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A REGIONAL RESEARCH PLAN FOR LEUCAENA PSYLLID CONTROL

Developed from the
F/FRED Leucaena Psyllid
Regional Research Workshop
held June 3-5, 1987
Manila, Philippines

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TABLE OF CONTENTS

Executive Summary i
The Role of the F/FRED Project in Regional Psyllid Research iii

I. Background 1

The nature of the problem 1
The process of developing a regional leucaena psyllid research plan 1
Role of the F/FRED Project in future psyllid research activities 6

II. A Regional Research Plan for Leucaena Psyllid Control 8

Organization and use of the plan 8
Defining management objectives of Leucaena leucocephala 8
Psyllid control research priorities 11
Current status of psyllid control research in Asia 12
Critical information and research gaps 13

III. Recommendations 14

List of Tables

Table 1. Meetings held on the topic of leucaena psyllid research since November, 1986.

Table 2. Leucaena management objectives.

Table 3. Action required to address psyllid control research priorities.

Appendices

Appendix 1. Action Plan and Recommendations for the Biological and Genetic Control of the Leucaena Psyllid 16

Appendix 2. Listing of Research Priorities and Current Research Status in Asia 34

Appendix 3. Regional Compilation of National Psyllid Research Plans 41

Appendix 4. National Psyllid Research Coordinators 51

Appendix 5. List of Participants 52

Appendix 6. Leucaena Psyllid Bibliography 54

EXECUTIVE SUMMARY

The regional research plan for leucaena psyllid (Heteropsylla cubana) control is the culmination of the efforts of many individuals from countries throughout Southeast Asia, Australia, Hawaii and the Pacific. As a regional research plan, it presents a unified and coordinated plan of research on a regional problem. Since the psyllid problem is shared by at least seven countries in Asia and the Pacific, it is logical that research efforts to control the pest should also be shared and coordinated. The main advantages of this approach are in more efficient use of scarce research resources, reduced duplication of efforts, and more rapid progress in problem resolution.
The regional plan contains four important planning documents:

1. A general action plan for the control of the leucaena psyllid (Appendix 1)

2. An analysis of management objectives for Leucaena by country (Table 2)

3. A regional list of research priorities by country (Appendix 2)

4. A regional plan for research, development, and implementation activities (Appendix 3)

This research plan encompasses the research and action plans of various countries affected by the recent leucaena psyllid infestation and identifies areas of common regional interest, as well as national priorities. A framework for the regional research plan and a listing of topic areas was also prepared as were research priorities and the current research status for each priority. Detailed descriptions of research components, estimated time frame for implementation, expected outputs, participating countries, principal investigators and institutions were merged from the national plans and are given in Section II and the Appendices.

Participating countries in the regional workshop included Australia, the Republic of China, Indonesia, Malaysia, the Philippines, Thailand, and the USA. Prior to this workshop, a series of national workshops were

organized. In close consultation with the F/FRED Psyllid Advisory Team and F/FRED Coordinating Unit, national plans were formulated in Indonesia, the Philippines and Thailand. Participating and contributing in this regional workshop were national psyllid research coordinators and representatives from national and international agencies such as the Nitrogen Fixing Tree Association, U.S. Agency for International Development, U.S. Department of Agriculture Forest Service, Winrock International and the FAO Regional Office for Asia and the Pacific.

At this meeting the national coordinators of participating countries elected Dr. Ida Nyoman Oka, the national coordinator for Indonesia, to serve as the regional coordinator to follow-up the recommendations made in this plan. The Forestry/Fuelwood Research and Development Project (F/FRED) will provide support for the regional coordinator for a one year period. The regional research plan was prepared to serve as a research proposal to be submitted to donor agencies for funding.

The following recommendations are made in this plan:

* Research topics which are not now being undertaken and are identified as high priority in this plan should receive international donor assistance as soon as possible.

* The regional coordinator selected at the F/FRED Leucaena Psyllid Regional Research Workshop be provided with adequate funding to allow follow-up of the regional plan and donor funding opportunities.

* Regional research efforts in the area of biological control should be coordinated with on-going research in psyllid-afflicted countries, and placed in an Integrated Pest Management (IPM) context.

* The regional plan should be used by psyllid researchers to enhance communications across national and institutional boundaries.

The Role of the Forestry/Fuelwood Research and Development (F/FRED) Project in Regional Psyllid Research

The Forestry/Fuelwood Research and Development project is designed to facilitate sharing of information and collaboration among researchers working with multipurpose tree species in Asia. One topic of serious regional concern at present is the outbreak of jumping plant lice (Heteropsylla cubana) on Leucaena leucocephala in Asia and the Pacific. The psyllid has already seriously damaged large plantings of leucaena in a number of countries and there are still no promising short-term control measures available.

Research on the psyllid and psyllid control is being conducted in at least 5 Asian countries at present. In its role as a networking project, F/FRED can assist scientists to coordinate and communicate their efforts across national boundaries more effectively. One way in which F/FRED has helped to strengthen this coordination and communication has been to encourage a series of meetings in Hawaii, Thailand, and the Philippines which largely focused on national and regional approaches to psyllid control research.

Finally, F/FRED has been actively involved in preparing this regional research plan and continues to support efforts to enhance psyllid control research in Asia.

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SECTION I

BACKGROUND

The Nature of the Problem

An insect pest called the leucaena psyllid (jumping plant lice) has spread rapidly to Asia and the Pacific in the past few years, often causing serious economic damage to the important multipurpose tree species *Leucaena leucocephala* (Lam.) de Wit.

The species is identified as *Heteropsylla cubana* Crawford (Homoptera: Psyllidae), also synonymously called *H. incisa*. *Heteropsylla spp.* are tiny (usually 1-2 mm) insects of the family Psyllidae, known as "jumping plant lice". The insects undergo five instars, all of which can cause damage to susceptible leucaenas.

Psyllids have long been known to feed on leucaenas in the Caribbean islands. In late 1983, they were discovered defoliating leucaena in Florida. In April 1984, psyllids were found in Hawaii and caused serious defoliation there since then. In 1985 and 1986 the insects arrived in the South Pacific, Australia and Southeast Asia and are expected to become pantropical.

The Process of Developing a Regional Leucaena Psyllid Research Plan

The regional research plan was developed through a series of national and regional meetings on the leucaena psyllid problem, beginning in November, 1986. Each meeting contributed to development of part of the plan by addressing national research programs, or by setting up a format for the regional plan itself (Table 1).

Part of this effort was coordinated by the Forestry/Fuelwood Research and Development (F/FRED) Project, which supported a Psyllid Advisory Team composed of Dr. Max McFadden, Dr. James Brewbaker, Mr. Alberto Barrion and an F/FRED Network Specialist. The F/FRED Coordinating Unit in Bangkok helped facilitate arrangements for meetings and provided logistical support for travel, publications, etc.

Table 1. Meetings held on the topic of leucaena psyllid research since November, 1986.

Meeting event	Dates	Venue	Sponsor	Outputs
Biological and Genetic Control Strategies for the Leucaena Psyllid	Nov. 3-7 1986	Molokai and Honolulu Hawaii	NFTA, F/FRED	General action plan, proceedings
Regional Leucaena Psyllid Working Party	March 23-25, 1987	Rama Garden Hotel, Bangkok Thailand	F/FRED	Regional planning framework
Leucaena: Psyllid Problems and Solution	March 26-27, 1987	RFD, Thailand	RFD, F/FRED, KUFF and NRCT	Thailand national research plan
Training Workshop on Leucaena Psyllid Infestation Management	June 1-4, 1987	PCARRD-Los Banos, Philippines	PCARRD	Refinement of national plan
F/FRED Leucaena Psyllid Regional Research Workshop	June 3-5, 1987	Manila Hotel, Philippines	F/FRED	First draft of a regional research plan

A general action plan and recommendations for control of the leucaena psyllid was developed at a meeting held in Hawaii in November 1986 (Appendix 1).

The objectives of this meeting included:

* Review the introduction and spread of H. cubana to areas outside of Central America.

* Review and synthesize current information on the biology of the insect.

* Review damage to leucaena under different management objectives.

* Review the socio-economic impacts associated with these outbreaks and the policy issues related to them.

* Review opportunities to strengthen existing quarantine procedures to prevent further spread.

* Review and synthesize current information on both short and long-term control of the psyllid.

* Develop a region-wide Integrated Pest Management (IPM) Plan which will include a cooperative research program to support both short- and long-term management strategies.

All of these objectives were attained except for the regional IPM Plan but, even there, priority research topics were identified for inclusion at a later date.

Working parties outlined the following general areas of research on psyllid control:

1. Leucaena network trials.
2. Leucaena genetic improvement.
3. Psyllid biology and quarantine procedures.
4. Policy and technology transfer.

This meeting and the subsequent action plan helped identify researchers and summarize who was doing what in psyllid research in Asia and the Pacific. The proceedings from this meeting, published by the Nitrogen Fixing Tree Association as Volume 7(2) of Leucaena Res. Reports (109 pages), provide the most comprehensive compilation of what was known about the psyllid problem and potential solutions.

One limitation of the general action plan developed in the November, 1986 meeting was that it did not include much detail about the type of research necessary to solve the psyllid problem, nor did it provide a detailed plan for coordinating regional research efforts.

As a follow-up to the November meeting, the F/FRED Coordinating Unit proposed a series of smaller national and regional meetings designed to result in a regional plan for research coordination. The general concept was to encourage national meetings in each of 3 or 4 countries (the Philippines, Indonesia, Thailand and possibly Malaysia), but with regional input from entomologists from each of the other 2-3 countries. For example, a meeting in the Philippines would be attended by one entomologist each from Indonesia, Thailand and Malaysia and by other people concerned with the psyllid problem in the Philippines. As more information on national programs became available, the approach was modified and this specific type of meeting was held only in Thailand.

Indonesia, the Philippines and Republic of China had each begun national research programs on the psyllid problem shortly after the infestation. The psyllid was not deemed to be a major problem in Malaysia, and the State Department of Agriculture in Hawaii and the University of Hawaii each began programs shortly after the psyllid arrived in Hawaii in 1984.

Two meetings were held in Bangkok during the month of March, 1987. The first was entitled "Regional Leucaena Psyllid Working Party Meeting" and was a small, informal meeting of representatives from the Philippines, Thailand, Taiwan, Indonesia and the United States. The purpose of this meeting was to prepare a framework for the regional research plan. Dr. Max McFadden, chairman of the F/FRED Leucaena Psyllid Advisory Team, chaired this meeting which produced a format for identifying important management objectives for Leucaena leucocephala and a separate format for summarizing national research plans. Planning was begun for the next regional meeting to be held in Manila in June 3-5, 1987.

The second March meeting was a national meeting entitled "Leucaena: Psyllid Problems and Solutions", held at the Royal Forest Department of Thailand, March 26-27, 1987. Papers were presented by both Thai and regional participants on the importance of leucaena, the psyllid problem and current psyllid control research. This meeting also provided a forum for the development of a

draft national research plan for psyllid control in Thailand. A sub-committee on psyllid research was proposed and has subsequently been approved by the National Research Council of Thailand.

A key component of the March 26-27 workshop was the development of a national research plan for Thailand, which serves as a mechanism for helping to communicate and coordinate research activities being undertaken by a wide range of institutions. This national assessment of the agencies involved in leucaena psyllid research and the types of research being done was also conducted in the Philippines, Indonesia, Malaysia and the Republic of China. A partial review of psyllid research in Australia was provided by R.A. Bray of CSIRO Cunningham laboratory. These listings showed high, medium or low priority ratings in the research categories the format developed at the informal "Regional Leucaena Psyllid Working Party Meeting".

Another national psyllid meeting was held in the Philippines in Los Banos and Cebu from June 1-4, organized by the Philippine Council on Agricultural Resources Research and Development (PCARRD) with support from the U.S. Agency for International Development. Scientific papers summarizing on-going psyllid research were presented and planned research discussed at this meeting. Participants also prepared a national planning summary utilizing the format developed in previous meetings. They selected Dr. Fernando Sanchez, Director of the National Crop Protection Center as National Coordinator for psyllid research.

Finally, a meeting entitled "F/FRED Leucaena Psyllid Regional Research Workshop" was held in Manila June 3-5, 1987. This meeting achieved the following four objectives:

1. Aggregation of prioritized management objectives for leucaena by country.

2. Aggregation of national research plans into a regional research plan.

3. Identification of high priority research needs by country for potential funding by bilateral and/or multilateral donors.

4. Selection of a regional coordinator.

Although only three countries had held meetings to develop national research plans (Indonesia, Thailand, and Philippines), representatives from the Republic of China, Australia, and Malaysia had completed the planning documents that were mailed out in advance. As a direct result, planning documents were available for all countries participating in the regional workshop. A list of the participants in this meeting is included as Appendix 5.

All of the national plans were presented and combined to provide the "Regional Compilation of National Psyllid Research Plans" (Appendix 3). The combined national research plans provided a fairly complete listing of institutions and individuals working on the leucaena psyllid in Asia and the Pacific. Psyllid research in the State of Hawaii has also been summarized in Appendix 3.

Participants characterized study areas as substantially done, on-going, or proposed and gave each study area a priority rating of high, medium or low (Appendix 2). Dr. I.N. Oka of Indonesia was selected as regional coordinator for implementation of the regional plan.

Role of the F/FRED Project in future psyllid research activities

The recommendations found in the Executive Summary and Section III provide the basis for future F/FRED involvement in regional psyllid control research. To date the F/FRED project has provided the mechanism for scientists to communicate both on-going research programs and plans for proposed research. F/FRED will continue to assist in that role as needed.

Specifically, this may include:

* Limited support for the Regional Psyllid Research Coordinator, including regional travel funds and a modest honorarium.

* Assistance in securing psyllid research funds from other donors. The Asian Development Bank (ADB), International Development Research Centre (IDRC), Food and Agriculture Organization (FAO) and the U.S. Agency for International Development (USAID) have expressed interest in funding additional psyllid research. It is hoped that this plan will help coordinate research funding efforts. Small seed-money grants may also be provided from the F/FRED small grants program.

* Provision of limited research funds as a "stop-gap" measure to increase psyllid research prior to the availability of major funding from other donors.

* Assistance to regional scientists in communication of research results and in collaboration with scientists outside of the region and notably in Hawaii and Australia.

* Support of the F/FRED Psyllid Advisory Team to assist the F/FRED project and the regional coordinator on an as needed basis and to review progress.

* Support of research to evaluate other promising multipurpose tree species with uses and growth characteristics similar to leucaena.

SECTION II

A REGIONAL PLAN FOR LEUCAENA PSYLLID CONTROL RESEARCH

Organization and use of the plan

This research plan is both descriptive and prescriptive in that it describes the types of research which are being done, and also identifies areas which are of high priority for future or proposed research.

One intention is for this plan to be used by researchers and research administrators who have interests in psyllid research. The plan provides a listing of research topics which have been completed, are on-going or are proposed. This should help them to plan future studies by providing an idea of the amount of effort which has been or is being put into a given area of psyllid research. This information, along with a listing of the institutions and names of individual scientists should allow researchers and administrators to communicate directly with others who share similar research interests.

Another intended use of this plan is for funding agency personnel who need to make decisions on where to invest psyllid research funds. The plan helps to identify the highest priority research areas and describes the status of research in each of the participating countries.

This section provides summaries of the detailed tables in Appendices 2 and 3. The Appendix tables provide listings of research priorities and research status by country.

Defining management objectives of *Leucaena leucocephala*

One of the first steps in an Integrated Pest Management (IPM) approach is the identification of the management objectives for the affected crop. While it is widely known that *Leucaena leucocephala* provides many products and service uses in Asia and the Pacific, the degree to which these are important varies greatly among countries.

An array of uses had been identified at the earlier national meetings and each use had been given a priority rating by each country. The aggregation of these national ratings indicates that Indonesia and the Philippines are the countries making the greatest use of the multipurpose characteristics of leucaena. It is obvious that in spite of the fact that leucaena is considered an important fuelwood species, the most important use is for animal food, either fodder or leafmeal. Other uses, if they are considered high priority, are related to special use, such as pulpwood in the Republic of China.

The management objectives table has several important functions. First, it identifies uses for leucaena. Second, it establishes the priority for the use and thereby helps to establish research priorities. Third, the nature of the use helps to identify a strategy for management. For instance, leucaena as animal fodder seems to preclude the use of chemical pesticides. Leucaena as pulpwood seems to indicate that chemical insecticide usage would be tolerated. Leucaena as a shade tree would indicate that perhaps another tree species would do just as well. In each situation, the management objective helps to focus on research needs by possibly eliminating a control tactic.

The summary of leucaena management objectives found in Table 2 was developed by the national psyllid research program coordinators, and largely reflects the opinions of scientists most closely involved in psyllid-related research in Asia. This summary is not intended to be a definitive ranking of management objectives for countries in the region, but rather provides a general idea of which uses are most important in what countries.

On a regional basis fodder production was by far the single most consistent management objective identified by participants, with both the highest average rating and the lowest standard deviation around the mean. Reforestation, woodfuel, green manure and leafmeal were ranked as moderately important. Pulpwood, timber shade and food uses were ranked as of lowest importance in the region. However, these rankings only provide an indication of broad general interest in the use of leucaena in Asia. A more important use of the rankings is to demonstrate the interactions between countries and management objectives. For example, with the exception of fodder and reforestation uses of leucaena, there was no management objective which was of importance in every country.

Table 2. Leucaena management objectives.

Country	Food/ Vegeta-bles	Fuel wood & Charcoal	Green manure Soil improvement	Fodder	Leafmeal	Shade	Reforesta-tion	Pulp wood & fiberboard	Timber	Total
Australia	0	0	0	3	0	0	1	0	0	4
Republic of China	0	1	1	2	1	0	1	3	2	11
Indonesia	1	3	3	3	2	3	3	2	2	22
Malaysia	0	1	1	2	0	1	1	0	0	6
Republic of the Philippines	1	3	3	3	3	2	3	2	2	22
Thailand	2	1	1	3	3	1	2	1	0	14
Total	4	9	9	16	9	7	10	7	6	
$\bar{x} \pm SD$	0.67 ± 0.82	1.5 ± 1.22	1.5 ± 1.22	2.67 ± 0.52	1.5 ± 1.38	1.17 ± 1.17	1.83 ± 0.98	1.33 ± 1.21	1.0 ± 1.10	

Priority ratings: 0 = no importance, 1 = low importance, 2 = moderate importance, 3 = high importance.

From a regional perspective it is most efficient to focus cooperative or collaborative research on the management objectives with the most widespread interest. In approximate order of importance these management objectives are:

1. Fodder
2. Reforestation
3. Fuelwood and charcoal
4. Green manure and soil improvement
5. Leafmeal
6. Pulpwood and fiberboard
7. Shade
8. Timber
9. Food and vegetables

Psyllid control research priorities

Psyllid control research priorities vary widely between countries within the region, as expected from the differences in management objectives. The listing of research priorities in Appendix 2 is essential for planning regional psyllid research because it provides a country by country listing of the current status of research by topic under each of the 7 research areas described in the regional plan (Appendix 3).

Appendix 2 is a status report which describes research as substantially done, ongoing, or in the proposal or planning stage. Each of these coded categories is also described in terms of high, medium, or low priority. Thus, not only is it possible to see quickly what research is needed during the first year for any research topic listed but also, what priority it carries. Likewise, if funds were sought for only high priority research across the region in the first year, it would be easy to find the high priority categories (noted as H_3) and summarize quickly regional or country needs by this category. This document will be instrumental in defining research needs by region and/or country to bring funding needs to the attention of national agencies or international donors.

The actions to be taken on these priorities might be grouped into three general categories as described in Table 3.

Table 3. Action required to address psyllid control research priorities.

Required actions	Priority and status rating *
New funding for research of broad regional importance	H_3 for most countries in the region
Additional funding for some national programs	H_3 for a few countries
Communication of progress of on-going studies	Mixture of H_3, H_2 and H_1 categories
Publication and dissemination of research information	H_1

* H rating is high priority. Subscripts refer to current status of research: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Current status of psyllid control research in Asia.

The Regional Research Plan in Appendix 3 is an important part of the planning process. In reality it is a bookkeeping document because it represents an aggregation of individual country research plans. For instance, one can see that under I.4 Life Table Studies, there are five countries interested in pursuing this research and the key investigator or institution that will do the work in each country is identified. Likewise, a time frame for the research is provided in the context of a five-year research effort and a description of the expected research output is provided. In this manner the research described for each country across all 7 research areas describes the regional research program. The seven research areas included in the regional plan are:

* Ecological Studies
* Host Relationships
* Impact Studies
* Management Strategies: Host Resistance
* Management Strategies: Biological Control
* Management Strategies: Chemical Control
* Management Strategies: Silvicultural Practices
* IPM Program and Implementation

There are several points that must be kept in mind when using Appendix 3. First, it is meant to be a dynamic planning tool. This means that at the end of each research season an assessment must be made of progress achieved and adjustments made to the plan in accordance with that progress. This may include changes in priority, changes in time line, changes in outputs, changes in who is doing the research, and additions or deletions of research described in the document.

Second, Appendix 3 provides no priority rating across the seven research areas in relation to which topic appears first in the document. Priorities for each general research topic can be assessed by referring to Appendix 2.

Critical information and research gaps

Information and research gaps in our knowledge of the psyllid and its control can be defined as those topics which are given the highest rating for proposed research. National programs already have research underway in a number of critical psyllid research topics. In general, the areas with the highest regional priority rating for proposed research were:

* sampling techniques and life table studies
* key factor analysis
* damage level as related to insect population density
* damage levels for appropriate control options
* role of insect toxins in damage
* translation of biological damage into socio-economic terms
* seed production of resistant varieties for distribution
* nature of resistance in leucaena
* screening of natural enemies for potential release
* establishment tests for biological control agents
* development of decision support systems to guide IPM implementation

These topics should be considered as gaps which are in most urgent need of additional financial support from donor agencies. The listing of priorities in Appendix 2 describes where these gaps are most seriously felt. Appendix 3 identifies which individuals and institutions are most interested in conducting additional research on these priority topics.

SECTION III

RECOMMENDATIONS

The following recommendations are derived primarily from the substance of Appendices 1-3. They were not formally proposed and adopted at the regional workshop, but have been reviewed and adopted by the workshop organizers and several of the key participants.

Recommendation 1: Research topics which are not now being undertaken and are identified as high priority in this plan should receive international donor assistance as soon as possible.

The most important topics are those identified as having broad regional interest (e.g. are given high priority by 3 or more countries).

Recommendation 2: The regional coordinator selected at the F/FRED Leucaena Psyllid Regional Research Workshop be provided with adequate funding to allow follow-up of the regional plan and donor funding opportunities.

While IDRC, ADB, and FAO have expressed interest in funding additional psyllid research, a great deal of follow-up may be necessary before critically important research topics are adequately funded. The regional coordinator is in a unique position to perform this role since he has an overview of all seven areas of research which are deemed important in the region.

Recommendation 3: Regional research efforts in the area of biological control should be coordinated with on-going research in psyllid-afflicted countries, and placed in an Integrated Pest Management (IPM) perspective.

Participants in the regional workshop expressed concern that major funding of potentially expensive research on exotic biological control agents might endanger major funding for other critical areas of psyllid research. The search for new exotic parasites and predators is time - consuming and may detract from current efforts to

utilize already available biocontrol agents. It is critical that any major psyllid research proposals be coordinated with regional scientists and placed in the context of other research needs and reviewed in light of existing regional biological control efforts.

Recommendation 4: The regional plan should be used by psyllid researchers to enhance communications across national and institutional boundaries.

This planning exercise has demonstrated the fact that a great deal of psyllid research has already taken place or is currently on-going. The regional plan provides a thorough listing of researchers and institutions which are actively involved in psyllid research, along with the topics being studied. Researchers are encouraged to communicate directly with other researchers working on similar topics in other institutions.

The contribution of the proceedings of the meeting on Biological and Genetic Control Strategies for the Leucaena Psyllid published by the Nitrogen Fixing Tree Association has also proved to be an invaluable resource in many institutions. Additional publications of this type should be encouraged to provide a regular update on psyllid research results.

Appendix 1

Action Plans and Recommendations for the Biological and Genetic Control of the Leucaena Psyllid

The following action plan is adapted from: NFTA. 1987. Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. A Special Edition of "Leucaena Research Reports" Volume 7(2). Honolulu Workshop participants divided themselves into the following four working groups to come up with an action and research agenda for the control of psyllids:

- Network Trials
- Genetic Improvement of Leucaena
- Psyllid Biology and Quarantine Issues
- Technology Transfer and Policy Issues

Section 3-1 summarizes all of the groups' conclusions about what is known about the psyllid problem, information gaps, and what should be done. Section 3-2 contains the complete reports from each group, as reported by each group's spokesman.

Section 3-1. Action Plan Summary

Group 1. Leucaena Network Trials

1-1. Psyllid resistant leucaena genotypes will be tested in standardized experiments under a range of environments in a network trial program to be coordinated by the Nitrogen Fixing Tree Association and Winrock-F/FRED.

1-2. Forage quality and yield under different management regimes of psyllid-resistant leucaena genotypes will be evaluated in standard trials within the research network.

1-3. Observed psyllid-resistant leucaena genotypes must be initially screened for resistance and distributed for research from a central clearing-house.

1-4. Network trials will include Latin American sites at which *Heteropsylla* and other psyllids have coevolved with leucaena.

Group 2. Leucaena Genetic Improvement

2-1. Resistance should be identified and quantified from native and experimental populations of Leucaena leucocephala, other leucaena species and interspecific leucaena hybrids.

2-2. All apparently psyllid-resistant leucaena genotypes should be distributed for testing in network trials, and proven genotypes will be distributed for commercial seed production.

2-3. Long-term breeding efforts should include definition of the genetics and physiology of resistance, as well as production of new resistant leucaena hybrids, including evaluation of commercial production of seedless hybrids.

2-4. Not recommended at this time are genetic engineering methods involving gene transfer from one species or genus to another, radiation mutation or other induced mutation methods, or tissue or cellular cultural methods that exploit mutations or modifications.

Group 3. Psyllid Biology and Quarantine Procedures

3-1. Natural enemies of Heteropsylla cubana, including predators, parasites, and pathogens, in its native and exotic ranges should be positively identified for biological control efforts.

3-2. Specific enemies that develop solely on H. cubana, e.g. parasitic wasps, are preferred for introduction in exotic areas.

3-3. Quarantine methods, such as spraying the cargo holds and passenger cabins of international commercial and military aircraft, should be implemented to prevent further spread of the psyllid and other insect pests.

3-4. The economic threshold level, or the psyllid population level that causes damage severe enough to justify the expense of control efforts, should be determined.

3-5. Basic studies on H. cubana, including nutritional requirements, reproductive and population biology, climatic and seasonal effects on psyllid populations, dispersal mechanisms and the possibility of psyllids being a disease vector, should be conducted.

3-6. Other multiple-purpose tree species should be evaluated as possible hosts for H. cubana and other pest psyllids.

3-7. Not recommended is use of pesticides for field control of psyllids, except for nursery stock.

3-8. Not recommended is indiscriminate introduction of general predators without consideration of their ecological impact and possible spread to other countries.

Group 4. Policy and Technology Transfer

4-1. Psyllid-control strategies should emerge from the collaborative efforts of scientists (entomologists,. pathologists geneticists, agriculturists, foresters, economists, social scientists and others), planners, administrators and farmers in an Integrated Pest Management effort.

4-2. Psyllid-control options should be evaluated in relation to prevailing leucaena uses on the basis of cost effectiveness, social impact, ecological impact and feasibility of implementation.

4-3. Other trees, both exotic and local, should be identified, tested and distributed to meet farmers needs for fodder, green manure, fuelwood and other products. Species trial programs are available from NFTA, Oxford Forestry Institute, FAO, Australian Centre for International Agricultural Research and other organizations.

4-4. Monocultures should be discouraged and polycultures encouraged to minimize impacts of pest invasions on farmers.

4-5. Except for research purposes, further plantings of psyllid-susceptible L. leucocephala as an exotic are discouraged.

4-6. Information and technology transfer on the psyllid problem should be supported by international agencies, such as FAO, USAID, NFTA, Winrock-F/FRED, IDRC, ADB, CSIRO, ADAB and GTZ.

4-7. NFTA encourages use of its publications, such as the annual Leucaena Research Reports and a periodic newsletter, as an international information clearing house on the psyllid.

State-of-the-art knowledge about the psyllid problem and proposed solutions.

1. LEUCAENA GENETIC IMPROVEMENT

1-1. Sources of Resistance

Individual trees and some varieties of Leucaena leucocephala have shown tolerance to the leucaena psyllid in many countries. In Hawaii, the varieties K527, K538, K584, K591, K636, K656 and K658 (all giants from N.E. Mexico) have been identified as psyllid tolerant. Psyllid-tolerant varieties observed elsewhere include K72 and K636 in Taiwan.

Also apparently tolerant to psyllids are some Leucaena diversifolia varieties such as K156 (4N), K165 (4N), K186 (4N), K410 (2N), K411 (2N) and CP33820 (4N) (Australia). Variation within varieties exists in both L. leucocephala and L. diversifolia. Leucaena species with very high resistance or immunity include L. collinsii, L. esculenta and L. pallida. Table 1 contains psyllid-tolerance ratings for Leucaena species.

1-2. Hybrids

Psyllid ratings on interspecific hybrids are summarized in Table 2. The interspecific hybrids display a range of resistance, verifying a high potential for the development of resistant commercial varieties. The most promising psyllid resistant hybrids are L. pallida x L. leucocephala and L. leucocephala (K636) x L. diversifolia (K156), but seed supplies of these crosses are extremely limited.

1-3. Information Gaps

* Genetics and biochemistry of resistance.
* Inducing flowering techniques of Leucaena species.
* Standardized psyllid resistance selection technique.

Table 1. Psyllid Ratings for Leucaena Species.

Species	Rating*	Tree height (m)	Biomass potential
L. collinsii	1-2	15	MED
L. esculenta	1-7	15	MED
L. pallida	1-3	8	HIGH
L. retusa	2-4	8	LOW
L. diversifolia 2n	3-7	18	MED
L. diversifolia 4n	4-8	20	HIGH
L. greggii	4-7	8	LOW
L. lanceolata	4-6	13	HIGH
L. leucocephala	4-9	22	HIGH
L. macrophylla	4-7	8	LOW
L. shannoni	4-6	10	MED
L. trichodes	4-7	8	LOW
L. lanceolata	5-8	8	MED
L. pulverulenta	6-9	20	HIGH

* 1-3 immune or highly resistant, 4-6 intermediate, some resistance of tolerance, 7-9 susceptible and often severely damaged. (From Sorennson and Brewbaker, 1986)

Table 2. Psyllid Resistance among Interspecific *Leucaena* Hybrids.

Female \ Male	COL 52	DIV 52	DIV 104	ESC 52	GRE 56?	LAN 52	LNS 52	LEU 104	MAC 52	PAL 104	PUL 56	RET 56	SHA 52	TRI 52	G.C.A.
L. collinsii	(1)					2	3								2.5
L. diversif. 2n	2	(5)	5			6	6	6					8		5.5
L. diversif. 4n			(6)			8	5	6		3			5		5.4
L. esculenta				(2)				3					3		3.0
L. greggii					(5)										–
L. lanceolata	3	6				(7)	5						5		4.8
L. lanc. sousae	3					5	(5)						4		4.0
L. leucocephala	3		6	3		7		(7)		4	7	5	6	6	5.2
L. macrophylla		3							(4)						3.0
L. pallida			3							(2)			5		4.0
L. pulverulenta	3		2			9	8	9			(8)		6		6.2
L. retusa	3		7	3				7		3	6	(4)	4		4.7
L. shannoni		6				6						4	(5)		5.3
L. trichodes						6	6							(6)	6.0

Ratings are the same as Table 1. (From Sorennson and Brewbaker, loc. cit.).

* Stability of resistance over time and environments, notably in natural ecosystems of Latin America.
* Agronomic value of some resistant Leucaena species and hybrids

2. PSYLLID BIOLOGY AND NATURAL ENEMIES

The leucaena psyllid (Heteropsylla cubana Crawford) has long been known as a pest of Leucaena spp. in its native Caribbean range, where it rarely causes significant damage. Since 1984, however, the leucaena psyllid spread rapidly throughout the Asia-Pacific region causing severe damage to leucaena production.

Psyllid species generally are highly host-specific. H. cubana can reproduce and develop successfully on several closely related Leucaena species, and perhaps Samanea saman. Both adults and immature stages of psyllids feed by inserting elongate, hair-like stylets into a plant's vascular tissues.

Biological control strategies encompass the use of predators, parasites and pathogens. Many parasites and predators have been recorded feeding on psyllids (Table 3). All parasites of the Psyllidae occur in the order Hymenoptera, except for several dipterous species in the family Cecidomyiidae. Parasites appear more host specific, in contrast to predators, which generally are opportunistic feeders on psyllids and other insects. Species of Anthocoridae, Syrphidae, Coccinellidae, and Neuroptera form the main predator complexes.

Entomogenous fungi parasitizing psyllids have been observed in Taiwan, Philippines and Papua New Guinea. Identified fungi genera include Conidiobolus, Fusarium, Entomophthora, Paecilomyces, Hirsutella and other unidentified fungi of Hypomycetes. The fungus Beauveria bassiana is under investigation as a possible means to controlling the leucaena psyllid in the Philippines.

2-1. Information gaps

Taxonomy

* Distribution of H. cubana in Tropical America.
* Identification, effectiveness, and distribution of natural enemies.

Table 3. Natural Enemies of *Heteropsylla Cubana*.

PARASITES	
Hymenoptera	
Encyrtidae	*Psyllaephagus* sp. nr. *rotundiformis* (Howard)
Eulophidae	*Tetrastichus triozae* (Burks)
PREDATORS	
Araneae	*Oxyopes javanus*
	Scipinia horrida
Coleoptera	
Coccinellidae	*Azya orbigera* Mulsant
	Coccinella septempunctata brucki Mulsant
	Coelophora inaegualis (Fabricius)
	Coelophora pupillata (Swartz)
	Curinus coeruleus (Mulsant)
	Cycloneda conjugata Mulsant
	Hippodamia convergens (Guerin)
	Menochilus sexmaculatus
	Olla abdominalis (Say)
	Oxyopes jayanus
	Scipinia horrida
Diptera	
Syrphidae	*Allograpta obligua* (Say)
Hemiptera	
Anthocoridae	*Paratriphleps laeyisculus* Champion
Miridae	*Rhinacloa forticornis* Reuter
Reduviidae	*Zelus renardii* Kolenati*
Neuroptera	
Chrysopidae	Unidentified green lacewing
Mantispidae	Unidentified mantispid

* Known to feed on coccinellids in Hawaii.

Biology

* Alternative hosts that support complete psyllid development.
* Identification of H. cubana biotypes.
* Climatic and seasonal effects on psyllid populations.
* Nutritional requirements of the psyllid.
* Nutritional status of host-effects on psyllid development.
* Longevity, survival and fecundity of H. cubana.
* Wind dispersal and flight range of adult psyllids.
* Developmental parameters of H. cubana.
* Identification of toxic secretions from feeding by the psyllid injurious to the host plant.
* Identification of the leucaena psyllid as a disease vector.

Section 3-2. Complete Action Plans of the Four Working Groups

Group 1. Leucaena Network Trials.

1. State-of-the-art

There appear to be leucaena genetic resources which are immune, resistant or tolerant to the leucaena psyllid. Several varieties of the species Leucaena leucocephala, other leucaena species, and some interspecific hybrids have shown promise. Species trials comparing leucaena with other species exist, but no effort has been made to study psyllid resistance using standardized methods and approaches.

2. Information Gaps

Very little is known of the stability of psyllid resistance over time, environment type or management regime. Nor have the end-use value of little-studied leucaena species such as Leucaena collinsii, or species hybrids, and the adaptability and growth rate of these species, varieties and hybrids been studied.

3. General approach to psyllid control

Network trials are defined here as experiments which use standardized methods by cooperating scientists over a wide range of environments.

a. Potentials and constraints: These experiments could provide critical information on how well the psyllid-resistant genotypes perform in different environments. The major constraints to implementation of trials include lack of seed, financial resources, and standard experimental designs and procedures.

b. Action required to remove constraints

1. Review of experimental techniques and design of experiments which assess psyllid resistance, growth rates and genotype adaptation to environment.

2. Commitment by researchers and institutions to conduct experiments of common design and the participation in combined analysis of data. This includes commitment of funds and collaboration with other research networks.

3. Collection and distribution of seed from leucaena species, hybrids and varieties which are thought to be psyllid resistant.

c. Impacts: These trials will help facilitate production of psyllid resistant germplasm for future planting programs. They will also result in information exchange and the dissemination of new germplasm resources to cooperating scientists.

d. Resources required: Funds for establishment, maintenance and monitoring of experimental plots is expected to come from both cooperating institutions and external funding agencies. Psyllid-resistant germplasm and coordination of the network trials program is expected from the Nitrogen Fixing Tree Association.

e. Duration of effort: A minimum of 2 years to continue indefinitely.

4. Summary and Recommendations

A. Immediate control measures. Network trials might provide germplasm which could be used in pilot-scale planting programs. This germplasm should not be used on a wide scale until it is further tested, thus network trials will not provide immediate control of the psyllid problem.

B. Long-term research imperatives. Network trials provide the only realistic means of evaluating the potential of stable psyllid-resistance over time and environment type. It is strongly recommended that these trials be initiated as soon as possible.

- Reported by Ken MacDicken

Group 2. Leucaena Genetic Improvement

This approach will not provide an instant solution to the psyllid problem. We must think in terms of two to three years for short-term projects and five years for longer. We have some generalized knowledge of resistance of some genotypes, but little knowledge of their agronomic suitability or of their yield. Given that we can select for resistance, many possibilities exist for improvement. The areas of research we discussed fall into four main areas. These are of course interrelated and overlap with other working group areas. Subheadings marked * need immediate action.

1. Multiplication and distribution of resistant genotypes (K636, *L. pallida*, *L. collinsii*)

   * A. Increased seed production for small-scale evaluation of existing germplasm
   * B. Commercial seed production (especially in current major seed producers Taiwan and India, and also Indonesia, Hawaii and Australia; needed in all developing areas)
   C. Training of seed producers--depends on region
   D. Research on promotion/stimulation of flowering in shy-flowering genotypes

2. Agronomic evaluation of resistant germplasm

   * A. Suitability for forage of species other than *L. leucocephala*--"quality", coppicing, ease of establishment. Could be best handled by organizations such as ILCA, CSIRO and University of Hawaii, using standard procedures
   * B. International testing program--to provide data relevant to stability of foliage yield, stability of resistance, and improved selection techniques

3. Understanding resistance

A. Mechanisms of resistance
B. Genetics and biochemistry of resistance
C. Development of improved selection techniques

4. Improvement by breeding

* A. Evaluation of the possibility of commercial production of (seedless) hybrids. Need data on robustness of sterility, definition of suitable species, and development of cultural techniques.
* B. Low technology, high-intensity selection within segregating F_2 populations of *L. leucocephala* and *L. diversifolia*--applicable to developing countries
C. Continuation of breeding work using interspecific hybrids, selecting for psyllid resistance, acid tolerance, cold tolerance, etc.

Notes:

A. We agreed that priority should go to the development of leucaena suitable for foliage production, with work for fuel/biomass of slightly lower priority, due to availability of alternative species.

B. The working group does not consider the following approaches profitable at this time for psyllid resistance in (polyploid) leucaena:

i. "genetic engineering" involving gene transfer from one species or genus to another
ii. radiation mutation or other induced mutation methods
iii. tissue or cellular cultural methods exploiting mutations or modifications

- Reported by Robert Bray

Group 3. Psyllid Biology and Quarantine Procedures

I. STATE-OF-THE-ART KNOWLEDGE:

A. Leucaena psyllid biology:
- Verification of biological parameters for Heteropsylla spp. with specific reference to H. cubana.
- Verification of host plants that support psyllid immature development.
- Review known parasites, predators and pathogens of H. cubana.
- Existing natural enemies in Hawaii (including Curinus coeruleus and Olla abdominalis) provide only partial biological control of the H. cubana.

B. Integrated Pest Management (IPM):
- Basic philosophies known but programs are undeveloped in most Pacific Nations.

C. Quarantines:
- Quarantine regulations are in place by most Pacific Nations.
- Disinfection of all international aircraft flights recommended.
- Problems with first class mail in some countries (eg. Guam, Hawaii). Quarantine inspectors cannot open and inspect first class mail.

II. INFORMATION GAPS:

A. Leucaena psyllid.

1. Taxonomy.
*** . Identity and distribution of Heteropsylla spp. in Tropical Americas.
*** . Identity and distribution of the natural enemies of the Heteropsylla spp. in Tropical Americas.
*** . Identity of natural enemies of H. cubana in its exotic range.

2. Biology.
. List of alternative hosts (supports complete development) of H. cubana.
*** . Developmental parameters for H. cubana.
. Nutritional requirements for the psyllid.
. Nutritional status of host plant-effects on development of psyllid.

*** . Longevity, survival and fecundity of H. cubana.
. Recognition and determination of any biotypes of H. cubana.
. Altitudinal and wind dispersion and flight range of adults.
. Geographical range (Calendar map) of psyllid.
*** . Climatic and Seasonal effects on psyllid populations.
. Identification of toxic secretions from psyllid feeding that may be injurious to the host plant.
. Determination of whether psyllids are a disease vector.

3. Insect-Plant Interaction.
*** . Development of methods to assess the impact of H. cubana on Leucaena spp.
*** . Development of methods to estimate abundance of H. cubana on Leucaena spp.
. Effects on psyllid populations when grafting resistant plant material onto susceptible stock.

4. IPM.
*** . Development of monitoring techniques (insect and plant).
*** . Determination of density-treatment levels (Economic Thresholds).
. Evaluation of pesticides.
*** . Base line data needed to develop an IPM program.

5. Quarantines.
*** . Effect of pesticides on shipments of natural enemies during disinfection of aircraft.
** . Lack of facilities and trained personnel to properly handle incoming shipments of beneficial organisms.
** . Funding and personnel for overseas exploration for natural enemies of the psyllid.
. Advance notice given to quarantine, customs and health authorities for all impending shipments.

III. GENERAL APPROACHES TO CONTROLLING H. cubana:

A. Potentials and Constraints:
** . A coordinating body and funding source for international programs is unknown at this point

*** . Biological Control -- Specific biotic agents preferred.
. Pesticides -- Expensive and impractical except on nursery stock.
*** . Resistant leucaena species or varieties -- Long term strategy, seed banks and distribution expensive and lacking.
** . Cultural control -- useful in special circumstances.

B. Action Required to Remove Constraints:
*** . Funds
** . Facilities
*** . Trained and dedicated personnel
** . Support of regional and national authorities
*** . Make use of, and extension of, existing overseas bases.

C. Duration of Effort: Three to five years.

IV. SUMMARY AND RECOMMENDATIONS:

There is general information on the natural enemies of Heteropsylla cubana in its exotic range but little information on the natural enemies that keep H. cubana at low levels in its native home. Evidence in Hawaii indicates the psyllid is only partially controlled by the coccinellid predator, Curinus coeruleus. H. cubana is morphologically very similar to related species that attack plants other than Leucaena and an expert taxonomist is needed to separate species of Heteropsylla. Any natural enemy attacking Heteropsylla spp. must be identified along with positive identification of the host species in order to find any H. cubana specific natural enemies.

There is a paucity of basic information on developmental parameters of H. cubana and the insect pest/ natural enemies/ host plant/ climatic interactions which prevent the development of an effective biological control or IPM program. Any experiments to determine host-plant resistance to the psyllid must be properly replicated and evaluated according to internationally accepted procedures.

Quarantine procedures need to be enforced and improved where needed. Although H. cubana appears to be widely distributed across the Pacific, quarantine regulations are the only means of deterring future accidental

introductions of other potential economic pests into the island ecosystem.

*** High Priority

- Reported by Wally Mitchell

Group 4. Technology Transfer and Policy Issues

1. <u>State-of-the-art-knowledge</u>

   a. The full range of management options should be considered for a given management area (country, region, island, etc.) including:
      - physical--pesticides, fire
      - culture practices--land preparation, planting, pruning, harvesting over time
      - biological controls (general vs. host specific)--predators (esp. lady beetles, spiders), parasites (esp. wasps), pathogens (esp. fungi)
      - genetic resistance--(esp. leucaena species, hybrid leucaena, other trees, grafts)
      - regulatory measures--regulations and quarantines

   b. Management options must be evaluated in relation to the dominant leucaena uses to the management area including: poles, pulp energy biomass (fuelwood, charcoal, dendrothermal) fodder (cut-and-carry, grazing, leafmeal), estate crops shade, green manure, land rehabilitation and soil conservation, human food, etc.

   c. Advise on the range of options available should be sought from all relevant scientific disciplines, including entomologists, foresters, agricultural scientists, economists, social scientists, pathologists, program administration specialists, wood energy specialists, extension specialists.

   d. The psyllid infestation problem can be contained only over a period of several years and will require international cooperation.

2. Information gaps

a. What is the likelihood of similar infestations occurring with apparently resistant leucaena species or hybrids or non-leucaena replacement species, and what can be done to reduce this likelihood?

b. What is the likelihood of biological control agents crossing national boundaries and what should be done?

c. What is the most practical and appropriate monitoring system to be established at regional and national levels?

d. What is the most appropriate policy for the avoidance of the psyllid in areas not yet affected and to avoid similar problems in the future?

3. General approaches for control

a. Goal: To manage the psyllid pest so that economic, social and ecological damage is reduced to and held at a tolerable level.

b. Evaluate a limited set of management options (mix of control measures) for a given management area time frame and dominant use pattern for leucaena on the basis of four considerations: cost effectiveness (or benefit-cost analysis where feasible), social impact, ecological impact, and feasibility of implementation.

c. Determine to the extent possible the consequences of taking no action, and always consider this as one option.

d. Establish national and regional level technology transfer mechanisms which, as much as possible:

- involve all relevant agencies and disciplines
- link the scientific and decision-making communities
- use a lead agency or single agency with a strong interest and apparatus from the highest to lowest levels of government

- take advantage of existing communication channels to speed transfer and reach a wider audience
- establish two-way technology transfer communications channels, bottom-up from a specific locality and top-down from other localities to report on: the spread of the pest and related damage, results of experimental controls, results of major control actions.

4. Summary and recommendations

a. Consider "no action" as an alternative

b. Do not try to find a single replacement for *Leucaena leucocephala*

c. Give special attention to local species and institute procedures for the evaluation of proposed replacement species

d. Establish a moratorium on the non-research planting of *Leucaena leucocephala* until resistant varieties are made available

e. Recommend to farmers and government programs that monoculture tree stands be avoided if a compatible species mix is available.

f. Establish a network for research on leucaena which includes psyllid resistance research but covers all major uses

g. Standardize monitoring methods and establish a technology transfer network which links country programs

h. Strengthen links among international donor and development agencies to improve technology transfer including: FAO, IBRD, ADB, USAID, USDA, IDRC, GTZ, ADAB, NFTA, IURO, F/FRED.

- Reported by David McCauley

Appendix 2. Listing of Research Priorities and Current Research Status in Asia.

Research Component	Countrywise Research Priority and Current Status*						Remark
	Austra-lia	ROC	Indone-sia	Malay-sia	Philip-pines	Thai-land	
I. ECOLOGICAL INVESTI-GATION:							- Need standardized methodology. - Standard methods for life history data, life table studies and key factor analysis will be developed by Banpot Napompeth.
1. Life history data.	H_3	H_2	H_2	H_2	H_2	H_2	
2. Seasonal abundance	H_2	H_2	H_2	H_3	H_2	H_2	
3. Sampling techniques	H_2	H_3	H_3	H_2	H_2	H_2	
4. Life table studies.	H_3	H_3	H_3	H_3	H_2	-	
- Biological LT.	-	-	-	-	-	H_2	
- Ecological LT.	-	-	-	-	-	H_2	
5. Key factor analysis.	H_3	H_3	H_3	H_3	H_2	H_2	

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 2 Listing of Research Priorities (Cont.)

Research Component	Countrywise Research Priority and Current Status*						Remark
	Austra-lia	ROC	Indone-sia	Malay-sia	Philip-pines	Thai-land	
II. HOST RELATIONSHIP:							- need to develop: - standard sampling techniques. - economic threshold level. - sequential sampling plans.
1. By management objective, define damage level related to insect population density.	H_3	H_3	H_3	H_3	H_3	H_3	
2. Determine damage levels for control options.	H_3	H_3	H_3	M_3	H_3	H_3	
3. Are insect toxins involved in damage?	L	H_3	H_3	H_3	H_3	H_2	
4. Are the psyllid acting as vectors for plant diseases?	L	L_3	H_3	H_3	H_3	H_3	
5. Is severity of damage related to tree stress?	M_3	L_3	H_3	L_3	H_3	H_3	

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 2. Listing of Research Priorities (Cont.)

Research Component	Countrywise Research Priority and Current Status*						Remark
	Austra-lia	ROC	Indone-sia	Malay-sia	Philip-pines	Thai-land	
III. IMPACT							- need quantification in terms of assessment.
1. Translate biological damage into socioeconomic terms for each management objective.	H_3	M_3	H_3	H_3	H_2	H_2	- high priority in all countries except ROC.

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 2. Listing of Research Priorities (Cont.)

Research Component	Countrywise Research Priority and Current Status*						Remark
	Austra-lia	ROC	Indone-sia	Malay-sia	Philip-pines	Thai-land	
IV. HOST RESISTANCE AS A MANAGEMENT STRATEGY:							- need exchange of materials, standardized testing, and standardized evaluation. - methodologies to be developed by J.L. Brewbaker, Fuh-Juinn Pan and R.A. Bray.
1. Search for genetic. materials	H_2	H_2	H_2	L	H_2	M	
2. Develop methodology for screening for resistance.	H_2	H_3	H_2	H_3	H_2	H_2	
3. Screen for psyllid resistance and growth characteristics using new & existing materials.	H_2	H_2	H_2	H_3	H_2	H_2	
4. Field testing of promising provenance (LPT).	H_3	H_2	H_2	L_3	H_2	H_2	
5. Production of seeds of resistant varieties for distribution.	H_3	H_3	H_2	L	H_3	H_3	
6. Determine nature of psyllid resistance in leucaena.	H_3	H_3	H_3	L	H_3	H_3	

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 2. Listing of Research Priorities (Cont.)

Research Component	Countrywise Research Priority and Current Status*						Remark
	Australia	ROC	Indonesia	Malaysia	Philippines	Thailand	
V. BIOLOGICAL CONTROL AS A MANAGEMENT STRATEGY							- need exchange of candidate biological control agents. - introduction of potential biological control agents within and outside of the region.
1. Search and evaluation of natural enemies:	-	H_2	H_2	-	-	-	
- indigenous	H_3	-	-	H_2	H_2	H_2	
- exotic	L	-	-	L	H_3	H_2	
2. Screening of natural enemies for potential release.	L	H_2	H_2	H_3	H_3	H_2	
3. Mass rearing potential.	L	H_3	H_1	H	H_3	H_2	
4. Establishment tests.	L	H_3	H_2	H	H_3	H_3	
5. Field test augmentative releases.	L	H_3	H_2	H	H_3	H_3	
6. Microbial control:	L	-	-	-	H_3	-	
- Search, evaluation and utilization of microbial control agents.	-	H_2	H_3	L	-	H_2	
- Test commercial microbial preparations.	-	-	-	L	-	M	

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 2. Listing of Research Priorities (Cont.)

Research Component	Countrywise Research Priority and Current Status*						Remark
	Austra-lia	ROC	Indone-sia	Malay-sia	Philip-pines	Thai-land	
VI. OTHER MANAGEMENT STRATEGIES							- need exchange of information on effective chemicals and application methods.
A. CHEMICAL CONTROL:							
1. Screen for selected compounds in greenhouse by mode of action.	L	L_2	L_1	L_3	L_1	L_3	
2. Field test effective compounds.	L_1	L_2	L_1	L_3	L_1	L_2	
3. Refine dosage rates and application techniques.	L_1	L_2	L_1	L_3	L_3	L_3	
4. Recommend compounds for use for each management objective together with guideline for use.	L_1	L_2	L_1	L_3	L_3	L_2	

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 2. Listing of Research Priorities (Cont.)

Research Component	Countrywise Research Priority and Current Status*						Remark
	Austra-lia	ROC	Indone-sia	Malay-sia	Philip-pines	Thai-land	
B. SILVICULTURAL PRACTICES:							
1. Evaluation of silvicultural and agroforestry management practices.	H_2	L_3	H_2	–	H_2	H_2	
2. Evaluation of alternative species.	H_2	H_2	–	–	H_2	H_3	
VII. IPM PROGRAMS AND IMPLEMENTATION:							
1. By management objective integrate findings and information from I-VI to develop IPM program.	H_3	H_3	H_3	H	H_3	H_3	
2. Develop decision support systems based on management strategies developed to meet each management objectives.	–	H_3	H_3	H	H_3	H_3	– need management guidelines for population monitoring
3. Provide appropriate technology transfer for IPM implementation.	–	H_3	H_2	H	H_3	H_3	

* Priority: H = high, M = medium, L = low.
Current status: 1 = substantially done, 2 = on-going and in progress, 3 = proposed and planned.

Appendix 3.

Regional Aggregation of National Psyllid Research Plans

The following is a detailed listing of areas of leucaena psyllid control research which is compiled from national programs. Study areas are listed in the following categories:

1. Ecological investigations.
2. Host relationships.
3. Impact.
4. Host resistance as a management strategy.
5. Biological control as a management strategy.
6. Other management strategies.
7. IPM programs and implementation.

Abbreviations used in this listing are:

CMU	-	Chiang Mai University
CSIRO	-	Commonwealth Scientific and Industrial Research Organization
DOA	-	Department of Agriculture
DOAE	-	Department of Agricultural Extention
FIO	-	Forest Industry Organization
FRIM	-	Forest Research Institute of Malaysia
HSDA	-	Hawaii State Dept. of Agriculture
KKU	-	Khon Kaen University
KU	-	Kasetsart University
KUFF	-	Faculty of Forestry, KU
MARDI	-	Malaysia Agricultural Research & Development Institutes
MIAT	-	Mae Jo Institute of Agricultural Technology
NBCRC	-	National Biological Control Research Center
NFTA	-	Nitrogen Fixing Tree Association
NRCT	-	National Research Council of Thailand
PSU	-	Prince of Songkla University
QDPI	-	Queensland Department of Primary Industries
RFD	-	Royal Forest Department
TFRI	-	Taiwan Forestry Research Institute
TISTR	-	Thailand Institute of Scientific and Technological Research
TPC	-	Thai Plywood Co.
UGM	-	Gadjah Mada University
UPM	-	Universiti Pertanian Malaysia

Appendix 3. Regional Compilation of National Psyllid Research Plans.

I. Ecological Investigations	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
1. Life History Data (H)	+	+				Report on life cycle time, number of generations, sex ratios, fecundity, etc.	Australia Indonesia Malaysia Philippines ROC Thailand USA	CSIRO Pardede; Soeprapto; Rauf. Lim GS - MARDI Tho YP - FRIM Dr. Venus Calilung Yu-Jen Chang - TFRI NBCRC, DOA, RFD, KUFF HSDA
2 Seasonal Abundance (H)	+	+	+			Report on numbers of adults and immatures over 1 year with emphasis on temperature, humidity, and rainfall relationships.	Australia Indonesia Malaysia Philippines ROC Thailand USA	CSIRO, Div.of Entomology/ Univ. Queensland Rauf; Soeprapto Lim GS - MARDI Tho YP - FRIM H. San Valentin, Lina Villacarlos Jong-Tai Chau - TFRI NBCRC, DOA, RFD, KUFF NFTA/UH
3. Sampling Techniques (H)	+	+	+					
4. Life Table Studies (H)		+	+	+	+	Report on sampling techniques that can be relied on to give absolute values for numbers of insects/unit of area.	Indonesia Malaysia Philippines ROC Thailand	Rauf; Soeprapto Lim GS - MARDI Tho YP - FRIM H. San Valentin Jong-Tai Chau - TFRI NBCRC
5. Key Factor Analysis (H)			+	+	+	Report on life table studies that quantifies life history and seasonal abundance as well as the key factors that influence generational survival,i.e:parasites & predators.	Indonesia Malaysia Philippines Thailand	Rauf; Soeprapto Lim GS - MARDI Tho YP - FRIM Raymundo Lucero NBCRC

II. Host Relationships	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
1. By management objective, define damage levels related to insect population density (H)	+	+	+	+		Report that quantifies biological damage to host by psyllid density (must be closely tied to life table studies and sampling techniques developed in I3.	Australia Indonesia Philippines Thailand	CSIRO Wardoyo; Didik H.San Valentin, R. Lucero NBCRC, DOA
2. Determine economic threshold for control options (H)			+	+	+	Based on information provided above quantify economic thresholds for various control tactics by management objectives. Include socio-economic constraints to certain control tactics and opportunities to minimize them.	Indonesia Philippines Thailand	Soehardjan; K.Untung-UGM Frederick Corey NBCRC, DOA, DOAE
3. Are insect toxins involved in damage? (M)			+	+		Report showing conclusively that damage is either related to density or toxin secreted during feeding.	Indonesia Thailand	Darma NBCRC
4. Are the psyllids acting as vectors for plant diseases? (M)			+	+		Report showing conclusively that damage is caused entirely by insect or by an organism that is being vectored by psyllid.	Indonesia Malaysia	Triharso Narani, Maziah - FRIM Lee S.S. - UPM
5. Is severity of damage related to tree stress? (L)				+	+	Report showing quantitative relationship between degree of damage and physiological condition of tree under water stress, nutritional stress or other forms of stress.	Australia Indonesia	CSIRO, Div.of Entomology Wardoyo; Didik

III. Impact	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
1. Translate biological damage into Socio-economic terms for each management objective. (H)		+	+	+	+	Report indicating appropriate economic translation of damage into losses, either monetary or otherwise including effects on social and economic values.	Indonesia Philippines Thailand	Soehardjan; K.Untung-UGM Artemio Rebugio NBCRC, DOA, DOAE

IV. Host Resistance as a Management Strategy	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
1. Search for genetic material.	+					Report on seed collection from resistant/tolerant forms in various Asian/Pacific countries and in various areas of Central & South America where H. cubana occurs.	Australia ROC Indonesia Philippines Thailand USA	R.Bray - CSIRO Fuh-Jiunn Pan - TFRI Dedy S, Siregar, Entari Enriqus Crizaldo; Aida Adalla TISTR NFTA/UH
2. Develop laboratory methodology for screening for resistance of Leucaena varieties to psyllids.	+	+					Australia ROC Indonesia Philippines Thailand	R. Bray - CSIRO Fuh-Jiunn Pan - TFRI Soehardjan Unknown yet TISTR
3. Screen for psyllid resistance and growth characteristics using new & existing material.	+	+	+			Report on standardized tests for resistance & growth with recommendations for field testing of selected cultivars.	Australia ROC Indonesia Malaysia Philippines Thailand USA	R. Bray - CSIRO Fuh Jiunn Pan - TFRI Dedy S/Siregar Zakaria/Ng - FRIM Unknown yet TISTR, CMU, RFD, KUFF,DOA NFTA/UH
4. Field testing of promising provenances (LPT).	+	+	+	+		Report on LPT trials from various participating countries.	Australia ROC Indonesia Malaysia Philippines Thailand USA	R. Bray - CSIRO Fuh-Jiunn Pan - TFRI Dedy S/Siregar Zakaria/Ng - FRIM Unknown yet TISTR, RFD, KUFF, DOA NFTA/UH
5. Production of resistant seed for distribution.			+	+	+	Report on seed production and distribution to participating countries.	Australia ROC Indonesia Philippines Thailand USA	R. Bray - CSIRO Fuh-Jiunn Pan - TFRI Dedy S/Siregar M. Dalmacio KUFF, TISTR, DOA NFTA/UH
6. Determine nature of psyllid resistance in leucaena.			+	+	+	Report on studies which document type of resistance: physical,genetic,biochemical.	Australia Indonesia Philippines USA	R. Bray - CSIRO Darma/Dedy S Aida Adalla NFTA/UH

V.	Biological Control as a Mgmt. Strategy	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
1.	Search and Evaluation of natural enemies: - indigenous - exotic	+	+				Same as for chemical Control (VI.A.)	ROC Indonesia Philippines Thailand USA	Huan-Ju Hsieh, Dept.of Pathology & Entomology, National Tawian Univ. Teguh S Gajah Mada Univ.(UGM) Clare Baltazar; Victor Gapud NBCRC, DOA HSDA
2.	Screen predators/ parasites for potential release.		+	+	+		Annual report of parasites and predators demonstrated to be effective in laboratory and limited field testing.	ROC Indonesia Philippines Thailand USA	Ann-Lee Yiau - Sinica Academic Institute Soeprapto: Bahagiawati; Siswanto; Kamandalu Clare Baltazar; Victor Gapud NBCRC, DOA HSDA
3.	Establishment tests.			+	+		Report on releases of sufficient quantities of individuals to be able to evaluate establishement.	ROC Indonesia Thailand USA	Ann-Lee Yiau Soeprapto; Bahagiawati; Siswanto; Kamandalu NBCRC, DOA, DOAE HSDA
4.	Mass rearing potential.			+	+		Report on tests in laboratory to indicate ease of rearing and relative cost of mass rearing of selected species for augmentative releases.	ROC Indonesia Thailand USA	Ann-Lee Yiau Soeprapto; Bahagiawati; Siswanto; Kamandalu NBCRC, DOA, DOAE HSDA
5.	Field test augmentative releases.				+	+	Report an augmentative releases in conjunction with appropriate population .	Indonesia Thailand USA	Soeprapto; Bahagiawati; Siswanto; Kamandalu NBCRC, DOA HSDA

V. Biological Control as a Mgmt. Strategy	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
6. Develop procedures for mass production.				+	+	Provide report on methodology developed for mass production	ROC Indonesia Philippines Thailand USA	Huan-Ju Hsieh Teguh S Ernesto Militante; Lina Villacarlos NBCRC, DOA HSDA
7. Microbial Control - Search, evaluation & utilization of microbial control agents. - Test Commercial microbial preparation.							ROC Thailand	Huan-Ju Hsieh DOA, NBCRC, RFD, KUFF

VI.	Other Management Strategies	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
	A. Chemical Control								
1.	Screen for selected compounds in greenhouse by mode of action.	+	+				Develop laboratory or greenhouse procedures to screen for desirable characteristics, after determining what these are.	Indonesia Malaysia Thailand	Didik MARDI - Lim GS DOA
2.	Field test effective compounds.		+	+			Provide report on effective compounds recommended for further refinement & testing.	Indonesia Malaysia Thailand	Didik MARDI - Lim GS DOA
3.	Refine dosages, formulations, & application techniques.			+	+		Provide report on recommended dosages and appropriate methods for application including timing to ensure maximum mortality, safety in application and to the environment (including parasites & predators).	Indonesia Malaysia Thailand	Didik MARDI - LIM GS DOA
4.	Recommend compounds for use by management objective; provide guidelines for use.			+	+		Publication of guidelines for use of compounds shown to be effective after screening & field testing.	Indonesia Malaysia Thailand	Didik MARDI - Lim GS DOA, RFD

VI. Other Management Strategies	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
B. Silvicultural Practices								
1. Evaluation of silvicultural & agroforestry management practices.	+	+	+	+	+	Develop silvicultural practices to deter psyllid populations & outbreaks.	Thailand	RFD, KUFF
2. Evaluation of alternative MPTS .	+	+	+	+	+	Alternative species to leucaena.	–	–

VII. IPM Programs & Implementation	Year 1	2	3	4	5	Expected outputs	Country	Principal Investigator(s)
1. By management objective integrate information from I - IV to develop strategies for management.	+	+	+	+	+		Indonesia Malaysia Thailand	Oka; Soemartono; A.Rauf; Soehardjan; Wardoyo MARDI/FRIM/DOA NBCRC, DOA, RFD, KUFF
2. Develop decision support systems based on strategies developed to meet mgmt. objective.		+	+	+	+		Indonesia Thailand	Oka; Soemartono; A.Rauf; Soehardjan; Wardoyo NBCRC, DOA, RFD, KUFF
3. Provide appropriate technology transfer to have IPM strategies implemented * Training * Publications * Demonstration areas * Media	+	+	+	+	+		Indonesia Thailand	Samino NBCRC, DOA, RFD, DOAE, KUFF

Appendix 4

National Psyllid Research Coordinators

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Appendix 5

List of Participants

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Observers

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Appendix 6

Leucaena Psyllid Bibliography

SOURCE: NFTA. 1987. Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. A Special Edition of "Leucaena Research Reports" Volume 7 (2): 109 pages. Waimanalo, HI.

Aloalii, Ione. 1987. The Leucaena psyllid in Western Samoa. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Anonymous. 1986. Ipil-ipil infestation in the Philippines: Strategies and approaches for its management. Proceedings Symp. on Ipil-ipil infestation in the Philippines; August 1, 1986; College, Laguna, Philippines.

Barrion, Roberto; R.M. Aguda and J.A. Litsinger. 1987. The natural enemies and chemical control of the Leucaena psyllid, H. cubana Crawford (Homoptera: Psyllidae) in the Philippines. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Beardsley, Jack. 1987. Psyllidae or jumping plant lice: Notes on biology and control. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Beardsley, J. 1986. Psyllidae or jumping plant lice: Notes on biology and control. Leucaena Research Reports 7: 2-5.

Bray, Robert. 1987. Genetic control options for psyllid resistance in Leucaena. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Bray, Robert and Don Sands. 1987. Arrival of the Leucaena psyllid in Australia: Impact, dispersal and natural enemies. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Brewbaker, J.L. 1987. Guide to the systematics of the genus Leucaena (Mimosoideae: Leguminosae). in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Brewbaker, J.L. 1986. Perspectives on the psyllid problem. Leucaena Research Reports 7: 1.

Brown, R.G. 1985. Studies on the taxonomy and ecology of the jumping plant lice (Homoptera:Psylloidea) of Panama. Doctoral dissertation for the Council for National Awards, Department of Biology, Liverpool Polytechnic; Department of Entomology, British Museum (Natural History).

Burckhardt, D. 1986. (Taxonomic paper on the psyllids). Zool. Jour. Linn. Soc. (In Press).

Burckhardt, D. 1986. Nomenclatorial note on Heteropsylla cubana Crawford (Homoptera, Psylloidea), a new pest in Pacific countries. Revue suisse Zool. 93(4):1023-1024.

Burdeos, A.T. 1986. The effect of psyllid population on defoliation of ipil-ipil. Research Problem in Plant Path 251. Epidemiology of Plant Diseases. ViSCA, Baybay, Leyte 7127-A, Philippines.

Burks, B.D. 1943. The North American parasitic wasps of the genus Tetrastichus - a contribution to biological control of insect pests. Proc. U.S. Nat. Mus. 93:505-608.

CAB International Institute of Entomology. 1986. Distribution maps of pests No. 481, December 1986. Heteropsylla incisa Sulc.

Calilung, V.J. 1986. Current research on the biosystematics and control of the ipil-ipil psyllid. Paper presented at the Forum on Ipil-Ipil Psyllid Infestation. UPLB, College, Laguna. May 1986.

Crawford, D.L. 1914. A Monograph of the jumping plant lice or Psyllidae of the New World. Bull. U.S. National Museum. No. 85, 185 pp.

De Guzman, Enriquito. 1987. Summary report: Status of psyllid infestation in the Philippines. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Donaldson, J.F. 1986. The leucaena psyllid. News Bulletin Entomological Society of Queensland 14:53.

Dudley, Nick. Psyllid-resistant Leucaena in biomass trial is a possible future seed source. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Escalada, Rodolfo. 1987. Experiences, work and observations on some aspects of the psyllid/Leucaena problem. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Esteban, I.D. 1986. Ipil-ipil psyllid infestation, dimensions, impacts and imperatives. Paper presented at the Forum on Ipil-Ipil Psyllid Infestation. UPLB, College, Laguna. May 1986.

Ford, Loren. 1987. Exploration for natural enemies of H. cubana in Latin America and the Caribbean. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Funasaki, G.Y. 1985. Koa-haole Psyllid. Reports of the Plant Pest Control Branch. Hawaii State Department of Agric. April, May, June.

Gapas, Jose. 1987. Socio-economic effects of Leucaena psyllid infestation in Central Visayas, Philippines. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Hodkinson, I.D. 1974. The biology of the Psylloidea (Homoptera): a review. Bull. Ent. Res. 64(2):325-338.

Hollenbeck, Leroy. 1987. Some economic implications of the psyllid (katu loncat) infestation on lamtoro (Leucaena) in Indonesia. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Hollingsworth, R.G., R.L. Thomas and W. Liebregts. 1985. New psyllid pest on leucaena in Western Samoa. Leucaena Research Rept. 6: 100-102.

Hsieh, Huann-Ju, Yu-Cheng Chang and Fuh-Jiunn Pan. 1986. Entomogenous fungi as a factor in biological control of leucaena psyllids in Taiwan. Leucaena Research Reports 7: 18.

Huann-Ju Hsieh, Yu-Cheng Chang and Fuh-Jiunn Pan. 1987. The potential of entomogenous fungi as a factor in control of psyllids in Taiwan. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Iablokoff-Khnzorian, S.M. 1982. Les Coccinelles Coleopteres-Coccinellidae. Tribu Coccinillini des Editions Boulee, Paris.

Jensen, D.D. 1957. Parasites of the Psyllidae. Hilgardia. 27(2):77-99.

Justo, H. and R.C. Saxena. 1986. Flight periodicity and interisland movement of the brown planthopper in the Philippines. IRRI Saturday Seminar, Los Banos, Laguna. 17 p.

Lapis, E.B. 1986. Psyllids invade the Philippines. Canopy Int. 12(2):1, 10.

Leeper, J.R. 1976. A review of Hawaiian Coccinellidae. Proc. Hawaii. Entomol. Soc. 22(2):279-306.

Lowry, J.B., E.A. Sumpter and R.G. Megarrity. 1986. Does the leucaena psyllid metabolize mimosine? Leucaena Research Reports 7: 19-20.

Machado, V.L.R. 1982. Morphology and biological aspects of Olla v-nigrum (Mulsant, 1866) and Cycloneda conjugata Mulsant, 1866 (Col., Coccinellidae) predators of Psylla sp (Homoptera, Psyllidae) on Sibipiruna (Caesalpinia pelthophoroides Benth.). Ph.D. dissertation. University of Sao Paulo, Brazil. 61 pp.

Malessy, C.H. Losses caused by H. cubana to the cattle industry in Nusa Tenggara Timur, Indonesia. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

McCauley, David. 1987. Tabular Summary of Country Reports. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

McFadden, M.W. 1986. Evaluation of the Leucaena/Heteropsylla Problem in Hawaii, the Philippines, and New Caledonia. Forestry Support Program, USDA Forest Service, Washington, DC.

Mitchell, Wallace. Concepts of pest control - Integrated Pest Management and Biological Control. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Mitchell, W.C. and Douglas F. Waterhouse. 1986. Spread of the Leucaena psyllid, Heteropsylla cubana, in the Pacific. Leucaena Research Reports 7: 6-8.

Moog, F.A. and J.A. Sison. 1986. Impact of the Ipil-ipil infestation on the animal industry. Bureau of Animal Industry, Visayas Avenuue, Quezon City, Philippines. (mimiograph).

Nakahara, Larry; Walter Nagamine, Shin Matayoshi and Bernarr Kumashiro. 1987. Biological control program on the Leucaena psyllid, H. cubana Crawford (Homoptera: Psyllidae), in Hawaii. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Nakahara, L.M. 1987. Notes and exhibitions. Proc. Hawaii. Entomol. Soc. (in press).

Nakahara, L.M. 1986. Notes and exhibitions. Proc. Hawaii. Ent. Soc. 26(1):11, 15.

Nakahara, L.M. 1986. Notes and Exhibitions--Heteropsylla in Hawaii. Proc. Haw'n. Entomol. Soc. 26:15.

Nakahara, L.M. 1986. Notes and Exhibitions--Definitive Identification of Heteropsylla spp. in Hawaii. Proc. Haw'n Entomol. Soc. (In press).

Nakahara, Larry M. and George Y. Funasaki. 1986. Natural enemies of the Leucaena Psyllid, Heteropsylla cubana Crawford (Homoptera: Psyllidae). Leucaena Research Reports 7: 9-12.

Nakahara, L.M.Y. & P. Lai. 1984. Psyllids; new state records. Hawaii Pest Report 4(2): 2-8. Hawaii Dept. of Agric., Honolulu, Hawaii.

Nitrogen Fixing Tree Association. 1986. Leucaena psyllids - The problem and proposed solution. NFT Highlight.

Oka, Ida N.; S. Wardoyo and M. Soehardjan. 1987. Leucaena psyllid (H. cubana Crawford): A new serious pest of Leucaena trees in Indonesia and its control. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Othman, A.B. and G.M. Prine. 1984. Leucaena accessions resistant to jumping plant lice. Leucaena Research Reports 5: 86-87.

Pan, Fuh-Jiunn. 1987. Psyllid resistance of Leucaena species in Taiwan. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Payot, J.A. 1986. Control of citrus Psylla gains headway. PCARRD Monitor 14(4):9.

Piggin, Colin and Viator Parera. 1987. Leucaena and Heteropsylla sp. in Nusa Tenggara Timur. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Pound, B. and L. Martinez Cairo. 1983. Leucaena: Its Cultivation and Uses. Overseas Development Administration, London. pp. 59-60.

Proverbs, Gerald. 1984. Leucaena: A versatile plant. CARDI, Barbados. p. 9.

Sands, D.P.A. 1986. Survey of Leucaena psyllid (Heteropsylla cubana) in Queensland. CSIRO Division of Entomology Report, Indooroopilly, Queensland, Australia.

Sands, D.P.A. and T.A. Weir. 1986. Predatory Coleoptera associated with the leucaena psyllid, Heteropsylla cubana (Crawford) (Hemiptera: Psyllidae) in Queensland. Journal of the Australian Entomological Society (in press).

Sorennson, Charles, and J.L. Brewbaker. 1987. Psyllid resistance of Leucaena species and hybrids. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Sorensson, Charles and James L. Brewbaker. 1986. Resistance of Leucaena species and hybrids. Leucaena Research Reports 7: 13-15.

Sorensson, C. and J.L. Brewbaker. 1984. Newly introduced psyllid in Hawaii injurious to leucaena. Leucaena Research Reports 5: 91-93.

Stechman, D.H.; H. Lataimaumi and S. Foliaki. 1987. Studies of H. cubana Crawford in Tonga. I. Observations on life cycle. II. Evaluation of predator fauna. III. Development of assessment technique. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Thomas, P.O. and W. Liebregts. 1986. Depredation of Leucaena leucocephala by psyllids in Western Samoa. Leucaena Research Reports 7: 21-23.

Tho, Yow Pong. 1987. The jumping plant lice in peninsular Malaysia: An information note. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.

Tran, L. 1986. Progress report on Ipil-Ipil, Insect pest: Heteropsylla incisa (Sulc.), synomym Heteropsylla cubana Crawford (Hemiptera: Psyllidae). Manila, 12.4.1986.

Universitas Nusa Cendana. 1986 d. Letter to the Governor of NTT about the Heteropsylla sp. insect (jumping lice) in Kabupaten Kupang, Kupang, 23 June 1986.

Villacarlos, L.T. 1986. Biological control of psyllid infesting Leucaena. Research Progress Report. ViSCA, Baybay, Leyte 7127-A, Philippines.

Waterhouse, D.F. & K.R. Norris. 1986. Heteropsylla incisa (Sulc) Hemiptera: Homoptera: Psyllidae. leucaena psyllid. ACIAR Canberra, 17.2. 1986.

Waterhouse, D.F. and K.R. Norris. 1987. Biological control: Pacific prospects. ACIAR Report. Inkata Press, Melbourne, Australia. (in press).

Yang, C.T. and S.J. Fang 1986. A serious pest, Heteropsylla cubana, of Pacific Islands (Homoptera: Psylloidea: Pauropsyllidae). J. Taiwan Museum 39(1):59-61.

Yantasath, Kovith and Jiraporn Watanakul. 1987. New psyllid pest on Leucaena in Thailand. in Proceedings of a Workshop on Biological and Genetic Control Strategies for the Leucaena Psyllid. Special Edition of Leucaena Research Reports, Volume 7(2): 109 pages, Waimanalo, HI.