Effectiveness of three introduced encyrtid parasitic wasps (*Acerophagus papayae*, *Anagyrus loecki* and *Pseudleptomastix mexicana*) against papaya mealybug, *Paracoccus marginatus*, infesting mulberry in Tamil Nadu

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ABSTRACT

Three exotic encyrtid parasitoids *viz., Acerophagus papayae, Anagyrus loecki* and *Pseudleptomastix mexicana*, introduced in India during 2010 under the classical biological control programme against an outbreak of papaya mealybug, *Paracoccus marginatus*, an alien polyphagous pest, were evaluated on mulberry in Tamil Nadu. The nucleus culture of these three parasitoids were received from National Bureau of Agriculturally Important Insects, Bangalore, mass multiplied and released in mulberry gardens severely infested by papaya mealybug in 6 locations, 3 each at Virudunagar and Tirunelveli districts of Tamil Nadu @ 200 individuals per location during November 2010. An average of 10.4% parasitism and 9.7% reduction in papaya mealybug population was noticed a month after release of parasitoids and the population of the papaya mealybug was decreased gradually corresponding to the increase in percent parasitism @ 2, 3, 4 and 5th months. The population of papaya mealybug from the mulberry garden was almost completely eliminated with 96.6% at 6th month corresponding to 72.2% parasitism. Among the parasitoids released, the highest proliferation and field activity was observed in the case of *A. papayae*, which accounted for 75.6 – 81.7% parasitization followed by *P. mexicana* (9.3-24.4%) whereas *A. loecki* registered comparatively very poor performance (0.7-9.0 %) and its field recovery was not found 4 month after release in mulberry ecosystem of Tamil Nadu, India.

Key words: *Acerophagus papayae, Anagyrus loecki*, bioefficacy, mulberry, papaya mealybug, *Paracoccus marginatus*, parasitoids, *Pseudleptomastix mexicana.*

INTRODUCTION

Outbreaks of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), an alien polyphagous pest was recorded over 84 plant species including agricultural and horticultural crops, trees, ornamental plants and weed species in Tamil Nadu state of India during 2009-2010. Heavy population build up and severe damage were noticed on 21 host plants of which ten were economically important crops including mulberry (*Morus alba* L.), the food plant of the silkworm, *Bombyx mori* L. (Jonathan *et al*., 2010; Mahalingam *et al*., 2010; Selvaraju and Sakthivel, 2011; Sakthivel *et al*., 2012). Infestation of papaya mealybug on mulberry adversely affected the plant growth and leaf yield. Leaf quality also deteriorated due to loss of moisture and nutrients and growth of black sooty mould on the honey dew secreted by the pest spread over entire leaves and rendered them unfit to feed the silkworms, in case of severe infestation. Papaya mealybug infested mulberry leaves when fed to silkworm adversely affected its growth, development and cocoon yield (Sakthivel *et al*., 2011b). The menace of *P. marginatus* over 500 ha of mulberry in Tamil Nadu slashed the cocoon productivity of the state by 61.8 % and its fast invasion into other potential silk producing states like Karnataka and Andhra Pradesh posed serious threat to Indian sericulture industry (Qadri, 2010; Sakthivel *et al*., 2010).

Since the pest was a stranger to India, the farmers in turn applied the chemical control measures with different insecticides at initial stage of its spread to protect their crops, in the absence of appropriate IPM packages. But this practice did not succeed due to the presence of a thick protective waxy coating over the body, wider host range of the pest and resistance to the chemical insecticides. At the same time, the native natural enemies were eliminated from the agro ecosystem as they were highly sensitive to the chemicals used (Sakthivel *et al.*, 2011a). Therefore, the pest could not be brought under control even after repeated chemical measures and so it spread to neighboring states *viz.,* Kerala, Karnataka, Andhra Pradesh and Maharashtra in a short period.

However, papaya mealybug was successfully brought under control in countries like Guam, Palau, Sri Lanka, Mexico, Puerto Rico, Dominican Republic and Florida after introducing classical biological control using three promising parasitoids namely, *Acerophagus papayae* Noyes and Schauff, *Anagyrus loecki* Noyes and *Pseudleptomastix mexicana* Noyes and Schauff (Meyerdirk *et al*., 2004; Muniappan *et al*., 2006). Indiscriminate application of insecticides in India during the initial stage of outbreak of papaya mealybug might have prevented the fortuitous introduction of these effective exotic parasitoids along with the spread of this alien pest. Efforts were thus taken by National Bureau of Agriculturally Important Insects (NBAII), Bangalore to import the exotic parasitoids, mass multiplication and release in hotspot zones by the Tamil Nadu Agricultural University, Central Silk Board and other agencies during 2010. In the present investigation, the comparative field bioefficacy of these three parasitoids was evaluated against the papaya mealybug infesting mulberry in Tamil Nadu, India.

MATERIALS AND METHODS

The nucleus culture of three exotic parasitoids of papaya mealybug *viz., A. loecki*, *A. papayae* and *P. mexicana* were obtained from NBAII during October 2010 and mass multiplied using papaya mealybug cultured on potato sprouts under laboratory condition as suggested by Shylesha *et al.* (2010a). Mulberry gardens irrespective of varieties and ages, infested heavily with papaya mealybug in 6 locations, 3 each at Virudunagar and Tirunelveli districts of Tamil Nadu, were selected for release of parasitoids. Two hundred individual parasitoids of each species were released per location in the cool hours of the day (between 6-7 am) in the month of November 2010. Pre-treatment count on the population of papaya mealybug as well as the parasitization was carried out a day prior to the release of parasitoids in all locations as described by Meyerdirk *et al.* (2004). Care was taken to avoid application of any chemical pesticide in these experimental locations during the study period. The counts on population of papaya mealybug and parasitization were undertaken at monthly intervals by fixed plot method. Random samples were taken from 30 plants per location and the population of the pest was recorded from 10 cm twig portions using hand lens. Simultaneously mummies with and without exit holes were also counted and the percent parasitism was worked out. Thirty mummies without exit holes from each location were isolated carefully using soft painting brush and kept in glass test tubes closed with thin muslin cloth using rubber bands, labeled and kept at room temperature for 30 days. Then the adult parasitoids that emerged from each of the test tubes were examined in laboratory under binocular microscope and the species identified following the keys and descriptions of Poorani (2010).

RESULTS AND DISCUSSION

The average population density of papaya mealybug on mulberry and percent parasitism before and after the release of parasitoids is given in Table 1. Heavy population load of 83.7 and 78.2 individuals/10cm twig portion was recorded in Virudunagar and Tirunelveli districts respectively, while no parasitism was observed in a pre-release survey in all six locations. An average of 10.4% parasitism and 9.7% reduction in papaya mealybug population was determined a month after the release of parasitoids. However, the population of the papaya mealybug was found to decrease considerably with a corresponding increase in percent parasitism over the next four months in both locations (Table 1). The average population of papaya mealybug from the mulberry gardens in the study sites was eliminated up to 96.6% after 6th months, with a corresponding level of 72.2% parasitism. Similarly, successful elimination of papaya mealybug from different crops after introduction of these parasitoids were also reported from different hot spot zones *viz.,* Erode and Coimbatore districts of Tamil Nadu (Kalyanasundaram *et al*., 2010), Kerala (Lyla *et al.,* 2012) and Karnataka (Shylesha *et al*., 2010b) . The results are also in agreement with the reports on success of classical biological control from various countries. The reduction of the papaya mealybug population density below detectable levels was observed in a six month period after release of these three parasitoids in Palau (Muniappan *et al*., 2006) whereas in Dominican Republic and Puerto Rico, 99% reduction in the pest population was recorded after one year (Kauffman *et al*., 2001; Meyerdirk and Kauffman, 2001). Similar success in classical biological controls of papaya mealybug with remarkable reduction in its population in Guam was reported to be the reduced the risk of spread of the pest in neighboring islands and Pacific region (Meyerdirk *et al*., 2004).

Among the parasitoids released, the highest proliferation and field activity was observed for *A. papayae* in both districts (Table 2) accounting for an average of 75.6 – 81.7% of the parasitization followed by *P. mexicana* (9.3-24.4%), whereas *A. loecki* registered comparatively very poor performance (0.7-9.0 %) and it was not recovered from the field 4 month after release in mulberry ecosystem of Tamil Nadu, India (Figure 1). The observation on *A. papayae* was similar to the findings of Muniappan *et al.* (2006) and Amarasekare *et al*. (2009), who reported highest acclimatization and predominant activity of this parasitoid in Republic of Palau and Florida, whereas they recorded low recovery of *A. loecki* and non establishment of *P. mexicana* under field condition.

Table 1. Population of *Paracoccus marginatus* on mulberry and rate of parasitism after release of parasitoids

Period	Virudunagar (Average of 3 locations)		Tirunelveli (Average of 3 locations)		Average		*%Reduction in PMB population (Avg. of all sites)
	PMB	Parasitism	PMB	Parasitism	PMB	Parasitism	
November 2010 (Pre-count & Release)	83.7 ± 6.1	00.0	78.2 ± 3.9	00.0	80.9 ± 3.5	00.0	–
December 2010	75.3 ± 5.3	11.3 ± 1.2	70.9 ± 4.0	9.6 ± 0.6	73.1 ± 4.2	10.4 ± 1.4	9.7 ± 0.2
January 2011	60.1 + 3.7	25.2 + 1.6	52.4 + 2.8	18.8 + 0.7	56.2 + 2.4	21.8 + 1.2	30.5 + 1.3
February 2011	33.8 + 4.01	53.4 + 3.9	28.2 + 2.0	35.2 + 1.5	31.0 + 3.0	44.3 + 2.8	61.7 + 2.3
March 2011	18.1 ± 1.2	60.0 ± 3.7	12.6 ± 0.9	65.8 ± 2.4	15.4 ± 0.9	62.9 ± 3.2	81.0 ± 3.1
April 2011	6.5 ± 1.0	65.2 ± 3.1	3.2 ± 0.5	71.2 ± 2.2	4.9 ± 0.7	68.2 ± 2.5	93.9 ± 3.6
May 2011	3.2 + 0.7	69.3 + 3.6	2.3 + 0.3	75.1 + 2.9	2.8 + 0.5	72.2 + 3.3	96.6 + 3.9

Values are mean ± SD, PMB= Papaya mealybug (No. /10cm twig portion) & parasitism (%)
*Per cent reduction over pre-count

Sympatric parasitoid species that share the single host species may become the competitors to each other and their competitive abilities, among other factors, may determine their relative abundance (Van Strien-van Liempt, 1983). When two species compete intensely enough over limited resources, then with time, one or the other can become extinct (Dent, 1995). The interspecific competition of these three parasitoids showed that *A. papayae and P. mexicana* prefer second instar papaya mealybug while *A. loecki* prefers third instars. *P. mexicana* exhibited a longer life cycle than the other two species(Amarasekare, 2010). However, superior competitive ability of *A. papayae* was recorded over *P. mexicana* and *A. loecki* in early instar, especially second instar mealybugs (Shylesha *et al*., 2010b). This might have limited the availability of un-parasitized later instar mealybugs which are preferred by *A. loecki*, to develop its progeny under field condition and which could lead to its extinction. At the same time, the longer development time of *P. mexicana* ultimately reduces its competitiveness to share second instar nymphs and it could be an important reason for its reduced effectiveness in the field compared to *A. papayae*. Therefore, when there is a dominant parasitoid species which can displace other species, the releasing of several species might not provide the expected efficiency of a biological control program. The present

Table 2: Comparative percent parasitism by three introduced parasitoids on *P. marginatus*

Period	Virudunagar (Average of 3 locations)			Tirunelveli (Average of 3 locations)		
	A. papayae	*P. mexicana*	*A. loecki*	*A. papayae*	*P. mexicana*	*A. loecki*
December 2010	83.5	06.2	10.3	79.9	12.3	07.7
January 2011	80.4	10.8	08.8	84.6	13.3	02.7
February 2011	83.2	13.1	03.7	88.9	11.1	00.0
March 2011	79.3	20.7	00.0	77.2	21.5	01.3
April 2011	78.7	21.3	00.0	76.1	23.9	00.0
May 2011	76.8	23.2	00.0	74.4	25.6	00.0
CD (P=0.05)	6.7	1.4	0.03	4.2	1.1	0.03

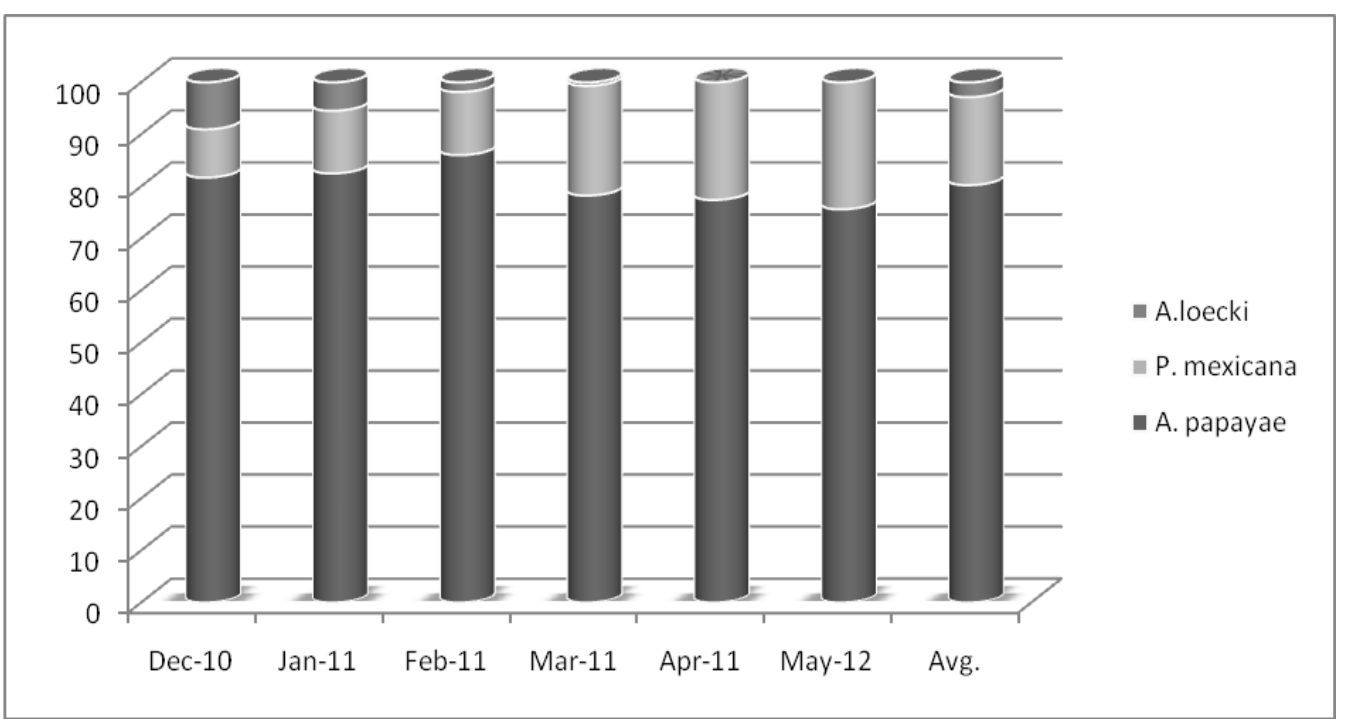

Figure 1: Comparative average field proliferation of *A. papayae, P. mexicana* & *A. loecki* during study period in mulberry ecosystem of Tamil Nadu

investigation also suggests that the release of around 200 individuals of *A. papayae* per location has been sufficient to eradicate the population of papaya mealybug successfully rather than releasing all three parasitoids. However, field diversity of *A. papayae* need to be conserved by avoiding application of insecticides with high toxicity and prolonged persistency to control other major pests of mulberry.

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