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THE IMPACT OF SOME ENVIRONMENTAL FACTORS ON THE FECUNDITY OF *PHENACOCCUS SOLENOPSIS* TINSLEY (HEMIPTERA: PSEUDOCOCCIDAE): A SERIOUS PEST OF COTTON AND OTHER CROPS

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Phenacoccus solenopsis Tinsley (Hemiptera: Sternorrhyncha: Pseudococcidae) was first recorded on cultivated cotton from Texas, USA in 1991. Since 2005, this New World species has emerged as serious pest of cotton in Pakistan and India, and is now a serious threat to cotton in China and other cotton-growing countries worldwide. The species is polyphagous and invasive, and can attack many other economic crops. So far, it has been reported from 173 species in 54 plant families, and from 26 countries in different ecological zones. The study found that host plant species and meteorological conditions had significant effects, whereas locality had no significant effect on the fecundity of the mealybug.
Keywords: *Phenacoccus solenopsis,* cotton, polyphagous mealybug, cotton mealybug, pest

INTRODUCTION

Phenacoccus. solenopsis Tinsley (Hemiptera: Sternorrhyncha: Coccioidea: Pseudococcidae) has been reported from 35 localities of various ecological zones of the globe (Ben-Dov *et al.*, 2009). It has a wide range of variation in morphological characters, biological adaptations and ecological adjustability (Hodgson *et al.*, 2008). *P. solenopsis* was initially reported as a pest of cotton in Texas, USA (Fuchs *et al*., 1991). In Pakistan, from the year 2005 onwards, it has been recorded as a serious pest of cultivated cotton (*Gosspium hirsutum* L.) (Abbas *et al.*, 2007; Muhammad, 2007; Hodgson *et al.*, 2008). It has also been reported as a serious pest in India (Nagrare *et al.*, 2008) and a potential serious threat in China (Wang *et al.*, 2009) and other cotton growing countries of the world. It has emerged as a potential serious pest of cotton in Pakistan (Hodgson *et al*., 2008). So far, it has been reported from 183 plants in 52 families (Ben-Dov *et al.*, 2009). These studies were undertaken in field conditions to determine the effect of host plant species, locality and different ecological conditions on its relative fecundity. Similarly, its fecundity on 10 different alternate host plant species was recorded to determine its relative preference and suitability as feed.

MATERIALS AND METHODS

***Effect of Host-Plant Species, seasons and Locality on Fecundity*:** The three host-plant species i.e. cotton *(Gossypium hirsutum* L., Malvaceae), Itsit *(Trianthema partulacastrum* L., Aïzoaceae) and Hazardani (*Euphorbia granulata* Forssk., Euphobiaceae) were used in this study. The study was carried out at Alipur (cotton-growing area of the cotton zone), Multan (mixed-crop area of the cotton zone) and Faisalabad (mixed-crop area of the non-cotton zone). The data was collected in three different months: July, August and September 2006. The same experiment was repeated next year to test the effect of seasons on the fecundity of the pest. The observations were made in July, 2006 (middle of the cotton-growing season), October, 2006 (end of cotton-growing season) and May, 2007 (start of cotton-growing season). The data was analyzed for statistical analysis using Minitab 15.0 software.

***Effect of Host-Plant Species on Fecundity*:** The effect of host-plant species on the fecundity of cotton mealybug *Phenacoccus solenopsis* Tinsley was studied on ten host-plant species. The plant species were not pre-determined initially because at that stage the pest, which was later on identified as *P. solenopsis* Tinsley, and its host plants were not known. The ten

host species found to be infested most frequently and heavily by the pest were selected. The following host-plant species were included in this study: itsit *(Trianthema patulacastrum,* Aïzoacaeae); tandla *[Digera muricata* (L.), Amaranthaceae); hazadani *(Euphorbia granulata)*, lady's finger *[Abelmoschus esculentus* (L.), Euphorbiaceae]; cotton *(G. hirsutum),* shoe flower *(Hibiscus rosa-sinensis);* gule dupehri *(Portulaca grandiflora* Hook, Portulacaceae); aksun *(Withania somnifera)*, chilli *(Capsicum annuum* L., Solanaceae); and lantana *(Lantana camara* L., Verbenaceae). For each host species tested, a mature adult female was collected from each of five plants. All the females selected were of the same size. Each female was dissected under a binocular dissection microscope to determine the number of eggs developing inside. The total number of eggs was counted and recorded. The number of developing eggs was taken as an indicator of the quality of that host-plant as a food source for the pest to support reproduction and development.

In addition, for each of the same ten plant species, a mature adult female was collected from each of ten plants in the field. All the females selected were of the same size. Each female was transferred to a Petri dish cage (described above) on a clean leaf of the same host-plant in the field. These females were caged individually to discover the total number of offspring produced by a single female in semi-natural conditions. The crawlers produced by each female were counted, recorded and destroyed, leaving the reproductive female alone again until she died in the cage. Rearing in this manner provided natural food, air and light, but there was no inter- or intra-specific competition, nor any interaction with natural enemies. The data obtained was analyzed statistically using Minitab 15.0 software, followed by a Tucky HSD test for significant differences between the means.

RESULTS

Effect of host-plant species, seasons and locality on fecundity: A female produced 2.6 ± 1.0 crawler sacs in her life (Abbas, 2009). In the initial experiment the effects of various factors on the number of crawlers (progeny) produced by cotton mealybug *P. solenopsis* on three different host-plants in the field were investigated. The three host-plants studied were cotton *(G. hirsutum)*, itsit *(Trianthema portulacastrum)* and hazardani *(Euphorbia prostrate)*. The comparisons of means revealed that the host-plant species had a significant effect on CMB fecundity (p value = 0.000, df= 2, MSE= 118.9). Locality has a non significant effect (p value = 0.26, df= 2, MSE= 118.9) and months of study in the first year (July, August and September) singly (p value= 0.26, df=2) and in interaction with each other factors and with the host-plant species had no significant effects on the number of progeny{(host * month : P value= 0.19, df=4) host *locality: p value =0.38, df= 8)(month*locality: p value = 0.23, df=4) (host*month*locality: p value = 0.36, df= 8)}.

The Analysis of variance shows that the response of the pest on various hosts is significantly different, which indicates that quality of feed has a significant effect on the biology of the pest. More suitable and preferred the feed is, more is the fecundity of the pest in the locality and same environmental conditions. In the preliminary experiment of the first year (2006), the population of the crawlers of *P. solenopsis* on cotton was significantly larger than that on either of the other two hosts [Itsit (*T. portulacastrum)* and Hazardani *(E. prostrate)],* which was tested with other host plants in year 2007, the comparison of means has been shown in table 1.. There was no significant difference between the latter two hosts in the number of crawlers produced as shown in the Figure1.

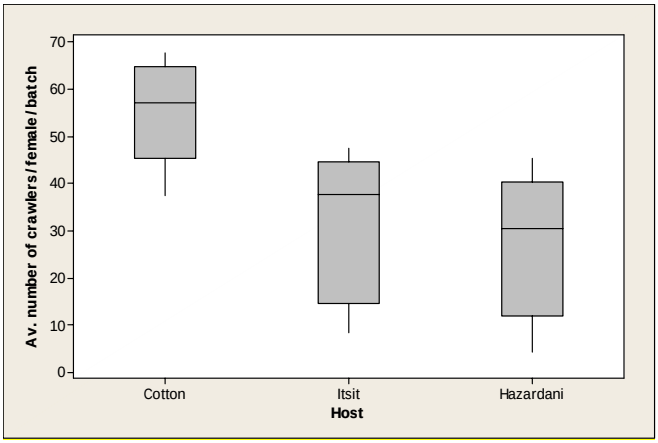


Figure1. Average number of crawlers per batch per CMB female, in different months, observed on three different Host-plant Species (Cotton, Itsit and Hazardani) in July and December 2006 and May 2007

***Effect of host-plant species on CMB fecundity*:** In view of the above results, more host-plant species were taken into observation at UAF in 2007 and the effect of ten host-plant species on fecundity was determined. The data obtained are summarized in Table 2 below. Analysis of this data showed that there were significant differences in the numbers of developing embryos per adult female between the host-plant species studied had statistically significant differences (p value = 0.000), the comparison of means was analyzed (Table 2).

Table 1. Average number of developing eggs visible in the body of a dissected, full-sized, field-collected adult female in August 2007

S.No.	Host plant		Eggs/female
	Local or English name	Latin name	
1.	Cotton	*Gossypium hirsutum*	92.4 ± 6.9a
2.	Lady's finger	*Hibiscus esculentus*	81.7 ± 5.8ab
3.	Shoe flower	*Hibiscus rosa-sinensis*	90.4 ± 7.1a
4.	Itsit	*Trianthema patulacastrum*	63.9 ± 6.3bc
5.	Hazadani	*Euphorbia granulate*	52.8 ± 5.9cd
6.	Tandla	*Digera muricata*	46.8 ± 7.2de
7.	Aksun	*Withania somnifera*	68.6 ± 6.8bc
8.	Gule dupehri	*Portulaca grandiflora*	51.6 ± 7.3cd
9.	Lantana	*Lantana camera*	48.4 ± 6.8de
10.	Chillies	*Capsicum annuum*	46.7 ± 5.7de

The values having same letters were statistically similar, α = 0.05
P = 0.000, pooled standard deviation = 6.60

Table 2. Average number of CMB crawlers in one batch, in different months and on various hosts

Month/Host	Cotton	Itsit	Hazardani	Monthly mean
July	62.4 ± 5.3	42.3 ± 4.7	36.7 ± 6.3	47.1 ± 12.6a
December	42.6 ± 5.3	12.5 ± 4.1	9.4 ± 5.2	21.5 ± 16.4b
May	58.7 ± 8.5	38.9 ± 8.6	37.8 ± 7.6	45.1 ± 12.4a
Host-wise average	54.6 ± 10.7a	31.2 ± 15.1b	28.0 ± 15.0b	37.9 ± 17.9

Values sharing same letters are not significantly different

The number of crawlers obtained in the field from females feeding on each of the hosts listed in Table 1 shows the same host-related trend. The average total number of crawlers produced per female on cotton in the field was significantly greater than that produced on chillies in the same conditions.

Fig.2 and 3 illustrate the effect of different host-plant species on the number of eggs and crawlers produced by one female CMB, respectively. In both figures, cotton *(G. hirsutum)* was the most favoured food source, enabling the pest to produce the maximum number of offspring, followed (in order of decreasing mealybug fecundity) by shoe flower *(H. rosa-sinensis),* lady's finger *(H. esculentus)*, aksun *(W. somnifera),* itsit *(T. patulacastrum),* hazardani *(E. granulate),* gule dupehri *(P. grandiflora),* lantana *(L. camara),* tandla *(D. muricata),* and lastly chillies *(C. annuum).*Compared to the initial study on three hosts in three months (July, August and September 2006), the second experiment included some different months of the year that have different meteorological conditions, to test whether varying environmental conditions had any effect on CMB fecundity. The observations were undertaken in July 2006 (cotton season), December 2006 (end of the cotton season) and May 2007 (start of the cotton season) on the same host-plant species.

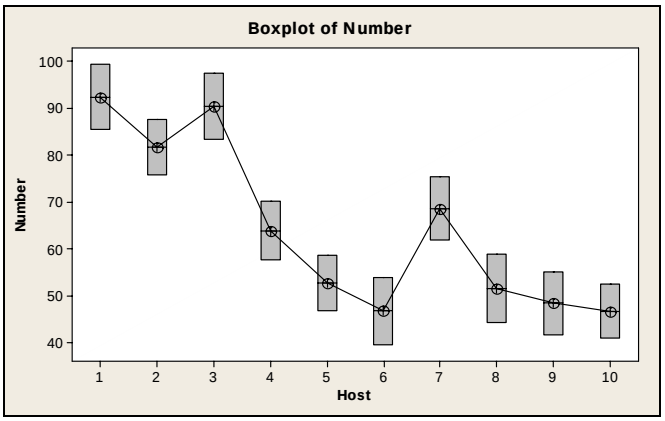


Figure 2. Box plot showing the range and mean number of developing eggs per dissected adult female of CMB, on various host plants at UAF in 2007

Analysis of means of the data revealed that the average number of the crawlers of the pest *P. solenopsis* in one batch varied significantly between the host-plant species studied (p = 0.002); and the average number of crawlers per female also varied significantly between different months (p = 0.002). The interaction of host-plant species and month did not cause significant variation in the average population of

CMB crawlers per female (p = 0.454). In overall comparisons, CMB fecundity was highest on cotton in July, when the temperature range was 28-41°C and relative humidity was 41.3±6.7%. In laboratory conditions the average number of crawlers per batch averaged 20-53; a female could produce up to four batches of crawlers at 2-5 day intervals.

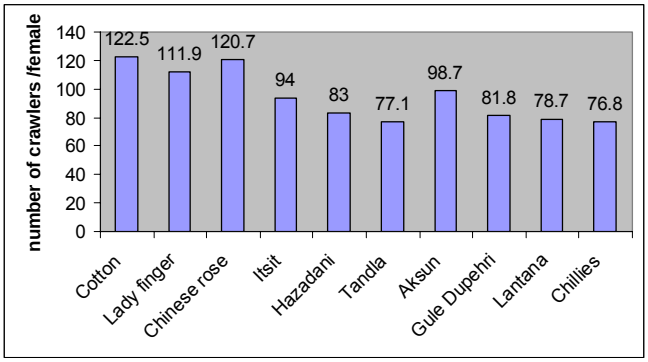
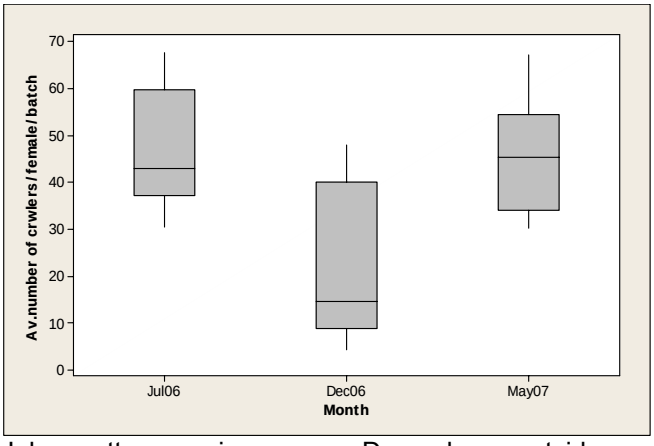


Figure 3. Total number of crawlers per female of CMB, on various hosts in July 2007.



July = cotton-growing season; December = outside cotton-growing season; May = season for early sown cotton

Figure 4. Average number of crawlers per batch per CMB female, in different months, observed on three different host-plant species (Cotton, Itsit and Hazardani)

Table 2 shows the average number of crawlers produced per batch on different host-plant species in the field. Cotton was the best quality food source (optimal host) as it enabled the mealybugs to reproduce prolifically. The number of crawlers produced on cotton was significantly higher (p = 0.000) than that on two other hosts [itsit *(T. portulacastrum)* and hazardani *(E. prostrate)].* The difference between the number of crawlers produced on each of the latter two hosts was not significant (p = 0.534).

The cumulative average of the number of crawlers produced differed significantly between the three different months (p = 0.002). The number of crawlers per female in July 2006 and May 2007 was not significantly different (p = 0.786), but differed significantly from the average population of crawlers per female produced in December, 2006 (p = 0.000). The prevailing environmental conditions for the corresponding weeks of the months in study are given in Table 3. Both the host-plant species and the month of observation significantly affected the fecundity of the pest *P. solenopsis* (p = 0.002) for both factors, see Table 3). These relationships are illustrated in Fig.1 and 4, respectively.

DISCUSSION

Host plant species are an important factor in the development of *P. solenopsis* as they provide the food source to the feeding population and food sources have a significant effect on fecundity and other biological features (Calatayud, 2003). Since the studies have revealed that different ecological factors have paramount impact on the fecundity of the pest. It could be a basis for future research in this regards to develop regression models with corresponding meteorological conditions population growth of the pest. These findings could be very helpful in making pest management decisions.

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Table 3. Environmental data for the weeks of study for the host-related fecundity experiment with ten host-plants at UAF

Date	Period	Maximum Temp. (°C)	Minimum Temp. (°C)	RH (%)	Rainfall (mm)
July 2006	3rd week	40.0 ± 1.3	29.4 ± 1.4	41.3 ± 06.7	0.0
Dec. 2006	1st week	21.8 ± 3.2	10.8 ± 3.2	60.6 ± 13.8	6.1 ± 16.3
May 2007	1st week	41.3 ± 3.2	24.7 ± 1.3	23.3 ± 06.2	2.1 ± 05.7

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