International Journal of Agriculture, Environment & Biotechnology
Citation: IJAEB: 7(4): 875-881 December 2014
DOI Number: 10.5958/2230-732X.2014.01399.0

ENTOMOLOGY

Biology of the papaya mealybug, *paracoccus marginatus* williams and granara de willink (Hemiptera: pseudococcidae)

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Paper No. 280 Received: 4 June, 2014 Accepted: 15 September, 2014 Published: 20 December, 2014

Abstract

The mealybug *Paracoccus marginatus* Williams and Granara de Willink completed 11generation in a year, 8 during March to October and 3 during November to February. The female and male nymphs completed development in 12.02 ± 4.44 to 17.92± 3.49 and 17.2 ± 3.00 to 21.25± 3.12 days respectively at during March to October, 21.59 ± 3.32 to 22.60 ± 4.49 and 22.81± 3.41 to 30.77 ± 2.38 days respectively during winter. The male and female ratio ranged from 1:1.20 to 1:3.41. Maximum oviposition period, minimum fecundity and maximum incubation period are 9 to 18, 108-154 and 9 days respectively in winter. Their mode of reproduction is entirely sexually. Life cycle is completed in 41 (maximum) and 27 (minimum) days during December- January and May respectively.

Highlights

- *Paracoccus marginatus* completed 11 generation in a year
- The male and female ratio ranged from 1:1.20 to 1:3.41.
- Maximum developmental period is in January and minimum is in May month.
- Mode of reproduction is entirely sexually

Keywords: Generation, life cycle, male and female ratio, development

The papaya mealybug, *Paracoccus marginatus* is a native of Mexico and/or Central America (Miller *et al.,* 1999) and it was described by Williams and Granara de Willink in 1992 (Ben-Dov, 1994) from the specimens collected in Mexico. It was first reported in St. Martin in the Caribbean in 1995 and since then has spread to 13 countries in the Caribbean, Florida in the US, and three countries each in Central and South America by 2000 (Miller *et al.,* 1999). In 2002, it was reported in the Pacific Islands (Muniappan *et al*., 2006) and in 2008 in Indonesia, India, and Sri Lanka (Muniappan *et al*. 2008). In 2009, it was reported from Bangladesh and Maldives and in 2010 in Cambodia, Philippines and Thailand (Muniappan, 2011; Seni and Chongtham, 2013).

The papaya mealybug, *Paracoccus marginatus* is a hemipteran insect and belongs to family Pseudococcidae. It can be distinguished by its greenish yellow body (Miller *et al.,* 1999) colour with large amounts of white waxy secretion. It is polyphagous (Miller and Miller, 2002) in nature and sucks the sap of the plant and weakens that. The leaves become crinkled, yellowish and wither. The

Table 1. Duration of first instar nymphs of *Paracoccus marginatus* Williams and Granara de Willink

Generation	Month	Particulars	Age of moulting (in days)	Temp.* (°C)	R. H.* (%)
1st	June	Range	4-9	26-34	93-68
		Mean (± S.D)	6.55 (1.87)		
		N*	87		
2nd	July August	Do	4-10	29-33	71-93
			6.89 (2.16)		
			89		
3rd	August Sep	Do	4-9	25-32	70-95
			6.86 (1.87)		
			85		
4th	Sep	Do	3-8	24-32	70-92
			5.67 (1.58)		
			73		
5th	Oct	Do	3-7	24-33	64-90
			5.14 (1.58)		
			74		
6th	Oct Nov	Do	4-10	19-28	50-89
			7.21 (2.16)		
			76		
7th	Dec-Jan	Do	7-17	10-26	40-88
			11.64 (3.32)		
			107		
8th	Jan-Feb	Do	8-16	9-24	38-84
			11.68 (2.74)		
			93		
9th	March-April	Do	5-11	15-31	34-88
			7.53 (2.16)		
			83		
10th	April May	Do	4-10	21-34	43-92
			7.09 (2.16)		
			80		
11th	May	Do	4-9	23-35	54-92
			6.36 (1.87)		
			74		

N: Individual numbers, Temp.: Temperature, R.H: Relative Humidity, S.D.: Standard Deviation

Table 2. Duration of second and third instar female nymphs of *Paracoccus marginatus* Williams and Granara de Willink

Generation	Month	Particulars	Age of moulting (in days)		Temp.* (°C)	R. H.* (%)
			2nd instar	3rd instar		
1st	June	Range	9-14	14-18	25-33	86-90
		Mean (± S.D)	11.07 (1.87)	16.11 (1.58)		
		N*	57	55		
2nd	July August	Do	9-17	15-21	25-33	70-92
			11.91 (2.74)	17.92 (2.16)		
			58	51		
3rd	August-September	Do	7-12	11-15	25-32	70-95
			9.84 (1.87)	13.43 (1.58)		
			45	42		
4th	Sep	Do	7-13	11-15	24-31	65-89
			9.64 (2.16)	12.85 (1.58)		
			48	46		
5th	Oct	Do	8-13	13-17	20-31	60-88
			9.88 (1.87)	14.66 (1.58)		
			45	41		
6th	Oct-Nov.	Do	10-17	16-24	17-28	43-90
			13.89 (2.45)	19.36 (2.74)		
			57	51		
7th	Dec- Jan	Do	16-23	21-29	12-23	60-84
			19.58 (2.45)	24.44 (2.74)		
			52	48		
8th	Jan-Feb	Do	15-22	20-26	12-24	38-87
			17.79 (2.45)	22.60 (2.16)		
			57	59		
9th	March-April	Do	11-16	15-20	17-31	25-90
			13.09 (1.87)	16.75 (1.87)		
			54	55		
10th	April May	Do	9-14	14-18	22-34	40-90
			11.34 (1.87)	15.94 (1.58)		
			53	51		
11th	May	Do	9-13	12-16	26-35	50-90
			11.14 (1.58)	13.98 (1.58)		
			50	48		

N: Individual numbers, Temp.: Temperature, R.H: Relative Humidity, S.D.: Standard Deviation

Table 3. Duration of second, third and fourth instar male nymphs of *Paracoccus marginatus* Williams and Granara de Willink

Generation	Month	Particulars	Age of moulting (in days)			Temp.* (°C)	R. H.* (%)
			2nd instar	3rd instar	4th instar		
1st	June	Range	8-12	13-16	21-24	25-35	63-90
		Mean (± S.D)	9.70 (1.58)	14.2 (1.29)	19.8 (1.29)		
		N*	17	15	15		
2nd	July- August	Do	9-13	14-17	20-23	25-33	80-92
			10.50 (1.58)	15.60 (1.29)	21.80 (1.29)		
			17	16	13		
3rd	August-Sep	Do	7-10	11-14	15-19	26-32	66-89
			8.64 (1.29)	12.69 (1.29)	17.00 (1.29)		
			17	16	16		
4th	September	Do	8-11	11-13	14-17	24-33	65-88
			9.44 (1.29)	12.19 (1.00)	15.44 (1.29)		
			18	16	16		
5th	Oct	Do	7-11	10-14	16-19	20-33	60-88
			8.71 (1.58)	11.63 (1.58)	17.73 (1.29)		
			31	30	30		
6th	Oct Nov.	Do	10-15	15-19	20-26	17-26	43-86
			12.33 (1.87)	16.93 (1.58)	22.79 (2.16)		
			46	44	43		
7th	Dec- Jan	Do	14-21	19-26	28-34	12-23	40-84
			17.39 (2.45)	22.44 (2.45)	30.77 (2.16)		
			41	36	35		
8th	Jan-Feb	Do	13-17	18-22	24-28	12-25	30-86
			14.76 (1.58)	29.89 (1.58)	25.92 (1.58)		
			29	27	26		
9th	March-April	Do	10-13	13-17	19-23	15-31	25-90
			11.92 (1.29)	14.84 (1.58)	21.25 (1.58)		
			26	25	24		
10th	April May	Do	8-12	13-16	17-20	21-34	40-87
			10 (1.58)	14.44 (1.29)	18.59 (1.29)		
			20	18	17		
11th	May	Do	7-10	11-14	16-18	23-36	50-90
			8.78 (1.29)	12.25 (1.29)	17.2 (1.00)		
			18	16	15		

N: Individual numbers, Temp.: Temperature, R.H: Relative Humidity, S.D.: Standard Deviation

Table 4. Oviposition period, fecundity, minimum incubation period, male female ratio and time taken to complete the generation of Paracoccus marginatus Williams and Granara de Willink

Gen-eration	Month	Oviposition period (days)	Fecundity (no.)	Min. Incubation period (days)	M:F*	Life cycle Completed (Days)	Temp.* (°C)	R. H.* (%)
1st	June	5-9	175-259	3	1:3.35	30	25-35	63-90
2nd	July August	6-10	165-243	4	1:3.41	32	25-33	80-92
3rd	August-Sep	4-10	153-263	4	1:2.64	29	26-32	76-89
4th	September	4-9	220-288	3	1:2.66	28	24-33	65-90
5th	Oct	4-9	298-324	3	1:1.45	30	20-33	60-87
6th	Oct Nov	6-11	232-286	5	1:1.23	32	17-28	43-89
7th	Dec-Jan	9-18	140-189	9	1:1.20	41	8-23	40-84
8th	Jan-Feb	9-15	108-154	7	1:1.90	38	9-26	30-86
9th	March-April	6-10	156-210	5	1: 2.07	33	15-31	25-90
10th	April May	5-9	169-258	4	1:2.65	31	21-34	40-87
11th	May	4-9	178-296	3	1:2.77	27	23-36	50-90

M:F=Male:Female, Temp.: Temperature, R.H: Relative Humidity

honey dew excreted by the bug and the associated black sooty mould formation impairs photosynthetic efficiency of the affected plants. In India it has caused havoc in agricultural and horticultural crops ever since its first report from Coimbatore in 2007. It has a broad range of host plants of over 60 species of plants including some important economically plants such as *Psidium guajava*, *Carica papaya*, *Zea mays*, *Solanum melongena* etc. (Chen *et al.,* 2011; Seni and Chongtham, 2013). It assumed the status of a major pest in 2009 when it caused severe damage to economically important crops and huge losses to farmers in Coimbatore, Erode, Tirupur and Salem districts of Tamil Nadu (Tanwar *et al.,* 2010).

Knowledge of the life history of an insect is very helpful in predicting its development, emergence, distribution and abundance. This information can further assist to device appropriate management tactics. Since there is a high possibility of spreading P. marginatus into other areas within India and surroundings, it is important to study its life history of this mealybug.

Materials and Methods

A number of mealybug colonies were collected from papaya plant, Mohanpur, Nadia, West Bengal. Then they were reared on sprouted potato tubers (*Solanum tuberosum* Linn.) in the laboratory at 24-34°C temperature and 84-96% relative humidity. The first instar nymphs hatched within 24 hrs. were reared. The cultures were maintained in a beaker, the mouth of which was covered and secured with a piece of cloth and rubber band. Daily observations were made on the number of ecdysis of male and female nymphs. To study the fecundity, five mated females were selected at random and they were left undisturbed till the formation of ovisac. Then the eggs were counted and detached females were kept separately to study the subsequent oviposition by the females. To study the minimum incubation period, the eggs laid during 24 hours; were kept separately to note the first day of hatching. These experiments were carried out continuously for one year. The temperature and relative humidity were recorded daily. Ten females were kept in isolation, away from the males, to study the mode of reproduction of the species. For identification of papaya mealybug we followed Miller and Miller, 2002 guidelines.

Results and Discussion

They were oval bodied insect, greenish-yellow in colour with yellowish body fluid. No dorsal stripes

are present on females and mealy waxes dusted on dorsum are not thick enough to hide their body colour. The body is fringed with many short waxy filaments; the caudal filaments are about one fourth of the body length. Adult male is deep red in color with transparent wing, vestigial mouthpart and longevity was 2-3 days.

The biological studies of the mealybug, P. marginatus, on sprouted potato throughout the year revealed that the duration of first instar nymphs, the sexes of which could not be distinguished, ranged from 3-17 days (Table 1). The duration was higher during the winter months 7-17 (11.64±3.32) days at 10-26°C and 40-88% R.H., whereas summer months were very congenial for their growth and took 4-9 (6.36±1.87) days for their development at 23-35°C and 54-92% R. H. and they completed 11 generation per year. The second instar female nymphs completed development at the age ranging from 7 to 23 days (Table 2). They took 16-23 (19.58±2.4) days at 12-23°C and 60-84% R. H. during winter month which was the longest developmental period. They took few days to complete this stage during May month only 9-13 (11.14±1.58) days. In case of third instar female nymphs; they completed development at the age ranging from 11 to 29 days (Table 2). The duration was maximum during the winter month 21-29 (24.44±2.74) at 12-23°C and 60-84% R. H. whereas they completed this stage very shortly during May month took only 12-16 (13.98±1.58) days at 26-35°C and 50 to 90% R. H.

The moulting of second, third and fourth instar male nymphs occoured within the cocoon at the age 7 to 21, 10 to 26 and 14 to 34 days respectively (Table 3). The developmental period was prolonged during winter months due to low temperature. The most favourable period for their development was observed at May month and they completed their development at the age of 7-10 (8.78±1.29), 11-14 (12.25±1.29), 16-18 (17.2±1.00) days respectively for second, third and fourth instars at 23 to 36°C and 50 to 90% R. H.

During the biological studies it is found that their sex ratio (M:F) varies during different seasons. It is varied from 1:1.20 in January month to 1:3.41 in July month (Table 4).

The female took longer time to complete oviposition during winter months (9 to 18 days) at 8 to 23°C and 40 to 84% R. H. when its fecundity rate was 140 to 189 (Table 4). During other season the fecundity increased and it laid maximum during October month when a female laid 298 to 324 eggs in 4 to 9 days to at 20°-33°C and 60-87% R.H. Low temperature adversely affected fecundity and oviposition period.

Sahoo *et al.* 1999 studied the biology of *Planococcus minor* mealybug on sprouted potato and found that they completed ten generations in a year, eight during February-November and two during November-January. Suganthy *et al*., (2012) studied the biology of *P. marginatus* on sunflower and found that the egg, first, second and third instar nymphal periods were 6.33±0.58, 4.00±1.00, 3.67± 0.58 and 5.00±1.00 days, respectively. Further this, they also studied the longevity of adult males and females and found that females took 20.33±1.53 day to complete their adult life, whereas, male took 1.67± 1.15 days to complete their adult period. Total life cycle of female *P. marginatus* was 39.33±2.53 days and for male it was 24.00±1.73 days. The oviposition period was 7.33±0.58 days and fecundity was 329.33±20.03 eggs on sunflower seedlings. In the present study fecundity rate of *P. marginatus* was from 140-324. Similar findings were reported by Amarasekare *et al.* (2008) who observed that the fecundity of *P. marginatus* was an average of 300 eggs at 25°C and Walker *et al*., 2011 who reported that the females of *P. marginatus* usually laid 100 to 600 eggs in an ovisac. As, there were striking differences present in male and female ratio in different generation. No doubt temperature has certain role behind that but it is not clear the main factor which are responsible. For this, details physiological study is very important to entangle that mystery.

For the studies to know the mode of reproduction, it was found that the five isolated females on sprouted potato were died at the age of 34-41 days, without laying any eggs. Thus, the species reproduces entirely sexually. Further this, as the sex ratio was

female biased, it again confirm its sexual mode of reproduction.

This life history information of *P. marginatus* will help us to understand the developmental period of different instars and which will further help in implementing a suitable integrated pest management (IPM) program.

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