IICA

TECHNICAL MEETING

AND

WORKSHOP ON BIOLOGICAL CONTROL

OF

PAPAYA MEALY BUG

Paracoccus marginatus

Basseterre, St Kitts
July 25-26, 2000

IICA OFFICE IN SAINT LUCIA

WHAT IS IICA?

The Inter-American Institute for Cooperation on Agriculture (IICA) is the specialized agency for agriculture in the Inter-American system.

As a hemispheric technical cOoperation agency, IICA can be flexible and creative in responding to needs for technical cooperation in countries, through its thirty-four Technical Cooperation Agencies, its five Regional Centers and Headquarters, which coordinate the implementation of strategies tailored to the needs of each Region.

The 1998-2002 Medium Term Plan (MTP) provides the strategic framework for orienting IICA's actions during this four-year period. Its general objective is to support the efforts of the Member States in achieving sustainable agricultural development, within the framework of hemispheric integration and as a contribution to human development in rural areas.

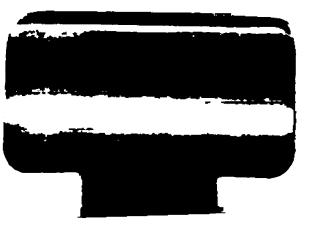
The Institute's work is aimed at making changes in agricultural -production, trade and institutions and in the people who work in the sector, using an integrated and systematic approach to development, which is based on competitiveness, equity and solidarity as the key to achieving the sustainable development of agriculture and rural areas.

The Member States of IICA are:

Northern, Central, Andean & Southern: Argentina, Belize, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, the United States of America, Uruguay, Venezuela.

The 14 Caribbean Regional Countries:
Antigua and Barbuda, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago,

Its Permanent Observers are: Arab Republic of Egypt, Austria, Belgium, Czech. Republic, European Communities, France, Germany, Hungary, Israel, Italy, Japan, Kingdom of the Netherlands, Portugal, Republic of Korea, Republic of Poland, Romania Federation and Spain.



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TECHNICAL MEETING
AND
WORKSHOP ON BIOLOGICAL CONTROL
OF
PAPAYA MEALY BUG
Paracoccus marginatus

Basseterre, St Kitts
July 25-26, 2000

Organized by :

The Ministry of Agriculture, Lands and Housing, St Kitts and Nevis
Inter-American Institute for Cooperation on Agriculture (IICA)
United States Department of Agriculture (USDA)
Caribbean Agricultural Research and Development Institute (CARDI)

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SECTION 3 - TECHNICAL PRESENTATIONS

LIST OF ACRONYMS / ABBREVIATIONS

APHIS	-	Animal and Plant Health Inspection Service
BAS	-	Barbados Agricultural Society
CA	-	Cooperation Agency
CAB-I	-	Centre for Agriculture and Biosciences International
CARDI	-	Caribbean Agricultural Research and Development Institute
CARINET	-	Caribbean Loop of Bionet International
CIPMNET	-	Caribbean Integrated Pest Management Network
ECS	-	Eastern Caribbean States
IICA	-	Inter-American Institute for Cooperation on Agriculture
PPQ	-	Plant Protection and Quarantine
UK	-	United Kingdom
USA	-	United States of America
USDA	-	United States Department of Agriculture
UWI	-	University of the West Indies
USVI	-	United States Virgin Islands

FORWARD

Paracoccus marginatus (Papaya mealy bug) a pest native to Central America was first cited in the West Indies, on the island of St. Martin, in 1996. Since then, the pest has been found in other Caribbean countries and Florida (USA). The pest attacks hibiscus and a wide range of other plants but prefers papaya. The damage caused by the pest is similar to that of ***Maconellicoccus hirsutus***, the Hibiscus Mealy Bug (HMB).

The pest has the potential to become a regional pest and in order to prevent a catastrophe similar to that caused by the advent of the HMB; it was necessary that strategies be developed to reduce its economic impact and so manage the pest infestation problem emerging in these countries. In pursuit of this objective, IICA in collaboration with USDA/APHIS/PPQ and CARDI drew up a cooperative programme designed to implement a biological control programme against the pest, in the Caribbean.

The technical meeting and workshop is an activity of the programme and was held in St Kitts on July 25-26, 2000. Participants were from most of the IICA Caribbean member countries viz Antigua and Barbuda, Barbados, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago and Suriname. In addition, there were participants from Montserrat, the Cayman Islands and the United States.

This undertaking provided a forum for information sharing as this related to the status of the pest in each of participating countries. As well, participants were equipped with resource material on approaches in respect of the management of infestation caused by the papaya mealy bug. The frank discussions among participants facilitated the definition of balanced recommendations and further served to enhance the scope for informed decision making in the respective countries.

This report is being prepared as a reference manual for the countries, especially those that could not participate. It is our hope that it will be used for the purpose for which it is intended.

ACKNOWLEDGEMENTS

The successful implementation of this technical meeting and workshop was the result of effective collaboration among partners. In this regard, due appreciation and gratitude are extended to the Government and people of the host country – St. Kitts, in particular the Ministry of Agriculture, Lands and Housing.

The technical cooperation amongst CARDI, IICA CA in St Kitts/Nevis and USDA/APHIS/PPQ and participating countries is recognized as invaluable to the assurance of appropriate technology transfer. In this regard, the distinguished contributions by the various Caribbean country representatives and other presenters of the papers are recognised. The technical information shared during this two-day encounter will undoubtedly serve as a useful reference, to the process of managing the pest infestation levels in the Caribbean.

The logistical support of Ms Ingrid Greene, IICA CA in St Kitts/Nevis, the staff of IICA Caribbean, the staff of CARDI, St Kitts and the Ministry of Agriculture and Ms Irene Lawrence is greatly acknowledged. The secretarial support provided by Ms. Deborah Biscombe during the compilation of this report is duly acknowledged.

SECTION 1

- **Introduction**
- **Opening Session**
- **Agendas - Technical Meeting**
  - Workshop
- **List of Known Countries infested with *Paracoccus marginatus***
- **Workshop Objectives**
- **Conclusions and Recommendations of Technical Meeting and Workshop**

Introduction

The ***Technical Meeting and Workshop for the Biological Control of the Papaya Mealybug Paracoccus marginatus in the Caribbean*** was held in St Kitts at the Conference Room of the Bird Rock Beach Hotel during period 25-26 July 2000, under the chairmanship of Mr. Everton Ambrose, Plant Protection Specialist, IICA, St. Lucia. The Honourable Cederic Liburd, Minister for Agriculture, Lands and Housing delivered the feature address and declared the proceedings opened. Dr L Barbara Graham, IICA Representative in the ECS and Dr. Dale Meyerdirk, USDA, also gave addresses.

The two-day event was attended by thirty participants and included representatives from fifteen (15) countries namely Antigua and Barbuda, Barbados, Cayman Islands, Dominica, Grenada, Guyana, Haiti, Jamaica, Suriname, St Kitts and Nevis, Montserrat, Saint Lucia, St Vincent and the Grenadines, Trinidad and Tobago and the United States Virgin Islands. Institutions participating included IICA, CARDI, USDA and CAB-I.

OPENING SESSION
PROGRAMME

0830 – 0840 Welcome Remarks by Chairman

- Everton Ambrose
  Specialist in Plant Protection, IICA

- The Chairman indicated that the Technical Meeting / Workshop was an activity of a project entitled **"Preventing the spread of *Paracoccus marginatus*, papaya mealy bug, in the Caribbean".**
- This project, remarked the Chairman, contributed to IICA's efforts targeted at creating awareness at emerging issues instead of emergencies when a pest strikes. The chairman duly emphasized the collaborative effort of IICA, USDA, CARDI, CAB-I and the Governments of the Caribbean.
- As iterated by the Chairman, the goal of this two-day activity was to determine (1) the extent of the papaya mealy bug infestation in the Caribbean, (2) the economic impact of the pest and (3) develop action plans to implement a biological control programme.

0840 – 0850 Remarks

- Dr L Barbara Graham
  IICA Representative in the ECS

- The IICA Representative for the ECS conveyed greetings on behalf of IICA and the good wishes of Dr Arlington Chesney, the Director of IICA Caribbean Regional Centre.
- The IICA Representative noted the collaborative effort of participating institutions viz IICA, CARDI, USDA/APHIS/PPQ and the Governments of the Caribbean and highlighted the benefits of intra-regional partnership amongst technical agencies, as this relates to the avoidance of conflicts and duplication and the efficient use of resources.
- Dr. Graham stated that this undertaking was foremost to the process of providing technical assistance to manage the papaya mealy bug before it becomes widespread in the countries and again drew attention to the need to consider the activity as a part of efforts at creating awareness of "*emerging issues*" in agricultural health instead of responding to emergencies.
- Dr Graham outlined the weaknesses of the latter approach and urged the countries to adopt this new "emerging issues" approach, which is oriented towards outlining requirements for national capacity building. She committed IICA to providing technical assistance for national capacity building.

0850 – 0900 Remarks

- Dr Dale Meyerdirk
  USDA

- Dr. Dale Meyerdirk outlined some activities being undertaken by USDA in an effort to manage the Papaya Mealy Bug.
- He further stated the offer of USDA to support the effort of Caribbean countries to combat the pest.
- He informed the participants that this was a fact finding activity and that everyone was there to learn.

0900 – 0925 Feature Address

- Honourable Cedric Liburd
  Minister for Agriculture, Lands and Housing

- The Minister for Agriculture, Lands and Housing, in his capacity as the Representative of the Government of St. Kitts and Nevis, welcomed the participants to the island of St. Kitts and expressed pleasure at the choice of location for this two-day technical meeting and workshop.
- Honourable Cedric Liburd emphasized the importance of this activity to the prosperity of the agricultural sector in the region. He stressed the significance to the management of the food security status of Caribbean countries and to improving the human capacity for agricultural health surveillance.
- The Minister noted the collaborative effort of the organizing institutions viz IICA, CARDI, USDA/APHIS/PPQ and the Governments of the Caribbean and encouraged this method of implementation of activities to better utilize the scarce resources available.
- All participants were urged to use this opportunity for meaningful collaboration and exchange of ideas and information. He urged the meeting to keep focused on the objectives of this exercise and looked forward to the implementation of concrete actions towards the control of the spread of infestation of the papaya mealy bug.
- The Honourable Cedric Liburd, Minister of Agriculture, Lands and Housing declared the technical meeting and workshop open, at the close of his address.

0925 – 0930 Vote of Thanks

- Dr Lilory Mc Comie
  Acting Country Team Leader and Entomologist, CARDI

- The Acting Country Team Leader and Entomologist, CARDI expressed sincere appreciation to IICA and other participating institutions for their effort at creating awareness of "*emerging issues*", in this instance preventing the spread of ***Paracoccus marginatus***, papaya mealy bug, in the Caribbean.
- The readiness of the host Government, in particular the Ministry of Agriculture, Lands and Housing, in facilitating the two-day technical meeting and workshop in St. Kitts was highly commended by Dr. Mc Comie. She also thanked all country representatives and other resource persons for their presence and expressed the hope that this event would be a fruitful and rewarding experience for all so involved.

0930 End of Opening Session - **Coffee Break / Refreshments**

Technical Meeting

Tuesday, July 25, 2000

AGENDA

1000	Country Reports on Status of *Paracoccus marginatus*
1200	**LUNCH**
1300	Country Reports
1400	Biology of Mealy bugs with Reference to Spread and Detection - ***Vyju Lopez***
1430	***COFFEE BREAK***
1500	Known Countries Infested and Economic Losses - ***Dale Meyerdirk***
1530	The Code of Conduct for the Introduction and Release of Exotic Biological Control Agents - ***Vyju Lopez***
1600	Proposed survey objectives and procedures - ***Dale Meyerdirk***
1630	Mealy bug Identification: Regional Capability, Logistics, Data Logging and Dissemination of Information - ***Vyju Lopez***
1700	Opportunity for Biological Control of *Paracoccus marginatus* - ***Dale Meyerdirk***
1730	Discussion
1800	Adjourn

WORKSHOP

Wednesday, July 26, 2000

AGENDA

0830	Objectives of Workshop - ***Dale Meyerdirk***
0845	Field Characters of *Paracoccus marginatus* - ***Dale Meyerdirk***
0930	Taxonomic Information on *Paracoccus marginatus* - ***Gary Miller***
1015	**COFFEE BREAK**
1030	Known host plants of *Paracoccus marginatus* - ***Lilory Mc Comie***
1100	Review of Mealy bug Biological Control Successes - ***Dale Meyerdirk***
1130	Comparison Re: The Control Strategies for *Maconellicoccus hirsutus* and *Paracoccus marginatus* - ***Wayne De Chi***
1200	**LUNCH**
1300	Proposed Sampling procedures for *Paracoccus marginatus* - ***Lilory Mc Comie***
1430	Baseline Data Collection of the mealy bug and its natural enemies prior to parasite releases (hibiscus and papaya) - ***Dale Meyerdirk***
1445	Parasite Shipment, Release and follow-up population density counts of mealy bug and parasites - ***Dale Meyerdirk***
1500	**COFFEE BREAK**
1530	Field Trip to Papaya plot infested with *Paracoccus marginatus* - ***Dale Meyerdirk and Lilory Mc Comie***
1600	Discussion
1630	Concluding Remarks and Follow up Actions
1700	Adjourn

LIST OF KNOWN[1] COUNTRIES

infested by
Paracoccus marginatus

Caribbean

Antigua and Barbuda

British Virgin Islands

Cuba

Dominican Republic

Guadeloupe

Haiti

Montserrat

Puerto Rico

St Barthelemy

St Kitts and Nevis

St Martin

United States Virgin Islands

Central America

Belize

Costa Rica

Guatemala

North America

Mexico

United States

[1] Known Countries as at July 2000

Workshop Objectives

The following objectives were detailed by ***Dale Meyerdirk :***

- Learn to identify *Paracoccus marginatus*
  - Field Characters
  - Laboratory – Taxonomic Information
- Review of Known Host Plants
- Review of Mealybug Biological Control Successes
- Similarity to Biological Control of *Maconellicoccus hirsutus*
- Parasites attacking *Paracoccus marginatus* in Mexico
- Baseline Data Collection Techniques
- Parasite Production and shipment
- Parasite Release Technique
- Follow-up Data Collection – Impact of Release

Conclusions and Recommendations
of
TECHNICAL MEETING and WORKHSHOP

During the Technical Meeting, 14 country reports were presented, by country representatives, on the status of the Papaya Mealy bug – *Paracoccus marginatus* in their respective countries. These were followed by six (6) technical presentations from resource persons Vyju Lopez and Dale Meyerdirk. The meeting came to a close after the discussion session, which followed the three (3) presentations by each of the two aforementioned resource persons.

The Workshop, on the following day, commenced with the deliberations on the objectives of the workshop. Throughout the rest of the in-house session of the Workshop, presentations from the four (4) resource persons kept in line the stated objectives of the Workshop. Following the afternoon coffee-break, participants were taken on a field trip to a papaya plot infested with *Paracoccus marginatus*.

CONCLUSIONS

The participants concluded that the two (2) day event was a very informative and timely undertaking. The approach served to achieve the objectives of determining the extent of the papaya mealy bug infestation in the Caribbean and the economic impact of the pest. However, there was not sufficient time for the development of an integrated pest management regime for the papaya mealy bug. Another principal conclusion of the meeting was that IICA would provide support in the coordination of activities of the papaya mealy bug.

RECOMMENDATIONS

The following recommendations represent the consensus opinion of participants, consequent upon the presentations and ensuing discussion on the respective papers at both the Technical Meeting and the Workshop:

1. Countries should consider a system of instant fining, as opposed to court litigation, for plant quarantine violations.

2. Countries should consider and discuss at a bilateral level, risk management options for quarantine pests instead of resorting to the banning of materials as a first option.
3. Countries should make use of the IICA/CARDI Protocol for Fresh Produce in Regional Trade.
4. The Protocol for the Hibiscus Mealy Bug (HMB) general or model protocol should be used as a reference to guide the development of procedures for specific pests.
5. CARDI should seek to accelerate work on the validation of the protocol for the HMB and the work on the use of magnesium phosphide as a plant quarantine treatment.
6. Non-infested countries should initiate a detection survey to determine their true status.
7. Infested countries should undertake an assessment to obtain baseline data of natural enemies. They should also monitor the situation after the release of exotic natural enemies.
8. Countries need to adhere to the Code of Conduct for the Importation and Release of Exotic Biological Control Agents when importing natural enemies.

FOLLOW-UP ACTIONS

It was agreed, by participants of the Workshop, that certain actions needed to be taken and in this regard:

1. CARINET to be the Coordinating Agency for the identification and as such, countries are to send slide mounts and tube samples to CARINET for identification. Sources for identification are Mr. Lennox Chandler, CAB-I (IIE) and USDA. USDA will only accept slide mounts.
2. A request sent to CAB-I (CARINET) to reduce the cost of identifications, if slides are submitted.
3. USDA offered to be a source for inoculation material or multiplication of natural enemies for countries for a limited period of time.
4. Posters/leaflets for public education to be funded as part of the IICA Project. Drs Lilory Mc Comie, CARDI and Viju Lopez, CAB-I to provide the technical input.

SECTION 2

Country Reports

- Antigua and Barbuda
- Barbados
- Cayman Islands
- Dominica
- Grenada
- Guyana
- Haiti
- Jamaica
- St. Kitts
- Nevis
- St. Lucia
- St. Vincent and the Grenadines
- Suriname
- Trinidad and Tobago
- United States Virgin Islands

Antigua and Barbuda

Janil P. Gore

Origin and Distribution

The papaya mealybug, *Paracoccus marginatus,* is a native of Central America and was first reported in the Caribbean in 1994 (Dominican Republic). The pest was positively identified in Antigua and Barbuda in June 1998 by G. Watson (CABI-UK). Up to June 1999, the papaya mealybug was not reported in Barbuda.
Distribution of the papaya mealybug in Antigua is islandwide.

Signs

Symptoms of infestation are similar to those of the Pink Hibiscus Mealybug. These include malformation of growing plant shoots. Affected plants are covered with a waxy or mealy material that reduces the effectiveness of some insecticides. The mealybug is usually found in association with aphids, sooty mold and ants.

Host plants

The pest attacks a wide range of plants; however, the most favoured plants are papaya, soursop and hibiscus. The pest is also found on the following plants:
Ornamentals: Jatropha, oleander, croton, frangipani; Fruit trees: guava, mango, sugar apple;
Weeds: Man-better-man, acacia
Vegetables and root crops: ochroes, pigeon peas, egg plant, cassava
Other crops: neem, sorrel, cotton

The attached table shows the frequency of reports of the mealybug on a variety of plants. It should be noted that Antigua and Barbuda experienced two hurricanes during October and November 1999. This could possibly have resulted in the visible reduction in reports for this and subsequent periods as many of the host plants would have been lost in the winds. In addition, infestation levels after the hurricanes were found to be noticeably low.

Control

In an effort to control *Paracoccus marginatus,* the Plant Protection Unit embarked on an intensive public awareness campaign. For short-term control, residents were advised to prune infested plants, bag immediately and burn while the remainder of the plant was to be treated with soap water, preferably in an insecticide formulation such as Safers soap insecticide. In extreme cases only chemicals such as Diazinon and Cygon were advised and used initially and then followed by a soap insecticide. This approach would facilitate the introduction of natural enemies as the preferred control strategy.

The Ministry of Agriculture introduced predaceous beetles *(Cryptolaemus montrouzieri)* into Antigua in 1998. Two sets of releases were made in 1998 (300 in February at one site and 4500 in September at some twenty sites). In January 2000, one release was made at one site. Visits

made to release sites revealed very low levels of establishment of the predator. It is important to note that Hurricane Georges passed shortly after the second release in 1998.

Dr. Hector Gonzalez, a mealybug expert from Mexico, visited Antigua in November 1999. Several affected areas were visited and the identification of mummified mealybugs was pointed out to accompanying officers. Presence of mummies indicated the occurrence of parasitism while the presence of low levels of the coccinelid larvae indicated the presence of a predaceous beetle. Samples of mealybug from a range of plants were taken for identification. This information is still pending. Preliminary investigations indicate that the parasitoid is a black wasp that is yet to be identified.

Present Activities and Future Plans

Projects have been submitted for funding re: control of the papaya mealybug and include training of technicians and the acquisition of rearing facilities for natural enemies. Primary use of native natural enemies is preferred.

A formal survey of *Paracoccus marginatus* is currently being launched and it is the intention of the Department of Agriculture through the Plant Protection Unit to use the expertise of officers who have received training on this pest in the recent past.

Table 1: *Frequency of Paracoccus marginatus (Papaya mealybug) on a variety of host plants in Antigua (1999-2000)*

Host	Frequency of report (%)		
	Jan-Jun 1999	Jul-Dec 1999	Jan-Jun 2000
	51 reports	14 reports	17 reports
I. Ornamentals			
Hibiscus	17.6	35.7	23.5
Croton	11.8	-	17.6
Bougainvillea	2.0	-	-
Ixora	2.0	-	-
Morning Glory	2.0	-	-
Poinsettia	2.0	-	5.9
Frangipani	2.0	-	-
Ferns	-	-	5.9
OTHER	11.8	14.3	29.4
II. Fruit trees			
Papaya	13.7	14.3	-
Citrus	3.9	7.1	5.9
Sugar apple	2.0	-	-
Guava	3.9	7.1	-
Mango	3.9	-	-
Soursop	3.9	7.1	5.9
Banana	2.0	-	-
WestIndian Cherry	-	-	5.9
III. Vegetables			
Eggplant	2.0	-	-
Pigeon Peas	3.9	-	-
IV. Weeds			
Man-better-man	2.0	-	-
V. Other			
Palms	3.9	-	-
Castor	2.0	-	-

Barbados

Edwina Kirton

Actions being undertaken to prevent entry:

1. Pre- clearance inspections in *Paracoccus marginatus* infested countries etc.
   - Antigua
   - Cayman Islands
   - St. Kitts

2. Quarantine inspections at ports of entry
   - Close working relationship between Quarantine, Immigration and Customs.

3. Continuous surveillance and monitoring of ports of entry, hotels and places considered high-risk areas.
   - Survey currently being carried out on Papaya and Cassava for *Paracoccus marginatus*.

Actions to be undertaken if found:

- Biological control measures will be implemented if *Paracoccus marginatus* is found.
- We are currently rearing the "Mealy Bug destroyer" *Cryptolaemus montrouzieri* in the laboratory as a first defense in the control of this pest if and when it comes to Barbados.
- Cultural control
  Pruning and burning and removing from the field

****Rearing of the predaceous beetle *Crytolaemus montrouzieri* on mealy-bugs found throughout Barbados as preventative measures in case Pink Hibiscus Mealy Bug [PHMB] enters the island. ****

The setting up of a National Coordination Committee comprising all stakeholders in Agriculture and Horticultural Sectors, i.e. BAS, CARDI, UWI, Farmers groups, Hotel associate, Technical staff and Nurseries.

Country/Island List of recorded mealybug species - Barbados

1. *Dysmicoccus boninsis*
2. *Dysmicoccus brevipes*
3. *Dysmicoccus neobrevipes*
4. *Ferrisia virgata*
5. *Geococcus coffeae*
6. *Hypogeococcus pungens*
7. *Nipaecoccus nipae*
8. *Phenaeoccus maderierensis*
9. *Phenacoccus parvus*
10. *Phenacoccus solenopsis*
11. *Planococcus halli*
12. *Platiococcus minor*
13. *Pseudococciis jackbeardsleyi*
14. *Pseudococcus landoi*
15. *Pseudococcus longispinus*
16. *Pseudococcus micocirculus*
17. *Rhizoecus epicopus*
18. *Sacchaaricoccus sacchari*

Cayman Islands

Joan D. Steer and Sasha M. Frederick

Introduction

The Cayman Islands are a British Dependent Territory located in the Western Caribbean. The country consists of three Islands: Cayman Brac, Little Cayman and Grand Cayman. Grand Cayman is the largest and most developed of the three. Together, they cover only 100 sq. miles. The islands have a total population of about 38,000 people. Tourism and Banking are the two major industries that contribute to the economy. Therefore, the Department of Agriculture's plant protection efforts are focused, not only on the farming community but a significant amount of effort is directed at the horticultural sector.

The arrival of the Pink Hibiscus Mealybug (PHMB) *Maconellicoccus hirsutus* to Grenada in 1994 and its subsequent spread through the Caribbean region prompted the Cayman Islands Department of Agriculture (DOA) to begin to examine all the local mealybug species more closely

The DOA moved very quickly to identify training for its technical staff in the areas of identification and characterization of Mealybug species. The Laboratory facilities were improved to be able to handle mealybug processing and slide preparation of permanent slide mounts. In 1998 the DOA conducted a National Mealybug Detection Survey and in January 1999 a National Mealybug Monitoring Programme was instituted. By this programme, 27 sentinel sites in Grand Cayman are inspected monthly by Technical staff members. As a result of the survey and monitoring programme mealybug samples have been collected and processed to provide valuable information on the status of mealybug and their associated host plants in the Cayman Islands.

The DOA is grateful to key institutions such as the Natural History Museum, UK; the United States Department of Agriculture (USDA APHIS); the Ministry of Agriculture, Barbados and the University of Florida for the assistance received in confirming the taxonomic identification of mealybug species

Status of the Papaya Mealybuy- (Paracoccus marginatus Willians & Granara de Willink) in the Cayman Islands:

How or when, *Paracoccus marginatus* was introduced into the Cayman Islands is not known. However, the first sighting of *Paracoccus marginatus* was made in early August 1999 on papaya *(Carica papaya)* and cassava *(Manihot esculenta)* in the western region of Grand Cayman. It is believed that this is also the country's first record since it was not identified in any of the samples that were collected during the National Mealybug Detection Survey. A DOA Technical staff member's participation in the Caribbean Regional Training Course on Mealybug and Whitefly Identification in Trinidad in April 1999, when *Paracoccus marginatus* was one of the subjects that received major attention, greatly assisted in the early detection of this pest.

Within ten days another sighting was made in Gun Bay in east Grand Cayman. A Rapid Detection Survey was conducted by the end of August 1999 in a one-mile radius of these two foci. Altogether four other suspicious sightings were found during this survey Figure 1. Confirmation of these six (6) suspicious samples along with two other samples collected later, one in central and the other in northern Grand Cayman, were confirmed by Mr. John S. Maxen, CABI Bioscience Identification Services, UK in May 2000.

Description of P. marginatus as observed in the Cayman Islands

The body of *Paracoccus marginatus* is yellow in colour and with a series of short waxy filaments, around the margin. The eggs are also distinctly yellow and are laid in an ovisac produced ventrally at the tip of the abdomen. Other macroscopic features of this pest include a usual change of body colour from yellow to black in 80% Ethanol and to dark brown to black in potassiun hydroxide.

Host Plant Range in the Cayman Islands

In the Cayman Islands *Paracoccus marginatus* has been observed predominantly on papaya (C. *papaya),* sorrel *(Hibiscus sabdariffa),* cassava *(M. esculenta),* broad beans *(Vicia faba) Jatropha* sp. and *Acalypha* sp. This mealybug pest has never been observed on hibiscus in the Cayman Islands.

Distribution

To date the pest has been observed in all five districts of Grand Cayman Figure I. Usually the infestation has been very heavy, but very confined to clumps of host plants in one area. New infestations have been found to be usually miles away rather than in adjoining fields. There has not been any complaint of mealybug problems in Cayman Brac or Little Cayman and surveys have not been done to date to determine whether or not this pest is present in the other two islands.

Damage

Paracoccus marginatus causes malformation of leaves and shoot growth, severe stunting and sometimes death of the host plant. In cassava and *Jatropha* sp. there is usually a severe stunting of the lamina and a characteristic bending of the leafstalk of the youngest leaves. Heavily infested plants have shortened internodes leading to a "bunchy top" appearance. *Paracoccus marginatus* usually produces a thick, white, waxy coating, with heavy honey-dew secretion.

Losses due to *Paracoccus marginatus* infestation can be devastating. The worst incidence in the Cayman Islands has been on a farm in Gun Bay, East End where the farmer lost several bean and sorrel plants before the infestation was put under control.

However, the Cayman experience is that if the pest is controlled early then the host plant usually puts out a new flush of leaves soon afterwards.

Control

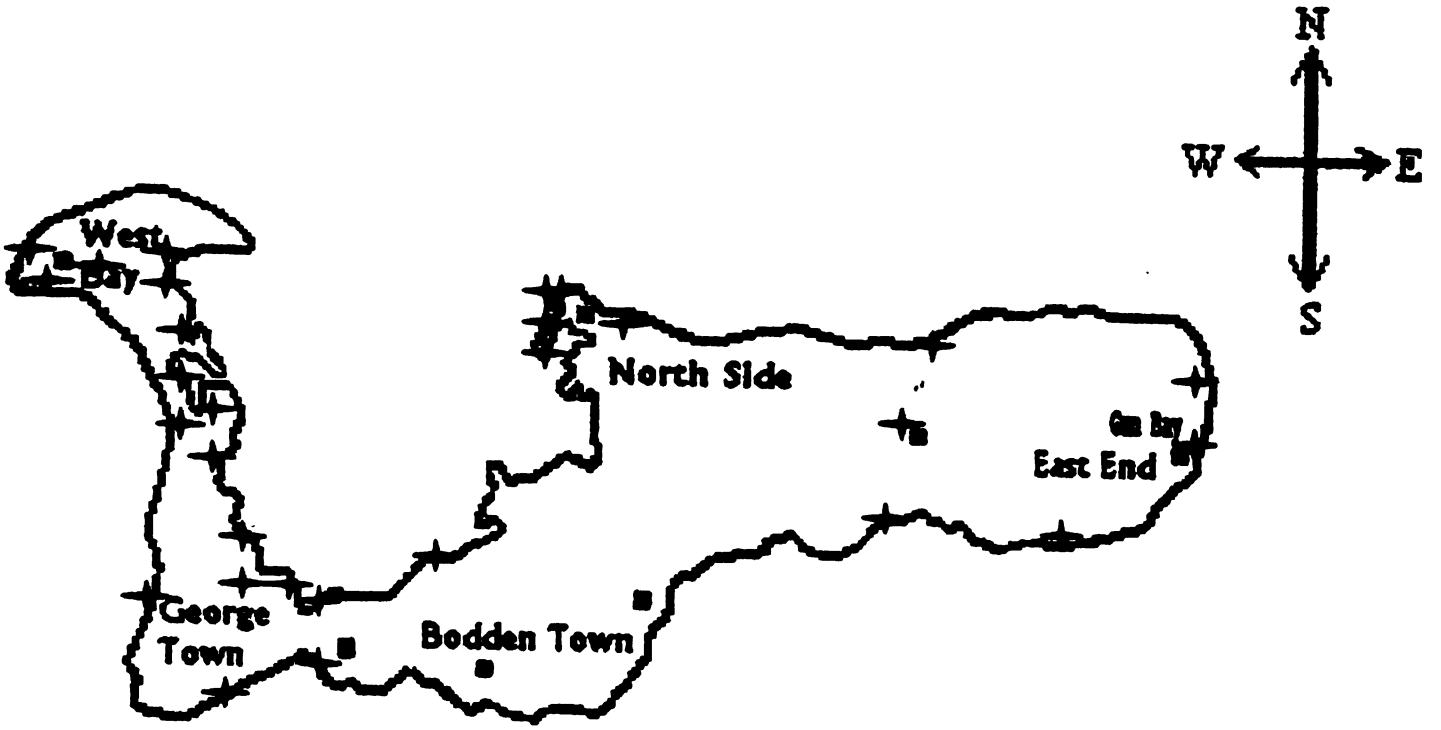
The DOA has been using Biological control as the approach against *Paracoccus marginatus*. In 1999, adults of the *Cryptolaemus montrouzieri* ladybug were imported from Oxnard Pest Control Association, California and released at all the infested sites. Very good establishment of these ladybugs was observed, especially on *Acalypha* sp.

In the Cayman Islands a high level of parasitism has been observed in colonies of *Paracoccus marginatus*. Predators such as lacewing larva (*Crysopidae*), and a small ladybug have also been found in association with colonies. Samples of the small parasitic insects (including wasps) that emerged along with the small local ladybug that is usually found associated with this pest have been sent to United States Department of Agriculture/ Animal and Plant Health Inspection Service (USDA, APHIS) for identification. Communication with Dr. Dale Meyerdirk suggests that these were Anagyrus-like wasps.

It is not known whether or not these parasitoids occur naturally in the Cayman Islands or if they were introduced along with the pest. In the meanwhile the Cayman Islands is committed to the use of biological agents as the preferred strategy for controlling *Paracoccus marginatus.*

The DOA considers the staging of this Technical Meeting and Workshop for the Biological Control of the Papaya Mealybug, *Paracoccus marginatus* in the Caribbean to be very timely and is very grateful that an invitation was extended to the Cayman Islands to attend and participate in the proceedings.

Figure I Map of Grand Cayman showing monitoring sites and locations where *Paracoccus marginatus* infestations were found during the Rapid Detection Survey August 1999.



P. marginatus

Legend:

Monitoring sites

Dominica

Naomi Commodore

Introduction

The Regions experience with the Pink Hibiscus Mealybug - *Maconellicoccus hirsutus,* has heightened our awareness of the destructive nature of these pests to our Agriculture. The report of the Papaya Mealybug - *Paracoccus marginatus* in the region makes it imperative that Dominica maintains its status and if it continues to be free of this pest, prepare for action should this pest be introduced into the country.

Biology

The body is yellowish-green in colour and has a series of short waxy filaments around the margin. Eggs are also yellowish-green in colour and are laid in ovisacs at the tip of the abdomen. The adult females are about 2.5 mm in length and members of the genus usually have 8-segmented antennae. *Paracoccus* has an incomplete metamorphosis and completes its life cycle in 30-45 days, with females having three instars and males four.

Distribution

The present distribution in Central America includes:

- Mexico
- United States
- Belize
- Costa Rica
- Guatemala

The pest was first reported in the West Indies from St. Martin (French Antilles) in May 1996. Since then it has been reported in:

- St. Bartholomew
- St.Thomas
- St. Croix
- British Virgin Islands
- Dominican Republic
- Haiti
- St. Kitts
- Nevis
- Antigua

Host Plants and Damage

Paracoccus marginatus is a polyphagous species native to the Central American mainland that can damage numerous host plants of which *Carica papaya* (pawpaw or papaya) is the favoured host. It has been reported to attack at least 42 host species. In the Caribbean, it has been prevalent on papaya, hibiscus, soursop, sugar apples, pumpkins, avocados, peppers, sweet potatoes, cherry, acalypha, frangipani, and claradendron.

Damage is similar to that of the Pink Hibiscus Mealbug (*Maconellicoccus hirsutus*) with the curling and crinkling of the leaves, rosetting and stunting of shoots. The adult secretes honeydew, which soils the leaves and stems and encourages the growth of sooty mold, a black fungus that affects the photosynthetic capacity of plants. Under intense attack, leaves eventually fall and the plant dies.

Materials and Methods

Leaf samples were taken from selected plots island-wide and examined for presence/absence of mealybugs. Aided by a hand lens and secateur, four leaves from the north, south, east and west of each tree were examined then placed in plastic bags, sealed and labeled. Samples are taken to the Laboratory for examination.

Survey Results

An island-wide survey was conducted to determine presence/absence of this pest in Dominica. The following is a table indicating results:

Date of Collection	Region	Location	Host Plant	Plot size	Results
13/06/00	North	Grange	Papaya	12 trees	No Paracoccus Found
13/06/00	North	Cottage	Papaya	13 trees	No Paracoccus Found
13/06/00	North	Portsmouth	Papaya	30trees	No Paracoccus Found
				25trees	No Paracoccus Found
			Hibiscus	Hedge	No Paracoccus Found
13/06/00	North	Borne	Papaya	15 trees	No Paracoccus Found
13/06/00	West	Grand Savanne	Papaya	65 trees	No Paracoccus Found
13/06/00	West	Grand Savanne	Papaya	50 trees	No Paracoccus Found
14/06/00	Southeast	La Plaine	Papaya	50 trees	No Paracoccus Found

Date of Collection	Region	Location	Host Plant	Plot size	Results
14/06/00	Southeast	La Plaine	Papaya	10 trees	No Paracoccus Found
15/06/00	Central	Layou	Papaya	25 trees	No Paracoccus Found
			Acalypha	Hedge	No Paracoccus Found
22/06/00	Northeast	Melville Hall	Papaya	104 trees	No Paracoccus Found
			Hibiscus	Hedge	No Paracoccus Found
26/06/00	South	Grand BayHall	Papaya	116 trees	No Paracoccus Found
		Botanical Gardens	Hibiscus	Hedge	No Paracoccus Found

Dominica's Status

Dominica is free of the Papaya Mealybug - *Paracoccus marginatus*. This pest has been reported in islands close to Dominica e.g. Antigua, St. Kitts and Nevis. There is much concern regarding the status (presence/absence) of the pest in the neighbouring islands of Guadeloupe and Martinique, with whom Dominica conducts an active Agricultural Trade.

Actions to be taken to prevent entry

- Alert Quarantine & Extension Staff of its presence in the Region.
- Inspect all products originating from mealybug-infested countries.
- Provide training for Plant Protection and Quarantine Staff and Extension Officers that will enable them to:
    1. know the signs and symptoms, of the infestation and
    2. to take samples and
    3. preserve samples for Laboratory identification/analysis.
- Conduct surveys every six months to determine presence/absence of *Paracoccus marginatus*
- Monitor closely, all mealybug-infested samples brought to the Laboratory.
- Keep abreast of Papaya Mealybug's distribution regionally.

Action to be taken if found

- Activate Emergency Action Plan for Exotic Pestsand Diseases

  The Emergency Action Plan for Pests and Diseases is an organized approach to prevent the introduction of exotic pest and diseases into a country and to contain or eradicate them if they enter. It provides for the creation of a National Emergency Pest and Disease Committee (NEPC), which is responsible for its administration. The NEPC functions as a sub-committee of the larger National Emergency Preparedness Organization (NEPO) which is chaired by the Minister of Communications, Works and Housing and which has the wider mandate of ensuring national preparedness for all disasters i.e. hurricane, flood, earthquake etc. The task

of the NEPC is to promulgate policies and coordinate inputs and activities of the different Government Ministries and other agencies.

Component activities

- Development and implementation of Legislation relating to Plant Protection and Quarantine.
- Surveillance - Port inspection and field monitoring.
- Proper handling and disposal of international garbage
- Public information.
- Monitoring and review of preventative measures.

Grenada

Paul Graham

Mealybug Species Present: (14 species)

1.	*Dysmicoccus boninsis*	Annonas
2.	*Dysmicoccus brevipes*	Pineapple
3.	*Dysmicoccus neobrevipes*	Annonas
4.	*Ferrisia virgata*	Annonas
5.	*Maconellicoccus hirsutus*	Multiple
6.	*Nipaecoccus nipae*	
7.	*Phenacoccus herreni*	
8.	*Phenacoccus madereirensis*	
9.	*Planococcus citri*	Multiple
10.	*Planococcus minor*	
11.	*Pseudococcus jackbeardsleyi*	Pumpkins
12.	*Pseudococcus longispinus*	Multiple
13.	*Puto barberi*	Ornamentals
14.	*Saccharicoccus sacchari*	Sugar Cane

Activities undertaken to prevent entry

- Intensification of quarantine surveillance at ports of entry
- Periodic updating of plant quarantine regulations
- Initiation of legal proceedings
- Development of capacity to rear and release selected natural predators.

Actions to be taken if Paracoccus marginatus is found :

- Immediate withdrawal of affected crops from exportation
- Determination of host range, distribution, intensity of infestation and natural host status
- Imposition of Internal Quarantine based on distribution
- Initiation of eradication efforts, if distribution is limited
- Implementation of IPM Strategy (biological and cultural).

Guyana

Abiola Gilead

Paracoccus marginatus is not known to be present in Guyana. During routine monitoring of infested pink mealy bug sites, and responding to calls from members of the public, there is a lookout for mealybugs similar to this pest.

Guyana benefited from the training in the identification of mealybugs of the Caribbean and if suspected samples of *Paracoccus marginatus* are collected, a preliminary identification will be done to determine whether it is this pest.

Actions being undertaken to prevent entry

- Strengthening of the coordination between Plant Quarantine and Customs Officers. Customs must request the services of Plant Quarantine Officers, for passengers carrying plant material.
- Plant material imported from countries infected with this pest will be thoroughly examined upon entering Guyana.
- Inspection of the plant material consignments on arrival at the port of entry will be intensified.

Control/Eradication

If the pest is found in Guyana, the Plant Protection Emergency Action Plan for Exotic Plant Pests and Diseases will be implemented to manage/control this pest.

The purpose of this emergency action is to allow the relevant agencies to provide requested support to the Ministry of Agriculture in its endeavors to control this new pest. The Government will provide funding for the operational expenses in managing the pest. If funds are limited, a request will be made for funding from other agencies.

The Emergency Action Plan Sequence of Events

1. Identification of the pest.
2. The Minister will be notified and the pest will be declared a notifiable pest.
3. The task force will conduct surveys to determine the distribution, infestation levels and the natural enemy status of the pest.
4. A public awareness campaign will be set up to alert the public about the presence of the pest, the damage, spread, and methods of control. Leaflets and posters will be distributed and an advisory will be aired on the radio.
5. A biological control program will be implemented.

In Guyana, there is an established biological control program for the control of the Pink Hibiscus Mealybug (PHMB). It will be determined if natural enemies of HMB will be effective in the control of *Paracoccus marginatus* or whether to introduce exotic natural enemies.
For infested sites that are isolated, plants will be cut and burnt.

Haiti

Pierre Guito Laurone

I. Introduction

St Kitts, one of the small islands of the Caribbean, was the seat of a workshop on the cochineal insect [*Paracoccus marginatus*] where more than thirty participants, most of whom were Anglophone, met during two consecutive days 25-26 July 2000. This initiative came about due to the fact that eighteen countries of the Caribbean, North America and Central America had been infested with the parasite. Actually, an inventory of almost 42 hosts was carried out during the years 1998-2000. The damage done until now by this cochineal insect is of great economic importance to large scale farming. Collected for the first time in Mexico in 1967, then begun to extend into the Central Americas (Belize, Guatemala and Costa Rica) and the Caribbean (Guadeloupe, St Kitts, St Dominique etc). Haiti is also mentioned among the countries affected by *Paracoccus marginatus*, even if the appearance date is not specified anywhere. Nonetheless, the damage is of lesser importance since the host plants are quite dispersed limiting the distribution of the females, which do not fly.

In the thrust to find a solution to this infestation, several pest control programes have been undertaken by certain concerned states, but only the biological control, until now, has had great success. During this workshop, many important points in relation to the *Paracoccus marginatus* were developed by specialists from CARDI, IICA and USDA. This was done with the aim of permitting each of the participants to be in a position of correctly carrying out a canvassing investigation, preparing a sample intended for identification, and acquiring the maximum amount of information relative to the distribution, biology and the means of control of this parasite.

II. Generalities and Biology of the Insect

The cochineal insect or *Paracoccus marginatus* belongs to the insect class of *Hemipterous* order and *Pseudococcidae* family. It lives in colonies in the aerial parts, in particular, on flowers, fruits, stems, branches and the underside of leaves and produces a large surface of impermeable wax of whitish colour. Generally, this cochineal is considered as the main enemy of its hosts by feeding on the sap, injecting toxins and certain dangerous micro-organisms at the same time. In spite of its life cycle which is not well defined, one is sure to observe a new generation every 30 to 40 days depending on the environment.

The male differs greatly from the female from a biological point of view.

TABLE 1: DIFFERENCE BETWEEN THE TWO SEXES

MALE	FEMALE
One (1) pair of mobile wings	No wings
Elongated body	Oval body with presence of filaments
Small size	Varied colour/often dark
Short life span	Body covered with wax
Complete transformation	Displacement over short distances
Death after mating	Longer life span
	Incomplete transformation Egg - 1st stage - 2nd stage - 3rd stage - Adult
	Egg 50>100
	Seldom viviparous
	Reproduction: sexual and/or parthenogenesis
	Death after laying season

Generally, the eggs are enclosed in a bag made of impermeable wax situated under the abdomen.

III. Spread

Within a particle, the cochineal insect propagates through man, animals, wind and water. In the case of two countries, the spreading is done by means of aerial maritime and land transportation through infested plant material.

IV. Signs

The damages caused by the *Paracoccus marginatus* are similar to those of the *Maconellicoccus hirsutus* in the case of a heavy infestation and vary from one species to the next. Whatever the stage of vegetation, the cochineal insect affects all the aerial parts of the plant and result in disastrous consequences for production. At times, certain infested plants perish without bearing fruit. The fruits, covered with a whitish wax and black spots all over are often deformed and cannot be marketed. In certain species, the damages range from deformation and reduction of the leaf surface, defoliation of the plant, reduction in the quality and quantity of the fruits to the death of the plant.

V. Control

Actually, there is no pesticide, in existence, registered for the control of the cochineal insect. However, certain pesticides like Diazinon 50WP and mineral oil, Cygon (Dimethoate 2.67 EC (lbs/gal), Malathion, Orthene are used in the fight against this parasite on small areas, but the results are partial. In this case, one must use a spraying material at high pressure so that the insecticide can finally go through the mass of wax so as to get to the insect that it covers. This difficulty is due mainly to the biological structure of the *Paracoccus margniatus*. To arrive at a

satisfactory result it is advisable that the number of sprayings be increased. However, this can lead to the emergence of resistant colonies and the disappearance of parasites and natural predators etc.

Cultivations that are resistant to this cochineal insect remain an efficient means of combating this problem. Despite the many years of research, there is not any micro-organism in existence (bacteria, virus, fungus) capable of being deadly to this insect. However, the only efficient means of control of the cochineal insect is the biological fight. In the large plantations and forests, some parasitical agents are known as the best means of combating this plague. Only *Anagyrus loecki*, *Apoangyrus californicus*, *Acerophagus* sp, *Procheiloneurus* sp, *Pseudleptomastix* sp and *Pseudophyeus* sp are registered as parasites capable of efficiently controlling this cochineal. These are available particularly in Mexico and the United States.

VI. Conclusions and Recommendations

The cochineal insect *Paracoccus marginatus* represents, like the pink cochineal of the hibiscus, a real danger for the countries of the Caribbean. All these countries should engage even more in a large scale combat with the aim of controlling this plague. The meeting in St. Kitts proves that the will power exists and the techniques to fight the infestation are available. Now, one only has to increase the struggle so as to arrive at the best possible results. Countries such as St. Kitts and Nevis, USA, Saint Lucia, St. Vincent and Jamaica have already put in place combat programs in order to find a reliable solution to this problem. Even countries not yet affected have already taken all the necessary phytosanitary steps that enable one to avoid the entry of this pest into their territory. Until now, in Haiti, no information relating to the evolution of this cochineal has been brought to the fore after its identification in 1999.

To avoid the worst, the officials of the Ministry of Agriculture, Natural Resources and Rural Development should take all the necessary steps with a view to setting up a program capable of collecting all the related information and the same time limiting the damage that it could cause.

Jamaica

Michelle Sherwood

Introduction

The Ministry of Agriculture in Jamaica has benefited from the experience garnered as it prepared for the likely introduction of the Pink Hibiscus Mealy Bug, PHMB *(Maconellicoccus hirsutus)*. The systems that were put in place for PHMB are still in place and fortunately are similar to what would be required in the event of other pest introductions such as the Papaya Mealy Bug (PM), *Paracoccus marginatus*. Hence, as the Ministry is more informed about the pest, its mechanisms to deal with it before and after introduction will become adequate.

Pest Status

The Ministry of Agriculture to date has been able to compile a list of mealy bug species present in Jamaica. This is being made possible through a survey completed in 1998, which identified the existence of the following mealybug species:

Phenacoccus solenopsis (Sorrel mealybug)
Pseudococcus longispinus (longtailed mealybug)
Planococcus citri (Citrus mealybug)
Ferrisia virgata
Saccharicoccus sacchari (Sugarcane mealybug)
Dysmicoccus brevipes (Pineapple mealybug)
Nipaecoccus nipae

Detection/Prevention Mechanisms

1. **Ports of Entry:** The confiscation of all contraband fruits, plant and plant parts at all ports of entry. This being **a** follow on of the Pink Hibiscus MealyBug (PHMB) programme the Customs Officers at these ports would already be aware of routine checks.
2. **Trap Plants:** It is not practical to check all ports, especially in the tourist areas where continuous traffic between islands occur by boat, yachts, cruise ships and private planes. There may be the smuggling of goods and the disposal of garbage infested with the pest. In these cases it is the Ministry's intention to use established hibiscus and croton plants (popularly grown on the north coast) as trap plants.
3. **Public education:** The education and cooperation of the public is crucial to early detection. All unusual cases of mealybug infestation should be reported to each Rural Agricultural Development Authority (RADA), extension office in each parish. The extension officers will be responsible for visiting the sites and collecting the samples, which will be forwarded to the Plant Protection Division for initial identification.

The public is to be reminded of the danger of importing plant material into the country and be discouraged from continuing such activity. Education will be done by way of posters, fact sheets, television and radio programmes in schools, communities and farming areas.

4. **Quarantine:** There is an increased stringency in the inspection of produce from known infested territories.
5. **Survey:** An islandwide survey of large farms growing cassava and papaya will be done. Personnel previously trained in the techniques of identifying mealybugs will do the identification. A second opinion will be sought through Mr. Lennox Chandler, Entomologist in the Ministry of Agriculture, Barbados.

Plan of Action, if Detected

There already exists a team of Agricultural personnel on a National 'PHMB task force'. This had been formed to deal with the PHMB issues; hence the papaya mealybug would a part of the mandate. The protocol previously existing for the PHMB *(Maconellicoccus hirsutus)* would also be applied to the papaya mealybug *(Paracoccus marginatus)*.

The list of things to be done if the pest is detected is as follows:

A. ***Technical Requirements***

1. Prepare/Obtain dossiers on *Paracoccus marginatus* and its natural enemies.
2. Obtain permits for importation of natural enemies from the National Resources Conservation Authority (NRCA) and Pesticides Control Authority (PCA).
3. Identify a source where the most effective natural enemies can be purchased.
4. Select release sites and monitor.
5. Establish rearing facilities (field insectary, laboratory facilities).
6. Conduct survey to determine pest free zone(s)
7. Discriminate application of pesticide to specific pockets of mealy bug infestation.

B. ***Public Education***

Expand educational programmes by radio, Television, posters and print to include information on the biological control programme, to encourage public cooperation when travelling overseas especially when returning from countries infested with PM.

C. ***Surveillance and Quarantine***

The continuation of the work by Plant Quarantine and Customs Officers will become crucial as any infestation found on illegally imported fruits or plant parts by passengers from Jamaica to any destination may result in an immediate ban of fresh produce from the country of origin.

D. ***Post harvest Treatment of Export Produce***

The treatment (cleaning, washing, fumigating) of likely infested hosts to be exported from the island.

E. Training

1. Personnel to be trained to rear the papaya mealy bug and its natural enemies.
2. To train extension officers to locate infestations on the preferred hosts.
3. Training of extension officers (RADA) in the release and monitoring of the pest and its natural enemies.

CONCLUSION

The papaya mealy bug has been proven to be very destructive in the countries where it has become established resulting in direct crop losses as well as export earnings. Jamaica would be similarly affected were the pest to enter and become established among its economic flora. The Ministry of Agriculture is therefore duly concerned and is prepared to do what is necessary to prevent initial introduction and if introduced to be able to act immediately to achieve containment and eradication.

St. Kitts

Kevin Bowry

Introduction

The Department of Agriculture first became aware of the presence of the Papaya mealy bug *(Paracoccus marginatus)* in St. Kitts & Nevis in 1997. It was later positively identified by I.I.E. through Dr. Moses Kairo of CABI Bioscience in 1998. It is not known how or when the mealybug was introduced.

Paracoccus marginatus has a yellowish-green appearance in colour for both adults and immature stages with a series of short waxy filaments around the margin that are ¼ the length of the body. The insect turns blue-black when placed in alcohol for a few days.
Eggs are also yellowish-green in colour and are laid in ovisacs at the tip of the abdomen.

Host Plants and Symptoms

Host plants included, fruit and tree crops eg. papaya, soursop and sugar-apple, Vegetable and food crops such as sweet potato, sorrel and eggplant, Ornamentals, eg. *Acalypha, Frangipani, Hibiscus*, weeds and wild plants such as acacia, *Glyricidia sepium* and hog plum. The host plant list is given in Table 1.

The symptoms of plant damage caused by *Paracoccus marginatus* are similar to those caused by *Maconellicoccus hirsutus* and are often confused with the latter. These include rosetting, stunted growth, sooty-mould build up, die back etc. Leaves, flowers and fruits are affected in addition to stems and branches.

Distribution

Paracoccus marginatus was found at several sites including, Bird Rock, Frigate Bay, Basseterre, Sandy Point, St Pauls and others shown in Figure I.

Mealy Bug Population

The mealybug population showed a dramatic decline from the initial mealy bug populations seen in 1998. This could be attributed to the effects of three hurricanes (1998-1999) as well as the impact of the parasites and predators. Many sites that were severely infested in early 1999 are now clean. The mealy bug population fluctuates on other sites and dramatic plant recovery can be seen on a number of plants such as Frangipani, Claradendron, Papaya, and Cassava at many locations.

The Impact of Natural Enemies in St Kitts

A number of natural enemies have been found attacking this new mealybug *(Paracoccus marginatus)*. This has impacted the population density in terms of monthly fluctuations of mealybug and parasitoid complex, the principal agents of control. Regular sampling at selected

sites on a monthly or quarterly basis, reveal some success in the control of this pest. Table 2. Lists predators and parasitoids found in St. Kitts and positively identified to date on the island.

The Impact Of Parasitoids

***Anagurus loecki*:** The level of parasitism by primary parasitoid *Anagyrus loecki* (on live encapsulated mealy bugs) ranged from 0.83% to 21.8%. The wasp was well distributed on the island and found on a range of host plants at eight of the 10 sample sites. The highest level of parasitism was noted in the Basseterre area. It was also found in the field over the sampling period from December 1999 to April 2000.

***Aprostoceitus* sp:** Is sometimes a primary, but more usually a secondary parasitoid of *Homoptera* and related insects. This parasitoid was found in Basseterre and St. Pauls. The levels of parasitism on live encapsulated mealybugs ranged from 2.6% to 44%.

***Cheiloneurus inimicus*:** The hyperparasitoid *Cheiloneurus inimicus* was also reared from live papaya mealybugs. This hyperparsitoid was found in the Basseterre area at levels of 1.7% to 12.8%.

Management of Paracoccus marginatus in St Kitts

The Department has recommended as short-term control measures, the use of insecticides such as *Imidacloprid,* trade name Attack that has provided effective control in papaya and the use of cultural practices such as pruning and burning.

For long-term sustainable control, natural enemies appear to be the best solution as is evident with the successful biological control of *Maconellicoccus hirsutus*. Given that indigenous natural enemies provide a fair level of control, it should be determined whether importation of exotic natural enemies is necessary.

Acknowledgment

Thanks are due to the Inter-American Institute for Cooperation on Agriculture (IICA) in collaboration with USDA for the planning of the workshop.

The parasitoides and hyperparasitoid were identified by CARDI through CARINET, with support from IICA.

I would also like to thank Lilory D. McComic (PhD), Entomologist, CARDI, for her assistance in the preparation of this report.

Mr Antonio Francis, Agricultural Assistant, Department of Agriculture. Thank you for your support and ideas for the preparation of this report.

TABLE 1. HOST PLANTS OF PAPAYA MEALY-BUG IN ST. KITTS

	COMMON NAME	SCIENTIFIC NAME
Fruit crops		
	Papaya	*Carica papaya*
	Soursop	*Annona muricata*
	Guava	*Psidium guajava*
	Carambola	*Averrhoa carambola*
	W. I cherry	*Malipighia punicifolia*
	Sugar apple	*Annona squamosa*
	Plum	*Spondias purpurea*
	Mango	*Mangifera indica*
	Wax apple	*Eugenia sp.*
	Madeira Fig	*Ficus carcia*
	Suriname Cherry	*Eugenia uniflora*
Vegetable-Food crops	Okra	*Abelmoschus esculentus*
	Egg plant	*Solanum melongena*
	String bean	*Phasoelus vulgaris*
	Tomato	*Lycopersicon esculentum*
	Pigeon pea	*Cajanus cajan*
	Seasoning pepper	*Capsicum sp*
	Hot pepper	*Capsicum fructescens*
	Sweet pepper	*Capsicum annum*
	Sorrel	*Hibiscus sabdariffa*
	Cassava	*Manihot esculenta*
	Sweet potato	*Ipomea batatas*
Ornamentals		
	Hibiscus	*Hibiscus rosa sinensis*
	Musseanda	*Mussaenda sp*
	Cat's tail	*Acalypha hispida*
	Ginger lily	*Alfinia sp*
	Ixora	*Ixora sp*
	Frangipani	*Plumeria*
	Acalypha	*Acalypha spp*
Wild Plants		
	Allamanda	*Allamanda.sp.*
	Acacia	*Acacia sp*
	Glyricidia	*Glyricida sepium*
	Hogplum	*Spondias mombin*

Table 2. Parasitoid and Predators of Paracoccus marginatus in St. Kitts

Parasitoid Order	Family	Scientific name	Common name	Comment
Hymenoptera	Encyrtidae	*Anagyrus loecki (Noyes Menezes)*	parasitic wasp	from live encapsulated mealybug
		Apoanagyrus nr californicus (Compere)	parasitic wasp	"
		Cheiloneurus inimicus (Compere)	hyperparasitoid	from live encapsulated mealy bug
	Eulophidae	*Aprostocetus.sp.*	secondary parasitoid	"
Predators				
Coleoptera	Coccinellidae	*Cryptolaemus montrouzieri*	Australian ladybird	observed in the field laboratory
		Scymnus sp	Ladybird beetle	"
Diptera	Syrphidae	?	Syrphid fly larva	"
	Cecidomymiidae	*Diadiplosis coccidarum (Cockerel)*	Gall midge	from encapsulated mealybugs
Neuroptera	Chrysopidae	?	Lacewing(chrysopid) larva	observed in the field

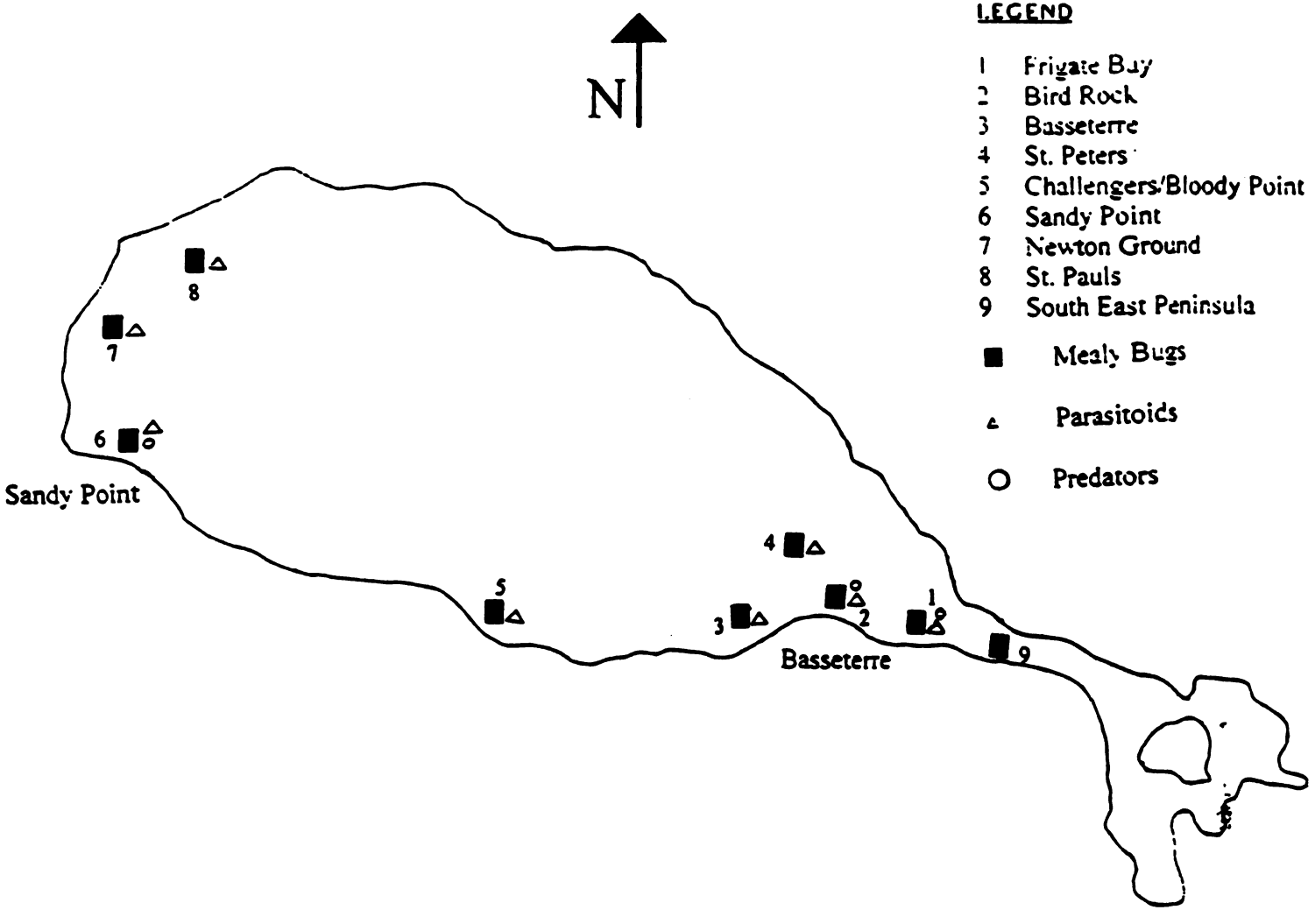


Fig 1 DISTRIBUTION OF PARACOCCUS MARGINATUS AND NATURAL ENEMIES IN ST.KITTS.

Nevis

Gregory Brandy

In Nevis a survey was done recently to estimate the severity of the papaya mealy bug, to define the length of time it has been active on the island and the infestation percentage.

Our findings indicated that there are over five hundred papaya plants in Nevis. Ninety percent of these plants are owned by farmers, locals and anyone who has a common interest in the papaya plant. The remaining ten percent are wild papayas, which are found in ghauts or on hillsides.

It is apparent that the papayas in Nevis are used for personal consumption and not for commercial use. This may be one of the reasons why not much interest has been placed on the papayas in Nevis.

Fifty two percent of the papaya plants in Nevis have been graded as medium infested. Twenty percent has been graded as low and twenty-eight percent has been graded as very low.

The papaya mealybug has also manifested itself on certain ornamentals including Hibiscus and Croton. The distribution of this particular mealybug is still a mystery to us in Nevis, although we have a few ideas. It has been proven that birds assist in the transportation of the Pink Mealybug. We must also remember that humans are great transport system for tiny insects.

At present we are not aware of any biological control agent which attacks the papaya mealybug in Nevis. We have also found that the Crytolaemus beetle, which attacks the pink mealy bug also on some occasions, attacks the PM, it does not fully feed on this particular species so we do not look at it as a bio-control agent.

The methods of control taken on Nevis are cut and burn and the application of chemicals

We are presently using two systemic chemicals, which are giving fair results.

St. Lucia

Guy Mathurin

Until June 2000, the papaya mealybug, *Paracoccus marginatus* had not been found or reported in St. Lucia.

In June 2000, a suspect sample was found on frangipani at Sandals La Toc in the Castries area. These samples were held for identification by our regional specialist, Mr. Chandler. Since he is unavailable at this time, they will be sent to IIE, UK for identification.

From the field however, there have been no reports of mealybug attacking papaya or cassava, which will be our first alarm signal. Most people in St. Lucia are aware of the hibiscus mealybug and tend to call Crop Protection when they find it on their properties.

Actions being undertaken to prevent entry.

- Quarantine officers continue to inspect plant material consignments on arrival at ports of entry.
- All plant material without plant import permits/phytosanitary certificates (especially in passenger luggage) is confiscated and incinerated.
- Public awareness campaigns on the importance of plant quarantine.
- Attempts still being made to upgrade the plant quarantine service.
- An island-wide survey to be carried out in August-September 2000 with special emphasis on papaya and cassava.

Actions to be taken if Paracoccus is found.

- Further surveys to determine distribution, host range, natural enemies.
- Expect already introduced natural enemies to play a role in lowering populations.
- Public awareness campaigns targeted at the travelling public, radio, TV and schools.
- Compliance with protocols for export of affected produce.
- Introduction, if necessary, of natural enemies for an integrated approach to the control of *Paracoccus*.

St. Vincent and the Grenadines

Philmore Isaacs

Introduction

Recent pest introductions into St. Vincent and the Grenadines have cost us dearly and estimated at over US$10 million. Even though we have brought under control the Pink Hibiscus Mealy Bug, we are still having the economic effects of trade embargoes. The effect of the mango seed weevil carries a similar story.

While papaya production is not significant in St. Vincent and the Grenadines due to the presence of bunchy top and canker diseases we are still interested in this particular workshop.
There has not been any report of the papaya mealy bug in St. Vincent and the Grenadines.

1. *Actions being undertaken to prevent entry of Papaya Mealy Bug.*

- Inspection of produce and planting materials is done at the port of entry;
- Import Permit is in place for persons wishing to bring plants into St. Vincent and the Grenadines;
- A pest risk analysis is done before such permits are issued.

2. *Actions to be taken should the Papaya Mealy Bug be identified in St. Vincent and the Grenadines.*

We have learned some valuable lessons from dealing with the Pink Hibiscus Mealy Bug. This should help us to deal with any new pest introduction.

- Get an early identification of the pest.
- Notify those concerned which would include the relevant countries and institutions
- Step up our public awareness effort;
- Re-focus our surveillance; learn to look specifically for PMB;
- Source and release the natural enemies;
- Monitor the situation.

But like black sigatoka and Moko disease of bananas, we do not wish the entry of the Papaya Mealy Bug.

Suriname

F. Remy Grauwde

1. Introduction

The Ministry of Agriculture, Animal Husbandry and Fisheries in Suriname benefited from the training in the identification of mealybugs of the Caribbean.The experiences as they are documented and the procedures for the conduct of surveys for the detection of the Pink Hibiscus Mealy Bug, PHMB, (*Maconellicoccus hirsutus*) have resulted in the look out for mealybugs similar to this pest. Fortunately, like the PHMB, up till now both the PHMB as well as the Papaya Mealybug, *Paracoccus marginatus*, has not been detected, nor reported in Suriname.

2. Detection / Prevention Mechanisms

2.1. Ports of Entry

According to the Plant Protection Ordinance, GB 1965 no.102, of Suriname it is prohibited to import any plant and/or plant parts into Suriname without a Phytosanitary Import Permit.

Therefore the Quarantine Officers, in collaboration with the Customs Officers, confiscate and destroy all plant and plant parts infested with an identified exotic plant pest or disease, particularly those from known infested countries.

2.2. Trap Plants

Since the Ministry of Agriculture knows that it is not feasible to check all ports and points of entry in the country, and due to smuggling of plants and plant parts at the borders with Guyana, French Guyana and probably also with Brasil. Efforts are being put towards the establishment/planting of primary hosts plants of these pests as trap plants for early detection. These host plants include Hibiscus and Croton.

2.3. Quarantine

There is an increased stringency in the inspection of produce from known infested countries. For example in the east, bordering French Guyana, where the pest is present the surveillance intensity is increased and passengers are awarded/notified that it is prohibited to carry any fruit and plant parts, particularly papaya, from French Guyana.

3. *Actions to be taken to prevent entry*

Since it is recognised that Plant Quarantine is considered to be the frontline of defence against the introduction of exotic plant pests and diseases, Plant Quarantine Inspectors are on the alert and have been trained/instructed in the identification of this pest as well as the handling of imported produce, aiming to prevent the entry of this new insect pest.

The most important action to prevent entry, according to the Plant Protection Ordinance, is that all import applications from known infested territories are REFUSED....!!!

4. *Actions to be taken if pest is discovered*

Currently an Emergency Action Plan for Exotic Plant Pests and Diseases is in preparation. This Action Plan contains guidelines and procedures for the eradication/control of a detected exotic plant pest or disease. It also allows all the relevant agencies to provide the necessary support in the endeavors to control /eradicate any new plant pest or disease.

In case an exotic plant pest or disease is detected and/or reported, then this action plan will be immediately enforced and implemented, including:

- Early identification of the pest
- Set up public awareness campaigns
- Surveillance
- Source and release of natural enemies
- Monitoring the situation

Trinidad and Tobago

Petal Ram

Introduction

As of July 21st, 2000, Trinidad and Tobago has not been infested with the Papaya Mealybug *(Paracoccus marginatus)*. The Ministry of Agriculture, Land and Marine Resources recognises the potential threat of this pest to certain of our ornamentals and tropical fruits in particular pawpaw *(Carica papaya)*. There is a thriving business for our pawpaw fruits as they are sold to local, regional and international markets. Locally at least some 109,436kg of fruits are purchased per month by agroprocessors, hotels, supermarkets and fruit and vegetable vendors. In 1999, 401,761 kg of fresh pawpaw fruits were exported. Comparing the quantity of exports of fruits before (1995) and after (1999) the presence of Pink Hibiscus Mealybug in Trinidad and Tobago, Table 1. showed that there was reduction in exports due to trade embargoes set up by our trading partners. Hence it is imperative that all efforts are made to keep *Paracoccus marginatus* out of Trinidad and Tobago. Our experiences (both at the local and regional level), of being recently infested with the exotic pest, the Pink Hibiscus Mealybug *(Maconellicoccus hirsutus)*, and St. Kitts' experience with the Papaya Mealybug, should be useful in helping us to avoid/delay for as long as possible the entry of the pest into our country.

Actions to Be Taken To Prevent Entry

Plant Quarantine

It has been recognised that Plant Quarantine is the first line of defense against the introduction of exotic plant pests and diseases. The Plant Quarantine officers are on the alert, and have been trained in identification of this pest as well as the handling of imported produce, with an aim to preventing entry of new pest into the country. A poster of photographs of *Paracoccus marginatus* with symptoms of infested plants on St. Kitts is presently displayed at our main port at Port-of-Spain through which goods from the islands are imported. The Entomologist of CARDI, Dr. Lilory McComie to whom our Ministry expresses its thanks, provided all these photographs, in addition to a wet sample of *Paracoccus marginatus* collected on pawpaw in St. Kitts.

Plant Quarantine officers who receive and process insect specimens intercepted at the ports have received training in slide preparation and identification of Mealybugs, which are of importance to the Caribbean region.

Trinidad and Tobago's Plant Protection Act is being reviewed/modified so as to allow strict enforcement of its laws for example at ports of entry. Also, it is compulsory that Phytosanitary certificates accompany all imported produce, if not the good is to be refused entry.

Table 1. Export data for pawpaws for Trinidad and Tobago 1999 and 1995 (Source: Central Statistical Offices' Trade Reports)

YEAR	COMMODITY	COUNTRY OF DESTINATION	QUANTITY (KGS)
1999	Pawpaw (fresh)	Canada	173,651
		UK	161,500
		USA	64,655
		Virgin Islands (British)	1,458
		Nambia	136
		St Vincent/Grenadines	136
		Stores and Bunkers	225
		Total	**401,761**
	Other Melons and Pawpaws (fresh)	Canada	28,075
		USA	14,877
		Stores and Bunkers	160
		Total	**43,112**
1995	Pawpaw (fresh)	Antigua/Barbuda	169,808
		Barbados	383
		Belgium	2,240
		Canada	319,913
		France	770
		Grenada	1,323
		Netherlands	1,050
		Netherland Antilles	1,814
		Puerto Rico	300
		St. Lucia	74,473
		St Vincent/Grenadines	1,165
		USA	87,299
		UK	91,074
		Stores and Bunkers	13,940
		Total	**765,552,**
	Other Melons and Pawpaws (fresh)	Canada	47,598
		St. Lucia	181
		USA	2,378
		UK	1,885
		Stores and Bunkers	150
		Total	**52, 192**

Public Awareness

"New mealybug threat, Pawpaw growers on the look out" was the headline of a feature article placed in our daily newspaper to inform our public of this potential pest. In addition to this, our mealybug hotlines are in place for receiving reports of any suspicious mealybug infestation. Our officers have responded to these and investigations so far have not revealed the presence of the pest.

Surveys

The National Hibiscus Mealybug Survey has been conducted twice per year for the last three years in both Trinidad and Tobago. Besides assessing the impact and distribution of the exotic and indigenous natural enemies on the Pink Hibiscus Mealybug, other mealybugs encountered in the field are being collected for identification. The samples collected from these surveys are processed at the laboratories; where the technicians are on the alert for the pest and have also been trained in slide preparation and identification of mealybugs, which are of importance to the Caribbean region. Hence there is ongoing monitoring for *Paracoccus marginatus*.

Training

Besides training of technicians in preparation of slides and use of keys for the identification of mealybugs of importance in the Caribbean region, training has also been directed at key players in the agricultural sector. For example NAMDEVCO (National Agricultural Marketing and Development Cooperation), which is Trinidad and Tobago's major marketing company - hosted a seminar entitled "A Step Beyond - Papaya Quality and Marketing Workshop" in March 1999. At this workshop participants were briefed on the identity, symptoms, potential risk and possible management practices of this pest. This information was also disseminated to Extension personnel associated with farmers who cultivate potential host crops such as pawpaw *(Carica papaya)*, cassava *(Manihot esculenta)*, avocado *(Persea americana)*, melongene *(Solanum melongena)* and soursop *(Annona squamosa)*.

Training is of particular importance since this pest shares some important hosts of Pink Hibiscus Mealybug, and that the symptoms of infestation of *Paracoccus marginatus* resemble those induced by the Pink Hibiscus Mealybug.

Networking

This is being maintained with the Entomologist of CARDI, Dr. Lilory McComie, and Dr. G. Watson of CABI Biosciences so that any new developments in the status of the Papaya mealybug would be made available.

Action to be taken if pest is discovered

Trinidad and Tobago's plan of action is to develop and implement an Integrated Pest Management (IPM) strategy to control the Papaya mealybug *(Paracoccus marginatus)*. Since this pest would be an exotic pest, this would make it an ideal candidate for Classical Biological Control - the main component of this IPM strategy. The activities therefore are outlined as follows: -

- **Surveys**
  - To determine host range and distribution of *Paracoccus marginatus*
  - To determine presence and distribution of indigenous natural enemies
  - To determine presence and distribution of exotic natural enemies
- **Identification (Expert)**
  This will be for the: -
  - Pest
  - Indigenous natural enemies
  - Exotic natural enemies
- **Evaluation**
  - The potential of the indigenous natural enemies to control the pest would be evaluated.
- **Sourcing of Exotic Natural Enemies of the Pest**
  - This will be collected from the area of origin of the pest.
- **Development of Laboratory Methods**
  - This is to enable mass production of the pest and its natural enemies, in vitro.
- **Release and Monitoring of Natural Enemies**
- **Impact Assessment Studies**
- **Develop Public Awareness Programs/Packages**
  - This will be developed through the use of information packages, such as posters and fact sheets, and by the use of the media to disseminate information in a timely manner.
- **Training**
  - Agriculture personnel would be trained in the area of Integrated Pest Management of the pest, *Paracoccus marginatus.*
- **Networking**
  - This will be achieved through the maintenance of collaborations and sharing of information inter-regionally, intra-regionally and internationally. At the moment CIPMNET is in existence and functioning within each country. However, there is an ongoing need for IPM matters, especially on *Paracoccus marginatus* in the Caribbean, to be reviewed and disseminated to the various Caribbean countries through the regional activities of CIPMNET.

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United States Virgin Islands

Lawrence Lewis

The papaya mealybug, *Paracoccus marainatus* has been identified in the United States Virgin Islands. The pest was first suspected to be present by Mr. Richard Warkinton in 1998 in the Hapenny beach area of Christiansted, St. Croix. Mr. Warkington works at the insectary on St. Thomas, USVI, for the USDA-APHIS PPQ. The work in 1998 concentrated on the Pink Hibiscus Mealy Bug (PHMB) and release of parasitic wasps (*Anagyrus*) to combat *Maconellicoccus hirsutus*. Mr.Warkington had gone to St. Croix to release wasps on PHMB, and noted the different species on papaya.

Though papaya is not an economic crop of any proportion in the Virgin Islands, backyard production is significant. Additionally, Dr Thomas Zimmerman of the University of the Virgin Islands is currently conducting research on papaya to identify varieties resistant to various diseases that could cause decline in production of fruit and early mortality of papaya plants. *Paracoccus marginatus* is therefore a significant pest in the Virgin Islands.

As noted earlier, the USDA has an insectary housed in a structure owned by the Virgin Islands Department of Agriculture. The insectary was developed to raise wasps to combat the pink hibiscus mealy bug. Now, this insectary is being used to produce parasitic wasps to combat the papaya mealy bug as well.

To date, three parasites have been released to combat *Paracoccus marginatus* on St. Croix, St. Thomas and St. Johns. They are of the genera - *Apoanagyrus, Acerophagus* and *Anagyrus*. A determination of the existence of the pest on other species has not been made by the USVI government.

It is difficult to determine the true potential of the pest/biocide in the USVI since the recent frequency of hurricanes and tropical storms - the most recent of which was Hurricane Lenny in November, 1999 - has destroyed most of the bearing papaya trees in the Virgin Islands.
However, younger plants are now fruiting and are being observed for the development of the pest and evidence of parasitization as a result of the recent releases of the parasites.

The Virgin Islands Government has not done any public service announcements relevant to the papaya mealybug. However the PSA, surveillance and quarantine work primarily done at the Ports and which was intensified for the PHMB is still in place and is effective in controlling the entry and export to the USA of these exotic mealybugs - as much as is humanly possible.

The USVI Government is happy to be a part of this effort to control invasive pests.

SECTION 3

TECHNICAL PRESENTATIONS

- Biology of Mealybugs with Reference to Spread and Detection **– Vyju Lopez**
- Code of Conduct for the Introduction and Release of Exotic Biological Control Agents **- Vyju Lopez**
- Proposed Survey Objectives and Procedures **– Dale Meyerdirk**
- Mealybug Identification : Regional Capability, Logistics, Data Logging and Dissemination of Information **- Vyju Lopez**
- Opportunity for Biological Control of *Paracoccus marginatus* **- Dale Meyerdirk**
- Field Characters of *Paracoccus marginatus* **- Dale Meyerdirk**
- Taxonomic Information on *Paracoccus marginatus* **- Gary Miller**
- Known Host Plants of *Paracoccus marginatus* **- Lilory Mc. Comie**
- Review of Mealybug Biological Control Successes **- Dale Meyerdirk**
- Comparison Re: The Control Strategies for *Maconellicoccus hirsutus* **- Wayne De Chi**
- Proposed Sampling Procedures for *Paracoccus marginatus* **- Lilory Mc. Comie**
- Baseline Data Collection of the mealybug and its Natural Enemies prior to Parasite Release [Hibiscus and Papaya] **- Dale Meyerdirk**
- Parasite Shipment, Release and Follow-up Population Density Counts of the Mealybug and Parasites **- Dale Meyerdirk**

Biology of Mealybugs with Reference to Spread and Detection

by
Vyju Lopez

Aspects of Biology

1. Feeding
2. Adult Biology
3. Developmental Biology
4. Reproductive Biology

1. Feeding in Mealybug

- Feed on a wide range of plants
- Ingest sterile plant sap
- Inject toxins / diseases into host plants
- During feeding, aggregate in large numbers
- Produce honey dew
  - Attracts ants
  - Encourages sooty mold

2. Adult Biology

→ Females
- Oval to round in shape
- Small in size
- Various colours, often obscure
- Varied amounts / types of wax over the body
- Move over short distances
- Live longer than males

→ Males
- Body elongate
- Very small
- Winged, mobile
- Two waxy anal cerci
- Short lived

3. **Developmental Biology**

- Fairly short life cycle [4 – 6 weeks]

Female Life Cycle:
Egg -- 1st. Instar -- 2nd. Instar -- 3rd. Instar -- Adult

Male Life Cycle:
Egg -- 1st. Instar -- 2nd. Instar -- 3rd. Instar -- Pupa -- Adult

- Eggs
  - 50 to over 1000 eggs per female
  - covered with impermeable wax
  - hatch over a period of days to produce 1st. instars or crawlers

- Ist. Instars or crawlers
  - Very small
  - Highly mobile
  - Disperse rapidly
  - Photosensitive

4. **Reproductive Biology**

- Sexual and / or parthenogenic
- Oviparous (rarely viviparous)
- Males die after mating
- Females die soon after egg production

Spread of Mealybugs

1. Between and within mainland
- Spread between island countries mainly by live stages on plant material
- Spread between countries on mainland by wind dispersal, animals and humans; as well as plant material.

2. Mechanisms of Movement
- Spread between and within countries by boat, airplane, road traffic and natural dispersal

a. by Boat
- between islands or along rivers
- transport of agricultural produce

- disposal of garbage by boats, yachts and cruise ships

b. by Airplane

- within or between countries
- on smuggled fruit and plant propagation material by passengers or crew
- inadvertent transmission of eggs and/or crawlers on clothing or body of passengers and/or crew

c. by Road Traffic

- transport of agricultural produce
- smuggled fruit and plant propagation material by road users
- inadvertent transmission of eggs and/or crawlers on clothing or body of passengers and/or crew

d. by Natural Dispersal of Eggs and Crawlers

- by wind and/or animals
- over short distances (generally not more than 10 kilometers)
- major risk for spread between countries sharing a land border

3. Feeding Habits

- Wide host range
- Close association with host increases chances of being carried/moved from one locality to another on plant material
- Production of honey dew (attracts ants)

4. Adult Biology

- Limited dispersal in females
- Highly fecund females (50 to more than 1000 eggs)
- Eggs covered with wax – protection and stickiness
- Protracted egg-hatch period

5. Developmental Biology

- Short life cycle
- Tiny photosensitive crawlers as dispersal agents
  - Wind
  - Ants, other insects, birds
  - Humans

- Plant material including fruits

Detection of Mealybugs

1. Feeding Habits
   - o Altered appearance of host due to toxins / diseases
   - o Presence of aggregations, particularly on the tips of host plants
   - o Presence of sooty mold on older leaves
   - o Presence of attendant ants (honey dew)

2. Adult / Developmental Biology

Detection of mealybugs is aided by:

- o Presence of large numbers of various stages, often on the tips of the host plant
- o Presence of wax producing stages
- o Females with ovisacs
- o Loose wax from empty pupal cases of males
- o Aggregations of flying males (use of traps)

Detection of mealybugs is hampered by:

- o Presence of very small numbers
- o Presence of stages with little wax, particularly crawlers
- o Stages in hiding e.g. under the bark of stems or the rim/ridges of fruits.

Code of Conduct for the Introduction and Release of Exotic Biological Control Agents[1]

by

Vyju Lopez

Outline of the Code of Conduct

The standards which describe the Code of Conduct for the introduction and release of exotic biological control agents are presented in a framework composed of seven parts encompassing procedures for:

- Import regulations
- Export certification
- Compliance procedures
- Pest Surveillance
- Exotic pest response
- Pest management
- Post – entry quarantine

These standards were endorsed in November 1995 by the 28th. Session of the FAO Conference.

The Code is concerned with the importation of exotic biological control agents capable of self-replication (e.g. parasitoids, predators, parasites, phytophagous arthropods and pathogens) for research, and field release of control agents used in biological control and those used as biological pesticides.

The Code does not deal with other pest control techniques, that are also sometimes referred to as "biological controls", notably, autocidal methods, resistant host plants, as well as behaviour-modifying chemicals and other novel biological products.

It is possible that this Code, after due evaluation, could also be applied to the introduction of exotic biological agents to control pest affecting human or animal health or the conservation of natural habitats.

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[1] The contents of this technical paper are extracts from an FAO publication entitled ***Code of Conduct for the Import and Release of Exotic Biological Control Agents [Rome 1996].*** This document was prepared by the Secretariat of the International Plant Protection Convention as part of the United Nations Food and Agriculture Organization's global programme of policy and technical assistance in plant quarantine.

The Code therefore deals with :

- the import of exotic biological control agents for research,
- the import and release of exotic biological control agents for biocontrol,
- the import and release of exotic biological control agents for use as biological pesticides where those products incorporate organisms which can multiply.

The Code does this by:

- identifying the three main groups involved in importing and releasing biological control agents: authorities (as the organizations representing government); exporters and importers;
- describing three responsibility phases of the process of import and release : the responsibilities of those involved before export; those before and upon importation; and those after importation.

The Code therefore details procedures in respect of the :

- Designation of the authority responsible
- Responsibilities of authorities prior to import
- Responsibilities of importer prior to import
- Responsibilities of exporter prior to export
- Responsibilities of authorities upon import
- Responsibilities of authorities before and upon release
- Responsibilities of importer after import and release

As regards the Observance of the Code, the stipulations are, inter alia, collaborative action on the part of: governments, individually or in regional groupings; international organizations; research institutes; industry, including producers, trade associations, and distributors; users; and other organizations such as environmental groups, consumer groups and trade unions.

Proposed Survey Objectives and Procedures

by

Dale Meyerdirk

Objectives

- Provide guidelines for Papaya Mealybug Survey in the Caribbean Islands
- Determine presence of Papaya Mealybug in Country
- Potentially delimit the infestation
- Select potential sites that are secure for the release of exotic parasites

Procedures

- Compose local host plant list
- Check only preferred host plants
- Develop transit line through host plant region
- Develop a second transit line at 90 degrees to the first line
- Repeat survey monthly, or as resources permit
- Types of Survey :

1. *Detection Survey*
   - Cross transit survey : Rapid detection survey
   - Check downwind
   - Three types of areas
     - ⇒ High Risk
     - ⇒ Downwind
     - ⇒ Host Areas

2. *Delimiting Survey*
   - When one or more mealybugs are found
   - Use site of detection as epicenter
   - Rely on visual survey
   - Biased to the primary host plants
   - Cross transit survey

Visual signs of Paracoccus marginatus

- Poor growth
- Defoliation
- White egg masses on terminals, leaves, fruit
- Bunchy leaves
- Dying and dead plants

Damage caused by Paracoccus marginatus

- Direct feeding
- Wilting of foliage / Defoliation
- Black sooty mold
- Bunchy leaf
- Death of plant
- Fruit discoloration
- Fruit covered with mealybugs and ovisacs

Measures

- Collect specimens in 70% alcohol
- Adult females
- Egg mass with old female body
- Paracoccus body turns bluish-black in alcohol
- Fill out label and place in bottle (pencil) :
  - Name of Collector, Location, Country, Date, Host Plant
- Send to "Designated" Identifier

Mealybug Identification : Regional Capability, Logistics, Data Logging and Dissemination of Information

by

Vyju Lopez

A. *Regional Capability*

- **What is needed :**

1. a trained taxonomist to carry out authoritative identifications
2. at least one person from each country trained in the skills necessary for preparing mealybugs (and other insects) for taxonomic identifications
3. trained personnel from the Ministries of Agriculture and other organizations capable of distinguishing between commonly occurring mealybugs and other homopteran pest such as aphids, scales and white flies
4. centralized insect collections / museums for the storage of identified material for future use.

- **What is available**

  - one regional taxonomist trained in the identification of mealybugs and other scale insects (Mr. Lennox Chandler. Barbados), however there is still a shortage of a good reference collection
  - at least one person from most Caribbean countries has been trained in techniques (slide preparation) for the identification of mealybugs (1997, 1999) and white flies (1999).

- **External Resources**

  - CABI, USDA, and other US-based organizations
  - The Internet has a wealth of information based on the work of regional / international organizations, universities, researchers and scholars.

B. Logistics

1. The first report of what could be a new pest, in a country, must be identified by an authority; because of important implications
   - trade
   - formulation and implementation of a biological control programme

2. Collection of Mealybugs for Identification
   - sections of infested plant material (not individual insects) should be collected
   - preserved in 70% ethanol and stored in small, strong water-tight vials
   - large amount of materials should be sent so that sufficient numbers of appropriate stages (adult females) could be found.

3. Equipment
   - secateurs or scissors
   - 70% ethanol
   - glass vials of appropriate size with air-tight covers
   - labels / data recording sheets.

C. Data Logging

1. Information on labels / data sheets
   - Site details [locality, district / county, country]
   - Host plant(s) on which collected
   - Date of collection
   - Name(s) and affiliation(s) of collector(s)

D. *Dissemination of Information*

Once a pest has been identified, disseminate this information to :

- FAO : which produces regular up dates and maintains a database of new pest introductions
- Trading partners (courtesy and promotion of fair trading practices, to allow partners to prepare for the possible spread of the new pest
- Local organizations, in order to alert them to a possible emergency situation
- Regional and international organizations for assistance in combating the problem.

Opportunity for Biological Control of *Paracoccus marginatus*

by

Dale Meyerdirk

Paracoccus marginatus, first thought to be *Spillococcus* sp is indigenous to :

- Belize
- Costa Rica
- Guatemala
- Mexico

Paracoccus marginatus is not an economic pest in Mexico and there are multiple primary parasites attacking this mealybug in Mexico.

There are four species of parasites presently in culture :

Apoanagyrus sp	*Anagyrus* sp
Acerophagus sp	*Pseudaphycus* sp

Cultures are maintained in :

- St. Thomas, USVI
- San Juan, Puerto Rico
- Newark, Delaware

Biological control can be carried out through :

- Inoculative release
- Redistribution of parasites from field collections
- Field Insectary Site Technique [see Annex 3]

Hymenoptera Parasites Reported Attacking *Paracoccus* spp

- *Adelencyrtoides*
- *Aenasius*
- *Alamella*
- *Anagyrus*
- *Aphycus*
- *Clausenia*
- *Gyranusoidea*
- *Leptomastix*
- *Prochiloneurus*
- *Pseudectroma*
- *Pseudococcobius*
- *Rhopus*

Parasites reared from *Paracoccus marginatus* :

- *Anagyrus* spp. – Florida, St. Thomas (USVI), Dominican Republic, St. Kitts(W. I.)
- *Acerophagus* spp - St. Thomas, Dominican Republic, St. Kitts
- *Prochiloneurus* spp - St. Thomas, Dominican Republic, St. Kitts (Hyperparasite)
- Unknown genera (all black species)

Parasitization :

- observed (October 11-12, 1998) from eight (8) papaya study sites in the Dominican Republic was zero to 14 percent.

- observed (October 11-12, 1994) from three (3) yucca study sites in the Dominican Republic was 2 – 16 percent.

- observed (December 13, 1998) from one (1) study site in St. Thomas, USVI, was 30 percent.

- ***Anagyrus*** was the most abundant parasite species found in the Dominican Republic and St. Thomas, USVI.

Field Characters of *Paracoccus marginatus*

by

Dale Meyerdirk

Distinguishing Field Characters

- Body color yellow under white wax
- No longitudinal depressions
- Short waxy filaments around body
- Short caudal filaments
- Body fluid yellow
- Egg sac produced under body of female
- Specimen in alcohol turns bluish-black color [common for Paracoccus species]

Systematics

- Oral-rim tubular ducts dorsally restricted to marginal areas of body
- Anal lobe with small anal bar
- 16-17 pairs of cerarii, some on head and thorax indefinite
- Without clusters of oral-collar tubular ducts on margin of thorax
- Few oral-collars posterior of anterior spiracles

Taxonomic Information on *Paracoccus marginatus*

by

Gary Miller

Background on Scale Insects

- Approximately 7,000 species
- Approximately 20 families
- Largest and most common families
  - Armored scales or Diaspididae
  - Soft scales or Coccidae
  - Mealybugs or Pseudococcidae
- Other families of scale insects
  - Felt scales or Eriococcidae
  - Ensign scales or Ortheziidae
  - Giant scales/ ground pearls or Margarodidae
- Unique characteristics of scale insect
  - with sucking mouthparts feed on plants
  - Sedentary
  - Females lack wings and have at least one less life stage than males
  - Males have one (1) pair of obvious wings - are "insect-like"
  - Males go through a complete metamorphosis
- Major pests particularly of long-lived plants such as trees, shrubs, and vines
- Cause damage by feeding, injecting toxins, producing honeydew and as vectors of viruses
- Scales are difficult to detect because of their small size and cryptic behavior
- Scales are well suited as targets of biological control

Background on Mealybugs

- About 2,000 species in 260 genera
- Include many agricultural pests such as the citrus mealybug, grape mealybug, cassava mealybug, longtailed mealybug, pink hibiscus mealybug, papaya mealybug, etc.
- Occur world wide on a diversity of hosts from grasses and sedges to trees and shrubs
- Most have legs but do not move often
- Adult females often produce filamentous ovisacs that enclose the eggs and are attached to the female's body
- Adult males usually live for a day or two and are attracted to the female by a pheromone
- Many species are able to reproduce parthenogenetically
- Mealybugs are named for the mealy wax that usually covers their bodies
- The female has 4 instars including the adult
- The male has 5 instars including a prepupa, pupa, and adult

- The first instar is the primary dispersal stage and often is transported by wind
- Mealybugs are tended by ants which apparently provide some protection from natural enemies
- Accurate identification can only be made by preparing them on slides and examining them with a compound microscope
- Preliminary identifications can be made using field and ecological characters

Mealybug Morphology

- oral-rim and oral-collar tubular ducts
- multilocular and trilocular pores
- cerarii
- anal-lobe bar
- translucent pores
- circulus
- antenna

Paracoccus: the Genus of the Papaya Mealybug

- Contains 79 species worldwide
- Found in many different regions of the world
- In addition to *Paracoccus marginatus* (the Papaya Mealybug), *Paracoccus burnerae* and *Paracoccus juniperi* are also pest species

Characteristics of the Genus

- anal-lobe bar present
- 8-segmented antennae
- cerarii numbering up to 17 pairs, usually with 2 conical setae
- auxiliary setae present in anal lobe cerarii only
- oral-rim tubular ducts present

Paracoccus marginatus - the Papaya Mealybug

Taxonomy

Phylum	:	Arthropoda
Class	:	Insecta
Order	:	Homoptera
Superfamily	:	Coccoidea
Family	:	Pseudococcidae

Characteristics of the Species

- cerarii present
- abdominal cerarii numbering 8 pairs
- oral rim tubular ducts present only on dorsal margins but absent from anal lobe segment
- multilocular disc pores absent from ventral lateral margins of thorax

Distinguishing Papaya MealybugInstars

The first instar

- without tubular ducts
- antennae 6-segmented
- hind tarsus longer than tibia
- with trilocular pores only

The second instar female

- without tubular ducts
- antennae 6-segmented
- hind tibia shorter than hind tarsus
- with more trilocular pores

The second instar - Male

- with tubular ducts
- antennae 6-segmented
- dorsal and ventral multilocular pores on thorax

The third instar - Female

- antennae 7-segmented
- without multilocular pores
- hind tibia longer than hind tarsus
- without vulva

The third instar - Male (pre-pupa)

- one (1) pair of small wing buds
- antennae unsegmented

The fourth instar - Male (pupa)

- one (1) pair of large wing buds, sclerotized
- antennae 10-segmented

The fifth instar - Male (adult)

- one (1) pair of large wings
- hind wings modified into halteres
- antennae 10-segmented
- fleshy setae on antennae
- genitalia well developed with aedeagus
- three (3) pairs of eyes

Papaya Mealybug: Field Characters

- yellowish color
- without markings on back
- hind filament about one fourth of body length
- egg sac under body of female
- turns black when preserved in alcohol

Field Characters of Other Mealybugs

(1) Longtailed mealybug, ***Pseudococcus longispinus***
- many filaments; last equals length of body
- with medial stripe
- no ovisac

(2) Jack Beardsley and Obscure Mealybugs, ***Pseudococcus longispinus*** and ***P. viburni***
- many lateral filaments; last, half length of body
- pink; no stripes
- ovisac covers part of body

(3) Citrus and Minor Mealybugs, ***Planococcus citri*** and ***P. minor***
- short filaments around body
- body pink
- median stripe
- ovisac beneath body

(4) Mexican and Madeira Mealybugs, ***Phenacoccus gossypii*** and ***P. madeirensis***
- filaments around body
- body gray
- two (2) dark stripes
- ovisac covers body except head

(5) Coconut Mealybug, ***Nipaecoccus nipae***
- filaments around body and on back
- body red
- wax usually thick, not mealy
- no ovisac

(6) Pink Hibiscus Mealybug, ***Maconellicoccus hirsutus***
- without lateral filaments around body or at most with 1 or 2
- body reddish brown to pink
- without stripes
- turns black when preserved in alcohol
- ovisac beneath body

(7) Striped Mealybug, ***Ferrisia virgata***
- with one (1) pair of filaments 1/4 to 1/2 length of body
- body grayish
- with two (2) stripes
- no ovisac
- crystalline rods on back

(8) Pineapple Mealybug, ***Dysmicoccus brevipes***

- filaments around body; caudal filaments 1/4 to 1/2 length of body
- body pink
- no ovisac

Conclusions

- This mealybug is distinctive and can be readily identified as an adult female
- It is distinguished by having an anal bar, 16-17 pairs of cerarii, dorsal oral rims restricted to margin, and multilocular pores absent from ventral margin
- All other instars can be distinguished
- A second species of Paracoccus is also potentially dangerous; ***Paracoccus burnerae*** from Africa is a serious pest on citrus
- It is distinguished by having a median abdominal row dorsal oral rims, hind tibial pores, ventral oral collar ducts anterior to prothoracic spiracle

Known Host Plants of *Paracoccus marginatus*

by

Lilory Mc Comie

Introduction

The papaya mealybug ***Paracoccus marginatus*** **(PM)** was first detected in St Kitts and Nevis in 1997. As with the other new introduction the pink hibiscus mealybug, ***Maconellicoccus hirsutus***, **PM** has a wide host range. Many of the primary host plants of the papaya mealybug e.g Jathropha, Acalypha, sp. and frangipani are secondary hosts of the hibiscus mealybug with some notable exceptions such hibiscus and soursop. Heavy infestations also produce dense waxy secretions and the white mass may be easily mistaken for that of the pink hibiscus mealybug. A list of host plants of the papaya mealybug in St.Kitts and Nevis is given in Table 1.

Expression of plant damage

- Many of the visual symptoms of plant damage are also quite similar to those expressed on plants attacked by the pink hibiscus mealybug particularly in cases of heavy infestation, or older PM colonies.
- The papaya mealybug seems to favour many plants with heavy latex and attack such plants at all stages of the plant life e.g. frangipani, Euphorbia sp. cassava, sweet potato, and papaya.
- In some plants, the mealybug colonizes mainly the flowers and fruits e.g. soursop .
- Various parts of the plant may be affected and a wide range of symptoms can be seen.
- Symptoms may vary from plant to plant however
- Leaves, stems, shoots, flowers and fruits may be affected.
- Some plants are quite tolerant of the mealybug. Leaves and stems show no visual symptoms even in the presence of large mealybug colonies e.g. soursop, Acalypha.
- Unlike the PHMB that is mainly a pest in urban areas, the papaya mealybug attacks a number of economically important crops. Many of these crops are under large-scale production in a number of islands – papaya, cassava, beans, eggplant, and soursop.

Leaves

- Curling. crinkling, twisting and general leaf distortion.
- Reduction in leaf size and surface area e.g. frangipani, papaya.
- Premature aging, chlorosis and leaf drop. The entire plant may be defoliated as a result e.g *Jathropha.*
- Sooty mould may cover the entire plant contributing to generally poor appearance and weakness of the plant.

Stems and shoots

- Shoots and young stems may be distorted and malformed.
- Arrested growth at the shoot terminals lead to shortened internodes and rosetting at the shoot tip e.g. papaya, hibiscus.
- Shoot tips may also be twisted and flowering suppressed e.g. eggplant, *Jathropha*, frangipani.
- Shoot and stem dieback may eventually occur if the infestation persists.

Flowers

- Flowers may be distorted and fail to open.
- Where they open, petals may be twisted and/or malformed or show various types of blemishes.
- Premature flower drop and poor fruit set may occur.

Fruits

- Fruit blemish and sooty mould may reduce the marketability and market value of fruits such a papaya, guava, soursop.
- Fruits may fail to develop normally and may be unusually small. Such fruits eventually shrivel and drop.

Acknowledgements

I wish to acknowledge the corporation and support of the Director of Agricultural Services, St. Kitts, Dr. Jerome Thomas; the Director of the Multipurpose Laboratory, Dr. Milton Whittiker and the staff of the Entomology Laboratory, Messrs Antonio Francis and Kevin Bowry. I also wish to acknowledge the contributions of CARDI's technicians, Messrs Austin Farier and Melvin James in St. Kitts and Walcott James in Nevis.

Table 1 Host plants of the papaya mealybug *Paracoccus marginatus* in St Kitts and Nevis

FAMILY	SCIENTIFIC NAME	COMMON NAME
Annonaceae	*Annona muricata*	Soursop
	Annona squamosa	Sugar apple
Anacardiaceae	*Mangifera indica*	Mango
	Spondias purpurea	Plum
	Spondias mombin	Hog plum
Apocynaceae	*Plumeria alba*	Frangipani
	Allamanda catharitica	Allamanda
	Nerium oleander	Oleander
Araceae	*Xanthosoma sp.*	Tannia
Caricaceae	*Carica papaya*	Papaya
Euphorbiaceae	*Acalypha hispida*	Cat's tail
	Acalypha wilkesiana	Copper leaf
	Acalypha spp.	
	Euphorbia sp.	
	Jatropha integerrima	
	Manihot esculenta	Cassava
Ipomoeaceae	*Ipomoea batatas*	Sweet potato
Leguminosae	*Acacia sp.*	
	Cajanus cajan	Pigeon pea
	Cassia sp.	
	Glyricidia sepium	Glyricidia
	Phaseolus vulgaris	Broad bean
Malpighiaceae	*Malpighia punicifolia*	West Indian Cherry
Malvaceae	*Abelmoschus esculentus*	Ochro
	Hibiscus sabdariffa	Sorrel
	Hibiscus rosa-sinensis	Ornamental hibiscus

Table 1 [continued]

FAMILY	SCIENTIFIC NAME	COMMON NAME
Moraceae	*Ficus carcia*	Madiera fig
Myrtaceae	*Psidium guajava*	Guava
	Eugenia uniflora	Suriname cherry
	Eugenia sp.	Wax apple
Oxalidaceae	*Averrhoa carambola*	Carambola
Rubiaceae	*Ixora sp.*	Ixora
	Hamelia sp.	
	Mussaenda erythrophylla	
	Pentas lanceolata	Pallida
Solanaceae	*Capsicum annum*	Sweet pepper
	Capsicum sp.	Seasoning pepper
	Capsicum fructescens	Hot pepper
	Lycopersicon esculuntum	Tomato
	Solanum melongena	Egg plant
Zingerberaceae	Alfinia spp	Ginger lily

Review of Mealybug Biological Control Successes

by

Dale Meyerdirk

World Review

- 39% of biological control programs have had some measurable degree of success
- 10,000 species of insect pest recorded worldwide
- only 416 species targeted for BioControl
- over 95% of the world's insect pests have had no biological control importation program directed against them

For Arthropods up to 1988

- 416 species of insect pest targeted
- 164 species [complete, substantial or partial biological control success]
  - ⇒ 75 species - complete control
  - ⇒ 74 species - substantial control
  - ⇒ 15 species - partial control

With respect to Mealybugs :

- 21 species of mealybugs
- 15 species with either complete, substantial or partial biological control
- Total of 164 targeted insects with complete, substantial or partial biological control
- 9% have been successful mealybug control programs

The Matrix in Annex 4 is an expose of the World Review on the Biological Control of Mealybugs.

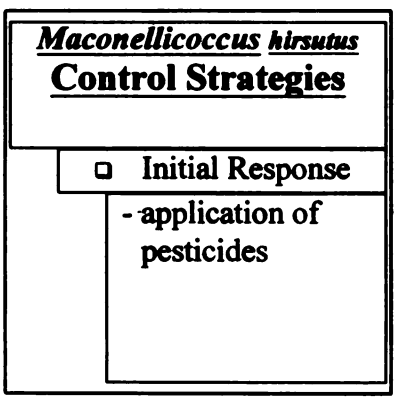
Comparison Re: The Control Strategies for *Maconellicoccus hirsutus*

by

Wayne De Chi

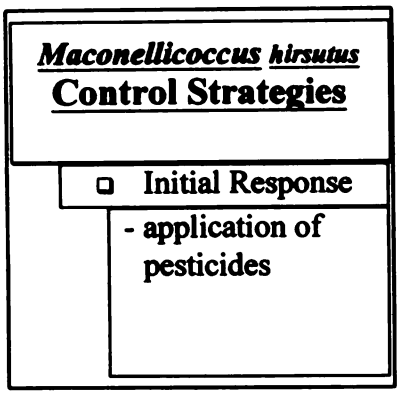
Objectives

A. To outline the strategies adopted for the control of *Maconellicoccus hirsutus* and *Paracoccus marginatus*
B. To provoke discussion on the control strategy for *Paracoccus marginatus.*



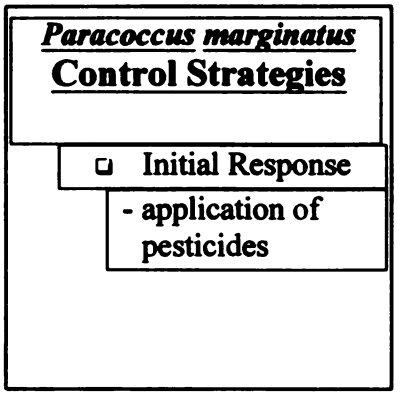
Short Term Strategy

1. Plant Quarantine Initiatives
   - Revision of plant protection regulations [import permits required for all imports]
   - Proclamation of "Notifiable Pest" status [hibiscus mealybug declared a "notifiable pest"]
   - Increased surveillance at ports of entry [continuing and increased surveillance at all ports]
2. Public Information / Education Awareness Programme
   - Press releases, newspaper articles
   - Television programmes [HMB video from Grenada and Trinidad aired on National TV]
   - Posters / Fact sheet production [distributed]
   - Public education [training of ministry's staff and holding of public meetings].
3. Surveillance
   - House to house survey in high risk areas
   - Country-wide surveillance.
4. National Initiative
   - Appointment of a National Committee
   - Task Force
   - Technical Advisory Committee
5. Control Procedures
   - Spray, Cut and Burn
6. Notification
   - Notification to the Food and Agriculture Organization (FAO) of the presence of the pest.



Medium - Long Term Strategy

1. Introduction of natural enemies of *Maconellicoccus hirsutus*
   - Cryptolaemus montrouzieri
   - Scymnus coccivora
   - Anagyrus kamali
   - Gyranusoidea indica
2. Construction of natural enemy mass rearing facility
3. Screening of appropriate pesticides for efficacy against HMB and natural enemy compatibility
4. Assessment and utilization of indigenous natural enemies in control of HMB.



Possible Action ?

- Short Term Action?
- Medium – Long Term Action?
- Notifiable Pest Status?
- Public Information / Education?
- Appointment of National Committee?

Systems Already in Place

- Increase surveillance at ports of entry
- Plant Quarantine heighten alert
- Notification to the Food and Agriculture Organization (FAO) of pest presence.

Collection and Screening of Natural Enemies from Mexico

- *Anagyrus sp*
- *Apoangyrus*
- *Acerophagus* [Hymenoptera: Encyrtidae]

Actions Taken

1. Visits

- Biological Expert from Mexico – Dr. Hector Gonzalez Hernandez
- Biological Expert from CAB-I Trinidad – Dr. Moses Kairo

2. Project Proposal – IICA Emerging Issues Fund
3. Workshop – St. Kitts

What is Needed

1. Surveillance
   (a) Country-wide surveillance
   (b) Training of Front Line Officers - Plant Quarantine Staff
   - Extension Staff
2. Research
   (a) Field data on indigenous natural enemies
   (b) Level of Control exerted - *Anagyrus kamali*
   Cryptolaemus montrouzieri
   Gyranusoidea indica

Proposed Sampling Procedures for *Paracoccus marginatus*

by

Liiory Mc Comie

Reasons for surveys:

To determine:

1. Distribution of mealybugs spatially, temporally and seasonally
2. Determine host preference – type of host plants, expression of host plant damage, plant recovery
3. Presence, type and impact of natural enemies - i.e. indigenous versus exotic natural enemies, level of parasitism or predation
4. Decision making in management of the mealybug–
   - efficiency of indigenous natural enemies versus introduced natural enemies;
   - rate of dispersal and establishment of (exotic) natural enemies;
   - need for additional introductions of the same species or other species of natural enemies
5. Where natural enemies are most effective – backyards, on farm, urban areas.

Conducting the survey

A survey instrument (questionnaire) may be developed for the region and modified to suit the local situation particularly because of variation in size of the islands, some variation in plant prevalence. The data to be collected will depend on the level of detail that may be required and this in turn will influence

- selection of sample sites,
- size and number of samples
- host plants selection,

Monitoring for parasites and predators

- Determine criteria for selecting sample sites – security, ease of access, presence of host plants, occurrence on predetermined sample plan, sites may also be stratified – back yard; roadside, farm
- Identify sites that can be monitored regularly - weekly, biweekly, monthly, quarterly
- Determine host plants to be sampled (these may not all be present at each site)– papaya, hibiscus, soursop, frangipani, egg plant,

- Identify sample units:
  - leaves - papaya and frangipani (plants with large leaves)
  - shoots – hibiscus, *Jathropha,* eggplant,
  - shoots and leaves – Acalypha
  - fruits - soursop
- Predators should be counted in the field (with confirmation in the laboratory)
  - ladybird beetles (larvae and adults) e.g *Cryptolaemus montrouzieri* and *Scymnus* spp.
  - syrphid larvae
  - chrysopid larvae
- Parasitism should be determined in the laboratory. Expression of parasitism should be determined by
  - counting and recording intact mummies and mummy cases
  - encapsulating at least 100 live mealybugs for emergence of parasitoids - up to one month after encapsulation
  - calculating the level of parasitism

LEVELS OF PARASITISM OF THE PAPAYA MEALYBUG
Paracoccus marginatus

Laboratory data sheet

Sheet No. 1

Island_____ Date of Collection_____ Collector(s)_____

Date	*Location*	*Host plant*	*No of mealybugs encapsulated*	*Level of parasitism*		*Physical appearance of parasites*				*Comments*
				No parasitized	*% parasitism*	Colour	Legs	Wing	Antenna	

Data summarized on sheet No 3

LEVELS OF PARASITISM OF THE PAPAYA MEALYBUG
Paracoccus marginatus

Sample Sites

Sheet No. 2

Island_____ Date of Collection_____ Collector(s)_____

Location of sample site	Host plants	Date of site visit												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Comments

Description of indigenous parasitoids of the papaya mealybug P*aracoccus marginatus* collected in St Kitts and Nevis

At least five different "types" of parasitoids have been collected from encapsulated mealybugs in St Kitts and Nevis. These may represent five or fewer species since some species may show individual and sex variations. For our laboratory exercise of determining the level of parasitism, the five "types" have been conveniently separated on the basis of certain observed physical characteristics described below

Type (Sp)	Body colour	Legs	Fore wings	Antenna	Thorax	Abdomen	Other
Sp I							
Sp II							
Sp III							
SpIV							
Sp V							

SUMMARY OF PAPAYA MEALYBUG PARASITISM DATA

Island_____ Site_____

Sheet No 3

Date of collection	Host plant	Total no of mealybugs Encapsula-ted	Total no of mealybugs parasitized	% Parasitism						Total % parasitism
				Sp I (No)	Sp II (No)	Sp III (No)	Sp IV (No)	SpV (No)	Undet-erminedr (No)	

Comment – complete a separate sheet for each site

LABORATORY COUNTS OF PAPAYA MEALYBUG ON FIELD COLLECTED HOST SAMPLES

Sheet No 4

Island_____ **Date collected**_____

Location	Host	Ovisacs		Adults with ovisacs	Virgin females	3rd instar	2nd instar	Crawlers	Mummies		Comments
		Eggs only	Eggs and crawlers						Intact	Empty	

Summarize data after doing tally

Baseline Data Collection of the Mealybug and its Natural Enemies Prior to Parasite Release [Hibiscus and Papaya]

by
Dale Meyerdirk

Once ***Paracoccus marginatus*** *(PM)* has been confirmed on an island, it may be desirable to discover the extent or the distribution of the population. In this regard, precaution should be taken to ensure that the PM is not accidentally spread through collection methods or procedures.

Prior to parasite or predator releases, the overall baseline data collection exercise should run weekly or biweekly until it is determined, through negative finds, that the PM is not present in a given area.

Detailed Sampling Procedures

1. If Host(s) are in New Flush
   (a) Examine all host localities, if possible. Unless otherwise recommended, the selection should be biased towards upwind and downwind borders of a given field or grove where the mealybug is likely to congregate, especially if a strongly predominant wind direction is present.
   Each host locality may be sampled, depending on the type of host. Hosts are best sampled if aggregated in wild stands, residential properties, or in cultivated fields. These fields or stands should be sampled at a minimum of five (5) different sites, following a predetermined pattern agreed to before by program staff or a technical advisory committee.
   (b) Restrict examinations to host(s), especially host with new growth. Looking for all the symptoms is the most important element in the detection of the mealybug; because by the time colonies are evident, the pest is already established and is difficult to control.
   Different host express different types of symptoms or different levels of symptoms depending on pest severity and general plant health. It is therefore important to become familiar with the symptoms to be expected in a given host. In general, check host(s), which appears to be unhealthy.

(c) Look for other tell-tale signs of mealybug, that is, individual mealybugs appearing as whitish speck on the host or terminals and leaves covered with white egg masses, nymphs and adults. Ants actively running up and down and forming trails leading up and down the hosts are also a tell-tale sign. Collect any white and especially yellowish-white forms seen, either by pruning the affected plant part or by picking of the leaf, bud or flower.
All samples should be put in individually marked and labeled paper bags for later study and identification. A dark colored beating sheet (the better to see the white mealybug) may be employed to collect mealybug specimens directly and to ferret out its presence when visual observation fails.

(d) Label each sample with the collector(s) name, the date, the host, and the exact location in enough detail; so that someone else can find the spot.

2. <u>When Host(s) Plants are not in New Flush</u>

(a) Examine the undersides of mature foliage and cracks and crevices of branches

(b) Examine all suspect secondary and reservoir hosts
- such as herbaceous weeds and shrubs

(c) Follow similar procedures as detailed for host in new flush
- i.e no. 1, (a) to (d) above

Mealybug Population Density Counts

= 4 Hibiscus Terminals (6 inches)
= 3 Papaya Leaves (whole of ½)

- % Parasitization
= encapsulate a total of 100 – 2nd, 3rd and adult females

Parasite Shipment, Release and Follow-up Population Density Counts of the Mealybug and Parasites

by

Dale Meyerdirk

Primary Parasites of Paracoccus marginatus - Mexico

- *Apoanagyrus* spp
  - (1) Black species
  - (2) Yellow species
- *Anagyrus spp*
  - (1) Banded antennae species
  - (2) Solid black antennae species
- *Acerophagus* spp
  - All yellow species, small, gregarious, antennae with 5 funicles and large clava
- *Pseudaphycus* spp
  - Dorsal thorax and head mostly orange to yellow. white tipped antennae, gregarious.

Parasite Production

- Potato Sprouts (Seed Potato) artifical host plant for ***P. marginatus***
- Parasites exposed to late second and third instars
- *Life cycle (72 degrees F.)*
  - *Apoanagyrus sp.* = *35 days*
  - *Anagyrus sp.* = *42 days*
  - *Acerophagus sp.* = *25 – 28 days*
  - *Pseudophycus sp.* = *28 days*

  - *Apoanagyrus sp.* = attacks 2^{nd} to 3^{rd} Instars
  - *Anagyrus sp.* = attacks late 2^{nd} to 3^{rd} Instars
  - *Acerophagus sp.* = attacks 2^{nd} to 3^{rd} Instars
  - *Pseudophycus sp.* = attacks late 2^{nd} to 3^{rd} Instar

Request for Parasites

- Formal **Request Letter** from Government Authorities to Shipper
- Formal **Government Permit** provided to Shipper
- Abide by FAO Code of Conduct
- Pre-select and secure potential release sites
- Perform pre-release Baseline Data Collections

Parasite Shipment and Release

- Federal Express, (24 hour shipment)
- Shipment Box kept cool with Blue Ice block
- Release same day received (avoid releasing in rain
- **DO NOT** hold in refrigerator
- Keep in air conditioned room for any prolonged periods of time
- Keep in cooler box for field release
- **DO NOT** leave in car with windows rolled up

ANNEX 1

LIST OF PARTICIPANTS

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ANNEX 2

Paracoccus marginatus William and Granara de Willink Host Plant List

Common Name	Reference	Scientific Name
Acacia	(Miller, et ale, In Press)	*Acacia Sp*
Copper-leaf	(Williams & DeWillink, 1992)	*Acalypha* Sp
Ragweed	(Williams & DeWillink, 1992)	*Ambrosa cumanensis*
Cherimoya	(NPAG, 1998)	*Annona muricata*
Soursop	(Kairo, 1998)	*Annona reticulata*
Custard-apple	(Miller, et ale, In *Press)*	*Annona squamosa*
Carambola	(NPAG, 1998)	*Averrhoa carambola*
Pigeon pea	(Abud-Antun, 1999)	*Cajanus cajan*
Pepper	(NPAG, 1998)	*Capsicum* Sp
Papaya	(Williams & DeWillink, 1992)	*Carica papaya*
Penda	(Abud-Antun, 1999)	*Citharexylum caudatum*
Citrus	(Avis Hammon, 2000)	*Citrus* X *paradisi* Macfad 'Thompson'
Citrus	(NPAG, 1998)	*Citrus* Sp
	(Kairo, 1998)	*Claradendron* Sp
Ivy Gourd	(Abud-Antun, 1999)	*Coccinia grandis*
	(Miller, et ale, In Press)	*Coccoloba* Sp
Croton	(Abud-Antun, 1999)	*Codiaeum variegatum*
Pumpkin	(Abud-Antun, 1999)	*Cucurbita moschata*
Pumpkin	(Abud-Antun, 1999)	*Cucurbita pepo*
Beans	(Williams & DeWillink, 1992)	*Fabaceae*
Cotton	(NPAG, 1998)	*Gossypium* Sp
Guazuma	(Miller, et ale, In Press)	*Guazuma ulmifolia*
Hibiscus	(Williams & DeWillink, 1992)	*Hibiscus* Sp
Chinese hibiscus	(Miller, et ale, In Press)	*Hibiscus rosa-sinensis*
Javilla	(Abud-Antun, 1999)	*Hura crepitans*
Sweet potato	(Miller, et ale, In Press)	*Ipomea* Sp.
Sweet potato	(Abud-Antun, 1999)	*Ipomea batatas*
Barbados nut	(NPAG, 1998)	*Jatropha curcas*
Peregrina	(Miller, et al., In Press)	*Jatropha integerrima*
Bardados nut	(Abud-Antun, 1999)	*Jatropha multifida*

Paracoccus marginatus William and Granara de Willink Host Plant List

Common Name	Reference	Scientific Name
Legumes	(Miller, et al., In Press)	Leguminose sp.
Mastuerzo.	(Abud-Antun, 1999)	*Lipidium virginicum*
Gourds	(Abud-Antun, 1999)	*Luffa cylindrica*
Tomato	(Abud-Antun, 1999)	*Lycopersicum esculentum*
Barbados cherry	(NPAG, 1998)	*Malpighia glabra*
W.I. cherry	(Kairo, 1998)	*Malpighia punicifolia*
	(Avis Hammon, 2000)	*Malvaviscus penduliforus*
DC. Mango	(Abud-Antun, 1999)	*Mangifera indica*
	(Miller, et al., In Press)	*Manihot chloristica*
Cassava	(Williams & DeWillink, 1992)	*Manihot esculenta*
Cat-claw m.	(Williams & DeWillink, 1992)	*Mimosa pigra*
Balsam-apple	(A.bud-Antun, 1999)	*Mormordica charantia*
	(Kairo, 1998)	*Mussaenda* sp.
Sorrel	(Kairo, 1998)	*Oxalis* sp.
Quinine-weed	(Williams & DeWillink, *1992)*	*Parthenium hysterophorus*
Avocado	(Miller, et al., In Press)	*Persea americana*
Lima bean	(Abud-Antun, 1999)	*Phaseolus lunatus*
Black pepper	*(NPAG, 1998)*	*Piper peltatum*
Frangipani	(Miller, et al., In Press)	*Plumeria* sp.
Sage	(NPAG, 1998)	*Salvia officinalis*
Umbrella tree	(NPAG, 1998)	*Schefflera* sp.
Chayote	(NPAG, 1998)	*Sechium edule*
Sida	(Miller, et al., In Press)	*Sida* sp.
Eggplant	(Miller, et al., In Press)	*Solanum melongena*
Terongan	(NPAG, 1998)	*Solanum torvum*
West Indian plum	(Bullock, 1999)	*Spondias* sp.
Rose apple	(NPAG, 1998)	*Szygium jambos*
	(Avis Hammon, 2000)	*Unida paniculata*
Corn	(Miller, et al., In Press)	*Zea mays*
Black-eyed pea	(Abud-Antun, 1999)	*Vigna ungiculata*

FIELD INSECTARY SITE (FIS) TECHNIQUE

Purpose:

* Develop a Classical Biological Control (BC) Programme for the Pink Hibiscus Mealybug in Newly Infested Countries
* Minimize Cost of Technology Transfer (ie Development of Insectary Facility)

Objectives:

* Release and Establish Exotic Natural Enemies
* Collect and Redistribute
* Evaluate Impact of Releases

Assumptions:

* Source of exotic natural enemies available
* BC specialist available to transfer technology and train local staff
* Financial support available for travel and per diem of BC specialist
* Local authorities approve programme and permit release of exotic parasites

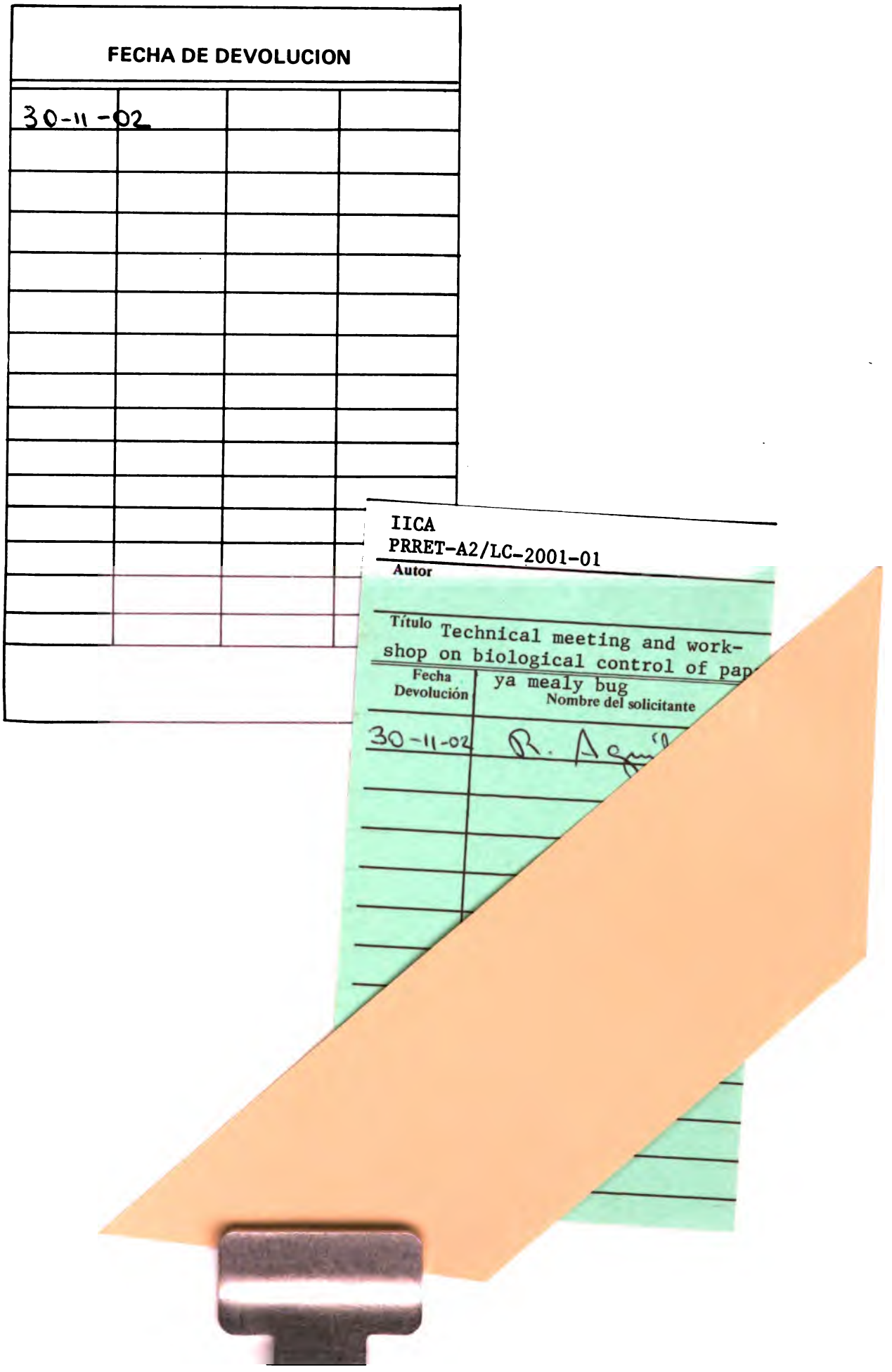
Four Country Visits by BC Specialist:

* **Trip 1**: Local arrangement developed, define BC programme and identify FIS
* **Trip 2**: Release and Collect Base-line Data
* **Trip 3**: Collect and Redistribute
* **Trip 4**: Evaluate Impact of BC and Report

BIOLOGICAL CONTROL OF MEALYBUGS
WORLD REVIEW

Mealybug Species	Common Name	Origin	Host Plants	Natural Enemy Species
Antonina graminis	Rhodes-Grass Scale	Asia	Pasture, lawn and turf grasses	*Anagyrus antoninae* *Neodusmtia sangwani*
Dysmicoccus boninsis	Gray Sugarcane Mealybug	North Pacific	Sugarcane	*Aphycus terryi* *Pseudaphycus mundus*
Dysmicoccus brevipes	Pineapple Mealybug	South America	Pineapple, sugarcane Banana	*Anagyrus coccidivorus* *Hambletonia pseudococcina*
Ferrisia virgata	Striped Mealybug	Tropical and Subtropical – World	Coffee, jute, coffee, cotton, citrus, sugarcane, cacao	*Cryptolaemus montrouzieri* *Pseudaphycus sp.* *Aenasius advena* *Phamurus sp (=Amitus sp)* *Acerophagus sp.* *Anagyrus sp.* *Blepyrus sp.* *Leptomastix sp.* *Pseudaphycus sp.*
Maconellicoccus hirstus	Hibiscus Mealbug	Southeast Asia	Hibiscus, mulberry, Acacia, guava, pigeon pea, cotton, grapes, citrus etc.	*Anagyrus kamali* *Anagyrus dacylopii* *Gyranuisoidea indica* *Crypotalaemus montrouzieri, etc*
Nipaecoccus nipae	Coconut Mealybug	Mexico	Avocado, banyan, guava, grape, mulberry, palms, ornamentals, etc.	*Hyperaspis silvestri* *Curinus coeruleus* *Cryptolaemus montrouzieri* *Pseudaphycus utliis*
Nipaecoccus vastator	Lebbeck Mealybug	Egypt India	Citrus, cotton, grape, hibiscus, mulberry and tamarind, *Zizphus sp, Acacia sp.*	*Cryptolaemus montrouzieri* *Anagyrus aegyptiacus* *Leptomastix phenacocci* *Anagyrus kamali*
Phenacoccus aceris	Apple Mealybug	European	Apples, cherry and currant	*Allotropa utilis*
Phenacoccus gossypii	Mexican Mealybug	Mexico	Ornamental and greenhouse plants: Chrysanthemum, coleus, geranium hollyhock, ivy, etc.	*Acerophagus pailidus*
Phenacoccus manihoti	Cassava Mealybug	South America	Cassava	*Epidinocarsis lopezi* *Anagyrus sp* *Acerophagus nr, Erii* *Aenasius advena* *Hyperaspis spp* *Diomus spp* *Leucopis sp. Etc* *(Over 130 species*

Mealybug Species	Common Name	Origin	Host Plants	Natural Enemy Species
Phenacoccus solani	Solanum Mealybug	?	Solanaceous ornamentals	*Acerophagus pailidus*
Planococcus citri	Citrus Mealybug	China	Many flowering plants Citrus, coffee, mango etc	*Pauridia peregrina* *Leptomastidea abnormis* *Leptomastix dactylopii* *Angyrus pseudococci* *Allotropa citri* *Cryptolaemus montrouzieri* *Scymnus bineavatus* *Exochomus metallicus*
Planococcus kenyae	Coffee Mealybug	Uganda and Tanganyika	Coffee, passion fruit, yams, pigeon peas, beans, potatoes, cotton, roses, guavas, mangoes, avocados, etc	*Chilocorus angolensis* *Anagyrus sp* *Anagyrus beneficans* *Leptomastix bifasciatus* *Pseudaphycus sp.* *Pauridia peregrina*
Planoccocoides njalensis	Cacoa Mealybug	West Africa	Cacoa plus 100 other plants	*Pseudaphycus angelicus* *Exochomus flavipes*
Pseudococcus comstocki	Comstrock Mealybug	Japan	Citrus pome and stone fruits and some ornamentals, catalpa and mulberry	*Pseudaphycus malinius* *Allotropa burrelli* *A. convexifrons* *Clausenia purpurea* *Anagyrus spp.* *Leptomastix sp.*
Pseudococcus citriculus	Citriculus Mealybug	Southeast Asia	Citrus, Aralia sp.	*Clausenia purpurea* *Cryptolaemus montrouzieri*
Pseudococcus calceolariae (=fragilis)	Citrophilus Mealbug	Australia	Citrus plus wide host range	*Coccophagus gurneyi* *Hungariella pretiosa* *Cryptolaemus montrouzieri* *Sympherobius amicus*
Pseudococcus longispinus	Longtailed Mealybug	Unknown	Citrus avocados, mangoes, various palms, oieander and ferns	*Anarhopus sydneyensis* *Hungariella peregrina*
Pseudococcus obscurus	Obscure Mealybug	Unknown	Citrus, pear, quince, grape and avocado	*Chrysoplatycerus splendens* *Cryptolaemus montrouzieri*
Pseudococcus maritimus	Grape Mealybug	North America	Grape, peas	*Zarphopalus corvinus* *Acerophagus notativentris* *Anagyrus subalbicornis* *Pseudleptomastrix squammulata* *Cryptolaemus montrouzieri*
Saccharicoccus sacchari	Pink Sugarcane Mealybug	Eastern Africa	Sugarcane, sorghum, Johnson grass and rice	*Anagyrus saccharicola* *Hyperaspis trilineata* *Cryptolaemus monrouzieri*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