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The determination some biological parameters of *Phenacoccus madeirensis* Green (Hemiptera : Pseudococcidae) on vegetable plants

Mustafa Gökhan BİLGİN[1,*], Asime Filiz ÇALIŞKAN KEÇE[2], Mehmet Rifat ULUSOY[2]
[1]Biological Control Research Institute, Adana, Turkey
[2]Plant Protection Department, Agriculture Faculty, Çukurova University, Adana, Turkey

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Abstract: This study has been conducted to determine some biological parameters of the *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) on four vegetable plants (7 different varieties); tomato (Hazera and Torry) (*Solanum lycopersicum* L.), eggplant (Adana Topağı and Anamur) (*Solanum melongena* L.), pepper (Safran and Zafer) (*Capsicum annuum* L.), and Pepino (Minski) (*Solanum muricatum* L.). Experiments were carried out in climate cabinets at 25 ± 2 °C, 60 ± 10% R.H., and 16L: 8D) in Plant Protection Department Nedim UYGUN Biological Control Laboratory of Agriculture Faculty, Çukurova University between 2017 and 2018. Life table data were analyzed by using an age-stage two-sex life table computer program. According to results of this study, *P. madeirensis* completed its life cycle on eggplant, tomato, pepper and pepino. However, eggplant has been determined as the most suitable host plant for *P. madeirensis* during this study and the highest values of life table parameters were obtained from eggplant (R_0 = 99.14 nymphs/female, r = 0.147 d − 1 , λ = 1.159 d − 1, GRR = 289.49 nymphs/female). Consequently, this invasive pest could potentially cause economic losses in vegetable crops.

Key words: Life table, *Phenacoccus madeirensis*, Maderia mealybug, vegetable

1. Introduction

Phenacoccus madeirensis Green (Hemiptera: Pseudococcidae) was first recorded in Madeira Island by Green (1923). This pest has been seen 558 countries in Southeast Asia, North Africa, and the Mediterranean regions[1] (Kaydan et al., 2012; Kaydan et al., 2016). As can be seen, *P. madeirensis* has a wide distribution, this pest has spread from Asian countries to Mediterranean countries (Beltra and Soto, 2011; Franco et al., 2011 Muniappan et al., 2011). This mealybug species was also determined in Turkey by Kaydan et al. (2012).

Madeira mealybug is known to be one of the most dangerous invasive mealybug species, with around 170 host plants from 45 families having a wide distribution of host plants[2]. This mealybug can damage all part of plants (Papadopoulou and Chryssohoides, 2012). *P. madeirensis* causes economically important damages on ornamentals, vegetables, and other agricultural crops (Kaydan et al., 2012). According to above reasons, Madeira mealybug have potential to cause damage on agricultural and urban areas in new colonized regions.

Life table studies is helpful to provide information about biological features and demographic parameters of insect pests (Carey, 1993). Some important parameters such as fecundity, mortality longevity can be found via life table studies. Thanks to these analyses, control management strategies will be developed and precautions will be taken. The biology of insects varies according to different host plant species (Price et al., 1980). There are many studies conducted for the determination life table parameters of mealybug species. Çalışkan Keçe (2019) studied about some biological parameters of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on vegetable plants. In addition, Tok et al. (2016) conducted a study about life table parameters of *P. madeirensis* on ornamental plants. Moreover, Moharum et al. (2018) studied some biological parameters on different temperatures (20, 25 and 30 °C). As can be seen, life table studies are one of the

[1] CABI (2000). Distribution maps of plant pests [online]. Website http://www.cabi.org/dmpp/?loadmodule=reviewandpage=4049andreviewid=15463andsite=164 [accessed 20 April 2019].

[2] Bhttp://scalenet.info/catalogue/phenacoccus%20madeirensis/.

* Correspondence: mgbilgin@hotmail.com

most important part to develop control strategies against invasive pest species.

This study focused on to determine life table parameters of *P. madeirensis* on four different vegetable plants. In addition, developmental time, preoviposition, oviposition, and postoviposition periods have been determined during this study. Four different host plant species and 7 different varieties, tomato (Hazera and Torry) (*Solanum lycopersicum* L.), eggplant (Adana Topağı and Anamur) (*Solanum melongena* L.), pepper (Safran and Zafer) (*Capsicum annuum* L.), and Pepino (Minski) (*Solanum muricatum* L.), have been used for this study.

2. Material and methods

2.1. Host plant culture

Host plants [tomato (Hazera and Torry), eggplant (Adana Topağı and Anamur), pepper (Safran and Zafer), and pepino (Minski)] were purchased from Commercial Greenhouses and placed into climate rooms in Çukurova University Plant Protection Department (Adana, Turkey). Host plant was kept in climate rooms at 25 ± 2 °C, 60 ± 10% R.H., and 16L:8D photoperiod.

2.2. Mealybug culture

Phenacoccus madeirensis was collected from vegetables and ornamental plants from Adana in 2017. The mealybug has been cultured on potato sprouts in climate rooms at 25 ± 2 °C, 60 ± 10% R.H., and 16L:8D photoperiod.

2.3. Experimental design

Experiments have been carried out in climate cabinets in the Nedim UYGUN Biological Control Laboratory of Çukurova University. Nine mm petri dishes were used in this study. Each host plant includes 100 replications. Life table parameters (preovulation, ovulation and postovulation periods, fertility, longevity, development time) were checked with daily counts for each replicate. The counts continued until the death of all individuals.

2.4. Statistical analysis

Analyses have been done by IBM SPSS 23 (IBM Corporation, Armonk, NY, USA). One-way ANOVA and Duncan tests ($p < 0.05$) have been used for comparisons of experiments characters. Population growth rates of *P. madeirensis* on the four vegetable plants were analyzed by an age-stage two-sex life table via using TWOSEX-MS Chart computer program (Chi and Liu, 1985; Chi, 1988)[3].

3. Results

According to results of this study, *P. madeirensis* developed on four vegetable plants (tomato, eggplant, pepper, and pepino) (Table 1). There were statistical differences between males and females in four host plants in terms of total premature times ($p \leq 0.05$). The shortest preadult duration for female and male was obtained from eggplant for female (20.8 ± 0.16 days) and male (22.8 ± 0.31). For male (26.5 ± 0.52) and female (25.6 ± 0.19) individuals, the longest preadult period was found in pepper (Table 1).

Differences in host plant species affected longevity, fecundity, and reproduction periods of *P. madeirensis*. Oviposition periods of the insect were found longer on Tomato than eggplant, pepper and pepino. Preoviposition periods were shorter on eggplant and pepper. Postoviposition periods were shorter on tomato and pepino. A significant difference was found statistically between host plant species in terms of preoviposition, oviposition, and postoviposition periods ($p < 0.05$) (Table 2). The results showed that the highest longevity for male and female was obtained from eggplant (18.6±0.65 and 9.1 ± 0.27 days), and tomato (20 ± 0.72 and 7.2 ± 0.25 days) (Table 2). In addition, in terms of fecundity, the highest values were obtained from eggplant (190.6 ± 16.88) and tomato (170.3 ± 13.86) (Table 2). A significant difference was found statistically between host plant species in terms of longevity and fertility ($p < 0.05$).

Life table parameters of *P. madeirensis* were different from different host plant species (Table 3). The highest values of the intrinsic rate of increase (r) were obtained from eggplant ($r = 0.147 \pm 0.03$ d – 1). The highest values of the finite rate of increase (λ) were found on eggplant ($\lambda = 1.159 \pm 0.04$ d – 1). Moreover, net reproductive rate (R_0) was found higher on eggplant (99.14 ± 1.14) than tomato, pepino and pepper. Mean generation time was found lowest on eggplant (31.06 ± 1.53 days). Gross reproduction rate (GRR) was found the highest when mealybugs were reared on eggplant (289.49 ± 88.49). Significant differences were determined statistically between different host plant species in terms of life table parameters ($p < 0.05$) (Table 3).

Hatching egg ratio of *P. madeirensis* was also obtained during this study. According to the result, egg viability was found between 83.3% and 90.8%. The highest hatching ratio was 91.2% and the lowest mortality was 8.8%. No significant difference found statistically between different host plant species ($p < 0.05$) (Table 4).

Figures 1–7 show the survival rate and the life table parameters (lx, mx and lxmx) for different host plant species of *P. madeirensis* for each life stage.

4. Discussion

This study showed that eggplant and tomato are more suitable host plants for *P. madeirensis* than pepper and pepino. There were a few studies on biology of *P. madeirensis* (Sinacori, 1995; Chong et al., 2003; Yeh et al., 2006; Tok

[3] Chi H (2014). TWOSEX - MSChart: a computer program for age-stage, two-sex life table analysis [online]. Website http://140.120.197.173/Ecology/ [accessed 10 December 2019].

Table 1. Immature stages (mean ± SE) of *Phenacoccus madeirensis* on different vegetable plants.

Host plants	Egg		I. nypmhal stage		II. nypmhal stage		III. nypmhal stage		Preadult	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Tomato (Hazera)	5.8 ± 0.08b* (n = 49)	5.8 ± 0.1b* (n = 42)	5.5 ± 0.08b* (n = 49)	5.6 ± 0.11b* (n = 42)	5.7 ± 0.1b* (n = 49)	5.6 ± 0.13c* (n = 42)	6.1 ± 0.1b* (n = 49)	7.5 ± 0.1b* (n = 42)	23.1 ± 0.18b* (n = 49)	24.5 ± 0.36b* (n = 42)
Tomato (Torry)	5.6 ± 0.09a (n = 42)	6.1 ± 0.08c (n = 47)	6.3 ± 0.1c (n = 42)	6.4 ± 0.08c (n = 47)	5.9 ± 0.1c (n = 42)	5.3 ± 0.09b (n = 47)	5.6 ± 0.1a (n = 42)	8.2 ± 0.99c (n = 47)	23.4 ± 0.22b (n = 42)	26.0 ± 0.26b (n = 47)
Eggplant (Adana Topağı)	5.9 ± 0.07b (n = 49)	5.8 ± 0.09b (n = 44)	4.8 ± 0.07a (n = 49)	5.1 ± 0.1a (n = 44)	4.7 ± 0.07a (n = 49)	4.9 ± 0.14a (n = 44)	5.4 ± 0.11a (n = 49)	7.0 ± 0.2a (n = 44)	20.8 ± 0.16a (n = 49)	22.8 ± 0.31a (n = 44)
Eggplant (Anamur)	5.9 ± 0.11b (n = 52)	5.6 ± 0.1a (n = 35)	5.5 ± 0.1b (n = 52)	5.6 ± 0.12b (n = 35)	5.4 ± 0.16b (n = 52)	4.9 ± 0.13a (n = 35)	5.5 ± 0.13a (n = 52)	7.6 ± 0.28b (n = 35)	22.3 ± 0.4a (n = 52)	23.7 ± 0.38a (n = 35)
Pepino (Miski)	5.9 ± 0.11b (n = 44)	5.8 ± 0.09b (n = 47)	5.6 ± 0.09b (n = 44)	5.3 ± 0.09a (n = 47)	5.9 ± 0.1c (n = 44)	5.2 ± 0.08b (n = 47)	6.1 ± 0.09b (n = 44)	7.6 ± 0.2b (n = 47)	23.5 ± 0.18b (n = 44)	23.9 ± 0.43a (n = 47)
Pepper (Safran)	6.4 ± 0.13c (n = 47)	6.3 ± 0.12c (n=35)	6.6 ± 0.14d (n = 47)	6.5 ± 0.19c (n = 35)	6.0 ± 0.11c (n = 47)	5.8 ± 0.14d (n = 35)	6.3 ± 0.12b (n = 47)	8.5 ± 0.3d (n = 35)	25.3 ± 0.36c (n = 47)	26.5 ± 0.52c (n = 35)
Pepper (Zafer)	6.3 ± 0.09c (n = 40)	6.2 ± 0.09c (n = 45)	5.9 ± 0.11b (n = 40)	5.7 ± 0.11b (n = 45)	6.7 ± 0.1d (n = 40)	6.0 ± 0.10d (n = 45)	6.7 ± 0.1c (n = 40)	8.4 ± 0.21d (n = 45)	25.6 ± 0.19c (n = 40)	26.3 ± 0.35c (n = 45)

*Columns followed by the different letters are statistically different [Duncan (5%) test].

Table 2. Fecundity and longevity parameters of *Phenacoccus madeirensis* on different vegetable plants.

Host plants	Preoviposition	Oviposition	Postoviposition	Adult female	Adult male	Total egg
Tomato (Hazera)	11.8 ± 0.68bc*	5.1 ± 0.2d*	3.1 ± 0.39b*	20.0 ± 0.72c*	7.2 ± 0.25c*	144.5 ± 11b*
Tomato (Torry)	13.1 ± 0.53c	3.9 ± 0.16b	2.5 ± 0.12a	19.5 ± 0.62c	5.4 ± 0.21c	170.3 ± 13.86d
Eggplant (Adana Topağı)	11.3 ± 0.70b	3.2 ± 0.14a	4.0 ± 0.08c	18.5 ± 0.19a	9.1 ± 0.27d	158.9 ± 11.41c
Eggplant (Anamur)	10.7 ± 0.51a	3.2 ± 0.16a	4.7 ± 0.22c	18.6 ± 0.65a	5.7 ± 0.34b	190.6 ± 16.88d
Pepino (Miski)	10.0 ± 0.54a	4.3 ± 0.2c	2.3 ± 0.15a	16.6 ± 0.67b	1.8 ± 0.2a	146.8 ± 15.25b
Pepper (Safran)	9.1 ± 0.59b	4.3 ± 0.15c	2.9 ± 0.18b	16.3 ± 0.60b	1.5 ± 0.52a	135.83 ± 12.18a
Pepper (Zafer)	9.3 ± 0.48b	4.78 ± 0.15d	2.62 ± 0.18b	16.6 ± 0.49b	1.6 ± 0.21a	158.75 ± 12.08c

*Columns followed by the different letters are statistically different [Duncan (5%) test].

Table 3. The life table parameters of *Phenacoccus madeirensis* on different vegetable plants.

Host plants	r	λ	Ro	T	GRR
Tomato (Hazera)	0.116 ± 0.03a*	1.123 ± 0.008b*	70.82 ± 4.5b*	36.74 ± 1.27b*	229.89 ± 17.11c*
Tomato (Torry)	0.127 ± 0.04b	1.121 ± 0.13b	71.53 ± 4.57b	36.62 ± 1.38b	265.24 ± 97.24d
Eggplant (Adana Topağı)	0.131 ± 0.01c	1.138 ± 0.03c	77.86 ± 2.54c	33.04 ± 0.54a	231.47 ± 2.47c
Eggplant (Anamur)	0.147 ± 0.03c	1.159 ± 0.04d	99.14 ± 1.14d	31.06 ± 1.53a	289.49 ± 88.49d
Pepino (Miski)	0.115 ± 0.05 a	1.117 ± 0.13a	64.62 ± 0.76a	37.23 ± 3.23b	198.28 ± 32.3b
Pepper (Safran)	0.114 ± 0.01 a	1.114 ± 0.03a	63.84 ± 5.73a	39.55 ± 6.01c	177.55 ± 16.45a
Pepper (Zafer)	0.113 ± 0.02a	1.115 ± 0.06a	63.50 ± 8.50a	39.47 ± 4.47c	176.96 ± 22.04a

*Columns followed by the different letters are statistically different [Duncan (5%) test].

Table 4. Hatching, female/male and mortality ratio of *Phenacoccus madeirensis* on different vegetable plants.

Host plants	Number of eggs	The ratio of hatching eggs (%)	Female/male ratio (%)	Mortality ratio (%)
Tomato (Hazera)	n = 101	90.1	53.8/46.2 n = 82	9.9
Tomato (Torry)	n = 98	90.8	47.2/52.8 n = 89	9.2
Eggplant (Adana Topağı)	n = 102	91.2	52.7/47.3 n = 93	8.8
Eggplant (Anamur)	n = 98	90.8	58.4/41.6 n = 89	9.2
Pepino (Miski)	n = 101	90.1	48.4/51.6 n = 91	9.9
Pepper (Safran)	n = 99	82.8	57.3/42.7 n = 82	17.2
Pepper (Zafer)	n = 102	83.3	47.1/52.9 n = 85	16.7

et al., 2016). In terms of hatching, Tok et al. (2016) found that the hatching time was 4–6 days for females and 4–6.2 days for males. Sinacori (1995) reported that egg hatching continued between 1 and 4 days at 30 °C. Our study has shown that the hatching time ranges from 5.6 to 6.4 days. Tok et al. (2016), the total preadult development time was found between 20.4 and 35.6 days for female and 21.1 and 35.1 days for male for four different ornamental plants. Additionally, Chong et al. (2003) reported that the total development time of *P. madeirensis* ranged from 21.9 to 35.6 days in different host plants. These results differ from our study in terms of preadult duration and development time because vegetable plants were used as host plants in this study. Although oviposition period of *P. madeirensis* was found shorter on eggplant than tomato, pepper, and pepino, the highest fecundity was obtained

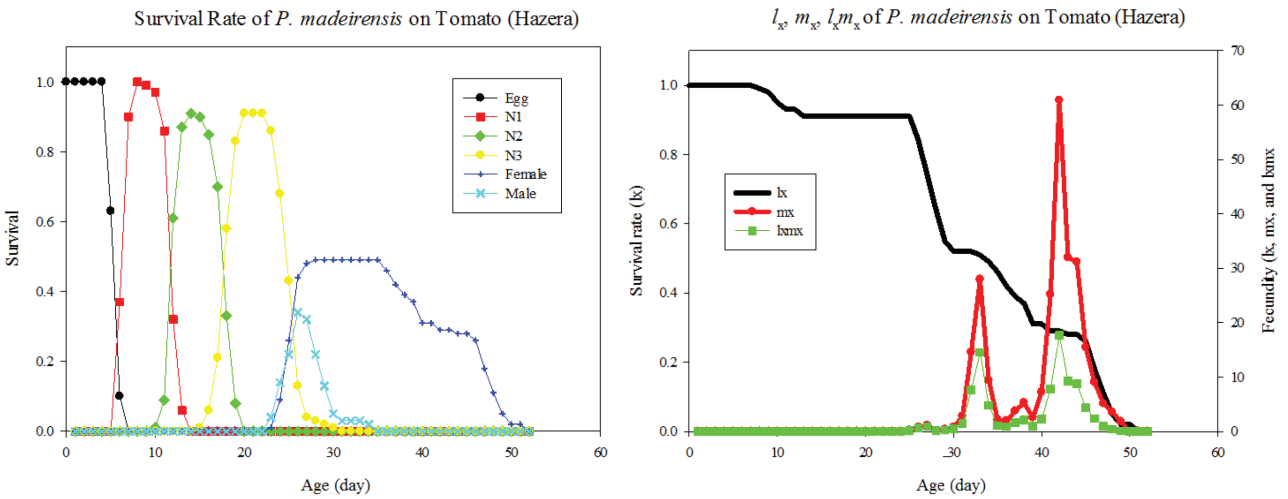

Figure 1. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Tomato (Hazera).

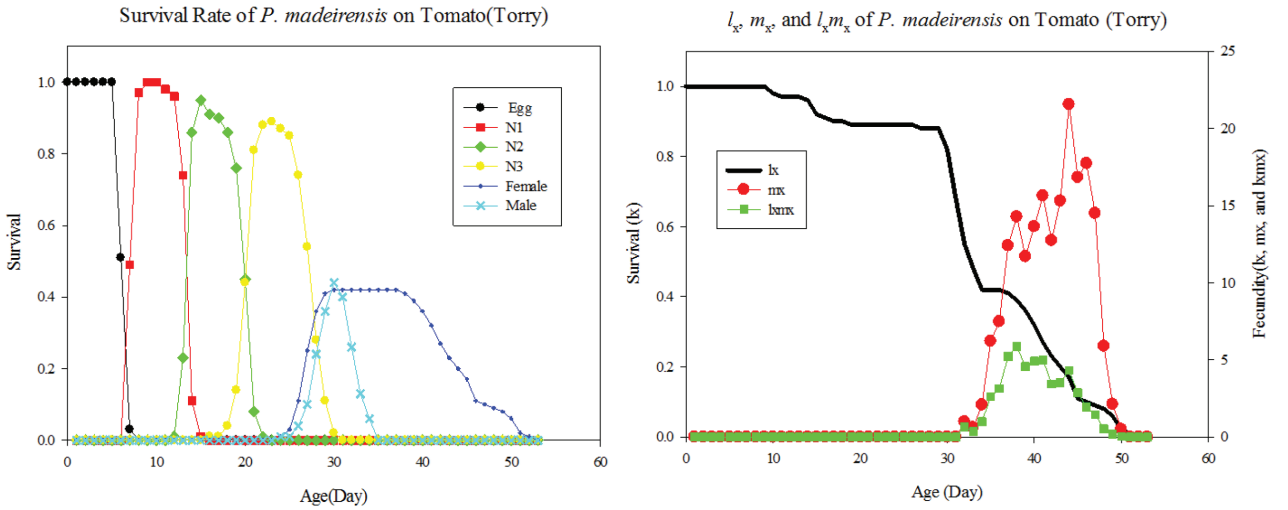

Figure 2. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Tomato (Torry).

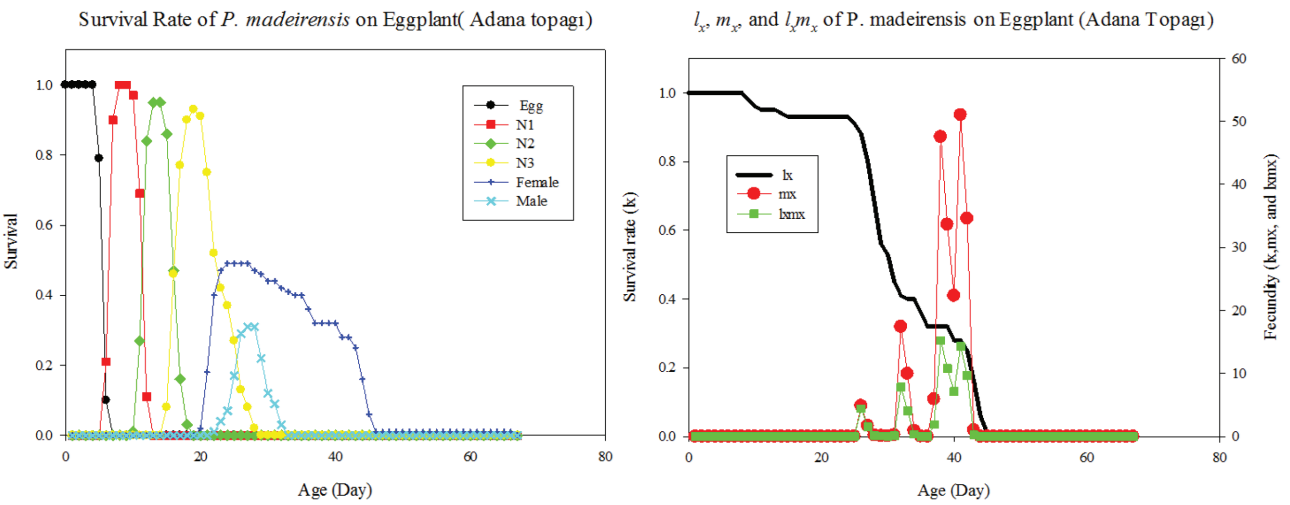

Figure 3. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Eggplant (Adana Topağı).

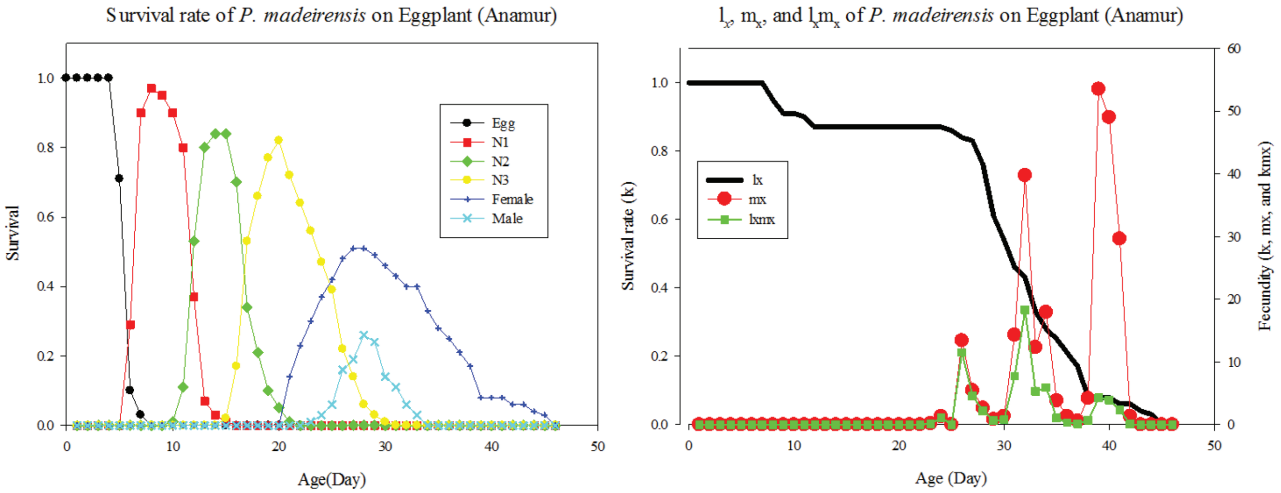

Figure 4. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Eggplant (Anamur).

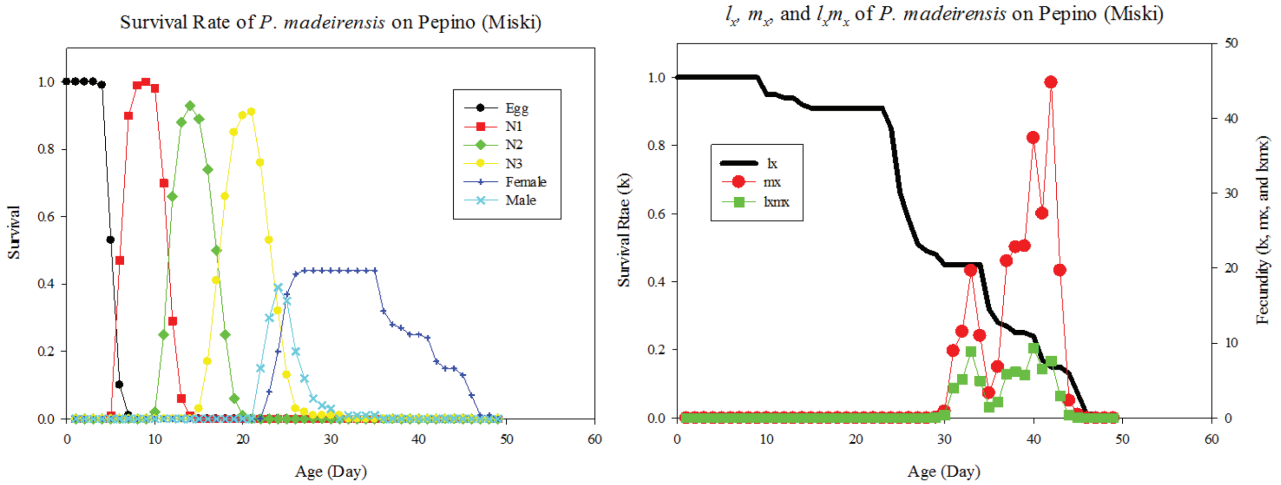

Figure 5. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Pepino (Miski).

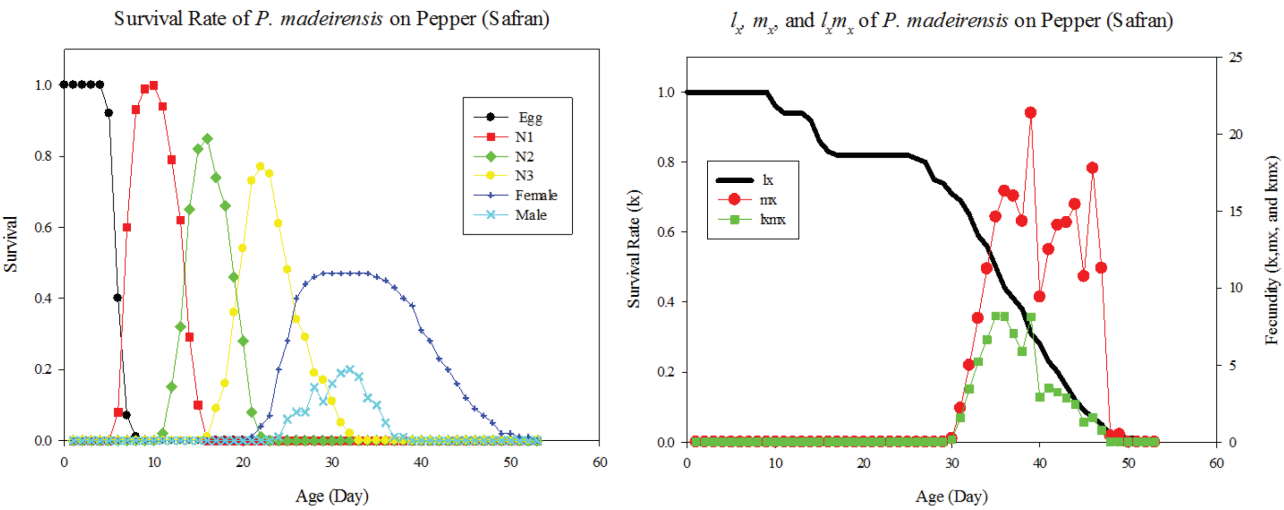

Figure 6. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Pepper (Safran).

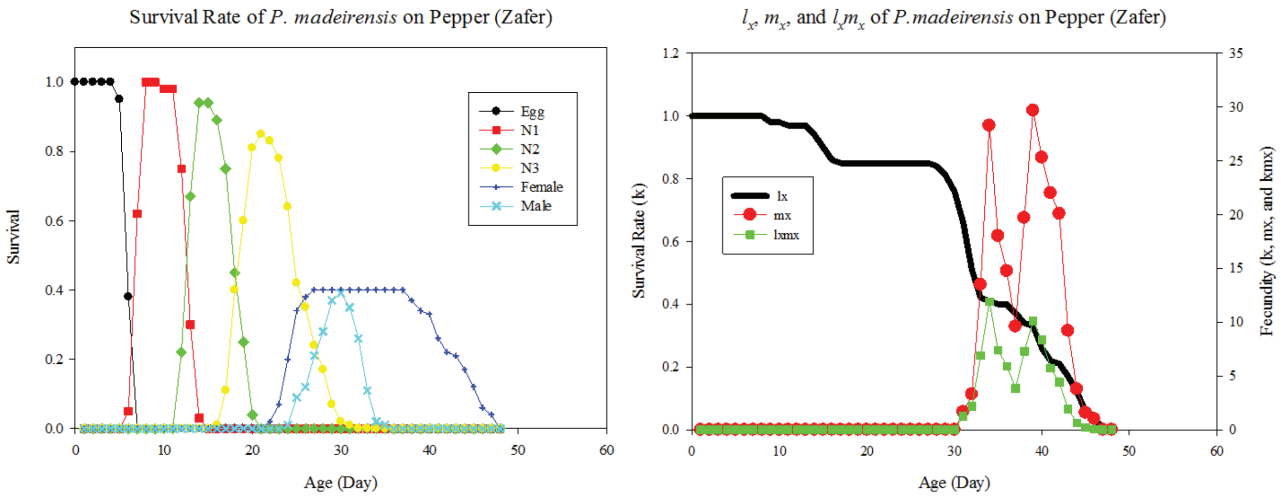

Figure 7. Survival ratio and life table parameters of *Phenacoccus madeirensis* on Pepper (Zafer).

from eggplant. According to Tok et al. (2016), oviposition period of *P. madeirensis* was between 4.2 and 5 days on four different host plants. Yeh et al. (2006) showed that the fecundity values of *P. madeirensis* varied between 67 and 493 eggs/females at different temperatures and in different host plants. Although there were slight differences in different host plants due to host plant differences, these results were similar to our study. Chong et al. (2003), who studied the longevity of *P. madeirensis*, showed that the longevity of male individuals was 2.7 days at 20 and 25 °C in chrysanthemum. In addition, Tok et al. (2016) found that the female individuals of longevity were between 12.8 and 15.2 days. The main reason for these differences in this study is due to host plant species.

This study showed that biological and demographic parameters of *P. madeirensis* differ according to different host plant species. These two parameters are one of the most important for the interpretation of life table data. Even with small changes in these two parameters, the estimate of population growth in pests can easily change (Goundoudaki et al., 2003). The highest values of intrinsic rates of increase (r) and finite rate of increase (λ) were found when mealybug developed on eggplant in this study.

In addition, the lowest mean generation time (T_0) has been obtained when mealybug reared on eggplant (31.06 ± 1.53). The highest net reproductive rate (R_0) and gross reproduction rate (GRR) were found when mealybug reared on eggplant (R_0 = 99.14 ± 1.14, GRR = 289.49 ± 88.49). Tok et al. (2016) conducted similar studies on ornamental plants and found that the lowest mean generation time, the highest R_0 values and the highest GRR were obtained from *Hibiscus syriacus* and *Cestrum nocturnum*. According to the studies mentioned, life table parameters can be easily affected by the difference in host plant species.

This study was conducted to determine the biological and demographic features of *P. madeirensis* on 4 different host plants and 7 different varieties. Madeira mealybug completes its life cycle on these vegetable plants (tomato, eggplant, pepper and pepino). These results will be helpful for developing control management strategies against *P. madeirensis*. In addition, the life table parameters will help prevent the spread of the Madeira mealybug in new farming areas and their economic losses.

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References

Beltra, B, Soto A (2011). New records of mealybugs (Hemiptera: Pseudococcidae) from Spain. Phytoparasitica 39: 385-387.

Carey JR (1993). Applied demography for biologists with special emphasis on insects. New York, NY, USA: Oxford University Press.

Chi H. 1988. Life – table analysis incorporating both sexes and variable development rates among individuals. Environmental Entomology 17: 26-34.

Chi H, Liu H (1985). Two new methods for the study of insect population ecology. Bulletin Institute Zoology Academia Sinica 24: 225-240.

Chong JH, Oetting DR, Iersel VWM (2003). Temperature effects on the development, survival and reproduction of the Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) on Chrysanthemum. Annals Entomolocical Society America 96 (4): 539-543.

Franco JC, Russo A, Marotta S (2011). An annotated checklist of scale insects (Hemiptera: Coccoidea) of Portugal, including Madeira and Azores Archipelagos. Zootaxa 3004: 1-32.

Çalışkan Keçe AF (2019). Life table parameters of cotton mealybug, *Phenacoccus solenopsis* Tinsley, 1898 (Hemiptera : Pseudococcidae) on four different plants. Türkiye Entomoloji Dergisi 43 (3): 271-278.

Goundoudaki, S, Tsitsipis JA, Margaritopoulos JT, Zarpas KD, Divanidis S (2003). Performance of the tobacco aphid *Myzus persicae* (Hemiptera: Aphididae) on oriental and Virgina tobacco varieties. Agricultural Forest Entomology 5: 285-291.

Green EE (1923). Observations on the Coccidae of Madeira Islands. Bulletin Entomological Research 14: 87-99.

Kaydan MB, Erkılıç L, Ülgentürk S (2012). An invasive mealybug species *Phenacoccus madeirensis* Green (Hemiptera: Coccoidea: Pseudococcidae) introduced recently into Turkey. Turkish Bulletin Entomology 2: 67-74.

Kaydan MB, Hayat M, Çalışkan AF, Ulusoy MR (2016). New record of a parasitoid (Hymenoptera: Encyrtidae) of the Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) from Turkey. Journal of the Entomological Research Society 18 (3): 107-112.

Moharum FA, El-Mageed A, Sanaa AM (2018). Life table parameters, thermal-requirements and development rate of the Madeira Mealybug *Phenacoccus madeirensis* Green, (Hemiptera: Pseudococcidae). Journal of Plant Protection and Pathology 9 (2): 127-130.

Muniappan R, Shepard MB, Watson WG, Carner RG, Rauf A at al. (2011). New records of invasive insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa. Journal Agricultural Urban Entomology 26: 167-174.

Papadopoulou S, Chryssohoides C (2012). *Phenacoccus madeirensis* Green, 1923 (Hemiptera: Pseudococcidae) on *Ocimum basilicum*: a new geographical record for Greece. EPPO Bulletin 42: 146-147.

Price PW, Bouton CE, Gross P, McPheron BA, Thompson JN at al. (1980). Interactions among three trophic levels: influence of plant interactions between insect herbivores and natural enemies. Annual Review Ecology Evolution Systematics 11: 41-65.

Tok B, Kaydan MB, Mustu M, Ulusoy MR (2016). Development and life table parameters of *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) on four ornamental plants. Neotropical Entomology 45 (4): 389-396.

Yeh YC, Li RZ, Chen CN (2006). Effects of temperature and host plant on the development and population parameters of the Madeira mealybug *Phenacoccus madeirensis* Green. Formosan Entomology 26: 329-342.