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Population dynamics, biology of mealybug *Phenacoccus solenopsis* (Tinsley) and its natural enemies in Vadodara, Gujarat

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Abstract

The population dynamics study of *Phenacoccus solenopsis* (Tinsley), a serious pest in Vadodara, India, were conducted during 2008-2011. The results show that the mealybug population is higher in the month of October on cotton (*Gossypium hirsutum* L.) and Okra (*Abelmaschus esculentus* L.). Whereas maximum population of mealybug were seen in the month of February on Tomato (*Lycopersicon esculentum* L.) and Potato (*Solanum tuberosum* L.) host plants. The correlation of mealybug population was done with abiotic and biotic parameters. The mealybug population was showing positive correlation with higher temperature, population of predator and parasitoids whereas negative correlation with lower temperature and humidity. Further the biology of the *Phenacoccus solenopsis* (Tinsley) was studied on *Hibiscus rosa-sinensis* (L.) under the laboratory conditions. The results on different biological parameters showed that the fecundity rate of female ranged from 300 to 750 which increased its survival rate. The longevity of female was higher (24.44±2.329 days) than male (1.960±0.8406 days). Hence, the information contained in this paper lead to the identification of proper management practises during effective reproductive period for *Phenacoccus solenopsis* management.

Keywords: *Phenacoccus solenopsis,* Population dynamics, *Hibiscus rosa-sinensis*, Biological studies

INTRODUCTION

Worldwide, the *Phenacoccus solenopsis* (Tinsley) is a major threat to agriculture and horticulture in many tropical and subtropical countries which was found to attack large number of plant species including crops, vegetables, ornamental plants and weeds [1, 2]. However ,a decade ago, the evidence of mealybug was reported from Uttar Pradesh, Madhya Pradesh and Karnataka [3,4]. Further detail studies support the strong evidences for its presence in India [5]. In India, *Phenacoccus solenopsis* was recorded from 22 plant species of 10 families comprising 7 field and vegetable crops, 3 ornamentals & 12 weeds which makes it polyphagous pest [6]. Due to large number of host range, mealybug seems to be present throughout the year [7]. The *Phenacoccus solenopsis* cause crinkling, twist and condense flower, bud, bolls growth and finally plant exploitation along yield loss [8].

Propensity to cause damage to various host plants and its association with various natural enemies motivated us to take the population dynamics and biological study of mealybugs. Application of these studies will be helpful during proper implementation of various control measures against this pest.

MATERIALS AND METHODS

Record of mealybug population

Observations on population dynamics of mealybug and its associated insects were recorded from the selected agricultural sites in Vadodara. The mealybugs were recorded on 15 cm apical shoot length from 2008 to 2011 at weekly interval from 25 randomly selected plants. Similar pattern was followed for associated insects.

Record of biological parameters

The biology of *Phenacoccus solenopsis* was studied on hibiscus twigs at room temperature (24.3-31.2°C, 48.9-71.7% R.H.) in the laboratory. Harboring *Phenacoccus solenopsis* colonies were collected from the fields and brought to the laboratory. The mealybug present on these collected twigs were gently removed with the help of soft camel hair brush and were released on the *Hibiscus rosa-sinensis* twigs (Twigs end was wrapped with wet cotton) kept in plastic box (20 x 15 cm^2) in laboratory.

Newly hatched crawlers were collected from the ovipositing female of laboratory culture and were placed` onto the hibiscus twigs. 25 replicates were used for this experiment. Daily observations were made on molting of nymphs to determine the nymph stages and its duration. Pre-oviposition, oviposition and post-oviposition period in case of females and longevity of female and male were recorded.

Statistical Analysis

Further correlation and regression were calculated by using SPSS 19 software with the biotic (associated insects) and abiotic factors (weather parameters) which are affecting the population of mealybugs.

RESULTS

In agriculture fields of Vadodara, *Phenacoccus solenopsis* infestation started appearing in the month of August which progressively increases on host plants, cotton (*Gossypium hirsutum*

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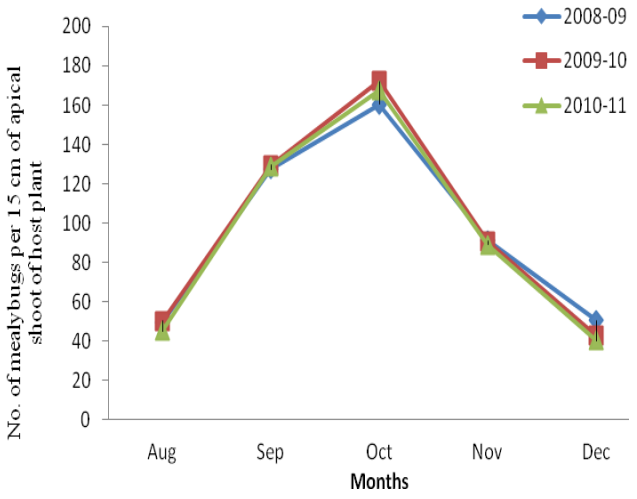
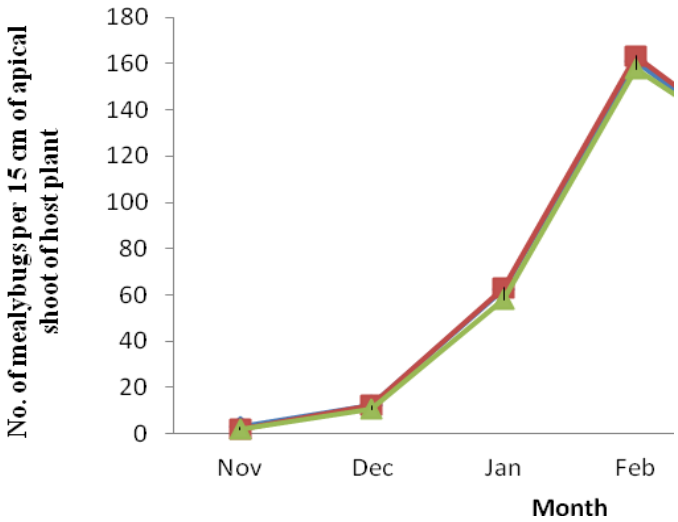
L.) and Okra (*Abelmaschus esculentus* L.). The maximum population was recorded during October month from both cotton and okra crops (Graph 1). The count appeared to be around 188 adults / 15 cm on apical shoot of cotton and okra host plants during peak season. Further population dynamics study of mealybug and its associated natural enemies were recorded from Tomato (*Lycopersicon esculentum* L.) and Potato (*Solanum tuberosum* L.). During this, the highest level of *Phenacoccus solenopsis* population was seen in the month of February (Graph-2).



Graph 1. Number of mealybug, *Phenacoccus solenopsis* Tinsley on apical shoot of host plants, cotton (*Gossypium hirsutum* L.) and Okra (*Abelmaschus esculentus* L.)



Graph 2. Number of mealybug, *Phenacoccus solenopsis* Tinsley on apical shoot of host plants, Tomato (*Lycopersicon esculentum* L.) and Potato (*Solanum tuberosum* L.)

During 2008-09 and 2009-10 of study period, the average maximum population of Coccinellids and Chrysoperla were 0.24 and 0.16 per host plant, respectively during the season. The percentage presence of parasitoids cocoons ranged between 0.7 to 30.5 per cent per host plant in year 2008-09, whereas in 2009-10, it was ranged between 0.5 to 35.4 per cent per host plant (Table-1 &2). Similarly in 2010-11, the average maximum population of Coccinellids and Chrysoperla were 0.28 and 0.2 per host plant whereas percentage presence of parasitoids cocoons ranged between 0.82 to 32.6 per cent per host plant (Table-3).

Table 1. Population dynamics of mealybugs, predators and parasitoid on apical shoot of host plant, Tomato (*Lycopersicon esculentum* L.) and Potato (*Solanum tuberosum* L.) in Agricultural field of Vadodara during 2008-09

Standard weeks	No. of Mealybugs/ Plant	Predator/plant		% Parasitoid Cocoons per Plant
		Coccinellids	Chrysoperla	
45	0.96	0	0	2.0
46	1.52	0	0.04	2.6
47	1.8	0	0.16	3.24
48	2.88	0.04	0.2	7.6
49	6.4	0	0.12	9.8
50	9.08	0.08	0.16	10.0
51	11.24	0.12	0	10.4
52	14.96	0.04	0	11.2
1	17.08	0.2	0	11.5
2	32.88	0.24	0.04	12.62
3	56.04	0.16	0.08	13.2
4	74.48	0.12	0.04	13.45
5	108.6	0.08	0	15.62
6	165.2	0.08	0	20.2
7	175.2	0.04	0	22.16
8	148.0	0.12	0	30.5
9	141.9	0	0	24.6
10	133.0	0.04	0	16.42
11	119.9	0.1	0	12.64
12	121.3	0.04	0	10.27
13	106.8	0.12	0	9.6
14	88.72	0.08	0	8.4
15	71.48	0.12	0	3.26
Correlation with mealybug Population		0.022	-0.56	0.742

Table 2. Population dynamics of mealybugs, predators and parasitoid on apical shoot of host plant, Tomato (*Lycopersicon esculentum* L.) and Potato (*Solanum tuberosum* L.) in Agricultural field of Vadodara during 2009-10

Standard weeks	No. of Mealybugs/ Plant	Predator/ Plant		% Parasitoid Cocoons per Plant
		Coccinellids	Chrysoperla	
45	1.760	0	0	1.7
46	2.040	0	0.04	2.04
47	2.320	0.12	0.16	2.1
48	2.880	0	0.08	4.04
49	7.840	0.12	0.16	6.8
50	11.00	0.12	0.2	8.0
51	12.20	0.16	0	9.25
52	17.40	0.08	0	10.0
1	21.96	0.12	0	11.6
2	40.68	0.1	0.12	12.2
3	59.80	0.24	0.04	14.8
4	78.72	0.24	0.08	19.6
5	114.4	0.12	0	18
6	169.8	0.1	0	26.4
7	188.6	0	0	28.45
8	152.0	0.16	0	35.4
9	142.9	0	0	22.8
10	133.0	0.04	0	18.36
11	120.2	0.24	0	14.46
12	122.3	0.04	0	10.4
13	106.8	0.12	0	9.2
14	95.52	0.16	0	7.6
15	67.72	0.04	0	4.28
Correlation with mealybug Population		0.0197	-0.537	0.817

Table 3.Population dynamics of mealybugs, predators and parasitoid on apical shoot of host plant, Tomato (*Lycopersicon esculentum* L.) and Potato (*Solanum tuberosum* L.) in Agriculture fields of Vadodara during 2010-11

Standard weeks	No. of Mealybugs/ Plant	Predator/ Plant		% Parasitoid Cocoons per Plant
		Coccinellids	Chrysoperla	
45	2.400	0	0	1.7
46	2.840	0	0.08	2.04
47	3.080	0.04	0.12	2.1
48	3.440	0.08	0.16	4.04
49	8.542	0.08	0.2	6.28
50	11.24	0.12	0.12	8.0
51	11.92	0.04	0.08	9.25
52	17.44	0.08	0	10.3
1	22.00	0.28	0	11.0
2	40.20	0.2	0	14.4
3	59.20	0.12	0.04	16.2
4	77.24	0.08	0.04	14.5
5	113.1	0	0.08	17.25
6	165.9	0.08	0	22.4
7	186.8	0	0	24.5
8	153.0	0.16	0	32.6
9	138.9	0.12	0	26.3
10	131.9	0.08	0	18.36
11	117.4	0.24	0	16.37
12	121.7	0.04	0	9.76
13	103.9	0.16	0	8.4
14	95.52	0.08	0	7.9
15	74.32	0.2	0	4.27
Correlation with mealybug Population		0.039	-0.597	0.799

In all three years of studies, the activity of parasitoids started during 43rd meteorological week and later gradually gained peak during 6th to 8th meteorological week. The highest percentage population of parasitoid (30.5 %, 35.4 % and 32.6 %) were recorded during 8th meteorological week. From 9th week onwards, it started showing gradual decrease in its population.

Population of mealybugs was also affected by the presence of abiotic (Maximum temperature, Minimum temperature, Humidity 8.30 hrs, Humidity 17.30 hrs) and biotic factors (Coccinellids per plant, Chrysoperla per plant, % of Parasitoid per plant).

Mealybug population is positively correlated with maximum temperature whereas it shows negative impact of humidity (Table-4). Coccinellid predators and percentage of parasitoids as biotic factor shows strong significant positive correlation with mealybug

population (Table-1, 2 &3). Regression indicated a significant relationship between variance (both biotic and abiotic factors) and mean population of mealybug. During 2008-2009: R^2 = 0.883, P < 0.0001 (df=7-27 , F= 29.09); 2009-10: R^2 = 0.922, (df=7-27, F=45.517) and 2010-11: R^2=0.909, (df= 7-27, F=38.646) were recorded.

Table 4. Correlation of Mealybug, *Phenacoccus solenopsis* Tinsley population with Abiotic factors

Abiotic parameters	2008-09	2009-10	2010-11
Maximum Temperature	0.433	0.166	0.324
Minimum Temperature	-0.187	-0.173	-0.313
Humidity at 5.30 a.m.	-0.566	-0.715	-0.551
Humidity at 8.30 p.m.	-0.693	-0.666	-0.683

The biological study results show that during our study, it was found that male of *Phenacoccus solenopsis* had two nymphal, pupal and adult stages (winged) while the female had three nymphal and the adult stages (wingless). The adult female of *P. solenopsis* had pre-oviposition, oviposition and post oviposition period of 7.120 ± 0.7810, 14.04 ± 0.9781 and 3.560 ± 0.7118 days, respectively. The female formed 3.520±0.7141 ovisacs during its life span in which around 540.8 ± 107.2 eggs were deposited that hatched within few minutes (3.634 ± 0.7342 minutes). The development period for first, second and third nymphal stage was 4.320±0.8524, 4.840±0.8 and 5.12±0.8327 days respectively (Table 5).

Table 5. Biological parameters of Female *Phenacoccus solenopsis* (Tinsley) on *Hibiscus rosa-sinensis* (L.) under laboratory conditions

Biological Parameters	Mean ± SD*	Range
Incubation period (minutes)	3.634 ± 0.7342 minutes	2.45 - 4.8 minutes
Nymphal duration (days)		
First nymphal stage	4.320±0.8524	3 - 6
Second nymphal stage	4.840± 0.8000	4 - 6
Third nymphal stage	5.120± 0.8327	4 - 6
Pre-oviposition period (days)	7.120± 0.7810	6 - 9
Oviposition period (days)	14.04± 0.9781	12 - 15
Post-oviposition period (days)	3.560± 0.7118	2 - 5
Fecundity (no. of eggs laid/ female)	540.8± 107.2	300 - 750
Ovisacs (no. of ovisacs/ female)	3.520±0.7141	2 - 5
Adult longevity (days)	24.44±2.329	21- 30
Total life cycle (days)	39.88±3.127	33 - 44

*Value of Mean of 25 replicates ± SD

The male was short lived with an adult life of 1.960 ± 0.8406 days, while female lived longer (24.44 ± 2.329 days). The total life duration of female ranged from days (39.88 ± 3.127 days) and that of male from days (19.20±1.756 days) (Table 6).

Table 6. Biological parameters of Male *Phenacoccus solenopsis* (Tinsley) on *Hibiscus rosa-sinensis* (L.) under laboratory conditions

Biological Parameters	Mean ± SD*	Range(days)
Nymphal duration (days)		
First nymphal stage	5.160±0.8000	4-6
Second nymphal stage	5.080±0.7594	4-6
Pupal period (days)	7.440±1.083	6-9
Adult longevity(Days)	1.960±0.8406	1-3
Total life cycle (Days)	19.20±1.756	17-22

*Value of Mean of 25 replicates ± SD

DISCUSSION

The importance of study of population dynamics of insect pests in the agricultural fields is helpful for assessing the pesticide productivity and timing of pesticide application. In the absence of such factors, the decision for pesticide utilization can only be motivated by prevailing conditions at the time of application and thus, misses an important dimension of pesticide problem [9].

The study on *P. solenopsis* in Agriculture Research Station, UAS, Raichur during 2008-09 recorded on NCS-145 BG-II cotton, grown over an acre in unprotected field, found that mealybug infestation started appearing in the month of September and gradually increased with the advancement of crop growth. The average population reached to 115.42/10 cm apical shoot in the third week of January and thereafter increased suddenly that it reached to an average of 180.42/10cm apical shoot in the 7th meteorological week. Later on, infestation of mealybug declined gradually and reached to average of 146.64/10cm apical shoot in the 14th meteorological week. They also reported that highest percentage of parasitoid (20.65 %) during 7th meteorological week which coincides with the higher population of mealybugs. When they did correlation with weather parameter, they found that mealybug population was significantly and positively correlated with maximum temperature (0.775) and negatively correlated with other parameters [10].

There was positive correlation among the mealybugs with temperature, whereas negative correlation was observed with relative humidity and rainfall in Punjab. All the meteorological parameters influenced the incidence of mealy bug on cotton in all the

districts studied in Faridkot district of Punjab where r-value is 0.71 in per cent infestation by mealybug and 0.76 in rows infested by mealy bug [11]. In Pakistan, the population of biocontrol agent i.e. predators and parasitoids shows positive correlation with mealybug, *Phenacoccus solenopsis* population [12]. Similar type of report of positive correlation between parasitoids and mealybug population was recorded from South Gujarat [13].

Hence, today it is gaining major concern for study. The study of its biology is important for understanding the form and extent of its population growth. Since, under field condition due to interference of biotic and abiotic factors, it is difficult to study the life history and pattern of biological activities of *P. solenopsis*. Hence, study was conducted under laboratory condition. The studies on biology of *P. solenopsis* were conducted in Biocontrol Research Laboratory, Anand Agricultural University, Anand during the year 2006-07 on pumpkin. It was found that longevity of female was 33.67 ± 1.19 days and the longevity of male was 8.70 ± 0.79 days at temperature and relative humidity range from 25 to 30°C and 75 to 80% respectively [14]. Similarly, studies on the biology of mealybug *P. solenopsis* under laboratory condition on potato sprouts at CCS Haryana Agricultural University, Hisar found that the total life span was 39.12 ±2.85 and 18.60±1.5 days in case of female and male respectively [15].

Research work conducted on biological studies of other species of mealybugs belonging to same family, *Maconellicoccus hirsutus* (green) reported that the duration of total life cycle of male and female was 31.7 and 29.5 days and 22.6 and 23.1 days at 21-24 and 30-34° C respectively on pumpkin [16]. The study of biology of *P. solenopsis* provides information regarding longer life span of adults with bigger size and increased waxy coating and higher food requirements leading to visibility of the pest and symptoms, respectively on the crop and is thus utilized for proper assessment for use of control measures in the field [17].

High fecundity rate of *P. solenopsis* shows its higher survival rate. The lower no. of male and short life span suggested that it is having role, i.e. only during reproduction.

CONCLUSION

The presence of large host range and high reproductive rate of mealybug, *Phenacoccus solenopsis* causes its persitance through out the year .This makes them a great threat in agricultural fields of Vadodara. The present study on biology of mealybug , *Phenacoccus solenopsis* give the understanding of mode and degree of its population growth. Hence, this information will be helpful during the development of sucessful Integrated Pest Management program (IPM) for *P. solenopsis* which is considered as major polyphagous pest in the world.

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