

Effect of Host Plant on Biology and Reproduction Parameters of Asian Citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) at Constant Temperature

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ABSTRACT

The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), is one of the most important and destructive pests of citrus in the world, because of its ability to vector bacteria *Candidatus Liberibacter americanus* and *Candidatus Liberibacter asiaticus*, the presumed causal pathogen of Huanglongbing (HLB) or greening disease. The biology and reproduction parameters of *D. citri* were studied at 27.5°C on four host plants corresponding to the four major varieties cultivated in Iran, namely, Marsh grapefruit (*Citrus paradisi*), local sour orange (*C. aurantium*), Mexican lime (*C. aurantifolia*), and Campbell Valencia orange (*C. sinensis*). The average developmental period of total nymphal stages and total cycle (egg to adult) were significantly longer on Campbell Valencia orange (21.2 and 24.1 days, respectively) than on other host plants. The mean of pre-oviposition period on four host plants varied (2.4-4.0 days) and was significantly longer on Campbell Valencia orange (4 days) than on other host plants. Oviposition rate and total eggs laid were not significantly different between the different hosts. Survival rate of *D. citri* was significantly lower on Campbell Valencia orange (42.1%) than on the three other varieties. The finite rate of increase (λ) and the r_m value of *D. citri* were higher on Mexican lime (1.20 and 0.17, respectively) than on the three other hosts. Also, mean doubling time was higher on Marsh grapefruit (11.84 Days) than on other host plants. These new data give more insight about susceptibility of the different varieties of citrus to *D. citri*.

Keywords: Campbell Valencia orange, Citrus pest, Huanglongbing, Marsh grapefruit, Mexican lime.

INTRODUCTION

The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Liviidae) is native to tropical and subtropical Asia (French *et al.*, 2001; Halbert and Manjunath, 2004). This pest feeds on foliage and twigs of its rutaceous host plants, but reproduces exclusively on new emerging leaves called

‘flush’ (Hall and Albrigo, 2007). *D. citri* damages citrus by depleting sap from the plant and injecting a salivary toxin that produces malformation of shoots and leaves. It also affects photosynthesis of the tree by excreting honeydew, which promotes the growth of sooty mold (Chien and Chu, 1996). Although flush deformation and occasionally flush death may result from adult and nymphal feeding injury under high

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populations (Michaud, 2004), *D. citri* is economically important because it vectors the phytopathogenic phloem limited bacteria *Candidatus Liberibacter asiaticus* (CLAs), and *Candidatus Liberibacter americanus*, presumably responsible for citrus greening disease or Huanglongbing (HLB) (Halbert and Manjunath, 2004). HLB is one of the deadliest citrus diseases in the world, for which there is no cure and all citrus cultivars are susceptible to the disease (Bové, 2006; Folimonova et al., 2009). Citrus trees die 3 to 5 years following CLAs infection. Fruits from infected trees are often misshaped, smaller than from uninfected trees, remain green in color, often drop prematurely, and are characterized by undesirable organoleptic properties (Wang and Trivedi, 2013). At present, the most common practice for management of HLB is aggressive use of insecticides to control the vector and removal of CLAs-infected citrus (Tiwari et al., 2011). However, tree removal is less applied in areas where infection is > 50%, such as Florida.

Host plant is one of the most important factors for insect development. Different host plant species often vary in suitability for specific insects in terms of their effects on survival, development, and reproductive rate (Yang and Liu, 2009). To provide an effective control management program, determining the influence of host plant on growth parameters and population characteristics of pests are essential. Comparison of *D. citri* life table parameters with the same values obtained for natural enemies will determine the efficiency of the parasitoids and predators in controlling this pest damage.

Several studies have been conducted on the development and reproduction of *D. citri* on different host species (e.g. Nehru et al., 2004; Nava et al., 2007; Tsagkarakis and Rogers, 2010), but only a few studies have constructed life tables for this psyllid species. All of these are related to the biology of *D. citri* in the Western Hemisphere (Nearctic region) (i.e. Liu and Tsai, 2000; Tsai and Liu, 2000; Alves et al., 2014). Surprisingly, there have been no detailed reports on host plant

effects on life table parameters of *D. citri* in Asia, where it is the known origin of the psyllid (Mead, 1977). The current study aimed to evaluate the life history of *D. citri* on four important commercial varieties of citrus in Iran, a major citrus growing region in Asia (FAO, 2017). This information may help for a better understanding of the biology and population dynamics of *D. citri* and lead to the development of a reliable pest population prediction system and management strategies against this pest.

MATERIALS AND METHODS

Plant and Insect Cultures

Four citrus varieties corresponding to the most commonly cultivated varieties in Iran were selected including local Sour orange *Citrus aurantium* L., Mexican lime *C. aurantifolia* (Christm.), Campbell Valencia orange *C. sinensis* (L.), and Marsh grapefruit *C. paradisi* Macfad. Citrus were grown from seed in plastic pots (12.5 cm diameter×13 cm height) containing a mixture of organic compost, peat moss (Terracult Company, Germany) and perlite (1: 2: 1). The pots were kept in a walk-in insect rearing room maintained at 27.5±1°C, 60±10% (RH) and a photoperiod of 16:8 hour (L:D). Stock laboratory cultures of *D. citri* were established on the four studied citrus plants from individuals that were field-collected from commercial orchards of Mediterranean sweet lemon, *Citrus limetta* Risso, in Jiroft County, in Kerman Province, Iran (28° 19' 54.32" N and 58° 14' 46.17" E). Psyllids were reared on seedlings of each host plant in separate screened cages for at least one generation before being used in the experiments. The insects were reared under the same physical conditions as the plants. Since *D. citri* lay eggs and can develop only on new emerging leaves (Catling, 1970), plants were pruned and fertilized with commercial chemical fertilizer NPK (20-20-20) to promote production of new growth.

Development

To study egg and nymphal development, approximately 300 adults of *D. citri* from the stock colony of each host plant were separately transferred to screened cages. For each host plant, a screened cage (50×50×50 cm) containing sixteen seedlings (15-20 cm height and approximately 5-10 leaves) was used. Plants inside each cage were visited every 12 hours with a handy lens and young terminal shoots containing eggs were cut and placed individually in small (0.5 mL) micro-centrifuge tubes filled with water. Each flush shoot was then placed in a Petri dish (9 cm diameter×1.5 cm high) with a 20 mm diameter hole in the middle of the lid, which was covered by a piece of fine net to provide ventilation. The Petri dishes were kept in an incubator at $27.5\pm1^{\circ}\text{C}$, $60\pm10\%$ RH and a 16:8 hour (L:D) photoperiod, and checked every 12 hours to record egg viability and egg development.

For nymphal development, on each host plant, at least 50 newly hatched nymphs (< 12 hours old) were individually transferred on excised young citrus leaves from the same variety using a fine camel hairbrush. The cut end of the petiole was placed in a small (0.5 mL) micro-centrifuge tube filled with water. Each leaf was then similarly placed in a Petri-dish as described above. Progress in development and survival of psyllid nymphs was assessed every 12 hours. The exuviae were used to determine molting. In order to prevent loss of nutrients in leaves, the nymphs were transferred to newly cut leaves of the same host plant every 3 days. After adult emergence, psyllids from the same host plant were sexed and used for reproduction experiments.

Reproduction

Newly emerged adults (< 12 hours old) of *D. citri* from the development experiment were then isolated as pairs in transparent glass tubes (10 cm in length×1.6 cm diameter) with flush shoots

(ca. 5 cm) and wet cotton in the bottom for moisture. The cut end of the young shoot was placed in a small (0.5 ml) micro-centrifuge tube filled with water. A minimum of 10 pairs in each treatment were selected for oviposition observations. Males that died were replaced with other males from the same rearing treatment. The egg production of each *D. citri* female was counted under stereomicroscope every 12 hours for the first 13 days of adult life. The eggs were then regularly observed until hatching to estimate fertility (egg survivorship). This experiment was done under the same physical conditions as described above.

Statistical Analysis

Data were first analyzed for normality using the Kolmogorov–Smirnov test (K–S test), and non-normally distributed data were transformed using arcsine square-root transformation before analysis. Levene's test was also performed to assess the homogeneity of variance. Data were then submitted to one-way ANOVA. Survivorship was compared pairwise among experimental treatments using a chi-square test. Life table parameters were calculated using the development and reproduction data (Carey, 2001). A VBA-macro for the Jackknife method was used to calculate life table parameters for the first 13 days of adult life as described by Vantornhout *et al.* (2005) and to calculate net Reproductive rate (R_0), intrinsic rate of population increase (r_m), finite rate of increase (λ), and Doubling Time (DT). Mean Jackknife pseudo-values for each treatment were subjected to ANOVA followed by the Tukey-Kramer HSD test to compare life table parameters of *D. citri* host plants ($\alpha=0.05$). Statistical software SPSS 16.0 for windows (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.



RESULTS

Development

Table 1, shows stage-specific developmental times of *D. citri* on the 4 studied host plants. The one-way ANOVA of egg hatching time was significant. Eggs hatched faster on Mexican lime than on Marsh grapefruit ($P < 0.001$) or Campbell Valencia ($P < 0.001$), but the difference was not significant between Mexican lime and local sour orange ($P = 0.16$). Moreover, psyllids reared on Mexican lime had the shortest development time in their 1st ($F_{3,329} = 5.49$, $P < 0.001$) and 5th ($F_{3,181} = 23.81$, $P < 0.001$) nymphal stages. However, rearing the psyllids on this host plant resulted in the longest duration of both second and third instars compared to other treatment groups (Table 1). Statistical analysis also indicated significant variation in total nymphal development time of *D. citri* among different groups. When the host plant was Marsh grapefruit, nymphal development of *D. citri* was almost 3 days faster than on Campbell Valencia ($P < 0.001$), but when it was local sour orange or Mexican lime, nymphal development time of *D. citri* was intermediate and not significantly different from that of the psyllids reared on Marsh grapefruit (Table 1). The longest total developmental time (egg-adult) of the psyllids was observed on Campbell Valencia ($F_{3,181} = 31.83$, $P < 0.001$).

Stage-specific survival rates of *D. citri* on the four studied host plants are reported in Table 2. Immature survival rate to adult emergence was the lowest when the host plant was Campbell Valencia ($\chi^2 = 9.861$, $P = 0.020$), but the differences were not significant when the host plants were Marsh grapefruit, local sour orange, or Mexican lime ($\chi^2 = 1.838$, $P = 0.399$). The highest viability for the egg stage was observed on local sour orange and Mexican lime, and the lowest on Campbell Valencia ($\chi^2 = 10.088$, $P = 0.018$). However, the viability of the nymphal stage was the highest when the

psyllids were reared on Mexican lime, instead of Campbell Valencia or local sour orange ($\chi^2 = 12.776$, $P = 0.005$).

Reproduction

D. citri age-specific survival rates (l_x) and fecundities (m_x) were plotted for each cultivar and revealed high mortality in immature stages on Marsh grapefruit and Campbell Valencia (Figure 1). The l_x curves did not descend from the adult emergence to 13 days afterward, as there was no female mortality during this period; the curves dropped to the zero after 13 days post-emergence due to experiment ending. Oviposition peaked about one day post-emergence on Campbell Valencia and one week on Mexican lime and Marsh grapefruit. The oviposition peaks were highest on Mexican lime and local sour orange, and lowest on Campbell Valencia. Some fluctuations were observed in life expectancy (e_x) curves due to nymphal mortality; the parameter ranged approximately from 20-23 at starting day of experiment on cultivars (Figure 2).

Reproductive parameters for *D. citri* females reared on the four studied host plants are reported in Table 3. One-way ANOVA was significant for variation in length of the pre-oviposition period among different groups ($F_{3,32} = 11.83$, $P < 0.001$). *D. citri* started laying eggs about 1.5 days sooner if it was reared on Marsh grapefruit instead of Campbell Valencia. However, the host plant did not affect the duration of the preoviposition period whether the host plant was Marsh grapefruit, local sour orange or Mexican lime (Table 3).

The overall model was significant for effects on fecundity (for both total and daily number of eggs laid during the first 13 days of female adult life). There was no significant difference in egg production on local sour orange, Mexican lime and Marsh grapefruit. However, rearing on Campbell Valencia drastically reduced the fecundity of the psyllids (Table 3). Based upon life table

Table 1. Development time (days) for egg, nymphal (n_1 - n_5), and total immature stage (egg-adult) of *Diaphorina citri* at 27.5°C, reared on four host plants.

Host plant	Eggs	Developmental time ^a						egg-adult
		n ₁	n ₂	n ₃	n ₄	n ₅	n ₁ , n ₅	
Marsh grapefruit	3.22 ± 0.06a	3.59 ± 0.29a	3.13 ± 0.19ab	2.59 ± 0.20c	3.81 ± 0.19b	5.40 ± 0.17bc	18.54 ± 0.35b	21.77 ± 0.35b
Local Sour orange	2.69 ± 0.03c	3.09 ± 0.14ab	2.61 ± 0.09c	3.02 ± 0.10bc	4.13 ± 0.12b	5.77 ± 0.09b	18.63 ± 0.16b	21.33 ± 0.16b
Mexican lime	2.58 ± 0.04c	2.69 ± 0.09b	3.47 ± 0.05a	3.61 ± 0.16a	4.16 ± 0.13b	5.05 ± 0.11c	19.01 ± 0.13b	21.59 ± 0.13b
Campbell Valencia	2.84 ± 0.03b	3.54 ± 0.16a	2.94 ± 0.11bc	3.28 ± 0.15ab	4.97 ± 0.11a	6.48 ± 0.14a	21.22 ± 0.26a	24.07 ± 0.26a
	F = 41.02	F = 5.49	F = 11.59	F = 7.15	F = 14.15	F = 23.81	F = 30.35	F = 31.83
	df = 3,437	df = 3,329	df = 3,236	df = 3,211	df = 3,187	df = 3,181	df = 3,181	df = 3,181

^a Means±SEM within the same column followed by the different letter are significantly different ($\alpha = 0.05$).

Table 2. Survivorship (%) of egg, nymphal, and total immature stage (egg-adult) of *Diaphorina citri* at 27.5°C, reared on four host plants.

Host plant	n ^b	Eggs	Survivorship (%) ^a								egg-adult
			nymph ₁	nymph ₂	nymph ₃	nymph ₄	nymph ₅	nymph ₁₋₅			
Marsh grapefruit	104	72.49b	85.72a	91.67a	93.34a	100a	100a	70.73ab	53.17ab		
Local Sour orange	152	85.66a	87.5a	90.57a	91.94a	95.77ab	100a	65.78bc	59.78a		
Mexican lime	114	78.11ab	89.11a	93.21a	96.27a	100a	100a	78.59a	62.46a		
Campbell Valencia	217	67.79b	81.58a	92.07a	91.09a	93.33b	97.37a	55.64c	42.15b		
		$\chi^2 = 10.088$	$\chi^2 = 2.159$	$\chi^2 = 0.272$	$\chi^2 = 2.151$	$\chi^2 = 9.628$	$\chi^2 = 3.926$	$\chi^2 = 12.776$	$\chi^2 = 9.861$		

^a Percentages within the same column followed by the same letter are statistically equivalent ($\alpha = 0.05$). ^b Initial number of eggs.

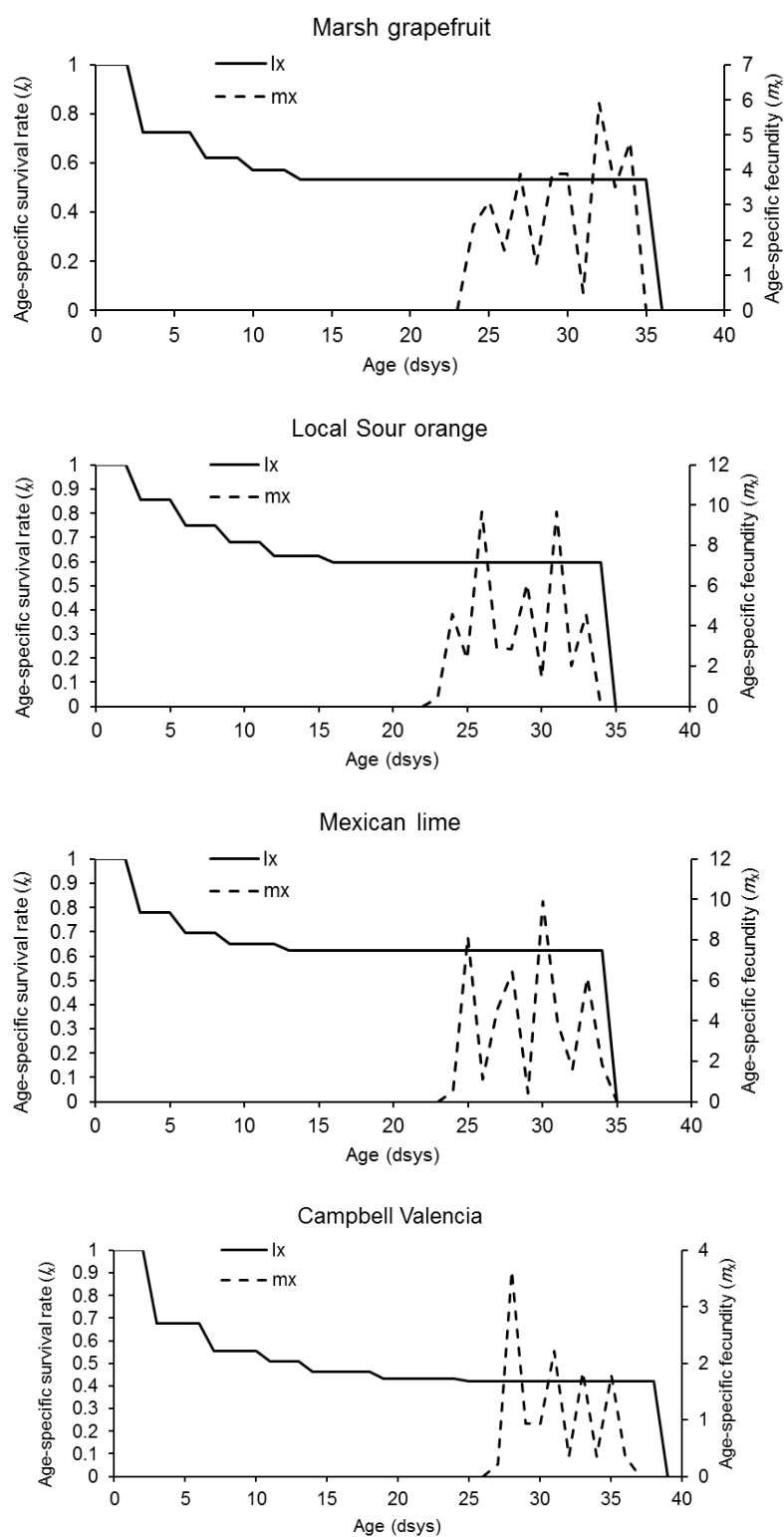


Figure 1. Age-specific survival rate (l_x) and age-specific fecundity (m_x) of *Diaphorina citri* on four host plants.

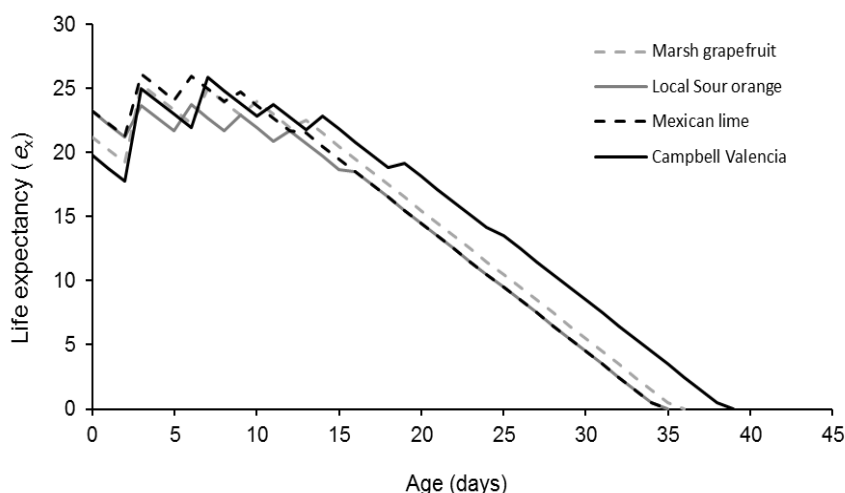


Figure 2. Life expectancy (e_x) of *Diaphorina citri* on four host plants.

Table 3. Reproduction of *Diaphorina citri* at 27.5°C, reared on four host plants^a.

Host plant	Pre-oviposition period (Days) ^b	Eggs/Female/Day	Total No of Eggs
Marsh grapefruit	2.38 ± 0.26b	5.27 ± 0.90ab	68.50 ± 11.66ab
Local sour orange	2.50 ± 0.17b	7.32 ± 0.78a	95.20 ± 10.13a
Mexican lime	2.70 ± 0.15b	6.86 ± 0.80a	89.20 ± 10.40a
Campbell valencia	4.0 ± 0.27a	2.55 ± 0.63b	33.13 ± 8.23b
	$F = 11.83$	$F = 7.17$	$F = 7.17$
	$df = 3,32$	$df = 3,32$	$df = 3,32$

^a Data are for the first 13 days of adult life. ^b Means ± SEM within the same column followed by the same letter are statistically equivalent ($\alpha = 0.05$).

analysis, the Mexican lime had the highest nutritional quality for *D. citri* (Table 4). Net Reproductive rate (R_0), intrinsic rate of increase (r_m), and finite rate of increase (λ) related were all highest for the psyllids reared on Mexican lime, and population Doubling Time (DT) was the shortest on this host plant. There were no significant differences in life table parameters for the other hosts.

DISCUSSION

Overall, host plant had a significant effect on the egg, nymphal, and total (egg-adult) development time of *D. citri*; however, the psyllid had similar developmental times on three of the studied hosts: Mexican lime,

Marsh grapefruit and local sour orange. Similarly, studies made by Tsai and Liu (2000) showed that grapefruit and sour orange may have similar nutritional quality for development of *D. citri*, though the insects reared on grapefruit had greater survival and reproductive values. They have noted that the grapefruit has the more surface per unit area because of more rippled and densely pubescent of surface of tissues.

The results showed that the mean incubation period on four host plants ranged from 2.58 to 3.22 days. This is slightly lower than in other studies where *D. citri* incubation period for eggs was 3.46 days at 28°C on orange jessamine (Liu and Tsai, 2000), 4.21 days at 25°C on sour orange (Tsai and Liu, 2000), 4.79 days at 25°C on Valencia Orange (Alves *et al.*, 2014), and

**Table 4.** Life table parameters (mean±SE) of *Diaphorina citri* at 27.5°C reared on four host plants^a.

Host plant	Intrinsic rate of increase r_m (d ⁻¹)	Net reproductive rate R_o (♀ offspring/♀)	Finite rate of increase λ (d ⁻¹)	Doubling time DT (Days)
Marsh grapefruit	0.0992±0.0070b	18.2170±0.4427b	1.1044±0.0126079b	7.1996±0.4373b
Local Sour orange	0.1157±0.0033b	28.4505±0.3365a	1.1227±0.0037b	6.0376±0.1837b
Mexican lime	0.1721±0.0250a	27.8572±0.3608a	1.1912±0.0302a	4.8414±0.6509b
Campbell Valencia	0.0627±0.0076b	6.9811±0.2477c	1.0650±0.0082b	12.0280±1.2730a
	$F=9.5505$ $df=3,32$	$F=780.6385$ $df=3,32$	$F=8.9478$ $df=3,32$	$F=19.0916$ $df=3,32$

3.63 days at 24°C on orange jessamine (Nava *et al.*, 2007). As to the nymphal development time, it ranged from 18.54 to 21.22 days, which was higher than previous studies where it was 13.11 days on sour orange at 25°C (Liu and Tsai, 2000), 10.60 days at 28°C on orange jessamine (Tsai and Liu, 2000), 13.19 days at 25°C on Valencia orange (Alves *et al.*, 2014), and 14.11 days at 24°C on orange Jessamine (Nava *et al.*, 2007). The survivorship of *D. citri* was quite similar to other studies with 42 to 62% survivorship from egg to adult in comparison with 32 to 66% on 6 different varieties at 24°C for Alves *et al.* (2014), 44 to 88% on four different varieties at 25°C for Nava *et al.* (2007), and from 68% to 84% on four different varieties at 25°C (Tsai and Liu, 2000). These differences might be due to local adaptation of *D. citri* population and the variations in temperatures and host species. It is also possible that the rearing techniques developed to maintain *D. citri*, insect strains and the adaptations of pests under laboratory conditions could affect the biology of this citrus psyllid (Nava *et al.*, 2007).

The survival rate of *D. citri* immatures was the lowest on Campbell Valencia. *D. citri* also had the lowest fecundity and intrinsic rate of increase on Campbell Valencia, demonstrating that this host was the less suitable tested host for this pest. Alves *et al.* (2014) evaluated the influence of five commercial varieties of citrus (*Citrus* spp. L.) (Hamlin, Natal, Pêra, Ponkan, and

Valencia) and orange jessamine (*Murraya exotica* (L.) Jack) on the development of *D. citri*. They showed that, based on biological parameters and the fertility life table, Valencia and orange jessamine were the most suitable hosts and Hamlin was the least suitable for the development of *D. citri*.

Ingestion of toxic compounds or the nutritional inadequacy of the host can cause differences in survival and developmental time due to changes in the insect physiology (Vendramim and Guzzo, 2012). The nutritional quality of the host plant, especially the quality of the sap and the availability of amino acids, can affect the development of *D. citri* (Teck *et al.*, 2011). The results of Souza *et al.* (2012) showed that the nitrate content of sap from the Valencia and Hamlin was different up to 20%. Thus, the nutritional diversities among the tested varieties likely caused the differences and influenced the development of *D. citri*.

Some of life table parameters such as intrinsic rate of increase, mean generation time, and population doubling time are useful indices to discuss about population growth under controlled conditions. Generally, the insects have shorter developmental times and greater total reproduction on suitable hosts (van Lenteren and Noldus, 1990). *D. citri* reared on local sour orange and Mexican lime had the highest intrinsic rate of increase and fecundity. These hosts maybe idoneous hosts for *D. citri*. The pre-oviposition period

of *D. citri* was similar for the three treatments (Marsh grapefruit, local sour orange, and Mexican lime) and was significantly lower than the pre-oviposition period for Campbell Valencia, indicating that the adults of *D. citri* after emerging did not have a mature reproductive system and needed time for feeding and maturing. The pre-oviposition period obtained in this study was lower than that of Nava *et al.* (2007) on Rangpur lime, Orange jessamine, and Sunki mandarin. The characteristics of host organs that are used for the feeding of *D. citri* can be effective on the pre-oviposition period. Results of Uechi and Iwanami (2012) suggested that the 88% of ovaries of females of *D. citri* were matured after 7 days feeding on young leaves, whereas there were only 33% mature ovaries on day 7 on old leaves.

The citrus psyllid is a major pest of citrus orchard all over the world. Determination of biology of this pest on different citrus trees is essential for IPM program. A reliable pest population prediction system and management strategies could be developed by performing different studies on pest biology and population dynamics. Differences in hosts plants around the world are among the most important factors that could influence pest biology and change the distribution and population density of the pest. Using life table parameters, the investigation of pest biology is more reliable and comfortable. Other biotic and abiotic factors including temperature and natural enemy density could be crucial in pest biology and should be included in biological studies.

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اثر گیاه میزبان روی زیست‌شناسی و پارامترهای تولید مثلی پسیل آسیایی مرکبات، *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) در دمای ثابت

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چکیده

پسیل آسیایی مرکبات، *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae)، یکی از آفات مهم و مخرب مرکبات در سراسر دنیا است. این آفت می‌تواند سبب انتقال باکتری *Candidatus Liberibacter asiaticus* و *Candidatus Liberibacter americanus* عامل بیماری میوه سبز مرکبات شود. زیست‌شناسی و پارامترهای تولید مثلی پسیل آسیایی مرکبات، در دمای 27/5 درجه سلسیوس روی چهار رقم از گیاهان میزبان شامل، گریپ فروت مارش (*Citrus*

(*paradisi*) نارنج (*C. aurantium*)، لیمو مکزیکی (*C. aurantifolia*) و پرتقال والنسیای کمپبل (*C. sinensis*) مورد ارزیابی قرار گرفت. میانگین دوره رشد و نمو تمام مراحل پورگی و نیز از تخم تا حشره بالغ، روی پرتقال والنسیای کمپبل (به ترتیب 21/2 و 24/1 روز) بطور معنی داری بیشتر از سه گیاه دیگر بود. میانگین دوره قبل از تخم ریزی روی چهار گیاه میزبان از 2/4 تا 4 روز متغیر بود و این دوره روی پرتقال والنسیای کمپبل (4 روز) بطور معنی داری بیشتر از سه گیاه دیگر بود. از نظر نرخ تخم ریزی و تعداد کل تخم گذاشته شده، بین چهار گیاه میزبان تفاوت آماری مشاهده نشد. نرخ بقاء پسپا آسیایی مرکبات روی پرتقال والنسیای کمپبل (42/1٪) بطور معنی داری کمتر از سه گیاه دیگر بود. مقدار نرخ متناهی افزایش جمعیت و نرخ ذاتی افزایش جمعیت روی لیمو مکزیکی (به ترتیب 1/20 و 0/17) بالاتر از سه گیاه دیگر بود. هم چنین میانگین مدت زمان دو برابر شدن جمعیت روی گریپ فروت مارش (11/84) از سه گیاه دیگر بیشتر بود. یافته های پژوهش حاضر اطلاعات جدیدی در مورد حساسیت ارقام مختلف مرکبات، نسبت به تغذیه پسپا آسیایی مرکبات نشان می دهد.