

Report on the Biological Control of papaya Mealy bug (*Paracoccus marginatus*) in Maldives



Officers Visited:

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Duration of the Visit: 4th to 15th Oct. 2010.

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Introduction:

Papaya Mealy Bug (PMB) (Figure 1) *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera :Pseudococcidae) is native to Mexico and / or central America (Miller et al.1999). It was first described in 1992 (Williams and Granara de Willink) and redescribed by Miller & Miller (2002). In April 2003 G.W.Watson, Natural history museum , London, England (Currently, California, Department of Food and Agriculture, Sacramento) confirmed the Identity of PMB following a March 2003 report of heavy infestations of mealy bugs on Papaya *Carica papaya* L. (Caricaceae) on the Island of Koror. PMB has a wide host range of over 60 species of plants (Meyerdirk & Kauffman 2001). Its distribution and damage symptoms have been reviewed by Meyerdirk et al. (2004).

Invasion of PMB in Sri Lanka was first reported to Horticultural Crop Research and Development Institute (HORDI) of Department of Agriculture in June 2008. There were evidences to think that the pest had been introduced to Sri Lanka through an illegal pathway. Due to invasive nature of the PMB and the absence of efficient natural enemies in the local environment it caused an epidemic level of infestation in all over the country within a very short period of time. Suitable cultural methods and effective safer insecticides were recommended immediately as control measures. The control obtained was either temporary or partial. Hence, a classical biological control program was designed by HORDI entomologists to control the pest. *Acerophagus papayae* (Hymenoptera: Encyrtidae), the most effective parasitoid in record to control PMB was imported to Sri Lanka from Puerto Rico. The arrival date of the parasitoid was 15th May 2009. Part of the parasitoid consignment was initially released to 10 different infested sites and rest was used for laboratory multiplication. Laboratory multiplied parasitoids were later released to more than 70 sites in all over the Island. Post surveys were made 1, 2 & 3 months after the parasitoid releases showed that parasitoids had established in all the released sites and controlled PMB infestation to a level of 95 to 100%. Also data showed that parasitoid had

spread to the other infested sites from the released sites. Based on this background HORDI scientists were invited to Maldives through FAO to share the experiences they gained in controlling PMB biologically with Maldivian counterparts and develop a biological control program for the PMB invasion in Maldives. The objective of the mission was to assess the PMB infestation level in Islands of Maldives and facilitate a biological control program by releasing the hand carried parasitoid, *A. papayae* from laboratory cultures of Sri Lanka.



Figure 1: *Paracoccus marginatus* adults with ovisacs

Activities intended to undertake during the mission

1. Inspection of infested islands.
2. Pre survey on assessing the status of papaya mealy bug (PMB) infestation and occurrence of natural enemies in infested sites
3. Release of hand carried *Acerophagus papayae* to infested sites
4. Record on other mealy bug spp. / pests present in the surveyed sites.
5. Inspection of pest status in Shangri-La Resort Island.
6. Assisting Maldivian counterparts to arrange a parasitoid rearing facility.
7. Training Maldivian counterparts in identification, field collection, mass rearing and release of PMB parasitoids.

Materials and Methods

Islands of Maldives in where PMB infestation was reported were visited and collected samples from infested sites (table 1) to assess the magnitude of PMB infestation and the presence/absence of natural enemies. Collected samples were examined under a stereoscopic microscope (figure 2) and assessments were made according to the format given in the table 2. Parasitoid adults emerged from the samples were collected using an aspirator (figure 3) and counted. Sample sizes of infested *Plumeria* and *papaya* were 5 leaves and one leaf per location respectively. However, to identify the other pests present at the sampling sites, especially other Coccid spp. a sample of 1-2 infested leaves / host plant were taken.

The parasitoids carried from Sri Lanka (500 adults) were released using the method described by Muniappan et al. (2008), to highly infested sites in Maldives immediately after infested leaf samples were taken for pre survey assessments. Locations of parasitoid releases are shown in table 3 and Figures 5 to 12. Farmer awareness program (figure 4) was carried out on the 6th Sept. 2010 at Southern Councilor's office in Addhoo atoll.

A PMB crawler collection box, a parasitoid collection bottle and a small dark chamber for rearing PMB were prepared at the office of the Agriculture Ministry in Male to train the Maldivian counter parts on preparation of those things. Moreover, they were trained on identification of mummified/ parasitized mealy bugs, adults of *Acerophagus papayae* and parasitized white fly (*Aleurodicus dispersus*) nymphs by *Encarsia* spp.

Also, a power point presentation was made to the relevant staff at the Agriculture ministry on followings:

- i History of PMB and its distribution
- ii. Identification of PMB and its natural enemies
- iii. Techniques of rearing PMB and *A. papayae*.
- iv. Transport and release of *A. papayae*.
- v. Laboratory mass rearing of *A.papayae*

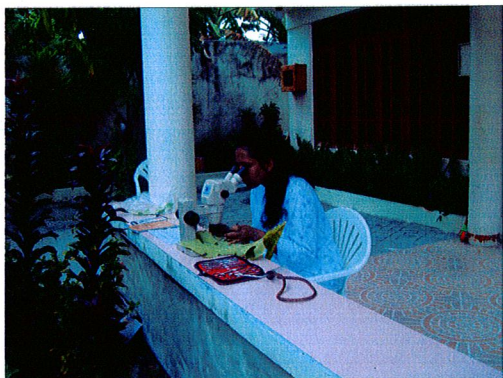


Figure 2: Taking counts from samples (Addhoo atoll and Male)

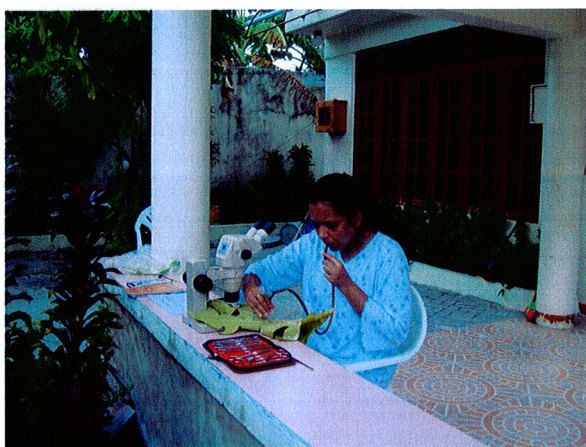


Figure 3: Aspirating adult natural enemies from samples

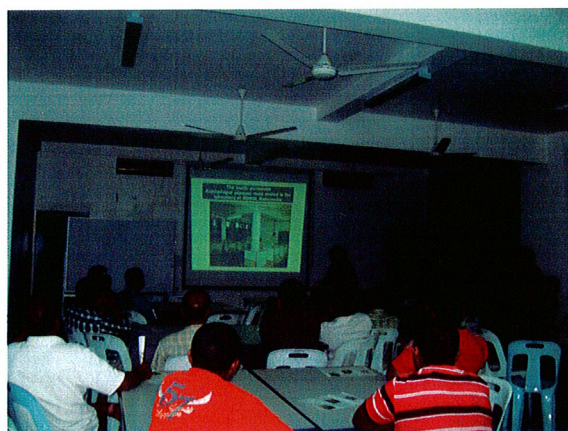


Figure 4: Farmer awareness program

Table 1: Locations of collection of samples during the pre survey.

Date	Name of the Island	Location	Plant species sampled
04/10/10	Male	President's Palace Near the old Mosque Public park	<i>Plumeria</i> <i>Hibiscus</i> <i>Jatropha</i> <i>Croton</i> <i>Plumeria</i> <i>Croton</i> <i>Ixora</i>
10/10/10	Male	Violet Magu Close to Susan Magu	<i>Plumeria</i> <i>Plumeria</i>
12/10/10	Male	Close to Sri Lankan Airline new office	<i>Plumeria</i>
5/10/10	Addhoo atoll 1. Hithadhoo	Oddassau - Location 1 Oddassau - Location 2 Mamendhoo – Location 3	<i>Papaya</i> <i>Papaya</i> <i>Papaya</i>
	2. Maradhoo	Location 1 Location 2	
	3. Maradhoo - feidhoo	Location 1	
	4. Fiedhoo	Location 1 Location 2	
6/10/10	Shangri-La Resort Island	Location 1	<i>Plumeria</i> <i>Reguea</i> <i>Seahibiscus</i>
11/10/10	Vilingilli Island	Locatuion 1 Location 2	<i>Hibiscus</i> <i>Ixora</i> <i>Plumeria</i>

Table2: Format used in data recording of pre survey on field release of *A. papayae* in Maldives

Date: Location: Host: Sample size:

Location No.	Leaf No.	Egg masses		Number of mealy bugs/ Leaf / sample									Natural enemies				Other
		L	D	Females			Nymphs			crawlers			<i>Spalgis epius</i>	<i>Crypto-laemus Spp.</i>	<i>Crysopa Spp.</i>	Suspected	
				L	P	D	L	P	D	L	P	D					

L-live, P- Parasitized, D-Dead

Table3: Hand carried parasitoids released sites in Maldives

Date of Release	Location Number	Island / Location
5/10/10	1	Hithadhoo/Oddassau
	2	Hithadhoo/Oddassau
	3	Hithadhoo/Mamendhoo
	4	Maradhoo
	5	Maradhoo
	6	Maradhoo- Fiedhoo
	7	Fiedhoo
	8	Fiedhoo



Figure 5: Location 1



Figure 6: Location 2



Figure 7 : Location 3



Figure 8: Location 4

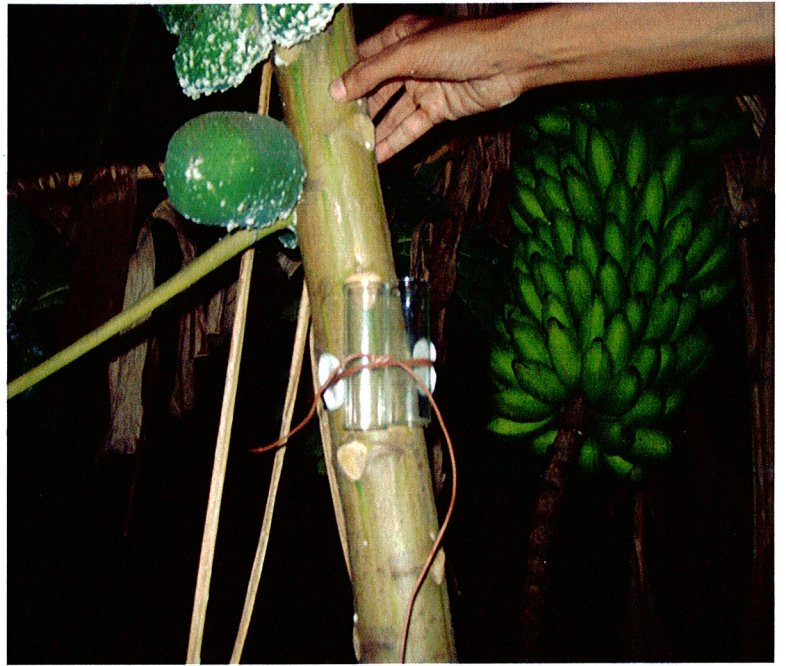


Figure 9 : Location 5

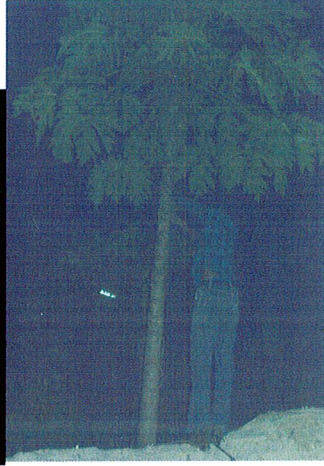


Figure 10: Location 6



Figure 11 : Location 7



Figure 12 : Location 8

Results and Discussion:

Presently the mealy bug infestation in Male was under control and observed a high rate of parasitism by *A. papayae* (figure 13) as much as up to 100% at some sites (table 4 and figure 15), the parasitoid that had been introduced to Sri Lanka from Puerto-Rico. The higher parasitism was reported from the places where insecticides were not applied to control PMB.

Also one larva of *Spalgis epius* (figure14), a predator of mealy bugs is found on a mealy bug infested croton leaf sample collected from Public Park in Male. However, it was noticed that routine application of insecticides was being made to control PMB at President's palace garden and Male public Park. Most of the insecticides used were in the broad spectrum category that kills harmful as well as beneficial insects. This may have led to occurrence of many other Coccid species in those two places (tables 5, 6 and figures16,17,18,19,and 20). Also, reappearance of PMB was observed at President's palace garden on a *Jatropha* spp. plant (table 4).

In Addhoo atoll the % parasitism of papaya mealy bug by *A.papayae* varied from 27-100. In here also, 100% parasitism was observed in places where insecticides were not used (table 4 and figure 21). However, where intensive use of insecticides was in practice, the PMB parasitism was low (table 4).

Moreover, in Addhoo atoll and Villigilli island there were very high infestations of white flies (*Aleurodicus dispersus*) on chili and papaya crops. In some places entire chili crop showed severe yellowing of leaves due to white fly damage (figure 22)

Even though parasitism of white fly nymphs by *Encarsia* spp. was observed, the percentage parasitism was very low. The main reason for this situation could have been due to indiscriminate use of insecticides, specially the broad spectrum insecticides such as profenophos, chlorpyrifos and prothiophos. Usually the spiraling white fly is under controlled by *Encarsia* spp. (parasitoid) and epidemics are observed when parasitoids get killed. (It is learnt that *Encarsia* had been released in Addhoo atoll several years ago).

Pest status of Shangri La Resort Island

Very high infestations of different spp. of Coccids (mealy bugs and scales) (figures: 23 and 24) were observed and there were places in which the entire vegetation was covered with sooty mould (figure 25) indicating that there had been severe infestations of mealy bugs/scales/white flies. Sooty mould is a fungi that grows on honey dew secreted by several insect spp. such as mealy bugs, scales white flies, aphids etc. (Frequent applications of insecticides have been noted in this island).

The prepared crawler collection box, PMB rearing chamber and adult parasitoid collection bottle are shown in figures 26,27 and 28. However, a bigger rearing facility with necessary apparatus such as insect rearing cages, movable racks, suitable plastic trays etc. are needed for mass rearing of parasitoids. Life cycle of *A. papaya* and classifications of other coccids reported are given in Appendix 1

Recommendations

1. Insecticide applications should not be made to control PMB infestations as *A. papaya* is established and performing very well in islands of Maldives.
2. Reduce the use of insecticides to increase populations of natural enemies such as *Encarsia* sp., and *Spalgis* sp.
3. Severity of Coccid and white fly infestations can be reduced by using selective insecticides.
4. For controlling high infestations of sucking pests such as Coccids (other than PMB) and white flies use of available cultural practices are essential to get the maximum benefit of existing bio control agents.

Table 4: % of Mealy bug and natural enemies found in sampling sites of Maldives from 4th to 15th 2010

Sample size: *Plumeria* – 5 leaves/ location

Papaya – 1 leaf/ Location

Atoll	Island	District	Location No.	Location	Sampling date	Host plant spp.	Total no. PMB/ Sample (C+N=A)	No.of <i>A.papayae</i> immersed	% PMB nymphal parasitism	% PMB adult parasitism by <i>A.papayae</i>	%Total PMB (Ny Nymphs+Adults) Parasitism by <i>A.papayae</i>
Male	Male		1	Mosque	4/10/10	Plumeria	307	3	100.00	100.00	71.83
			2	President'palace garden	4/10/10	Jatropha	04	-	-	-	-
			3	Violet Magu	10/10/10	Plumeria	1000	2	94.31	60.57	67.36
			4.	Air Lanka office	13/10/10	Plumeria	200	2	100.00	100.00	100.00
	Vilingilli			Mosque	11/10/10	Papaya	196	3	100.00	100.00	100.00
Addhoo	Hithadhoo	Oddassau	1	Farmer field	5/10/10	Papaya	65	0	14.28	62.96	27.69
	Hithadhoo	Oddassau	2	Farmer field	5/10/10	Papaya	175	3	53.33	82.14	40.57
	Hithadhoo	Mamendhoo	3	Home garden	6/10/10	Papaya	995	68	86.91	88.37	44.41
	Maradhoo		4	Road side	5/10/10	Papaya	686	35	50.83	43.64	62.56
	Maradhoo		5	Home garden	5/10/10	Papaya	397	0	75.95	52.83	33.67
	Maradhoo - feidhoo		6	Home garden	5/10/10	Papaya	1330	0	60.59	64.41	37.59
	feidhoo		7	Home garden	5/10/10	Papaya	181	5	70.37	76.92	37.56
	feidhoo		8	Road side	5/10/10	Papaya	44	0	37.50	100.00	52.27
Airport island	Airport island	-	9	Airport hotel site	9/10/10	Papaya	00	00	00	00	00

C-Crawlers N- Nymphs A- Adults

Table 5: Mean number of *Rastrococcus invadens* and *Pseudococcus longispinus* observed/ leaf

Island : Male

Host plant : Plumeria

Location	Mean number of mealy bugs/leaf	
	<i>Rastrococcus invadens</i> (Mango mealy bug)	<i>Pseudococcus longispinus</i> (Long tailed mealy bug)
Near the old mosque	13.6	15.2
Violet Magu	6.0	4.33
Near new Airlanka Building	6.33	0

Table 6: Other *Coccid* spp observed in Islands of Maldives

Other <i>Coccid</i> spp	Host plants	location
<i>Pseudococcus longispinus</i> (Long tailed mealy bug)	Croton	President's palace garden (Male island)
<i>Ferrisia virgata</i> (Striped mealy bug)		Male public park President's palace garden
<i>Ceroplastes species</i> (Wax scale)	Ixora Croton	Male public Park
<i>Phanacoccus solenopsis</i> (Cotton Mealy bug)	croton	Male public park
<i>Dysmicoccus neobrevipes</i> (gray pineapple mealy bug)	Croton	Male public park, President's palace garden
<i>Rastrococcus invadens</i>	Reguea, plumeria, papaya	Sangrila resort island, Male island, Addhoo atoll, Vilingilli Island
Snow scale (<i>Pinnaspis</i> spp.)	Sea hibiscus	Sangrila holiday resort
<i>Aleurodicus dispersus</i> (Spiraling whitefly)	Chili, <i>Plumeria</i>	Addho o atoll



Figure 13 : Parasitized PMB on *Plumeria* leaves in Male

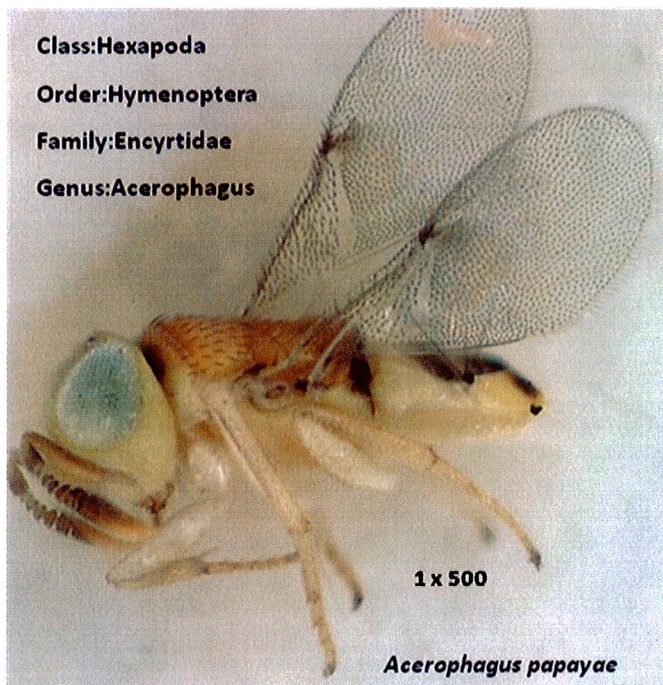


Figure 14 : *A.Papaye* adult



Figure 15 : Ape fly (*Spalgis epius*)

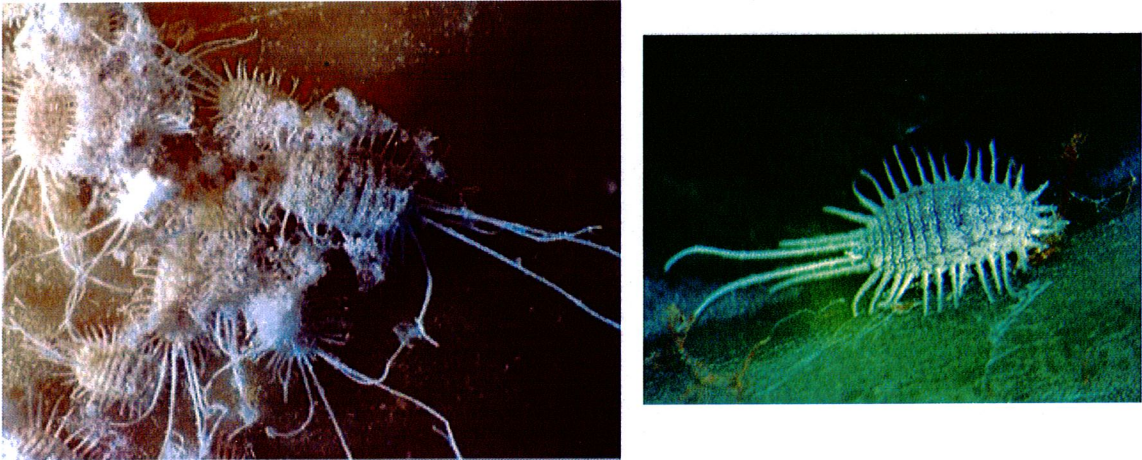


Figure 16 : *Pseudococcus longispinus* (Longtailed mealy bug)



Figure 17: *Ferrisia virgata* (Striped mealy bug)

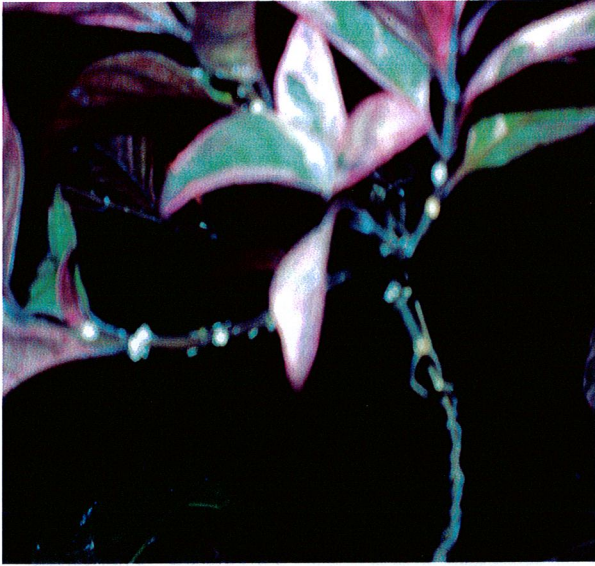


Figure18: *Ceroplastes species* (Wax scale)



Figure 19 : *Phanacoccus solenopsis* (Cotton Mealy bug)



Figure 20 : *Dysmicoccus neobrevipes* (gray pineapple mealy bug)

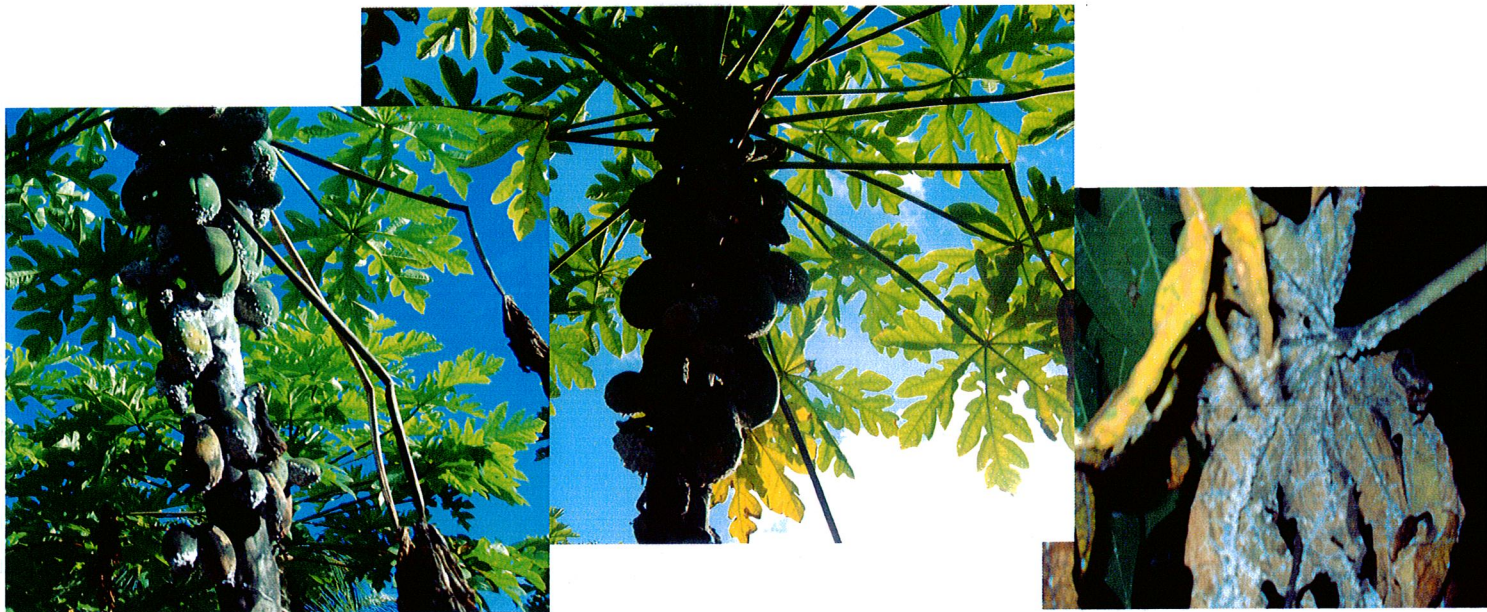


Figure 21: Parasitized PMB in Addhoo atoll

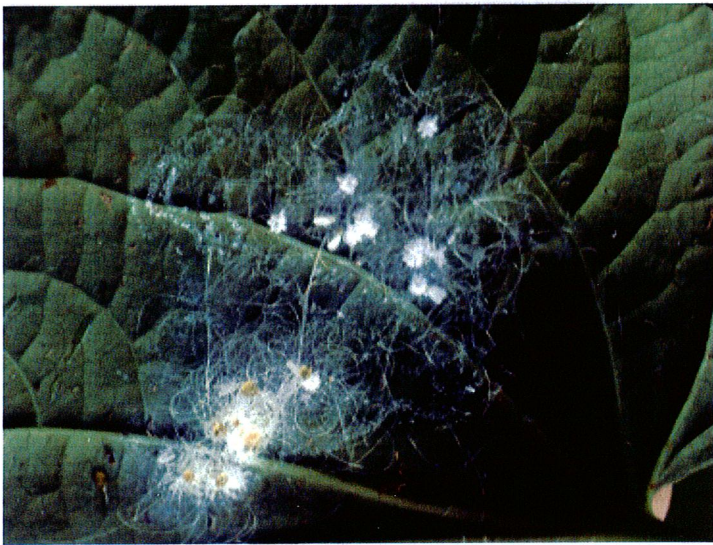
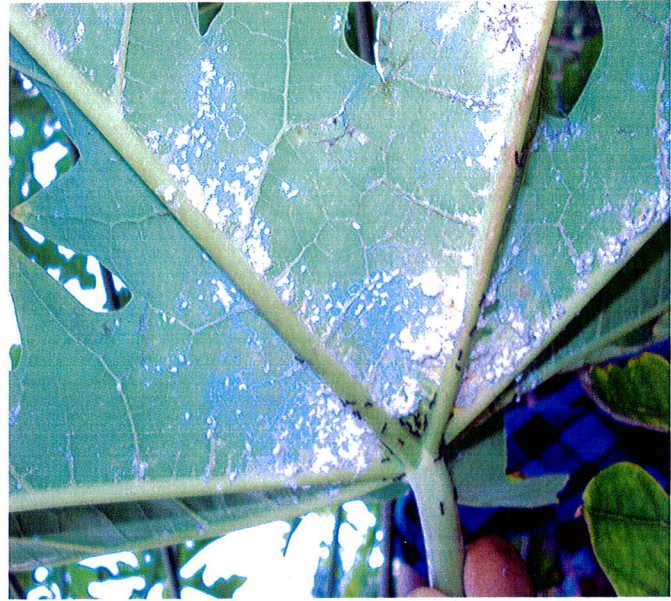


Figure 22: *Aleurodicus dispersus* (Spiraling whitefly) infestation on chili and papaya in Adhoo atoll



Figure 23 : Infestation of *Rastrococcus invadens* on Reguea in Shangri La Resort Island



Figure 24 : Snow scale (*Pinnaspis spp.*) infestation on sea hibiscus in Shangri La Resort island



Figure 25 : Growth of Sooty mould on different plant spp. in Shangri-La Resort Island



Figure 26 : Crawler collection box

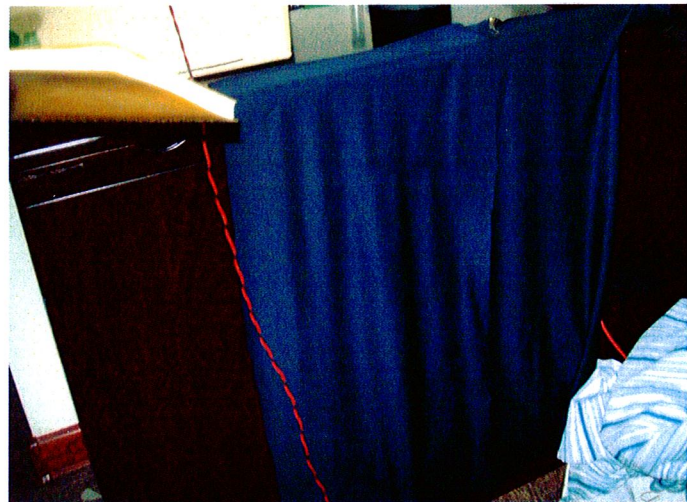


Figure: 27: PMB rearing chamber

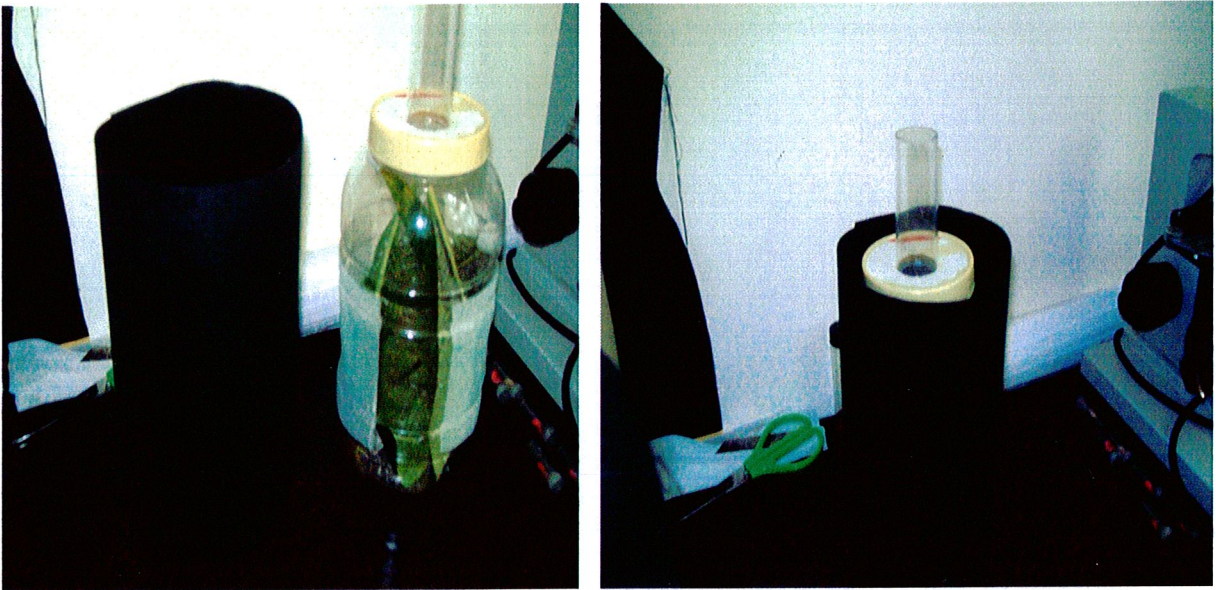


Figure 28 : Adult *A. papayae* collection bottle

Appendix 1

***A. Papayae* Life cycle**

Adult lays one egg inside each nymph body and entire life cycle completes within the body of the mealy bug.

Development time (Egg to Adult)

Male- 13-14 days

Female-14-15 days

Longevity-

Male- 22-24 days

Female – About 13-14 days mated/unmated which are able to oviposit

Female –About 32-33 days mated/unmated without oviposition

Unmated females lay male only progeny and mated females lay both female and male progeny (approximately 1:1 ration of males and females). Reproductive period- 12-14 days.

A pappae can develop well in both second and third instars papaya mealy bugs, So sprouted potatoes with second and third instars are suitable for their rearing.

Classification of *Pseudococcus longispinus*

Order: Hemiptera

Family :Pseudococcidae

Genus: Pseudococcus

Classification of *Ferrisia virgata* (Striped mealybug)

Order : Hemiptera

Family :Pseudococcidae

Classification of *Ceroplastes sp.*(Wax scale)

Order: Homoptera

Family : Coccidae

Classification of *Phanacoccus solenopsis* (Cotton Mealy bug)

Order :Hemiptera

Suborder :Sternorrhyncha

Family :Pseudococcidae

Classification of *Rastrococcus invadens*

Order: Hemiptera

Family :Pseudococcidae

Genus :Rastrococcus