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Original article (Orijinal araştırma)

Life table parameters of cotton mealybug, *Phenacoccus solenopsis* Tinsley, 1898 (Hemiptera: Pseudococcidae) on four different plants

Pamuk unlubiti, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae)'in dört farklı bitkide yaşam çizelgesi parametreleri

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Abstract

Cotton mealybug is one of the most widespread invasive mealybug species and causes economically serious damage to vegetables, ornamentals and other agricultural crops. This study was conducted between 2018-2019 in Çukurova University, Faculty of Agriculture, Department of Plant Protection, Nedim Uygun Biological Control laboratory for the determination life table parameters of *Phenacoccus solenopsis* Tinsley, 1898 (Hemiptera: Pseudococcidae) on four host plants (cotton, eggplant, pepper and tomato). This study conducted in climate cabinets at 25±2ºC, 60±10% RH and 16:8 h L:D photoperiod. Thirty replicates (individual insects) were used for each host plant. Petri dishes (6 cm diameter) were used for these experiments. Eggplant was determined as the most suitable host plant, with highest values of life table parameters ($R_{0=}$184 nymphs/female, $r_{m=}$0.269/d, λ=1.31/d, GRR=264 nymphs/female) were obtained with eggplant.

Keywords: Cotton mealybug, life table, *Phenacoccus solenopsis*, vegetables

Öz

Pamuk unlubiti sebzeler, süs bitkileri ve diğer ürünlerde ekonomik olarak ciddi zararlara neden olan en yaygın istilacı unlubit türlerinden birisidir. Bu çalışma 2018-2019 yılları arasında Çukurova Üniversitesi, Ziraat Fakültesi, Bitki Koruma Bölümü, Nedim Uygun Biyolojik Mücadele Laboratuvarında, *Phenacoccus solenopsis* Tinsley, 1898 (Hemiptera: Pseudococcidae)'in dört farklı konukçu bitki (pamuk patlıcan, biber ve domates) üzerinde yaşam çizelgesi parametrelerinin hesaplanması amacıyla yapılmıştır. Çalışma 25±2ºC, 60±10% RH and 16:8 h L:D gün aydınlatmalı iklim kabinlerinde, 30 tekerrürlü olarak kurulmuştur. Bu denemeler için 6 cm'lik petri kapları kullanılmıştır. En yüksek yaşam çizelgesi parametrelerine ($R_{0=}$184 nimf/dişi, $r_{m=}$0.269/d, λ=1.31/d, GRR=264 nimf/dişi) sahip olan patlıcan en uygun konukçu bitki olarak belirlenmiştir.

Anahtar sözcükler: Pamuk unlubiti, yaşam çizelgesi, *Phenacoccus solenopsis,* sebzeler

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Introduction

Phenacoccus solenopsis Tinsley, 1898 (Hemiptera: Pseudococcidae) (cotton mealybug), was first described by Tinsley (1898) from specimens collected in New Mexico, USA. Cotton mealybug has been found in Cyprus, Egypt, Iran, Israel, and Turkey in the Palearctic Region (Kaydan et al., 2013; García Morales et al., 2016). According to Fand & Suroshe, (2015), this pest has caused damage to 202 host plant species from 55 families. In Turkey, *P. solenopsis* has been detected in the whole Eastern Mediterranean Region on 72 host plants species in 55 families (Çalışkan-Keçe & Ulusoy, 2018). In addition, *P. solenopsis* has caused more the 60% economic losses in cotton (*Gossypium hirsutum* L.) between 2005-2009. *Phenacoccus solenopsis* is known as one of the most a harmful pest of vegetables and ornamental and other agricultural crops plants (Fand & Suroshe, 2015) and is one of the most widespread invasive mealybug species.

Phenacoccus solenopsis can spread rapidly to uninfested areas, via international trade (Fand & Suroshe, 2015). Due to the high reproductive ratio of *P. solenopsis* and inefficient control methods in new regions, the cotton mealybug can reach unexpectedly high populations and cause serious damage. As for other mealybug species, *P. solenopsis* is also covered with white powdery wax, and this negatively affects the control strategies. Therefore, chemical control is not an effective solution (Joshi et al., 2010). Detailed information about the life cycle of *P. solenopsis* can help to determine the best timing for application of insecticides and biological control agents.

A number of studies of the biology of *P. solenopsis* have been conducted in recent times (Fand & Suroshe, 2015). The biology of *P. solenopsis* has been studied under different temperature conditions by several research groups (Kumar & Kontodimas, 2012; Prasad et al., 2012; Kumar et al., 2013). In addition, host plant suitability has been studied (Çalışkan et al., 2016; Dogar et al., 2018; Nagrare et al., 2018). Nevertheless, for the reasons given above, comprehensive studies of the life table parameters of *P. solenopsis* on different vegetable crops should be undertaken to help develop control strategies in agriculture areas.

This study aimed to determine biological characteristics (developmental time, longevity, preoviposition, oviposition and postoviposition period) and the life table parameters of *P. solenopsis* on four plant species, cotton, eggplant (*Solanum melongena* L.), pepper (*Capsicum annuum* L.) and tomato (*Solanum lycopersicum* L.) under laboratory conditions.

Materials and Methods

Host plant culture

The four host plants (cotton, eggplant, pepper and tomato) used were obtained from Çukurova University, Faculty of Agriculture, Plant Protection Department, Nedim Uygun Biological Control Laboratory between 2018-2019. The plants were cultivated in a climate room (25±2ºC, 60±10% RH and 16:8 h L:D photoperiod) without any insecticide application.

Mealybug culture

Phenacoccus solenopsis was cultured on sprouted potatoes under laboratory conditions (25±2ºC, 60±10% RH and 16:8 h L:D photoperiod).

Experiments

The experiments were conducted in a climate room (25±2ºC, 60±10% RH and 16:8 h L:D photoperiod). Thirty replicates (individual insects) were used for each host plant.

Petri dishes (6 cm diameter) were used for these experiments. Preoviposition, oviposition and postoviposition stages of the females, and the survival parameters for both sexes were recorded daily.

Statistical analysis

One-way ANOVA and Duncans test ($p \leq 0.05$) were used for analysis of data. Statistical analysis was performed by using IBM SPSS STATISTICS 23.

Population growth parameters of *P. solenopsis* on the four plant species (cotton, eggplant, pepper and tomato) were analyzed with an age-stage, two-sex life table (Chi & Liu, 1985; Chi, 1988). TWOSEX-MS Chart (Chi 2014) was used to analyze data of life table.

Result and Discussion

The cotton mealybug completed its life cycle on cotton, eggplant, pepper and tomato. Mean developmental periods of preadult stages were found between 15.2 and 27.7 d for females and between 16.7 and 23.8 d for males (Table 1). The shortest female developmental time obtained was 15.2±0.27 d on eggplant and 16.7±0.20 d for males on cotton. Female and male developmental times (preadult) on eggplant and cotton was longer than when mealybug reared on tomato and pepper. Significant differences were found between plant species for developmental time of preadult stages ($p<0.05$).

Table 1. Developmental time (mean±SE) of *Phenacoccus solenopsis* individuals on four host plants

Host plants	First nymphal stage		Second nymphal stage		Third nymphal stage		Total preadult	
	Female	Male	Female	Male	Female	Male	Female	Male
Cotton	6.8±0.26 a (n=16)	6.8±0.26 a (n=13)	4.5±0.26 a (n=16)	4.1±0.29 a (n=13)	4.6±0.22 a (n=16)	5.9±0.10 a (n=13)	15.6±0.40 a (n=16)	16.7±0.20 a (n=13)
Eggplant	6.4±0.14 a* (n =18)	7.0±0.39 a (n=12)	4.5±0.25 a (n=18)	4.7±0.43 a (n=12)	4.3±0.11 a (n=18)	6.0±0.17 a (n=12)	15.2±0.27 a (n=18)	17.6±0.56 a (n=12)
Pepper	6.6±0.27 a (n=15)	6.3±0.33 b (n=15)	3.7±0.19 b (n=15)	5.5±0.35 b (n=15)	5.3±0.25 b (n=15)	7.7±0.26 b (n=15)	15.9±0.42a (n=15)	19.6±0.51 b (n=15)
Tomato	8.9±0.65 b (n=14)	8.6±0.63 c (n=16)	10.4±1.26 c (n=14)	9.2±1.15c (n=16)	8.5±0.94 c (n=14)	6.0±0.43 a (n=16)	27.7±1.81 b (n=14)	23.7±1.09 c (n=16)

* Columns followed by the same letters are not statistically different according to the Duncan (5%) test.

Figure 1 show survival rates of *P. solenopsis* on different host plants. This figure helps to interpret each stage of *P. solenopsis* in terms of survival rates. According to Figure 1, eggplant and cotton were better hosts than pepper and tomato. Life table parameters are given in Figure 2.

Host species affected preoviposition, oviposition and postoviposition periods of *P. solenopsis* ($p<0.05$) (Table 2). The longest oviposition period was found on eggplant (15.9±1.18 d) and the shortest on tomato (8.31±1.61 d). In addition, fecundity of *P. solenopsis* differed according to host ($p<0.05$) (Table 2). The highest fecundity was obtained on eggplant (307±23.1) and the lowest on tomato (95.1±18.8). In addition, significant difference was found for longevity of females and males on different hosts ($p<0.05$) (Table 3).

The maximum values for life table results were obtained on eggplant (r_m=0.269/d, λ=1.31/d, $R_{0=}$184 nymphs/female and GRR=264 nymphs/female) (Table 2).

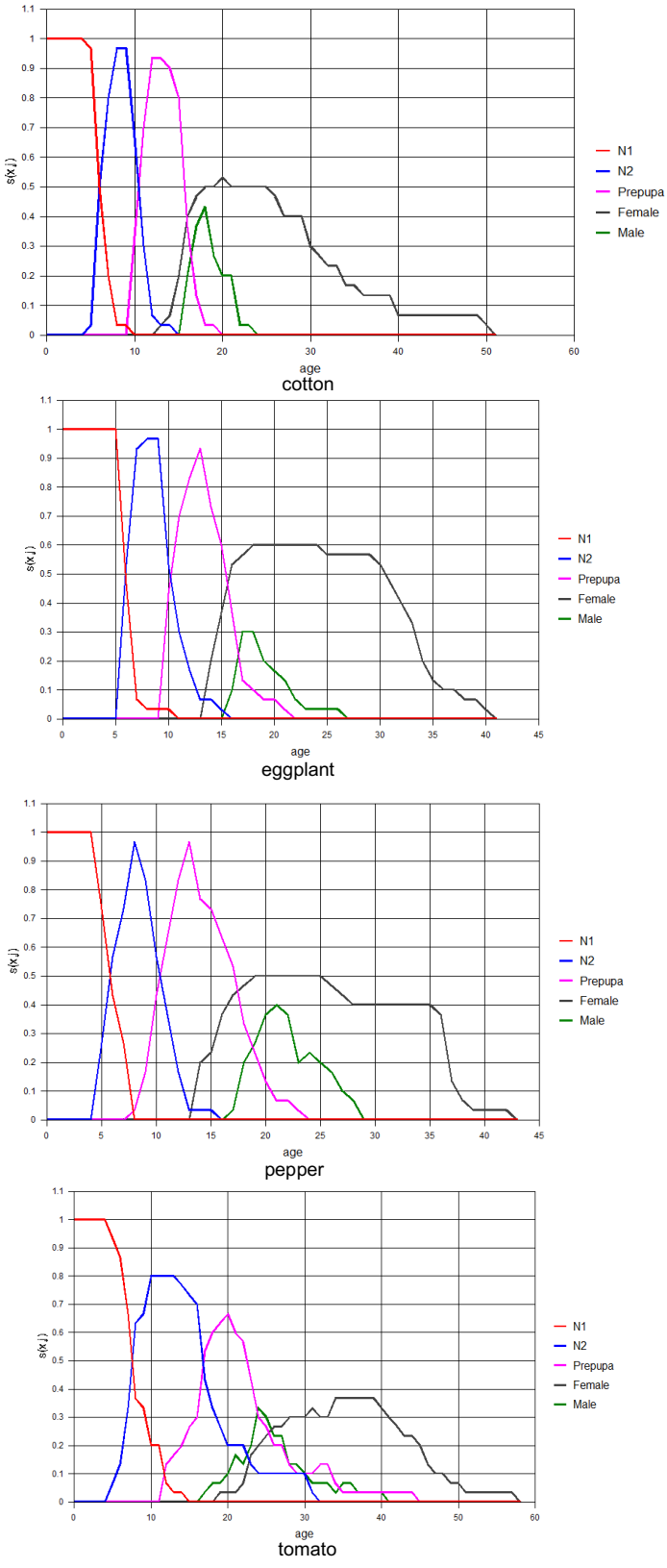

Figure 1. Survival ratio of *Phenacoccus solenopsis* for each stage on four host plants.

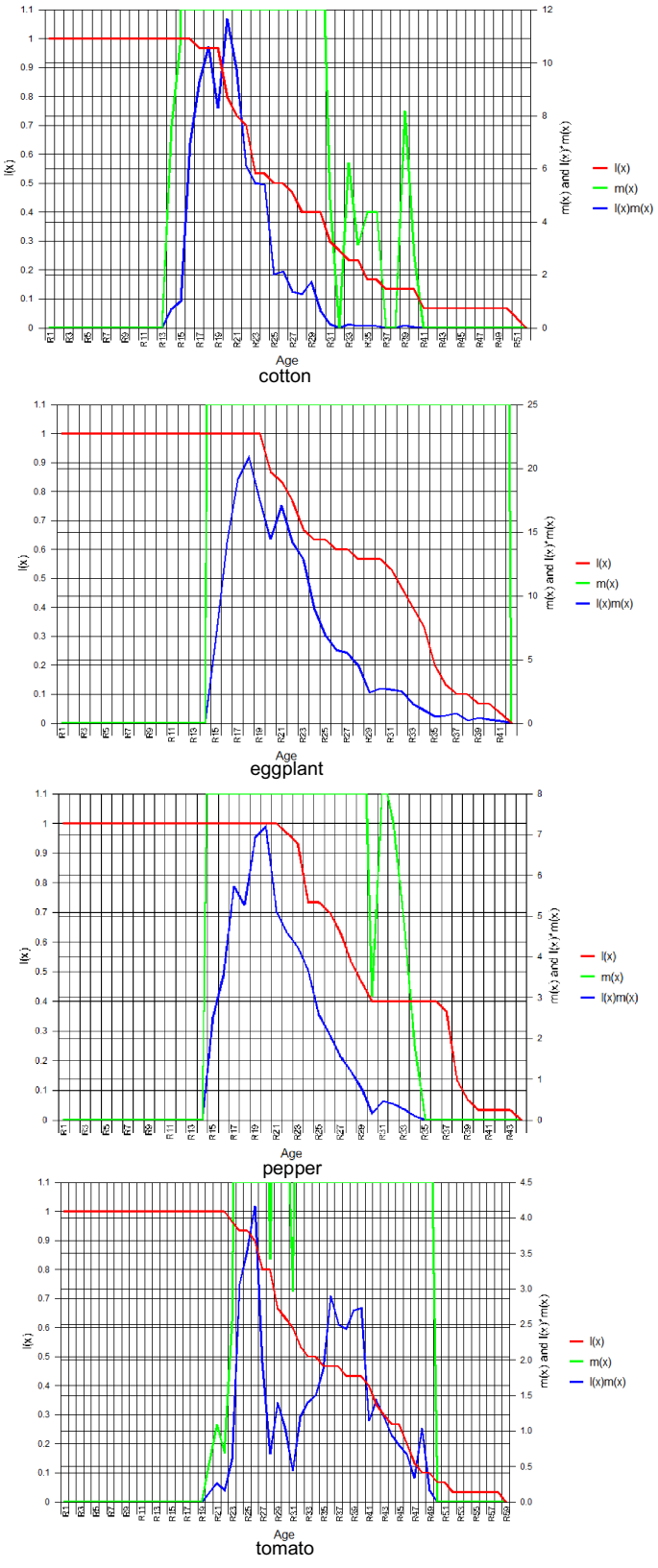

Figure 2. Age specific life table graphics (lx, mx, lxmx) of *Phenacoccus solenopsis* on four host plants.

Table 2. The life table parameters of *Phenacoccus solenopsis* on four host plants (n =30, mean±SE)

Host plant	r_m	λ	R_0	T	GRR
Cotton	0.230±0.13 c	1.26±0.58 b	85±9.0 c	19.4±1.48 a	118±18.3 c
Eggplant	0.269±0.23 d	1.31±0.25 c	184±14.6 d	19.3±4.36 a	264±14.2 d
Pepper	0.207±0.19 b	1.23±0.22 b	58±10.6 b	19.6±0.93 a	67±3.0 a
Tomato	0.123±0.10 a	1.13±0.33 a	44±5.7 a	30.9±1.70 b	98±2.9 b

*Within columns means followed by the same letter are not statistically different according to the Duncans test (5%).

Table 3. Reproduction and survival parameters of *Phenacoccus solenopsis* on four host plants (n=30, mean±SE)

Host plant	Pre-oviposition	Oviposition	Post-oviposition	Fecundity	Longevity	
					Female	Male
Cotton	15.9± 0.42 a	9.8±0.98 c	7.6±2.28 b	159±29.8 c	17.8±1.90 b	4.0±0.44 b
Eggplant	15.2±0.27 a	15.9±1.18 d	2.8±0.57 a	307±23.1 d	18.6±0.82 b	3.5±0.34 a
Pepper	15.6±0.46 a	8.7±1.37 b	11.1±1.8 6 d	117±24.3 b	20.0 ±1.29 c	5.2±0.30 c
Tomato	28.1±1.92 b	8.3±1.61 a	8.6±1.73 c	95±18.8 a	16.3±1.20 a	5.1±0.31 c

*Within columns means followed by the same letter are not statistically different according to the Duncans test (5%).

According to results of this study, biological features of *P. solenopsis* changed significantly with different host plant species. Eggplant was the most suitable host in this study. Development time of cotton mealybug on eggplant (15.2 d) and cotton (15.6 d) were superior to pepper and tomato. Sana-Ullah et al. (2011) found that females of *P. solenopsis* developed in 17 d on *Hibiscus rosa-sinensis* L. at 25ºC and 65% RH. Also, Dogar et al. (2018) reported that, *P. solenopsis* developed faster on *H. rosa-sinensis* than other hosts. In addition, Nagrare et al. (2018) found that cotton is one of the most suitable host plants for cotton mealybug because it completed its development in 16.6 d.

Pre-oviposition, oviposition and postoviposition durations of cotton mealybug were affected by host species. The highest fecundity and longest longevity were found on eggplant (307 nymphs/female, 33.8 d), followed by cotton. Dogar et al. (2018) found that the highest fecundity of *P. solenopsis* on cotton. Çalışkan et al. (2016) found that *Hibiscus syriacus* L. and *H. rosa-sinensis* were particularly suitable host plants for cotton mealybug fecundity.

Each host plant species was different for *P. solenopsis* population parameters. Eggplant was the best host in this study. The intrinsic rate of increase (r_m) and net reproduction rate (R_0) are one of the most important parameters for determining the population increase of insects (Goundoudaki et al., 2003). The data presented here had the highest values of r_m and R_0 with eggplant and cotton. Whereas, the lowest values were on tomato and pepper. Therefore, eggplant and cotton are better hosts than pepper and tomato for *P. solenopsis*.

Various other studies have determined life table parameters of *P. solenopsis* on different host plants under laboratory conditions (Fand et al., 2010; Guan et al., 2012; Kedar et al., 2013; Kumar et al., 2013; Çalışkan et al., 2016; Dogar et al., 2018; Nagrare et al., 2018). Nagrare et al. (2018) found that the highest net reproductive rate was on cotton (284 females/female/generation) and the lowest value was obtained on tomato. According to Kumar et al. (2013), the highest r_m and R_0 values were on cotton (0.215/d and 141 nymphs/female). In addition, Çalışkan et al. (2016) found that the highest r_m and R_0 values were on *H. syriacus* and *H. rosa-sinensis*. Moreover, Dogar et al. (2018) showed that the highest r_m values were on *H. rosa-sinensis.*

According to the results of this study, *P. solenopsis* has potential to cause economically serious damage to vegetable and cotton crops. If natural enemies are not sufficient, *P. solenopsis* will seriously damage vegetable and cotton crops. Owing to broad host range of *P. solenopsis*, this mealybug can spread rapidly within and between agricultural areas.

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