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STUDIES ON BIOLOGY AND MORPHOMETRICS OF PAPAYA MEALYBUG, *PARACOCCUS MARGINATUS* (WILLIAMS AND GRANARA DE WILLINK) ON PAPAYA

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ABSTRACT
Papaya mealybug, *Paracoccus marginatus* each female lay about 400 to 600 eggs. Egg period ranged from 8 to 10 days with an average of 8.60 days. Females undergo only three instars and no sexual dimorphism between male and female instars. However, the duration of female I, II, III instar nymphs were 5.8, 5.2 and 4.6 days respectively. Males undergo four instars and the duration of I, II, III and IV instar male nymphs were 5.8, 6, 2.6 and 4.2 days respectively. Males have longer development period (27.2 days) than females (24.2 days). The average length and breadth of the female I, II, III instar nymphs and adult female was 0.35 + 0.07mm, 0.24 + 0.09mm; 0.61 + 0.09mm, 0.41 + 0.11mm; 0.93 + 0.09mm, 0.48 + 0.08mm and 2.32 + 0.14mm, 1.04 + 0.11mm respectively. The average length and breadth of the male I, II, III, IV instar nymphs and adult male was 0.35 + 0.07mm, 0.24 + 0.09mm; 0.61 + 0.09mm, 0.41 + 0.11mm; 0.81 + 0.08mm, 0.35 + 0.09mm; 0.98 + 0.08mm, 0.47 + 0.07mm and 1.47 + 0.04mm, 0.44 + 0.08mm respectively.

INTRODUCTION

Papaya mealybug (PMB), *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), native to Mexico and Central America (Muniappan *et al*., 2008). In India, the pest was first reported from Coimbatore during 2008 infesting papaya and there after the list of agricultural and horticultural crops infested by this invasive pest is expanding (Ballal *et al*., 2012). PMB is a polyphagous pest which cause damage to a large number of economically important field crops, tropical and sub tropical fruits and the ornamental plants (Miller and Miller, 2002).

Papaya mealybug females usually lay 100 to 600 eggs in an ovisac. Egg laying usually occurs over the period of one to two weeks. Egg hatch occurs in about 10 days, and nymphs or crawlers begin to actively search for feeding sites. Female crawlers have four instars, with a generation taking one month to complete, depending on the temperature. Males have five instars, the fourth of which is produced in a cocoon and referred to as the pupa (Walker *et al*., 2003). Yelitza Colemenarez *et al*. (2004) studied the biology of *P. marginatus* on four different hosts *viz*., papaya, bean, cotton and jatropha. Developmental period was shortest on papaya followed by bean, jatropha and cotton. The life cycle varied from 15 to 32 days depending on the host plant species used. Males have longer developmental time (27-30 days) than females (24-26 days) at 25±1ºC, 65±2% RH and 12:12(L: D) photoperiod (Tanwar *et al*., 2010). There was a little information on the biology and morphometrics of *P. marginatus* on papaya. Therefore, the present study provides novel information on the biology and morphometrics of *P. marginatus* on papaya.

MATERIALS AND METHODS

Studies on biology of papaya mealybug was carried out on papaya leaves under laboratory at mean temperature 25 ± 2°C and relative humidity 75 ± 2% in the Department of Entomology, RARS, Tirupati.

Mass culturing of PMB in the laboratory

Mass culturing of PMB *P. marginatus* was carried out on potato sprouts under laboratory conditions at 23 ± 2ºC and 75 ± 2 % RH.

Rearing of PMB on sprouted potatoes

Potato could be used as an alternate food source for rearing of mealybugs (Tsugawa, 1972), Sagarra and Vincent (1999), Serrano and Laponite (2002). Two months old robin eyed healthy seed potatoes were brought from potato merchant in Tirupati market and kept in a dark air conditioned room for four to five days to induce sprouting. Sprouted potatoes were washed in water and disinfected by using 1 % carbendazim solution. Later, two centi-meter incisions was given using a sharp blade and treated with gibberellic acid 100 ppm solution for half an hour. The potatoes were air dried and transferred to plastic trays (each plastic tray @ 10 tubers/ tray placed at about 2 cm apart in each tray of 18" diameter) containing

solarized sand. These trays were kept in rearing room and watered gently. The potatoes were kept for germination. Sprouting was observed within a week and ready for infestation with mealybugs.

Inoculation of PMB on potato sprouts

Ovisacs of the PMBs obtained from papaya fields were placed using a camel hair brush over the sprouts (each potato with 3-5ovisacs) or placed the infested leaves over the potato sprouts for two days. Mass culture of mealybugs was obtained within 25 to 30 days. Temperature in the rearing room was maintained at 23 ± 2ºC as mentioned by Mani and Krishnamoorthy (1990)

Biology of papaya mealybug in the laboratory

Eggs collected from a single female were placed on the papaya leaves @ 30 eggs per leaf using a camel hair brush. Eggs were taken from the laboratory reared culture within 24 h of oviposition. Petri plates were checked daily for egg hatch and shed exuviae. The number of days to egg hatch, emergence, survival of each instar and emerging adult males and females were recorded. The developmental period for the survival of eggs and first instar were not separated by gender. The gender of each individual mealybug was determined during the latter part of the second instar when males changed their colour from yellow to pink. During this time, the second instar nymphs were separated and transferred to new leaves. The developmental period of male and female were recorded separately. For each papaya leaf, 30 eggs were used and replicated five times. All experiments were carried out at 25 ± 2 ^{0} C. Duration of total life cycle of PMB was worked out separately for males and females.

Morphometrics of papaya mealybug

Morphometrics of eggs and each instar of males and females were measured using Progres CT_3 software at Department of Entomology, IFT, RARS, Tirupati and expressed in millimetres (mm).

RESULTS AND DISCUSSION

The biology and morphometrics of papaya mealybug, *P. marginatus* was studied in the laboratory and the duration of different developmental stages and data pertaining to morphometrics are presented in Table 1 and Table 2, respectively.

Culture of papaya mealybug was maintained successfully on potato sprouts during the study period.

Biology of papaya mealybug

A brief description of individual developmental stages is illustrated hereunder.

Egg

Each female of *P. marginatus* lay about 400 to 600 eggs. Egg period ranged from 8 to 10 days with an average of 8.60 days. Eggs are greenish yellow in colour and laid in an ovisac, which was about 3-4 times of the body length and entirely covered with white waxy substance. The ovisac developed ventrally on the adult female. The present results are in close agreement with the findings of Tanwar *et al*. (2010), Thangamalar *et al*. (2010) and Walker *et al*. (2003) who reported that duration of egg period of papaya mealybug was about ten days. In contrary to the present investigation Kalaniyangoda *et al*. (2011) reported that duration of egg period of papaya mealybug was 4 to 7 days.

The average length and breadth of eggs were 0.24 and 0.13 mm respectively. The present results are comparable with the findings of Kalaniyangoda *et al*. (2011) who reported the length and breadth of papaya mealybug as 0.3-0.1mm, 0.15-0.10mm respectively.

Nymphal stages

There are three nymphal stages and no pupal stage in the life cycle of a wingless female. Whereas, males undergo four instars to become adult. Males have longer developmental period than females.

First instar nymph (gender not determined)

Eggs were developed into first instar nymph. First instar was somewhat elongated than egg. Quick movements could be seen from first instar. The first instar development period lasts for 5 to 6 days with an average of 5.80 days. The present results are comparable with the findings of Mani *et al*. (2012) who reported that the first instar nymphal period was about 6.5 days. In contrary to the results of present investigation Kalaniyangoda *et al*. (2011) reported that duration of first instar period of papaya mealybug was 2 to 3 days.

The average length and breadth of first instar nymph were 0.35 and 0.24 mm, respectively. The present results are in close agreement with the findings of Miller and Miller (2002), Al-Helal *et al*. (2012) and Kalaniyangoda *et al*. (2011) who reported that the length and breadth of papaya mealybug first instar nymph as 0.4mm and 0.2mm; 0.42 + 0.07mm and 0.27 + 0.02mm and 0.4-0.2mm, 0.20-0.10mm, respectively.

Second instar female

The size of the body increased in first instar before entering into second instar. In the second instar, the movement of crawlers are sluggish and the insects settled at food source. The second instar female development period was observed for 5 to 6 days with an average of 5.20 days. The present results of the present study are in close agreement with the findings of Mani *et al*. (2012) who reported that the second instar female nymphal period was 5.5 days.

The average length and breadth of second instar female nymph were 0.61 and 0.41 mm, respectively. The present results are in close agreement with the findings of Miller and Miller (2002) and Al-Helal *et al*. (2012) who reported the length and breadth of second instar female 0.7mm and 0.4mm respectively.

Third instar female

The size of the second instar increased and yellow in colour before entering into third instar. The third instar female development period lasted for 4 to 5 days with an average of 4.60 days. The results of the present study are in close agreement with the findings of Mani *et al*. (2012) who reported that the third instar female nymphal period was 5.2 days. In contrary to the results of present investigation Kalaniyangoda *et al*. (2011) reported that duration of third instar female of papaya mealybug was 8 to 10 days.

The average length and breadth of third instar female nymph were 0.93 and 0.48 mm, respectively. The present results are in close agreement with the findings of Al-Helal *et al*. (2012)

Table1: Duration of different developmental stages of papaya mealybug,*P. marginatus* on papaya

Stage of the *P. marginatus*	Developmental period (no. of days) Male (Mean + S.E)	Female (Mean + S.E)
Egg	8.60 + 0.19	8.60 + 0.19
First instar nymph	5.80 + 0.19	5.80 + 0.19
Second instar nymph	6.00 + 0.29	5.20 + 0.37
Third instar nymph	2.60 + 0.34	4.60 + 0.26
Fourth instar nymph	4.20 + 0.22	-
Adult	27.2 + 0.28	24.2 + 0.33

Table 2: Morphometric dimensions of different developmental stages of papaya mealybug, *P. marginatus* on papaya

Stage of the *P. marginatus*	Male (Mean + S.E)		Female (Mean + S.E)	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
Egg	0.24 + 0.11	0.13 + 0.10	0.24 + 0.11	0.13 + 0.10
1st instar	0.35 + 0.07	0.24 + 0.09	0.35 + 0.07	0.24 + 0.09
2nd instar	0.61 + 0.09	0.41 + 0.11	0.61 + 0.09	0.41 + 0.11
3rd instar	0.81 + 0.08	0.35 + 0.09	0.93 + 0.09	0.48 + 0.08
4th instar	0.98 + 0.08	0.47 + 0.07	-	-
Adult	1.47 + 0.04	0.44 + 0.08	2.32 + 0.14	1.04 + 0.11

who reported the length and breadth of third instar female mealybug as 0.89 + 0.11mm and 0.51 + 0.02mm respectively.

Adult female

The live adult was covered with powdery white wax, wingless and without any longitudinal depressions. Short waxy filaments develop around the body margin including short caudal filaments. The total developmental period for adult female was 24 to 26 days with an average of 24.2 days. The present results are in close agreement with the findings of Mani *et al*. (2012) who reported that the adult female development period was 24 to 26 days. In contrary to results of the present study Walker *et al*. (2003) reported that adult female development period was 30 days.

The average length and breadth of adult female were 2.32 and 1.04 mm, respectively. The results of the present investigation are in close agreement with the findings of Dharajothi *et al*. (2011), Miller and Miller (2002) and Galanihe *et al*. (2010) who reported the length and breadth of adult female as 2.2mm and 1.4mm, respectively.

Second instar male

The second instar male developmental period lasted for 6 to 7 days with an average of 6.00 days. The results of present study are in close agreement with the findings of Mani *et al*. (2012) who reported the second instar male nymphal period as 6.6 days.

The average length and breadth of second instar male nymph were 0.61 and 0.41 mm, respectively. The results of the present study are in close agreement with the findings of Miller and Miller (2002) who reported the length and breadth of second instar male papaya mealybug as 0.6mm and 0.3mm, respectively.

Third instar male

The body colour of the third instar males changed from yellow to pink. The third instar male development period lasted for 2 to 4 days with an average of 2.60 days. The present results are in close agreement with the findings of Mani *et al*. (2012) who reported that the third instar male nymphal period was 2.4 days. In contrary to the results of present investigation Kalaniyangoda *et al*. (2011) reported that the duration of third instar male was 5 to 7 days.

The average length and breadth of third instar male nymph were 0.81 and 0.35 mm, respectively. The results of the present study are in close agreement with the findings of Miller and Miller (2002) who reported the length and breadth of third instar male papaya mealybug as 0.9mm and 0.4mm respectively. In contrary to these results Al-Helal *et al*. (2012) reported the length and breadth of third instar male as 0.23 + 1.05mm and 0.59 + 0.15mm mm, respectively.

Fourth instar male

Fourth instar of males separated from others and made their own colonies and within 2-3 days they covered their body by a cocoon. The fourth instar male development period lasted for 4 to 5 days with an average of 4.20 days. The results of present investigation are in close agreement with the findings of Mani *et al*. (2012) who reported that the fourth instar male nymphal period as 4.1 days.

The average length and breadth of fourth instar male were 0.98 and 0.47 mm, respectively. The present results are in close agreement with the findings of Miller and Miller (2002) and Al-Helal *et al*. (2012) who reported the length and breadth of fourth instar male as 1.0mm and 0.3mm; 0.98 + 0.07mm and 0.49 + 0.02mm, respectively.

Adult male

Adult males have 10-segmented antenna, a heavily sclerotized thorax and head, and well developed wings. The total developmental period for adult male 26 to 29 days with an average of 27.2 days. The present results are in close agreement with the findings of Mani *et al*. (2012) who reported that the adult male development period was 27 to 30 days. The average length and breadth of adult female were 1.47 and 0.44 mm, respectively. The results of present study are in close agreement with the findings of Galanihe *et al*. (2010) who reported that

the length and breadth of adult male were 1.0mm and 0.3mm, respectively. The present results on biology of papaya mealybug are in close agreement with the findings of Veeresh Kumar *et al*. (2014) revealed that the females had three nymphal instars without any pupal stage, while the male had three nymphal instars besides, pre-pupal and pupal stages. The total nymphal period for female ranged from 14 to 21 days, (mean- 17.32 ± 1.6 days) while for male the range was 16 to 23 days, (mean- 18.9 ± 1.3 days). The fecundity of the female mealybug ranged from 248 to 967, with an average of 618.9 ± 19 eggs.

In the present investigations, the total life cycle of *P. marginatus* i.e., from egg to adult ranged from 24 to 29 days. The average life span of male was 27.20 days and female was 24.20 days. Males have longer development period when compared with females, because males are having four instars whereas females have three instars only. The results of present investigation are in conformity with the findings of Tanwar *et al*. (2010) who reported that the total life cycle of males have longer developmental time (27-30 days) than females (24-26 days). The present results are also comparable with Mani *et al*. (2012) who reported that females undergo only three instars and males undergo four instars. Males have longer development period (27-30 days) than the females (24-26 days). In contrary to the results of present study Walker *et al*. (2003) reported that male have five instars and females have four instars only.

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