Record of Papaya Mealybug, *Paracoccus marginatus* Williams & Granara deWillink and its Natural Enemies on Papaya, Guava, Grapes and Plumeria in Punjab

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ABSTRACT: Regular pest surveillance during 2015-16 lead to record of the occurrence of Papaya mealybug, *Paracoccus marginatus* Williams & Granara de Willink on guava, grapes, papaya and plumeria in Punjab, India. Infested plant parts were sampled and different stages of mealybug thus collected were reared under laboratory conditions. While rearing papaya mealybug, two encyrtid parasitoids, *Anagyrus* sp. and *Acerophagus papayae* Noyes & Shauff and an aphelenid hyperparasitoid, *Marietta leopardina* Motschulsky were recovered from mealybug infested plant parts.

Keywords: *Acerophagus papaya*, *Anagyrus* sp., Papaya mealybug, *Paracoccus marginatus*, Punjab

INTRODUCTION

In Punjab, guava and grapes are cultivated on commercial scale with an area of 8205 ha and 420 ha, respectively. Papaya is a minor fruit crop which is grown under protected conditions and in kitchen gardens for household consumption (Anonymous, 2015). Whereas, plumeria is an ornamental tree which is grown along the avenues for aesthetic purposes. All these plants are infested by a number of insect pests which hamper their growth and production. The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink, is among one of the most important insect pests damaging these crops. This invasive mealybug most probably originated in Mexico or Central America (Tanwar et al., 2010, CABI, 2015). It was first recorded from Florida, USA during 1998 (Miller et al., 1999). Recently, it has been reported spreading in Asia and West Africa (IITA, 2015). Since its first report in India from Coimbatore, Tamil Nadu in 2007, it has done severe damage to horticultural and agricultural crops (Muniappan et al., 2008). *Paracoccus marginatus* has a wide host range including tropical fruits, vegetables and ornamental plants. It is a severe pest of papaya (Tanwar et al., 2010, Bhawane et al., 2011, Chellapan et al., 2013a) and mulberry (Tanwar et al., 2010, Lalitha et al., 2015) in India. Mealybug, *P. marginatus*, is reported to attack *Plumeria* spp. in various countries (Cham et al., 2011, Chen et al., 2011) and from India (Muniappan et al., 2008, Chellapan et al., 2013b, Gowda et al., 2014). Tanwar et al., (2010), Chellapan, (2011) and Sakthivel et al., (2012) have also reported guava as a host of papaya mealybug, *P. marginatus* in India.

Keeping in view the potential threat of new insect-pests, regular surveys and surveillances were undertaken to monitor pests infesting horticultural crops in Punjab. This study reports infestation of papaya mealybug on three fruit crops viz., guava, grapes and papaya and an ornamental plant plumeria, along with two parasitoids, *Anagyrus* sp., *Acerophagus papayae* Noyes & Shauff and a hyperparasitoid, *Marietta leopardina* Motschulsky associated with it, from Punjab.

MATERIALS AND METHODS

Survey of *P. marginatus* and its natural enemies

Regular surveys were conducted in farmers fields, Fruit Research Stations of Punjab Agricultural University (PAU), Ludhiana in different districts, at Fruit Research Farm and College Orchard, PAU, Ludhiana to record new insect-pests and their natural enemies on different horticultural crops. Guava orchards were in open cultivation, grapes under protected cultivation and papaya both under open field and protected cultivation. Other vegetation in the vicinity included agricultural and horticultural crops such as rice, wheat, maize, cotton, vegetables and fruits.

Collection of specimens

Field observations were taken for papaya mealybug infestation and its damage. All the plant parts were
carefully observed for infestation grading and leaf samples were collected for laboratory rearing of mealybug and its natural enemies. The random selection and collection method was followed for the study providing every sampling unit an equal chance to be chosen. Every leaf was considered as a single sampling unit and a total of six leaves along with their twig (two leaves each from lower, middle and upper canopy) were sampled from randomly selected trees. Three trees were sampled randomly and considered as three replications from each location to avoid any errors. The leaves were cut with a sharp knife and placed in plastic sealed carry bags and labeled with date and locality of collection. The samples thus collected were brought to the entomology laboratory at Department of Fruit Science for sorting, grading and population counts for mealybug for each crop. Later on, these specimens were kept in glass jars and covered with muslin cloth on top for rearing the mealybug and to observe any natural enemies emerging from such infested specimens.

Identification of specimens

The mealybug specimens were collected from infested leaves, twigs and fruits using a brush and placed into well labeled vials containing 70 per cent alcohol for identification. Natural enemies were also preserved in glass vials and both mealybug and natural enemies were submitted to National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru for identification.

Population counts

For grading the infestation of *P. marginatus*, whole plants of the species were examined for occurrence and infestation levels as described by Arif et al., (2009) (Table 1).

The natural enemies emerged from the collected samples in the laboratory were sorted as per different species and populations thus emerged were recorded for calculation of per cent parasitism.

**RESULTS AND DISCUSSION**

**Incidence of *P. marginatus***

During this study, papaya mealybug, *P. marginatus* was observed to infest guava, grapes, papaya and plumeria (Table 2). Maximum infestation of this mealybug was observed on plumeria, followed by papaya, guava and grapes. As per the grading of the plants for mealybug infestation, plumeria and papaya were observed to be highly infested with all the stages of mealybug present in high numbers. All the plant parts such as leaves, twigs, stem and fruits were covered by the different stages of mealybug. Higher infestation in case of papaya was observed under protected cultivation as compared to the open field cultivation. Guava had a medium range of infestation with all the mealybug stages available in large numbers. Whereas, grapes had a low infestation with low number of mealybug population observed on different plant parts. The results of percent infestation demonstrated that highest per cent infestation was present in plumeria (85 %) followed by papaya (70%), guava (45%) and grapes (20%).

**Seasonal activity on different hosts**

Plumeria was infested throughout the year with mealybug population. However, population was minimal in winter season as well as during rainy season. Population was recorded on papaya during July-February. During May-July, infestation was recorded on guava and in case of grapes, August-September was the infestation period for *P. marginatus*.

<table>
<thead>
<tr>
<th>Table 1. Grading of <em>P. marginatus</em> infestation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
</tr>
<tr>
<td>Incidental</td>
</tr>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>High</td>
</tr>
</tbody>
</table>
**Damage symptoms**

Infestation of mealybug, *P. marginatus*, appears like masses of cottony growth on infested plant parts (Plate 1). Almost all the above ground plants were heavily infested in case of plum eria and papaya *viz.* stem, leaves, twigs and fruits. Young growth, tender leaves and fruits were more infested. Leaves, twigs and fruits were infested with papaya mealybug in case of guava. Leaves, internodes of twigs and berries were infested in grapes. Feeding by mealybug and injecting toxic substances into the plant parts resulted in yellowing, drying and stunting of the plants. Young growth became stunted as well as deformed. Crinkling and curling of leaves was observed along with chlorosis which led to falling of leaves. Heavy infestation was noted along with midrib and veins. Infested fruits do not develop fully and fall prematurely. Heavy infestation led to complete defoliation of plum eria and papaya plants. Honey dew secretion by mealybug resulted in sooty mould development which was observed deposited on leaves and berries of grapes and all the infested parts of papaya (leaves, stem and fruits) and plum eria (stem, leaves and twigs). However, sooty mould was not observed in case of guava. Heavily infested fruits of papaya, grapes and guava were rendered inedible.

**Per cent parasitism by natural enemies**

During the current studies, two parasitoid species namely, *Acephagus papayae* and *Anagyrus* sp. and a hyperparasitoid, *Marietta leopardina* were observed emerging from the infested samples of mealybug kept in observance under laboratory conditions. Encapsulations in the mealybug population were also observed demonstrating the possible defense mechanism of mealybug against its natural enemies. Maximum numbers of parasitoids were recovered from plum eria followed by papaya, grapes and guava. Maximum percent parasitism was of *A. papayae* followed by *Anagyrus* sp. and *M. leopardina*.

### Table 2. Extent of mealybug infestation on different host plants from Punjab

<table>
<thead>
<tr>
<th>Host</th>
<th>Scientific name</th>
<th>Family</th>
<th>Type of cultivation</th>
<th>Infestation</th>
<th>Per cent infestation</th>
<th>Seasonal activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guava</td>
<td><em>Psidium guajava</em> L.</td>
<td>Myrtaceae (myrtle)</td>
<td>Open field</td>
<td>Medium</td>
<td>45</td>
<td>May-July</td>
</tr>
<tr>
<td>Grapes</td>
<td><em>Vitis vinifera</em> L.</td>
<td>Vitaceae</td>
<td>Protected</td>
<td>Low</td>
<td>20</td>
<td>August-September</td>
</tr>
<tr>
<td>Papaya</td>
<td><em>Carica papaya</em> L.</td>
<td>Caricaceae</td>
<td>Protected and open field</td>
<td>High</td>
<td>70</td>
<td>July-February</td>
</tr>
<tr>
<td>Plum eria</td>
<td><em>Plumeria</em> spp.</td>
<td>Apocynaceae</td>
<td>Open avenue plantation</td>
<td>High</td>
<td>85</td>
<td>Throughout the year</td>
</tr>
</tbody>
</table>

Fig. 1: Percentage parasitism by *A. papayae*, *M. leopardina* and *Anagyrus* sp. on different hosts during 2015 and 2016 from Punjab
Other natural enemies observed

Generalist predators such as larvae and adults of ladybird beetles, especially *Scymnus* sp. (Coleoptera: Coccinellidae), green lacewings (Neuroptera: Chloropidae) and syrphid flies were found feeding on papaya mealybug individuals but they were observed to have a low impact on mealybug populations. This mealybug has been reported to attack more than 40 host plants in Sri Lanka, but papaya and *Plumeria* were its most favoured hosts. Jackfruit, bread fruit, citrus, guava, mango, banana, pomegranate were the recorded hosts among fruit crops (Galanahi et al., 2010). Papaya mealybug is reported on papaya, cassava, eggplant, jatropha and hibiscus plants from Malaysia along with its natural enemies viz. four species of chalcidid parasitoids with *A. papaya* being the most abundant. *Apertochorysa* sp. and *Cryptolaemus montouzieri* Mulsant, which are common predators were also reported feeding on *P. marginatus* (Mastoi et al., 2011). Survey results from Tamil Nadu reported 133 host species belonging to 48 families with 33 hosts as highly infested and 31 host species were medium infested (Sakthivel et al., 2012). Classical biological control through parasitoids like *Anagyrus loecki* Noyes & Menezes., *Pseudolitostethylus mexicana* Noyes & Schaff and *A. papaya* have been reported to keep the pest under check in the Caribbean islands (Muniyappan et al., 2006). Three parasitoids- *A. papayae*, *P. mexicana* and *A. loecki* were received by the then National Bureau of Agriculturally Important Insects, Bengaluru during July-October, 2010 and distributed to different states in India (Mani et al., 2012). There was 80-90 per cent reduction in mealybug population by *A. papayae* in various regions of India (Shylesha et al., 2010, Shylesha et al., 2011, Krishnamurthy et al., 2011 and Qadri et al., 2011).

Encapsulation is reported to be a common defence mechanism in Homopteran families Coccidae (soft scales), Diaspididae (armored scale) and Pseudococcidae (mealybugs) and is indication of an invasion by an external organism (Blumberg, 1997). United States Department of Agriculture and Agricultural Research Service and co-operators in Mexico collected five parasitoids of *P. marginatus* namely *Anagyrus papayae* nr. *californicus* Compere, *A. loecki*, *A. papayae*, *Pseudaphycus* sp. and *P. Mexicana* (Hymenoptera: Encyrtidae) (USDA, 1999, 2000; Meyerdirk and Kaufman, 2001; Noyes and Schaff, 2003). Three parasitoids, *A. loecki*, *A. papaya* and *P. mexicana* were released in Guam and 1 year after the release, 100 per cent reduction in mealybug population was reported on *Hibiscus* sp. and *Plumeria* sp. (Meyerdirk et al., 2004). Amaramsakare et al., (2009) studied the establishment of three previously released parasitoids in Florida, USA and reported that *A. papaya* more efficiently caused the mortality of *P. marginatus* by parasitizing and had a higher percentage parasitism as compared to *A. loecki* in both the open-sleeve cage (31.0% vs 2.3%) and the no-cage treatments (21.4% vs 1.6%). Third released parasitoid *P. mexicana* was not recovered during their studies. *Cryptolaemus montouzieri* and *Chilocorus nigritus* (Fabricius) (Coleoptera: Coccinellidae) were reported feeding on papaya mealybug in Guam but their populations were not efficient in controlling mealybug population.

Several natural enemies viz., predators *Spalgius epius* (Westwood), *Scymnus* sp. and one parasitoid, *A. papaya* and *A. loecki* were recorded on papaya mealybug. Among the three natural enemies observed, *S. epius* were in good numbers and found predating upon all the stages of papaya mealybug (Patil et al., 2011). Saengyot and Burikam (2011) reported 10 species of host plants and 11 species of natural enemies for *P. marginatus* from Thailand. These natural enemies included parasitoids, *Anagyrus* sp. and *Anasius* sp., predators, *Cryptogonus orbicularis* (Gyllenhall), *Sasajiscymnus quinquepunctatus* (Weise), *Scymnus quadrillum* Motschulsky, *Scymnus* sp., and *Stethorus* sp., *S. epius*, *Chrysoperla* sp., *Mallada basalis* (Walker) and an unidentified syrphid fly. Also, it was reported that *Anagyrus* sp., *S. quinquepunctatus*, and *S. epius* were the dominant species of natural enemies. *Acerophagus papayae* is reported to be very useful in biological control of papaya mealybug in India (Mani et al., 2012). A study by Mastoi et al., (2015) reported two predators (*C. montouzieri* and *Apertochorysa* sp.), one primary parasitoid (*A. papayae*) and three hyperparasitoids (*Chartocerus* sp., *M. leopardina* and *Chelloneurina* sp.) in Malaysia with *C. montouzieri* and *A. papaya* being the most abundant.

In conclusion, papaya mealybug is becoming an important insect-pest of horticultural crops in Punjab. There is an urgent need for attention towards its management and declining its spread to another host plants. As some of its natural enemies have been observed in Punjab, there is need to adopt safe management practices so as to encourage population of natural enemies present in the horticultural ecosystems. There is requirement to procure the natural enemy cultures and their field releases after mass culturing to effectively manage the proliferation of this invasive mealybug population.

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Plate 1. Infestation of *P. marginatus* on different hosts and their damage symptoms

*marginatus* on different hosts and Dr. A. Rameshkumar, NBAIR, Bengaluru for identifying natural enemies.

**REFERENCES**


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