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Life Table Parameters, Thermal-Requirements and Development Rate of the Madeira Mealybug *Phenacoccus madeirensis* Green, (Hemiptera: Pseudococcidae)

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ABSTRACT

This study of life table parameters, thermal-requirements and development rate of *Phenacoccus madeirensis* Green, (Hemiptera: Pseudococcidae) reared at 20, 25 and 30°C in department of scale insects and mealybugs laboratory, Plant Protection Research Institute. The main longevity eggs, nymphs,adult female and male development From 20°C to 30°C, greater temperature significantly shortened the period on development regarding every developmental stage. The low aggregate length about nymphal development of females was once 20.65, 28.95 and 47.85 days of 20, 25 and 30°C, respectively. Immature stage about females required a short length (between two or three days) for development than Immature stage males within 20°C in conformity with 30°C. Thehighest percentage on hatching at 25 °C. The percentage of eggs so much survived in imitation of adult male (23%) used to be perfect at 25°C. The survival rates from egg in conformity with adult female was best possible (34.44 %) at 30°C.The effects about *P. madeirensis* females life table parameters then reared of Potato sprouts at the three examined temperatures 20, 25 or 30°C, the mean generation time (T) was once 51.46, 28.64 then 20.71, respectively. The population on *P. madeirensis* could keep doubled each 8.96, 4.37 or 3.03 days, respectively. The net reproductive rate (Ro), representing the total female births was once 115.09, 93.91 or 53.61. The value on the intrinsic rate of increase (r_m) was once 0.08, 0.16 then 0.23 respectively. The finite rate of increase (λ) about *P. madeirensis* was once 1.08, 1.17 and 1.26 time out of 20°C to 30°C, respectively. Degree day requirements to *P. madeirensis* required 357.14 DD in accordance with completed theirs improvement beside egg stage in accordance with adult female, while out of egg according to male was 400 DD.

Keywords: The Madeira mealybug, *Phenacoccus madeirensis* Green, life table, thermal-requirements.

INTRODUCTION

Identified for the Madeira mealybug *Phenacoccus madeirensis* Green, (Hemiptera: Pseudococcidae) by Bader and Moharum (2017), was the first time in Egypt. This species was recorded in Italy by Marotta & Tranfaglia (1990) and more recently in France (Matile-Ferrero & Germain, 2004), Mediterranean region (Williams, 2004) Crete (Jansen *et al.,* 2010), Portugal (Franco *et al*., 2011),Spain (Beltra & Soto, 2011), mainland Greece (Papadopoulou & Chryssohoides, 2012), Turkey (Kaydan *et al*., 2012), and Tunisia (Halima-Kamel *et al*., 2014).

Ben-Dov *et al*., (2013) reported that it is could be Neotropical in origin and has now invaded parts of the Afrotropical, Neotropical, Nearctic, Australasian and Oriental Zoogeographical Regions.

P. madeirensis is a polyphagous species, recorded on many herbaceous crops, ornamentals, and fruit trees (Ben-Dov *et al*., 2012). Ben-Dov *et al*., (2014) recored it on 170 plant species belonging to 45 plant families. *P. madeirensis* found in Japan, attacks mango, soursop and passion fruit and economically important plants for example, soyabean, mungbean, myoga ginger, jute and sweet basil (Kondo *et al.*, 2001), on cotton in India (Shylesha and Joshi, 2012). In Egypt *P. madeirensis*, recorded for the first time on *Hibiscus rosa-sinensis* L. (Malvaceae) at Alexandria and *Cestrum nocturnum* L. (Solanaceae) at Giza (Bader and Moharum, 2017). Williams & Granara de Willink, (1992) and Papadopoulou & Chryssohoides, (2012), reported that*P. madeirensis* feeds on all parts of the host plant.

Understanding the development on that pest is essential into predicting the population level regarding the mealybug then deciding the timing about insecticide features to acquire positive control. Little is recognized respecting the effect on temperature regarding the improvement concerning *P. madeirensis*. The life cycle about a female *P. madeirensis* consists of an egg stage, three nymphal instars, and then a grown-up stage.

Chong *et al*. (2003, 2004) have studied the life history of *P. madeirensis*in Georgia. Sinacori (1995) reported the developmental times of *P. madeirensis* in Italy.

The high survival rate and reproductive capacity of *P. madeirensis* allows the mealybug population to reach an economic damaging level within a relatively short period of time.

An understanding of the thermal requirements of the pests and their natural enemies is useful in selecting biological control agents that are best adapted to the environmental conditions experienced by the pests (Jervis and Copland 1996) and in predicting the distribution range of the natural enemies (Kontodimas *et al.,* 2004).

This study aimed to investigate developmental time, adult longevity, as well as the life table parameters of *P. madeirensis* and thermal-requirements.

MATERIALS AND METHODS

Insect Rearing

Nymphs and adults of *Phenacoccus madeirensis* Green were collected from different hosts, including potato *Solanum tuberosum* (L.) and *Cestrum nocturnum* L. (Solanaceae) at Giza dring 2017. Insects were reared on Potato sprouts and in 20.3 cm diamceramic pots. The first generation was completed at the above mentioned host in order to exclude parasitized females from the experiment.

Effect of Constant Temperature

Age-specific life-tables of *P. madeirensis* on Potato sprouts was generated from data recorded on constant temperature (20, 25 and 30 ± 1 °C) and RH (65± 1%) utilizing a completely randomized design (CRD) with 5 replications. Five adults were released on Potato sprouts in a small box. Ten newly eclosed nymphs produced from the 5 adults were transferred to a new set of box where development and mortality were observed and recorded daily until the death of each individual. The survival rate of female (or male) from egg to adult was calculated by dividing the total number of adult female (or male)

emerged by the total number of eggs used in the initial infestation, then multiplied by 100%.

Life table parameters for *P.madeirensis* reared on Potato sprouts were calculated by a BASIC computer program (Abou-Setta *et al.,* 1986).

Constructing a life table, using rates of age-specific (Lx), and fecundity (M_x) for each age interval (x) was assessed. The following population growth parameters were determined: the net reproductive increase (R_o), the intrinsic rate of increase (r_m), the mean generation time (T), the doubling time (DT) and the finite rate of increase (λ). The life tables were prepared from data recorded daily at the developmental time (egg to first egg laid) and the survival of females. Interval of one day was chosen as the age classes for constructing the life table.

Degree day requirements hold been developed using a range on non-linear functions up to expectation mark the temperature /growth rate kin (Wagner *et al.*, 1984), but for most species the linear approximation is acceptable (Taylor and James, 1993).

The eggs Incubation period, larval stage was used in accordance with account developmental rates (1/developmental time) according to Omkar (2004), who have been regressed in opposition to temperature. The regression parameters yet slopes had been ancient to calculation the lower temperature introduction because improvement (T_0) and the thermal constant (K), Campbell *et al.*, (1974).

Data analysis:

Data of developmental times of immature stages, pre-oviposition, and oviposition periods, total longevity of females, fecundity, fecundity rate, then the males longevity of *P. madeirensis* reared over Potato sprouts at three examined temperatures have been subjected because certain course evaluation one way analysis of variance (ANOVA), and the means were separated using Duncan's Multiple Range Test (CoHort Software, 2004).

RESULTS

Duration of Developmental Stages:

The Madeira mealybug *Phenacoccus madeirensis* Green, almost eggs, nymphs adult female and male reared at 20 and 30°C in Department of scale insects and mealybugs laboratory, Plant Protection Research Institute. From 20°C according to 30°C, higher temperature significantly shortened the duration of development regarding each developmental stage (Table 1). Eggs hatched in 12.5 ± 0.51days at 20 °C. This was once exceedingly duration required than at 25 then 30°C, respectively (Table 1).

The duration of development within each and every nymphal instars at 20 °C was persistently longer duration.

The mean total duration of nymphal development of females was once 20.65, 28.95 and 47.85 days. Longevity males required a longer duration (between two or three days) for nymphal development than females into 20°C in accordance with 30°C.

Table 1. Developmental times (mean ±SE and LSD) between days of immature stages of *Phenacoccus madeirensis* Green at three constant temperatures.

Temperature	Egg	First	Second	Third female	Prepupa male	Pupa male	Egg to adult	
							Female	Male
30	5.40 ± 0.60c	5.40±0.50c	4.90±0.45c	4.95±1.00c	1.35±0.49c	4.80±0.83c	20.65±1.18c	21.85±1.34c
25	8.55±0.51b	7.60±0.68b	6.45±0.51b	6.35±0.49b	2.15±0.37b	5.80±0.41b	28.95±1.19b	30.55±1.23b
20	12.50±0.51a	13.25±0.55a	9.90±0.97a	12.20±0.77a	4.45±0.60a	9.15±0.59a	47.85±1.63a	49.25±1.94a
L.S.D	0.343	0.369	0.432	0.494	0.314	0.402	0.856	0.975

Within the same temperature range, the length out of egg in conformity with adult development for a female was additionally significantly shorter than up to expectation on a male.

Table 2. Developmental times (mean ±SE and LSD) in days of mature stages and Mean total fecundity of Phenacoccus madeirensis Green at three constant temperatures.

Temperature	Female longevity	Male longevity	Fecundity
30	32.6±1.50a	21.85±1.35a	192.1±14.86a
25	48±1.62b	30.55±1.23b	237.5±27.76b
20	73.1±1.62c	49.25± 1.94c	283.25±21.04c
L.S.D	1.00	0.975	13.845

Adult males founded afterward the adult molt over females, relying about the temperature. The variations among the low total period on development within males and females reduced including higher temperature (Table 2).

Survival Rates.

Most eggs hatched out of 20°C according to 30°C, with the highest percentage of hatching at 25 °C. In less temperature treatments (20 °C) coused higher mortality for eggs and nymphs. Survival rates over nymphal instars at 25 and 30 °C have been very high, ranging between 82.67 and 94.29 % (Table 3).

Table 3. Survival percentage of individual instars of male and female Phenacoccus madeirensis Green at three constant temperatures.

Temperature	Egg	First	Second	Third female	Prepupa Male	pupa male	Egg to adult	
							Female	Male
30	83.33	82.67	93.55	94.29	91.30	90.48	34.44	21.11
25	88.89	88.00	92.42	94.12	92.59	92	31.00	23.00
20	75.00	77.33	89.66	92.00	92.00	91.30	23.00	21.00

On average, 92 % of third-instar females survived to adulthood. Almost entire prepupal males (91.30%) inside the assessments survived to the next instar (pupal). More than 90.48 % of male pupae correctly emerged as adults from their tests. The proportion of eggs that survived to adult male (slightly 23%) was highest at 25°C. The survival rates from egg to adult female was highest (34.44 %) at 30°C (Table 3).

Life table parameters:

Life table parameters of *P. madeirensis* females now fulfilled on Potato sprouts at the three tested temperatures 20, 25 and 30°C. The highest net reproductive rate (R_o), representing the total female births used to be 115.086 at 30°C. This means as the population of this mealybug, *P. madeirensis* would keep able in conformity with complete 115.086 times at the end of every generation. R_o was 53.612 at 20 °C and 93.913 at 25 °C. The value of the intrinsic rate of increase (r_m) was once 0.077, 0.159 and 0.229 when *P. madeirensis* was nursed at the three tested temperatures (20, 25 and 30 °C), respectively.

The mean generation time (T) used to be 51.456, 28.635 and 20.708 days at 20, 25 and 30°C, respectively. The population of *P. madeirensis* could be doubled each and every 8.958, 4.370 and 3.025 days at 20, 25 and 30 °C, respectively. The finite rate of increase (λ) of *P. madeirensis* was once highest at 30°C, as capacity so much its population expanded 1.258 times per female per day.The respective values over λ had been decrease (1.080 and 1.172 times, respectively) at 20°C and 25°C (Table 4).

Table 4. Life table parameters of Phenacoccus madeirensis Green at different temperatures.

Parameter	20 °C	25 °C	30 °C
The net reproductive rate (R_o)	53.61	93.91	115.09
Mean generation time (T)	51.46	28.64	20.71
The intrinsic rate of increase (r_m)	0.08	0.16	0.23
Finite rate of increase (λ)	1.08	1.17	1.26
Time of population doubling (In2 / r_m)	8.96	4.37	3.03

Degree-Day Requirements

Minimum developmental thresholds (T_0) on egg was (12.91), first nymph (13.05), second nymph (10.13), third females (12.75). Degree day requirements according to *P. madeirensis* required 357.14 DD to complete their development beyond egg stage to adult female, while from egg in conformity with male was once 400 DD (Table 5).

Table 5. Linear regression analysis concerning temperature against developmental rate, degree-days requirements, and minimum developmental thresholds of Phenacoccus madeirensis Green.

Treatment	Regression	R^2	a	b	T_0	K
Egg	y = 0.0105x - 0.1356	0.9714	-0.136	0.011	12.91	95.24
First	y = 0.011x - 0.1435	0.9998	-0.144	0.011	13.05	90.91
Second	y = 0.0103x - 0.1043	0.9992	-0.104	0.010	10.13	97.09
Third	y = 0.012x - 0.153	0.9783	-0.153	0.012	12.75	83.33
Prepupa	y = 0.0516x - 0.8132	0.9984	-0.813	0.052	15.76	19.38
Pupa	y = 0.0099x - 0.0843	0.9755	-0.084	0.010	8.52	101.01
Egg to dult female	y = 0.0028x - 0.0342	1	-0.034	0.003	12.21	357.14
Egg to dult male	y = 0.0025x - 0.0307	0.9998	-0.031	0.003	12.28	400.00

DISCUSSION

In this study we recorded the mean total duration of nymphal development of females was once 20.65, 28.95 and 47.85 days. Longevity males required a longer duration (between 2 or 3 days) for nymphal development than females into 20°C in accordance with 30°C. These results similar to (Sinacori 1995) who find that P. madeirensis reared on sprouted potatoes livid 22 according to 31 day at 30 °C. (Chong 2001) who found 20.8 _ 0.4 d at 30°C, 28.5 _ 0.2 d at 25°C, and 47.3 _ 0.6 d at 20°C. Also (Lema or Herren 1985) found P. manihoti Matile-Ferrero 36-46 d and (Herrera et al. 1989) P. herreni Cox 41-91 d on 20 and 25°C. While (Lema and Herren 1985) recorded, a female P. manihoti lived 38day.

We find that degree day requirements to *P. madeirensis* required 357.14 DD to complete their development from egg stage to adult female, while from egg to male was 400 DD. While, Johnson (2010) found that beyond the nonlinear mannequin predictions, it used to be performed as the 2nd then 3rd nymphal instars should only improve upon decrease developmental thresholds concerning ten then 14.8 °C respectively. For the egg stage, the estimated lower developmental beginning (T_0) used to be 13.3 °C then the thermal constant (K) 85.5 degree-days. The linear regression tale regarding the lower developmental introduction because of the 1st nymphal stage was once decrease than up to expectation because the egg and pupal stages. *P. burnerae* would require 666.7 degree-days atop a decrease developmental threshold on 8.7°C according to full one generation (egg to adult)

REFERENCES

Abou-Setta, M. M.; Sorrell, R. W. and Childers, C. C. (1986). Life 48: A BASIC computer program to calculate life table parameters for an insect or mite species. Fla. Ent. 69: 690-697.

Bader, S. A. and Moharum, F. A. (2017). The Madeira mealybug *Phenacoccus madeirensis* Green, (Hemiptera: Pseudococcidae) a new record of mealybug in Egypt. Alex. J. Agric. Sci. 62:(30).329.

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

Ben-Dov, Y., Miller, D. R. and Gibson, G. A. P. (2011). ScaleNet, A database of scale insects of the world. Updated 9January 2011 (Webpage: <http:// www. Sel.Barc.Usda.Gov.Scalenet), (Date accessed: April 2012).

Ben-Dov, Y.; Miller, D. R. and Gibson, G. A. P. (2013). ScaleNet, scales in a country Query results. http://www.sel.barc.usda. gov/scalenet/backgrd. htm [accessed on 22 January 2014].

Ben-Dov, Y.; Miller, D. R. and Gibson, G. A. P. (2014). Scale Net, a database of scale insects of the world. Updated January (Web page: http://www. Sel. Barc. Usda. Gov. Scalenet), (Date accessed: April 2013).

Campbell, A., Frazer, B.; Gilbert, N.; Guitierrez, A. and Mackauer, M. (1974). Temperature requirements of some aphids and their parasites. J. Appl. Ecol. 11: 431-438.

Chong, J. H., van Iersel, M. W. and Oetting. R. D. (2004). Effects of elevated carbon dioxide levels and temperature on the life history of the Madeira mealybug (Hemiptera: Pseudococcidae). J. Ent. Sci. 39: 387-397.

Chong, J. H.; Oetting, R. D. and van Iersel, M. W. (2003). Temperature effects on the development, survival, and reproduction of the Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae), on Chrysanthemum. Ann. Ent. Soc. Am. 96: 539-543.

CoHort CoStat Software (2004). www. cohort. com. Monterey, California, USA.

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

Halima-Kamel, M. B.; Germain, J. F.; Mdellel, L. and Abdelaoui, K. (2014). *Phenacoccus madeirensis* (Hemiptera: Pseudococcidae): a new species of mealybug in Tunisia. Bulletin OEPP/EPPO. Bull. 44 (2), 176–178.

Jansen, M. G. M.; Ben-Dov, Y. and Kaydan, M. B. (2010). New records of scale insects from Crete Island, Greece (Hemiptera: Coccoidea). Bull. Soc. Ent. Fr. 115:483–484

Jervis, M. A. and Copland, M. J. W. (1996). The life cycle. In ''Insect Natural Enemies –Practical Approaches to Their Study and Evaluation'', Chapman & Hall, London, 63–161.

Johnson, T. (2010). Biology of the oleander mealybug, *Paracoccus burnerae* (Brain) (Hemiptera: Pseudococcidae). scholar. sun. ac. za 85pp.

Kaydan M. B.; Erkılıç, L. and Ülgentürk, S. (2012). An invasive mealybug species *Phenacoccus madeirensis* Green (Hemiptera: Coccoidea: Pseudococcidae) introduced recently into Turkey. Turk. Bull. Ent. 2:67–74

Kondo, T.; Uesato, T. and Kawai, S. (2001). *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae), a recently introduced exotic pest in Japan. Boll. Zool. Agrar Bachicoltura Ser II 33:337–341

Kontodimas, D. C.; Eliopoulos, P. A.; Stathas, G. J. and Economou, L. P. (2004). Comparative temperature-dependent development of *Nephus includens* (Kirsch) and *Nephus bisignatus* (Boheman) (Coleoptera: Coccinellidae) preying on *Planococcus citri* (Risso) (Homoptera: Pseudo-coccidae): Evaluation of a linear and various non-linear models using specific criteria. Environ. Ent. 33: 1–11.

Marotta, S. and Tranfaglia, A. (1990). New and little known species of Italian scale insects (Homoptera: Coccoidea). In: Proceedings of the sixth international symposium of scale insect studies, Part II. Cracow, Poland: August 6–12, 1990. Agricultural University Press, Cracow: 107-112.

Matile-Ferrero, D. and Germain, J. F. (2004). *Eriococcus munroi* (Boratynski) new pest on lavandin in France and note on two mealybugs new for France (Hemiptera, Eriococcidae et Pseudococcidae). Bull. Soc. Ent. Fr. 109:191–192

Omakar B. E. (2004). Influence of prey species on immature survival, development, predation, and reproduction of *Coccinella transversalis* Fabricius (Col., Coccinellidae). J. Appl. Ent. 128: 150-157.

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

Shylesha. A. N. and Joshi. S. (2012). Occurrence of Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) on cotton in India and record of associated parasitoids. J. of Bio. Cont., 26 (3), 272–273.

Sinacori, A. (1995). Bio-ethological observations on *Phenacoccus madeirensis* Green (Coccoidea: Pseudococcidae) in Sicily. Isr J. Entomol. 29:179–182

Taylor, A. and James, D. G. (1993). Effect of temperature on development and survival of *Amblyseius victoriensis* (Womersley) (Acari: Phytoseiidae). Internat. J. Acarol. 18.2, 185-188.

Wagner, T. L.; H. Wu, P. J. H. Sharpe, R. M. and Schofield, R.N. (1984). Modelling insect development rates: A literature review and application of biophysical model. Ann. Ent. Soc. Am. 77: 208 – 225.

Williams, D. J. (2004). Mealybugs of Southern Asia. The Natural History Museum, Kuala Lumpur: Southden S.D. N, B.H.D. 896 pp.

Williams, D. J. and Granara de Willink, M. C. (1992). Mealybugs of Central and South America. CAB International, UK.

جداول الحياة والاحتياجات الحرارية ومعدلات النمو لنوع البق الدقيقى *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae)

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تم تربية البق الدقيقى *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) على ثلاث درجات حرارة هى ٢٠، ٢٥ و ٣٠ مº فى معمل الحشرات القشرية و البق الدقيقى بمعهد بحوث وقاية النباتات على درنات البطاطس المنبتة. ووجد أن جميع الأعمار أكملت نموها على هذه الدرجات و أنه بزيادة درجة الحرارة ينخفض مدة النمو و ان فترات النمو من البيضة للإناث البالغة كانت ٢٠.٦٥، ٢٨.٩٥ و ٤٧.٨٥ يوم على درجات الحرارة ٣٠ ,٢٥و٢٠ مº على التوالى و أن فترات النمو من البيضة للذكور البالغة كانت أكبر بمعدل يومين او ثلاثة. و أن أعلى معدل للفقس كان على ٢٥ مº و أعلى نسبة للوصول من طور البيضة إلى الذكور البالغة كانت ٢٣% على ٢٥ مº اما الوصول لطور الإناث البالغة كانت ٣٤.٤٤ % على ٣٠ مº. ومن خلال جداول الحياة فقد سجلت مدة الجيل ٥١.٤٦ , ٢٨.٦٤ و ٢٠.٧١ يوم على٢٠، ٢٥ و ٣٠ مº على التوالى و كانت قادرة على تضاعف الجيل (DT) خلال ٨.٩٦ , ٤.٣٧ و ٣.٠٣ يوم على٢٠، ٢٥ و ٣٠ مº على التوالى و صافى معدل الخصوبة (Ro) ١١٥.٠٩ , ٩٣.٩١ و ٥٣.٦١ على ٣٠, ٢٥و ٢٠ مº على التوالى و معدل التزايد الحقيقى (r_m) كان ٠.٠٨ , ٠.١٦ و ٠.٢٣ أنثى / أنثى/ يوم على ٣٠, ٢٥و ٢٠ مº على التوالى أما عن معدل التكاثر (λ) فقد سجل ١.٢٦ , ١.١٧ و ١.٠٨ فرد / أنثى/ يوم على ٣٠, ٢٥و ٢٠ مº على التوالى . أما عن الوحدات الحرارية اللازمة للنمو(K) من طور البيضة إلى الإناث البالغة كانت ٣٧٥ وحدة حرارية ولطور الذكور البالغة ٤٠٠ وحدة حرارية.