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BIOLOGICAL PARAMETERS ON COTTON MEALYBUG, *PHENACOCCUS SOLENOPSIS* TINSLEY UNDER THREE DIFFERENT PHOTOPERIODS CONDITIONS

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Abstract

The present investigation aimed to study the effects of different photoperiods on some biological parameters of the cotton mealybug, *Phenacoccus solenopsis* Tinsley. This experiment was carried out in Plant Protection Department, Faculty of Agriculture, Zagazig University, Egypt during the period extended from January to November 2019. The obtained results showed that there were three nymphal instars for females. While, males have two nymphal instars and pupal stage. The suitable photoperiod for *P. solenopsis* females; nymphal duration, fecundity, generation and life cycle was 12 hrs. lighting followed by 24 hrs. lighting which both12 hrs. lighting and 24 hrs. lighting accelerate the biological parameters than 24 hrs. darkness. On the other hand, the suitable photoperiod for males; nymphal duration, pupal stage duration, and males longevity was 24 hrs. darkness followed by 12 hrs. lighting and 24 hrs. lighting which elongated the biological parameters, with the exception of males longevity whereas the increase in lighting photoperiod decrease the males longevity. These results of this investigation should be considered effective factors for developing the integrated pest management (IPM) program.

Keywords: *Phenacoccus solenopsis,* biological parameters, photoperiods

Introduction

The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is one of the major pests in the agricultural fields which infested agricultural and horticultural crops belonging to 21 different families (Arif *et al.,* 2009; Vennila *et al*., 2011 and Nabil and Hegab, 2019). The infestation by adult and immature of mealybug caused huge yield loss. They feed on leaves of host plants by sucking tissue and sucking the cell sap, which caused yellow leaves. During the feeding, they secrete honeydew, which caused development of sooty mould and loss of photosynthesis, which eventually leaves and host plant death (Wang *et al*., 2009). It is an invasive insect species recorded for the first time in Egypt at 2010 infested weed plants (Abd-Rabou *et al*., 2010) from this date many efforts has been done to registered the pest on many crops, *P. solenopsis* recorded for the first time on tomato plants at Qalyoubia Governorate (Ibrahim *et al*., 2015) and registered for the first time on four economical crops i.e., okra, eggplant, maize and nalta jute at Sharkia Governorate (Nabil *et al.,* 2015). Also, *P. solenopsis* recorded as a new pest of potato plants in Abu Hummus distract, Beheira Governorate, Egypt (Rezk *et al*., 2019).

Environmental factors, such as photoperiod can play important roles in insect development. Adult metabolic rates and longevity were varied with photoperiod measurements. In addition, the photoperiod has been shown to influence postembryonic growth in some insect species (Lanciani and Anderson, 1993). Many researchers studied the effects of different photoperiods on the developmental duration, fecundity and dynamics for the laboratory population of the cotton mealybug, *P. solenopsis*. They mentioned that the developmental durations of the 1st and 3rd instar nymphs and the fecundities of female adults varied significantly among different photoperiods (Wang *et al*., 2014). Numerous studies have researched insects and their responses to photoperiod, but there has been little research to show if the duration of light alters development rates in mealybugs. Therefore, the present study aimed to determine the effect of photoperiods on the duration of developmental rates of cotton mealybug, *P. solenopsis*.

This research represents an initial effort to study the biology of *P. solenopsis* under different photoperiods because the information about the effects of photoperiods on its biology was scanty. The information generated may be used for designing a comprehensive pest management program and prediction models for the cotton mealybug.

Materials and Methods

Collection of Insects

Biological study on *Phenacoccus solenopsis* Tinsely was conducted at Plant Protection Department, Faculty of Agriculture, Zagazig University, Egypt. This study was conducted between January and November 2019. The populations of its pest was collected from eggplant, *Solanum melongena* L. at Hihya districts, Sharkia Governorate, Egypt.

Potato Culture and Cotton mealybug rearing

Potato tubers, *Solanum tuberosum* L. were washed thoroughly in water and put on moistened plastic dishes 30 cm. Water was sprinkled daily to keep the plastic dishes moistened to encourage sprouting. After 28-30 days, potatoes produced sprouts of 5-7 cm. Then sprouted potatoes were caged individually under lamp glass and the insects were transferred with the aid of camel hair brush to the potatoes sprouts and reared under laboratory conditions of 25±1°C, 65±5% RH and different photoperiods (complete darkness, 12 hrs. lighting and 24 hrs. lighting) at 2000 lx light density. The mealybug females settled on potatoes sprouts started to lay eggs. The crawlers emerged out, started feeding, and developed to adults. The newly adult females were separated and placed on a new potato sprouts kept under the same laboratory conditions with the help of fine camel hairbrush. Biological studies were started with neonate crawlers of the second generation. A total of 175 crawlers drawn from different females but laid on the same day were observed and followed to study the biological aspects of females and males parameter. The crawlers were observed daily in the morning by the aid of binocular microscope to determine the nymphal instars durations with checking for exuviate that were visible through the loose waxy filaments. The preoviposition, oviposition, postovipostion periods for female, longevity, life cycle and generation periods were calculated. The crawlers laid by females of *P. solenopsis* were examined under binocular microscope and counted for calculating fecundity. The number of males out of the total population that survived to adult stage and longevity of males were studied (Nabil, 2019).

Statistical Analysis

The analysis of variance (ANOVA) and means were compared using least significant difference (LSD) were performed using the CoStat program at 0.05 probability level (COSTAT (2005).

Results and Discussion

Results presented in Table (1) showed that three nymphal instars were recorded for females. On the other hand, males showed have two nymphal instars and pupal stage.

Effects of different photoperiods on the biological parameters of *Phenacoccus solenopsis* Tinsley

Data presented in Table (1) showed the effects of different photoperiods (complete darkness, 12 hrs. lighting and 24 hrs. lighting) at 2000 lx light intensity on the female developmental stages of cotton mealybug, *P. solenopsis.*

Effect of photoperiods on the immature stages

Female nymphal stage

Data arranged in Table (1) showed that three nymphal instars were recorded for females. The first nymphal instar duration of *P. solenopsis* females varied significantly between tested photoperiods, ranged from 5 to 8 with average of 6.7±0.1, from 6 to 8 with average of 6.7±0.1 and from 6 to 9 with average of 8.2±0.1 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, respectively. Statistical analysis showed that there was a highly significant difference between the mean duration of *P. solenopsis* females 1st nymphal instar between the above different photoperiods where LSD (Least Significant Difference) was 0.24.

Data tabulated in Table (1) mentioned that second nymphal instar duration of *P. solenopsis* females varied significantly between tested photoperiods. It a ranged from 4 to 7 with average of 5.5± 0.1, from 3 to 5 with average of 3.8± 0.1 and from 4 to 7 with average of 4.8± 0.1days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, successively. Statistical analysis showed that there was a highly significant difference between the mean duration of *P. solenopsis* females 2nd nymphal instar under the above different photoperiods where LSD was 0.20.

Data in Table (1) clarified that the third nymphal instar duration of *P. solenopsis* females varied significantly between the three photoperiods. It ranged from 5 to 7 with average of 6.4± 0.1, from 4 to 6 with average of 4.6± 0.1 and from 6 to 9 with average of 7.6± 0.1days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, consecutively. There was a highly significant difference between the mean duration of *P. solenopsis* females 3rd nymphal instar and the tested different photoperiods where LSD was 0.21.

Male nymphal stage

Data presented in Table (1) showed that males have two nymphal instars the first nymphal instar duration of *P. solenopsis* males varied significantly between the tested photoperiods. It ranged from 5 to 7 with average of 5.5± 0.1, from 6 to 9 with average of 7.8± 0.1 and from 8 to 11 with average of 9.6± 0.2days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, respectively. Statistical analysis showed that there was a highly significant difference between the mean duration of *P. solenopsis* males 1st nymphal instar and the above mentioned different photoperiods where LSD was 0.42.

Data tabulated in Table (1) revealed that the second nymphal instar duration of *P. solenopsis* males varied significantly according to the tested photoperiods. It ranged from 5 to 8 with average of 6.9± 0.2, from 6 to 11 with average of 7.7± 0.3 and from 5 to 8 with average of 6.6± 0.2days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, successively. Statistical analysis showed that there was a highly significant difference between the mean duration of *P. solenopsis* males 2nd nymphal instar and the above tested photoperiods where LSD was 0.58.

Male pupal stage

Data in Table (1) showed that males pupal stage durations of *P. solenopsis* varied significantly owing to the tested photoperiods. It ranged from 8 to 9 with average of 8.6±0.1, from 9 to 12 with average of 10.5±0.2 and from 7 to 14 with average of 9.3±0.2 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, respectively. Statistical analysis showed that there was a highly significant difference between the mean duration of *P. solenopsis* males pupal stage and the above mentioned photoperiods where LSD was 0.50.

Our findings were agreed with the results of Wang *et al.* (2014) studied the developmental duration of *P. solenopsis* under different photoperiods and mentioned that the developmental durations of the 1st and 3rd instar nymphs of adult female varied significantly among different photoperiods.

Table 1 : Effect of three photoperiods conditions on the biological parameters of the immature stages of *Phenacoccus solenopsis* Tinsley reared on potato sprouts at 25±1°C and 65 ±5% R.H.

Biological Parameters	Durations(in days) of immature stages ± SE /range							
	Complete darkness		12/12 (L: D)		Complete lighting		F. test	LSD
	Mean ± SE	Rang	Mean ± SE	Rang	Mean ± SE	Rang		
Female nymphal stage 1st instar	6.7^{b}±0.1	5-8	6.7^{b}±0.1	6-8	8.2^{a}±0.1	6-9	**	0.24
2nd instar	5.5^{a}±0.1	4-7	3.8^{c}±0.1	3-5	4.8^{b}±0.1	4-7	**	0.20
3rd instar	6.4^{b}±0.1	5-7	4.6^{c}±0.1	4-6	7.6^{a}±0.1	6-9	**	0.21
Male nymphal stage 1st instar	5.5^{c}±0.1	5-7	7.8^{b}±0.1	6-9	9.6^{a}±0.2	8-11	**	0.42
2nd instar	6.9^{b}±0.2	5-8	7.7^{a}±0.3	6-11	6.6^{b}±0.2	5-8	**	0.58
Male pupal stage	8.6^{c}±0.1	8-9	10.5^{a}±0.2	9-12	9.3^{b}±0.2	7-14	**	0.50

± (SE) = Standard error. L.S.D. = Least significant differences. (r**) indicates highly significant correlation at 0.05% level of probability

Longevity of adult stage of *Phenacoccus solenopsis*

Adult female durations

Data arranged in Table (2) showed that the pre-oviposition periods of *P. solenopsis* females varied significantly between tested photoperiods. It ranged from 10 to 18 with average of 14.8±0.2, from 9 to 19 with average of 14.6± 0.2 and from 10 to 18 with average of 13.4± 0.2 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, respectively. Statistical analysis showed that there was a highly significant difference between the mean of pre oviposition periods of *P. solenopsis* females and the above mentioned photoperiods where LSD was 0.53.

Data presented in Table (2) clarified that the oviposition period of *P. solenopsis* females varied significantly between the three tested photoperiods. It ranged from 5 to 9 with average of 5.6± 0.1, from 11 to 18 with average of 14.0± 0.2 and from 7 to 15 with average of 11.4± 0.2 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, consecutively. There was a highly significant difference between the mean of oviposition periods of *P. solenopsis* females and the tested photoperiods where LSD was 0.55.

Data in Table (2) showed that the post-oviposition period duration of *P. solenopsis* females varied significantly between the tested photoperiods. It ranged from 2 to 11 with average of 6.6± 0.3, from 3 to 5 with average of 4.0± 0.1 and from 1 to 4 with average of 2.4± 0.1 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, respectively. Statistical analysis showed that there was a highly significant difference between the mean duration of postoviposition period of *P. solenopsis* females and the above different photoperiods where LSD was 0.47.

Data arranged in Table (2) showed that the longevity of *P. solenopsis* females varied significantly between the tested photoperiods of complete darkness, 12 hrs. lighting and 24 hrs. lighting. It ranged from 19 to 34 with average of 27.0± 0.3, from 24 to 41 with average of 32.7± 0.3 and from 22 to 32 with average of 27.2± 0.2 days on the above mentioned photoperiods, respectively. Statistical analysis showed that there was a highly significant difference between the tested photoperiods and mean of *P. solenopsis* females longevity where LSD was 0.86.

Table 2 : Longevity (in days) of adult stage of *Phenacoccus solenopsis* Tinsley when reared on potato sprouts at 25±1°C and RH 65 ±5% R.H. under three photoperiods conditions

Biological parameters	Durations(in days) of adult stage ± SE /range							
	Complete darkness		12/12 (L:D)		Complete lighting		F.test	LSD
	Mean ± SE	Rang	Mean ± SE	Rang	Mean ± SE	Rang		
Female: Pre-oviposition period	$14.8^{a}\pm0.2$	10-18	$14.6^{a}\pm0.2$	9-19	$13.4^{b}\pm0.2$	7-15	**	0.53
Oviposition period	$5.6^{c}\pm0.1$	4-9	$14.0^{a}\pm0.2$	11-18	$11.4^{b}\pm0.2$	95-452	**	0.55
Post-oviposition period	$6.6^{a}\pm0.3$	2-11	$4.0^{b}\pm0.1$	3-5	$2.4^{c}\pm0.1$	1-4	**	0.47
Female longevity	$27.0^{b}\pm0.3$	19-34	$32.7^{a}\pm0.3$	24-41	$27.2^{b}\pm0.2$	22-32	**	0.86
Male longevity	$3.3^{a}\pm0.1$	2-4	$2.5^{b}\pm0.1$	2-4	$1.2^{c}\pm0.1$	1-2	**	0.25

± (SE) = Standard error. L.S.D. = Least significant differences. (r^{**}) indicates highly significant correlation at 0.05% level of probability

Adult male longevity

Data arranged in Table (2) revealed that the longevity period of *P. solenopsis* males varied significantly according to the tested photoperiods of complete darkness, 12 hrs. lighting and 24 hrs. lighting. It a ranged from 2 to 4 with average of 3.3±0.1, from 2 to 4 with average of 2.5± 0.1 and from 1 to 2 with average of 1.2±0.1 days on above tested photoperiods, respectively. Statistical analysis showed that there was a highly significant difference between the aforementioned photoperiods and mean duration of *P. solenopsis* males longevity where LSD was 0.25.

Fecundity, life cycle and generation

Data tabulated in Table (3) mentioned that the fecundity (crawlers/female) of *P. solenopsis* females varied significantly according to the photoperiods. It ranged from 15 to 76 with average of 51.0± 2.0, from 172 to 480 with average of 346.0±7.0 and from 95 to 452 with average of 226.0±9.0 crawlers/ female on complete darkness, 12 hrs. lighting and 24 hrs. lighting, successively. Statistical analysis showed that there was a highly significant difference between the mean fecundity of *P. solenopsis* females and the tested photoperiods where LSD was 18.22.

Data tabulated in Table (3) mentioned that the life cycle duration of *P. solenopsis* females varied significantly between the tested photoperiods. It ranged from 57 to 87 with average of 72.5±0.7, from 63 to 98 with average of 80.4±0.7 and from 63 to 84 with average of 75.0±0.5 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, consecutively. Statistical analysis showed that there was a highly significant difference between the above mentioned photoperiods and mean duration of *P. solenopsis* females life cycle where LSD was 1.81.

Data in Table (3) clarified that the generation period of *P. solenopsis* varied significantly between the three tested photoperiods. It ranged from 25 to 37 with average of 33.3±0.2 from 24 to 35 with average of 29.7± 0.3 and from 29 to 40 with average of 34.0± 0.3 days on complete darkness, 12 hrs. lighting and 24 hrs. lighting, respectively. There was a highly significant difference between the mean generation periods of *P. solenopsis* and the different photoperiods where LSD was 0.68.

Table 3 : Fecundity, generation and life cycle (in days) of *Phenacoccus solenopsis* Tinsley female when reared on potato sprouts at 25±1°C and 65 ±5% R.H. under three photoperiods conditions

Biological parameters	Durations(in days) of adult stage ± SE /range							
	Complete darkness		12/12 (L:D)		Complete lighting		F. test	LSD
	Mean ± SE	Rang	Mean ± SE	Rang	Mean ± SE	Rang		
Fecundity (Total average of crawlers / female)	51.0^{c}±2.0	15-76	346.0^{a}±7.0	172-480	226.00^{b}±9.0	95-452	**	18.22
Generation	33.3^{b}±0.2	25-37	29.7^{c}±0.3	24-35	34.0^{a}±0.3	29-40	**	0.68
Life cycle	72.5^{c}±0.7	57-87	80.4^{a}±0.7	63-98	75.0^{b}±0.5	63-84	**	1.81

± (SE) = Standard error. L.S.D. = Least significant differences. (r^{**}) indicates highly significant correlation at 0.05% level of probability

These results were similar with Wang *et al*., 2014 who studied the developmental duration of *P. solenopsis* under different photoperiods and mentioned that the fecundities of adult females varied significantly among different photoperiods. The number of crawlers produced per female under 16 hrs. light period was significantly higher than those under the 12, 10, and 8 hrs. light periods.

Generally, it could be notes that the suitable photoperiod for females of *P. solenopsis* nymphal duration, fecundity, generation and life cycle was 12 hrs. lighting followed by 24 hrs. lighting which accelerate the biological parameters than 24 hrs. darkness. While, the suitable photoperiod for males of *P. solenopsis* nymphal duration, pupal stage duration, and males longevity was 24 hrs. darkness followed by 12 hrs. lighting and 24 hrs. lighting which elongate the biological parameters than other tested photoperiods ,with the exception of males longevity whereas the increase in lighting photoperiod decrease the males longevity.

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