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Observations on papaya mealybug, *Paracoccus marginatus* Williams & Willink (Hemiptera : Pseudococcidae) damaging some crops in Bangladesh

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A B S T R A C T

The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink is a small Hemipteran insect belonging to the Family Pseudococcidae was recorded from immature, mature papaya fruits and foliages from BCSIR Vegetable Garden during March, 2011. It is a small polyphagous insect pest sucking saps from the attacking fruits and leaves. *P. marginatus* passes through egg and three nymphal stages to become adult. Generally, three and four nymphal instars occur in case of female and male mealybug, respectively. The adults are most active in warm, dry and humid weather. The male adult mealybugs possess two pairs of wings. Female have no wings and move by crawling short distances or by being blown in air currents. Female usually lays 100 to 600 eggs. Eggs are greenish-yellow in colour measuring 0.120 cm diameter and laid in an ovisac that 3-4 times the body length. Eggs are covered with white waxy substances developed ventrally by the adult female. Egglaying is continued up to 2 weeks and 150-200 eggs were deposited during this period. The life cycle is completed within 29 days at an average room temperature of 25 ± 1ºC and 67 ± 5 % RH. The adult life span for male and female were 29 and 27 days, respectively. *P. marginatus* is a devastating insect pest causing immense damage to the field crops, vegetables and ornamental plants of economic importance in Bangladesh perspectives.

Keywords: Papaya mealybug, *Paracoccus marginatus*, egg, biology, vegetable crops

Introduction

The papaya mealybug (PMB), *Paracoccus marginatus* Williams and Granara de Willink is a small, yellowish insect pest attacking leaves and fruits of papaya and it belongs to the Family Pseudococcidae under the Order Hemiptera and Sub-order Homoptera. Its body is generally covered with thick waxy caudal filaments around the margin. The ants help in the dispersal and transportation of this mealy bug. According to Williams and Willink (1992a, 1992b), *P. marginatus* was collected in Mexico during 1955. It belongs to the order Hemiptera Sub-order Homoptera under the family Pseudococcidae. This is usually called as papaya mealybug. The PMB is to be native to Mexico and/or Central America and it has never attained status of the serious pest due to the presence of an endemic natural enemy complex. This pest got introduced without their native natural enemies and posed a potential threat to papaya (Regupathy & Ayyasamy 2012) in India and Bangladesh. PMB is usually quite small, yellowish in appearance and inconspicuous and is found on the leaves, twig, stems, and fruits of the host plants. Females are elongate oval with distinct segmentation and covered with waxy secretion which may be extended into lateral or terminal filaments. This species was described in 1992 in the Neotropical Region occupying Belize, Costa Rica, Guatemala and

Mexico. Walker *et al.* (2003) stated that *P. marginatus* was recorded from the 14 Caribbean countries. Invasion of PMB in Asia during May, 2008 was first reported by Muniappan *et al.* (2008) from Java, Indonesia and Tamil Nadu in India. In May, 2009 IPM (Integrated Pest Management) and CRSP (Collaborative Research Support Program) Scientists found PMB at Joydebpur, Bangladesh. *P. marginatus* is a noxious insect pest attacking papaya and other crop plants of economic importance.

Materials and Methods

The present research work was confined to the study on papaya mealybug, *P.marginatus* Williams and Granara de Willink. *P.marginatus* was collected from papaya leaves and unripe fruits of plants in the BCSIR Vegetables Research Field from April to September 2011 for experimental purposes. Investigation was initiated in March, 2010 and completed in August, 2011. Fifteen specimens of mealybugs were studied for morphometric studies. Collection sites were BCSIR Vegetable Research Field and adjacent areas of Dhaka city. During the survey on the incidence of this mealybug, the parameters included were temperature, relative humidity, photoperiod, rainfall etc. *P. marginatus* was collected with the help of fine and soft camel brush and forceps. Different nymphal stages, male and female adults of *P. marginatus* were collected randomly from papaya plants at fortnightly intervals. The collected specimens were kept in different glass vials and small Petri dishes (6cm diameter). The mealybug and some beneficial hymenopteran parasites belonging to the family Encyrtidae, Braconidae and other insects associated with this mealybug were preserved in 80% alcohol with a drop of glycerine. The insects were mounted temporarily on slides in lactophenol and permanent mounts were also made for the purpose. The mealybug mouth parts with chitins were removed by boiling them in hot KOH solution before processing. These were dehydrated in desired grades of ethyl-alcohol and mounted in canada balsam along with xylene solvent. The mounted specimens were labeled properly for future uses.

The specimens or newly prepared slides were examined under a binocular dissecting microscope and a compound research microscope. A simple millimeter scale was used in binocular dissecting microscope for taking necessary measurements of egg, nymphal stages and adults of *P. marginatus*. Stage-micrometer used for calibration. Measurements of minute parts were taken with the help of ocular micrometer fitted with the compound microscope. For detail and distinct description, microphotographs of different nymphal stages and photographs of adult male and female *P. marginatus* were taken at the Zoology Section, BCSIR Laboratories, Dhaka with the aid of Digital Camera (Canon Power Shot A 470, 7.1 pixel). To depict a clear picture of *P. marginatus* infesting unripe fruits and leaves of papaya plants, some photographs in natural habitat were also taken.

Taxonomic identification of the mealy bug, *Paracoccus marginatus* was performed earlier by Dr. Nurul Alam, CSO, BARI, Joydebpur, Gazipur from the International Institute of Entomology London, U.K. Our collected specimen of mealybug was compared with his identified specimen from 11E (International Institute of Entomology, London, U.K.) and confirmed our collected specimens as *P. marginatus* Granara de Willink (Hemiptera : Pseudococcidae). We also confirmed this specimen as *P. marginatus* dissolving in ethanol when it turned bluish-black in colour. For understanding, fluctuation and seasonal abundance of *P. marginatus*, some papaya plants of the experimental field was selected randomly and total numbers of mealybug in a single papaya fruit/leaf of each plant was marked, counted and recorded fortnightly. Thus, the incidence of mealybugs from the months of March to August, 2010 and 2011 were taken and calculated carefully. The abundance of mealybug was estimated as total numbers of mealybug observed and recorded for the purpose. The highest and lowest numbers of occurrence of mealybug was also taken into consideration. Collected samples of papaya fruits and leaves having mealybug infestation were taken in the laboratory room and reared. The samples were observed carefully for insect predator or parasitoid emergence, if any. Many insects including black ants were found associated with *P. marginatus*. Some encyrtid and braconid insect parasitoids belonging to the order Hymenoptera and other insects were collected associated with this PMB. Those were collected and preserved for future study.

Results and Discussion

PMB (*P. marginatus* Hemiptera: Pseudococcidae) is a small polyphagous sucking insect. This noxious insect pest passes through egg and three nymphal stages to become adult female. Its embryonic development is termed as pauro-metabolic metamorphosis or simple metamorphosis. In case of *P. marginatus,* generally four and three nymphal instars took place in case of male and female mealybug, respectively. Our observation included biology, morphometrics and some taxonomic aspects of *P. marginatus* and those are described below:

Egg

Adults of *P. marginatus* are most active in warm, dry and humid weather. Females are wingless and move by crawling short distances or by being blown in air currents. Females usually lay 100 to 600 eggs. Eggs are greenish yellow in colour and laid in an ovisac, about 3-4 times of the body length and entirely covered with white waxy substance. The ovisac is developed ventrally on the adult female. Egg laying is continued over a period of 1-2 weeks. The adult female of *P. marginatus* laid about 150 to 200 eggs inside the ovisacs. Eggs are pink coloured, grain like measuring 0.120cm in diameter. Thangamalar *et al.* (2010) observed that the fecundity of *P. marginatus* at 20 and 25^{o}C, they described that eggs hatched in about 3-4 days and 10 days at the temperature gradients respectively.

After hatching, the nymphs or crawlers begin to actively search for feeding sites for their survival and dispersal.

Nymphal stages

There are three nymphal stages and no pupal stage in the life cycle of a wingless female and eggs are laid in a small, white ovisac of woolly wax. Whereas males pass through four instars to become adult. Males have longer development time (27-30 days) than females (24-26 days) at 25 ± 1°C, 65 ± 2% RH and 12 : 12(light : dark) photoperiod.

First-instar nymph (gender not determined)

Length of first instar nymph was 0.42 ± 0.074 mm and 0.27 ± 0.024mm in width. This instar appears yellowish in colour. Dorsum with 9 (7 -10) pairs of cerarii ; cerarii indefinite, cerarii with 2 conical setae. Cerarius 12 absent. Cerarius in anal lobe without auxiliary setae, 2 conical setae, 1 trilocular pore; Dorsal body setae more slender than cerarian setae. Multilocular pores absent; triloculars pores scattered over surface, forming 2 longitudinal lines on each side of abdomen, excluding cerariian setae. Discoidal pores absent. Oral-rim tubular ducts and oral-collar tubular ducts are absent. Longest sub-medial seta on 7th segment 5(4-8) µ long; without sub-medial setae on 8th segment. Slide mounted characters - body 0.4 (0.3-0.6) mm long and 0.2 (0.2-0.3) mm wide. Similar taxonomic features were described by (Douglass *et al.*, 2002, Hu *et al.* 2005).

Second-instar female

Length of second instar nymph was 0.6 ± 0.054mm and 0.4 ± 0.089mm in width. Body colour appeared yellow in field conditions. Dorsum with average 6 (4-11) pairs of cerarii ; cerarii indefinite, cerarii with 2 conical setae. Cerarius 12 absent. Anal lobe cerarius with 1 auxiliary setae, 2 conical seate, 2 (2-3) trilocular pores, sometimes with 1 discoidal pore. Dorsal body setae more slender than cerarian setae. Multilocular pore absent; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular ducts absent. Longest sub-medial seta on 6th segment about 6(5-6)µ long; sub-medial setae

Table 1.
Measurement (mm) of different instars of male and female *P. marginatus* (Mean ± S.D)

Instars	Male		Female	
	Length	**Width**	**Length**	**Width**
1st	0.42 ± 0.074	0.27 ± 0.0244	0.42 ± 0.074	0.27 ± 0.0244
2nd	0.6 ± 0.054	0.4 ± 0.089	0.6 ± 0.054	0.4 ± 0.089
3rd	0.232 ± 1.05	0.59 ± 0.156	0.89 ± .111	0.51 ± 0.02
4th	0.98 ± 0.075	0.49 ± 0.02	-	-
Adult Female	-	-	2.08 ± 0.354	1 ± 0.063

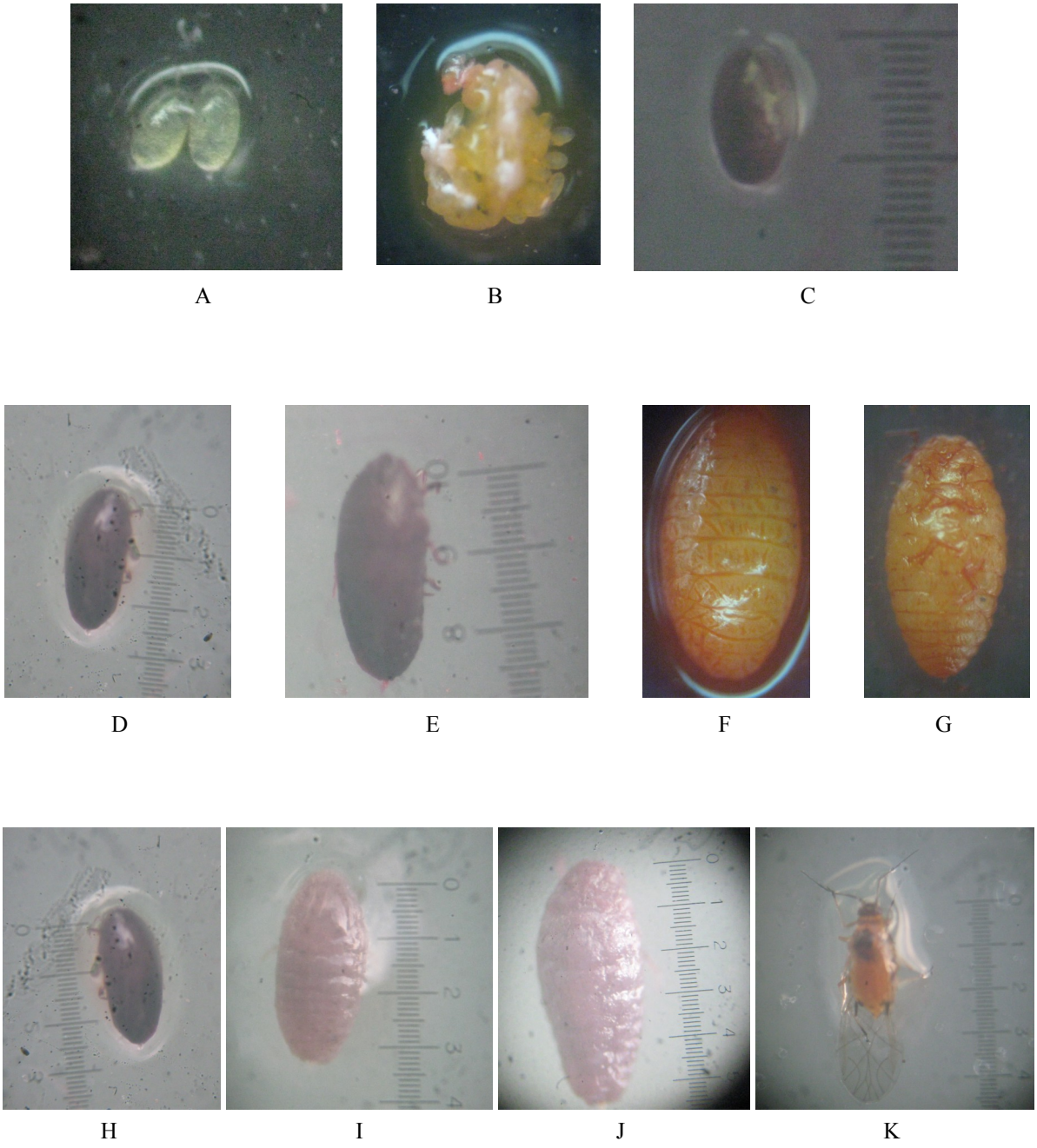

Fig. (A) Newly hatched egg of *P.marginatus*; (B) Eggs enclosed in ovisac of *P.marginatus*; (C) 1st nymphal stage of *P.marginatus* (male and female); (D) 2nd nymphal stage of *P.marginatus* female; (E) 3rd nymphal stage female of *P.marginatus*; (F) Adult female (Dorsal) of *P. marginatus*; (G) Adult female (Ventral) of *P. marginatus*; (H) 2nd nymphal stage male of *P.marginatus*; (I) 3rd nymphal stage male of *P. marginatus*; (J) 4th nymphal stage male of *P.marginatus*; (K) Adult male of *P.marginatus*.

located on the 8th segment is devoid of setae. Slide-mounted characters-Body 0.7(0.5-0.8) mm long and 0.4 (0.3-0.5)mm wide. Taxonomic characters in cerarius setae resmbles male. Our observation complies with the view of Douglass *et al.*(2002).

Third-instar female

Length of third instar nymph was 0.89 ± 0.111mm and it was 0.51 ± 0.02mm in width. Body appears yellow in colour during field observation. Dorsum with 6(1-10) paris of cerarii ; cerarii indefinite, when present, with 2-conical setae and 1 trilocular pore between conical setae. Cerarius 12 absent. Anal lobe cerarius with 1(1-2) auxiliary setae, 2 conical setae, 5 (4-7) trilocular pores, 0(0-1) discoidal pores. Dorsal body setae more slender than cerarian setae. Multilocular pores absent; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular duct rarely present near position of cerarius 8(of 10 specimens examined, 4 had 1 oral rim or large oral-collar on at least one side of body). Oral-colar tubular ducts are absent. Longest sub-medial seta on the 7th segment is 7(5-10) μ long; 1(0-2) sub-medial setae located on 8th segment. Slide-mounted characters: Body 1.1 (0.7-1.8) mm long and 0.7(0.3-1.1) mm wide. Similar taxonomic features were also described by (Douglass *et al.* 2002).

Adult female

The live adult covered with powdery, white wax and without any longitudinal depressions. Short waxy filaments develop around the body margin including short caudal filaments. The body contents are yellow when alive but they turned black in less than one day after death, even when preserved in ethyl alcohol. In the present study, the length of adult female was 2.08 ± 0.354 mm and it was 1 ± 0.063 mm in width. Body looks like yellow in colour during field observation. Dorsum with 18 pairs of cerarii; cerarii 1, 2, 4, 5, 7 and 9 with 2 conical. Setae ; cerarii 3, 6 and 18 with 3(2-3) conical setae; cerarii 8, 11 and 18 with 2(0-2); cerarii 10 and 14 with 1(0-2) conical setae; cerarii 12, 13 and 15 with 2(0-3) conical setae. Cerarius 12 without auxiliary setae. with 2(0-3) conical setae, 5(0-8) trilocular pores, 1(0-3) discoidal pores. Anal lobe cerarius with 1(1-3) auxiliary setae, 2 conical setae, 13(10-18) trilocular pores, 2(0-3) discoidal pores. Dorsal body setae more slender than cerarian setae. Multilocular pores absent; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore, oral-rim tubular ducts usually restricted to marginal areas associated with cerarii, 1 specimen examined with 1 mediolateral duct on segment 1 and 1 in medial area of mesothorax of 21 specimens examined. In slide mounted adult females from the oriental region, this is the only species of *Paracoccus* that totally lacks, oral-rim ducts in the sub-median or median areas of the dorsum. Slide-mounted characters: Body 2.2 (1.5-2.7) mm in length and 1.4 (0.9-1.7) mm in width. Similar taxonomic features were also described by (Douglass *et al.* 2002).

Second-instar male

Length of second instar nymph was 0.6 ± 0.054 mm and 0.4 ± 0.089 mm in width. Body looks like yellow in colour during field observation. Dorsum with 4 (2-5) pairs of cerarii; ceranii indefinite, when present, with 2 conical setae and 1 trilocular pore between conical setae. Cerarius 12 absent. Anal-lobe cerarius with 1(1-2) auxiliary setae, 2 concial setae, 2 (2-3) trilocular pores, without discoidal pores. Dorsal body setae more slender than cerarian setae. With 1(0-2) multilocular pores in medial areas of thorax and head, present on 6 out of 10 specimens examined; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular ducts absent. No submedial setae on the 8th segment. Slide-mounted characters- body 0.6(0.5-1.0) mm long and 0.3 (0.2-0.6) mm wide.

Third-instar male (pre-pupa)

Length of third instar nymph was 0.23 ± 1.05 mm and 0.59 ± 0.156 mm in width. Body looks like yellow in colour during field observation. Dorsum without cerarii; posterolateral margins of segments 5 or 6, 7 and 8 each with 2 setae conspicuously longer than remaining setae on abdominal segments. Multilocular pores in medial areas of head, forming row on prothorax and metathorax, usually without pores on mesothorax, occasionally with 1 or 2 medially, in rows on most abdominal segments, fewer in medial area, absent from 8th and 9th segments, trilocular pores absent; discoidal pores rare. Oral-rim tubular ducts absent. Oral-collar tubular ducts present around body margin, medial and submedial ducts sometimes present on prothorax and metathorax and with 1 or 2 abdominal segments. Longest submedial seta on the 7th segment 18 (15-20) μ long; without submedial setae on the 8th segment. Slide-mounted characters: Body 0.9 (0.8-1.1) mm long, 0.4 (0.3-0.4) mm wide. The prepupa can be distinguished from all other instars by having multilocular pores, oral-collar tubular ducts antennae without definite segmentation, tibia and tarsus fused, no labium, no aedeagus and no definite constriction for the head.

Fourth-instar male (pupa)

Length of fourth instar nymph was 0.98 ± 0.075 mm and 0.49 ± 0.02 mm in width.Body colour appeared pink but occasionally yellowish. Dorsum without cerarii; posterolateral margins of segments 3, 4 or 5 to segment 8 each with 2 setae conspicuously longer than remaining setae on the abdominal segments. Multilocular pores absent from head, forming conspicuous row on prothorax, mediolateral clusters on metathorax, without pores on mesothorax. In mediolateral clusters on each side of abdominal segments of 1-6 or 7 trilocular pores absent; discoidal pores associated with multiloculars and oral collars. Oral-rim tubular ducts absent. Oral-collar tubular ducts present near body margin of prothorax and the abdominal segments 1 or 2 to 7 or 8 forming clusters ducts. Longest submedial seta on is located the 7th segment and 20(16-28) μ in length. Slide mounted characters: Body 1.0

(0.9-1.0) mm in length and, 0.3(0.3-0.4) mm in width.

Adult male

Length of adult male was 1.5 mm and 0.5 mm in width. Body colour appeared pink, but occasionally yellowish. Adult males have 10-segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and well-developed wings. Slide-mounted characters: Body elongate oval, 1.0 (0.9-1.1) mm long; greatest width at thorax and 0.3(0.2-0.3) mm. Similar taxonomic features were described by (Affinis 1968; Douglass *et al.* 2002). The optimum temperature for the development of *P. marginatus* is between 20 to 25^{o} C and the minimum temperature is 21^{o}C. Developmental times for male and female nymphs and adult males are similar at 25 ^{o}C and 30^{o}C.

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