



Biology of papaya mealybug, *Paracoccus marginatus* on laboratory hosts, sprouted potato and long bottle gourd

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Abstract

In this study, biological parameters of the papaya mealybug (PMB), *Paracoccus marginatus* Williams and Granara de Willink, on two hosts, sprouted potato (*Solanum tuberosum*) and long bottle gourd (*Lagenaria siceraria*) vegetables, were investigated under semi-controlled laboratory conditions; to determine the host suitability for rearing of this insect that to be used for augmentation of its natural enemies and for experimental animal in scientific research. Papaya mealybugs have established and completed their lifecycle on both of the hosts; however, there were differences in the biological parameters. The total lifespan of *Paracoccus marginatus* on sprouted potato was 38.8±4.4 days for female and 25±2.3 days for male while on long bottle gourd, it was 30.8±5.8 days for female and 22.4±2.6 days for male, respectively. The observed nymphal period of the PMB female varies from 15 to 20 (17.8±2.28) days on sprouted potato and 13 to 17 days (15.0±2.0) on long bottle gourd. The nymphal period exhibited by the PMB male on sprouted potato and long bottle gourd was 22.2±2.0 and 20.8±2.3 days, correspondingly. Longevity was not affected by hosts for males and averaged 2.6±0.5 days. In contrast, the longevity of the female on both hosts found dissimilar; for sprouted potato and long bottle gourd, it was 21.6±2.6 and 17.8±2.8 days, respectively. The fertility of PMB female on sprouted potato and long bottle gourd was observed as 168.8±60.5 and 103.4±30.8 crawlers, the first instar nymphs of PMB, per female, respectively. Parthenogenesis occurred in PMB on both of the laboratory hosts. Sprouted potato are preferable as laboratory host as compared to long bottle gourd.

Keywords: papaya, mealy bug, host, biology, longevity, parthenogenesis

1. Introduction

The papaya mealybug (PMB), *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), is a small, soft-bodied scale insect. The body of nymphs and adult female of PMB is a yellowish and covered with cottony type waxy material. Immature and adult males are slightly pinkish and wings are present on males (Wu *et al.*, 2014) [23]. Reproduction of PMB could be occurred by sexually and asexually (parthenogenesis) (Mani *et al.* 2012) [11]. It is invasive and polyphagous species of mealybugs. It is active in warm and dry weather and completes lifecycle rapidly (Al-Helal *et al.*, 2012) [1]. Reproduction occurs throughout the year and it can complete several generations in a single year (Rao *et al.*, 2010) [18]. The earliest specimens of this insect were collected from Mexico in 1955 and first described by Williams and Granara de William (1992) [22] and re-described by Miller and Miller (2002) [13]. PMB is inborn of Mexico/Central America and nearby areas (Miller *et al.*, 1999) [12]. This pest first time reported in Asia in 2008 at Tamil Nadu Agriculture University, Coimbatore, India (Muniappan *et al.*, 2008) [14] and in Pakistan it was observed in 2008 in coastal areas at Malir, Karachi and district Lasbella, Balochistan (Bajwa *et al.*, 2015) [4].

Papaya Mealybug feeds on about 133 plant species, belonging to 48 families. Favorite plant species of papaya mealybug include papaya, tropica, eggplant, avocado, citrus, tomato, mulberry, hibiscus, potato sprouts, peppers, beans, pea, plumeria and cotton (Sakthivel *et al.*, 2012) [20]. Due to heavy infestation of the papaya mealybugs on papaya, direct

feeding causes distorted foliage, falling of leaves after becoming yellow and curve and deformation of buds. The papaya mealybug excretes honeydew which develops black molds on the leaves which hinders the process of photosynthesis and gaseous exchange resulting in chlorosis, falling of unripen fruit, and consequently, the stem becomes lean. Extreme invasion of this insect not only contaminates the yield but also leads to the destruction of the whole plant (Muniappan *et al.*, 2011) [15].

Cultural and biological control is preferred for mealybugs over the chemical. In cultural control, sanitization is done by cutting and burning of the infested leaves and branches. To prevent the movement of these pests, barriers such as sticky bands are used near the branches and leaves (Biswas *et al.*, 2015) [5]. In biological control, natural enemies of papaya mealybug including parasitoids (*Acerophagus papayae*, *Anagyrus loecki* and *Pseudleptomastix mexicana*), predators, and pathogens are to be utilized (Galanihe *et al.*, 2010) [8].

For the prediction of development, emergence, distribution, and abundance, understanding the life history of a pest insect is very significant (Amarasekare *et al.*, 2008) [3]. Several researchers have studied biology of PMB on different hosts such as; Amarasekare *et al.* (2008) [3] studied life history of PMB on *Hibiscus rosa-sinensis* L., *Acalypha wilkesiana* Muell.-Arg., and *Plumeria rubra* L. and Parthenium hysterophorus L.; Chellappan *et al.* (2013) [7] studied biology and morphometry on papaya, jatropha, mulberry and potato; Seni and Sahoo (2015) [21] studied biology of PMB on papaya, parthenium and brinjal plants;

and Nisha and Kennedy (2017) ^[17] Studied Life cycle of papaya mealybug on plants of papaya, cotton, tapioca, mulberry, brinjal, hibiscus and potato sprouts and reports variation in parameter in life stages for one and other reason. For the review of existing literature, this seems that the researchers have not poured much attention to study the life history of *Paracoccus marginatus* on laboratory hosts.

In pest management, life history information plays a vital role, specifically when biological control methods are to be applied. Owing to the high possibility of *Paracoccus marginatus* invading other areas in Pakistan, it is crucial to study its life history using different hosts in field and laboratory in different geographical and ecological conditions. In the present study, the biological parameters of *Paracoccus marginatus* were studied to determine time periods of various stages of its life on two different hosts, sprouted potato and long bottle gourd in the laboratory. Comparative preference of hosts was also determined to find out the best host for the rearing of this insect in the laboratory that would help in the rearing of its natural enemies in biological control program and research.

2. Material and Methods

In the present study, the comparative biological parameters of papaya mealybug (PMB), *Paracoccus marginatus* were determined on two hosts comprising of sprouted potatoes and long bottle gourd that were used for rearing this insect for mass rearing of natural enemies in the biological control program. The experiments were conducted in the Biological Control Laboratory, PMRI, PARC-SARC, Karachi located at coastal city of Pakistan during July to December 2017, under room temperature (Range 27-33°C), relative humidity (Range 60-90% RH), and light-dark hours were remained seasonal inside the laboratory.

Papaya mealybugs were collected from papaya plants and identified by the comparison with the characteristics and description provided by William and Granara de Willink (1992) ^[22], Miller *et al.* (1999) ^[12] and Chellappan *et al.* (2013) ^[7]. For rearing of papaya mealybugs, two hosts were selected, sprouted potato (*Solanum tuberosum*) and long bottle gourd (*Lagenaria siceraria*). The procedure for potato sprouting was followed as described by Kanwal *et al.* (2017) ^[9] and medium sized, healthy and having 2-3 cm long sprouts on potato were used in the experiments. Healthy, medium-sized and unwashed long bottle gourd were selected.

The biological parameters were investigated such as; adult longevity, development time, fertility and parthenogenesis. For adult longevity of female, third instar female was selected from the laboratory culture and placed on each host in the jars till became adult by finding exuviae. The experiment was replicated five times on each host and number of days from adult emergence till death was recorded as the pre- oviposition, oviposition and post-oviposition period. The time period from adult female emergence to start egg pouch considered as the pre-oviposition, the time from the starting of the pouch to complete the pouch formation considered as the oviposition, and the time from separation of female from the pouch till the death of female was considered as the post-oviposition period. Similarly, adult male longevity was recorded in days on both hosts by observing pupa for adult male emergence till death.

The effect of two hosts on the female and male

developmental parameters of *Paracoccus marginatus* was assessed under laboratory conditions. To record the time period for the development of the first instar nymph, adult female pouches were observed daily from its formation till first instar nymph emergence. The first instar nymphs, 50 in number, which were observed on same day were placed on each host in five separate jars till they became second instar nymphs and period was recorded in days. For the second instar, a bunch of 50 crawlers which hatched into second instars on the same day were placed on each sprouted potatoes and long bottle gourd in five jars for each and observed every day. Similar procedure was followed to record the time period of development of third instar. The interval between stages was observed through exuviae and size on the hosts and morphological changes were observed under the magnifying glass. To study the development time in males, second instars mealybugs, were differentiated as the male became light pink in color and females were yellowish in color, were kept five separate jars for each host and observed daily. Hence the development time period of second instar nymph, pre-pupa and pupal stages were recorded in days.

To observe the fertility, adult female mealybugs were kept separately in five jars, one female three males each, for each host from pouch development till death. The number of crawlers, first instar mealybug, were seen, separated and recorded every day and considered as fertility.

To determine the Parthenogenesis, second instar female nymphs were selected from culture and placed on each host, five each, till the development of adult female. The crawlers, first instar PMB, thus produced from pouches of unmated females were considered as parthenogenesis.

3. Results and Discussion

The experiments were conducted to record time periods of various stages of the development of *Paracoccus marginatus* on sprouted potato and long bottle gourd in the laboratory conditions. Fertility and parthenogenesis were also observed. The statistical significant difference was determined by applying an inferential statistical technique called t-test using Microsoft Excel, 2013.

The lifecycle and biological parameters of *P. marginatus* on two host plants revealed that there are differences in the developmental time periods of different stages by calculating range and mean \pm standard deviations (SD) and were tabulated in Table 1. The life cycle observed on sprouted potato was 33-44 (38.8 \pm 4.43) days and 21-27 (25.0 \pm 2.34) days for females and males respectively. The life cycle observed on bottle gourd was 28-38 (30.8 \pm 5.80) days for females, and 20-26 (22.4 \pm 2.60) days for males. Munwar *et al.* (2016) ^[16] found the life cycle period as 39.2 \pm 1.12 day for female and 24.6 \pm 1.03 day for male on brinjal, confirmed the obtained results. On the other hand, the present results are contrary to the results reported by Rasheed *et al.* (2016) ^[19] who found the total life cycle as 24 to 29 days on papaya.

For the first instar nymph the short duration was seen on long bottle gourd 4-6 (4.8 \pm 1.09) days and that on sprouted potato was maximum as 5-7 (6.4 \pm 0.89) days. The findings of this study are in conformity with the Rasheed *et al.*, (2016) ^[19] who observed the duration of the first instar as 5.8 days on papaya. In the study conducted by Munwar *et al.*, (2016) ^[16] on brinjal, the duration of the first instar nymph duration was recorded as 4.1 \pm 1.2 days which is also

in the similar to the present results. However, Chellappan *et al.*, (2013) ^[7] found the duration of first instar on four different hosts including Papaya, Mulberry, Jatropha, and Potato as 4.4±0.52, 5.9±0.52, 4.2±0.57 and 3.56±0.53 days and the results on potato are dissimilar to that of presented study.

The duration of second instar female and male was 5-6 (5.6±0.54) days on sprouted potato and 6-7 (6.4±0.54) days on long bottle gourd. The results presented by Rasheed *et al.*, (2016) ^[19] revealed the duration of the second instar as 5.2 days for females and 6 days for males which are in fair agreement with the present results. Munwar *et al.* (2016) ^[16] and Chellappan *et al.* (2013) ^[7] also concurred with the presented results. According to Munwar *et al.* (2016) ^[16] duration of the second instar was 4.4±1.07 days for females and 4.3 days for males on brinjal. Chellappan *et al.* (2013) ^[7] reported this duration on Papaya, Mulberry, Jatropha, and Potato as 4.2±0.63 days, 5.4±0.52 days, 3.8±0.42 days, and 4.22±0.44 days for females and 4.3±0.67 days, 4.7±0.48 days, 3.6±0.52 days and 5.22±0.67 days for males, respectively. Longer developmental period of second instar on long bottle gourd may be due to different hosts and temperatures.

The duration of third instar of *P. marginatus* on sprouted potato and long bottle gourd was witnessed as 5-7 (6.2±0.83) days and 3-4 (3.6±0.54) days for females, and 4-5 days (same on both hosts) for pre-pupa accordingly. The duration for female and male was different. Chellappan *et al.* (2013) ^[7] had similar results and reported the duration on Papaya, Mulberry, Jatropha, and Potato as 5.1± 0.32, 5.1±0.88, 4.7±0.67 and 6.11±0.60 days for female and male had almost similar on all hosts as 2.6±0.53, 2.3±0.67, 2.3±0.48 and 2.56±0.53 days, correspondingly, the results of males were not aligned with the present results. Munwar *et al.* (2016) ^[16] reported this duration as 6.2±1.3 days for females on brinjal. This is in conformity with the present results. Rasheed *et al.* (2016) ^[19] reported this period as 4.6 days for female and 4.2 days for male which is again not in good agreement with the present results.

The observed duration of pupal males was 5-6 (5.6±0.54) days on sprouted potato and 4-5 (4.4±0.54) days on long bottle gourd. The study presented by Munwar *et al.* (2016) ^[16] also strengthens the observed results in which the duration of pupal males on brinjal was found as 5.6±0.43 days. Conversely, the study of Amarasekare *et al.* (2008) ^[3] on different plants showed that the duration of pupal males on each host plant varied 2.6±0.1 and 4.5±0.1days.

The total nymphal period of male assessed in the current study was longer than that of females for both hosts. The total nymphal period of females was 15-20 (17.8±2.28) days and 13-17 (15.0±2.0) days while for males it was 19-24 (22.2±2.04) days and 18-23 (20.8±2.28) days on sprouted potato and long bottle gourd, respectively. Rasheed *et al.*, (2016) ^[19] second the presented results and observed the total nymphal period for female ranging from 14 to 21 days, and for males, it was 16-23 days.

Table 1. Also gives adult longevity of papaya mealybug on sprouted potatoes and long bottle gourd. The pre-oviposition period of female *P. marginatus* seen as 5-7 (6.2±1.09) days on sprouted potato and 2-5 (3.8±1.30) days on long bottle gourd. These results on potatoes were supported by Chellappan *et al.* (2013) ^[7]. The oviposition period varied from 7-9 (7.8±0.83) days on sprouted potato and 9-11 (10.2±0.83) days on long bottle gourd. The results are not showing similarity with that of Kumar *et al.* (2014) ^[10] who reported the oviposition period as 11 to 15 under the field conditions. The post-oviposition period duration on potatoes was found as 6-8 (7.2±1.09) days and on long bottle gourd it was 4-5 (4.4±0.54) days. The obtained results were similar to Munwar *et al.* (2016) ^[16] who stated almost the same results on brinjal. The results are not in a good match with Kumar *et al.* (2014) ^[10] who claimed the duration of post-oviposition as 7 to 9 on Jatropha.

In the present study, fertility on sprouted potato was determined as 100-250 (168.8±60.49) while that on long bottle gourd was 80-150 (103.4±30.78) crawlers per female. The results obtained by Chaellappan *et al.* (2013) ^[7] were 442.6±28.98 on Papaya, 375.4±13.01 on Potato, 350.6±23.98 on Jatropha and 318.8±16.36 on mulberry. Nisha and Kennedy (2015) ^[17] observed the fecundity as 559.48 on papaya and 282.53 on tapioca which is not in consent with the present findings. Most of the researchers reported that *P. marginatus* usually lay 100 to 600 eggs in ovisac (Miller and Miller, 2002) ^[13]. The results well matched with Amarasekare *et al.* (2008) ^[2] found the fecundity ranging between 82.0±11.7 (30°C) and 300.2±40.4 (25°C).

Parthenogenesis occurs in papaya mealybug reared on both hosts, sprouted potatoes and long bottle gourd and are in agreement with the statement of Mani *et al.* (2012)^[11] regarding the occurrence of parthenogenesis in papaya mealybug (CAB International, 2001) ^[6] but, Amarasekare *et al.* (2008) ^[3] reported no parthenogenesis occurs in papaya mealybug.

Table 1: Development periods, Adult Longevity, Total Life Cycle and Fertility of Papaya Mealybug, *Pracoccus marginatus* on Sprouted Potato and Long Bottle Gourd

Developmental Stage and Fertility	Duration (Days) (Mean ± SD)		t-value (t-critical two tail)	P-value (two tail) α-0.05
	Sprouted Potato	Long Bottle Gourd		
First Instar Female Nymph	5-7 (.6.4±0.89)	4-6 (4.8±1.09)	2.529 (2.306)	0.035
Second Instar Female Nymph	5-6 (5.6±0.54)	6-7 (6.4±0.54)	2.309 (2.364)	0.049
Third Instar Female Nymph	5-7 (6.2±0.83)	3-4 (3.6±0.54)	5.814 (2.306)	0.0006
Total Nymphal Period of female	15-20 (17.8±2.28)	13-17 (15.0±2.0)	2.064 (2.306)	0.072
First Instar Male Nymph	5-7 (6.4±0.89)	4-6 (4.8±1.09)	2.530 (2.306)	0.035
Second Instar Male Nymph	5-6 (5.6±0.54)	6-7 (6.4±0.54)	-2.309 (2.364)	0.049
Pre-Pupa Male	4-5 (4.4±0.54)	4-5 (4.6±0.54)	-0.577 (2.306)	0.579
Pupal Stage Male	5-6 (5.6±0.54)	4-5 (4.4±0.54)	3.464 (2.306)	0.008
Total Nymphal Period of Male	19-24 (22.2±2.04)	18-23 (20.8±2.28)	1.021 (2.306)	0.337
Adult Longevity Female	18-24 (21.6±2.60)	15-21 (17.8±2.77)	2.231 (2.306)	0.056
Pre-oviposition	5-7 (6.2±1.09)	2-5 (3.8±1.30)	3.151 (2.306)	0.013
Oviposition	7-9 (7.8±0.83)	9-11 (10.2±0.83)	-4.535 (2.306)	0.002

Post-oviposition	6-8 (7.2±1.09)	4-5 (4.4±0.54)	5.112 (2.446)	0.002
Adult Longevity Male	2-3 (2.6±0.54)	2-3 (2.4±0.54)	0.577 (2.306)	0.056
Total Life Cycle Female	33-44 (38.8±4.43)	28-38 (30.8±5.80)	2.448 (2.36)	0.044
Total Life Cycle Male	21-27 (25.0±2.34)	20-26 (22.4±2.60)	1.658 (2.306)	0.136
Fertility (1 st Instar)	100-250 (168.8±60.49)	80-150 (103.4±30.78)	2.154 (2.446)	0.075

4. Conclusion

During the development, reproduction and the longevity of *Paracoccus marginatus*, host plants have to play a vital role to affect biology. From the results discussed above, it is concluded that the total life cycle and other biological parameters of PMB varies with the difference in hosts in the laboratory conditions. Virgin PMB females produced pouches and crawlers were seen on both hosts in laboratory conditions. Papaya mealybug completes more than one generations on sprouted potato while on long bottle gourd it hardly completes a single generation. The sprouted potato was found to be the favourite host for the mass rearing of PMB and to be utilized for a long time in the laboratory as compared to long bottle gourd that rot sooner and develop fungus and unfit for further rearing of mealybugs.

5. References

- Al-Helal MA, Ahmed KN, Khanom NEP, Bulbul S. Observation on Papaya Mealybug, *Paracoccus marginatus* Williams and Granara (Hemiptera: Pseudococcidae) damaging some crops in Bangladesh. *Journal of Plant Protection sciences*. 2012; 4(2):8-15.
- Amarasekare KG, Chong JH, Epsky ND, Mannion CM. Effect of temperaure on the life history of the mealybug *Paracoccus marginatus* (Hemiptera: Pseudococcidae). *Journal of Economic Entomology*, 2008; 101:1798-1804.
- Amarasekare KG, Mannion CM, Osborne LS, Epsky ND. Life history of *Paracoccus marginatus* (Hemiptera: Pseudococcidae) on four different host plant species under laboratory conditions. *Environmental Entomology*. 2008; 37(3):630-635.
- Bajwa BE, Mahmood R, Ahmed S. Baseline survey & Need Assessment of Biological Control Interventions in Horticultural Crops of Sindh and Baluchistan, Pakistan-CABI, 2015, 39.
- Biswas MJH, Khan MAM, Ahmed KS. Control strategies of papaya mealybug, *Paracoccus marginatus* Williams and Willink in the laboratory condition. *International Journal Appied Sciences and Biotechnology*. 2015; 3(4):687-691.
- CAB International, Crop Protection Compendium. (Wallingford, UK; CAB International), 2001.
- Chellappan M, Lawrence L, Ranjith MT. Biology and morphometry of *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae). *Entomon*. 2013; 38(2):97-110.
- Galanihe LD, Jayasundera MUP, Vithana A, Asselaarachchi N, Watson GW. Occurrence, distribution and control of papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), an invasive alien pest in Srilanka. *Tropical Agricultural Research & Extension*. 2010; 13(3):81-86.
- Kanwal S, Tahir S, Channa MS, Mahmood R, Keerio ID, Rehman A. *et al.* Fecundity, longevity and developmental time of parasitoid, *Acerophagous Papayae* on papaya mealybug, *Paracoccus marginatus*. *Pakistan Journal of Entomology*. 2017; 32(1):1-10.
- Kumar V, Topogi SC, Prasad BSR, Revanasidda, Tharini KB, Kumar CTA. *et al.* Biology and management of mealybug, *Paracoccus marginatus* Williams and Granara de Willink on *Jatropha curcas* L. *Journal of Applied and Natural Science*. 2014; 6(2):770-778.
- Mani M, Shivaraju C, Shylesha AN. *Paracoccus marginatus*, an invasive mealybug of papaya and its biological control—An overview. *Journal of Biological Control*. 2012; 26(3):201-216.
- Miller DR, Williams DJ, Hamon AB. Notes on a new mealybug (Hemiptera: Coccoidea: Pseudococcidae) pest in Florida and the Caribbean: The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink. *Insecta Mundi*. 1999; 13(3-4):179-181.
- Miller DR, Miller GL. Redescription of *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Coccidae: Pseudococcidae), including descriptions of the immature stages and adult male. *Proceeding of the Entomological Society of Washington*, 2002; 104:1-23.
- Muniappan R, Shepard BM, Watson GW, Carner GR, Sartiami D, Rauf A. *et al.* First Report of the papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), in Indonesia and India. *Journal of Agricultural Urban Entomology*. 2008; 25(1):37-40.
- Muniappan R, Shepard BM, Watson GW, Carner GR, Rauf A, Sartiami D. *et al.* New records of invasive insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa. *Journal of Agricultural and Urban Entomology*. 2011; 26(4):167-174.
- Munwar A, Mastoi MI, Gilal AA, Sehezad A, Bhatti AR, Zia A. *et al.* Effect of different mating exposure timings on the reproductive parameters of mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae). *Pakistan Entomologist*. 2016; 38(1):65-69.
- Nisha R, Kennedy JS. Lifecycle of *Paracoccus marginatus* Williams and Granara de Willink on diferent host plants vis-à-vis divergent natural selection. *Journal of Entomology and Zoology Studies*. 2017; 5(3):91-102.
- Rao GVR, Marimuttu S, Wani SP, Rao VR. Insects pests of *Jatropha curcas* L. and their management. *Information bulletin*. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics, 2010, 24.
- Rasheed VA, Krishna TM, Bhaskar B. Studies on biology and morphometrics of papaya mealybug, *Paracoccus marginatus* (Williams and Granara de Willink) on papaya. *The Bioscan*. 2016; 11(4):2093-2096.
- Sakthivel P, Karuppunchamy P, Kalyanasundaram M, Srinivasan T. Host plants of invasive papaya mealybug, *Paracoccus marginatus* (Williams and Granara de Willink) in Tamil Nadu. *Madras Agriculture Journal*. 2012; 99(7-9):615-619.
- Seni A, Sahoo AK. Weather factors influencing

- population of papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae). *Journal of Plant and Pest Science*. 2015; 2(2):41-47.
22. Williams DJ, Granara de Willink MC. Mealybugs of Central and South America. CAB International, UK, 1992, 644.
23. Wu F, Liu Z, Shen H, Yu F, Ma J, Hu X. *et al.* Morphological and molecular identification of *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in Yunan, China. *Florida Entomologist*. 2014; 97(4):1469-1473.