Inadequate maintenance	Citrus aged
Low-HLB	32.29	7.29	21.88	18.75
High-HLB	39.87	12.42	13.73	20.92
Chi-square	1.146	1.155	2.242	0.063
P-value	0.284	0.282	0.134	0.8

An asterisk (*) indicates significance difference between region ($P < 0.05$).

most frequently reported in residents' backyards in both regions (χ^2 = 414.24, df = 4, P < 0.001). While no significant differences were found between high-HLB and low-HLB regions for leafminers and citrus mites, variations were observed for other citrus pests (Table 4). In particular, more residents in areas where HLB is prevalent detected hemipteran pests on their plants than those in areas where HLB incidence is low. Residents were also asked to select among these pests what they believed to be the most damaging to their citrus fruit. ACP was ranked as the main concern in 35.49% of residents' responses, followed by mealybugs (24.35%), citrus leafminers (22.54%), and russet mites (17.62%).

While 91.85% of all residents (n = 528) inspected their plants for pests and diseases, the monitoring methods used in all regions were significantly different (χ^2 = 874.78, df = 2, P < 0.001). Residents primarily used visual inspection (90.71%) to monitor for pests and diseases, followed by sticky traps (3.21%). Less than 1% reported using sprays as a substitute for pest inspection. There were no significant differences between regions for either method (Visual inspection: χ^2 = 0.001, df = 1, P < 0.968, sticky trap: χ^2 = 7.735e–34, df = 1, P < 1).

Identification and Detection of ACP

During the survey, residents' knowledge regarding ACP was tested. Two magnified images of an adult and nymph were displayed (as opposed to the wide shot image of ACP in Fig. 2D), and respondents were asked to select from a multiple-choice question presenting 5 citrus pests, the name corresponding to the pest depicted in the images (Fig. 3). Regardless of the region considered, the majority (72.4%) identified ACP correctly (Fig. 3). Residents were also asked if they had seen this pest on their trees. Surprisingly, only 7.37% reported ACP infestation on their citrus trees. However, in 70.84 % of cases, ACP detection was reported in areas with high-HLB incidence

Table 4. Citrus pests detected in residents' backyards

Pests	Detection	Region		Chi-square	P-value
		Low-HLB (%)	High-HLB (%)		
Mealybug	Never found	62.37	52.68	4.284	0.038*
	Found	25.76	37.07	6.788	0.009*
Citrus leafminer	Never found	22.15	30.99	4.681	0.030*
	Found	73.29	65.26	3.489	0.061
Asian citrus psyllid (ACP)	Never found	76.11	64.53	7.309	0.006*
	Found	13.99	25.62	9.883	0.001*
Russet mite	Never found	75.43	70.79	1.092	0.296
	Found	20.14	24.26	0.961	0.326

An asterisk (*) indicates significance difference between region (P < 0.05).

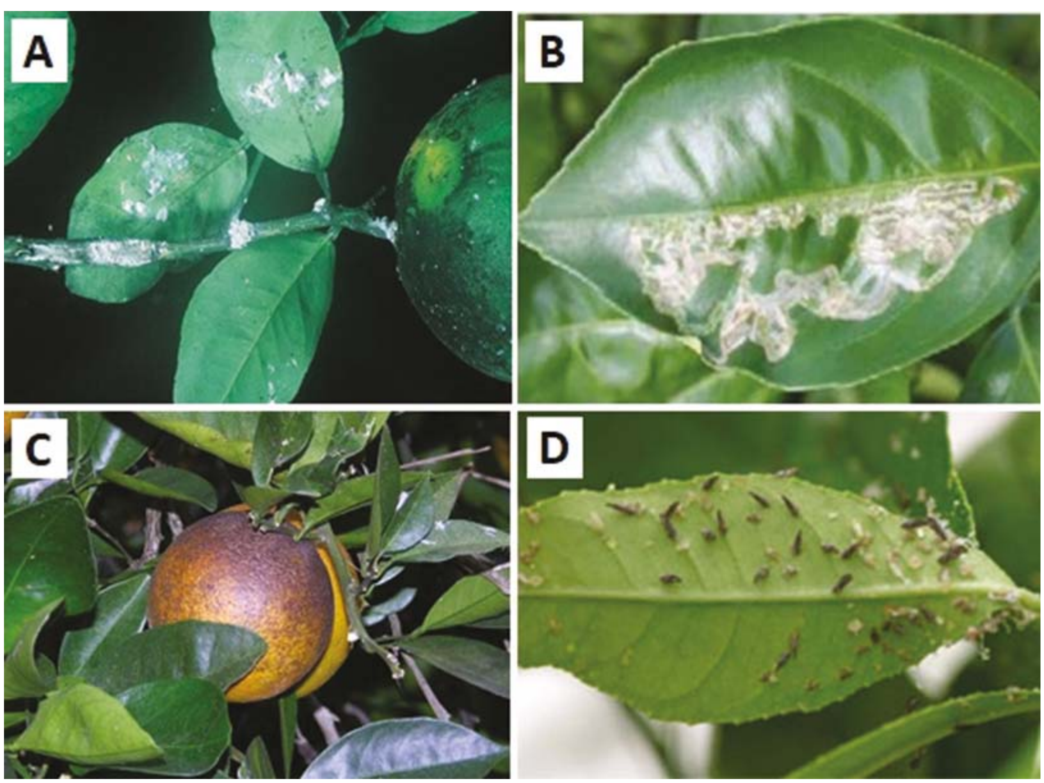

Fig. 2. Photos used to investigate the citrus pests most likely to be found in residents' backyards. A) citrus mealybugs; B) leafminer damage; C) Russet mite damage; D) Asian citrus psyllid. Credit photos: A) UF/IFAS CREC, B) ucanr.edu, C) Don Ferrin, D) Michael Rogers, UF/IFAS.

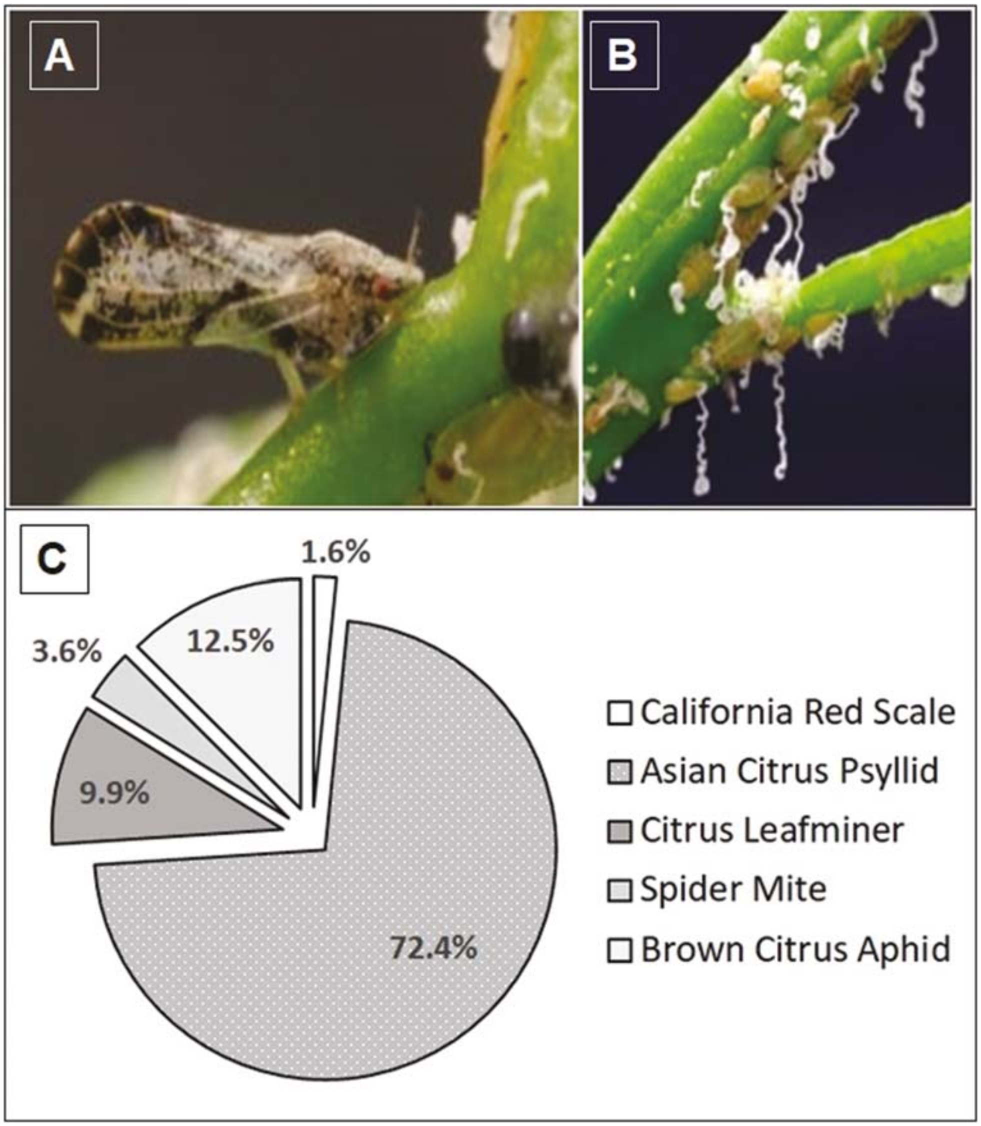

Fig. 3. Homeowner answers, C) when they were asked to name Asian citrus psyllids based on the 2 pictures, A and B) provided. Credit photos: A and B) Michael Rogers, UF/IFAS.

Table 5. Control strategies currently used by residents with ACP infestation

Control strategies	Region		Chi-square	*P*-value
	Low-HLB	High-HLB		
	%, $n = 7$	%, $n = 17$		
Biopesticide	14.29	23.53	2.06e–31	1
Conventional insecticide	0.00	29.41	1.123	0.289
Biological control	0.00	23.53	0.645	0.421
Manual destruction	57.14	47.06	9.94e–33	1
Trapping	0.00	11.76	0.018	0.892
Pruning	57.14	23.53	1.235	0.266
Other	14.29	29.41	0.067	0.795
None	14.29	11.76	1.42e–33	1

rather than in low-HLB incidence ($\chi^2 = 4.1667$, $df = 1$, $P < 0.041$). Among those who find ACP on their trees, 62.5% have found them more than 2 years ago.

Management Practices Used to Control ACP and HLB in Backyards

Except for a few residents, most have tried various strategies to control ACP (Table 5). These range from the use of cultural practices to the application of insecticides. In terms of management strategies against HLB, tree removal was the tactic most reported in both regions, as was tree pruning in areas with low HLB incidence (57.14%). Other strategies, such as conventional insecticides, biological control, and trapping, were only reported by residents in areas where HLB is prevalent (Table 5). In addition to these tactics, residents mentioned the use of mesh bags, micronutrient fertilizers, or removing alternative ACP/HLB hosts such as orange jasmine bushes.

Residents declared using control methods against ACP at various frequencies (Fig. 4); the frequency of intervention was higher in areas with high HLB rates as compared to those with low HLB rates ($\chi^2 = 30.167$, $df = 4$, $P < 0.001$). Only a few (33.34%) stated that their tactics were effective, while almost half (47.6%) said the strategies used were not effective. Others (19%) found that control methods did not provide the expected outcomes at all.

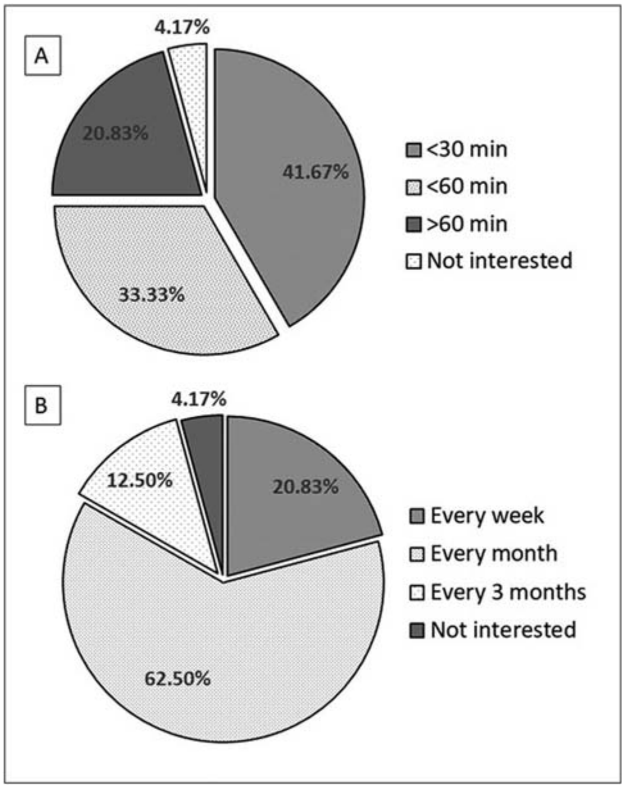

Fig. 4. Homeowner response regarding: A) spending time in ACP backyard management and B) frequency of intervention in ACP backyard management.

Table 6. Control methods residents would be willing to implement against ACP in the future

Control strategies	Region		Chi-square	*P*-value
	Low-HLB	High-HLB		
	%, $n = 310$	%, $n = 219$		
Conventional insecticide (Chemical insecticide)	49.68	39.27	5.197	0.022*
Bioinsecticide (Natural insecticide)	75.48	76.71	0.049	0.823
Biological control (predator, fungus, or parasite)	63.87	72.15	3.626	0.056
Visual Repellent (Reflective mulch)	36.77	37.90	0.029	0.863
Tree bagging	23.23	28.31	1.495	0.221
Odor repellent (Essential oil)	50.65	50.23	3.81e-05	0.995
Other	6.45	6.39	1.28e-30	1

An asterisk (*) indicates significance difference between region ($P < 0.05$).

Although lack of knowledge and the cost of control methods were mentioned, the biggest challenges for residents were the ineffectiveness of control methods (41%) and the time required to control the pest (30%). Most residents stated that they did not intend to devote more than 30 minutes monthly to ACP control (Fig. 4).

Willingness to Implement Management Practices if Psyllid and HLB Detected in Backyards

We asked residents what strategy they would be willing to apply in the future to control ACP and HLB. Residents reported they would primarily be willing to try out environmentally friendly solutions such as biological or olfactory repellents (Table 6). There was less interest in testing physical tactics, such as tree bagging and reflective mulch across regions. We also found that residents in regions with low HLB incidence were slightly more likely to use conventional insecticides to control ACP infestations than those living in high-HLB-incidence regions. Conversely, in high-HLB areas, more residents reported being willing to test biological control than in areas with low-HLB distribution (Table 6). Eighty-six percent (86%) of residents reported being willing to spend money to control ACP efficiently ($\chi^2 = 235.37$, $df = 1$, $p < 0.001$), and among those, 79% said they would spend up to $100 annually. Residents indicated they would preferentially control ACP on a weekly and monthly basis than on a quarterly and annual basis ($\chi^2 = 547.7$, $df = 4$, $P < 0.001$) (Fig. 5). Most residents would be willing to devote more than 60 min a month to ACP control ($\chi^2 = 157.87$, $df = 3$, $P < 0.001$) (Fig. 5).

Infected Tree Removal

Finally, we surveyed residents about their thoughts on tree removal due to HLB infection. We found that 81.85% would be willing to destroy infected trees as compared with only 3.59% who would not. The remainder (14.6%) were unsure whether they would dispose of their trees. Almost half (47.45%) would be willing to remove their plants immediately after the disease is detected, and around a quarter (28.54%) would prefer to dispose of infected citrus trees after their decline. Only 5.86% would remove their tree if there was financial compensation or a gift of a new tree (Table 7). Interestingly, there was no difference in residents' behavior regarding HLB tree removal depending on which area they were living in.

Discussion

Citrus Fruits in Residents' Backyards

Most of the citrus plants have been installed in residents' backyards for more than 5 years; however, due to the HLB epidemic, residents in the high-HLB areas tend to have fewer trees than those in the low-HLB areas. Differences in the citrus species cultivated are likely due to climate considerations (mandarin trees such as satsuma are cold tolerant) rather than a consequence of HLB. This is because the species is particularly suited to cold climatic conditions and, being a cold-hardy citrus, dormant trees can survive freezing temperatures (14–18 °F) prevailing in northern Florida without severe injury (Martini and Andersen 2018, Andersen et al. 2023).

Residents have gained knowledge in citrus care primarily through the University of Florida Extension programs (UF/IFAS Extension). This bias may be due to the initial distribution of the survey through UF/IFAS Extension agents. In addition, residents living in areas with a low prevalence of HLB disease were more prone to use more resources (blogs and social media) to gain knowledge about citrus care. This behavior could reflect their interest in acquiring more knowledge about the disease to take timely action in the event of early detection. Residents paid more attention to citrus care practices, which can have direct impact on the growth and production of their trees, than to pest and disease control, although many considered pests and diseases to be the main culprits in citrus yield decline. Residents' behavior suggests that they have less interest in controlling pests and diseases if their trees continue to produce fruit. This finding presents an interesting educational opportunity given the importance of preventing HLB, which would mean decline is never observed.

Contribution Level of Residents in ACP and HLB Management

Most residents were likely able to identify ACP by name because they had already been informed about the pest through workshop

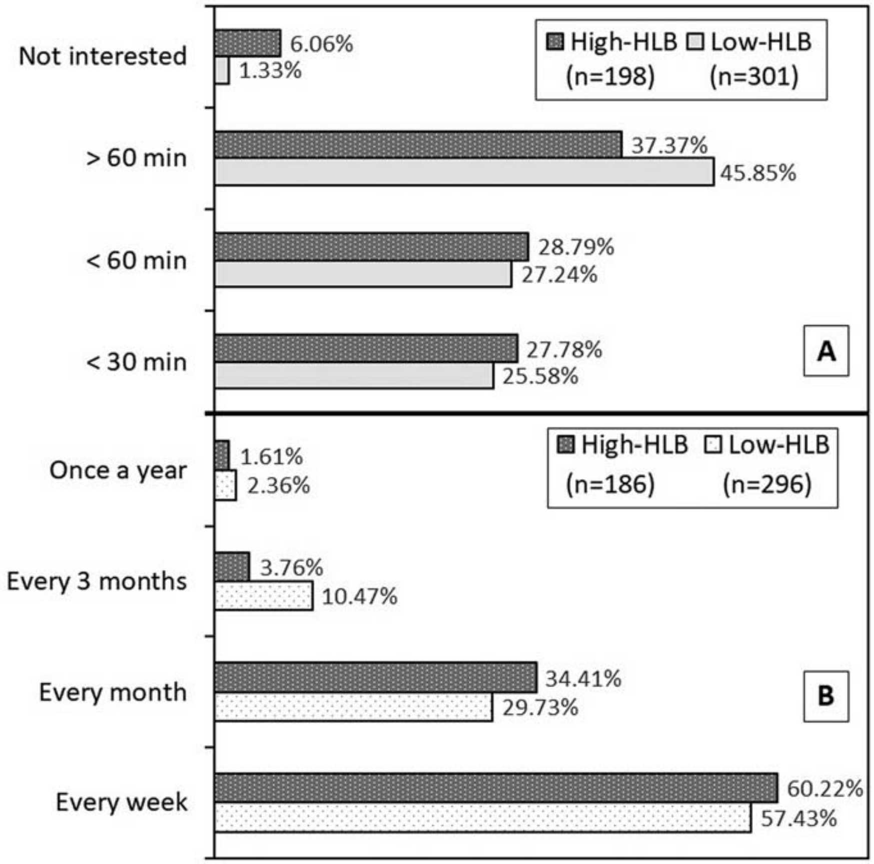

Fig. 5. Homeowner responses regarding: A) intervention frequency and B) time to be devoted by residents to manage ACP in the future.

Table 7. Residents' consent regarding removal of HLB symptomatic trees

Response	Region		Chi-square	*P*-value
	Low-HLB	High-HLB		
	%, *n* = 310	%, *n* = 219		
Yes immediately	50.32	43.38	2.210	0.137
Yes, but after the tree has declined	25.81	32.42	2.437	0.118
Yes, if I receive compensation (financial or a gift)	5.16	6.85	0.392	0.531
No	3.55	3.65	2.32e–31	1
Not sure	15.16	13.70	0.118	0.73

training programs, websites, social networks, or other means previously mentioned. This demonstrates basic identification skills in both high and low-HLB areas. However, the identification of ACP in pictures did not translate to detection in the field, as only 7.37% of residents declared to have found ACP on citrus in the last 2 years, a number extremely low as compared to the prevalence of ACP locally (Britt et al. 2020, Graham et al. 2020). Interestingly, when provided a picture with a larger scale with ACP adults and nymphs, wax, and honeydew but no indication of the pest identification (Fig. 2D), more residents declared to have found it on their property, probably because this picture translated more to what residents are experiencing in their trees. Therefore, for residents, recognizing ACP on macro pictures does not provide the skill to recognize it in the field. This finding could be exploited to improve the extension program. While photos or slides can be used for an initial introduction to pest identification, field activities need to be integrated as practical skills for detecting pests in situ.

It was noted that the tactics implemented to control ACP (Table 5) were not considered effective, as they failed to control the psyllid infestation of trees and reduce the spread of HLB. An important takeaway is that the maximum amount of time they were likely to devote to monitoring and managing ACP may not exceed 1 h per month; therefore, the less time it takes to manage ACP, the more likely residents are to engage. Monthly reminders (text message or email) of scheduled phytosanitary tasks would be an excellent incentive to keep residents informed of what needs to be done.

An important takeaway from this survey is that few (3.55%) residents were against removing HLB trees from their property. Some (30.97%) have specified conditions (compensation or significant decline) for destroying their citrus trees, but overall, we could not find a strong defiance against tree removal, which should continue to be promoted, especially in low-HLB areas to reduce bacteria inoculum (Bassanezi et al. 2013).

Residents in both regions have unanimously expressed their intention to help combat the spread of the pest, preferentially by using biological tactics (organic or natural insecticides and bioagents) and repellents more than other strategies such as insecticides, reflective mulch, and tree bagging. Residents in low-HLB areas would be more prone to use pesticides in the event of ACP detection than those from high-HLB areas. Insecticides are the most rapid way of slowing the vector's spread. Reflective mulch and tree bagging are 2 tactics recently implemented by the UF to prevent citrus infestation by ACP (Gaire et al. 2022) and are being tested with residents as part of research conducted by IFAS/UF. This is very interesting and promising research that should be widely supported by citizens who promote environmentally friendly pest control tactics. Our survey suggests that it may take longer for them to adopt these methods and be convinced of their outcome, as these methods also have an aesthetic impact on resident properties.

The demographic results (predominantly white at 88.69%) were a significant deviance from the demographics of the State of Florida (White 52.3%, Hispanic/Latino 27.1%, and Black or African American 17.0%) (U.S. Census 2023), which is considered a limitation of the survey. Additionally, most respondents were those with whom the IFAS extension service usually collaborated, leaving possible ambiguity regarding the diversity of respondents' answers to some questions.

This study is an important step toward refining ACP control measures in urban habitats. Additional initiatives to boost residents' awareness, monitor ACP populations and HLB incidence, assess damage according to growth stage, and advise on appropriate means and timing of control are needed and are key elements of outreach programs for sustainable ACP and HLB management. Extension specialists should, therefore, be aware of the significance of this work in better addressing residents' needs. Specifically, basic knowledge in ACP identification is still needed even in areas where HLB is endemic. Also, we noticed that many homeowners are reluctant to use innovative tools for ACP control. Short workshops conducted within Extension offices with hands-on activities with preserved ACP specimens, trees bagging, or reflective mulch demonstrations have been conducted by our team and have been shown to improve involvement in ACP management and increase willingness of HLB tree removal (Exilien & Martini, unpublished data). In areas where HLB is still rare, HLB detection and HLB tree removal should remain the priority (Bassanezi et al. 2013). Our survey shows that tree removal is less controversial than initially anticipated and that the rate of acceptance by homeowners increases if compensation is offered. A State program for tree removal where another tree or financial compensation is offered could help mitigate HLB in areas where the disease is still rare but spreading.

Supplementary Material

Supplementary material is available at *Journal of Integrated Pest Management* online.

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Romain Exilien (Data curation [lead], Formal analysis [lead], Investigation [equal], Methodology [equal], Visualization [lead], Writing—original draft [lead], Writing—review & editing [equal]), Laura Warner (Methodology [equal], Supervision [supporting], Writing—review & editing [equal]), Lauren Diepenbrock (Investigation [supporting], Supervision [supporting], Writing—review & editing [equal]), Danielle Williams (Funding acquisition [supporting], Investigation [supporting], Writing—review & editing [supporting]), and Xavier Martini (Conceptualization [lead], Funding acquisition [lead], Investigation [equal], Methodology [equal], Project administration [lead], Supervision [lead], Writing—review & editing [equal])

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