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# Phenological Response of Cotton Mealybug, *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Pseudococcidae) to Three Prominent Host Plants

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**Abstract.-** The phenological studies of cotton mealybug (*Phenacoccus solenopsis* Tinsley) (Sternorrhyncha: Pseudococcidae) were carried out on three host plants of economic importance [cotton (*Gossypium hirsutum*), China rose (*Hibiscus rosa-sinensis*) and okra (*Abelmoschus esculentus*)] under controlled environmental conditions (40° C, 65% RH and 10:14 light: dark regime). The development of all female nymphal instars was more rapid on cotton followed by China rose and okra, whereas the development of male nymphal instars was fastest on China rose followed by cotton and okra. Male instars lasted for longer than those of female on all tested host plants. Duration of 1$^{st}$, 2$^{nd}$ and 3$^{rd}$ male nymphal instars on cotton was 6.88 days, 4.49 days and 5.11 days and 4.33 days, 3.86 days and 7.73 days for female respectively. Total longevity of mated and unmated females was 41.47 and 61.33 days on China rose which was significantly longer than 37.86 days and 51.39 days on cotton and 34.55 days and 43.33 days on okra. Total longevity of male was 20.83 days on okra followed by 19.66 and 18.72 days on China rose and cotton, respectively. The pre-oviposition period was 9.58 days on cotton, 8.38 days on China rose and 8.75 days on okra. Maximum number of 265 eggs were laid on cotton followed by 212.6 eggs and 160.2 eggs on China rose and okra, respectively. Egg laying period was 12.47 days on China rose followed by 8.99 days on cotton and 6.77 days on okra.

**Keywords:** Cotton mealybug *(Phenacoccus solenopsis),* cotton, okra, China rose.

## INTRODUCTION

Cotton mealybug (*Phenacoccus solenopsis)* Tinsley (Sternorrhyncha: Pseudococcidae) recently invaded Pakistan and India and has become a serious threat to cotton crop. Its common name is because of the white, powdery or mealy wax secretion which covers the body of the adult females. Cotton mealybug is the only species adapted to living in concealed locations, such as galls or grass sheaths and have reduced amounts of the mealy secretion (McKenzie, 1967; Miller, 1991). It has been reported in most of the cotton growing areas in Pakistan. It feeds and reproduces on a wide range of host plants round the year and has been reported from 35 localities of various ecological zones in the world (Arif *et al.*, 2009; Abbas *et al.*, 2010; Aheer *et al.*, 2009; Ben-Dov *et al.*, 2009). Mealybugs of genus *Phenacoccus* are polyphagous in nature and attack a variety of crops, fruits, vegetables, ornamentals and weeds but cotton is the prime target. In the initial stage it breeds on all types of weeds round the year and then migrates to cotton crop. It has also been reported from India, China and other cotton growing countries in the world (Fuchs *et al*., 1991; Nagrare *et al.*, 2009; Wang *et al*., 2009). In Pakistan the control of *P. solenopsis* got an impetus since it has gained the status of damaging pest of cotton in 2005 when first recorded. For designing sustainable integrated program, it is imperative to know the biology of *P. solenopsis.*

Male passes through four developmental stages of egg, nymph, pupa and adult while female passes through three developmental stages of egg, nymph and adult. The fully grown adult female is covered with white waxy powder and has yellowish white color with some black spots on the dorsal side of the body.

It establishes and spreads more easily than many other insect pests because of high reproductive rate, ability to spread through natural carriers (wind, water, birds and human beings) and waxy coating that protects it from insecticides and

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natural mortality factors. So far very little is known about the biology of *P. solenopsis.* Therefore, considering the economic importance of the pest, a series of studies were conducted to investigate the development, survival and reproduction of *P. solenopsis* on three host plants.

## MATERIALS AND METHODS

A series of experiments were conducted to study the bionomics of *P. solenopsis* on three prominent host plants *viz.*, cotton (*Gossypium* sp.), China rose (*Hibiscus* sp.) and okra (*Abelmoschus esculentus*) under controlled environmental conditions. The newly emerged nymphs of cotton mealybug were placed on fresh leaves in Petri dishes. The developmental stages of newly emerged nymphs were observed till their mortality. During the study the number of days for each nymphal instar, pre-oviposition period, number of eggs per female and number of egg laying were recorded. The data was recorded daily. The leaves of tested host plants were replaced after every two days with fresh leaves.

Adult females were collected from the cotton fields and reared in laboratory under controlled environmental conditions on the tested host plants for two generations before starting the trial. Thirty adult females were collected from the stock and exposed to each tested host plant. The females were observed daily for egg collection. Newly hatched 1$^{st}$ instar nymphs were transferred on well washed and blotted leaves at each host plant. Each insect was placed on separate leaf of host plant in a Petri dish. The insects were observed daily for molting under a dissecting microscope at 10 x magnification. Developmental duration of each nymphal instar for male and female was calculated for each insect at all the tested host plants. The percent survival of nymphs was calculated on each host plant by the number of insects (male and female) that successfully survived to next day divided by total number of insects at the start of the day x 100. Male adult life was calculated as the duration between the adult emergence and mortality, whereas, the male total life was calculated as the duration between the egg hatching and mortality. After adult emergence the males were immediately transferred to another Petridish for mating. Female longevity was calculated as the duration between hatching of the egg and the mortality of the female.

In other experiment, the effect of tested host plants on the fecundity and possibility of asexual reproduction were investigated. In this study 40 insects were selected for each host plant. Twenty females were assigned to non mating treatment to investigate the asexual reproduction and other twenty females were assigned to mating treatment. Each female in the mating treatment was paired with newly emerged male of the same age and observed for mating. The female was assigned to mating as the male emerged from their pupal cocoons of the same host plant. After emergence the males were ready for mating within few minutes and the females were receptive at that time. The pre-oviposition period was taken, the duration between the mating time and the 1$^{st}$ day of egg laying, the oviposition period, the duration between the start and the end of egg production and the post oviposition period, the duration between the end of egg production and the mortality, was recorded for all the ovipositing females on all the tested host plant. The recorded data was analyzed statistically using computer software MSTATC and means were separated using LSD test.

## RESULTS

*Developmental period of nymphal instars*

The tested host plants had a significant effect on the developmental time of male and female nymphal instars of *P. solenopsis*. Female had shorter instar intervals on cotton as compared to China rose and okra (Table I). The first instar remained for significantly longer period reared on okra than on cotton and China rose. First instar nymphs required an average of 5.06 days, 4.73 days and 4.33 days on okra, China rose and cotton, respectively. The duration of the 2$^{nd}$ instar on all three host plants was almost the same (3.86, 3.93 and 4.06 days on cotton, China rose and okra, respectively) was non-significant ($F$=1.75; df=2,4; $P$=0.2844) . The duration of 3$^{rd}$ instar on cotton was 7.73 days which was statistically similar to 7.86 days on China rose but was significantly shorter than the 8.26 days on okra. Overall, the tested host plants had a significant effect on the developmental period of female *P. solenopsis*; as 15.93 days on cotton, 16.53 days on China rose and 17.40 days on okra were significantly different ($F$ =20.80; df =2,4; $P$ =0.0077) from each other. The offered host plants had a significant effect on the development of male nymphal instars as well. The developmental period (6.69 days) of male *P. solenopsis* on China rose was shorter than the 6.88 days on cotton and 7.47 days on okra. The 2$^{nd}$ instar stayed for 5.22 days on okra was statistically different from 4.49 days on cotton and 4.38 days on China rose.

Pupation period was relatively longer on China rose. Males required an average of 6.11 days, 5.11 days and 5.36 days to emerge from their pupal cocoons on China rose, cotton and okra, respectively. The total (nymphal + pupal) developmental period of 18.32 days of male *P. solenopsis* on okra was significantly more than 17.18 days on China rise and 16.48 days on cotton.

*Longevity*

The male adult life was not affected by the offered host plant; as 2.11 days, 2.55 days and 2.49 days adult life on cotton, China rose and okra, respectively was statistically non-significant. However, total longevity (20 days) of male on okra was significantly different from the total longevity (19.66 days) of male *P. solenopsis* on China rose and (18.72 days) on cotton (Table II). Significant differences were also found among the three host plants in term of total longevity of mated and unmated female of *P. solenopsis*. Unmated and mated females lived significantly longer on China rose. The shortest longevity (43.37 days and 34.55 days) of unmated and mated females *P. solenopsis*, respectively on okra was observed which was significantly lower than the 51.39 days and 37.86 days of unmated and mated females of *P. solenopsis*, respectively lived on cotton.

*Fecundity*

Although, the pre-oviposition period of cotton mealybug was not affected by the offered host plants, the oviposition period was greatly affected by the host plants; as 8.99 days on cotton, 12.47 days on China rose and 6.77 days on okra were significantly different from each other (Table III). The effect of host plants on the post oviposition period of the cotton mealybug was negligible and statistically similar. The number of eggs laid per single laying of mealybug on cotton were significantly more than those on China rose and okra. The number of eggs per laying on the later two host plants were statistically similar. All the tested three host plants had strong effect on the total number of eggs laid by mealybug in its life span; as 265.00 eggs laid on cotton were significantly different from 212.60 eggs laid on China rose. Similarly, eggs laid on China rose were also statistically ($F$=105.29; df=2,4; $P$=0.0003) more than 160.2 eggs laid on okra.

*Mean percent survival*

The tested three host plants had a strong effect on the percent survival or percent mortality of *P. solenopsis.* Results showed that maximum mortality of 27% on okra, 17% on China rose and 6% on cotton of the test insect was recorded one day after emergence (Fig. 1). During first four days after emergence, the percent survival rate of *P. solenopsis* was 85%, 71% and 53% on cotton, China rose and okra, respectively. Overall mean percent survival rates from day 1 to day 10 of the test insect was 72% on cotton and 61% on China rose which were the highest ones, while the lowest 41% mean percent survival rate was noticed on okra.

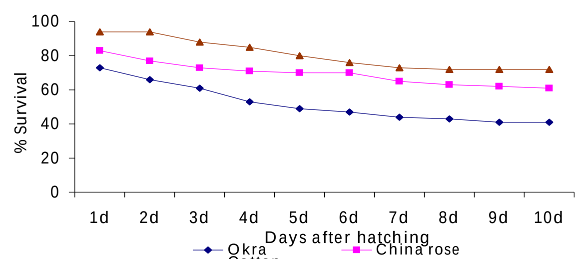


Fig. 1. Mean percent survival of *P. solenopsis* on three host plants.

## DISCUSSION

Development, longevity and fecundity of *Phenacoccus solenopsis* were affected to varying degrees by the tested host plants. To reach its adult stage, nymphs of *P. solenopsis* required fewer days

**Table I.-** **Mean duration (days** ±SE) **of male and female nymphal instars of *P. solenopsis* at three prominent host plants.**

| Hosts plant | 1st Instar | 2nd Instar | 3rd Instar | Total nymphal period |
|---|---|---|---|---|
| Female | | | | |
| Cotton | 4.33 ±0.50 c | 3.86 ±0.36 a | 7.73 ±0.46 b | 15.93 ±0.26 c |
| China rose | 4.73 ±0.40 b | 3.93 ±0.25 a | 7.86 ±0.36 b | 16.53 ±0.49 b |
| Okra | 5.06 ±0.46 a | 4.06 ±0.26 a | 8.26 ±0.47 a | 17.40 ±0.47 a |
| LSD | 0.244 | 0.3041 | 0.2378 | 0.2378 |
| CV | 2.24 | 3.37 | 1.32 | 0.63 |
| **Male** | **1st Instar** | **2nd Instar** | **Pupation period** | **Total nymphal + pupal period** |
| Cotton | 6.88 ±0.32 ab | 4.49 ±0.56 b | 5.11 ±0.32 b | 16.48 ±0.56 b |
| China rose | 6.69 ±0.51 b | 4.38 ±0.53 b | 6.11 ±0.32 a | 17.18 ±0.45 b |
| Okra | 7.74 ±0.86 a | 5.22 ±1.43 a | 5.36 ±0.81 ab | 18.32 ±1.50 a |
| LSD | 0.8838 | 0.5018 | 0.7553 | 0.7620 |
| CV | 5.48 | 4.70 | 6.11 | 1.95 |

Values in a given column followed by the same letter are not significantly different at the 5% level of probability using LSD test.

**Table II.-** **Longevity (days ± SE) of male and female *P. solenopsis* reared on three prominent host plants.**

| Hosts plant | Male longevity | | Female longevity | |
|---|---|---|---|---|
| | Adult life | Total longevity | Unmated | Mated |
| Cotton | 2.11 ±0.32 a | 18.72 ±0.73 c | 51.39 ±3.47 b | 37.86 ±3.02 b |
| China rose | 2.55 ±0.58 a | 19.66 ±0.39 b | 61.33 ±3.38 c | 41.47 ±1.33 a |
| Okra | 2.49 ±0.56 a | 20.83 ±0.99 a | 43.33 ±3.58 c | 34.55 ±2.46 c |
| LSD | 0.8111 | 0.9096 | 1.505 | 2.539 |
| CV | 15.02 | 2.03 | 1.28 | 2.95 |

Values in a given column followed by the same letter are not significantly different at the 5% level of probability using LSD test.

**Table III.-** **Fecundity (Mean** ±SE) **of *P. solenopsis* females reared at three prominent host plants.**

| Host plant | Pre-oviposition period (days) | Oviposition period (days) | Post-oviposition period (days) | Total eggs laid | Eggs/ laying |
|---|---|---|---|---|---|
| Cotton | 9.58 ±1.92 a | 8.99 ±2.78 b | 1.83 ±0.79 ab | 265.0 ±123.36 a | 40.64 ±10.50 a |
| China rose | 8.38 ±1.23 a | 12.47 ±1.13 a | 2.66 ±1.00 a | 212.6 ±29.70 b | 31.19 ±4.07 b |
| Okra | 8.75 ±1.49 a | 6.77 ±1.64 c | 1.41 ±0.54 b | 160.2 ±71.91 c | 27.10 ±5.52 b |
| LSD | 1.924 | 1.189 | 1.036 | 20.05 | 9.008 |
| CV | 9.53 | 5.57 | 23.22 | 4.16 | 12.05 |

Values in a given column followed by the same letter are not significantly different at the 5% level of probability using LSD test.

on cotton than on China rose and okra. The longest total developmental period was observed in nymphs reared on okra. In case of female, 3rd instar remained for longer period and 2nd instar for the shortest one; whereas, in case of males, 1st instar was the longest one. Females had three nymphal instars whereas males had two nymphal instars and a pupation period. Basinger (1934) observed two nymphal instars for male and three for female of *P. gossypii* and *Pseudococcus gohani*. Hodgson *et al.* (2008) also reported two nymphal instars in case of male and three in case of females for *P. solenopsis*. Total developmental period of male was approximately one day longer than the female. Males emerged from their pupal cocoons one day after the adult molt of female at all three tested host plants. The male adult of *P. solenopsis* lived for 2-3 days and the tested host plants did not significantly affect the adult male life span. These results are in accordance with the results of Aheer *et al.* (2009) who reported that adult males of *P. solenopsis* reared on China rose lived for 2-3 days.

Total longevity of mated and unmated females reared on China rose was significantly longer than the total longevity on the other tested plants. The longest total longevity of unmated and mated females was found when reared on China rose. Males reared on okra had longest total longevity in contrast to the shortest one reared on cotton. Both males and females completed their development faster on cotton.

Pre-oviposition period did not vary significantly when reared on different host plants. Oviposition and post oviposition period was significantly longer for females reared on China rose. Females reared on okra had shortest oviposition and post oviposition periods. Total eggs and eggs per laying was greater for the females reared on cotton and China rose leaves. The females reared on okra laid fewer eggs and eggs per laying. The differences in the development of the mealybug on different host plants may have been caused by quality, accessibility or actual ratio of nutrients in the tested host plants. Majority of the ovipositing females died immediately after the last egg laying. *P. solenopsis* reproduced sexually. None of the unmated female which was assigned to non mating treatment produced eggs. Chong *et al.* (2003) also reported sexual reproduction in *P. madeirensis*.

*P. solenopsis* with rapid development, high reproductive capacity, variety of host plants and lack of early management in the absence of cotton crop can cause a significant loss to the cotton crop. Arif *et al.* (2009) reported 154 host plants of *P. solenopsis* including field crops, vegetables, ornamentals, weeds, bushes and trees but economic damage was observed on cotton, okra, brinjal and China rose. In the absence of cotton crop *P. solenopsis* breeds round the year on the alternate host plants specially China rose and then migrates to the cotton crop. In some localities farmers grow okra and cotton side by side and thus helping in its survival.

The findings of the present studies will help to forecast population buildup during crop season and off-season however further season-long studies under field conditions along with its natural enemies could play a crucial role in decision making. A close vigilance to the most preferred host plants and considering the susceptible stage for management practices may lead farmers to save the cost and quality of their fiber.

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