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Diurnal Patterns of Flight Activity and Effects of Light on Host Finding Behavior of the Asian Citrus Psyllid

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Abstract The Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Psyllidae), is an invasive pest of citrus in the United States. The psyllid feeds and reproduces primarily on new flush growth of citrus and other rutaceous plants. Because it vectors the bacterial causal agents of the deadly citrus greening disease, *D. citri* is potentially a pest of economic importance in all citrus growing areas where it occurs together with the disease. We investigated the diurnal patterns of its flight activity in the field and the effects of light on its host selection and egg laying behaviors. The numbers of adult psyllids caught on yellow sticky traps were 3 to 4-fold higher during daytime than nighttime. Daytime flight activity of *D. citri* adults also varied with time of the day with peak catches occurring at midday from 1200 to 1500 h. Illumination of the traps at night increased their attractiveness to adult psyllids by 5-fold. Similarly, light significantly increased plant colonization by adults and female egg deposition on potted plants in the laboratory. These results showed that the flight activity and host selection behavior of adult psyllids are regulated by light and circadian rhythms. Thus, adult psyllids utilize light as visual cues in their host-plant selection process.

Keywords *Diaphorina citri* · light · phototaxis · circadian rhythm-host plant selection · Huanglongbing

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Introduction

The Asian citrus psyllid, *Diaphorina citri* (Kuwayama) (Hemiptera: Psyllidae) is native to tropical and subtropical Asia, but has invaded the U.S. in the last decade (Halbert and Manjunanth 2004; French et al. 2001). *D. citri* feeds on foliage and twigs of its rutaceous host plants, but reproduces exclusively on new flush shoot growth. In south Texas, *D. citri* overwinter as adults from November to early February and population growth is observed from mid February to early November (M. Sétamou unpublished data). Although flush deformation or epinapsis and occasionally flush death may result from adult and nymphal feeding injury under high populations (Michaud 2004), *D. citri* is economically important because it vectors the bacterial pathogen of citrus greening disease or Huanglongbing (Halbert and Manjunath 2004). Citrus greening is one of the deadliest citrus diseases in the world for which there is no known cure (Bové 2006). Citrus greening disease was reported for the first time in the U.S. in Florida in 2005 (Halbert 2005), but has since spread throughout most of the citrus producing areas of that state and into other states in southeastern U.S. and Mexico, thus posing a major threat to the sustainability of U.S. citrus industry.

Because *D. citri* is an oligophagous insect with a host range restricted to plants in the Rutaceae family (Aubert 1990), it is therefore reasonable to believe that olfaction plays an important role in its host finding and selection process. The use of olfactory cues by adult psyllids in host plant selection has been demonstrated in olfactometer studies (Patt and Sétamou 2010; Wenninger et al. 2009; Sanchez 2009). In addition, the presence of olfactory sensilla on the antennae of adult *D. citri* was reported (Onagbola et al. 2008), and these sensilla may be responsive to different host plant odors. Studies on the repellent effects of guava to adult *D. citri* have been reported (Zaka et al. 2010), further supporting the hypothesis of olfactory cues perception by *D. citri*. However, the differential responses of adult psyllid to un-baited color traps with preferences to yellow and red traps (Hall et al. 2010; Sanchez 2009) also suggest that visual cues may also be involved in the host selection process of this pest. Wenninger et al. (2009) have shown that the responses of *D. citri* adults to host plant odor in the olfactometer was dependent on the presence of light. Hence, both olfactory and visual cues may play an important role in the host finding and selection process by *D. citri*. In south Texan citrus orchards, *D. citri* was more abundant on perimeter trees along the south-eastern side of groves as well as on the south-eastern quadrant of tree canopy (Sétamou et al. 2008). These are more illuminated than others, suggesting that light may play an important role in the behavior of this pest. Similarly, Hall (2009) reported higher *D. citri* densities on the east side of the grove in Florida, again, probably as a result of better illumination. Attraction to light has been demonstrated in many Hemipteran species. The positive response of adult to light or phototaxis has been reported for the eucalyptus psyllid, *Cardiaspina densitexta* (White 1970) and for the carrot psyllid, *Trioza apicalis* (Nissinen et al. 2008). In our laboratory colonies, *D. citri* adults readily fly toward light in rearing cages and aggregated on illuminated plant parts (M. Sétamou unpublished data). Thus far, no studies have reported the effects of light on the behavior of *D. citri* and its diurnal flight pattern.

The objectives of the present study were (1) to evaluate the effects of light on the behavior of this pest and (2) to better understand the diurnal flight pattern of *D. citri*. Our working hypothesis was that higher trap catches would be observed during daytime and on illuminated traps at night if *D. citri* exhibits a strong attraction to light. Results of the present work can potentially improve monitoring programs for the psyllid and also help in the scheduling of pesticide spray applications.

Materials and Methods

Insects

Diaphorina citri adults used in the experiments were obtained from laboratory colonies maintained at the Texas A&M University-Kingsville Citrus Center, Weslaco, TX. Adults were collected from a grapefruit (*Citrus*×*paradisi* Macf.) orchard at the Citrus Center and reared for several generations on potted orange jasmine (*Murraya paniculata* (L.) Jack) plants maintained in screened cages at 26±5°C, a photoperiod of 14 L: 10 D, and 45±5% RH. Lighting was provided by four fluorescent lamps producing a light intensity of ca. 1,200 lux at the plant foliage level. Newly emerged and mated individuals (~7 d-old) were used in the experiments.

Plant Materials

Potted grapefruit (var. 'Rio Red') and orange jasmine plants grown in Miracle-Gro® potting soil (Miracle-Gro®, Lawn Products, Inc. Marysville, OH) under natural ambient conditions were used in the tests. Plants were regularly pruned to induce production of new flush shoots, and only plants (1 year old) with new flush growth were used in the experiments.

Comparison of Daytime Versus Nighttime Trap Catches of Adult *D. citri*

Double-sided yellow sticky traps (Trece Inc., Adair, OK) were suspended ~1.5 m above ground onto the outer canopy of trees using a white twist tie. Two trapping periods of 12 h each were compared: daytime for which traps were deployed from 07:00 h to 19:00 h and nighttime with trap deployment from 19:00 h to 7:00 h. The study was conducted for 12 non-consecutive days (pairs of day and night) between early March and early April 2008, when the duration of daylight is somewhat similar to nighttime in south Texas. Only data of non-rainy periods and nights without bright moonlight were considered. For each trapping period, four traps were randomly placed along the eastern perimeter of a 5-ha block of 5 year-old 'Rio Red' grapefruit. Traps were separated by a minimum distance of 10 m. To ensure that trap handling time did not affect its trapping efficiency, four additional traps were deployed at the beginning of each trapping day at 7:00 h and retrieved the following morning at 7:00 h for a total of 24 h exposure time. When traps were retrieved at the end of the trapping period, they were placed in Ziploc plastic bags (26.8×27.3 cm) (S.C. Johnson &Son, Inc., Racine, WI) and brought to the laboratory where *D. citri* adults were counted under a microscope. The grapefruit block did not receive any insecticide treatment two months prior to and during the study. A paired t-test was used to compare the number of *D. citri* adults caught on sticky traps deployed during daytime and nighttime. In addition, the sum of daytime and nighttime data for each trapping day was compared to the full 24 h cycle trapping data using a log-likelihood ratio test.

D. citri Trap Catches during Different Daytime Periods

D. citri flight activity in relation with the time of the day was studied using yellow sticky traps for seven non-consecutive days from April to May 2008. For this study, five traps were deployed on trees along the southern perimeter of the same unsprayed grapefruit block for each of the four periods: 6:00–9:00 h, 9:00–12:00 h, 12:00–15:00 h and 15:00–18:00 h. For each trapping day, five additional traps were deployed from 6:00 to 18:00 h and served as control. A multi-observational (i.e., measurements over time) analysis of variance (PROC ANOVA) followed by Ryan-Einot-Gabriel-Welsch multiple range test was used to compare the numbers of *D. citri* trap catches during the four daytime periods. A log-likelihood ratio test was used to compare the sum of *D. citri* trap catches during the four periods and those trapped on traps exposed for 12 consecutive hours.

Effect of Light on *D. citri* Trap Catches at Night

To examine the effect of illumination at night on *D. citri* trap catches, four 32-watt T8 straight-line fluorescent lamps (2.6 cm diameter and 122 cm long) with a mean light output of 2,800 lumens and a color temperature of 4,100 K (model F32T8/XL/SPX41/ECO, General Electric, www.gelighting.com) each were randomly positioned on trees along the eastern perimeter of a 1.5 ha block of 5 year-old Meyer lemon trees at the Texas A&M-Kingsville Citrus Center in Weslaco. The lemon trees were regularly pruned to maintain their height ca. 1.5 m. The lamps were held horizontally on two wooden posts at approximately 2 m above ground such that the entire canopy of a lemon tree was illuminated. The lamps were separated by a minimum distance of 20 m, which prevented the overlapping of their diffusing light. The lamps were connected to a timer that automatically turned them on at 19:00 h and off at 7:00 h the following morning, thus providing 12 continuous hours of fluorescent light. A double-sided sticky Trece™ yellow sticky trap was placed at the outer canopy of the lemon tree under the light (30–50 cm below the lamp) so that both sides of the trap were fully illuminated. Light intensity at the level of the traps was~2,000 lux as measured by a light meter (ISO-17025, Fisher Scientific, www.fishersci.com). Four additional traps placed on randomly selected non-illuminated trees with similar lamps served as controls. All traps were deployed at ca. 19:00 h and retrieved at ca. 7:00 h the following morning. The study was conducted for eight non-consecutive nights from March to April 2008. Only nights with no rainfall and bright moonlight were selected for the study. A paired t-test was used to compare *D. citri* trap catches of illuminated and non-illuminated traps.

Effect of Light on *D. citri* Host Selection and Oviposition

Potted grapefruit plants (~ 30 cm tall) were used for this test. Each plant was covered with a 2-L clear plastic bottle (diameter 16 cm, height 35 cm). The top end of the plastic was sealed with a fine mesh for aeration and that also prevented adult psyllids from escaping. Each potted plant was infested with five pairs of *D. citri* before sealing the top end of the bottle. All infested potted plants were placed within a card box by groups of five. Four card boxes (i.e. 20 plants) were covered with a clear screen to prevent *D. citri* from escaping, and placed under a fluorescent lamp that provided continuous illumination of ~3,000 lux. The other four boxes (i.e. 20 plants) were individually covered with a black cotton cloth to create continuous darkness. All boxes were kept in the laboratory at 24±2°C, 60±5 RH. The number of adults found on plants was recorded on four occasions during the first day, and twice daily until the fourth day after infestation. For plants placed in darkness, a red light was used to record the position of psyllids for about 2 min per plant and the box was immediately covered. After the last observation on the fourth day, plants were individually examined for the presence of *D. citri* eggs that were counted using a 10x hand lens. Numbers of adult psyllids observed on plants during each observation period were subjected to a repeated measure analysis of variance using the Proc Mixed of SAS (Littell et al. 1996). The numbers of eggs recorded on illuminated plants and those kept under complete darkness were compared using a t-test. A chi-squared test was performed to evaluate the effect of illumination on plant preference for *D. citri* oviposition.

Settling of *D. citri* Adults on Host and Non-host Plants as Affected by Light

Guava, (*Psidium guajava* L. cv. Pearl [Myrtales: Myrtaceae]), is a non-host plant for *D. citri* and has been shown in some instances to repel adult psyllids (Zaka et al. 2010). A choice test in which flush shoots from a host plant (grapefruit) and the guava non-host plant were simultaneously provided to adult psyllids was conducted in the laboratory under either light condition with an illumination of ~3,000 lux or darkness. In this experiment, clear glass desiccators (Secador® Techni-Dome® 360 Vacuum Desiccator, Bel-Art Products, www.belart.com) with a perforated circular tray to support aquatubes were used. Ten cm long excised flush shoots of either plant were individually put in the aquatubes containing hydroponic (General Hydroponics, Sebastopol, CA) solution soon after collection to maintain their turgidity. Host plant flush shoots were obtained from 2 year-old potted 'Rio Red' grapefruit, while guava flush shoots originated from young potted plants (~12 months old) grown in Miracle-Gro® potting mix soil. Two aquatubes containing flush shoots of either tested plant were placed on opposing ends along a diameter of the tray (Fig. 1), such that the airflow is symmetrical and distributed equally onto the flush shoots tested. Five pairs of mated *D. citri* adults were released in the desiccator that was immediately covered with the clear plastic lid. Three desiccators were simultaneously run under each of the two lighting conditions. The trial was replicated six times. The number of adults settling on either plant was recorded after 24 h. A two-way ANOVA was used to evaluate the effects of light condition, plant type and their interaction on number of *D. citri* adults found on flush shoots (Zar 1999).

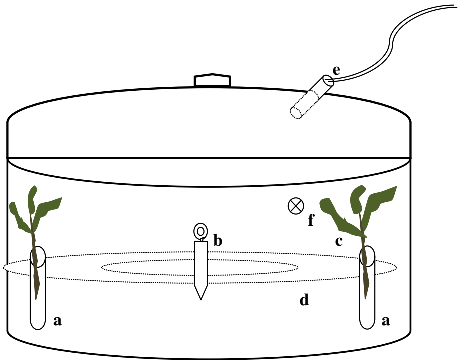


Fig. 1 Schematic diagram of a desiccator arena used for *Diaphorina citri* choice test between host and non-host plant flush shoots. **a** aquatube containing hydroponic solution, **b** Eppendorf tube containing adults released in the arena, **c** flush shoot of tested plant, **d** perforated tray used to hold aquatubes, **e** aeration connected to a vacuum pump, **f** aeration orifice covered with a fine mesh on side of the desiccators

Statistical Analysis

All analyses were performed using SAS for windows version 9.2 (SAS Institute 2008). All trap counts were log (x+1)-transformed before analysis, but actual means are presented in the results. Appropriate analyses used for collected data for each study are presented under the study description.

Results

Comparison of Daytime Versus Nighttime Trap Catches of Adult *D. citri*

There was no significant difference between the cumulative number of nighttime and daytime *D. citri* trap catches and the number of psyllids caught over a 24 h-period (paired $t=1.11$, $df=47$, $P=0.27$, Fig. 2a) suggesting that handling of traps did not affect their trapping efficiency. Over the 12 days, traps deployed during daytime caught a total of 253 adult psyllids, whereas traps deployed at nighttime caught only 73 psyllids. Although *D. citri* adults were readily caught on yellow sticky traps both at nighttime and daytime in the 24 h cycle, the mean trap catches was 3.5-fold higher during daytime compared to nighttime (paired $t=4.42$, $df=47$, $P<0.0001$, Fig. 2b), suggesting a greater flight activity of adult psyllids during daytime.

D. citri Trap Catches during Different Daytime Periods

Low numbers of adult *D. citri* were captured during the four observation periods with daily maximum trap catches not exceeding 18 individuals. There were significant differences in the mean number of *D. citri* captured on traps between the four periods ($F=4.53$, $df=3$, 24, $P=0.01$). The mean number of *D. citri* during the early afternoon from 12:00 h to 15:00 h was significantly higher than those of the morning trapping periods (06:00 h–9:00 h and 09:00 h-12:00 h), but was comparable to the mean trap catches of the late afternoon period from 15:00 h to 18:00 h (Tables 1 and 2).

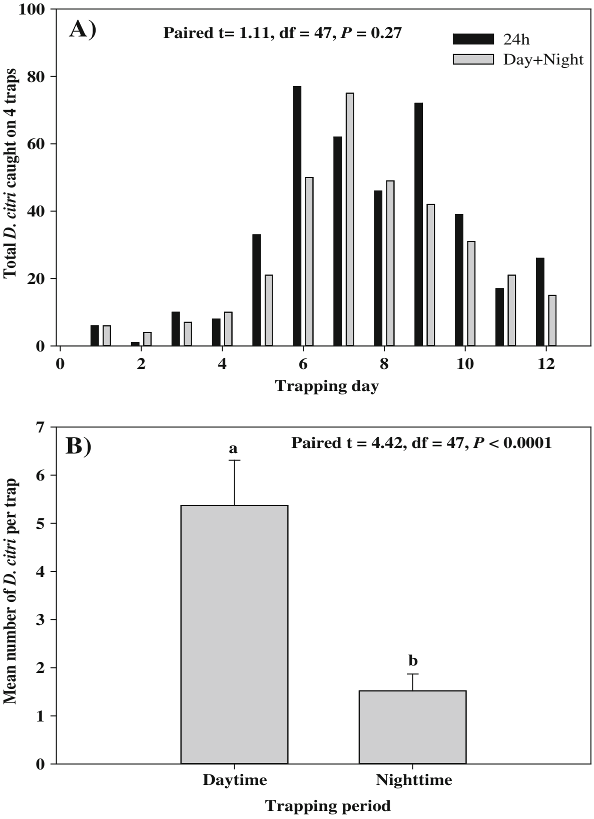


Fig. 2 *Diaphorina citri* trap catches during daytime and nighttime over a 12-days period. **a** Comparison between trap catches over a 24 h-period and cumulative daytime and nighttime catches to evaluate the effect of trap handling; **b** Mean comparison between daytime and nighttime trap catches

Effect of Illuminating Trees on *D. citri* Trap Catches at Night

Very low numbers of adult *D. citri* were captured on traps at night under darkness. Significantly higher mean numbers of adult *D. citri* were caught on traps placed under light than their non-illuminated counterparts (t=4.05, df=7, P=0.005). Illumination of traps at night improved their *D. citri* trapping efficiency by 5-fold (Fig. 3).

Table 1 Mean number of adult *D. citri* caught on yellow sticky cards during different periods of day

Daytime period (h)	No. adults	Percentage
0600–0900	2.3±1.1 a	12
0900–1200	2.1±0.7 a	11
1200–1500	9.9±2.2 b	51
1500–1800	4.7±1.6 ab	26

No. of adults are presented as mean *D. citri*±SEM of 4 traps over a 7-non-consecutive day period. Different letters represent groups that significantly different (P<0.05), Ryan-Einot-Gabriel-Welsch multiple range test

Table 2 Settling and oviposition of *D. citri* on illuminated versus non-illuminated grapefruit plants

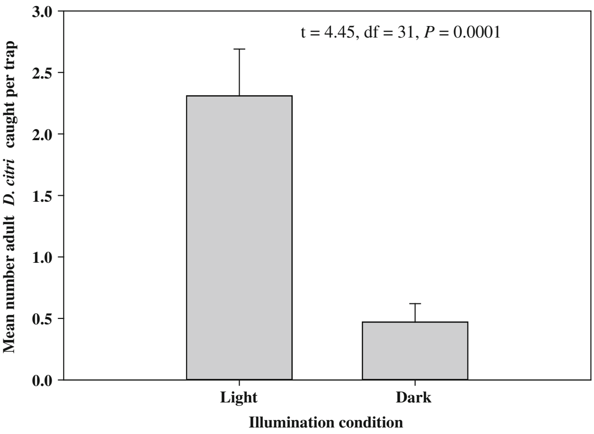
Plant condition	No. of *D. citri*/plant	% infested plants	No. eggs/plant
Illuminated	3.87±0.21	45	12
Non-illuminated	2.34±0.21	5	11
Statistic	t=5.03	G=9.52	t=4.89
df	18	1	8
P-value	< 0.0001	0.002	0.001

No. of *D. citri*/plant are presented as least squared means±SEM of 20 plants. A log-likelihood ratio (G) test was used to compare % plants infested with *D. citri* eggs

Effect of Light on *D. citri* Host Selection and Oviposition

In the host selection trial, the number of *D. citri* adults that settled on citrus plants varied with observation time (F=5.36; *df*=10, 180; P<0.0001) and illumination (F=34.48; *df*=1, 180; P<0.0001), but not with the interaction between time and illumination (F=1.5; *df*=10, 180; P=0.14). Numbers of *D. citri* adults observed on plants were consistently higher on illuminated plants than their non-illuminated counterparts throughout the experiment (Fig. 4). On average 81% of adults settled on citrus host when plants were illuminated versus 46% on non-illuminated plants, suggesting that light increased *D. citri* host selection by 1.8-fold. The remaining psyllids were found sitting on the side of the boxes or on the edge of plastic pots. Out of the 20 plants tested, only one plant was infested with eggs in darkness, whereas *D. citri* females laid eggs on 9 plants held under continuous illumination. The presence of light stimulated the oviposition behavior of *D. citri* females (log-likelihood ratio test, G=9.52, *df*=1, P=0.002). This also translates into higher (t=4.89, *df*=8, P=0.0012) egg deposition on infested plants under light (mean=14.4, SE=1.9) than under darkness (number of eggs=5).

Fig. 3 Effect of illumination on *Diaphorina citri* trap catches at night



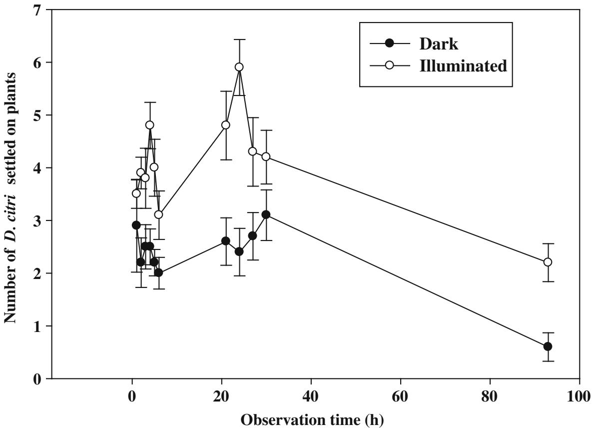


Fig. 4 Settled Asian citrus psyllids on illuminated versus non-illuminated grapefruit plants. *Error bars* are ±1 standard error of the mean

D. citri Adult Settling on Host and Non-host Plants

In a choice test between a host shoot and a non-host shoot, settling of *D. citri* adults was affected by illumination condition ($F=29.19$; $df=1$, 68; $P<0.0001$), but the effect of plant type was marginally significant ($F=3.62$; $df=1$, 68; $P=0.07$). However, the interaction between plant type and light condition was significant ($F=4.03$; $df=1$, 68; $P=0.012$), suggesting that the number of *D. citri* that settled on plant shoots varied with the light condition of the arena. Significantly more *D. citri* adults settled on illuminated shoots of either plant type (mean=4.7, SE=0.53) than compared to non-illuminated ones (mean=1.8, SE=0.18). In the illuminated arena, *D. citri* clearly preferred citrus host shoots to non-host guava shoots ($F=4.85$; $df=1$, 34 $P=0.03$), but numbers of adults that settled on the grapefruit host shoot did not significantly differ from those found on guava shoots in the non-illuminated arena (Fig. 5).

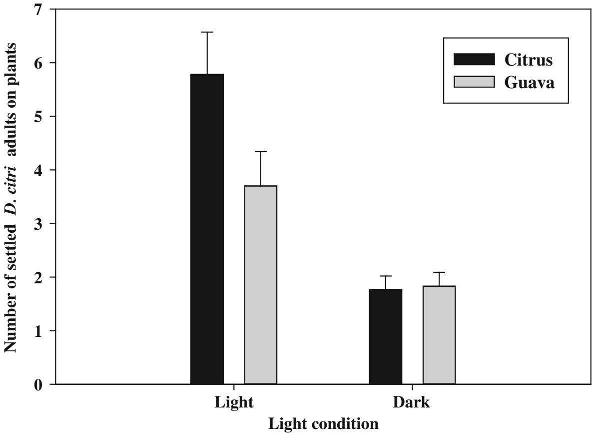


Fig. 5 Number of *Diaphorina citri* adults settled on host (*Citrus* × *paradisi*) and non-host (*Psidium guajava*) flush shoots in choice tests under light and darkness (under each light condition, plant species with overlapping error bars surrounding the means are not significantly different, $P>0.05$)

Discussion

Results of the present study clearly show that the behavior of *D. citri* is strongly affected by light. Adult psyllids exhibit positive phototaxis, and their host plant and target selections are determined by the presence of light. Because of the importance of light in *D. citri* behavior, adults were mainly trapped during the daytime indicating that the Asian citrus psyllid is a diurnal species. Very few adults were caught on yellow sticky cards at night, suggesting a lack of movement and/or an inability of locating the trap at night. The few number of adults caught on traps deployed at night may result from crepuscular light present after dawn and before dusk during the test period. Providing illumination at night increased the numbers of adults trapped by 5-fold or more, clearly showing that psyllids do move at night provided there is a source of light. Light is therefore one of the major entrainments to *D. citri* adults, as it induces their movement even in an environment where they would usually not do so. However, trap catches of illuminated traps at night (Fig. 3) were still lower than daytime trap catches (Fig. 2), suggesting that in addition to light, temperature may play an important role in *D. citri* movement.

The comparison of numbers of *D. citri* caught on sticky traps varied with the period of day, with higher trap catches during the afternoon hours. This was probably a result of higher insolation and air temperature during these hours in south Texas as solar radiation and air temperature have been shown to be positively correlated with weekly trap catches of *D. citri* (Hall 2009) and the intensity of these two factors vary with daytime. The US Weather bureau reports hotter temperatures in the afternoon compared to morning hours. Furthermore, solar radiation was greatest from 12:00 h to 15:00 h compared to any other daytime periods in this study (http://rredc.nrel.gov/solar/old_data/nsrdb/). Trap catches are a result of adult psyllid movement between trees within the groves and between groves. Since the flight and jumping activities by *D. citri* adults are more pronounced on windless, warm, sunny afternoons (Aubert and Hua 1990), it is not surprising that higher numbers of *D. citri* were caught during the afternoon hours. Variation in insolation with daytime can also lead to differential release of plant volatiles which will subsequently affect adult *D. citri* behavior. Production and emission of volatile organic compounds in plants vary with daytime (Lerdau et al. 1997).

Under illumination, when given the choice between citrus shoots and guava shoots, adult psyllids significantly preferred their host plant over the non-host plant (Fig. 5). But such preference was not observed under darkness. Guava is a non-host plant for *D. citri*, and some studies have reported its repellent effect on this insect (Zaka et al. 2010). The lack of discrimination between its host plant and non-host plant under darkness is a clear indication that *D. citri* requires light in its host recognition and selection. In addition, adult *D. citri* settling on both host and non-host shoots was significantly higher under light than under non-illuminated conditions. The mean number of adult psyllids recorded on non-host guava shoot under light (mean=3.7, Fig. 5) was significantly higher than that recorded on citrus host shoot under darkness (mean=1.8, Fig. 5), suggesting that light and visual cues may have a stronger effect than other host-related cues in *D. citri* host plant selection. Similar observations of the importance of light for target selection have been made with the carrot psyllid, *Trioza apicalis* (Hemiptera: Triozidae); *T. apicalis* preferentially selected a non-host leaf placed under light over a carrot host leaf held under weak light condition (Nissinen et al. 2008). Although *D. citri* adults respond positively to volatile cues produced by its Rutaceae host plants (Patt and Sétamou 2010; Wenninger et al. 2009), their non-discrimination between a host and a non-host flush shoot under darkness was somewhat surprising. But under illumination, adult psyllids exhibit a strong preference for their citrus host plant over the non-host guava. In addition, adult colonization of illuminated guava was higher than non-illuminated grapefruit. Thus, in addition to volatiles, visual cues may be required for *D. citri* host recognition explaining the higher numbers of adult psyllids settling on grapefruit flush shoots over the non-host guava shoots when light is present. Such synergism of visual and olfactory cues for host plant selection has also been reported for the carrot psyllid (Nissinen et al. 2008). Light may facilitate the perception of flush shoot color, leading to higher host selection and colonization. *D. citri* adults strongly prefers juvenile flush shoots of its host citrus host plants that are lime green in color over mature shoots that are dark green, and these two types of leaves have different reflectance values (Sétamou, unpublished data). Preference of juvenile over mature leaves was reported in the eucalyptus psyllids *Heteropsylla cubana* Crawford (Lapis and Borden 1995), *Ctenarytaina eucalypti* (Maskell) and *C. spatulata* (Taylor) (Brennan and Weinbaum 2001), and was mainly attributable to the differences in the color of these two developmental stages.

The significantly higher number of infested grapefruit seedlings with eggs under light compared to darkness also indicates that *D. citri* oviposition may be stimulated by light. This increase in female oviposition on illuminated plants may be the result of higher numbers of adults colonizing these plants.

Our results show that *D. citri* is positively phototactic and its behavior is governed by light. Because of the importance of light in its movement, *D. citri* is mainly a diurnal insect species with little movement at night when the perception of visual cues is reduced. But illumination during the scotophase somewhat increases the movement of *D. citri* adults. The higher numbers of *D. citri* trapped during the period of higher solar radiation and air temperature is indicative of the stimulatory effect light intensity and temperature on *D. citri* behavior. In laboratory colonies, *D. citri* adults readily move toward light, and preferentially colonize illuminated plants or plant parts. Such observations indicate that light is one of the most important factors governing *D. citri* host finding behavior.

Because *D. citri* is the vector of the deadly citrus greening disease, aggressive area-wide psyllid control programs are being implemented throughout all major citrus producing states in the United States (Rogers 2008; Sétamou 2009). Estimating adult psyllid densities in groves will assist in measuring the efficacy of the control programs and determining treatment thresholds. The use of yellow sticky traps (Hall 2009) and tap sampling (Hall et al. 2007) have been recommended for estimating *D.citri* adult populations in groves. In light of the variation observed in psyllid captures with respect to the time of day and light intensity in the present study, estimates of *D. citri* populations will tend to vary with the sampling method used and the time of day. For tap or beat tray sampling, more reliable estimates will be obtained if the sampling is done when psyllid movement is reduced from late evening to early morning hours. This time period may also be more convenient for chemical spray application. In contrast, although sticky traps are useful in obtaining *D. citri* population density estimates, trap catches are strongly influenced by adult psyllid moving behavior, which in turn is determined by light intensity.

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