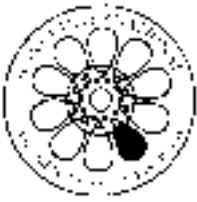




Department of
AGRICULTURE
FISHERIES &
FORESTRY -
AUSTRALIA



Needs Assessment in Taxonomy of Arthropod Pests of Plants in Countries of South East Asia: Biosystematics, Collection and Information Management

**A report prepared by
Ian D. Naumann and M. Md Jusoh**

September 2002

PREFACE

The Australian Agency for International Development (AusAID) manages the Australian Government's overseas aid program with the objective of assisting developing countries to reduce poverty and achieve sustainable development. Because AusAID itself is not an implementing agency, it achieves results by engaging both public and private sector contractors to design and deliver activities on the ground. AusAID has recognised the importance of building regional capacity in quarantine-related areas. It aims to do this through the development of a strategic approach, based on an assessment of needs, to assist developing countries strengthen their quarantine systems and thereby enhance agricultural and rural development.

In October 2001, the Office of the Chief Plant Protection Officer (OCPPO), Agriculture, Fisheries and Forestry – Australia (AFFA), in collaboration with ASEANET, sought funding from AusAID to undertake a comprehensive survey of the capacity and needs of regional institutions holding collections of arthropod pests of plants. The financial support provided by AusAID for this activity through its APEC Support Program is gratefully acknowledged.

Generous assistance in the preparation and delivery of this project was provided by Dr Soetikno S. Sastroutomo, ASEANET Technical Secretary, ASEANET National Co-ordinators and other scientists in the countries visited. We wish to thank them and other officials who spoke with us for their time, hospitality and support for the assignment.

While some countries of South East Asia have substantial entomological (=arthropod) collections, as well as numerous lists, unpublished reports and formal publications on plant pests occurring within their borders, the links between the collections and the records have not always been strong. Many records are not accompanied by voucher specimens or these specimens may now be difficult to locate. Preservation of specimens has not always been a priority and critical material has been lost or exists under threat of destruction. Many specimens that do exist are not supported by essential 'passport' data and cannot meet the international standard for a pest record. Other specimens (often accompanied by usable data) lie unidentified in collections. Consequently, few of the countries visited can meet the obligations imposed on members of the World Trade Organization (WTO) by the Agreement on the Application of Sanitary and Phytosanitary Measures. To a greater or lesser extent, these countries cannot adequately describe the health status of their agricultural industries, thus causing difficulties in managing plant health within their borders.

The problem is twofold:

- Firstly, there is a lack of capacity to identify insects and their relatives, and adjust when names have changed over time;
- Secondly, there has been a failure to give priority to the preservation of specimens over time.

The situation in the countries visited is not unique. Many countries have not assigned institutional responsibilities for building collections and those that do exist are often the result of the enthusiasm and dedication of a small number of scientists working on restricted budgets. Often the arthropod collections are seen as relics of a by-gone era and no longer central to scientific work, or they are seen as relevant only to "low-priority" projects attempting to document the world's invertebrate fauna. As Integrated Pest Management strategies have become prominent, plant health scientists have grasped the importance of being able to identify beneficial arthropods, and of the need for taxonomy and reference

collections. However, it is only in very recent times that collections have been recognised also as a priority for countries trading under WTO rules.

A number of the countries in the region are relatively well endowed with entomologists, including a handful specialising in taxonomic research. These scientists are well placed to support the development of collections if asked to help. Further, ASEAN Senior Officials on the Environment have endorsed the concept of ASEANET, providing a platform for regional collaboration in taxonomy and biosystematics. Key decision makers in agriculture also need to be briefed on the importance of arthropod collections with strong recommendations for giving the development of these facilities a high priority. No one can expect chief executives and politicians to know how important these facilities are – they must be told in terms that they can relate to, that is national development and trade. They also need to understand that these facilities are important to all countries of the region, not just to those countries seeking export markets. Countries importing agricultural commodities need the information contained in collections if they are to develop robust quarantine policies and, given the common borders between countries in the region, there is a strong case for collaborating for security against plant pests that may damage crops and indigenous flora.

The attached report contains a work program for moving forward. It is in part generic, and in part specific to individual countries or agencies. Some specific needs for training, collection and information management, and equipment have been identified. Others will become apparent as progress is made on the more general approach to building diagnostic capacities, building, rehabilitating and curating the collections, and managing the data contained therein.

The introductory chapters of this report incorporate text from a companion document, *Needs Assessment in Taxonomy and Biosystematics for Plant Pathogenic Organisms in Countries of South East Asia* (Evans, Lum and Murdoch, 2002).

I.D. Naumann
M. Md. Jusoh
G. Evans
K.Y. Lum
L. Murdoch

September 2002

CONTENTS

PREFACE	II
1. SUMMARY AND RECOMMENDATIONS	1
2. INTRODUCTION	11
2.1 BACKGROUND TO THE ACTIVITY	11
3. THE CONTEXTUAL ISSUES – WHY THE FOCUS ON PLANT HEALTH?....	13
3.1 PLANT HEALTH AND TRADE	13
3.1.1 <i>What Constitutes a Pest Record</i>	14
3.2 SUSTAINABLE DEVELOPMENT	14
3.3 ENVIRONMENTAL PROTECTION	15
4. COLLECTIONS OF ARTHROPODS.....	16
4.1 THE PURPOSE AND FUNCTIONS OF COLLECTIONS.....	16
4.1.1 <i>The Role of Collections in Trade</i>	16
4.1.2 <i>Collections and Diagnostics - The Key to Plant Protection</i>	16
4.1.3 <i>Collections and Biodiversity</i>	17
4.2 PROTECTING AND MAINTAINING COLLECTIONS	17
4.2.1 <i>Security</i>	17
4.2.2 <i>Curatorial Needs</i>	17
4.3 INFORMATION MANAGEMENT	18
4.3.1 <i>Networks</i>	18
4.3.2 <i>Databasing</i>	19
5. AGRICULTURE IN SOUTH EAST ASIA - COUNTRY PROFILES	21
5.1 BRUNEI DARUSSALAM.....	21
5.2 INDONESIA	21
5.3 LAOS.....	22
5.4 MALAYSIA	23
5.5 MYANMAR.....	23
5.6 PHILIPPINES	23
5.7 SINGAPORE.....	24
5.8 THAILAND	24
5.9 VIET NAM	25
6. CURRENT STATUS OF ARTHROPOD COLLECTIONS IN ASEAN.....	26
6.1 BRUNEI DARUSSALAM.....	26
6.1.1 <i>Plant Pest Unit, Brunei Agricultural Research Centre (BARC)</i>	27
6.1.2 <i>Royal Brunei Museum</i>	28
6.1.3 <i>Ministry of Health</i>	29
6.1.4 <i>Biology Department, Universiti Brunei Darussalam</i>	30
6.1.5 <i>Environment Unit, Ministry of Development</i>	31
6.1.6 <i>The Way Forward for Brunei</i>	31
6.2 INDONESIA	31
6.2.1 <i>Faculty of Biology, Gadjah Mada University</i>	32
6.2.2 <i>Faculty of Agriculture, Gadjah Mada University</i>	33
6.2.3 <i>Faculty of Agriculture, Padjadjaran University</i>	34
6.2.4 <i>Institut Teknologi Bandung (ITB)</i>	34
6.2.5 <i>SEAMEO BIOTROP</i>	35
6.2.6 <i>Central Research Institute for Food Crops (CRIFC)</i>	36
6.2.7 <i>Bogor Agricultural University</i>	37
6.2.8 <i>Museum Zoologicum Bogoriense (MZB)</i>	38
6.2.9 <i>Research and Development Centre for Oceanography</i>	39
6.2.10 <i>Indonesian Agricultural Quarantine Agency (IAQA)</i>	39

6.2.11	<i>The Way Forward for Indonesia</i>	40
6.3	LAOS	40
6.3.1	<i>Soil and Crop Protection Centre, Houiyang</i>	40
6.3.2	<i>National Research Centre, NaPook</i>	41
6.3.3	<i>Quarantine Section, Department of Agriculture</i>	41
6.3.4	<i>Plant Protection Centre, Department of Agriculture</i>	42
6.3.5	<i>National IPM Program Headquarters</i>	44
6.3.6	<i>The Way Forward for Laos</i>	44
6.4	MALAYSIA	44
6.4.1	<i>Entomology Section, Universiti Kebangsaan Malaysia (UKM)</i>	45
6.4.2	<i>Plant Protection Department, Universiti Putra Malaysia (UPM)</i>	46
6.4.3	<i>Malaysian Agriculture Research and Development Institute (MARDI)</i>	47
6.4.4	<i>Crop Protection and Quarantine Division, Department of Agriculture</i>	48
6.4.5	<i>Forest Research Institute Malaysia (FRIM)</i>	49
6.4.6	<i>Agriculture Research Centre, Semongok</i>	51
6.4.7	<i>Forest Research Centre, Kuching</i>	51
6.4.8	<i>Universiti Malaysia Sarawak (UNIMAS)</i>	53
6.4.9	<i>Forest Research Centre, Sandakan</i>	54
6.4.10	<i>Agricultural Research Centre, Kota Kinabalu</i>	55
6.4.11	<i>Malaysian Cocoa Board</i>	56
6.4.12	<i>Institute for Tropical Biology and Conservation (ITBC)</i>	56
6.4.13	<i>The Way Forward for Malaysia</i>	58
6.5	MYANMAR	58
6.5.1	<i>Plant Protection Division, Myanmar Agricultural Service</i>	59
6.5.2	<i>Yezin Agricultural University</i>	62
6.5.3	<i>Forest Department, Ministry of Forestry</i>	63
6.5.4	<i>Natural History Museum, Yangon Zoological Gardens</i>	64
6.5.5	<i>Hlawga Natural History Museum</i>	64
6.5.6	<i>National Museum</i>	65
6.5.7	<i>The Way Forward for Myanmar</i>	65
6.6	PHILIPPINES	66
6.6.1	<i>Plant Quarantine Laboratory, University of the Philippines Los Baños</i>	67
6.6.2	<i>Department of Entomology, University of the Philippines Los Baños</i>	67
6.6.3	<i>Museum of Natural History, University of the Philippines Los Baños</i>	68
6.6.4	<i>Department of Entomology, Benguet State University</i>	69
6.6.5	<i>College of Agriculture, Central Luzon State University</i>	70
6.6.6	<i>Philippines Rice Research Institute (PhilRice)</i>	70
6.6.7	<i>Crop Protection Division, Department of Agriculture</i>	71
6.6.8	<i>National Museum of the Philippines</i>	72
6.6.9	<i>The Way Forward for the Philippines</i>	73
6.7	SINGAPORE	74
6.7.1	<i>Raffles Museum of Biodiversity Research</i>	74
6.7.2	<i>Entomology Laboratory, Agri-food and Veterinary Authority</i>	76
6.7.3	<i>Environmental Health Institute</i>	76
6.7.4	<i>Singapore Botanic Gardens</i>	77
6.7.5	<i>The Way Forward for Singapore</i>	77
6.8	THAILAND	78
6.8.1	<i>National Biological Control Research Centre (NBCRC)</i>	78
6.8.2	<i>Department of Entomology, Kasetsart University</i>	81
6.8.3	<i>Entomology and Zoology Division, Department of Agriculture</i>	82
6.8.4	<i>Forest Insect Group, Royal Forest Department</i>	84
6.8.5	<i>Department of Plant Protection, Mae Jo University</i>	85
6.8.6	<i>Department of Entomology, Chiang Mai University</i>	86
6.8.7	<i>Department of Entomology, Khon Kaen University</i>	86
6.8.8	<i>Department of Pest Management, Prince of Songkla University</i>	88
6.8.9	<i>The Way Forward for Thailand</i>	89
6.9	VIETNAM	91

<i>6.9.1 National Institute of Plant Protection (NIPP)</i>	91
<i>6.9.2 Forest Science Institute of Vietnam</i>	93
<i>6.9.3 Hanoi Agricultural University</i>	94
<i>6.9.4 Institute of Ecology and Biological Resources (IEBR)</i>	95
<i>6.9.5 The Way Forward for Vietnam</i>	97
7. REFERENCES	99
ATTACHMENT 1: QUESTIONNAIRE	100
ATTACHMENT 2: REGIONAL CONTACTS	105

1. SUMMARY AND RECOMMENDATIONS

I.D. Naumann, M. Md. Jusoh, G. Evans, K.Y. Lum and L.J. Murdoch

The Project Team

In February 2002 the Australian Agency for International Development (AusAID) allocated resources from its APEC Support Program for a stock take and needs assessment of collections of arthropod pests of plants¹ throughout the countries of South East Asia. The assignment was undertaken by Dr Ian D. Naumann from the Office of the Chief Plant Protection Officer (OCPPO), Agriculture Fisheries and Forestry – Australia (AFFA) and Dr Md. Jusoh Mamat of the Malaysian Agricultural Research and Development Institute (MARDI) in his capacity as Network Coordinator of ASEANET.

ASEANET is the South East Asian LOOP of BioNET-INTERNATIONAL, an organisation that works cooperatively and on a world scale to enhance the capacity of developing nations to undertake taxonomy work. ASEANET's mission is to achieve self-reliance in taxonomy and biosystematics² of insects, nematodes and micro-organisms for its member countries through sharing of resources and the reciprocal provision of expertise and services in plant health. Work programs focus on effective networking through the application of information and communication technologies, human resources and training, rehabilitation of biological collections and development and application of new technologies. ASEANET was established after formal endorsement at the 9th ASEAN Senior Officials Meeting on the Environment in September 1998.

The Contextual Issues

For developing countries in the ASEAN region, agricultural and rural development is vital for sustainable growth and poverty reduction. The development challenge facing these countries is to manage their plant health to maximise productivity, address food security concerns, conserve natural resources, and generate rural income by participating fully in international trade in agricultural products. The industrialised and more advanced of the developing countries of the region also need robust plant health infrastructure to manage plant pests, to preserve the integrity of quarantine borders and to support trade in agricultural commodities.

In order to address these challenges, ASEAN countries must have a detailed knowledge of their plant health status and be able to access information on the biology, distribution, host range and economic status of plant pests and pathogens³. Biological collections contain much of this information and are of fundamental importance to regional countries as they seek to improve their quarantine security, protect agriculture and natural resources, and underpin market access negotiations in the global trading environment.

¹ Arthropod or entomological collections comprise specimens of insects, mites, spiders and their relatives, which have been preserved either dry (usually pinned), in alcohol or as microscope slide preparations.

² Taxonomy and biosystematics deal with the identification (naming) and classification of all living organisms and are the foundation on which all other biological sciences depend.

³ Hereinafter the term pest is used to include arthropod pests, nematodes and plant pathogens.

Plant Health and Trade Policy

The establishment of the World Trade Organization (WTO) in 1995 is widely seen as providing new opportunities for trade in agricultural commodities. The reality, however, may be very different unless barriers based on health and quarantine are managed effectively under the WTO Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures. SPS measures are domestic standards or regulations covering such matters as the presence of microbial contaminants, toxins, heavy metals and pesticide residues in food and pests, weeds and pathogens. The SPS Agreement removes the rights of countries to arbitrarily restrict access to domestic markets on health and safety grounds and calls on members to harmonise sanitary and phytosanitary measures on a global basis by adopting international standards, guidelines and recommendations, where these exist.

Among other things, the SPS Agreement requires prospective exporting countries and target markets to provide scientific evidence to substantiate any claims regarding the presence or absence of pests. It is not acceptable to indicate that a pest is 'not known to occur'; rather, evidence needs to be presented to support the assertion that the pest is 'known not to occur'. In this regard, diseased specimens and culture collections are the only internationally recognised evidence of the existence of a pest in a country. If a country is able to provide accurate records to validate the pest status of a region, overseas market access bids for agricultural products can be processed quickly, with obvious benefits to the rural sector. Long delays are encountered when these data are not available and this can be a source of ongoing trade friction.

Status of Disease Arthropod Collections in ASEAN

In Section 6 of this report the Project Team presents its observations on arthropod collections in the institutions that were included on their schedule of visits in Brunei Darussalam, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. While the purpose of the assignment was to assess collections of relevance to agriculture, the Project Team also visited collections of forest research institutions and natural history museums. This was done because arthropod collections, wherever they occur, tend to include at least some specimens of pest and beneficial species, as well as material of no known, direct economic significance. Because of this intermingling of species in most collections, it is impossible to consider pest arthropods collections entirely independently of "biodiversity" collections. Furthermore, the expertise to identify arthropods pests often resides with specialists in universities, forest institutes or natural history museums.

Institutional responsibilities for maintaining arthropod collections are ill-defined in several of the countries visited. This is reflected, in part at least, in the low level of resources allocated to maintaining specimens and the poor state of some collections. The well-being of these valuable national resources is largely dependent on a small number of dedicated scientists in government agencies, research establishments and universities⁴. The Project Team identified a number of matters that need to be addressed to improve the arthropod collections in ASEAN countries in order to bring these to an adequate standard to

⁴ In this regard the situation is not so very different from what exists in Australia, with only a few collections protected by legislation and most functioning in an environment of declining real resources when aggregate funding for agricultural research and development has remained relatively constant in real terms. Recognising the problem, and with plant health now a major trade policy issue, new money is beginning to flow to Australia's collections through Plant Health Australia.

support national plant health policy, including pest risk assessments to underpin market access negotiations. These matters are listed below⁵:

- A need to enhance understanding among some senior managers, and even some plant health professionals, of the importance of herbaria and collections as the most vital component of a country's plant health infrastructure;
- Insufficient numbers of plant health professionals in most agencies/institutions, especially trained specialists for identifying arthropods;
- A need to enhance understanding among some plant health professionals of the opportunities to use the informal global network of specialists to assist them to identify arthropods – providing a cost-free way of having specimens identified;
- A need to enhance the maintenance of existing herbaria and collections in some institutions to arrest the loss of valuable records;
- A need to improve infrastructure for maintaining collections;
- A need to improve 'passport' data on specimens to meet the International Plant Protection Convention (IPPC) standard (ISPM No. 8⁶) for a pest record;
- A need to improve systems for extracting data on specimens held in collections;
- A need to improve understanding among scientists in regional laboratories and universities of the role they might play in supporting the development of national collections; and
- A need to improve understanding among some senior managers of the importance of plant health as a trade policy issue.

Recommendations

RECOMMENDATION 1

Noting the need to create awareness among senior managers and plant health scientists in the ASEAN region of the critical importance of arthropod collections, it is recommended that donor agencies consider supporting a meeting to consider the issue of institutional responsibilities for these national facilities.

This might be achieved by (1) including the matter on the agenda of the next (3rd) ASEANET LOOP Coordinating Meeting (LCC), which is to be hosted by Brunei in early 2002, and (2) expanding participation in the LCC Meeting to include institutional managers responsible for National Plant Protection Organisations (NPPOs) and other plant health agencies. It is suggested that the 3rd ASEANET LCC Meeting seeks support for a portfolio of activities structured to build capacity in identifying arthropod pests, building and maintaining collections, and data management.

⁵ To a greater or lesser degree, the problems identified by the Project Team are encountered in institutions in Australia and elsewhere.

⁶ ISPM No.8 refers to the IPPC standard that sets out minimum data requirements to establish a pest record.

RECOMMENDATION 2

It is recommended that donor agencies give consideration to supporting series of small workshops which bring together selected scientists and technical staff from member countries and an internationally recognised expert or experts to enhance diagnostic, specimen preparation and networking skills to pursue identification of arthropod pests of regional concern.

Important objectives would be to assess the effectiveness of currently diagnostic tools, assess the effectiveness of such workshops in promoting networking, and to test the concept that regional collaboration is viable. Information gathered during the present survey indicates that workshops on the following groups of arthropods are high priorities: Hymenoptera (especially parasitic wasps); Coleoptera (especially predatory and phytophagous beetles); Diptera-Tephritidae (fruit flies); Acarina (mites); Thysanoptera (thrips); Lepidoptera (moths and larvae).

This recommendation recognises that for the foreseeable future a critical resource in the region will be a group of highly skilled graduates:

- who perform the bulk of the region's diagnostic work;
- undertake limited independent taxonomic research themselves; and
- liaise frequently with each other and a small number of regional taxonomic specialists.

RECOMMENDATION 3

Recognising the varying levels of skills in specimen preparation and collection management, the Project Team recommends that relevant donor agencies approach ASEANET with a proposal to host a series of regional workshops bringing together plant health scientists and technical staff responsible for collecting, preparing and managing arthropod specimens, with view to exchanging information on preparation, preservation techniques, storage needs, loans, record keeping and data standards (including data required to meet the ISPM No. 8, the IPPC international standard for a pest record).

And,

RECOMMENDATION 4

It is recommended that relevant donor agencies approach ASEANET with a proposal to support a series of small workshops to consider opportunities for the development of databases to key arthropod collections.

These workshops might be coordinated or co-funded by the Global Biodiversity Information Facility as part of this organisation's Outreach and Capacity Building Program. Matters for consideration might include the data required by developing countries from proposed information systems, the choice of appropriate software, the development of national networks and nodes, data capture techniques, and access to up-to-date nomenclatural databases and gazetteers.

RECOMMENDATION 5

It is recommended that donor agencies give consideration to supporting specialised/targeted training for selected ASEAN scientists in taxonomy and related areas, to enhance regional capacity to identify pest and beneficial arthropods, develop new diagnostic tools, take advantage of global networks and opportunities, improve collection management, and provide guidance to the management of digital data.

Options include: (1) mentoring, through short visits to enable one-on-one sessions and longer term support by email; (2) six-twelve month placements during which a developing taxonomist works with an experienced specialist in the latter's institution, while continuing to perform some work duties for his or her own country (e.g. continuing to provide some identifications); (3) M.Sc. or Ph.D. training within or outside the region.

RECOMMENDATION 6

Noting the problems of recurrent funding for maintaining essential diagnostic facilities and deficiencies in accommodation provided for arthropod collections, it is recommended that relevant donor agencies give consideration to opportunities for providing what would be relatively modest support for plant health infrastructure.

The buildings and associated infrastructure of several South East Asian collections are amongst the finest in the world. The facilities of the MZB, at Cibinong in Indonesia, and the new quarters for collections at the University of Sabah are notable examples of modern museum design for tropical climates. However, such modern facilities are the exception rather than the rule, and in reality few collections and taxonomists in the region currently occupy purpose-built facilities. That having been observed, it is premature to advocate the construction of a series of state-of-the-art museums and laboratories throughout the region. Minor renovations of existing rooms, the installation of adequate air-conditioning and de-humidification units, and the upgrading of fire prevention facilities would enhance the security of many of the collections visited during this survey. This agenda should be pursued in the short term, rather than a building program, which would leave institutions with facilities whose running costs would cripple annual operating budgets.

RECOMMENDATION 7

It is recommended that relevant donor agencies give consideration to the opportunities for selectively providing essential laboratory equipment and specialist literature to the new ASEANs to match advances in the capacity of their scientists to make use of the equipment and publications.

The present survey reveals that many laboratories require dissecting microscopes to enable specimen preparation and routine identification of small arthropods.

An emerging need is for digital cameras. These make it possible to take a photograph of an arthropod pest or its damage to a crop plant, and send the image via the internet to a specialist anywhere in the world for rapid identification, or the image can be posted to an internet "Listserver" where hundreds or thousands of subscribers will see it. The exchange of digital images also enables real-time collaboration between scientists, and has the potential to overcome part of the impediment of isolation that hampers taxonomic specialists in the South East Asian region.

Access to specialist literature for the identification of arthropods is a widespread and recurring problem in the region. Even with the advent of digital technologies, the publication of taxonomic information remains paper-based, scattered and somewhat arcane. Knowing what has been published and obtaining copies of taxonomic papers and books can be problematic even for specialists in developed countries. For the foreseeable future it seems that paper and CD-based technical literature will be essential tools for the identification of arthropods. It was noted that often specialists had obtained or purchased specialist literature with their own resources and that this material did not form a permanent library associated with the collection. This could create problems when specialists move on or retire.

RECOMMENDATION 8

Noting the commonalities between the Global Taxonomy Initiative (GTI) under the Convention on Biodiversity, it is recommended that ASEANET and regional plant health specialists participate in regional GTI discussions with the view to establishing plant health diagnostic needs firmly in the regional GTI agenda.

Furthermore, it should be noted that in many instances the expertise required for the identification of arthropod pests might be developed through programs whose explicit aim is the documentation of biodiversity. Opportunities for joint priority setting, collaboration and co-funding should be explored.

RECOMMENDATION 9

Noting that many arthropod collections containing records of significance to plant health reside within universities, it is recommended that each University take steps towards formal recognition of collections under their control.

This recognition implies that the University's governing body understands that the collection is of long-term value, approves certain management arrangements, commits to the allocation of resources for the upkeep of the collection, and avoids decisions that might adversely affect the security of the collection. Normally, management arrangements would include the nomination of a senior member of staff as having overall responsibility for the collection and of at least a part-time curatorial assistant. The goals and policies of the collection should be documented. In the event that a University does not wish to maintain a collection beyond the term of a particular staff member or activity, arrangements should be made for the transfer of the collection to another appropriate agency or institution.

It is recommended that where a University formally recognises a collection and approves the collection's role, the full cost of the collection should be shown as a budget item.

It is not unreasonable that academic staff who are assigned or assume responsibility for a recognised collection, should in turn receive recognition for their contributions in this role. This might include the formal title of "Director" or "Curator", acknowledgment in proposals for promotion or tenure, reduction in teaching hours, or a salary supplement. In many cases it will also be reasonable that curatorial assistants receive some specialist training and appropriate recognition for the acquisition of collection-related skills.

RECOMMENDATION 10

It is recommended that institutions, which maintain collections, give consideration to the establishment of advisory boards where these do not already exist.

An independent Advisory Board, Council or Committee can form an important component in the governance of a major collections or museum. The composition and role of such a body will vary according to the nature of the institution or agency, management structure, and the overall purpose of the collection or museum. Commonly, an Advisory Board will include a representative of the collection's management, independent scholars or specialists, a cross-section of those who use or benefit from the collection, and a representative of an appropriate funding agency. As for its role, a Board commonly considers matters of broad policy, assists with the development of funding proposals, and provides important linkages to users of the collection and expertise associated with the collection. For many of the arthropod collections surveyed in this report, an Advisory Board might include representatives of agencies with responsibilities including quarantine, biological control, Integrated Pest Management, forest health, and biodiversity. Where a University maintains more than one collection or museum, a single body with oversight of all of these entities might be appropriate.

RECOMMENDATION 11

It is recommended that curators and officials responsible for collections give consideration to the formation of national networks of entomological collections.

Within most ASEAN countries, networking among collections and museums holding arthropod collections appears to be weak. While many curators and specialists have regular dealings with other collections within their own country, many other work quite independently. In countries such as Indonesia, Thailand, Malaysia, the Philippines and perhaps Vietnam, where collections are numerous and geographically dispersed, it might be worth considering the formation of a national Council of Entomological Collections. Such a body could act as a forum for discussion of common problems, opportunities and goals. Two models for such a body are the Australian Council of Heads of Australian Entomological Collections (CHAEC) and the North American Entomological Collections Network (ECN). Both meet annually, during scientific meetings of the respective entomological societies. Discussions within these bodies commonly range from broad policy matters, such as approaches to national funding bodies, to day-to-day curatorial issues, such as where to find a reliable supplier of insect pins. From the formation of a national Council or network it is a small step to the notion of a distributed national collection.

A within-country Council or network would complement the work of the inter-country network, ASEANET. The within-country network would enable local needs and objectives to be fed into the development of regional plans, and provide a mechanism for the local implementation of regional strategies.

RECOMMENDATION 12

It is recommended that regional institutions with capacity to provide identifications continue to waive fee-for-service charges for this service wherever appropriate and possible.

At almost every institution plant health scientists reflected on the cessation of the identification service previously provided by specialists based at the Natural History Museum, London. This service had been available free of charge for most of the twentieth century, firstly from the Imperial Institute of Entomology (IIE), then from the Commonwealth Agricultural Bureau, and finally from the increasingly commercial CAB International (CABI). Identifications can still be obtained from specialists at the Natural History Museum, London, but at substantial cost. CABI and the Natural History Museum are typical of institutions in the developing world in that they are required to at least recover costs of “non-core” activities, such as providing identifications. It is now nearly impossible to secure identification services at no or low cost. While this state of affairs might be regrettable, it must be accepted. As has been observed many times in recent years, specialists in developing countries can overcome this impediment by forming co-operative, regional, support networks.

While a fee-for-service system has its supporters, it is of dubious practicality in the cash-poor environment of South East Asian agricultural agencies.

RECOMMENDATION 13

The profile of arthropod collections in the region should be raised by publishing the summary information on the collections, and listing them on appropriate internet sites.

The arthropod collections within the region are largely unknown to the world's taxonomic community. Consequently, specialists undertaking original taxonomic research tend not to visit the collections or borrow material from them in the course of their work. Thus, most collections fail to benefit from what is in essence an ad hoc but free sorting and identification service. The profile of regional collections can be raised by the publication of summary information, including contact details. Collections should be listed on the ASEANET Internet site and added to the directory of world entomological collections maintained by the Bernice P. Bishop Museum, Honolulu, Hawaii. Some collections in this survey do not have a loans policy or housekeeping procedures to support the lending of material for research purposes.

RECOMMENDATION 14

In view of the extreme difficulties experienced by many regional plant health specialists in gaining access to taxonomic literature, initiatives towards the creation of regional or global master names databases are supported.

And,

RECOMMENDATION 15

In view of the current difficulty of collating information on arthropod specimens which have been collected in the region and are now preserved in institutions outside the region (e.g. in Europe, North America and Australia), it is recommended that institutions holding such material give priority to publishing metadata describing their holdings or give priority to records from the South East Asian region in their data digitising programs.

Further,

RECOMMENDATION 16

It is recommended that donor agencies selectively assist the provision of CD-based information even where this information is available via the Internet.

While many countries and institutions in the region enjoy reliable, broadband access to internet information resources, many do not and will not in the immediate future.

2. INTRODUCTION

G. Evans, K.Y. Lum, L.J. Murdoch, I.D. Naumann and M. Md. Jusoh

For developing countries in the South East Asian region, agricultural and rural development is vital for sustainable growth and poverty reduction. The development challenge facing these countries is to manage their plant health to maximise domestic productivity, address food security concerns, conserve natural resources, and generate rural income by participating fully in international trade in agricultural products.

In order to address this challenge, these countries must have a detailed knowledge of their plant health status and be able to access information on the biology, distribution, host range and economic status of plant pests and pathogens. Biological collections, and the associated expertise in taxonomy, are repositories of such information and are of fundamental importance to regional countries as they seek to improve their quarantine security, protect their natural resources, and underpin market access negotiations in the global trading environment.

2.1 Background to the Activity

This activity is an initiative of the Office of the Chief Plant Protection Officer (OCPPO) and ASEANET, a Technical Cooperation Network for sustainable development through capacity building in taxonomy.

ASEANET was established after formal endorsement at the 9th ASEAN Senior Officials Meeting on the Environment in September 1998. It is the South East Asian LOOP of BioNET-INTERNATIONAL, an organisation that works cooperatively and on a world scale to increase the capacity of nations to undertake biosystematic work. A particular goal of BioNET is to enhance the ability of developing nations to identify, document and understand their arthropods, fungi, nematodes and other microorganisms. The organisation encompasses biosystematic issues relevant to agriculture, forestry, fisheries, international trade, international treaties and conventions, natural resource management, conservation and biodiversity.

The regional subgroups of BioNET are known as 'LOOPS' (Locally Organized and Operated Partnerships) and comprise a regional secretariat and a contact institution in each member nation. ASEANET's mission is to achieve self-reliance in taxonomy and biosystematics for ASEAN member countries through sharing of resources and the reciprocal provision of expertise and services in plant health. Four work programs to build capacity in taxonomy and biosystematics have been proposed by ASEANET. These programs cover:

- Development of information and communication services
 - Includes establishing a standardised database system which links regional institutions involved in taxonomy to facilitate common access to information both within and between countries.

- Human resource development and training
 - With the objective of improving access to formal training courses in taxonomy and biosystematics in the region.
- Rehabilitation of resources
 - This program encompasses both the rehabilitation of centres holding collections of regional importance and the repatriation of collection information.
- Development and application of new technologies
 - This includes the acquisition and/or development of biochemical, molecular and computer-based diagnostic systems, including electronic keys.

The rehabilitation of biological collections, together with the adoption of information technology to improve access to the valuable data lodged in the collections, has been identified by ASEANET as a priority area for member countries. However, the implementation of an effective work program to build capacity in this area is dependent on having an understanding of the relative strengths, weaknesses, and needs of countries in the region.

It was against this background that the OCPPO and ASEANET sought financial support from AusAID to undertake an assessment of the needs of regional institutions holding plant pathogen collections. The collaborating agencies outlined their objectives for the needs assessment in the following terms:

- To conduct a survey of regional countries to gather comprehensive information with respect to the status of institutional capacities and practices in taxonomy and identification of arthropods, including collection management, data handling, information management, infrastructure and human resources.
- To assess the existing level of diagnostic and taxonomic expertise available to support arthropod collections and the areas of critical need.
- To determine the needs of regional countries to achieve realistic self-reliance as envisaged for an operational regional network in taxonomy.

Because collections do not exist in all countries of the region, the needs assessment focused on those countries that have some capacity in taxonomy and biosystematics. These countries are Brunei Darussalam, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, Singapore and Viet Nam.

3. THE CONTEXTUAL ISSUES – WHY THE FOCUS ON PLANT HEALTH?

G. Evans, K.Y. Lum and L.J. Murdoch

The completion of the Uruguay Round of trade negotiations under the General Agreement on Tariffs and Trade and establishment of the World Trade Organization (WTO) in 1995 are seen as holding particularly significant implications for plant health and crop protection. The WTO Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures sets conditions, based on scientific principles and risk assessment, to protect agricultural industries from exotic pests⁷, yet at the same time facilitate trade in agricultural commodities. The Agreement allows members to restrict access to their markets on health and safety grounds, but these restrictions must be transparent and technically justified.

In order for countries to benefit from the spirit of trade liberalisation embodied in the agreement establishing the WTO and participate fully in international trade, they must be able to comply with SPS obligations. The basic infrastructure underpinning plant health is vital if quarantine services are to meet the requirements of the SPS Agreement for a scientific analysis of the risk of moving pests with traded commodities. 'Basic plant health infrastructure' encompasses: a capacity to accurately and rapidly identify pests; and an ability to provide detailed records on the occurrence and distribution of pests, based on voucher specimens and effective monitoring and surveillance systems.

Capacity in plant health is also important to promote sustainable development and protect biodiversity. In this section, we discuss the role of plant health in:

- *Trade* - countries seeking to export agricultural commodities must know what pests could affect those commodities and be able to provide scientific data to support market access negotiations.
- *Sustainable development* - plant pests continue to reduce productivity in all agricultural enterprises. Countries that have an accurate knowledge of their plant health status, and the ability to detect, identify and manage incursions of exotics, are better able to assess the risks associated with the importation of commodities from overseas and develop sustainable pest management programs, providing improved protection to the rural sector.
- *Environmental protection* - pests of agricultural commodities can also threaten ecosystems and natural habitats. Sustainable pest management, including the prevention, containment and control of invasive species, is vital for both biodiversity conservation and agricultural production.

3.1 Plant Health and Trade

A key element in negotiations for market access is the capacity of quarantine services to provide a detailed pest risk analysis (PRA), based on records of the occurrence and distribution of plant pests in exporting countries.

⁷ The term 'pest' is used to include both arthropod pests and plant pathogens.

PRAs cover such matters as:

- The plant health status of agricultural industries in the country or region from which the commodities are to be sourced;
- The likelihood of pests of concern being transported with commodities and establishing in the importing country;
- Potential damage that introduced pests might cause to crops and native flora; and
- The efficacy of phytosanitary measures that might be used to manage identified risks.

Under the SPS Agreement, both the prospective exporting country and the target market must be able to provide scientific evidence to substantiate any claims regarding the presence or absence of plant pests. This information should include details about a pest's geographical distribution, its biology and economic importance. It is not acceptable to indicate that a pest is 'not known to occur'. Rather, evidence needs to be presented to support the assertion that the pest is 'known not to occur'. If a country is able to provide accurate records to validate the pest status of a region, overseas market access bids for agricultural products can be made quickly, with obvious benefits to the rural sector. Long delays are encountered when these data are not available and this can be a source of ongoing trade friction.

3.1.1 What Constitutes a Pest Record

The SPS Agreement identifies the International Plant Protection Convention (IPPC) as the international organisation responsible for phytosanitary standard setting and the harmonisation of measures affecting trade. The IPPC complements the SPS Agreement by providing the international standards that help to ensure that phytosanitary measures have a scientific basis for their implementation and are not used as unjustified barriers to international trade.

The IPPC has recognised that all importing and exporting countries need reliable information concerning their plant health status if they are to conduct risk analyses, establish and comply with phytosanitary regulations, develop pest management programs, and maintain pest free areas. To assist countries meet their obligations under the SPS Agreement for the provision of accurate plant health data, the IPPC has set out the requirements for a pest record in the standard *Determination of Pest Status in an Area* (ISPM No.8). The standard identifies the basic information that is needed to constitute a pest record, namely:

- current scientific name of the organism;
- life stage or state (e.g. larva, fruiting bodies);
- taxonomic group (e.g. family, order);
- identification method (e.g. taxonomic description by a specialist);
- date and place (locality) recorded;
- prevalence;
- scientific name of the host(s), where appropriate;
- host damage, or circumstances of collection; and
- references or other information pertaining to the observation.

3.2 Sustainable Development

Incursions of exotic pests pose an ongoing threat to sustaining primary production in all enterprises. The impact of the movement and establishment of exotic organisms varies considerably, depending on the biology of the pest and its host range. In some cases,

existing measures applied to manage endemic pests will control the exotic pest at no additional cost to the rural sector. In other instances, an exotic incursion may have major implications for specific agricultural industries through crop losses, increases in production costs, and immediate loss of markets. There is also the possibility that the threat posed by new exotic pest will extend beyond agriculture, to amenity flora, environmental ecosystems and the general public.

Potential impacts of an exotic incursion include:

- Yield loss in host crops and/or downgrading of quality;
- On-going increases in production costs due to additional control and disinfestation measures;
- Economic losses due to market access restrictions;
- Additional research and development costs;
- Damage to environmental ecosystems and/or amenities (gardens, parks, etc); and
- Risks to human health.

The ability to manage endemic pests and address exotic threats through contingency planning is vital for countries seeking to increase agricultural production and the export performance of the rural sector. Pre-emptive strategies underscored by a strong capability in taxonomy, plant health data management, diagnostics and surveillance are central to any biosecurity strategy and are increasingly important in international trade as a result of the SPS Agreement.

3.3 Environmental Protection

The transborder movement of invasive species is widely recognised as potentially causing environmental harm. Under the Convention on Biological Diversity (CBD), contracting Parties have an obligation to *prevent the introduction of, control or eradicate those alien species, which threaten ecosystems, habitats and species*. This includes plant pathogens, arthropod pests, weeds and other organisms that threaten the stability of managed (agriculture and forestry) and natural ecosystems.

However, the control and management of invasive species presents a substantial challenge because it requires an understanding of their biology, population dynamics, status in the country, and ecological and economic impacts. Basic capacity in plant health, including the ability to identify, control and monitor these organisms, is vital if countries are to fulfil the requirements of the CBD for the prevention of the movement of invasive species and the mitigation of their impacts on biodiversity.

4. COLLECTIONS OF ARTHROPODS

G. Evans, K.Y. Lum, L.J. Murdoch, I.D. Naumann and M. Md. Jusoh

4.1 The Purpose and Functions of Collections

The arthropods associated with agricultural crops and native flora include a diverse array of insects, mites and their relatives. In some cases these species cause direct damage to host plant by feeding or other habits, but there are also many species, especially among the plant-sucking bugs, which are vectors of plant diseases. Collections of arthropods serve a number of purposes. In particular, they:

- Facilitate the preparation of market access bids for agricultural products and ensure that quarantine decisions are appropriate;
- Support the timely identification of pests and natural enemies, especially where technical publications for diagnosis do not exist, are unobtainable or are inadequate; and
- Record biodiversity.

4.1.1 The Role of Collections in Trade

Information on the presence or absence of a pest is available from many sources and has varying levels of reliability. However, in the context of international trade, records based on voucher specimens that are held in properly curated collections provide the most reliable evidence of a country's plant health status. This is because these specimens can be re-examined to prove their veracity or to obtain more precise data on the circumstances under which the specimens were obtained and on their distribution.

On the other hand, published records that are not supported by voucher specimens cannot be validated and are a potential impediment to agricultural trade. Erroneous records can be extremely difficult, time-consuming and expensive to disprove to the satisfaction of a prospective trading partner. As a result, specimens and other material contained in biological collections provide a country with a powerful tool to assist bids for market access and to justify measures to exclude potentially harmful exotic species.

4.1.2 Collections and Diagnostics - The Key to Plant Protection

Collections of arthropods, and the associated taxonomic expertise, provide critical support to decision makers during the development of quarantine measures and response strategies for incursions by exotic arthropods because they hold vital information concerning a pest's distribution, life cycle, natural enemies and alternative host(s). These resources also underpin the day-to-day management of endemic pest problems and can be particularly valuable to the development of Integrated Pest Management strategies.

In the case of incursions by exotics, a decision on whether to control, eradicate or manage an outbreak must be taken quickly and is heavily dependent on the ability to obtain a fast and reliable identification of the species involved. Reference collections containing well-curated specimens provide the soundest basis with which to compare unknown species and facilitate the rapid and accurate identification of exotics.

Accurate identification is important because a correct diagnosis will minimise economic and environmental losses. Conversely, the incorrect identification of an arthropod can have serious implications, particularly in terms of productivity, quality and trade. Inappropriate control measures may be applied and/or opportunities for eradication lost.

4.1.3 Collections and Biodiversity

The rich biodiversity of countries in the South East Asian region is well recognised. Taxonomy and biosystematics have an important role in conserving these valuable resources. These disciplines provide the scientific tools to identify, catalogue and monitor biodiversity. Collections contribute to our knowledge of biodiversity and also hold data on pathogens that threaten natural ecosystems as well as agriculture. This information is vital for countries seeking to protect their natural resources and meet their international obligations under the Convention on Biodiversity (CBD).

Systematic biology also affords access to biological information crucial to support the sustainable use of natural resources. For example, the ability of plant protection officers to develop integrated pest management programs in order to minimise reliance on pesticides is dependent on the accurate identification of biological control organisms, such as natural predators and parasites.

4.2 Protecting and Maintaining Collections

Arthropod collections frequently contain tens or hundreds of thousands of records, including dry (usually pinned) specimens, “wet” specimens stored in alcohol, and slide mounts. Given the value of these collections for agriculture and the environment, it is absolutely critical that they have appropriate protection and are adequately maintained. In this section, we discuss their security and curatorial needs.

4.2.1 Security

Collections require physical security as well as recognition of their value by government.

Statutory protection is vital to ensure that legal arrangements are put in place for the permanent care and curation of important biological collections. In terms of physical security, the specimens need to be housed in secure, fireproof premises in which temperature and humidity are controlled. Specimens must be maintained in conditions best suited to their long-term survival. Ideally, collections should be located in the same building or nearby to the associated taxonomists and curators, but separated from other activities such as the rearing of live insects.

4.2.2 Curatorial Needs

The maintenance and curation of collections would not be possible without staff skilled in taxonomy and with knowledge of the principles and practices of biosystematics. Biosystematics is the development of classifications that are based on anatomical characters and biological features. Biosystematics takes into account morphological, historical,

geographical data as well as biological information such as host range or parasitic associates, and commonly includes analytical studies to determine biological or evolutionary relationships. Taxonomy is the practice of identifying, describing and naming organisms based on the rules of zoological nomenclature. Taxonomy provides the basis for identification and classification of organisms to the genus, species and sub-species levels. The development of any collection is dependent on continued research in both of these disciplines.

Staff responsible for the curation of collections need access to diagnostic keys and specialist scientific literature. While print sources predominate, increasing numbers of these diagnostic keys are available in electronic format, on CDs or from internet sites. Staff also need dissecting microscopes, compound microscopes and good quality light sources to enable the preparation and identification of arthropod specimens.

Pinned arthropod specimens can be stored either in wooden store boxes or in specially designed drawers in wooden or metal entomological cabinets. Collections in which dry specimens are pinned into movable trays within standardised drawers are easiest to manage and protect. Alcohol-preserved specimens tend to be accommodated in small vials, which are stored in racks, boxes or bathed in alcohol in large jars. Very small specimens are commonly mounted on glass microscope slides, usually in permanent, clear media under very thin, glass cover slips. Microscope slides are stored either flat or vertical in drawers or boxes. For all specimens, labels should be associated with specimens and use durable ink and paper.

In addition to looking after the collection and providing taxonomic support to quarantine services and agricultural industries, taxonomists increasingly need to be proficient in the use of electronic databases to manage disease records and other data held in the collection. Many curators regard access to computer indexing or databasing systems as a priority.

While it is difficult to judge how many people are required to support any one collection, there is a need for adequate staffing to:

- curate the collection;
- validate existing records;
- provide specialist identifications of new specimens;
- maintain a database of records;
- undertake research into particular groups of organisms;
- build links with national and international specialists; and
- provide advice to quarantine authorities, scientists, diagnostic services, and industry.

Taxonomic resources are in a state of decline in most countries and expertise is often lost as specialists retire or move from research positions into management roles. For this reason, succession planning is vital to ensure the long-term security of collections.

4.3 Information Management

4.3.1 Networks

While most general entomologists would be able to identify the more common families and species of arthropod pests in their region, the ability to identify very small, rare or exotic species to the species level requires specialist skills and experience. It is unlikely that any

collection would have associated with it staff that are skilled in the identification of all possible pathogenic organisms. Therefore, taxonomists need to be part of a network providing ready access to the skills of national and international experts on the identification of specific groups. One of the goals of ASEANET is to establish such a network of specialists for the South East Asian region.

Networks make it possible for material to be sent to the relevant specialists within the network for identification - although this may involve increased costs and delays. International networks can also assist taxonomists to keep up to date with advances in their field of expertise (e.g. in relation to new diagnostic techniques) and exchange knowledge with their overseas counterparts. For instance, advances in molecular diagnostics are already having an impact on the way in which many some arthropods are identified. These techniques can greatly assist taxonomists identify cryptic species and biotypes. In addition, a working relationship with specialists in other countries can enable staff to obtain important reference specimens and literature to which they would not have otherwise had access.

4.3.2 Databasing

Under the IPPC and WTO, countries have an obligation to maintain accurate records of their plant health status and to provide these on request to other countries. These records, based on curated specimens, are of particular importance in securing access to overseas markets and in providing details for PRAs by importing countries. As a result, officers in quarantine and plant health services frequently call upon specialist staff associated with collections to provide information on the identity, occurrence and/or distribution of plant pests. This can pose some problems: firstly, unless the disease records are properly managed and available to the user organisation electronically, the information can be extremely difficult to retrieve in a timely manner; and secondly, some curators are reluctant to release data where there is some question as to the veracity of the record.

Given the importance of the information contained in collections, there is clearly a need for the records to be fully databased and available to users electronically. Specialised information technology systems are available which facilitate the convenient and rapid location of specimens and disease records held in collections. The software needed for this task is relatively inexpensive, however the process of 'populating' the database is more costly. Data capture is a persistent and widespread problem during the early stages of database development and consequently an on-going commitment is required from the relevant institutions to allocate resources for data entry. Another major consideration in the development of any database is the quality and quantity of the underlying information. In many institutions, a significant amount of work is required in the taxonomic area, both in validating existing records and clearing a backlog of unidentified specimens. It is also important that countries establish minimum data standards for their pest records to ensure that they can meet the international standard set out under the IPPC.

In most countries there is no central repository of plant health information since reference collections holding pest and disease records are usually scattered among numerous institutions. This impedes the ready flow of information and, because different levels of priority may be accorded to the individual collections, the quality of the data can also be highly variable. Recent developments in information technology mean that it is now possible to overcome this problem. Distributed database technology enables diverse, geographically isolated databases to be linked so that all of the available data can be accessed from a single point. In a sense, the technology creates a single, virtual national (or

regional) database that can be maintained and regularly updated at the local level. The disease records can then be accessed via an Internet web site, with appropriate consideration given to ownership, access control and authorisation (certain data may be password-protected). User queries can generate lists of species, and provide information on their distribution and host range.

A distributed database system that has the capacity to collect and integrate plant health data from a number of institutions is possible provided that:

- institutions responsible for collections each have their records held in an electronic database that has an internet connection;
- resources are available to link the databases to a query portal which recognises the databases and can extract data from them; and
- the institutions are willing to share their data and have an ongoing commitment to maintain their collection as part of the network (this will include meeting agreed minimum data standards).

There are now several successful implementations of distributed database technology, including the “Species Analyst” network which links 90 specimen-based biodiversity databases associated with major collections in the Americas. Distributed database technology is currently being used to develop a national pest and disease database in Australia.

5. AGRICULTURE IN SOUTH EAST ASIA - COUNTRY PROFILES

G. Evans, K.Y. Lum and L. J. Murdoch

The needs assessment focuses on nine countries in the region where some capacity in taxonomy and biosystematics for arthropods is known to exist. These countries are Brunei Darussalam, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. This section provides an overview of the status of agriculture in these countries, particularly in relation to production, exports and development plans for the agricultural sector. Except where otherwise indicated, the information and statistics have been sourced from the ASEAN Agriculture section of the Malaysia Agricultural Directory & Index 2001/02 (published by Agriquest Sdn. Bhd).

Important food crops grown in South East Asia include rice, maize, soybean, and root crops, and the major industrial crops are rubber, oil palm, coconut, tea, coffee and cocoa. The region currently contributes a number of agricultural commodities to the world market including oil palm (Malaysia and Indonesia), rubber (Thailand, Malaysia and Indonesia) and rice (Thailand, Viet Nam and Philippines). Those countries with a strong positive balance of trade in agricultural products include Thailand, Malaysia and Viet Nam. Liberalisation of the global market is expected to encourage farm diversification, production and trade of higher-value products.

5.1 Brunei Darussalam

Oil and gas are the mainstay of Brunei's economy. Agriculture is a very small sector, contributing less than 3% to Gross Domestic Product (GDP) in 1998. As a result, the country is heavily reliant on imported food products, although the government is trying to diversify the economy and increase food production. The aim is to improve self-sufficiency levels, particularly for rice, fruits and vegetables. In 1998 domestic production of rice, the staple food, was only about 1,000 tonnes.

5.2 Indonesia

Agriculture is a major employer and important source of income in Indonesia, accounting for 23% of GDP in 1998.

The varied agro-ecological conditions in Indonesia support a wide range of crops. The inner islands of Java, Madura and Bali, which have fertile volcanic soils, are the centre of production and are intensively cultivated with food crops. The poorer soils of the outer islands are planted mainly to tree crops. Spices (including clove, nutmeg and pepper) are produced in the Indonesian archipelago.

Indonesia is a major world producer of coconut, oil palm, coffee, cocoa and rubber. Other important crops include rice and cassava (the major crops are listed in Table 1). In many cases, the yield and quality of crops are limited by poor genetic material and/or the use of cultivars not suited to specific locations.

Table 1: Production of major crops in Indonesia (kt), 1998

Industrial Crops		Food Crops	
Product	Production (kt)	Product	Production (kt)
Cocoa	175	Banana	2,500
Coffee	421	Cassava	16,318
Cotton	8	Coconut	141.5
Jute	12	Dry beans	500
Palm oil	5,000	Groundnut	1,037
Pepper	56.3	Maize	7,987
Rubber	1,750	Papaya	355
Sugarcane	23,121	Peanuts	34
Tea	163	Potato	554
Tobacco	84	Oranges	380
		Rice	47,770
		Soybean	1,881
		Vegetables	4,722

The government has recognised that the existing structure of the agriculture sector in Indonesia, based on primary commodities and reflecting the centrist planning and control approach to policy, is no longer appropriate. The Ministry of Agriculture is keen to develop a new approach to rural development based on the empowerment of rural communities and a facilitating role for government. In its Agricultural Development Program for the period 2000-2004, the Ministry outlined priority areas, which included the development of:

- A Food Security Enhancement Program to enhance the availability of the main food commodities with adequate quality, yield and productivity increases; and
- A globally oriented Agribusiness Development Program to promote the development of businesses that are able to produce competitive agricultural products, add value to increase income, create employment opportunities and promote regional and national economic development.

5.3 Laos

Agriculture is a major component of the economy in Laos, contributing 51.5% to the GDP in 1997, and employing about 85% of the labour force.

Rice is the main crop, accounting for about 80% of the planted area or 630,000 ha. However, a lack of irrigation means that production is largely dependent on rainfall and many provincial governments are now trying to produce a satisfactory dry season crop. In 2000, the wet season rice crop was about 1.64 million tonnes and the dry season crop was only 390,405 tonnes. The major non-rice crops grown in Laos are maize, soybean, tuber crops, peanut, tobacco, cotton, sugarcane and vegetables.

The Ministry of Agriculture and Forestry recently conducted its first agricultural census. The survey collected data on the crops cultivated, inputs, farm size, labour and livestock, and is intended to assist in planning for the future.

5.4 Malaysia

The agricultural sector is continuing to expand in Malaysia but, in relative terms, is contributing less to the national GDP, accounting for 9% of the GDP in 1999.

Plantation crops, including oil palm, rubber and cocoa, dominate the sector. Malaysia is the world's largest producer of oil palm and its associated products (palm kernel oil and cake). It is also an important producer of rubber, cocoa and pepper. All of these crops require intensive labour inputs for harvesting and processing. These high labour costs have seriously affected the profitability of rubber plantations in Malaysia and consequently there has been a shift to oil palm.

More than 90% of Malaysia's agricultural products are exported and there is an increasing trend towards the export of processed commodities as the government encourages value-adding by the sector.

Rice is the only food crop grown in significant volumes (1,940 kt in 1998), although production does not meet local demand. The government is concerned about the reliance on imports and has launched a number of incentives to increase food security. As a result, fruit and vegetable production are important growth areas.

5.5 Myanmar

The agricultural sector is the major employer in Myanmar⁸, representing approx. 62% of the labour force and accounting for 35.5% GDP in 1998.

Myanmar's main crop is rice, with 5.76 million hectares sown to monsoon and summer rice in 1998/99. Edible oil (including peanuts, sesame, sunflower and rape seed) is the second most important agricultural commodity followed by pulses (peas and beans). Myanmar also produces maize, mainly for animal feed, industrial crops such as rubber, cotton and jute, and a range of fruits and vegetables (e.g. potatoes, onion, garlic) for the domestic market. Along with forest products, rice and pulses generate a significant proportion of the nation's export revenue.

5.6 Philippines

Although the economy is dominated by the services, manufacturing and construction sectors, agriculture remains a major employer in the Philippines. However, poor land distribution and low productivity mean that its share of the GDP is decreasing steadily. In 1997, agriculture accounted for 13.5% of GDP.

The Philippines produces a wide range of crops, but coconut and rice (8,555 kt in 1998) dominate. Coconut is a major agricultural export, accounting for nearly half of world production. Fruits, including bananas, pineapples and mangoes, are also important in terms of exports (see Table 2).

⁸ This information on agricultural production in Myanmar was sourced from a 1999 publication titled: *Myanmar Agriculture Service and Current Situation of Some Major Crops*, Ministry of Agriculture & Irrigation, Myanmar.

Table 2: Main agricultural export earnings for the Philippines (US\$ million), 1999

Commodity	Value
Banana	241
Coconut (oil)	342
Coconut (desiccated)	89
Copra cake	18
Mango	32
Pineapple (canned)	82
Sugar	70

5.7 Singapore

Given its small land area and highly industrialised nature, Singapore is anything but an agricultural powerhouse. Agriculture (together with fisheries) accounts for only 0.2% of the GDP and the country is heavily reliant upon agricultural imports from neighbouring countries, particularly Malaysia and Indonesia, and to a lesser extent Australia. Nonetheless, Singapore is an important producer and exporter of orchids and some other ornamental plants. In 1999, exports of orchids and aquatic plants were valued at S\$40 million. Some fruits and vegetables are produced for domestic consumption (18,928 tonnes in 1999).

5.8 Thailand

In recent years, Thailand has moved from an agricultural economy based on the export of rice, rubber and teak, to an industrialising country that is more reliant on services and construction. However, half of the population still depends on agriculture for their income and the sector contributed 11% to GDP in 1997.

Rice, sugarcane, rubber and cassava are among the main commodities produced by Thailand's agricultural sector (see Table 3). In fact, Thailand is the leading exporter of rice in the world, but the production is from a large area with low yield. It is also the largest producer of natural rubber, however its low market price has meant that the government is now proposing to fell 47,000 hectares of rubber a year for replanting with other crops.

Table 3 - Production & exports of Thailand's main agricultural products, 1999/2000

Commodity	Production (kt)	Exports (kt)
Cassava	18,750	5,320
Coffee	80	28
Maize (livestock-feed)	4,390	68
Oil palm	3,510 (fresh palms)	?
Pineapple	2,350	475 (canned pineapple)
Rice (main- & off-season)	23,330	6,840
Rubber	2,200	2,030
Soybeans	340	?
Sugarcane	53,140	3,890 (sugar exports)

[Source: Annual Report 2000 (1 April 1999 - 31 March 2000),
Bank for Agriculture and Agricultural Cooperatives, Thailand]

Although vast, Thailand's agricultural sector is hampered by low productivity. This is primarily because most of the production is by smallholders with limited access to technology, irrigation, financial resources and infrastructure. The Thai government has recognised the need to improve the productivity of the agricultural sector. In a bid to reform the sector, in mid-2000 it introduced a new set of incentives to encourage agricultural investment. These include longer tax exemption periods and duty-free imports of raw materials and machinery.

5.9 Viet Nam

Viet Nam is largely agricultural with 80% of its population rural-based. Agriculture contributes about 25% to the national GDP, however it is gradually being overtaken by the faster-growing industry and services sectors.

Rice is the major food crop and good yields have enabled Viet Nam to position itself as one of the top rice exporters in the world. Other important crops include coffee and rubber (see Table 4). In 1997, Viet Nam became the fourth largest exporter of coffee in the world and the largest in the region, mainly due to increased plantings and extremely good yields. Almost all of the crop is the cheaper Robusta variety which is exported for 5% of the country's export earnings.

Table 4: Agricultural production in Viet Nam (kt), 1997

Industrial crops		Food crops	
Product	Production (kt)	Product	Production (kt)
Coffee	400.3	Cassava	1,983
Cotton	14.1	Groundnut	353
Jute	22.3	Maize	1,641
Rubber	180.7	Other cereals	2,916
Sugarcane	11,428	Rice	27,646
		Sweet potato	1,643
		Soybean	102.5

6. CURRENT STATUS OF ARTHROPOD COLLECTIONS IN ASEAN

I.D. Naumann and M. Md. Jusoh

Prior to undertaking this needs assessment the Project Team developed a questionnaire to capture information on the collections and the human resources underpinning these in each of the countries to be visited. The questionnaire was sent to the ASEANET National Coordinators with a request that they distribute these to plant health agencies to complete and return. Few of these were returned in advance of the on-site visits, although most National Coordinators had these for the Project Team on arrival, with others promised. A copy of the questionnaire is at Attachment 1.

In drafting the questionnaire the Project Team was cognisant of the difficulties faced by scientists from non-English speaking backgrounds and avoided asking respondents to distinguish between records and reports of arthropods in the country. In the context of international trade, records of pests based on voucher specimens deposited in properly curated collections provide reliable evidence of the plant health status of the country. Voucher specimens can be re-examined to prove their veracity or to obtain more precise information on the circumstances under which the specimens were obtained. On the other hand, published reports that are not supported by voucher specimens cannot be verified. Misidentifications leading to erroneous reports cannot be easily corrected and can be time consuming and expensive to disprove to the satisfaction of a potential trading partner.

6.1 Brunei Darussalam

The schedule of visits in Brunei was organised by Mr Jamaluddin Hj. Mohd. Yusoff, ASEANET National Coordinator for Brunei and until recently Head of the Plant Pests Unit, Department of Agriculture. With Mr Jamaluddin now leading another group within the Department of Agriculture, Mr Jomari bin Hj. Ahmad has assumed the duties of Head of the Plant Pests Unit, and will take over as ASEANET Coordinator for Brunei. Both Mr Jamaluddin and Mr Jomari participated in discussions.

Key appointments for the Project Team in Brunei were:

- Discussions with Mr Haji Abdullah Haji Bagol, Acting Deputy Director, Department of Agriculture;
- Visit to Plant Pest Unit, Department of Agriculture, Kilanas;
- Visit to Royal Brunei Museum, Kota Batu;
- Discussions with public health officers and visit to laboratories of Ministry of Health;
- Visit to Universiti Brunei Darussalam; and
- Discussions with Ms Martinah Hj. Tamit, Environment Unit, Ministry of Development.

All appointments were in or very close to the capital of Brunei, Bandar Seri Begawan.

6.1.1 Plant Pest Unit, Brunei Agricultural Research Centre (BARC)

The Brunei Agricultural Research Centre was established in 1928 as an agricultural and livestock extension station. New laboratories and offices have been added to the complex, most notably in the late 1970s, and BARC is now the main centre for agricultural research in Brunei. The first entomologist, D.J. McCrae, was appointed to the Department in 1970.

The Plant Pest Unit maintains an arthropod collection of approximately 5000 specimens, about 75% of which are relevant to agriculture. The 4500 pinned specimens are stored in approximately 24 high quality, wooden cabinets imported from the United Kingdom. Specimens are pinned into movable cork slats, are in good condition and generally well labelled. There appears to be adequate space for future expansion. The collection room is air-conditioned but climate control could be enhanced by the addition of a de-humidification unit. While the collection is generally secure, staff expressed some concerns for the risk of damage by museum pests and mould. While the movable slats are a flexible storage system, the transfer of specimens to unit trays could be considered. The security of the collection would also be improved by the provision of a basic smoke or fire detection system.

Part of the alcohol collection is stored in wooden cabinets, in which the vials are organised within unit trays designed for geological specimens. These specimens are referred to only occasionally. This storage system requires that vials must be checked individually for evaporation and topped up with alcohol on a regular basis. This time-consuming, curatorial task could be reduced by storage of vials in large jars of alcohol. Another part of the alcohol collection is stored in vials and jars in a glass-fronted cabinet. The high light levels will cause fading and deterioration of these specimens over time.

A small number of specimens have been arranged in display units.

Overall, the collection is growing at a moderate rate, principally through specimens collected by staff during surveys of rice, fruit, vegetable and ornamental crops. Currently, fewer than 100 identifications are required each year but the number is increasing. About 3000 specimens have been identified to species and the remainder of the collection has been sorted to family level. As noted above, identifications previously were provided through IIE but this service has been discontinued. There are no taxonomic specialists in Brunei to whom the Unit can otherwise turn.

Working facilities in the Unit's laboratories are good. Bench space and microscopes are adequate and, in general, museum supplies can be purchased when required. Some parts of the collection (e.g. the fruit fly collection) have benefited from visits by taxonomic specialists from overseas. In general specimens are not available for loan.

Staff of the Unit have broad expertise in entomology, plant protection or pest management, which is consistent with their wide range of duties. Three staff members are more closely associated with the collection (i.e. spend about 50% of their time on collection-related activities) and have particular skills in specimen preparation, the recognition of insect families, and the identification of fruit flies. Training in the identification of thrips, mealybugs, hard and soft scales, mites, predators, and parasites was highlighted as a major need. The recent transfer of Mr Jamaluddin has created a critical gap in the small Unit. There is no local pool of graduates in entomology from which the Department can recruit so a replacement must be sought abroad.

The collection is well documented through a series of journals and a card index which together record label and other data (e.g. additional information on host plant) and the scientific name of the arthropod. Many species were identified by IIE in the United Kingdom and it is noted if IIE specialists retained duplicate specimens; correspondence files record the specialist who provided the identification. These paper records are being transferred to flat, digital files. The small book, *Insects of Agricultural Importance in Brunei* (McRae, 1981), is a useful, though dated adjunct to these records. There is no database but the Unit is well placed to adopt such a system, with appropriate training in the use of specialist software.

Currently, BARC is not fully networked. Many PCs operate as stand-alone units and floppy discs and CDs are used routinely. There is a central point of access for email and other Internet access. A LAN should be a future priority.

Critical scientific literature can be difficult to obtain, but the major impediment stems from the small size of the Unit and the remoteness of Brunei. It is difficult for the entomologist to cover all fields and literature of potential importance. Taxonomic literature is notoriously dispersed and, as yet, the Internet does not provide an effective, efficient means of locating the results of taxonomic research. The CABI Crop Compendium and various CD-based diagnostic tools (products based on LINNAEUS II and LUCID) are used.

BARC currently does not have any capacity in DNA diagnostics.

Resources for the collection are provided from a “special” component of the annual budget.

What is the best way forward for BARC and Brunei? Brunei has so few specialists that its capacity to assist other ASEAN countries is limited. However, facilities in Brunei are good and both BARC and the University could be considered for training courses. Brunei is well placed to provide economical accommodation and other on-ground assistance for such training courses.

Priorities for BARC might include:

- Installation of basic smoke or fire detection system in collection rooms;
- Adoption of a “double jar” storage system for alcohol collection;
- Training in the identification of thrips, mealybugs, hard and soft scales, mites, predatory and parasitic insects; and
- Evaluation of specimen database systems.

Discussions at BARC were with:

- Mr Jamaluddin Hj. Mohd. Yusoff, former Head of the Plant Pests Unit
- Mr Jomari bin Hj. Ahmad, current Head of the Unit

6.1.2 Royal Brunei Museum

The Royal Brunei Museum is situated 6.5 km from the centre of Bandar Seri Begawan on a dramatic site high above the Brunei River. Established in 1965, it has fine collections of cultural and historical artefacts, and natural history specimens. The popular, public galleries are currently under renovation.

The arthropod collection comprises approximately 25 000 specimens, almost all of which are pinned. They are accommodated in about 60 10-drawer, wooden cabinets, in an air-conditioned room. Additional, unsorted, “acquisition” material is kept in several dozen wooden boxes. Unit trays are not used. The room is cramped but there appears to be adequate expansion space in the existing cabinets. The collection appears to be secure although staff indicated that excessive humidity can be a problem; there are smoke detectors but there remains some concern over the risk of fire.

Generally specimens are well prepared although it is evident that some training in specimen preparation would be of value: some specimens were poorly set and many labels were not of archival standard. Only 25% of the collection would be of agricultural relevance. It is strongest in larger insects, in particular Lepidoptera, Coleoptera and orthopteroids. The Hemiptera collection is strong in cicadas but weak in the smaller, pest groups, such as the pentatomids, mirids and scale insects. The collection is growing at a rate of 400-800 specimens annually, mostly from surveys in natural habitats. Commonly, specimens are collected at light or other traps and do not have host plant data.

The Museum has only occasional contact with specialists in other institutions in Brunei. In recent times assistance with identifications has come through linkages with overseas specialists (e.g. Japanese ant specialists, a bee specialist from the United Kingdom). The Museum is prepared to lend material to *bona fide* researchers but the actual number of such loans appears to have been small. Occasionally, the Museum is able to provide financial assistance to visiting specialists.

Four staff are associated with the collection. Most have acquired their skills in specimen preparation, curatorial techniques and the identification of insects via “on the job” training. Staff indicated difficulties in gaining access to taxonomic literature. As is the case at BARC it seems that the major problem is discovering what is available. Use of CD-based products is increasing but staff were not familiar with software such as LUCID.

Funding for the collection comes mostly through the Ministry of Culture, Youth and Sports. The Museum also receives limited funding from private sponsors.

The Museum publishes a journal which could serve as a good outlet for regional taxonomic work. However, it was suggested that from time to time the journal has difficulty attracting suitable manuscripts.

In summary, a priority for the Royal Brunei Museum would be:

- Training in preparation and labelling techniques for arthropods.

Discussions at the Museum were with:

- Mariani Hj Abu Bakar
- Tuah bin Atar
- Hajah Kolam Hj Grayson

6.1.3 Ministry of Health

The Ministry of Health maintains a very small reference collection of mosquitoes as part of its vector surveillance program. Facilities for this program were excellent. The program is not directly relevant to the current survey, other than to note that it has a pool of trained

collectors and insect identifiers. While skills are confined to mosquitoes at present it is potentially a resource for Brunei.

Discussions were held principally with:

- Mr Kamaludin bin Mohammad Yassin

6.1.4 Biology Department, Universiti Brunei Darussalam

The Biology Department was established in 1987 and provides programs for students enrolled for a degree in Education and students intending careers in science. B.Sc (Hons) and M.Sc. programs in Biological Science are planned for 2002-3. The Department maintains a herbarium and museum, and utilises the University's Field Studies Centre within the Ulu Temburong National Park for teaching and research. The Field Studies Centre is convenient and attractive to overseas scientists undertaking research on tropical biodiversity. Because of the Centre and the University's other modern facilities, the Department has hosted a number of academic visitors with specialist taxonomic expertise. Clearly, these specialists are a potential resource for the Royal Brunei Museum and the Department of Agriculture, if visits can be coordinated and perhaps supported across the three institutions.

The insect collection within the Departmental Museum amounts to about 3500 pinned specimens, about 25% of which are relevant to agriculture. The collection is stored in four high quality, 20-drawer, wooden insect cabinets, imported from the USA. Fruit flies, butterflies and odonates have been identified to species, but most other material is sorted at most to family. In general specimens are well prepared and well labelled. Apart from the fruit fly specimens, few specimens are accompanied by host data. The collection is growing slowly, through the incorporation of specimens from research projects of faculty members and visiting scientists, and the addition of selected specimens from collections assembled by undergraduates for assessment.

The part-time curator of both the Museum and the Herbarium trained for six months at Kew Gardens, London, but has developed most of her skills in the curation of insect specimens "on the job", in particular from visiting specialists. Additional training in specimen preparation and curation would be welcome. One of the technical staff based at Temburong is about to undertake training in insect identification and databasing at the Museum Zoologicum Bogoriensis, Indonesia. Occasionally assistance with the identification of specimens is sought from the Royal Brunei Museum or the Natural History Museum, London, but in general the identification of specimens is left to individual researchers.

The University does not have an electron microscope facility, but Departmental laboratory facilities are good, including excellent microscopes and a digital camera. Work on fish DNA diagnostics is expected to commence next year. Computer and Internet access is good, although the University's local network can be unreliable.

Because the University is very new, the library lacks much of the older literature that would assist in the identification of insects. Literature could be borrowed or purchased if required, but simply discovering what is available is a major impediment.

There is no database to the collection.

The upkeep of the Museum is supported from general teaching funds and this has, thus far, been adequate. The Department has had some success in attracting external sponsorship for major projects of a biodiversity nature.

A priority for Department would be the addition of an arthropod taxonomist to the Department's teaching roster, to enhance instruction in the identification of invertebrates and broaden the Department's biodiversity research profile.

It is suggested that the Department give consideration to the:

- Appointment of an academic member of staff whose research interests include the taxonomy of a group of arthropods.

Discussions were held with:

- Dr Kamariah Binti Hj Abu Salim, Head of Department
- Awg Helen Pang Yoke Kiew, Curator of Departmental Museum and Herbarium

6.1.5 Environment Unit, Ministry of Development

This Unit carries responsibility for a range of international obligations and national policy relating to the environment and biodiversity. There should be on-going consultation with the Ministry regarding initiatives to coordinate or enhance regional capacity to identify biological species.

6.1.6 The Way Forward for Brunei

The way forward for Brunei may include the hosting of international training workshops. The country's collections are well placed to benefit from visits by taxonomic specialist from overseas, provided the community of Brunei academics, government entomologists and collection managers maintain active liaison.

The following were identified as workshop priorities for Brunei:

- Training in the identification of Thysanoptera (thrips), Coccoidea (scale insects), Acarina (mites), predatory and parasitic insects (including Hymenoptera).
- Database development.

6.2 Indonesia

The survey program in Indonesia was arranged by Dr Soenartono ("Tony") Adisoemarto (formerly Director of the Museum Zoologicum Bogoriense) on behalf of Dr Effendy A. Sumardja, ASEANET Country Coordinator and Assistant Minister for Global Environment, State Ministry of the Environment). The program comprised the following visits:

- Faculty of Biology, Gadjah Mada University, Yogyakarta;
- Faculty of Agriculture, Gadjah Mada University;
- Faculty of Agriculture, Padjadjaran University, Bandung;
- Institut Teknologi Bandung;
- Bogor Agricultural University, Bogor;

- SEAMEO BIOTROP, Bogor;
- Central Research Institute for Food Crops, Bogor;
- Museum Zoologicum Bogoriense, Cibinong;
- Research and Development Centre for Oceanography, Jakarta; and
- Indonesian Agricultural Quarantine Agency, Jakarta.

6.2.1 Faculty of Biology, Gadjah Mada University

Gadjah Mada University is one of the foremost institutions for tertiary education in Indonesia and has two entomology “departments”: (1) the Laboratory of Entomology, within the Faculty of Biology; and (2) the Department of Entomology and Plant Pathology, within the Faculty of Agriculture. Each maintains a separate arthropod collection, but some staff hold appointments to both Faculties. The University’s undergraduate student numbers are high and each year about 200 students take courses in plant protection. Entomology classes average 70 students.

The Faculty of Biology arthropod collection is housed in approximately 100 wooden, glass-topped boxes that are kept in wooden cabinets. The size of the collection was difficult to ascertain but probably was less than 10 000 specimens. It was estimated that 25-50% of these are relevant to agriculture. The laboratory accommodating the collection has no air-conditioning but there are other small, air-conditioned rooms nearby which might be more suitable for the collection. Specimens were pinned directly into the bottom of boxes; unit trays are not used. There appears to be little space for expansion within existing boxes and cupboards. Boxes are shelved two layers to each rack; because the upper layer of boxes rests directly on the lower layer, removal of a box commonly jars its neighbour, which almost certainly causes minor physical damage to specimens.

Specimens were generally well labelled and there were no obvious signs of deterioration. However staff indicated that mould and other museum pests could be a problem. Preserved specimens are used both for teaching and research. They derive either from staff research projects or from student collections, and most were collected in Java or Bali. For economic reasons, student collections often employ dress making pins, which are subject to rapid corrosion. There are important holdings of fruit flies resulting from the taxonomic work of Dr Santianawati and international collaborations with Dr Elmo Hardy, Hawaii, USA. The collection is looked after by one technician and is not growing rapidly at the present time. Assistance with identifications is most frequently sought from Bogor. Many boxes contain only unidentified specimens. The Laboratory would welcome training in arthropod identification and in the preparation of specimens. Of the 5 entomologists in the Laboratory of Entomology, 2 have taxonomic interests. All were of the opinion that their greatest need was for information from overseas. They were not familiar with CD products such as the CABI Crop Compendium or LUCID diagnostic tools. There is no database to the collection but staff were aware of databasing initiatives at the Centre for Research in Biology, Bogor, and saw that these had the potential to create national pest lists for Indonesia.

The Laboratory also maintains live “collections” in the form of cultures of silk worms and parasitic wasps, and an expanding “butterfly house”.

In summary, the needs of the Department include:

- Additional trained staff.
- Technical literature from overseas.
- Segregation of teaching and reference specimens.
- Re-shelving of insect boxes so that physical damage reduced.

Discussions at the Faculty of Biology took place with:

- Professor Sukarti Moeljopawira, Dean, Faculty of Biology
- Professor Jesmandt Situmorang, Laboratory of Entomology
- Professor Endang S. Soetarto, Laboratory of Microbiology
- Dr Hari Purwanto, Laboratory of Entomology
- Dr M. Si Trijoko, Laboratory of Animal Taxonomy
- Dr Siti Sumarmi, Laboratory of Entomology

6.2.2 Faculty of Agriculture, Gadjah Mada University

The Faculty of Agriculture collection is somewhat larger than that of the Faculty of Biology and is spread over 18 wooden cabinets, each of 16 drawers. The size of the collection was difficult to determine, but would be less than 30 000 specimens. It is estimated that more than 75% of the specimens would be relevant to agriculture. Specimens were generally well labelled although a few had been mounted on sewing needles rather than non-corrosive entomological pins! Specimens have accumulated over a period of about 30 years, through collections by staff and students, throughout Indonesia. The growth of the collection was rapid over the first 15 years of its existence, but has slowed in recent times. Two members of staff with taxonomic interests are able to devote 25-50% of their time to taxonomic work and maintenance of the collection. They were familiar with some CD products but had no experience with interactive identification tools such as LUCID or LINNAEUS II. Work towards rehabilitating the collection had begun. The collection was slowly being reorganised and segregated into discrete teaching and museum collections; 2 staff had attended a recent databasing course in Bogor and both were keen to adopt the Biolink software to assist with collection and data management.

Staff would most welcome training in the identification of arthropods, especially aphids and leaf miners, and in curatorial techniques. Microscopes seemed adequate, but there is no digital camera.

The collection is recognised as a university facility, but has no specific funding.

The Department has a taxonomically valuable linkage to Dr Sri Suharni Siwi, of the CRIFC, Bogor, who is a visiting lecturer to the University and who provides assistance with identifications. Otherwise there appear to be few linkages to other Indonesian or overseas institutions. Staff highlighted again the difficulties that they experience now that the IIE is not available to provide low cost identifications.

Three 16-drawer cabinets in the Biological Control laboratory form a significant annex to the main collection. The collection contains representatives of target species and biological control agents that have been studied and/or released. Some material requires labelling and some specimens are mounted on unsuitable pins. The collection is integral to the work of

the Laboratory and a valuable, resource. The Laboratory has a relatively good library of specialist literature to assist with identifying insects, but even this cannot cover the wide range of taxa involved in biological control.

In summary, the needs of the Faculty of Agriculture (Gadjah Mada) seem to be:

- Pins.
- Digital camera.
- Specialist taxonomic literature.
- Training (identification of aphids and leaf-miners; curatorial techniques).
- More linkages to other Indonesian taxonomists (e.g. MZB, Cibinong).
- Re-curation of the collection in the Biological Control Laboratory to ensure that all material is labelled and that valuable information is not lost.

Discussions took place with:

- Dr Y. Andi Trisyono, Department of Entomology and Plant Pathology
- Dr Eddy Mahrub, Department of Entomology and Plant Pathology
- Mr Suputa
- Mr Noegroho SP

6.2.3 Faculty of Agriculture, Padjadjaran University

Padjadjaran University and its Faculty of Agriculture date from the late 1950s. The Plant Protection Department maintains a very small collection of 300-400 specimens, almost all in alcohol. Immature Lepidoptera (caterpillars), Coleoptera and Hemiptera make up the bulk of the material and about 75% of the specimens are of agricultural relevance. Specimens derive principally from collections by students and academic staff in cropping regions of West Java. There are also representatives of stored product pests. The small slide collection comprises about 50 preparations for demonstrating arthropod morphology; all appear to have been obtained from an overseas biological supply house. There is a small budget allocation to cover the purchase of alcohol for the collection. Training in the identification of Hymenoptera would be welcomed.

While the Department has 5 tenured academics undertaking diverse research in the area of plant protection, it is at present difficult to recognise the Departmental collection as a major repository for data on arthropod pests of plants in Indonesia.

Discussions were with:

- Ir. Tohidin
- Mr Yusup Hidayat

6.2.4 Institut Teknologi Bandung (ITB)

The ITB was established in 1920 as a Dutch Technische Hogeschool and today is generally acknowledged as one of Indonesia's premier universities. It is an established leader in science and engineering. Entomological research is undertaken within the Department of Biology and currently encompasses work on aphid pests of horticulture, insects associated with mushrooms, and biodiversity studies. There is also interest in fruit flies and insects associated with citrus, coconut, cabbage, onions, potatoes and fruit. The "collection" is scattered among the laboratories of researchers and there is no curator.

The Project Team met with postgraduate students undertaking forest and agro-biodiversity studies. These studies were generating large collections of arthropod specimens and significant challenges in identification and specimen management. Often species could be identified only to family and “morphospecies”. In another postgraduate laboratory there were some 20-30 wooden insect boxes, containing mostly butterflies and beetles. Some specimens are 40+ years old, others were collected much more recently. Labelling is far from consistent; many specimens are labelled cryptically or using only code numbers. Specimen preparation is also inconsistent.

The major decision for the ITB is whether it wishes to consolidate its dispersed collections into a single, departmental resource. This would require the purchase of appropriate storage cabinets, location in an air-conditioned room, and the allocation of staff time for minimum care and maintenance. The benefits would include a growing reference resource, a repository for voucher specimens, and more uniform standards for specimen preparation, labelling and maintenance.

In general, facilities in the Biology Department (e.g. modern laboratories, microscopes, digital camera, Internet access) are very good. Leading edge diagnostic tools (e.g. a CD for identifying beetle families of world based on Entkey software) were in use. Some postgraduate students are becoming quite familiar with particular groups of arthropods, and represent a small pool from which future taxonomists might emerge, with suitable encouragement and training.

For the present, ITB cannot be considered to have a reference collection that serves as a long-term repository for information on plant pests, nor is it providing formal training in taxonomy.

Discussions at ITB were held with:

- Professor Soelaksono Sastrodihardjo, Entomology Laboratory
- Dr Tati S. Subahar, Ecology Laboratory
- Dr Achmad Sjarmidi, Ecology Laboratory
- postgraduate students

6.2.5 SEAMEO BIOTROP

The South East Asian Regional Centre for Tropical Biology, which is usually referred to as BIOTROP, is one of twelve centres under SEAMEO (the South East Asian Ministers of Education Organization). The stated goal of BIOTROP is develop expertise within the region so that member nations might address critical problems in the area of forest management, agricultural pests and aquatic biology. Staff members describe its activities as “more applied” compared to the “more basic” research undertaken in LIPI. It receives funding from the Indonesian government, SEAMEO (from contributions by member nations) and other agencies. At the present time operational and “project” funding appears to be scarce. Established in 1968, BIOTROP currently occupies modern quarters which include laboratories and facilities for meetings and training. Laboratory facilities are adequate and include basic, teaching microscopes. Centre staff commonly have joint appointments with the Bogor Agricultural University.

BIOTROP maintains a small collection representing about 265 pests of stored products. The collection comprises about 1000 alcohol vials, each numbered, well labelled and catalogued.

It is kept in a very compact wooden cabinet in a tidy, air-conditioned laboratory and is clearly well tended. The collection is used for reference and teaching purposes, but has grown little in the past decade in the absence of “project money”. Despite the fastidious documentation it is difficult to collate information such as which species have been recorded from a particular area or in a nominated commodity. However, the collection is a tractable candidate for the development of a modern, specimen-based database. A starting point might be the two Lotus Symphony databases that summarise the surveys from which the collection largely derives (Haines 1997).

BIOTROP regularly receives stored product pests from all over Indonesia for identification, although specimens are not received from quarantine officers, who presumably perform their own identifications.

Staff consider their Internet access to be good and that generally they are able to obtain information required for their work.

Needs of SEAMEO include:

- Training in identification.
- Adoption of a specimen database.

Discussions at SEAMEO BIOTROP were with:

- Dr Sunjaya
- Ir Kasno

6.2.6 Central Research Institute for Food Crops (CRIFC)

The collection of CRIFC is one of the largest and most important entomological collections in Indonesia. In 1989 some 3247 species were recognised in the collection. The bulk of the collection is of agricultural relevance. It is housed in about two dozen, large, wooden entomological cabinets, which are in increasingly poor condition, with ill-fitting seals which have allowed some damage by museum pests. Rehabilitation of the collection, with the assistance of AusAID Government Sector Linkages Program (GSLP) funding, has commenced but funding in future years will be necessary to complete the transfer of specimens to secure cabinets. The collection room has neither air-conditioner nor de-humidifier. The alcohol collection is stored in large jars in huge, glass-fronted cabinets.

Following the recent installation of a Biolink database package and training in its use, CRIFC has commenced databasing its collection. It has become apparent immediately that the lack of a checklist or catalogue to the Indonesian insects is a major handicap to this work.

CRIFC is a key resource for Indonesian agriculture and critical provider of identifications. Dr Siwi is an active taxonomist with special interests in leafhoppers (Hemiptera) and fruit flies. CRIFC has been active in collaborative projects and energetic in seeking external funding. However resources for the collection and taxonomic work is meagre.

Needs of CRIFC:

- Improved specimen storage facilities (modern cabinets with unit trays).
- Training in the identification of Hymenoptera.
- Specialist literature.
- Digital camera.
- High quality dissecting microscope.

Discussions were held with:

- Dr Sri Suharni Siwi
- Ms Trisnaningsih

6.2.7 Bogor Agricultural University

Bogor Agricultural University had its origins in a school of agriculture and veterinary science established by the Dutch in the early 1900s. The Faculty of Agriculture now occupies a very modern building with enviable facilities. Each year about 60 undergraduate students commence plant protection courses and between 5 and 10 begin postgraduate work in entomology.

The Department of Plant Pests and Diseases, within the Faculty of Agriculture maintains an entomological collection, which occupies about 200 drawers in five large, wooden cabinets. Ten new cabinets have been ordered and there are plans to refurbish and develop the collection as a reference and teaching resource. Specimens are in fair condition, with some evidence of damage by museum pests (psocids dermestids, mould). Most specimens are labelled adequately but many of the identifications are rather old. The collection is accommodated in a modern, air-conditioned laboratory. The Department has acquired a number of large, new (and empty) display cabinets, which temporarily consume considerable floor space. A quantity of insect boxes and other items are stacked neatly awaiting stowage. There is also a significant quantity of useful entomological literature amassed during the colonial era.

The Department has a diversified research program, including work on leaf-mining *Liriomyza* (Diptera: Agromyzidae), which is supported by ACIAR and involves collaboration with scientists from CSIRO and DNRE, Victoria. The *Liriomyza* project includes taxonomic work, which is largely undertaken at CSIRO, Canberra. Departmental staff have taxonomic skills covering the scale insects, aphids, whiteflies, Hymenoptera and weevils. A good selection of reference works were in use in the research laboratories, but access to new journals is limited. Internet access is generally good, although lengthy outages are possible. Some staff have experience in molecular diagnostics and one laboratory is equipped with PCR machines.

Overall, the Department appears to have the potential to enhance its role in supporting diagnostics and taxonomy in Indonesia. The collection and taxonomy have the support of the Head of Department, one trained member of staff with taxonomic interest emerges as the collection's "curator", the Department has a healthy postgraduate program, and the University is geographically well placed to collaborate with taxonomic specialists at the Museum Zoologicum Bogoriense, Cibinong, and CRIFC, Bogor, in postgraduate training.

Discussions took place with:

- Dr Purnama Hidayat
- Professor Soemartono Sosromarsono
- Dr Muhammad Machmud
- Dr Dewi Sartiami

6.2.8 Museum Zoologicum Bogoriense (MZB)

The MZB was established in the late nineteenth century by the Dutch and for most of its life resided with the herbarium in a colonial building within the internationally renowned Bogor Botanical Gardens. Recently the MZB has moved to new quarters on the Indonesian Institute of Sciences (LIPI) campus at Cibinong, about 15 km north of Bogor. The new building provides amongst the very best storage conditions for a natural history collection in South East Asia.

The entomological collection stands at about 2 million specimens and is the largest in the region. Pinned specimens are kept in unit trays in several hundred near-new metal cabinets. Alcohol specimens are stored in jars shelved with other zoological specimens. The collection halls enjoy state-of-the-art, central air-conditioning and de-humidification systems, and incorporate numerous modern design features. Specimens are well prepared and well labelled, and the collection has been growing rapidly. The focus is upon biodiversity studies and the bulk of the material is from natural habitats rather than cropping systems. Few specimens have host data. Two full-time technicians, 2 collection managers, and over a dozen taxonomists, several “emeritus”, are associated with the collection. The collection and its facilities are attractive to overseas taxonomic specialists and many projects on the Indo-Australian arthropod fauna are making substantial use of the MZB.

The facilities of the MZB are excellent but with the run-down of donor funds provided to establish the museum, some challenges are emerging. The 24-hour climate control is expensive to maintain but essential. The very dry atmosphere in the collection halls promotes evaporation of alcohol and has highlighted the need for better-sealing specimen jars.

A Biodiversity Information Centre is a focal point for the databasing of zoological and herbarium specimens. Initial, “borrowed” databases packages have given way to a purpose-built, specimen-based database and the Centre is a participant in current, GBIF-coordinated, global initiatives to link and develop databases. It is possible that in the near future the entomological collection will adopt a Biolink database system, which the Centre will link to its IBIS system.

For the future the MZB must face:

- Challenge of maintaining a large, high-cost facility.
- Challenge of maintaining adequate taxonomic and technical staff.

On the other hand, it has major opportunities for:

- Hosting training courses in identification and specimen preparation.

- Attracting overseas funding for specific research collaborations with specialists. Of course, MZB staff must maintain their own skill levels and profile to continue to be attractive as collaborators.
- Improving its specimen database.

Meetings and discussions at MZB were with:

- Dr Siti Nuramaliati Prijono, Director
- Pudji Aswari
- Dr Yayuk Suhardjono
- Ir Lily Pudji Astuti
- Dr Rosaichon Ubaidillah
- Mr Roementyo

6.2.9 Research and Development Centre for Oceanography

The Centre is responsible for a diverse range of oceanographic research and maintains an important reference collection of marine organisms. It has large collections of arthropods but none of the material is relevant to agriculture or forestry.

Discussions took place with:

- Ms Rianta Pratiwi Afriadi, Marine Biologist and Collection Curator
- Mr Muswerry Muchtar, Head of Oceanographic Division

6.2.10 Indonesian Agricultural Quarantine Agency (IAQA)

IAQA has a broad quarantine role in Indonesia and a network of laboratories from Sumatra to West Irian. It has diverse international linkages, including formal agreements and joint projects with the Australian Quarantine Inspection Service (AQIS) and the Northern Territory's Department of Business, Industry and Resource Development. The Jakarta laboratories have recently been refurbished but regional facilities are of more variable standard. Each regional centre maintains a small reference collection and the spectrum of species represented varies from region to region. Requests for identifications from the regions tend to be sent to CRIFC, Bogor.

There is strong interest within the organisation in on-going training and courses in the identification of arthropods would be particularly welcome. The molecular diagnostics of fruit flies is of particular interest.

IAQA possesses the PDI Database System that was developed and provided by AQIS but this has lapsed into disuse. The need for an Internet-based information system, including a database, to service the far-flung network of laboratories is recognised, but at present not all laboratories have Internet connections.

The entomological reference collection in Jakarta is "embryonic". Only a handful of species are represented, although specimens have been skilfully prepared. The curator would welcome training in curatorial techniques and identification.

In summary, the needs for IAQA include:

- Training for the curator in specimen preparation and identification.
- A small number of entomological cabinets.

- Coordinated program to accumulate a selective reference collection.
- Development of a prototype information system (basic information on common species of quarantine significance); the system's content could be increased progressively and, as connections allowed, the system could eventually be made available to regional laboratories.

Discussions were with:

- Mr Suwanda A.Z., Director of Cooperative Affairs
- Ms Rumenda Ginting

6.2.11 The Way Forward for Indonesia

The preceding pages have identified the elements of a program of training workshops addressing diverse curatorial and identification needs. Priorities include training in the identification of Hymenoptera and in specimen preparation.

Some rehabilitation priorities have also been enumerated. In particular, the transfer of the pinned collection of CRIFC, Bogor to secure cabinets is a high priority.

IAQA, Jakarta faces the task of building of a small reference collection to enable it to provide support to the far-flung network of Indonesian quarantine officers.

In addition there appears to be a case for the development of a formal network encompassing the Indonesian institutions that maintain collections and undertake taxonomic work. A formal network would offer a framework within which issues such as a rational approach to databasing, loans and developing taxonomic capacity can be discussed.

6.3 Laos

Activities in Laos were organised by Mr Phousit Phoumavong, National IPM Coordinator and Director of the Soil and Crop Protection Centre, Ministry of Agriculture and Forestry, and ASEANET Coordinator for Laos. Five centres were visited for discussions and laboratory inspections:

- Soil and Crop Extension Centre, Houiyang;
- National Research Centre, NaPook;
- Quarantine Section, Laboratory and facilities at Friendship Bridge;
- Plant Protection Centre, Department of Agriculture, Salakham; and
- FAO IPM Program offices, Salakham.

6.3.1 Soil and Crop Protection Centre, Houiyang

The Soil and Crop Extension Centre is a facility of the National Agriculture Forestry and Extension Service, within the Ministry of Agriculture and Forestry. The Centre lies to the north of Vientiane and comprises several office and laboratory buildings surrounded by extensive cultivated fields. The Centre's major role is the implementation of IPM in rice. This work may be extended to encompass fruit crops in the future. No reference collections were seen.

Discussions at Houiyang were principally with:

- Mr Phousit Phoumavong

6.3.2 National Research Centre, NaPook

The National Research Centre is another facility of the National Agriculture Forestry and Extension Service. Research on rice has been a major focus but activities are greatly curtailed at present because of funding shortfalls.

The reference collection of the Plant Protection Section comprises a small number of pinned specimens and about 1200 vials of specimens preserved in alcohol. The pinned material is poorly labelled and identified, and of little long-term value. About 200 vials contain specimens which have been identified to species level, but these generally lack locality or host data. Another 1000 vials do have adequate data. However, these have not been identified and generally contain mixtures of species. All material is accommodated in a large laboratory with adequate storage and working space but no air-conditioning. The collection is looked after by a junior member of staff. It derives from survey work undertaken in the past, often in collaboration with international visitors (e.g. from the International Rice Research Institute in the Philippines). Rehabilitation of the existing collection at NaPook is not regarded as a high priority.

The literature resources available for identifying arthropods appears to be very limited and microscope facilities in the entomological laboratory are poor.

6.3.3 Quarantine Section, Department of Agriculture

While Laos shares borders with Thailand, Myanmar, China, Vietnam and Cambodia, it is with Thailand that it exchanges the greatest volumes of goods and commodities. The main route for imports and exports is via the Friendship Bridge, which crosses the Mekong River about 10 km southeast of Vientiane. The Lao Quarantine Section divides its modest resources (a total of 5 staff) between inspection facilities at the Friendship Bridge and a laboratory on the main road between the Bridge and Vientiane. Quarantine facilities have been proposed for Wattay International Airport (which serves Vientiane) but are not a major priority since little in the way of agricultural produce currently leaves or enters Laos by air.

Approximately 200 tonnes of agricultural commodities, principally coffee, cardamom and dried fruits, are exported from Laos each year to or via Thailand. Certification that these commodities are free of pests and inspection of imported commodities such as soy grits, maize, fruit and cut flowers form the greater part of the Lao Quarantine Section's work. Vagile pests and diseases are free to disperse naturally across the Lao border, but it is asserted that Laos remains free of some pests present in nearby countries. This warrants inspection of commodities, for example for infestations of fruit fly. Timber and timber products are also exported and the Quarantine Service certifies fumigation facilities which treat export goods.

The Quarantine Service maintains paper records of pests detected on export commodities but the exact origin of the pests is not known (records simply state "Laos"). At six-monthly intervals records are collated and sent to the Department of Agriculture in Vientiane, but it is not known whether these are published or summarised in any readily accessible form. Pest

identifications are performed in the Quarantine Section's laboratory. There is a useful handbook to enable the identification of Lao stored product pests, but no such books exist for other commodities or groups of pests. Quarantine officers were of the opinion that the up-to-date information required for a series of handbooks on the pests of Lao agriculture does not exist and that crop surveys would be essential. Because of the similarities between the Lao and Thai language and script, reference works published in Thailand are more readable and potentially more useful than publications from Vietnam, where technical publications employ a script based on the Latin alphabet. The laboratory has adequate working space and a small number of very serviceable microscopes. There is a very small reference collection to assist with the performance of identifications.

The major needs for the Quarantine Section include:

- At least an additional 3 trained personnel (one person trained in recognition of each of the following groups – arthropods, pathogens and weeds; training in Thailand was suggested as most appropriate).
- Laboratory equipment.
- Literature for performing identifications.
- A Quarantine Act (currently the Quarantine Service derives its authority from Customs legislation).

The Chief of Plant Quarantine also has duties as Provincial IPM Coordinator but reported that IPM extension work did not in general create major requirements for identifications.

The Ministry of Agriculture and Forestry is said to be one of the better-funded Ministries in Laos but nevertheless resources are limited in this very poor country. Salaries tend to be low and it is difficult to attract and retain trained staff.

The organisational structure within the Ministry was difficult to comprehend during the short visit, but it did appear to the Project Team that there was some overlap (e.g. there appeared to be plant protection interests in both the National Agriculture and Forestry Extension Service and within the Department of Agriculture) or confusion in roles, and that some functions were poorly covered (e.g. it was not really clear which centre or division provided technical advice to IPM extension).

Discussions in the Quarantine Section were with:

- Mr Thongsavanh Taipangnavong

6.3.4 Plant Protection Centre, Department of Agriculture

The Plant Protection Centre at Salakham comprises three small units: entomology (2 professional staff); plant pathology (2 professional staff); and plant quarantine.

The arthropod collection is very small and comprises a few old specimens and additional material collected within the past 12 months. Many pinned specimens lack labels and have been identified to order level only. They would not fulfil IPPC requirements for pest records. The standard of preparation is variable. While new material has been conscientiously prepared, staff would derive enormous benefit from participation in technical training courses and long-term association with specialists outside Laos. This would facilitate the acquisition of essential skills in pinning, setting and labelling. The

alcohol collection comprised a handful of drying or dried-out vials. Little, if any, of this material would warrant rehabilitation.

In reality, the reference collection must be rebuilt from scratch. Cabinets and unit trays, pins, jars, vials and paper for labels are all required. The collection room is kept within a 1970s-era building which is spacious, but in need of some refurbishment, air-conditioning and a de-humidification unit. Existing dissecting and compound microscopes are inadequate, as are the literature resources to assist with routine identifications.

We suggest a series of targeted crop and regional surveys, in collaboration with overseas specialists. This would provide successive batches of fresh material for processing, identification and management. It is envisaged that specimens would be shared with overseas institutions.

Compared to many other South East Asian countries, Laos has a high percentage of its land area covered by forest and a low population. It is well placed to preserve substantial biodiversity; a collection that provides a national focal point for the study of this biodiversity is highly desirable. A nuclear collection at Salakham could provide such a focal point and a port-of-call for visiting specialists and collectors. Additional opportunities for development of collection infrastructure and on-going collecting may flow from the establishment of a collection.

Staff require training in:

- The basics of specimen preparation and curation.
- Identification skills.
- Use of the Internet to obtain and assess information.

Perhaps the best way forward is via a program established in partnership with an entomological institution in a developed country, and having the following basic elements:

- Crop surveys;
- Reciprocal visits;
- Enhancement of Lao skills in specimen preparation and curation;
- Training for Lao staff in routine identification, research management and IT skills;
- Minor refurbishment of existing laboratory; and
- Provision of microscopes and sufficient cabinets, pins etc to initiate a modern arthropod collection.

The emphasis would be upon the use of existing laboratories, at least for the immediate future, and a small initial outlay for capital items. Because of the importance of correct identifications of parasitic and predatory arthropods to IPM programs, it might be appropriate to make these groups an early priority. The overall aim would be to establish the nucleus of a national collection.

Discussions at the Plant Protection Centre were with:

- Mr Viengsavay Sengsourivong, Head, Plant Protection Section
- Mr Soleumy Phithayaphone, Deputy Head, Plant Protection Section
- Mr Tiangkham Vongsabouth

6.3.5 National IPM Program Headquarters

The National IPM Program is an initiative to develop IPM in rice and vegetable production in Lao. The Program is sponsored by FAO under the supervision of the National Agriculture and Forestry Extension Service, with headquarters in modern offices at Salakham, adjacent to the Plant Protection Centre. The Program does not maintain a collection. Discussions were held regarding priorities for Lao agricultural research and infrastructure, and the implementation of donor programs.

Discussions:

- Mr Jan Willem Ketelaar, Team leader

6.3.6 The Way Forward for Laos

Laos confronts the challenge of having no specialist expertise in arthropod taxonomy and almost negligible reference collections.

It is suggested that this challenge be met through a series of modest projects comprising the collection, preparation, identification, storage and documentation of specimens from targeted crop or regional surveys (for additional details, see the section above which discusses the Plant Protection Centre, Salakham). These activities, undertaken in close collaboration with overseas specialists, offer opportunities for capacity building on a scale appropriate to the prevailing economic and scientific infrastructure.

6.4 Malaysia

The Project Team's activities in Malaysia, were arranged by Dr Soetikno S. Sastroutomo, ASEANET Technical Secretary, Kuala Lumpur, and comprised visits to the agencies listed below.

Peninsular Malaysia:

- Entomology Section, Universiti Kebangsaan Malaysia (UKM), Bangi;
 - Plant Protection Department, Universiti Putra Malaysia (UPM), Serdang;
 - Malaysian Agriculture Research and Development Institute (MARDI), Serdang;
 - Department of Agriculture (DOA), Peninsular Malaysia, Kuala Lumpur; and
 - Forest Research Institute Malaysia (FRIM), Kepong.
- Peninsular Malaysia has several collections but very limited taxonomic expertise.

Sarawak:

- Agriculture Research Centre, Semongok;
 - Forest Research Centre, Kuching; and
 - Universiti Malaysia Sarawak, Kota Samarahan
- No current information is available on the entomological collections of the Sarawak Museum, Kuching. Established in 1886, the Sarawak Museum is one of the oldest in the region and custodian of important Borneo natural history collections. Early curators included the entomologists R.W.C. Shelford, J.C.

Moulton and E. Mjöberg. Arnett *et al.* (1993) reported that the entomological collection comprised about 30 000 specimens, most of which had been collected prior to the 1920s. This material was stated to be accommodated in “336 drawers and 12 boxes”, with type material segregated from the general holdings. The Museum publishes a scientific journal, the *Sarawak Museum Journal*.

Sabah:

- Forest Research Centre, Sepilok, Sandakan;
 - Agricultural Research Centre, Kota Kinabalu;
 - Malaysian Cocoa Board, Kota Kinabalu; and
 - Universiti Malaysia Sabah, Kota Kinabalu.
- The Project Team did not visit the Insect Reference Centre maintained by Sabah Parks at Kinabalu Park. According to information supplied by Sabah Parks, the collection totals 44 757 specimens, comprising 35 160 pinned, 9224 in alcohol, and 373 on display. The collection is especially rich in Lepidoptera and Coleoptera, represents the insect biodiversity of the Mt Kinabalu region, and is of greater relevance to forestry than agriculture.

6.4.1 Entomology Section, Universiti Kebangsaan Malaysia (UKM)

The Centre for Insect Systematics was established in 1993 based on the insect collections of the UKM Department of Zoology. The collection has grown to become one of the largest and most important in Peninsular Malaysia. Taxonomic specialists in the Coleoptera (in particular the Chrysomelidae), Hemiptera (Cicadidae) and Hymenoptera are associated with the Centre. In 1996 the Centre launched the journal *Serangga*, which has become quickly an important vehicle for the publication of taxonomic papers dealing with the arthropod fauna of South East Asia.

The collection comprises approximately 100 000 pinned specimens, about 80 000 of which have been identified, and includes a significant number of types of chrysomelid beetles and cicadas. About 25% of the collection is of agricultural relevance. The collection has expanded rapidly in recent years, principally from surveys in forest habitats. Specimens have been expertly prepared and labelled, and are accommodated in unit trays in good quality entomological cabinets. The collection rooms are air conditioned and well organised, but increasingly cramped.

Internet access is good. CD products for the identification of Coleoptera were in use and had been demonstrated during undergraduate teaching classes. Specialist taxonomic literature, especially that dealing with Coleoptera and cicadas was on hand. The laboratory was equipped with a good dissecting microscope, and had access to a microscope-mounted digital camera and the University’s electron microscope facility. A Ph.D. student discussed her recent analytical studies of cicadas which had employed computer-based phylogenetic packages. The collection is not databased and staff would require some training before they would embark on any databasing activity.

The Centre has produced a small number of graduates who have been well-trained in taxonomy. Regrettably, there are few employment opportunities and these students have or are destined to move to other disciplines on completion of their postgraduate studies. With the retirement of the senior taxonomist the Centre’s future within UKM comes into question.

UKM provides support in the form of academic salaries and modest research funds, but does not support the Centre formally in its own right. The Centre has attracted significant funding from the Malaysian government agency IRPA. The Centre has developed important, specialist linkages to the international taxonomic community, and has the potential to attract an increasing number of specialists working on the South East Asian insects.

Staff expressed an interest in training in the identification of weevils and scarab beetles, and groups of Hymenoptera. Exposure to the diagnostic program LUCID would also be of advantage.

The principal challenge for the Centre is to continue to survive following the approaching retirement of key staff. This scenario has been enacted countless times throughout the developed world where important university collections have repeatedly fallen into disuse. In Peninsular Malaysia the problem is particularly acute in that there is no national, natural history museum, which could assume management of the UKM collection if the latter were “orphaned”.

In summary, the key needs for UKM appear to be:

- Succession planning for key staff.
- Training in the identification of Hymenoptera.
- Training in the development of LUCID-based diagnostic tools.

Discussions at UKM were with:

- Professor Mohamed Salleh Mohamed said
- Ms Salmah Yaakop

6.4.2 Plant Protection Department, Universiti Putra Malaysia (UPM)

UPM came into being in 1971 as Universiti Pertanian Malaysia, through the merger of the Faculty of Agriculture of the old University of Malaya and the Agriculture College, Serdang. During the 1980s the scientific and technological scope of the university increased culminating in the change of name to Universti Putra Malaysia. UPM now occupies a large, modern campus with approximately 1500 academic staff and a student body of over 32 000.

The small arthropod collection of UPM resides within the Plant Protection Department and has a greater agricultural bias than that at UKM. It comprises fewer than 10 000 specimen and is cared for by a junior member of staff, whose duties include the preparation of undergraduate teaching materials. A specialist in the taxonomy of fruit flies has moved to an administrative position within the University and a junior member of staff associated with the collection has also recently moved. The University is planning to replace the latter person with a technician with some taxonomic interests. The University has hosted several identification training courses and would be interested in participating in additional courses in the future.

Specimens at UPM are generally well prepared and labelled, and are mostly identified to species level. They are safely pinned into wooden drawers with tightly-sealing lids. The drawers run on a sturdy, open, aluminium frame in a small, air-conditioned room. Apparently there is some prospect of a new building, which would accommodate the collection. The University would value advice on optimal design and climate control for the collection. The open design of the drawer racks allows light to fall on some drawers and

some accumulation of dust. It is particularly noticeable that the collection lacks the specialist literature essential for the identification of arthropods.

The UPM collection has been well managed and there is a prospect for more spacious quarters and additional curatorial assistance. If these are forthcoming it should continue to provide support for teaching and complement the collections at UKM.

In summary, the key needs for UPM appear to be:

- Advice on museum design and climate control.
- Development of a small library of diagnostic literature.

Discussions at UPM were with:

- Dr D. Zolkhifli Omr
- Mr Mohamed Salleh

6.4.3 Malaysian Agriculture Research and Development Institute (MARDI)

MARDI was established in 1969 to take a leading role in agricultural research in Malaysia. From the initial cluster of pre-existing, government, agricultural branches and laboratories that formed the initial nucleus, MARDI has grown to become a large, modern agency with facilities throughout Malaysia, a broad research portfolio, and diverse international linkages.

An arthropod reference collection amounting to approximately 30 000 specimens is housed at MARDI's Serdang laboratories. The collection comprises approximately 24 000 pinned specimens, about 590 specimens in alcohol, some 2350 slide mounts (mostly thrips), and an additional quantity of dry specimens. All are relevant to agriculture but do not come from regular, structured crop surveys. Specimens are generally well prepared and labelled, although some lack critical data. The number of specimens requiring identification exceeds 800 per year and this figure is increasing each year. Identifications are performed by MARDI officers. In the past, specimens were occasionally referred to specialists at the Natural History Museum, London or in Japan, but the use of U.K. specialists has largely ceased due to increased charges. MARDI does not employ an arthropod taxonomist. The 5 officers associated with the collection have developed impressive skills in specimen preparation and in the identification of certain groups of arthropods, but all would value short-term training in specialist identifications. Officers have basic computer skills but are not familiar with specialist diagnostic or databasing software.

The pinned collection is divided into two sections. One section is arranged by taxonomic grouping (order) and accommodated in wooden boxes in a small, metal compactus. The compactus mechanism is rough and there is reasonable concern that in the long term repeated movement will damage specimens. The second section of the collection is arranged by crop and accommodated in wooden cabinets. The cabinets are of variable quality and in some the drawer lids do not fit tightly. In general specimens are in good condition, but there have been instances of damage by mites. The alcohol collection is divided between a cupboard and open shelving. The overall impression is that the collection is well cared for, but increasingly cramped and, in the near future, in need of more secure cabinets. The collection room is air-conditioned. Microscopes are adequate, although there is no digital camera. Another group within MARDI is purchasing the imaging software Automontage but this is not at present available for use by the collection staff.

Substantial paper records accompany the collection. A journal, a card catalogue and files of original correspondence fully document specimens that were identified by specialists at the Natural History Museum, London. Databasing using Microsoft Access has commenced. Staff are not familiar with the databasing software Biolink and it might be appropriate for them to evaluate this before expanding the current data capture initiatives.

The collection attracts modest financial support from MARDI which covers basic care and maintenance.

The first priority for the custodians of this collection would appear to be the appointment of a taxonomist to oversee its future development and utilisation. Next priority would be the training of support staff in the identification of important pest and beneficial arthropods. The progressive transfer of specimens to more secure storage units and the development of a single database are also recommended.

This is an important, well cared-for collection. Curation and identifications fall to competent technical staff, but there is no specialist taxonomist.

In summary, the initial priorities for the MARDI collection appear to be:

- Appointment of an arthropod taxonomist.
- Additional, secure storage cabinets.
- Digital camera.
- Training in the identification of pest and beneficial arthropods.
- Development of a specimen database.

Discussions were with:

- Dr Mohamed Rani Mat Yusoh
- Mr Mohamed Abul Majid
- Mr Jayprakash Pertabrai

6.4.4 Crop Protection and Quarantine Division, Department of Agriculture

The Department of Agriculture collection is one of the largest, oldest and most important zoological and agricultural collections in Malaysia. It is estimated to contain some 86 000 specimens, including many collected during the colonial era and some which are said to have come via the original Raffles Museum, Singapore and the Selangor Museum, which was severely damaged during World War II.

The collection comprises approximately 76 000 pinned specimens in 522 wooden store boxes, about 3500 alcohol vials, about 1200 slide mounts, and some additional specimens preserved dry with host material. All are relevant to agriculture, having been collected by crop protection officers, during surveys and field trials, by quarantine inspectors, farmers, pest control operators and extension officers. The collection is not growing rapidly at present but material continues to be received from regular surveys of citrus, mango, hot peppers, long beans and sweet corn. Specimens generally are accompanied by standard data, including many valuable host plant associations. Many older specimens are in poor or fragile condition, sometimes with decaying pins.

Specialists at the Natural History Museum, London, have identified many specimens, but the costs of this service have become prohibitive. In recent times the Department has frequently

called upon MARDI, FRIM (see below), Malaysian universities, “the National Museum” and IRRI (in the Philippines) for assistance with identifications.

Store boxes are accommodated on open shelves in extremely cramped conditions. A miscellany of papers, boxes and other impedimenta has accumulated in the collection room. It is now difficult to examine some parts of the collection and nearly impossible to maintain cleanliness.

Antiquarian entomological books, exquisite works of art, card catalogues and other documents associated with the collection are little-known national treasures. They, like the specimens, will remain at extreme risk until the collection and associated materials can be rehabilitated and stored under more suitable, climate-controlled conditions.

There is one entomologist with taxonomic interests associated with the collection, and a technician on the verge of retirement.

Attention to the physical security and amenity of the collection is a critical priority and would involve:

- Refurbishment of existing storage space, including the provision of adequate air-conditioning and de-humidification units, and the exclusion of non-essential items;
- Initiation of a long-term program for the careful rehabilitation of critical specimens at risk; and
- Conservation treatment of historically important books, artworks and other documents, and their transfer to secure storage adjacent to the collection.

The appointment and training of a skilful curatorial assistant is an essential adjunct to this rehabilitation program. Training would of necessity encompass curatorial techniques and identification skills.

The Department of Agriculture plays a key role in the description of Malaysia’s plant health status and has the major responsibility for quarantine. It has published a catalogue to the plant pests and diseases recorded from Peninsular Malaysia between 1920 and 1978, and this catalogue is currently being updated, with the assistance of collection records and associated documentation. There is interest in the development of appropriate web delivery of this information, potentially via a database and a WAN (Wide Area Network) serving the Department’s geographically dispersed officers.

Discussions at the DOA were with:

- Ms Asna Booty Othman, Director
- Mr Yusof Bin Othman
- Mr Haw Leng Ho

6.4.5 Forest Research Institute Malaysia (FRIM)

The Forest Research Institute lies approximately 15 km from Kuala Lumpur. The Institute maintains a small, public museum which exhibits different types of woods, information on forest-dependent industries, and various wood products. The reference and research collections are much more extensive, and the arthropod collection is one of the largest and finest in the country.

The arthropod collection comprises approximately 160 000 pinned specimens and 7500 slide mounts. The alcohol collection includes many series of termites and totals perhaps 430 000 individuals. Specimens are well prepared and labelled, and accommodated in high quality wooden cabinets, in a spacious, air-conditioned collection room. It is clear that curatorial care of the highest standard has been sustained over many years. The Entomology Unit is in the process of implementing an ISO9001:2000E Quality Management System for the type collection.

Probably the greatest physical concern for the FRIM collection is the absence of suitable fireproofing. There is no sprinkler system.

The collection derives from collections in plantations and natural forests during scientific expeditions, research and postgraduate projects. It has also received voucher specimens from abroad, such as material deposited by visiting scientists from Japan. About 25% of the collection would be relevant to agriculture. The collection continues to grow, with an increasing number of specimens in need of identification (at present 100-400 specimens require determination each year). FRIM occasionally calls upon taxonomic specialists at UKM, UPM and USM, or at the Natural History Museum, London; CSIRO Entomology, Australia; and Kyushu or Hokkaido Universities, Japan.

FRIM has a very important termite collection, reflecting the taxonomic research of the late Y.P. Tho and current curator L.G. Kirton. Other significant holdings include the collection of wood-boring beetles, a large collection of geometrid moths assembled in conjunction with a now-completed biodiversity study, and large numbers of stingless bees. Parts of the collection have benefited from the attention of taxonomic specialists, several of whom have visited Kepong in recent years. While the collection is in good order, it of course could benefit from additional working by taxonomic specialists.

Microscope facilities are good and there are excellent literature resources for some groups, e.g. termites. Staff associated with the collection have good Internet access and are familiar with standard computer applications. Some data are stored electronically in FoxPro and Excel files, but specialist specimen databases, such as Biolink, have not been evaluated.

As noted, FRIM has established a number of international linkages that span forest health and diagnostic matters. FRIM's own expertise encompasses entomology, taxonomy and pest management. The Unit is keen to provide assistance to any national or international capacity-building exercises, but it is small (just 2 professionals) which inevitably limits the contributions it could make. FRIM staff expressed interest in receiving specialist training in the identification of Lepidoptera, Coleoptera and Hemiptera. Staff were not familiar with computer diagnostic tools such as LUCID.

The FRIM collection demonstrates abundantly the standards that can be achieved with modest funding, professional guidance from practising taxonomists, and skilful, dedicated technical assistance. The collection has been developed as an adjunct to applied research, and the high curatorial standards mean that it continues to be useful to that research.

Discussions at FRIM were principally with:

- Dr Grace Tabitha LimWui Oi

6.4.6 Agriculture Research Centre, Semongok

The programs of the Agriculture Research Centre focus on citrus and other fruit crops, vegetables, herbs, rice and apiculture. There are 9 staff in the entomology group (3 professionals, 6 technical support). The Centre maintains a collection of approximately 22 000 specimens, of which about 25% are relevant to agriculture. The collection is growing at the rate of less than 100 specimens annually, principally via the addition of specimens collected by Centre staff or farmers on an *ad hoc* basis. Specimens are pinned and stored in about 125 wooden store boxes, which are shelved in an air-conditioned collection room. There are also 40-50 wooden drawers of commodity-based collections. Generally specimens are well prepared and labelled, although some specimens are bulk- rather than individually-labelled. Some boxes of lower value “acquisition” material are not as well prepared or labelled. In general the collection is secure, although the need for fireproofing was identified by Centre staff.

About 15 000 specimens have been identified, mostly in the past by IIE, CIE or CABI specialists. Usually, the identifier of specimens has not been recorded and it is unclear whether duplicate material was retained in the Natural History Museum, London. Occasionally the Centre has called upon specialists in MARDI or Australia (especially to identify fruit flies). The Centre is occasionally called upon by Sarawak quarantine officers to assist with the identification of arthropods. None of the entomology group has specialist taxonomic skills and training in the following areas would be welcomed: specimen preparation; and identification of parasitoids and other beneficial arthropods, e.g. predatory Hemiptera.

The stereomicroscope in the collection room is adequate for performing identifications. There is no digital camera.

There is no database to the collection, but Wan (1970) *A List of insects and other animals of economic importance of Sarawak ...* provides a rudimentary index to the collection and a starting point for a databasing exercise.

Initiatives that would assist the ARC, Semongok include:

- Training in specimen preparation and identification.
- Participation in a Listserver.
- Development of a collection database.

Discussions took place with:

- Mr Ron Ah Goh
- Mr Stephen Leong Chan Teck
- Ms Megir Gumbek

6.4.7 Forest Research Centre, Kuching

The Forest Research Centre is responsible for a large and rapidly expanding collection of more than 500 000 specimens. About 25% of the collection is relevant to agriculture and another 25% to forestry. The collection reflects strong interests in forest biodiversity and active, recent collecting, especially in the Lambir Hills National Park. The flood of

specimens far exceeds 1000 specimens per annum and includes specimens collected during regular surveys of plantation trees (e.g. dipterocarps, Australian *Acacia*). The majority of specimens derive from light traps, collecting from a canopy crane, and Malaise traps, and tend to lack confirmed host plant associations. Most specimens are well prepared and labelled.

The Entomology Unit of the Centre comprises 15 staff, including 3 entomologists. Two entomologists are closely associated with the collection and have taxonomic interests in Coleoptera (especially Cerambycidae) and Lepidoptera respectively. Collectively about 30% of their time is available for maintaining the taxonomic adequacy of the collection. About 5000 species are recognised in the collection, but much of the vast material has not been identified to species-level or even sorted into manageable taxonomic units (e.g. families, subfamilies). Occasionally, assistance with identifications or taxonomic matters is sought from Universiti Kebangsaan Malaysia (UKM) (Coleoptera: Chrysomelidae) or Universiti Malaysia, Sarawak (UNIMAS) (Coleoptera; Lepidoptera), but more commonly the Centre's entomologists utilise international linkages, especially with specialists in several universities in Japan and the National Science Museum, Tokyo. Training in identifying Coleoptera and Lepidoptera were seen as a priority need.

Almost all identified specimens had been databased.

Internet access is good but resources to purchase specialist taxonomic literature are limited.

The collection receives its major financial support from the State Government of Sarawak and the Federal Government of Malaysia. Some additional funding is obtained from external sources.

The pinned collection is housed in large wooden cabinets in an air-conditioned room. Unfortunately, for budgetary reasons, it is sometimes necessary to turn off the air-conditioning. The alcohol collection, which amounts to about 10 000 specimens, is stored in two separate rooms for which the air-conditioning is not adequate. Fireproofing is another matter for concern.

The way forward for the FRC, Kuching includes:

- Taxonomic training (e.g. via 1-2 month attachment to specialists, which would require external funding) for entomologists associated with collection.
- More basic training for technical staff.
- Need to develop specific projects to give some focus to the acquisition of material (and perhaps give additional, motivating direction to technical staff).
- Attracting specialists to work with the collection and undertake basic sorting.
- Transfer of the collection to unit trays to enable management.
- Additional space: Because of the size of the collection the need for more space is inescapable, and a new building, which was discussed, would seem a priority.

The collection is potentially an important focal point for taxonomic work in Sarawak. It is large and comprises "interesting" new material that could attract overseas taxonomic specialists to visit or borrow material.

Discussions took place with:

- Mr Ernest Chai Oi Khun
- Mr Paulus Meleng
- Mr Marfaisal Marzuki

6.4.8 *Universiti Malaysia Sarawak (UNIMAS)*

UNIMAS accepted its first student intake in 1993 and now offers undergraduate and postgraduate (M.Sc. and Ph.D.) academic training in a broad range of scientific disciplines. The Institute of Biodiversity and Environmental Conservation within UNIMAS maintains a collection of about 40 000 specimens, about 25% of which are of agricultural relevance. The collection is growing at a steady rate of 100-400 specimens annually, from staff and postgraduate student research projects (most of which have a biodiversity focus) and from undergraduate student collections submitted for assessment. Perhaps only about 1000 specimens are identified to species. The Institute is largely self-reliant in obtaining identifications, although staff occasionally call upon research colleagues throughout the world for informal assistance. International linkages exist with Germany, Spain, Korea and the Philippines. Two professionals and one technician are associated closely with the collection, but only about 10% of their time is available for maintaining its taxonomic adequacy.

The collection is housed in a large, air-conditioned room that also accommodates research students and staff. Pinned specimens are kept in about 150 drawers in high quality cabinets imported from the USA. A new building is anticipated and improved temperature and humidity control will be sought.

Postgraduate projects include one Ph.D. project on citrus psyllid and four M.Sc. biodiversity projects focusing on Lepidoptera (database of Sarawak butterflies, vertical distribution of macro-moths in rainforest canopy) or Coleoptera (Cerambycidae: Lamiinae). Students tend to utilise “morphospecies” concepts rather than undertake taxonomic studies in the strict sense, but one student is gravitating to essentially taxonomic work. This demonstrates how postgraduate “biodiversity” projects can stimulate the emergence of taxonomic skills. Other staff projects include initiatives to document the insect of Borneo.

The standard of preparation and labelling of specimens is variable, and reflects the lack of training in curatorial techniques among part-time technical staff.

Budgetary limitations can restrict access to specialist taxonomic literature. Internet access is good. The CABI Crop Compendium does not seem to be much used but an Australian guide to the identification of aquatic invertebrates (a LUCID-based CD product) has proved adaptable to the Sarawak aquatic insect fauna.

The collection has no dedicated funding and resources for its support derive from research grants.

The future for UNIMAS ideally includes:

- An expanded teaching role and the potential to generate postgraduate students with an interest in taxonomy.
- Support for visits by overseas taxonomic specialists.

- As the collection grows, nomination of one technician as having prime (but probably part-time) responsibility for the collection; this person would require training in specimen preparation and curation.

Discussions were with:

- Dr Fatimah Abang, Director, Institute of Biodiversity and Environmental Conservation
- Dr Dennis Hill, Associate Professor, Institute of Biodiversity and Environmental Conservation

6.4.9 Forest Research Centre, Sandakan

The first entomologist was appointed to the Sabah Forest Department in 1966. From 1978 until 1991 the collection received support from the Japanese International Cooperation Agency (JICA) which enabled the appointment of an entomologist, Professor Ryozi Yoshii, and facilitated the services of a series of Japanese volunteers under the Japanese Overseas Cooperation Volunteer scheme. However, the major expansion of the collection commenced in 1985 when Dr Chey Vun Khen became the first Sabah entomologist to lead the Entomology Section. The Section's program now covers both forest pests and forest biodiversity, and the development of the reference collection is an integral part of this program.

The collection currently totals over 100 000 specimens, of which about 75% are relevant to forestry. Almost all specimens were collected in Sabah, largely by hand or from light traps. Well over 800 specimens are acquired annually and the acquisition rate is increasing. The collection is particularly strong in macro-Lepidoptera and many families of Coleoptera, for example Cerambycidae. The pinned material is housed in about 50 wooden cabinets of various design and quality. Some cabinets do not provide secure seals and it would be prudent at least to transfer the existing wooden drawers to tightly closing, metal cabinet shells, and ideally to transfer all specimens to metal drawers. The collection does not employ a unit tray system although this could be adopted if the collection were moved into metal drawers.

Temperature and humidity control are good but there are occasional power failures that disrupt the continuous running of the air-conditioning units. Fireproofing of the collection is also a matter of concern.

It is estimated that 10 000 species are represented in the collection, but many are unnamed and have been recognised as "morphospecies" in the context of biodiversity studies. Dr Chey has particular expertise in Lepidoptera, Coleoptera and termites, and collaborates with a wide range of national and international specialists, e.g. at Universiti Kebangsaan Malaysia in peninsular Malaysia in connection with work on chrysomelid beetles, in the U.K. and Australia in connection with Lepidoptera. Numerous postgraduate students based at U.K. universities and the Universiti Malaysia Sabah have used the Centre as a base for the field component of thesis research. The Centre is an international focal point for biodiversity studies and taxonomists, and a significant resource for the development of taxonomy in the region generally.

In summary the way forward for FRC, Sepilok, might include:

- Eventual transfer of the collection to secure metal storage cabinets.
- Installation of fireproofing.
- Continuing encouragement of visits and collaboration by international specialists.

6.4.10 Agricultural Research Centre, Kota Kinabalu

Entomological research commenced at the Centre in 1937 and the insect collection (which includes some specimens dating back to 1917) has been accommodated in its current quarters since 1963. The collection is conservatively estimated to comprise about 30 000 specimens.

The pinned collection currently occupies about 60 wooden cabinets and about 150 store boxes. A unit tray system is in use in the cabinets. Some of the cabinet drawers consist of synoptic collections of pests grouped by crops. The store boxes generally contain “duplicate” material. Specimens are well labelled. Some 1985 species, all of agricultural relevance, are represented. About 200 species are represented in the alcohol collection, which is held in vials within about 60 large jars. The jars also contain alcohol so routine topping up of alcohol can be done efficiently. Arthropod specimens are obtained each year from regular hand and light trap collections in rice, vegetable, maize and fruit crops, but fewer than 100 specimens are added per year to the collection. A full-time technical assistant is responsible for the collection, under the direction of an entomologist with skills in crop protection. There is no taxonomist at the Centre, and assistance with critical identifications has occasionally been sought from MARDI or CABI, though specimens are no longer sent to CABI. Access to important scientific literature is difficult and taxonomic literature including name changes is particularly elusive. Staff expressed concern that some of the names employed in the collection may be significantly out of date.

The collection is housed in a large room with air-conditioning units (which run approximately 8 hours per day, i.e. during working hours) and de-humidification units (which run 24 hours per day). Thus far, this regime and a liberal scattering of BHC granules throughout the collection have prevented significant mould problems and outbreaks of museum pests. The major concern seems to be for adequate fireproofing.

There was enthusiasm for training in the identification of any groups associated with crops, with parasitic Hymenoptera a particular priority. Most identifications are made by direct comparison with identified specimens in the collection and this is reasonably satisfactory, as it appears that the pest spectrum in important crops in Sarawak is more or less stable. However, this approach to identifying insects is less successful with parasitic Hymenoptera. CD-based identification tools and information sources are not in use, and it was unclear whether computers in use would allow this. Information is obtained via the Internet but access can be restricted since the research complex has limited telephone lines.

Few specialists visit the collection, although such visits are welcomed. Currently, specimens are not lent but requests from bona fide researchers would be considered in future.

The card catalogue associated with the collection is an additional, valuable source of information on pest species and host plant associations. In a very promising initiative, this is

currently being transferred to a Microsoft Access database. At present records are accessible by directly contacting the Centre.

There is no specific funding for the maintenance of the collection. The assistant associated with the collection will retire in approximately one year, but no replacement is currently being trained in specimen preparation or in the general care of the collection.

Priorities for the ARC, Kota Kinablu include:

- Development of a loans policy and a profile so that specialists borrow or visit to assist with updating of collection.
- Further development of the database, including obtaining assistance in updating names.
- Training of a new technician in specimen preparation and collection maintenance.
- Training in identification, especially parasitic Hymenoptera.
- Fireproofing.

Discussions were with:

- Mr Jinius Jipanin

6.4.11 Malaysian Cocoa Board

The Malaysian Cocoa Board maintains five research stations in peninsular Malaysia, Sarawak and Sabah, and conducts a diverse research program dealing with all aspects of the cultivation and management of cocoa. The Board's linkages include research collaborations with the Departments of Agriculture in Sarawak and Sabah, with Malaysian universities, and with the American Cocoa Research Institute. The cocoa pod borer (the larva of a gracillariid moth) is a focus for much of the Board's current entomological research.

The Malaysian Cocoa Board collection comprises approximately 50 boxes of cocoa and coconut insects collected throughout Malaysia. The collection, which was not seen by the Project Team, is accommodated in new, air-conditioned facilities at Tawau, on the southeast coast of Sabah. The collection is maintained by a part-time technician. The Board does not employ a taxonomist, but is keen to send staff to identification training courses relevant to the management of pests in cocoa.

Discussions were with

- Dr I. Azhar, Director General
- Dr Lee Ming Tong, Deputy Director General (Research)
- Dr Lee Choon Hui

6.4.12 Institute for Tropical Biology and Conservation (ITBC)

The Institute for Tropical Biology and Conservation (ITBC) was established as a Unit of Universiti Malaysia Sabah (UMS) soon after the University came into existence in 1994, and now has an academic complement of 11 with about a dozen support staff. The Institute has roles in postgraduate teaching, research and development, is responsible for the university's natural history reference collections, and is creating an Internet-based biodiversity information system. Currently, there are 15 M.Sc. and 4 Ph.D. students. The M.Sc. programme includes a 28-hour "identification" unit in which students become familiar with

the taxonomy of a selected sub-group of animals. While scholarships are available for postgraduate research degrees they are not available for M.Sc. degrees by coursework, a state of affairs that limits the development of broad training in taxonomy.

The Institute's research and development program has grown rapidly to encompass studies in biodiversity (e.g. insect fauna of the rainforest canopy; bio-monitoring) and systematics (e.g. of termites and ants), ecological processes, the use of biodiversity (e.g. as sources of natural, medicinal products) and ecotourism. Most fieldwork takes place in Bornean rainforests or freshwater ecosystems. The reference collections (BORNEENSIS) include an herbarium, an insect collection and a collection of living plants. A curator's position is currently under recruitment. Currently, the Institute has expertise in the identification of a wide range of arthropod groups, including butterflies, ants, dung beetles, trichogrammatid wasps, termites, lucanid and other beetles, and aphids. Many biodiversity studies rely on the recognition of "morphospecies" rather than the application of formal, species-level nomenclature.

The insect collection is currently in wooden boxes, drawers and vials, stacked awaiting transfer to a modern compactus system. It totals about 32 000 specimens, mostly from collections in natural habitats. The Institute's quarters are new. The collection rooms are spacious and serviced by high capacity, air-conditioning and de-humidification plants. Laboratory facilities are excellent: light microscopes, digital cameras, an electron microscope, and the basic equipment for a molecular laboratory, were either installed or expected.

Institute staff and postgraduates are variously familiar with software for the management of biological information, e.g. Biolink and Specify for the management of specimen data, Worldmap for the analysis of distribution data. A biodiversity database which will be accessible via the Institute's website is under development.

The Institute maintains a rich network of national and international collaborations, e.g. with the Sabah Forestry Department, universities in Japan and Europe, the Natural History Museum (U.K.) and WWF. The Institute receives funding directly through the University and has secured additional support from external sources such as the U.K. Darwin Initiative, the Royal Society of London, the Danish DANCED Programme, and Japan's JIRCAS programme.

The future for ITBC should include:

- Seeking funding for scholarships for M.Sc. training in systematics.
- Extending collaborative links beyond existing biodiversity network with a view to developing R&D projects in the area of pest diagnostics.
- Further development of the website as a site for e-publication of identification tools, e.g. using LUCID.
- Hosting of workshops in identification training.

Discussions were with:

- Professor Maryati Mohamed
- Assoc. Professor Menno Schilthuizen

6.4.13 The Way Forward for Malaysia

Malaysia possesses several of the finest and most important arthropod collections in South East Asia. However, these are widely scattered geographically and there are few formal or informal linkages. There seems to be a conspicuous need for a federation of Malaysian collections, which might provide a forum in which challenges, initiatives and opportunities could be discussed, and collaborations forged. We recommend the formation of such a federation. In this context, we also note that there is a case to be made for the creation of a national museum of natural history. A national museum could be seen as a valuable resource for the suggested federation and a much-needed focal point for the collections of peninsular Malaysia. A national museum might create additional employment opportunities for taxonomists, a possible home for collections no longer receiving institutional support, and perhaps even an additional source of funding for taxonomic research across the country. In October 2000 representatives of 16 Malaysian institutes with interests in taxonomy or collections developed a proposal for a national network for consideration by the national funding body MOSTE. This proposal should be renewed.

The preceding pages have identified rehabilitation needs or desirable improvements for several Malaysian collections. Refurbishment of the Department of Agriculture collection, Kuala Lumpur is the most substantial and urgent challenge. Next to this in urgency may be consideration of the Forest Research Centre collection in Kuching, which will soon outgrow its existing quarters. Because of this collection's size, its rate of growth and the absence of a unit tray system, FRC Kuching could rapidly become intractable. New accommodation and a review of the acquisition strategy may become increasingly urgent in the near future.

Malaysia small group of taxonomic specialists are an important national and regional asset. Furthermore, UKM in Peninsular Malaysia and ITBC in Sabah, and possibly also UNIMAS in Sarawak, present opportunities for postgraduate training in taxonomy, and are thus also of national and regional importance. However, for these training opportunities to be grasped, funding is required for scholarships to assist students from developing countries.

Independent databasing and digital documentation initiatives are underway at MARDI, the Department of Agriculture in Kuala Lumpur, FRIM, the Agricultural Research Centres in Semongok and Kota Kinabalu, the Forest Research Centre in Kuching and at ITBC, Sabah. Although the initiatives are somewhat heterogeneous, together they comprise a substantial commitment towards a national biological information system. In the near future a small workshop to explore the coordination and integration of these activities could be timely. This might be facilitated by a Malaysian approach to the Outreach and Capacity Building Program of the Global Biodiversity Information Facility.

Training requirements within Malaysia vary from a workshop on the identification of Hymenoptera (especially parasitic wasps) and possibly some other arthropod groups, to training for taxonomic specialists in the use of LUCID software for constructing diagnostic tools.

6.5 Myanmar

Activities in Myanmar were organised by Mrs Phyu Phyu Lwin, ASEANET Coordinator for Myanmar and Assistant Manager, Plant Protection Division, Myanmar Agricultural Service.

Appointments for the Project Team were:

- Discussions with staff and visit to laboratories of the Plant Protection Division⁹, Myanmar Agricultural Service, Ministry of Agriculture and Irrigation, Yangon (discussions also attended by academic staff from Yezin University of Agriculture);
- Discussions with officers of the Forest Department, Ministry of Forestry, Yangon;
- Visit to Natural History Museum, Zoological Gardens, Yangon;
- Visit to Hlwaga Natural History Museum, approximately 32 km north of Yangon;
- and
- Visit to National Museum, Yangon.

6.5.1 Plant Protection Division, Myanmar Agricultural Service

The Yangon laboratories of the Plant Protection Division are the focal point for research on plant pests and diseases in Myanmar. The Central Agricultural Research Institute, Yezin (see below), also undertakes research in entomology and plant pathology, but has no reference collection or specialist taxonomic capacity. Within the Myanmar Agricultural Service there is a strong commitment to the implementation of integrated pest management (IPM) in the country's agricultural systems, and this is reflected in the Plant Protection Division's activities, which fall into seven broad areas:

1. IPM (e.g. research on the fungus *Metarhizium* and other biological control agents, on sterile insect release technologies, and on the development of IPM packages for groundnut and cabbage pests);
2. Entomology (including pest surveillance and scouting as part of IPM strategies, classification and identification of insect pests and pesticide trials);
3. Plant pathology (including monitoring of plant parasitic nematodes, and research on the biological and chemical control of nematode pests, monitoring of bacterial and fungal diseases of crops, screening of resistant crop varieties for susceptibility to bacterial and fungal diseases occurring in Myanmar; inspection of seeds for seed-borne diseases, maintaining records of seed-borne diseases and providing

⁹ The report on plant pathogen collections by Evans, Lum & Murdoch (2002), which is the companion document to the present report, does not deal with Myanmar. The following notes provide brief data on the Plant Pathology Section of the Plant Protection Division.

The pathology laboratory currently plays a largely support role to the IPM Laboratory and research activities are relatively restricted. Currently, the laboratory does not undertake any work on plant viruses. There is neither a reference herbarium nor a culture collection. Interruptions to the electricity supply are frequent, which creates major difficulties for the preparation of media and inocula, and in the general maintenance of cultures. Microscope slides and cover slips are in short supply. There is a PCR machine at the national Seed Bank (part of the Central Agricultural Research Institute, Yezin) but the Plant Protection Division does not appear to have facilities for molecular diagnostics of pathogens. There are no facilities for electron microscopy anywhere in Myanmar.

Officers of the Plant Protection Division are aware of the need for a pathology reference collection and enhanced diagnostic facilities. Training and assistance in the development of essential facilities is required. Not surprisingly diseases of tropical fruit are of particular interest at the present time.

Basic training and facilities for the establishment of a pathology reference collection are required. However, because of the uncertain electricity supply the maintenance of a culture collection remains problematic.

- recommendations for their control; identification of toxin-producing fungi on grains and other food commodities);
4. Weed science (including research on distribution and control);
 5. Plant quarantine (inspection of consignments and issue of phytosanitary certificates and import endorsements; treatment of commodities; post-entry quarantine);
 6. Stored product pests (including studies on the biology and identification of stored product pests; research on control measures; inspection; and providing recommendation for storage systems; fumigation of export products); and
 7. Pesticide Analysis (evaluation of pesticides prior to registration; monitoring of pesticide residues on commodities and in the environment; monitoring of levels of mycotoxins in food crops).

The accurate identification of pests and natural enemies is critical to most of these areas. In the past the Plant Protection Division often called upon specialists in the Natural History Museum, London for diagnostic assistance. This service is now prohibitively expensive. Myanmar has no arthropod taxonomists of its own. As a result identifications must be performed by professional or technical officers with general entomological skills or experience in other disciplines, such as biological control or IPM.

Regular, comprehensive surveys of Myanmar's diverse agricultural systems for pests and diseases are beyond the resources of the Division. However, officers of the Division do undertake frequent fieldwork. Surveys of rice, tomato, cotton and beans in recent years, have resulted in a series of well-illustrated booklets describing pests and beneficial arthropods associated with this crops. The rice booklet was completed with the assistance of an international agrochemical company. A recent ACIAR-sponsored compilation (Morris and Waterhouse, 2001) summarises information on 222 arthropod pests and 170 weeds known to occur in Myanmar. However, knowledge of natural enemies remains very poor and this hampers the efficient development of IPM strategies.

The Plant Protection Division maintains a small arthropod reference collection. Pinned specimens are housed in six Bioquip cabinets, which are in good order with well-sealing doors and drawer lids. The cabinets are kept in a large laboratory occupied by about half a dozen staff. The laboratory is well ventilated but lacks air conditioning. Specimens are in good condition and there is minimal evidence of museum pests. The pinned mounts have been prepared with care but it is clear that training in specialist techniques would be very helpful. Training in the preparation and mounting of very small arthropods would be a priority, especially since many of the natural enemies which are important to IPM strategies fall into this size range. Guidance in the preparation of labels would also be valuable. At the present time the purchase of entomological pins, which cannot be obtained within Myanmar, is a particular problem.

The alcohol collection is relatively small and comprises principally immature insects. Essential, preserving chemicals are available in Myanmar and can be purchased as required.

There is no collection of slide-mounted specimens, although temporary preparations are sometimes made for identification purposes. Training in the preparation of permanent slide mounts is essential if members of staff are to be expected to perform critical identifications of important groups such as mites and thrips. The laboratory does not have an oven for baking slide mounts.

Most preparatory work and routine identifications are performed with the naked eye or with the assistance of low-magnification hand lenses. The Division does have some good-quality,

dissecting and compound microscopes but it is necessary to keep these in a separate, air-conditioned laboratory.

There is a small, separate collection of alcohol-preserved, parasitic insects in the Division's IPM laboratory. The vials are labelled minimally but more complete data have been recorded in a series of notebooks. It is appropriate that some specimens are maintained as working collections in relevant laboratories, but it is also important that fully-labelled voucher specimens are deposited as soon as is practicable in the central reference collection. Current work in the IPM laboratory on chrysopid lacewings (which are beneficial predators of pests) exemplifies the difficulties confronting biological control practitioners in Myanmar at the present time. Because of the absence of taxonomic expertise within the country the lacewings cannot be identified reliably to species. Because of the general impediments to international collaboration, exchange visits and access to technical literature, it is difficult for researchers in Myanmar to take advantage of pertinent discoveries made by biological control practitioners in neighbouring countries.

The Division's library includes an excellent collection of general texts and some specialist monographs. However, overseas journals and taxonomic manuals are notably absent. The library does have the CABI Crop Compendium and some other references in CD format. Internet access is limited by government regulation in Myanmar, so for the present the Division's staff are unable to make use of the many freely available information resources. International communication by email is permitted.

There was considerable interest in Listservers such as PestNet. Because it is not possible to gain access to the Listserver website (Yahoo) from within Myanmar, it will be difficult individuals within Myanmar to register to receive PestNet email. The Division's staff members do not have personal email addresses. Nevertheless, it is recommended that email addresses be solicited from the Division and added to the PestNet mailing list.

General IT skills of staff are good, but there appeared to be little experience in the development of complex databases or of modern identification tools such as LUCID or LINNAEUS II.

Officers indicated that they had no experience in pest risk analysis and that training would be welcome.

Routine fieldwork by officers of the Division provides opportunities for more comprehensive and targeted surveys of pest and beneficial arthropods. Officers are familiar with common entomological collecting techniques but could benefit from specialist training, e.g. in the collection of micro-wasps.

Training in the identification of pests and natural enemies was requested. The Division would be willing to host small training workshops. The Division's younger graduates are a valuable resource and in the immediate future they will be relied upon to provide "parataxonomic" support to the work of the group. It would appear that there is no realistic prospect of training arthropod taxonomists within Myanmar in the immediate future.

In summary, the following might form the basis for an initial capacity-building program for the Division:

- Training in the collection and preparation of very small arthropods (e.g. micro-wasps, mites). This could be linked to routine fieldwork during which pests and beneficial

arthropods could be collected from targeted crops or areas. Preparation techniques would include the making of card and slide mounts, and some micro-dissection techniques. Minor items such as a small oven for baking slides, mounting media and dissecting implements would need to be provided.

- Training in the identification of selected groups of pest and beneficial arthropods (parasitic wasps, thrips and mites). To maximise the opportunities for the Division's younger graduates and support staff to attend, the training should take place within Myanmar.
- Acquisition of additional dissecting microscopes. These need not be of the highest research quality nor affording very high magnification, and would be used for specimen preparation and undertaking preliminary identifications.
- Acquisition of specialist identification manuals and critical taxonomic literature. This could be achieved in conjunction with identification training courses.
- Acquisition of adequate numbers of entomological pins.
- Training in the use of computer identification tools, such as LUCID. This also might be achieved during identification training workshops.
- An introduction to specialist databasing software sufficient to guide future choices of information technology.
- Training in pest risk analysis.
- Installation of air-conditioning and de-humidification units in the laboratory which houses the arthropod collection.
- Progressive acquisition of additional insect cabinets and slide storage cabinets (as required).
- Identification of an acceptable protocol for participation in PestNet and related Internet discussion groups, and access to other selected Internet information resources.
- Establishment of closer linkages with Royal Forest Department and NBCRC, Bangkok.

Discussions:

- Mr Than Aye, Head of Division
- Mr U Myo Nyunt, Plant Quarantine Officer
- Mr U Myo Myint, IPM Section Head
- Mr U Hlaing Min, Information Technology Manager
- Mrs Phyu Phyu Lwin, Entomology Section Head
- Ms Aye Aye Than, Entomologist
- Ms Moe Thida, Entomologist
- Ms Zin Linn Myatt, Entomologist
- Ms Ni Ni Saing, Entomologist
- Mr Aye Min Soe
- Ms May May Khin, Pathology Section Head
- Ms Myin Nu Thwin, Pathologist
- Ms Pa Pa Win, Pathologist
- Ms Maw Maw San, Pathologist
- Ms Nilar Maung, IPM

6.5.2 Yezin Agricultural University

This institution was not visited but academic staff from the Department of Entomology travelled to Yangon to participate in round-table discussions held at the Division of Plant Protection.

Yezin University was established in 1924 in Mandalay as an agricultural college and research institute. At various times it has been associated with either the University of Rangoon (now known as the University of Yangon) or the University of Mandalay, and in 1973 it moved physically from Mandalay to the village of Yezin, near Pyinmana, which is approximately 410 km north of Yangon. In 1993 it was transferred administratively from the Higher Education Department to the Ministry of Agriculture. Yezin University now provides four-year undergraduate degrees in agricultural science (in which the final, elective year includes two Plant Protection streams) and postgraduate training to M.Sc. level. On average about 300 undergraduates enrol each year for first year agriculture subjects. The University has separate Departments of Entomology, Plant Pathology and Forestry, including about half a dozen entomologists.

The collection of the Department of Entomology is maintained for teaching rather than reference purposes. It was indicated to the Project Team that specimens generally lack appropriate data. The University apparently lacks facilities and special skills for identifying arthropods, but faculty members are interested in developing the required infrastructure and skills. There appears to be particular interest in the identification of fruit flies.

Professor Myint Thaug of the Department of Entomology, Yezin participated in round-table discussions at the Plant Protection Division, Yangon.

Specific objectives for Yezin Agricultural University might include:

- Development of a small reference collection an adjunct to its teaching collection.
- Participation in training courses for specimen preparation and identification (with obtaining expertise in fruit fly identification an initial priority).

6.5.3 Forest Department, Ministry of Forestry

Officers of the Forest Department indicated that arthropod pests and diseases were not a major concern for the Department. Most timber was harvested from natural, mixed forests, in which a measure of natural control seems to prevail. Problems occasionally emerged, especially in plantation monocultures, in which case the Forest Department called upon expertise in the Plant Protection Division of the Ministry of Agriculture. Myanmar has some plantings of exotics, including Australian eucalypts but, as yet, few pest or disease problems are evident.

The Forest Department does not appear to maintain reference collections or any specialist expertise in the identification of forest pests.

The Ministry of Forestry receives a percentage of its revenue from the sale of logs and sawn timber, and this income has assisted the Ministry to upgrade some of its facilities in recent years.

In view of the Forest Department's limited interest in arthropod pests and diseases it would be more effective to persist with the current reliance on the Plant Protection Division for technical assistance with problems as they arise. The Forest Department could consider providing some assistance in the resourcing of the PPD, to ensure that this expertise was available when required. In turn, the PPD might consider strengthening its linkages with

forest pest and disease specialists in the other South East Asian countries, e.g. in the Royal Forest Department, Bangkok; and FRIM, Malaysia.

Discussions were held with:

- Dr U Shwe Kyaw, Director General

6.5.4 Natural History Museum, Yangon Zoological Gardens

The Yangon Zoological Gardens were established in 1901 and currently occupy approximately 28 hectares close to the city centre. The Natural History Museum, a two-storey building opened in 1966, falls under the administration of the Gardens and is a popular adjunct to the live-animal enclosures. Most the Museum's display space is occupied by stuffed, mounted or alcohol-preserved vertebrates, aquatic invertebrates, wood samples and spectacular art work with a zoological theme. There are no insect exhibits. Displayed specimens are generally in good condition although there is some evidence of matting of hairs and feathers. The building is not air-conditioned. There are no research or reference collections, and all holdings are on public display. There are no research staff.

The Natural History Museum is well positioned to serve as a public education facility. It is well patronised and could be used to “show case” the arthropod biodiversity of Myanmar. For the present however, it has no collections of arthropods and no “back-of-house” facilities to commence such a collection.

6.5.5 Hlawga Natural History Museum

The Hlawga Natural History Museum is a modern building within the Hlawga Wildlife Park, a short drive from Yangon. Interesting displays combining prepared specimens, photographs and maps, depict the forest reserves of Myanmar, biodiversity and conservation themes. There is a small specimen store and office adjacent to the public display area, but the Museum has no research collection or taxonomists. The curator indicated that the Museum is popular on weekends and public holidays, indicating significant interest in natural history.

It is expected that Hlawga will continue to play an important role as an interpretive and educational centre, rather than as a depository for large, reference collections. Hlawga and other reserves fall under the administrative umbrella of the Ministry of Forestry.

In recent years a number of international institutions and agencies have worked in various ways with wildlife authorities in Myanmar to conserve the country's remarkable fauna. For example, the Smithsonian National Zoo (DC and Va., USA) began its association with Chatthin Wildlife Sanctuary, north west of Mandalay, with a narrow interest in the breeding of captive thamin deer. However, the program expanded through the 1990s to encompass broad goals of raising community awareness of biodiversity and demonstrating the importance of conservation. In the late 1990s the Chatthin program included a short training course in the collection and preservation of insects, and the establishment of a tiny collection. The fate of this embryonic collection is unknown.

6.5.6 National Museum

The National Museum is a division of the Ministry of Culture. It occupied several different premises in Yangon prior to moving to the present, large, modern building in 1996. The public galleries focus upon the history and culture of Myanmar, and include many spectacular installations and objects. The gallery of palaeontological specimens comes as something of a surprise among the extensive exhibits of arts, crafts and anthropological relics.

The Project Team visited the Museum opportunistically during out-of-work hours and it is not known whether there is an extensive collection of zoological or fossil specimens in addition to those on public display. There is neither an arthropod collection nor an arthropod taxonomist. The possible role of the Museum as a repository for a national zoological collection (which might include arthropod specimens) may be topic for discussion in the future.

It is recommended that:

- The role of the National Museum as a possible repository for natural history specimens be reviewed.

6.5.7 The Way Forward for Myanmar

A major challenge for Myanmar is to devise acceptable strategies to overcome the impact of isolation. The current limitations to Internet access might be overcome by developing a list of URLs which give access solely to plant health information and then securing institutional access to these sites through the national ISP. The list could be developed in consultation with an international plant health body or regional organisation. Email communication presents fewer difficulties and greater participation in Listserver discussions by Myanmar scientists is encouraged. Direct liaison with the moderators or managers of Listservers may be necessary to enable initial subscription or changes to email addresses.

First steps could be taken towards the development of a national strategy for biological collections. We suggest a small meeting of representatives of organisations responsible for biological collections (including the Plant Protection Division and Yezin Agricultural University, the Ministry of Forestry, Ministry of Culture) and discussion of long-term roles. The arthropod collection at the Plant Protection Division might logically be designated as the “National Arthropod Collection of Myanmar”, with a role complementary to the National Museum and the Natural History Museum. Alternatively, the concept of a distributed “national collection of biological specimens” might be preferred.

Currently, there appears to be little prospect for the training of an arthropod taxonomist within Myanmar. However, Myanmar does possess an impressive group of young graduates with emerging entomological and plant health skills. This group would benefit greatly from specialist identification training workshops. Managers can look optimistically to this group for individuals who demonstrate aptitude for taxonomic work and enthusiasm for future, postgraduate training outside the country.

International interest in the arthropod biodiversity of Myanmar seems to be embryonic. However, as opportunities for travel and scientific work within Myanmar increase, so too

will the number of visiting international specialists. Myanmar can expect to capture benefits, providing its scientific agencies such as the Plant Protection Division are able to host visits, offer working space, and provide secure, professionally-curated storage facilities for deposition of reference specimens. This would require:

- Acquisition of dissecting microscopes, insect pins, specialist literature;
- Installation of air-conditioning and de-humidification units in the collection room; and
- Progressive acquisition of additional storage cabinets.

A detailed, capacity-building program focusing principally on the Plant Protection Division is proposed above. This includes a series of training workshops to increase skills in:

- Preparation of small arthropod specimens;
- Identification of Hymenoptera (wasps), Thysanoptera (thrips), Diptera-Tephritidae (fruit flies) and Acarina (mites);
- Computer identification tools such as LUCID-based products;
- Database development; and
- Pest risk analysis.

6.6 Philippines

Visits and discussions in The Philippines were arranged by:

1. Dr Horacio O. San Valentin, Senior Science Research Specialist, Department of Environment and Natural Resources and ASEANET National Coordinator; and
2. Dr Bonifacio Cayabyab, Plant Quarantine Support Laboratory, National Crop Protection Centre.

The following institutions were visited:

- Plant Quarantine Support Laboratory, National Crop Protection Centre, University of the Philippines Los Baños, College, Laguna;
- Department of Entomology, University of the Philippines Los Baños;
- Museum of Natural History, University of the Philippines Los Baños;
- Department of Entomology, Benguet State University, Baguio;
- Central Luzon State University, Muñoz;
- Philippines Rice Institute, Maligaya, Muñoz, Nueva Ecija;
- Crop Protection Division, Manila; and
- National Museum of the Philippines, Manila.

The Project Team is aware that its coverage of Philippines arthropod collections has been incomplete.

The International Rice Research Institute, Los Baños maintains an entomological reference collection of about 90 000 specimens, principally relevant to rice cropping systems. Material from this collection has been accumulated over many decades from localities throughout South East Asia. It was not possible to arrange a visit during the days the Project Team was in the Los Baños area. The collection is curated by Dr Alberto T. Barrion, an internationally known specialist in the taxonomy of spiders and insects associated with rice.

The collection at the University of San Carlos, Cebu City is reported to comprise about 20 000 pinned specimens and a large quantity of unmounted material. Pinned specimens are stored in cabinets and are available for loan (Tumilap, 1984).

The Biological Museum, Visayas State College of Agriculture, Bayaby, Leyte is reported to contain about 35 000 specimens, including a significant collection of slide-mounted mites (Arnet *et al.*, 1993).

6.6.1 Plant Quarantine Laboratory, University of the Philippines Los Baños

The Plant Quarantine Support Laboratory maintains a collection of about 50 wooden store boxes of pinned insects, several dozen vials of alcohol-preserved specimens, and two small boxes of slides. Specimens are well prepared and labelled. The collection is curated by Ms Jessamyn Recuenco-Adorada, who is a specialist in the taxonomy of Coccinellidae (Coleoptera). The Laboratory provides identifications of diverse arthropods in support of various applied projects. Microscope facilities are fairly basic. Ms Recuenco-Adorada has experience of several database packages, including Microsoft Access, Biota and Platypus, and identification tools based on LUCID. Access to information is an impediment to taxonomic work and to providing an identification service. The collection is checked every 1-2 months for incipient damage by mould or museum pests. Thus, the collection's security is a result of its relatively small size and an attentive curator. It is understood that Mr Mario V. Navasero, another entomologist on the staff of the National Crop Protection Centre, has expertise in the taxonomy of Psylloidea.

Priorities for the Laboratory appear to be:

- Accommodation of the collection in a room with adequate air-conditioning and de-humidification units.
- Improved microscope facilities.
- Improved access to taxonomic literature.

Consultation and discussions were held with:

- Professor Eliseo P. Cadapan, Director, National Crop Protection Centre; and Professor, Department of Entomology
- Dr Bonifacio Cayabyab
- Ms Jessamyn D. Recuenco-Adorada

6.6.2 Department of Entomology, University of the Philippines Los Baños

The Department of Entomology provides the most comprehensive, tertiary-level training in entomology in the Philippines. It includes 7 academic staff with taxonomic interests as follows:

Dr Stephen Reyes (Hymenoptera, especially aculeate wasps and bees)
Dr Victor Gapud (Hemiptera, esp. aquatic and semi-aquatic families, Odonata, Collembola)
Dr Leonila A. Corpuz-Raros (mites)
Professor Leo C. Rimando (retired; tetranychoid and raphignathoid mites)
Dr Venus J. Calilung (retired; aphids)

Dr Clare Balthazar (retired; parasitic Hymenoptera)
Dr Grace F. Barroga (galerucine Chrysomelidae-Coleoptera)

and two postgraduate (M.Sc.) students:

Ms Sheryl A. Yap (weevils)
Ms Aimee Lynn A. Barrion (geometrid moths)

This group represents the only substantial aggregation of arthropod taxonomists in the Philippines. The large, university insect collection is housed in the same building as the Department, but Departmental staff have no formal appointments as curators of the collection. As a result, the arthropod taxonomists appear to provide a negligible contribution to the upkeep and organization of the country's premier collection.

Departmental staff experience difficulties in purchasing adequate computing resources. The library is adequate for older taxonomic publications but is very incomplete for newer journals. Some use has been made of CD-based identification tools, including one product employing LUCID.

Initial objective for Department and University:

- In the interest of better management of the University's arthropod reference collection, the establishment of close, formal linkages between Departmental taxonomists and the University's Natural History Museum (see below) is seen as a high priority.

Discussions were principally with:

- Dr Virginia R. Ocampo
- Dr Stephen Reyes

6.6.3 Museum of Natural History, University of the Philippines Los Baños

The UP Los Baños Museum of Natural History was established in 1976 and comprises about seven separate collections, most of which are housed in various departments scattered over of the UPLB campus. The public galleries of the Museum include spectacular displays of large arthropods. The main entomological collection occupies a large room in the Department of Entomology, some distance across campus from the main Museum Building. The entomological collection has been rebuilt since its destruction during World War II and now, with over 100 000 pinned specimens and over 10 000 slide mounts, it is once again the largest arthropod collection in the Philippines.

The curator, Dr Ireneo Lit, is a taxonomist, specialising in the coccoids (scale insects) and with additional expertise in butterflies and stick insects. His current duties are wide-ranging and leave little time for taxonomic work or the upkeep of the arthropod collection.

The pinned insects are housed in wooden cabinets and store boxes, under poor conditions. Climate control is erratic and the collection room is crowded with boxes, literature, unsorted specimens and extraneous material. Adequate cleaning and collection maintenance is impossible with the current level of curatorial resources. Although the standard of labelling and identifications is variable, the collection is a scientific resource of national and international significance. Currently, it is at extreme risk.

The collection requires substantial rehabilitation. Reliable air-conditioning and de-humidification units are essential. The collection room must be cleared of extraneous material which encourages museum pests. Large numbers of vials from which alcohol has evaporated must be assessed; probably, most are of little residual value and can be discarded. Insect cabinets should be assessed for security. The room requires adequate fireproofing. Because of the size of the collection, the evident challenges in the way of rehabilitation, the need to integrate the collection closely with the work of the Department of Entomology, and the need to take into account other collections dispersed about the University campus, a detailed assessment and rehabilitation plan is almost certainly required. Following rehabilitation, a maintenance regime, including regular inspections of the collection for museum pest and mould damage, should be established. It is recognised that the Natural History Museum, the Department of Entomology and the University all operate in an environment in which resources are very limited. Nevertheless, the collections are an important component of the national estate and, in the long run, essential to maintaining the country's scientific capacity to identify arthropod pests.

Close, formal linkages must be re-established with taxonomic specialists in the Department of Entomology. The re-building of these linkages is regarded as a high priority by the current Museum Director.

Priorities for the Museum of Natural History can be summarised as follows:

- Conduct a detailed assessment of the arthropod collection as a basis for the rehabilitation of the collection room, storage cabinets and specimens.
- Initiate discussions directed towards the establishment of closer linkages between the Museum and taxonomic specialists in the Department of Entomology.

Discussions took place at the Museum with:

- Dr Ireneo Lit hosted the Project Teams' visit to the Museum.

and several weeks later, at a conference in South Africa, with:

- Assoc. Professor Lourdes B. Cardenas

6.6.4 Department of Entomology, Benguet State University

The small collection of the Department of Entomology is used largely for teaching. Specimens are added each year from student collections and utilised in practical classes. Inevitably specimens are frequently damaged and discarded. The standard of specimen preparation and labelling varies from adequate to poor. Specimens are kept in wooden store boxes in a small room which lacks air-conditioning. While the collection is satisfactory for undergraduate teaching it cannot be regarded as a durable reference collection. The Department has a crop protection focus and undertakes no taxonomic research.

Discussions were with:

- Assoc. Professor Bonie S. Ligat
- Casiano S. Pagadan

6.6.5 College of Agriculture, Central Luzon State University

Originating in 1907 as an agricultural school, Central Luzon State University achieved its present status in 1964. It now provides tertiary training across a range of disciplines and is the leading institution in a cluster of science facilities near the city of Muñoz, approximately 150 km north of Manila.

The College of Agriculture maintains a small arthropod collection for teaching and reference purposes. At the time of the Project Team's visit much of the collection was being transferred to new wooden cabinets. This made it difficult to assess the precise size of the collection but it is likely to amount to fewer than 10 000 specimens. Specimens come almost entirely from the Central Luzon area and many derive from student collections submitted for assessment. A high percentage of specimens are of agricultural relevance. Pests of various commodities are exhibited in a series of 16 metal display drawers. The collection also includes some dried plant specimens demonstrating insect damage.

A junior technician, with two years on-job experience, manages the collection. The standard of preparation and labelling is variable, and some specimens are mounted on unsuitable pins. Training in curatorial techniques would be welcomed. The collection room lacks air-conditioning, but specimens have been protected from museum pests by the preventive use of naphthalene and malathion. Specimens which are currently exposed to sunlight should be shielded to minimise deterioration and fading of colours.

The collection is used frequently. Identifications are made with the assistance of overseas texts and manuals prepared at UPLB. The collection's dissecting and compound microscopes are of teaching rather than research standard. Staff were unfamiliar with CD-based identification tools. One staff member is a specialist in the taxonomy of fruit flies and agromyzid flies. The Internet is used to seek information, but access can be slow.

Priorities for the Central Luzon State University collection seem to be:

- Training in the preparation and curation of arthropod specimens.
- Installation of air-conditioning and de-humidification units in the collection room.
- Segregation of reference and teaching collections.
- Protection of display specimens from sunlight with opaque curtains or cardboard covers.

Discussions were held with:

- Dr Elaida R. Fiegalan
- Ms Arlene G. Villameva

6.6.6 Philippines Rice Research Institute (PhilRice)

The Philippines Rice Research Institute is located nearby to the Central Luzon State University. Since 1985 it has undertaken diverse research and extension programs relating to the cultivation and protection of rice and a few key vegetable crops grown alternately with rice. Facilities are modern, and the Institute's collection is kept in a centrally air-conditioned office/laboratory. The collection is small. Pinned specimens occupy two high-quality, wooden cabinets. There is also a small number of alcohol vials and about 20 boxes of slide-mounted material. Specimens are well prepared and labelled, and have been identified and

arranged within the last 10 years by Professor V.P. Gapud, a visiting taxonomist from UP Los Baños. A PhilRice staff member is now responsible for care and maintenance. Currently, the collection is in good order and secure, but not in active use.

Equipment and laboratory facilities appear to be good. PhilRice maintains an informative website including pest dossiers.

The staff member responsible for the collection would welcome training in specimen preparation and identification. This would assist in survey work for other projects, and enable greater use of existing reference collection.

Priority for PhilRice:

- Training in specimen preparation and identification.

Discussions at PhilRice were with:

- Evelyn M. Valdez
- Gertrudo Arida

6.6.7 Crop Protection Division, Department of Agriculture

The Crop Protection Division has broad, national responsibilities for the management of insect pests, plant diseases, rodents and weeds. It has recently been reduced in size from approximately 100 staff to 32, with the transfer of many of its provincial officers to regional departments of agriculture. The collection of the Crop Protection Division was commenced in the late 1940s and now comprises about 30 000 pinned specimens, all of which are of agricultural relevance. Specimens have been acquired from crops throughout the Philippines, although in recent times the number of specimens added to the collection each year has slowed markedly. Currently, there are no regular surveys of crops. The collection includes some quarantine interceptions from an earlier era.

Although the collection is not widely known, it provides identifications, without charge, for regional staff and quarantine officers (the Philippines quarantine service does not maintain a collection and relies on the Crop Protection Division and UPLB for identifications). Difficult identifications are sent to UPLB and may attract an identification fee of 50 pesos per specimen. The fee is sometimes waived. This identification fee is a matter of some concern and was raised previously at the Central University of Luzon. While a fee-for-service system has its supporters, it is of dubious practicality in the cash-poor environment of South East Asian agricultural agencies. Fees charged by CABI/NHM (UK) are largely beyond agency budgets. In recent times, few taxonomic specialists have visited the collection of the Crop Protection Division; currently specimens are not lent out.

Three staff, including one entomologist, are associated with the collection, all on a part-time basis.

Publication of pest records is regarded as important but difficult because of budgetary limitations. The Division collates pest records received from regional centres, and maintains a database of Philippines' pests in a Microsoft Excel format. Records are mostly of familiar species and voucher specimens are not forwarded routinely to Manila.

The collection is housed in large, wooden cabinets, which are old and no longer provide secure storage. Some larger insect specimens show evidence of damage by museum pests. The cabinets contain a mixture of drawers and wooden boxes. This, combined with the absence of a unit tray system, renders the collection difficult to manage. Temperature and humidity control is no longer possible due to failure of units. The collection resides in a large, timber-panelled room, which affords adequate expansion space for the immediate future.

Priority needs for the collection are:

- Adequate air-conditioning and de-humidification units.
- Replacement of the timber cabinets.
- Training in identification (especially of Coleoptera, Lepidoptera, Hemiptera and Diptera) and curatorial techniques.
- Development of a formal database.

Discussions were with:

- Ms Wilma R. Cuaterno, Chief, Crop Protection Division
- Mr George Paul S. Karganilla, Supervising Agriculturalist

6.6.8 National Museum of the Philippines

The National Museum began to accumulate its large natural history collections in the early 1900s and today the Museum occupies one of three huge, colonial-era buildings near Rizal Park in central Manila. The insect collection amounts to an estimated 121 000 specimens, including about 108 000 pinned. Specimens have been acquired from all over the Philippines, from natural and managed landscapes, and about 25% of the collection would be of agricultural significance. The collection continues to grow at a rate of over 800 specimens annually. Specimens are generally well prepared and well labelled, although many labels are yellowed with age.

The entomologist-curator is a taxonomic specialist in the Lepidoptera, and an authority on Philippines butterflies and mosquitoes. Occasionally assistance with identifications will be sought from UPLB or from overseas specialists in Japan or Germany. The entomologist has a little technical help with routine curatorial tasks but, in general, human resources seem inadequate for managing this large, old collection.

The collection is stored in a mixture of wooden drawers and store boxes that are either contained in wooden and metal cabinets, or stacked about the collection rooms. The collection is very cramped. Papers and other items are stacked atop cabinets, creating a significant fire and pest hazard. Some cabinets and cupboards are inaccessible because of accumulations of material in front of them. Occasionally drawers lack moth balls and a few already have evidence of damage by museum pests. In some drawers moth balls have dislodged and roll freely about doing random damage to fragile, pinned specimens. Alcohol specimens are stored in a heterogeneous array of domestic jars. There is a fire detector but no sprinkler system. The central air-conditioning seems adequate.

The museum does lend material to *bona fide* researchers and visiting specialists do come to study the collections, although bench space is extremely limited.

The collection is not particularly well equipped. Microscopes are barely adequate and there is no computer. The entomologist largely uses his personal library to support his research.

The public display areas include a modern, informative and visually appealing insect exhibit. It is clear that if resources were available the reference collection could be rehabilitated to a high standard.

It is anticipated that the collections will move in coming years to another large, colonial-era building in the Rizal Park area. It is hoped that this will provide more storage space and the opportunity for the purchase of additional storage cabinets.

It is interesting to note that substantial upgrading of the National Herbarium, which is a Department of the National Museum, has been made possible with the assistance of grants from funding sources in the USA. This option might be explored by the Museum on behalf of the entomological collections.

It is suggested that initial priorities for the National Museum might include:

- Transfer of the arthropod collection to more spacious quarters.
- Inspection of drawers for mechanical, pest and mould damage.
- Acquisition of microscopes for preparation and examination of small arthropods.

Discussions took place in Manila with:

- Mr Venezia U. Samarita
- Ms Elma Naqas;

and several weeks later, in South Africa, with:

- Dr Domingo Madulid, Director, National Herbarium

6.6.9 The Way Forward for the Philippines

Since the present survey probably has provided an incomplete coverage of the arthropod collections of the Philippines and taxonomic capacity, remarks here should be taken as somewhat tentative.

It is heartening to note that the Philippines does have a workable number of arthropod taxonomists, principally clustered in the Los Baños area. Many of these specialists have responsibilities that go beyond taxonomic research and coverage of the major arthropod taxa is incomplete. Nevertheless, this cluster of specialists can be expected to continue to provide the country with much needed taxonomic support. The Philippines can also look to the University of the Philippines, Los Baños, to continue to provide training to at least a small number of new taxonomists and curators.

That the arthropod collections and expertise are scattered across the Philippines represents one of the country's greatest challenges. Certainly, there is scope for coordination of strategies and programs across institutions. This might best be achieved through the creation of a national forum in which representatives of all biological collections participated.

The preceding pages begin to identify a program of rehabilitation and training for Philippines institutions. The most pressing refurbishment need is for the rehabilitation of the collection of the Museum of National History, Los Baños. This is likely to be a major and costly undertaking. A possible approach to rehabilitation is discussed above in sections

dealing with the University of the Philippines. In addition to this critical problem, the collection rooms at the National Crop Protection Centre, Los Baños, at the Central Luzon State University, Muñoz, and at the Crop Protection Division, Manila, all require air-conditioning and de-humidification units. The pinned collection at the Crop Protection Division, Manila should be transferred into new storage cabinets as soon as possible. To this could be added various needs for better dissecting microscopes and improved access to taxonomic literature.

Training needs include instruction in the preparation and curation of arthropod specimens, in the identification of Coleoptera, Lepidoptera, Hemiptera and Diptera, and in database development.

6.7 Singapore

Ms Chew Ping Ting, Research Officer, Nature Conservation Branch, National Parks Board, Singapore Botanic Gardens, arranged discussions in Singapore. The Project Team:

- met collectively with representatives of the:
 - Raffles Museum of Biodiversity Research, National University of Singapore;
 - Agri-food and Veterinary Authority of Singapore; and
 - Environmental Health Institute, Ministry of the Environment;
- viewed the natural history collections and facilities of the Raffles Museum; and
- briefly visited the research offices of the Singapore Botanic Gardens, National Parks Board.

6.7.1 Raffles Museum of Biodiversity Research

The Raffles Museum of Biodiversity Research (RMBR) resides within the Department of Biological Sciences, National University of Singapore, and is by far the largest collection of zoological specimens in Singapore. It is also one of the oldest and most widely known collections in South East Asia. The RMBR includes material from the first Raffles Museum, which was established in 1849 through the enthusiasm of the famous administrator-naturalist, Sir Stamford Raffles.

Singapore has a long history as the principal administrative centre for the British colony of “Malaya” and as a scientific focal point in the region. Curators of the first Raffles Museum participated in expeditions throughout the South East Asian region and exchanged specimens with the Sarawak Museum (now in Malaysia), the Museum Zoologicum Bogoriensis (Indonesia), and various museums in the United Kingdom, the USA and Europe, and with the Bombay Natural History Society (India). In 1926 the insect collections of the Raffles were transferred from Singapore to the Selangor Museum in Peninsular Malaysia (in exchange for mammal and bird collections) and these insects now form part of the Department of Agriculture Collection, Kuala Lumpur, Malaysia. In 1969 the Raffles Museum was renamed the National Museum of Singapore but it was decided that this new institution would retain only cultural artefacts. The zoological collections, including insects that had accumulated since 1926, were shunted first to the Singapore Science Centre, and then to a series of temporary sites within the University of Singapore and Nanyang University. In 1986 the collections finally were transferred to the present-day quarters on the new campus of the National University of Singapore. The RMBR today includes collections from the old Raffles, and collections from Nanyang University and from long-

resident, Singapore academic, Professor D.H. Murphy. The Raffles collections continue to grow as an adjunct to biodiversity projects in Singapore and the ASEAN region. More than 800 specimens are acquired each year and the number requiring identification is increasing each year.

The modern-day Raffles Museum is one of the best-known collections in the region and its journal, the *Raffles Bulletin of Zoology*, is widely subscribed throughout the world. The Museum's website is: <http://rmbn.nus.edu.sg>

The entomological collections of the RMBR comprise approximately 86 000 specimens. About 25% of these are relevant to agriculture. All are stored under modern, climate-controlled conditions (the 24-hour air conditioning system maintains temperatures in the range of 22 - 24°C and 55 – 60% relative humidity). Pinned specimens are stored in wooden cabinets and boxes in a separate, somewhat cramped entomological collection room. Alcohol-preserved specimens are shelved in a manually-operated compactus system with the other liquid collections of the Museum. Funding for maintenance and development of the entomological collection is modest. The physical security of the collection, access to information, and essential equipment are not major problems at RMBR. Three staff are associated with the entomological collections: Mrs M.C. Yang is a taxonomist with particular interest in aquatic insects; Assoc. Professor S.H. Ho is primarily interested in pest management; and there is one technician (“curator”) who lacks formal training in the identification of insects. Additional staff, especially staff with taxonomic training, would seem desirable to facilitate efficient and optimal use of this important collection. Although the RMBR conducts a vigorous and varied postgraduate program, at present the National University of Singapore does not appear to be training new arthropod taxonomists. While there are some possibilities for Singapore to assist with training of persons from other nations in the ASEAN region (e.g. through programs of the Singapore Ministry of Foreign Affairs), the comparatively high cost of living in Singapore can cause difficulties for agencies of other countries. A program in Integrated Pest Management is mooted at the sister-university, the Nanyang Technological University; it is expected that the RMBR would be both a resource and specimen depository for this program. The RMBR has a Fellowship program to support short-term (2-6 week) research visits by external specialists. This might be utilised to facilitate the re-curation of parts of the collection. Currently RMBR entomologists are not involved in projects in molecular diagnostics but within the Department of Biological Sciences would seem to offer opportunities for collaborative work if appropriate projects and funding were identified. The RMBR has employed a MUSE Database system for vertebrate specimen records and a BRAHMS system for the herbarium, but digitising of the entomological collection has not yet commenced. The centre is interested in evaluating alternative specimen database systems.

Profitable steps for the RMBR might include:

- Utilisation of Fellowship Program to support visiting specialists in key arthropod groups, to assist with identification and curation.
- Participation by the collection technician in identification training course.
- Recruitment of another insect taxonomist.
- Evaluation of Biolink and other specimen database systems.
- Exposure to LUCID and LINNAEUS II diagnostic products.

Consultations and discussions were held with:

- Mrs Man Chang Yang and several other staff of the RMBR participated in formal and informal discussions.

6.7.2 Entomology Laboratory, Agri-food and Veterinary Authority

The Agri-food and Veterinary Authority's (AVA's) Entomology Laboratory deals principally with arthropod pests of vegetables, orchids, fruit trees, ornamentals, aquatic plants and stored products. The Laboratory is currently preparing a new catalogue of the arthropod pests of Singapore, and officers are aware of the appearance or emergence of a number of new pests, as well as the apparent disappearance of some species previously regarded as economically significant. The AVA maintains a small collection of approximately 4200 specimens, 75% of which are of relevant to agriculture. Most specimens received for identification have been collected by AVA officers during the course of surveillance. Although the Entomology Laboratory comprises six permanent staff, no more than 5% of their time is available for maintenance of the taxonomic adequacy of the reference collection. Staff are familiar with the LUCID software for constructing interactive diagnostic keys. A LUCID-based key to stored product pests is in use and "LUCID Builder" is currently being employed to create a simple, in-house, training tool.

The physical security of the collection is a matter of concern. The facilities are not fireproof and lack adequate humidity control. Infestations by museum pests (mould, mites and booklice) are key threats. Currently there are no dedicated funds for the maintenance of the reference collection; resources for the collection's upkeep must be taken from the general operational expenditure of the Plant Health Centre of the AVA.

The AVA occasionally makes use of specialist expertise at the National University of Singapore. Previously specimens were sent routinely to specialists at CABI in the United Kingdom, but this practice has ceased with increased costs. A Microsoft Access database has been developed and currently contains about 3000 records. It is not clear whether the database includes all label data that would be required to meet international standards.

Based on discussions, priorities for the AVA collection would appear to be:

- Attention to physical security, especially air conditioning and de-humidification.
- Training in identification for officers.

The Project Team met with:

- Mr He Liansheng

6.7.3 Environmental Health Institute

The Environmental Health Institute maintains a small collection of approximately 1460 specimens, principally mosquitoes and cockroaches collected by public health inspectors. While the collection largely falls outside the scope of the current survey, the new Institute is relevant in that it is planning to undertake molecular diagnostic work and could be considered as a collaborator in projects on the molecular diagnostics of fruit flies or other pest flies. The reference collection has no specific, dedicated funding. Routine collections of common species are discarded after identification. In general the Institute's laboratories are modern and well equipped. The Institute could be borne in mind as a potential collaborator on molecular diagnostics of pest flies

The principal contact for the collection is:

- Mrs Lam-Phua Sai Gek

6.7.4 Singapore Botanic Gardens

The Singapore Botanic Gardens maintains a small arthropod collection (approximately 2500 specimens) as an adjunct to its large Herbarium (of over 650 000 specimens) and public displays. It employs no arthropod specialists. The Herbarium has a strong program in the documentation and analysis of the South East Asian flora and cannot be overlooked as a catalyst of taxonomic work in general in the ASEAN region. Experienced plant taxonomists from the Gardens research staff could have some co-supervisory role in the training of new taxonomists. Similar co-supervision of postgraduates with entomological thesis topics has proved fruitful in Australian universities.

Discussions were held with:

- Ms Chew Ping Ting
- Ms Cheryl Chia Siew Wah, Research Officer (Nature Conservation).

6.7.5 The Way Forward for Singapore

Singapore's strengths include the country's general infrastructure and funding, the well-maintained collection of the Raffles Museum of Biodiversity Research (RMBR), and a group of well-trained taxonomists. Singapore's taxonomists have a strong regional focus and tend to have very well-developed international linkages.

However, it is by no means straightforward for Singapore to build upon these strengths. While the collection at RMBR is well maintained there is little physical space for expansion. By the same token, there are only a few Singapore entomologists with taxonomic expertise. The University of Singapore could be looked to as a training ground for regional taxonomists. However, the cost of living in Singapore is high, which is a genuine impediment for prospective students from the region's developing countries. Thus, it is not easy for Singapore to have a major impact on taxonomic capacity in the region.

Singapore will continue to be of regional importance, for example through the RMBR as a secure repository for reference material, through the *Raffles Bulletin of Zoology* as a publications outlet, and through its Museum Fellowship program which could be used to assist regional specialists or to "borrow" expertise from other parts of the world. An expansion of the Fellowship program to enable regional specialists to complete taxonomic projects in a well-resourced environment would be a welcome initiative. The recruitment of even one additional, tenured arthropod taxonomist to the RMBR staff could make a substantial contribution to regional capacity.

Other capacity-building opportunities for Singapore include: participation by technical staff in identification training courses; and exposure to specialist taxonomic software such as Biolink, LUCID and LINNAEUS II. It was also indicated to the Project Team that the room housing the arthropod collection of the Agri-food and Veterinary Authority requires air-conditioning and de-humidification units.

6.8 Thailand

The schedule of visits in Thailand was organised by the ASEANET Country Coordinator, Dr Banpot Napompeth, Director, National Biological Control Research Centre, Bangkok. The schedule included visits to four institutions in Bangkok and universities in northern, north-eastern and southern Thailand:

- National Biological Control Research Centre laboratories on campuses of Kasetsart, Mae Jo, Khon Khaen and Prince of Songkla Universities;
- Department of Entomology, Faculty of Agriculture, Kasetsart University (Bangkhen campus), Bangkok;
- Division of Entomology and Zoology, Department of Agriculture (DOA), Ministry of Agriculture and Cooperatives, Chatuchak, Bangkok;
- Forest Insect Group, Division of Forest Environment Research and Development, Royal Forest Department, Ministry of Agriculture and Cooperatives, Chatuchak, Bangkok;
- Department of Plant Protection, Mae Jo University, 10 km north of Chiang Mai;
- Department of Entomology, Chiang Mai University;
- Department of Entomology, Khon Kaen University; and
- Department of Pest Management, Prince of Songkla University, Hat Yai.

6.8.1 National Biological Control Research Centre (NBCRC)

The National Biological Control Centre (NBCRC) implements biological control programs against insect pests, vectors and weeds of agricultural and public health importance throughout Thailand. It undertakes research and extension services in biological control and IPM and provides academic and non-academic training in these disciplines. Established in 1975, NBCRC now comprises a headquarters complex on the Bangkhen Campus of Kasetsart University, Bangkok and four Regional Centres. NBCRC is funded through the National Research Council of Thailand. It has a wide network of collaborative links with national and international institutions, and many staff hold academic appointments with host universities. Each Centre maintains a collection of arthropods. An on-going, national program of the NBCRC is the survey and collection of natural enemies of insect pests and natural enemies of weeds in Thailand. Specimens from this program are deposited in collections in each Regional Centre and in the main NBCRC collection in Bangkok. Voucher specimens of biological control agents are also deposited in these collections.

6.8.1a NBCRC Headquarters, Kasetsart University (Bangkhen Campus)

The NBCRC Headquarters is well equipped and has an enviable, specialist, reference library. The main NBCRC collection, known as the Natural Enemies Reference Depository (NERD), is housed in an air-conditioned room in modern cabinets. It comprises approximately 740 pinned specimens and 1850 alcohol vials, all of which are relevant to agriculture. The collection is growing at a moderate rate (estimated 100-400 specimens per year) from surveys of field, horticulture, vegetable and forest crops. Two entomologists are associated with the collection but neither have specialist training in taxonomy and it is estimated that only 10% of their time is available for maintaining the taxonomic adequacy of the collection. Specimens are well curated and well labelled. Storage space may become an issue in the

future but for the present the major security concern is fireproofing. In principle, Regional Centres of NBCRC send representatives of species from their collections to Bangkok.

Occasionally, expertise in the nearby Department of Agriculture or in the Central Regional Centre of NBCRC (see below) is called upon to assist with taxonomic or identification matters. Specialist, taxonomic literature can be difficult to obtain. Training in the identification of parasitic Hymenoptera and predatory Coleoptera are seen as priorities. Currently there is a list of the species represented in the collection but no formal database recording label data; training in database development and management would be required to establish a database system that encompassed the Bangkok and Regional Centres.

Priorities for the NBCRC Headquarters collection (NERD) and associated staff might include:

- Training in identification of parasitic Hymenoptera and predatory Coleoptera.
- An introduction to database development and management.

Discussions regarding NBCRC collections and facilities were held with:

- Dr Banpot Napompeth
- Mr Kosol Charernson
- Dr Weerawan Amornsak
- Ms Thitima Thongtab
- Ms Sudarat Chavalit

6.8.1b NBCRC Central Regional Centre, Kasetsart University (Kamphaeng Saen Campus)

The Central Regional Centre is located approximately 90 km west of Bangkok. The Centre was not visited but information was obtained through discussions in Bangkok with the Assistant Director, Mr Kosol Charernson, and via the questionnaire. The Central Regional Centre collection comprises approximately 7540 specimens, about half of which have been identified. The collection is growing at a similar rate to the NBCRC Headquarters collection (100-400 specimens annually), principally from surveys of sugarcane, pommello, mango and weeds. The Central Regional Centre frequently calls upon taxonomic expertise in the Department of Agriculture (MOAC) and the Department of Entomology, Kasetsart University, Bangkok, and occasionally calls upon expertise in the Museum of Natural History, London. Two staff members are associated with the collection and provide about 25% of their time to taxonomic activities. Mr Kosol has postgraduate training in taxonomy and is a specialist in the parasitic Hymenoptera. Staff associated with the collection have some skills in database management but there is no formal database to the collection.

6.8.1c NBCRC Northern Regional Centre, Mae Jo University

The Northern Regional Centre is on the campus of Mae Jo University, about 10 km north of Chiang Mai. The Centre focuses upon insect pests of fruit trees and other insect pests and weeds in the northern highlands. The region includes the most mountainous agricultural lands in Thailand. The Centre maintains a small collection of about 1270 specimens, mostly in alcohol. All are of agricultural relevance. Specimens are housed in 5 wooden insect cabinets (total of 100 drawers), and are generally well labelled and secure. Specimens come from surveys of field, vegetable, ornamental and fruit tree crops, and weeds in the northern region of Thailand. Between 400 and 800 specimens are collected each year, some are

identified locally; others are forwarded to the NBCRC Headquarters or Central Regional Centre for identification. Some species appear to be identified only to family. Specimens representing common species are not always retained. Interest was expressed in general training in the identification of insect pests, mites and natural enemies. The Centre employs 12 staff, including three entomologists. Most are contract employees, and only two entomologists, including the officer-in-charge, Dr Charnnarong Doungsa-ard have permanent status. Approximately 25% of staff time is devoted to identification and collection-related activities. The Centre is generally well equipped for its work, although some reservations were expressed regarding the adequacy of microscopes for performing routine identification work. Air-conditioning, de-humidification and the sealing of insect cabinets were raised as a concern by local staff but in general the collection does not seem seriously at risk. Four staff members have basic knowledge of Microsoft Access but there is no database to the collection.

There was some discussion of databasing and the needs of the Regional Centres. Currently Dr Banpot regards the development of a structured database to NBCRC collections as a low priority.

Discussions regarding the Northern Regional Centre were held with:

- Dr Banpot
- Dr Charnnarong Doungsa-ard

6.8.1d NBCRC North Eastern Regional Centre, Khon Kaen University

The programs of the North Eastern Regional Centre of NBCRC, on the campus of Khon Kaen University, have emphasised the biological control of insect pests of pulses, rice, crucifers, fruit, sugarcane, tobacco and weeds in the plateau region of north-eastern Thailand. Entomopathogens, including nematodes, are of particular interest to some programs. As in all Regional Centres, there is an on-going program to collect and document the natural enemies of pests and weeds. The Centre's collection comprises slightly more than 600 specimens stored in modern, wooden insect cabinets with glass fronts. Specimens are well prepared and labelled. All are of agricultural relevance. Specimens are added at a modest rate (less than 100 annually) and either identified locally or forwarded to Department of Agriculture or NBCRC Headquarters, Bangkok. The collection is in good condition and secure, although the collection room lacks air-conditioning. A technician cares for the collection on a part-time basis and, overall, approximately 10 hours of staff time per week is allocated to maintaining the taxonomic adequacy of the collection. The technician has some expertise in the identification of species to family and species level but training in the identification of Hymenoptera, Lepidoptera, Coleoptera, Arachnida and mites was identified as a significant need for the Centre.

Collections of pests and natural enemies are documented in annual reports but the specimens are not databased in the formal sense. Publications of the Centre include an illustrated booklet "Insect Pests and their Natural Enemies of Economic Crops in the Northeast of Thailand".

Prime needs identified for the NBCRC North Eastern Regional centre seem to be:

- Training in the identification of Hymenoptera, Lepidoptera, Coleoptera and spiders.
- Provision of air conditioning for the collection room.

Principal discussions regarding the North Eastern Regional Centre collections were with:

- Dr Banpot
- Dr Nutcharee Siri, Director
- Dr Manochai Keerati-kasikorn

6.8.1e NBCRC Southern Regional Centre, Prince of Songkla University

The Southern Regional Centre of the NBCRC implements programs on the biological control of insect pests and weeds in peninsular Thailand. Pests and weeds of plantation crops and fruit trees are of particular importance. The collection is conservatively estimated to comprise about 800 specimens. All are of agricultural relevance. Currently most new material comes from surveys of yardlong beans, luffa, cucumber, kale and citrus (especially lime, orange and pomelo trees). Pinned specimens are accommodated in six wooden, glass-fronted, insect cabinets, each with 20 drawers. There is ample space for future expansion. Specimens are pinned directly into the cork bottoms of the drawers. A few vials of alcohol-preserved specimens are also kept in these drawers, held in place by pins. The bulk of the alcohol collection is stored in a metal filing cabinet. Specimens are generally well prepared and labelled. There is a good collection of coccinellids and some excellent display drawers. However, labels indicate that many specimens were reared in NBCRC insectaries and thus provide little information on distribution. Also, many of the labels associated with alcohol-preserved specimens are written on paper of variable quality using inks of dubious permanence. Commonly, these labels are attached to the outside of vials, where they are subject to abrasion and loss. The collection shares an air-conditioned room with live cultures of insects. Two staff are directly associated with the collection, but neither have specialist taxonomic or curatorial training. Occasionally the Centre calls on expertise in the Department of Agriculture, Bangkok or the Natural History Museum, London for assistance with identifications. According to the Centre's Director the collection is used infrequently. The Centre has a small library but lacks specialist identification literature. Staff do not have Internet access because the LAN of the University has not yet been extended to the Centre.

Prime needs of the Southern Regional Centre are:

- Training in specimen preparation, collection management, and the identification of pest and beneficial insects.
- Rehabilitation of alcohol preserved specimens (re-labelling; transfer to large jars).
- Separation of rearing facilities and insect collection.
- Establishment of Internet access.

Discussions were held with:

- Dr Banpot
- Dr Jiraporn Peteharat

6.8.2 Department of Entomology, Kasetsart University

The Department of Entomology comprises some 21 academic staff based at either the Bangkheng or Kamphaeng Saen campuses. The Department conducts broad academic training and research. Undergraduate courses in IPM and entomology each attract 30 – 35 students each year, and there are currently approximately 50 M.Sc. and 10 Ph.D. students in the postgraduate program. The Department maintains an insect collection of over 200 000

pinned specimens, 5000 vials and 12 000 slides. About 75% of these specimens are relevant to agriculture. The collection is housed in storage cabinets, under cramped conditions. A large, donated butterfly collection (approximately 8000 specimens) remains in storage boxes and vulnerable to museum pests. Additional, secure storage cabinets are required, especially to accommodate type specimens. The alcohol collection also requires secure storage cabinets. Climate control is inadequate; new air conditioning and de-humidification units are required; it is understood that existing units are not run continuously. The collection has no curator; one technician undertakes essential care and maintenance work when time allows from other duties. Currently there are no major research programs making use of the collection. The collection is not documented; there is no database and no list of type material. Assoc. Professor Chitapa Ketavan has an interest in Diptera and Professor Angsumarn Chantrapat has expertise in eriophyiid mites. The collection continues to grow by 100-400 specimens annually, from surveys of rice, sugarcane, maize, cotton, vegetable and ornamental crops. Undergraduates each submit a collection representing 60 identified insect families for assessment and some specimens from these collections are transferred to the Departmental reference collection. Generally specimens in the collection are well labelled and prepared. The Department occasionally calls upon specialists from the NBCRC, the Department of Agriculture (MOA, Bangkok), and Chulalongkorn and Chiang Mai Universities. There are also linkages of this kind with institutions in Japan, Europe (e.g. The Musee National d'Histoire Naturelle, Paris) and the USA. "Parataxonomist" training in the identification of Diptera, including species of fruit flies, was seen as a priority.

The most urgent needs of the Department of Entomology appear to be:

- Appropriate air conditioning and de-humidification units for the collection room.
- Additional insect cabinets for type material and specimens currently occupying store boxes.
- Storage cabinets for alcohol collection.
- Allocation of increased time of a technician to maintain the collection.
- Training in the identification of Diptera, especially fruit flies.

Principal discussions were with:

- Assoc. Professor Chitipa Ketavan

6.8.3 Entomology and Zoology Division, Department of Agriculture

The arthropod collection of the Department of Agriculture (DOA) is the largest and oldest in Thailand. Currently it comprises over 600 000 specimens, housed in a series of museum and exhibit rooms, in a Ministry building on the Bangkhen campus of Kasetsart University.

The collection was established in 1931 and the early entomological work of the Department (e.g. insect surveys throughout Thailand, biological studies of pests) centred on the collection. An expatriate English entomologist, W.R.S. Ladell, directed the work and specimens were sent routinely to the Natural History Museum, London for identification. Ladell also obtained specimens from E.J. Godfrey, an English schoolteacher who was a long-term resident in Thailand and an important early collector of insects. Prior to 1931 most insect collections in Thailand had been made by European visitors who retained the specimens in their private collections or deposited material in institutions in their own countries. In 1935 M.L. Chakratong Tongyai, took over as Chief of Entomology in the Department. He was a graduate of the outstanding entomology program of Cornell University, USA, and on returning to Thailand brought to the Department's collection such

important curatorial innovations as the use of unit trays. From 1935, the collection continued to grow through the diversifying work of the Department and through the efforts of a series of dedicated staff, some of whom had academic connections with either Kasetsart or Chulalongkorn University and were active in taxonomic research. The collection also expanded with the incorporation of material from the Rice Department, a separate government entity that merged with the DOA in 1972.

At the present time the collection is maintained principally in wooden insect cabinets and boxes in several air-conditioned rooms. Taxonomists and other staff associated with the collection work in the collection rooms or in adjacent laboratories and offices. In general the pinned specimens are well curated, well labelled and secure. As in insect collections worldwide, many specimens remain in individual store boxes, which creates management difficulties and increases the risk of damage by museum pests. The collection is large and current quarters do not offer significant expansion space for the future. Notably, at present there is insufficient room in the air-conditioned, collection rooms for the alcohol collection. The high temperatures to which these specimens are now exposed increase the rate of evaporation of liquid preservatives and promote deterioration of specimens. Finally, curators have highlighted the lack of overall fireproofing as a matter of concern.

An impressive array of insects is presented in a public exhibition room associated with collection. Insect diversity and other topics are demonstrated in a series of attractive and informative displays.

Currently there are 6 permanent, professional staff associated with the collections and their expertise is in the taxonomy of spiders, mites, Coleoptera, Hymenoptera, thrips, scale insects and mealy bugs. There is one technician. Overall about 80% of the time of staff is devoted to collection maintenance, curation and taxonomic work. In view of the economic importance of Lepidoptera and micro-Hymenoptera, the absence of specialists in these groups is a significant handicap. The Lepidopterist position appears to have been lost through retirement. As noted, the collection totals some 600 000 specimens, of which about 80% are relevant to agriculture. The mite collection, which amounts to approximately 14 500 slides, is entirely of agricultural relevance. The collection is growing unevenly. Between 100 and 400 mites and similar numbers of spiders are received each year for identification, but on average for all major taxonomic groups, the number of specimens or series received each year is perhaps less than 100. There are an estimated 400 000 unidentified specimens in the collection, and staff have indicated that they would welcome training in the identification of the following groups: Lepidoptera, Coleoptera, Hymenoptera, Hemiptera and Thysanoptera to address this backlog. Occasionally staff make use of expertise elsewhere in Thailand (e.g. Kasetsart University, Thai Royal Forest Department) or overseas (e.g. in Germany, Poland, South Africa, Japan, Canada and Australia). Staff are called upon to provide lists of pests to facilitate international market access bids for Thai agricultural commodities. A list of the insect, mite and other zoological pests of economic plants in Thailand was published by the DOA in 1991 but this is now regarded as out-of-date and incomplete.

There is no database to the collection but research staff are interested in the development of such a system.

Some staff were familiar with computer-based diagnostic tools but none had hands-on experience with LUCID.

In the view of the Project Team the forward planning of the DOA could include:

- Transfer of alcohol collection to an air-conditioned room.
- Review of fireproofing of collection.
- Appointment of a taxonomic specialist in the Lepidoptera.
- Training in the identification of Lepidoptera, Coleoptera, Hymenoptera, Hemiptera and Thysanoptera.
- Updating of list of economic pests of Thailand, either as a printed document or as a web database.
- Evaluation of specimen database software.
- Progressive adoption of modern methodology, e.g. LUCID or LINNAEUS II software for developing diagnostic tools, computer-based phylogenetic programs (such as PAUP) for analytical studies, molecular methods for difficult taxonomic problems.
- Collaborative taxonomic projects with specialists outside Thailand.

This large and admittedly demanding agenda reflects the Project Team's perception that the DOA can build upon its strengths to provide leadership in the taxonomic capacity building in Thailand. Among the strengths of the DOA are its broad expertise, the size and quality of its collection, and its geographical location close to several other important academic and research institutions.

Principal discussions were with:

- Mrs Vatana Charanasri
- Mrs Wipada Vungsilabutr

6.8.4 Forest Insect Group, Royal Forest Department

The Royal Forest Department maintains a collection of approximately 17 400 specimens, comprising 16 400 pinned and 1000 in alcohol. All are relevant to forestry and about 25% to agriculture. Approximately 45% of the collection is unidentified. Pinned specimens are stored in wooden insect cabinets, and generally are secure, well curated and well labelled. Specimens are received from field surveys (both plantations and natural forests), various research projects (e.g. collections of termites, ants and other soil insects as part of a land use project), farmers and foresters. Between 100 and 400 specimens are received each year for identification. The Forest Insect Group occasionally makes use of expertise in Thai institutions (e.g. Kasetsart University, Khon Khaen University, DOA) or overseas (e.g. Forestry and Forest Products Research Institute, Japan; CSIRO and ACIAR, Australia). The Group has some on-going collaborative projects with overseas agencies. In the past, assistance with the identification of insects has been obtained from the Natural History Museum, London. The Forest Insect Group includes 9 staff, including 2 professionals and one technician with expertise in entomology. Approximately 60% of the time of entomologists is devoted to maintaining the taxonomic adequacy of the collection. Training in the identification of the following groups was sought: Coleoptera (dung beetles and other scarabs, fireflies), Lepidoptera (Noctuidae, Geometridae, Lymantriidae), Hymenoptera (including Formicidae) and Isoptera. A Checklist of the forest insects of Thailand was prepared by Departmental officers and published in 1995. A Microsoft Access database to the collection has been developed, although it was not clear to the Project Team whether specimens that had been databased had been labelled with record numbers. The Project Team discussed with Dr Chaweewan Hutacharern, Director of the Division, the desirability of a small workshop to identify the way forward for Thai institutions in the development of

databases. About 200 specimens are in need of some repair but in general the Royal Forest Department collection is well cared for and secure, albeit in cramped conditions.

The following might assist the Royal Forest Department to optimise the use of its arthropod reference collection and human resources:

- Training courses in the identification of Coleoptera (dung beetles and other scarabs, fireflies), Lepidoptera (Noctuidae, Geometridae, Lymantriidae), Hymenoptera (including Formicidae) and Isoptera.
- A workshop on the evaluation of specimen databases (e.g. Biolink, WADA Access system).

Discussions took place with:

- Dr Chaweewan Hutacharern, Director of Division
- Mr Surachai Chondumrongkul
- Mr Supachote Eungwijarnpanya

6.8.5 Department of Plant Protection, Mae Jo University

The Department comprises 10 staff, none of whom are taxonomists. The Department delivers academic training in IPM and currently has approximately 50 postgraduate students in entomology and plant pathology. The collection occupies about a dozen wooden insect cabinets and a few store boxes. The estimate of “over 1500 specimens” provided in the Department’s response to the questionnaire is almost certainly conservative. The standard of preparation and labelling is very variable. Many specimens are pinned with dressmaker’s or decorative pins. Some are inadequately labelled. Similarly the standard of identification is quite variable. Collections derive largely from surveys of field crops and fruit trees, and from the collections submitted by undergraduates for evaluation. All specimens come from the Northern Region of Thailand and about 50% are relevant to agriculture. Occasionally specimens are forwarded to Kasetsart University, the Royal Forest Department, Chiang Mai University, Prince of Songkla University or the NBCRC for identification. Training in the identification of parasitic Hymenoptera and predators was seen as a priority. There is no database to the collection and staff have no experience in the development of collection-based databases. The collection is housed in an impressive, spacious, two-year old building with abundant natural light. However, it appeared that the air-conditioning was not optimal for the storage of museum specimens. The collection is cared for on a part-time basis by a technician with general B.Sc. training. The collection has no direct university funding and is supported out of the Department’s general budget allocation.

In the absence of a trained taxonomist on the academic staff, it is suggested that the technician responsible for the collection receive training in the preparation of insect specimens and in the identification of insect families. The teaching and reference components of the collection should be segregated. Specimens that have been inadequately prepared or labelled could be relegated to teaching or display functions.

Priorities for the Mae Jo collection appear to be:

- Training in specimen preparation and identification to family level for the technician-curator.
- Segregation of teaching and reference collections.

Discussions were principally with:

- Dr Khayan Suwan, Head of Department

6.8.6 Department of Entomology, Chiang Mai University

The Department currently comprises 8 teaching staff who provide broad undergraduate training in entomology, including courses in the identification and management of insects of agricultural significance. Undergraduates acquire a working knowledge of important insect families and major pest species. The Department's M.Sc. course includes several units focusing on the identification of insects or on the principles and techniques of taxonomy. At present there are about 20 students in the M.Sc. program.

The Departmental insect collection comprises about 29 500 specimens, mostly pinned. All are of agricultural relevance. The collection is growing at a rate of 100 – 400 specimens annually, from surveys of vegetable, field crops, flowers, ornamentals, orchards and forests; from collections submitted by undergraduate students for assessment; from field work by academic staff; and by inter-institutional exchange. There is no curator. Two technicians with training in entomology allocate 1 – 2 hour per week to the maintenance of the collection. Occasionally specimens are sent to the Department of Agriculture, Bangkok for assistance in identification, but more commonly expertise is sought outside Thailand, e.g. from the Natural History Museum, London, Sweden or Japan. Some of these interactions reflect the research associates of Departmental staff and do not attract a fee for service. On the other hand, some Hemiptera and Coleoptera collected as part of a project on longans and lychees have been sent away for identification for a fee. In general, staff are able to obtain information required and internet access is adequate. CABI Abstracts are used routinely.

The collection is not documented and there is no database.

Currently Dr Hans Bänziger is the principal contributor to the collection. Dr Bänziger's research focuses upon pollination, Lepidoptera and aphids.

The collection is housed in 20 wooden cabinets, each containing 20 drawers. The collection room has no climate control and there is evidence of damage by mould and psocids. Currently the collection is at risk of further deterioration. Specimens generally have been well prepared and labelled and represent a significant resource of pest records.

Discussions were held with:

- Associate Professor Sanit Ratanabhumma, Chairman of Department
- Dr Hans Bänziger
- Associate Professor Vichian Hengsawad
- Dr Manas Titayavan

6.8.7 Department of Entomology, Khon Kaen University

The city of Khon Kaen is located centrally in Indochina and lies just 160 km from Vientiane, the capital of Laos. The University sees its future as linked to the region as a whole and one of its goals is to create closer ties with institutions in Laos, Vietnam and Cambodia. The University has also actively cultivated international linkages with universities in the USA, Canada, Germany, the UK, Japan and Australia. The Department of

Entomology comprises 12 staff who provide broad undergraduate and postgraduate training in entomology within the Faculty of Agriculture. Research projects include work on the vectors of rice diseases, allelochemicals, insect resistance to pesticides, and systematics. Dr Yupa Hanboonsong has published on the taxonomy of dung beetles, aquatic Hemiptera and the diversity of edible insects.

The Department maintains an insect collection of over 57 000 specimens of which about 75% are relevant to agriculture. The collection is growing rapidly. Specimens are added from collections associated with research projects, expeditions, exchanges with other Thai government agencies (e.g. the Royal Forestry Department) and surveys of field crops (rice, sugarcane, kenaf, peanuts), fruit crops, natural forests, and animal dung. Occasionally the Department calls upon expertise in the NBCRC, the Department of Agriculture, Bangkok or the Department of Entomology, Kasetsart University, or in the National Science Museum, Japan, for assistance with identification. At present only about 1% of the collection (e.g. dung beetles, aphids, some pests, well-known Lepidoptera and Coleoptera) are identified to species. The bulk of the collection is sorted only to family level. Staff regard training in the identification of Lepidoptera (larvae and adults), parasitic and predatory Hymenoptera, Coleoptera and aquatic insects as high priorities. Three staff (one entomologist and two technicians) are associated directly with the collection; about 50% of their time is devoted to maintaining the collection and undertaking taxonomic or biodiversity studies. Another Departmental entomologist has research interest in aphids and allocates approximately 10% of her time to taxonomic and related work. The aphid component of the insect collection amounts to about 60 specimens preserved dry, 30 species in alcohol, and a few slide-mounted specimens. The fruit fly collection has in the past benefited from participation in a large collaborative project with Griffith University, Australia.

The insect collection is housed in a reasonably modern building in a large room with windows on three sides. The room is no longer air-conditioned. Specimens are stored in wooden cabinets: pinned insects are in unit trays and alcohol vials in neat racks. The dung beetle collection is in particularly good order, reflecting current research interests and external funding. Specimens are generally well prepared and well labelled. While it would be advantageous to transfer the collection to modern metal cabinets, the first priority for the safe keeping of this important collection should be the establishment of climate control, either through the provision of air-conditioning and de-humidification units and/or the judicious use of cross-ventilation opportunities.

Given that only a small percentage of the collection is identified to species it might seem premature to initiate a specimen database. However, the collection is rich in species-level data for scarabaeine dung beetles, which are of worldwide interest. This data resource could provide an entrée for the Department into global databasing projects, with the prospect of international funding to assist with database development and data entry.

Staff are familiar with electronic information resources, such as the CABI Crop Compendium, and a beetle identification guide recently published on CD. They had no experience of diagnostic tools based on LUCID software but were keen to assess these products and the underlying technology. Internet access was rated as good and providing useful information. However, access to printed information, especially primary journals is limited.

Taxonomic work within the Department has benefited from substantial funding from the Biodiversity Research Council of Thailand (BRT Program) and support from UNESCO.

However, the collection does not receive a recurring maintenance allocation from the University budget.

Priorities identified for Khon Kaen are:

- Training in the identification of Lepidoptera, Hymenoptera, Coleoptera and aquatic insects.
- Air conditioning and de-humidification units for the collection room.
- Initiate a specimen database as a pilot project (e.g. focusing on dung beetles).
- Training in the development of diagnostic tools using software such as LUCID.
- Development of international collaborative projects capitalising on the presence of taxonomist with biodiversity interests.

Discussions were held with:

- Dr Yupa Hanboonsong, Head of Department of Entomology and Director, Office of International Agriculture
- Dr Sivilai Sirimungkararat
- Dr Supanee Pimsamarn
- Ms Chutinan Choosai
- Dr Assanee Pachinburavan, Dean, Faculty of Agriculture

6.8.8 Department of Pest Management, Prince of Songkla University

The Department of Pest Management provides undergraduate and postgraduate training in pest management, emphasising IPM and the use of parasites, predators and pathogens of pest species. There are 5 entomologists, whose research interests range from the systematics of fruit flies to pheromones and pesticides. Dr Surakrai Permkam is a specialist in fruit flies and aquatic Hemiptera. Undergraduate classes are large and increasing in size, numbers escalating from about 60 in 2001 to 100 in 2002. Currently there are 7 – 8 M.Sc. students in the postgraduate program. Students receive training in the use of electronic information sources, such as the CABI Crop Compendium and in the use of CD-based identification tools.

The Departmental collection is conservatively estimated at comprising something over 21 000 mostly-pinned specimens, about 25% of which are relevant to agriculture. Only about 500 of these specimens are identified to species level. Material is added to the collection according to the research interests of staff and via collections submitted by undergraduates for assessment. The collection is housed in a large room which is air-conditioned 24 hours per day. Pinned specimens are kept in store boxes shelved in approximately 25 wooden, wardrobe-like cupboards. Labelling is of variable quality and many specimens lack adequate locality data. A notable exception is the well-prepared and well-labelled fruit fly collection deriving in part from a collaborative, international project. The collection room has large workbench with good natural light and a good Wild M5 dissecting microscope. The collection occasionally hosts international specialists, most recently a dragonfly specialist from Japan. The Department has diverse international linkages and occasionally makes use of expertise in Singapore, Japan, Australia, the Netherlands, the USA and the UK to obtain assistance with identifications. Within the Department identifications are performed largely by Dr Surakrai or an M.Sc. student.

Overall only about 5% of staff time is allocated to the upkeep of the collection or taxonomic work, and there is no regular funding from the University budget for collection maintenance.

There is no database to the collection. No clear distinction seems to be made between reference and research specimens (i.e. specimens which are to be kept indefinitely) and teaching specimens (which are subject to damage and loss each year in undergraduate classes). This distinction and physical segregation is necessary if the collection is to be regarded as a permanent repository.

Because of the proximity of Prince of Songkla University to the Thai-Malaysia border the collection and taxonomic expertise associated with it could provide support to quarantine operations at the border.

Needs for the Prince of Songkla University appear to be:

- More recognisable distinction between permanent reference collection and teaching material.
- More secure cabinets for shelving of insect store boxes.
- Funded collaborative project in systematics, e.g. on aquatic Hemiptera, building on current interests.
- Discussions with the Department of Agriculture, Bangkok (including taxonomists and officers of Agricultural Regulatory Division) regarding possible role of the collection as a regional reference collection for quarantine.

Discussions were held with:

- Dr Aran Ngampongsai (for Head of Department)
- Dr Sieng Kritsaneepaiboon, Dean, Faculty of Natural Resources
- Dr Prawit Towatana, Associate Dean for Research and International Relations

6.8.9 The Way Forward for Thailand

Thailand can take pride in its entomological collections. Taken as a whole, the many hundreds of thousand of specimens that have been preserved provide a broad and solid foundation for characterising the country's pest and beneficial insects. Of course, much remains to be done. Many hosts, habitats and regions remain poorly collected, and in the absence of modern diagnostic keys the identification of many species is problematic. Regrettably, little of the information residing in existing collections is widely accessible. Networking among the geographically scattered collections tends to be weak.

The level of taxonomic research in Thailand reflects neither the opportunities created by the country's collections nor the cornucopia of modern techniques available internationally. It meets neither the present needs of Thailand's diverse agricultural and forest industries, nor the future needs of the country's quarantine and market access agencies.

The great challenge for Thailand is to create a viable network from its scatter of collections, to nurture the pockets of taxonomic research that do exist, and revitalise taxonomic research where it has become moribund.

In view of the large number of collections throughout Thailand and the great number of common issues, we recommend that representatives of entomological or perhaps all biological collections consider the formation of a formal, national network. The first step toward this might be a national forum at which curators, taxonomists and users of taxonomy are represented. The agenda of the proposed forum might include training priorities, governance models, the concept of a virtual national collection, diagnostic networks,

participation by Thailand in the activities of the Global Biodiversity Information Facility, and a submission to government for a collection improvement program.

The preceding pages have identified a program of workshops addressing needs for training in:

- *Identification* of various arthropod groups, in particular Hymenoptera, Coleoptera and Lepidoptera, as well as Diptera (fruit flies), Hemiptera, Thysanoptera, Isoptera and Araneae (spiders).
- *Specimen preparation and curation of specimens.*
- *Databasing technologies.* The need for an early introductory workshop on specimen databases is heightened by the opportunities offered by the Global Biodiversity Information Facility (GBIF), the intense international interest in database development, the diversity of software, and the variety of possible approaches.
- The use of software such as LUCID and LINNAEUS II to create diagnostic tools, phylogenetic analysis packages such as PAUP, imaging systems such as Automontage, and analytical/predictive software such as Worldmap and CLIMEX.

In some instances training might be more effective through one-to-one training. This could be facilitated through exchange visits, involving specialists and institutions from developed countries, and Thai graduates who had demonstrated aptitude or enthusiasm for taxonomic work. The Thailand-Australia Government Sector Linkages Program offers particular opportunities in this respect.

Thailand has few taxonomists but does have a pool of skilled, science and agriculture graduates. With appropriate specialist training, these increasingly experienced scientists and technicians can be looked to provide much of the diagnostic capacity that will be required. Ideally, these diagnosticians will support each other through a national diagnostic network.

The notion of a national diagnostic network is particularly appealing for Thailand. The NBCRC network demonstrates the viability of networking across great distances within Thailand, and indeed the NBCRC has created its own, internal diagnostic network. Also, the cluster of collections, research taxonomists and entomologists with advanced identification skills in the Chatuchak district of northern Bangkok represents an ideal proving ground for networking protocols and technologies.

Networking models to be considered might include: (1) the so-called Northern Australian Diagnostic Network, developed under the auspices of an Australian Co-operative Research Centre; (2) the diagnostic network supporting the quarantine agency APHIS in the USA; and (3) a model built around the Australian Plant Pest Database. Diagnostic networks tend to comprise complementary centres of expertise which exchange or share information, and are linked via the Internet. Preliminary identification of arthropods can often be performed on the basis of digital images transmitted from one national centre to another, or to an international specialist in another country.

The survey of arthropod collections in Thailand has also recognised a set of priorities for a collection rehabilitation program. These include:

- Installation of air-conditioning and de-humidification units in the collection rooms at Kasetsart and Khon Kaen Universities, and transfer of the alcohol collection at the Department of Agriculture, Bangkok to an air-conditioned room; and

- Additional, secure cabinets for pinned and alcohol collections at Kasetsart University, and new cabinets for shelving store boxes at Prince of Songkla University.

6.9 Vietnam

The program of activities in Vietnam was coordinated by Ms Nguyen Thi Mai Chi of the National Institute for Plant Protection (NIPP) on behalf of Dr Nguyen Van Tuat, Director General, NIPP, and Profesor Vu Quang Con, Director, Institute of Ecology and Biological Resources (IEBR) and ASEANET Country Coordinator for Vietnam. The program comprised laboratory visits and discussions at:

- National Institute of Plant Protection, Ministry of Agriculture and Rural Development, Chem, Tu Liem district;
- Forest Science Institute of Vietnam, Chem, Tu Liem district;
- Hanoi Agricultural University, Gia Lam district; and
- Institute of Ecology and Biological Resources, Ministry of Education, Cau Giay district.

All Institutions are in the vicinity of Hanoi.

6.9.1 National Institute of Plant Protection (NIPP)

NIPP is the most important repository of information on arthropod pests of agriculture in Vietnam. Its activities encompass research on a broad range of pests, pathogens and weeds, their distribution and control. Fruit crops, including citrus, rice, cotton, cashew nuts, coffee, ground nuts, edible grapes, oil palm, coconut palm and rubber are among the most important cash crops. Much of the research is directed towards the implementation of IPM. Some investigations are undertaken on behalf of the Plant Protection Department, another group within the Ministry of Agriculture and Rural Development (MARD).

NIPP maintains a collection of perhaps about 100 000 pinned arthropod specimens and about 15 000 specimens in alcohol. Most of these are kept in one large room which is increasingly cramped and lacks air-conditioning. The collection can be divided into three distinct eras, reflecting Vietnam's twentieth century history:

- 1) The "colonial era" specimens often have incomplete or cryptic locality data, tend to lack host data, range in physical condition from good to fair, and were mostly identified by French specialists. These specimens are mostly stored in boxes on runners in old wooden cabinets, many of which are in run-down condition.
- 2) "Chinese era" specimens tend to have better locality and host data. These were identified by Chinese specialists during the 1960s and many of these records were published.
- 3) "Modern era" specimens are also in somewhat variable physical condition. Some derive from surveys of citrus and rice, the results of which were published. Unfortunately, the voucher specimens of some records have been destroyed by mould and others are labelled with code numbers rather than full collection and host data. Some specimens are stored in good, metal insect cabinets, either purchased from Australia (from the same manufacturer which supplies the Australian National Insect Collection) or "cloned" in Vietnam from the Australian model. Large unit trays with

balsa bottoms are preferred. Apparently, in humid Vietnamese conditions the unit trays that are used widely in Australian institutions tend to expand and become difficult to move.

There are also several small, “satellite” collections in nearby laboratories. Among these is a well-curated collection of fruit flies, associated with an international project and maintained under secure conditions in a particularly well-appointed laboratory. There is also a very small slide collection comprising about 170 specimens.

The organization of the collection is idiosyncratic. Several different storage systems are in use, which makes management very difficult, and many of the cabinets do not provide physical security. There is little space either for rearranging specimens or accommodating new material. Much of the collection requires re-curation and identifications need to be revised to reflect current knowledge. Because of the collection’s history, one species can be represented in several different parts of the collection, and may bear several different names reflecting changes in prevailing usage.

The collection will remain at risk and intractable until:

- the collection room is furnished with an air-conditioning and de-humidification units; and
- the collection is transferred to standard metal cabinets and which use an appropriate unit tray system.

The collection is a critical resource for Vietnam as it seeks to define its plant health status. It is also an important source of biodiversity information, one which complements the collections of the Institute of Ecology and Biological Resources (IEBR, see below). The NIPP collection is not as well known as that at IEBR and rarely loans specimens to taxonomists or other researchers. It does not have a management system for tracking loans. Clearly, NIPP should move toward developing such systems in order to capture the ancillary benefits of taxonomic work by the global taxonomic community.

Dissecting microscopes in the NIPP entomological laboratories are not adequate for performing critical identifications. There is no digital camera and no access to scanning electron microscopy. Technical publications that are essential for diagnostic work, especially English language publications, are very scant. Computer facilities are at present limited. Staff have access to email and could make use of Internet information resources and Listservers such as PestNet, but would require some training. There seemed to be little familiarity with current global initiatives such as GBIF and the GTI. As noted above, a significant number of records have been published. These books might provide a basis for an initial databasing project to go hand in hand with the reorganisation of the collection.

Over the coming years NIPP will be expected to play a critical role in assisting Vietnam to meet its SPS obligations. The arthropod reference collection and associated diagnostic specialists will be required to support this role. This will be impossible without a significant upgrading of infrastructure.

Officers of NIPP would benefit from specialist training workshops on arthropod identification. It would also be prudent to examine strategies to ensure the continuity in NIPP of essential taxonomic and collection management skills currently provided by experienced and emeritus staff.

Close linkages with IEBR specialists and management are a key to the long-term success of both institutions. Linkages might be strengthened by cross-membership on respective advisory boards, or joint funding of research proposals.

In summary, the way forward for NIPP should include:

- Major reorganisation of collection to combine old and new material, and adopt uniform, modern nomenclature.
- Installation of air-conditioning and de-humidification units in collection room.
- Transfer of the collection to standard metal cabinets that employ a unit tray system.
- Acquisition of dissecting microscopes appropriate for preparation and identification of small arthropods.
- Evaluation of specimen databasing software.
- Training in the identification of major arthropod groups.
- Development of closer, formal linkages with IEBR (see below). This represents a major undertaking but reflects the Project Team's assessment of the key role of the NIPP reference collection, both in its own right and as a resource for the growing specialist expertise at the IEBR.

Discussions and consultations took place with:

- Dr Nguyen van Tuat, Director General
- Dr Nguyen van Cam, former Director
- Dr Pham van Lam, entomologist
- Dr Quach Thi Ngo, Curator
- Ms Nguyen Thi Mai Chi

6.9.2 Forest Science Institute of Vietnam

Forest science in Vietnam dates from the early 1960s but it was not until 1988 that the Forest Science Institute was created to draw together disparate research in this industry of increasing economic importance. Native forests remain of prime significance but there are increasing plantings of Australian *Eucalyptus*, *Casuarina* and *Acacia* and *Pinus* species of various origins. Plantations have been established both by the government and by private enterprise. The latter provide some resources to combat pest outbreaks but do not undertake strategic research and development. Long term R&D remains the responsibility of the government. There have been significant recent collaborations between the Institute and Australian forest health specialists, including ACIAR-funded studies of the *Hypsipyla* moth. The plant protection group of the Forest Science Institute comprises 10 staff including 2 entomologists.

There are about 20 major forest pests in Vietnam but there is no formal, consolidated listing of these. Occasionally expertise is called upon from Australia or Japan. None of the Institute staff profess specialist taxonomic skills.

The Institute has a small collection of about 6750 pinned specimens, some derived from ACIAR-funded, collaborative work on eucalypt and *Acacia* pests in region. Some of the specimens from these surveys remain overseas. Earlier collections of forest arthropods were destroyed during the wars of the mid-twentieth century. There is no special allocation of resources for the maintenance of the Institute collection, and what is needed is provided from general research and operating funds. The collection resides mostly in an air-conditioned room in about 25 store boxes that are kept in an oven. While this protects the specimens

from museum pests and mould, specimens are becomingly increasingly dry and brittle. Specimens are generally well labelled but there is scope for improvement. The alcohol collection comprises about 7500 specimens; there is no slide collection. There is a good microscope with a digital camera. Computer facilities are reasonable but some training in the use of new technologies (e.g. specialist diagnostic tools) is required. The library does not have adequate holdings of technical publications necessary for the identification of forest arthropods.

The Forest Science Institute is accommodated in a modern building with an air-conditioned laboratory space adequate to house the small reference collection. It seems unlikely that the collection will grow rapidly in the near future. Consideration could be given to transferring it to standard cabinets. Officers indicated that an improvement in the fire security of the building would be desirable. The Institute is currently a few minutes walk from NIPP; some opportunities for cooperation in collection maintenance and curation may emerge in the future.

It is suggested that the Forest Science Institute give consideration to:

- Transferring its insect store boxes to an appropriate, secure cabinet.

Discussions were held with:

- Dr Nguyen Hoang Nghia
- Dr Pham Quang Thu
- Mr Nguyen Van Do

6.9.3 Hanoi Agricultural University

Hanoi Agricultural University was established in 1956 and is one of the oldest tertiary institutions in Vietnam. The 10 faculties are dispersed over a 205-hectare site in the Gia Lam district about 12 km east of Hanoi. Many buildings are of recent construction or have been refurbished within the past 10 years. There are approximately 490 teaching staff for a student body of over 3000. There are separate Departments of Entomology and Plant Pathology, which together offer undergraduate, M.Sc. and Ph.D. training in plant protection. Currently there are 8 M.Sc. students and 9 Ph.D. candidates. As in many other institutions there is a major focus on IPM. The University has international linkages to over 60 universities and organizations, including an enduring and mutually productive association with plant pathologists of the University of Sydney.

The Department of Entomology appears to be quite active and will host the next (4th) Conference of the Entomological Society of Vietnam. Research interests of Departmental staff include the biological control of weeds and vegetable, cotton and soybean pests; thus, lepidopterous pests, trichogrammatid wasps, thrips and agromyzid flies. Currently, there seems to be little emphasis on whiteflies, but this could emerge as a pest in the future. Identifications tend to be performed by the “generalist” entomologists on staff. There are no taxonomists on the Faculty, which limits the amount of training that can be provided in the area of arthropod taxonomy. Obviously, the appointment of a taxonomist to the Faculty would complement existing disciplines and enable more comprehensive academic training.

It was pointed out that the government of Vietnam provides some funding to assist students to travel abroad for postgraduate training and that it was sometimes also possible for government officers and university staff to obtain support to attend international training

courses. However, students and experienced scientists alike commonly lacked fluency in English and were unable to take advantage of these opportunities. It is estimated that 80-85% of students find employment, although salaries are not high. It would appear that Vietnam is nurturing a potent scientific workforce, which will benefit enormously from increasing international collaboration and experience. It is also interesting to note that neighbouring countries are taking advantage of the opportunities provided by Vietnam. At the present time, about 35 students from Laos and Cambodia are studying at Hanoi Agricultural University.

Unfortunately, research funding from governmental and university sources remains modest.

Internet access for the Faculty is good and officers were familiar with basic software. None were familiar with specialist diagnostic or databasing software commonly used by taxonomists.

Undergraduate students in entomology spend some time in crop systems familiarising themselves with common arthropods and are required to collect a small number, usually 20-30, for identification. Thus, student collections do not represent a rich source of specimens for preservation. The Department's reference collection is small (probably fewer than 5000 specimens) and is more representative of larger, more charismatic arthropods, such as butterflies and dragonflies, than the smaller groups. Specimens are in excellent condition, well labelled and housed in fine, new, metal cabinets manufactured in Japan and purchased with Japanese assistance. The cabinets occupy an air-conditioned room in a central university building remote from the Department of Entomology. While this favours the safe keeping of the collection, it would not be convenient were the collection to be growing rapidly or in more active use as a research tool.

It was felt that the most significant step that the University could take would be to appoint a taxonomist to the teaching staff. This would be prerequisite to renewed development of the reference collection.

Among the current staff there is specific interest in:

- Training in the identification of thrips.

Discussions were with:

- Dr Nguyen Van Dinh, Head of Planning Division
- Professor Hung

6.9.4 Institute of Ecology and Biological Resources (IEBR)

The IEBR maintains the largest arthropod collection in Vietnam and has by far the greatest number of arthropod taxonomists.

IEBR was founded in 1990 and has a broad commission to study the species and ecosystems of Vietnam, to make recommendations on natural resource management, and to provide training in taxonomy, ecology and related disciplines. Thus, the Institute's programs seek to:

- document the flora and fauna of Vietnam;
- describe the structure and function of its terrestrial and aquatic ecosystems; and

- develop strategies for the conservation of biodiversity and the sustainable use of natural resources.

Over the past 12 years the Institute has carried out numerous biological surveys of various regions of Vietnam, assembled impressive zoological and botanical collections, and initiated an ambitious program of descriptive publications. Most recently, the Institute has placed added emphasis on research and monitoring which have a direct economic impact or provide immediate advice for environmental management. The Institute has rapidly established a large number of international collaborations, ranging from associations fertilised by interest in Vietnam's astonishing fauna of rare vertebrates (such as its deer and primates) to joint surveys of the Vietnamese insect fauna. The Institute's complement of 120 staff includes over 50 with Ph.D. or equivalent qualifications, 25-30 M.Sc. students, 7-10 Ph.D. candidates and several post-doctoral researchers. The Institute's 16 internal groupings include:

- Department of Insect Ecology, whose research encompasses natural enemies of agricultural pests and IPM;
- Department of Insect Rearing Technology, which has a particular focus on the rearing of parasites of agricultural pests;
- Department of Nematology, whose projects have ranged from the taxonomy of free-living nematodes to applied studies of plant parasitic and entomopathogenic groups (including development of integrated nematode management strategies in rice coffee and cinnamon; assessment of damage caused by pine wilt nematode *Bursaphelenchus* in upland trees);
- Department of Remote Sensing Ecology, which focuses on the use of biological databases and GIS technology;
- the Zoological Museum, which is responsible for the reference collections, exhibits and faunal publications (*Fauna of Vietnam*); and
- Department of Insect Systematics, which includes specialists in the Hymenoptera, Diptera, Hemiptera and Lepidoptera, and postgraduate students of Coleoptera, and spiders.

The IEBR is Vietnam's taxonomic "engine room". It has an enviable breadth of expertise and a burgeoning reference collection. Its staff includes several young, emerging taxonomists whose descriptive and diagnostic skills are already impressive. The major challenge for the Institute is to nurture and enhance the analytical skills of its undoubted human resource. The challenge can be met by continued international collaboration, by good access to international literature and scientific fora, and by the enhancement of capacity in leading-edge technologies. A related challenge will be the wise selection of research priorities. This second challenge can be met in part by enhanced linkages with other institutions within Vietnam.

The IEBR arthropod collection is distributed among several research groups. Its overall size is difficult to estimate but would be in excess of 100 000 specimens. Most specimens have been collected in recent years, are well prepared and have good provenance data on modern, machine-printed labels. Exceptionally, data for some specimens had been recorded on poor quality paper with a ballpoint pen. The majority of specimens have been mass collected during surveys and are not accompanied by host plant data. Many await identification. The collection shows evidence of international collaboration with identifications performed with the assistance of respected European and North American specialists.

Several different approaches to specimen storage were noted. For example, in one laboratory specimens were pinned into insect store boxes which were stacked on benches or the floor. In another laboratory, specimens were accommodated in drawers in modern

entomological cabinets. There had been isolated instances of damage by mould, which highlights the importance of humidity control, but in general, the recently collected specimens housed in the modern IEBR building remain in good condition. The oldest part of the entomological collection is housed, along with a very large collection of vertebrate specimens, in antique wooden cabinets in an older building, a short walk from the IEBR. The storage area is cramped (not the least by the oversized mounts of stuffed vertebrates!) and climate control is inadequate. This old pinned and layered insect material presents major curatorial challenges. Transfer of the pinned specimens to modern cabinets should be a higher priority than rehabilitation of the layered material. Integration of this material with the more modern collection would also be sensible.

Undoubtedly, the long-term management of what is rapidly becoming a very large collection will depend upon the adoption of uniform storage techniques. A system based on cabinets and unit trays usually provides the greatest flexibility and handling efficiency. It is understood that discussions for the creation of a National Museum of Natural History are well advanced. Most likely the Museum would be accommodated in new floors to be added to the IEBR building (which is itself of modern construction). The establishment of a Museum of Natural History presumably would provide the catalyst for a consolidation of the currently dispersed zoological and botanical collections of IEBR, and the adoption of uniform storage cabinets.

There is a tremendous need for specialist taxonomic literature. Internet access is relatively expensive and staff expressed a preference for CD-based diagnostic products. Staff were familiar with standard computer programs but were not familiar with specialist applications such as the LUCID or the various programs for phylogenetic analysis. The Institute has developed a local specimen database, based on Microsoft Access. Officers were not aware of GBIF and related international databasing initiatives but immediately grasped their significance.

Priorities for IEBR that were apparent to the Project Team might be summarised as follows:

- Adoption of uniform storage techniques and standards, including transfer of pinned specimens to modern cabinets employing a unit tray system.
- Acquisition of additional specialist taxonomic literature.
- Training in the use of diagnostic software, such as LUCID and LINNAEUS II, and phylogenetic analysis packages, such as PAUP.

Discussions at IEBR were with:

- Professor Vu Quang Con, Director
- Dr Le Xuan Canh, Vice Director
- Dr Tran Minh Hoi, Vice Director
- Mrs Le Khuong Thuy

And numerous officers and students involved in arthropod taxonomy and curation of entomological collections.

6.9.5 The Way Forward for Vietnam

Vietnam is currently preparing young taxonomic specialists on a scale exceptional for the region. The preceding pages have identified a program of training workshops and collection rehabilitation that will provide the best possible national framework within which these

young specialists can work. However, it is to be expected that in the coming years Vietnamese taxonomic specialists will also have an increasing regional role.

Major priorities for Vietnam include:

- A major rehabilitation of the collection at the National Institute of Plant Protection;
- Adoption of uniform approaches to specimen storage at the Institute of Ecology and Biological Resources;
- Increasing adoption of modern taxonomic methodologies, such as databasing technologies, diagnostic software such as LUCID and LINNAEUS II, phylogenetic analysis packages such as PAUP, imaging systems such as Automontage, and analytical/predictive software such as Worldmap and CLIMEX; and
- Participation in Global Biodiversity Information activities.

7. REFERENCES

Arnett, R.H. Jr, Samuelson G.A. and Nishida G.M. (1993) *The Insect and Spider Collections of the World*. By Ross H. Arnett Jr., G. Allan Samuelson and Gordon Nishida. 2nd edition. Sandhill Crane Press: Gainesville. vi + 310 pp.

Evans, G., Lum K.Y. and Murdoch L. (2002) *Needs Assessment in Taxonomy and Biosystematics for Plant Pathogenic Organisms in Countries of South East Asia*. A report for AusAID. Available from the Office of the Chief Plant Officer, Department of Agriculture, Fisheries and Forestry – Australia: Canberra.

Haines, C.P. (1997) *Insects and Arachnids in Indonesian Food Stores - Biodiversity in a Man-Made Environment*. pp. 95 – 123. In: Pest Management for Stored Food and Feed. BIOTROP Special Publication No. 59.

Tumilap, M. (1984) *The Entomological Collection of the University of San Carlos*. The Philippine Scientist, 21: 176 – 180.

Morris, H. and Waterhouse D.E. (2001) *The Distribution and Importance of Arthropod Pests and Weeds of Agriculture in Myanmar*. 73 pp. ACIAR: Canberra.

ATTACHMENT 1: QUESTIONNAIRE

**ASEANET NEEDS ASSESSMENT OF REGIONAL
ARTHROPOD COLLECTIONS – 2002**

Questionnaire

CONTACT INFORMATION

YOUR NAME:

NAME OF YOUR INSTITUTION:

ADDRESS:

PHONE:

FAX:

E-MAIL ADDRESS:

COLLECTION DETAILS

1. Please specify the type and size of the existing collection(s) of arthropods:

TYPE OF SPECIMENS	COLLECTION SIZE	
	Number of identified specimens*	Number of unidentified specimens
1. Preserved specimens:		
<input type="checkbox"/> Dry		
<input type="checkbox"/> Wet		
2. Slide specimens		
3. Others (please specify below)		

* 'Identified' here refers to those specimens identified down to species, genus or family level or any other Recognizable Taxonomic Unit (RTU).

2. Please indicate if the following information is recorded for identified specimens:

- | | |
|----------------------------------|--------|
| 2.1 Scientific name of arthropod | yes/no |
| 2.2 Scientific name of host | yes/no |
| 2.3 Date and place of collection | yes/no |
| 2.4 Name of identifier | yes/no |

3. What percentage of specimens held in the collection is relevant to agriculture:

- None
- 25%
- 50%
- 75%
- All

4. What is the source(s) of specimens received by your institution?

5. Is the number of specimens to be identified increasing each year? yes/no

If yes, please indicate the number of unidentified specimens received each year:

- < 100
- 100 - 400
- 400 - 800
- > 800

6. Is the identification of unidentified specimens regarded as urgent? yes/no

7. Are specimens obtained from regular surveys for arthropods? yes/no

If yes, what crops are being surveyed:

8.A. To what extent does your institution access the expertise of *national* specialists:

- Never
- Occasionally
- Frequently

Please indicate which national specialists/organizations you have contact with:

B. To what extent does your institution access the expertise of *international* specialists:

- Never
- Occasionally
- Frequently

Please indicate which international specialists/organizations you have contact with:

9. Do you know if type and other specimens collected in your country are held in overseas institutions? yes/no

If yes, please indicate how many, where they are held, and if there is any opportunity for repatriating this material:

10. Are any parts of the collection in need of rehabilitation? yes/no

If yes, please provide details:

HUMAN RESOURCES

11. For staff associated with your collection, please indicate how many are permanent/contract, as well as the age, area of expertise, and level of staff:

	NUMBER OF STAFF
Type of Employment	
Permanent	
Contract	
Age	
20 – 30	
31 – 40	
41 – 50	
50+	
Area of Expertise	
Entomology	
Acarology	
Plant Protection	
Pest management	
Other	
Level	
Professional	
Technical support	

12. Does your institution have a plan for replacing staff nearing retirement?
yes/no

13. Do staff require training in the identification of important groups? yes/no

If yes, please provide details:

14. Do you have difficulty accessing key scientific literature? yes/no

15. How many staff have skills in information management (eg. use of electronic databases) to support the collection:

16. What percentage of staff time is spent on maintaining the taxonomic adequacy of the centre (include activities such as curation & research, but not administration):

17. Have the specimens been verified in recent times? yes/no

If yes, please provide details (i.e. by whom, when and how):

18. Would the material held in the collection meet the standard for pest records as set out by the IPPC (International Plant Protection Convention) (*ISPM No. 8: Determination of Pest Status in an Area*)? yes/no

If no, please indicate reasons:

INFORMATION MANAGEMENT

19. Are the records of arthropods held in your collection easily accessible by your National Plant Protection Organization (NPPO)? yes/no

If yes, can other institutions access this information (please indicate how):

20. Are these records available electronically (eg. computerized database)?
yes/no

If yes, please indicate the type of databasing software used:

21. Does your country have a national database of plant pest records? yes/no

SECURITY

22. Do you consider the building in which the collection is housed to be adequate, in terms of space, physical security (fireproof), etc? yes/no

If no, please identify key concerns:

23. Is the reference collection protected by legislation? yes/no

24. Which organization(s) owns, and is responsible for, the reference collection:

25. How does this organization(s) relate to the government Ministry(s) responsible for agricultural trade-related issues:

FUNDING

26. What is your estimate of the level of *government* funding that is specifically allocated for reference collections and taxonomic work:

27. What are the main sources of funding *external* to your organization, including aid agencies/programs (funds received from 1998 – 2001):

Funding Source	Amount (US \$)
1.	
2.	
3.	
4.	
5.	

IDENTIFIED NEEDS

28. What are the major challenges facing your institution:

- Staffing
- Infrastructure
- Funding
- Accessing information
- Training in new technologies
- Other

29. Do you have any additional comments?

--

ATTACHMENT 2: REGIONAL CONTACTS

BRUNEI

Plant Pest Unit, Brunei Agricultural Research Centre (BARC)	
Address	Crop Development Division Department of Agriculture Ministry of Industry & Primary Resources Bandar Seri Begawan Brunei Darussalam Bb3510
Website	www.brunet.bn/gov/doa/barc.htm
Contact person 1	Mr Jomari Bin Haji Ahmad
Phone	673-2-670421
Fax	673-2-661354
Email	Barc001@brunet.bn
Contact person 2	Mr Jamaluddin Hj. Md. Yusoff
Email	Barc001@brunet.bn
Number of specimens	Approx 5,000
Entomology and Malaria Lab Unit, Public Health Services	
Address	Ministry of Health Jalan Menteri Besar BE 3910 Brunei Darussalam
Contact person 1	Mr Kamaludin bin Md. Yassin, Public Health Officer
Phone	673-2-381640 x 7829
Fax	673-2-381851
Email	Thunder_1@hotmail.com
Biology Department, Universiti Brunei Darussalam	
Address	Tungku Link Rd Bandar Seri Begawan Be1410 Brunei Darussalam
Website	www.ubd.edu.bn
Contact person 1	Dr Kamariah Binti Hj Abu Salim, Head of Department
Phone	673-2-249001 x 387

Fax	673-2-249502
Email	kamsalim@fos.ubd.edu.bn
Contact person 2	Awg Helen Pang Yoke Kiew, Curator of Museum & Herbarium
Phone	673-2-249001 x 299
Email	Helen@fos.ubd.edu.bn
Number of specimens	About 450 (species)
The Environment Unit, Ministry of Development	
Address	4 th Floor, Ministry of Development Bandar Seri Begawan 1190 Brunei Darussalam
Website	www.brunet.bn/gov/modev/environment/ouroffice.html
Contact person 1	Martinah Hj. Tamit, Environment Officer
Phone	673-2-383222 x 507
Fax	673-2-383644
Email	uas@mod.gov.bn
Royal Brunei Museum	
Address	Jalan Kota Batu Bandar Seri Bagawan BD 1510 Brunei Darussalam
Phone	673-2-244545
Website	www.museums.gov.bn
Contact person 1	Mariani Hj Abu Bakar
Contact person 2	Tuah bin Atar
Contact person 3	Hajah Kolam Hj Grayson
Number of specimens	25,000

INDONESIA

Gadjah Mada University, Yogyakarta	
Address	Gadjah Mada University Yogyakarta 55281 Indonesia
Section	Faculty of Biology
Contact person 1	Prof. Sukarti Moeljopawira, Dean, Faculty of Biology
Phone/ Fax	62 274 580839
Email	biologi@ugm.ac.id
Contact person 2	Prof. Jesmandt Situmorang, Laboratory of Entomology
Phone	62-274-902354 ext. 20
Fax	62-274-580839
Email	jemandts@hotmail.com
Contact person 3	Dr. Hari Purwanto, Laboratory of Entomology
Phone	62 274 902261 580839
Contact person 4	Prof. Endang S. Soetarto, Microbial biologist
Phone	62 274 902260
Fax	62 274 580839
Number of specimens	10,000
Section	Faculty of Agriculture
Contact person 1	Dr. Y. Andi Trisyono, Department Head, Department of Entomology and Phytopathology
Phone	62 274-902169
Fax	62 274-563062
Email	andi@faperta.ugm.ac.id
Section	Department of Entomology and Plant Pathology
Contact person 2	Dr. Eddy Mahrub, Entomologist
Phone	62 274 902701
Fax	62 274 563062
Number of specimens	30,000

Faculty of Agriculture, Padjadjaran University, Bandung	
Address	Plant Protection Dept. Jl. Raya Jatinangor – Ujung Berung Bandung 40600
Contact person 1	Ir. M.S. Tohidin, Entomologist, Faculty of Agriculture
Phone	62-22-7798652
Number of specimens	450
Institut Teknologi Bandung (ITB), Bandung	
Address	Lab Tek. XIITB Jl. Ganesa 10 Bandung 40132 Indonesia
Contact person 1	Dr. Tati S. Subahar, Laboratorium Ekologi
Phone	62 22 250 9172 73ext. 3136
Fax	62 22 251-1575
Email	tati@bi.itb.ac.id
Contact person 2	Dr. Achmad Sjarmidi, Laboratorium Ekologi
Phone	62 22 250-9172-73 ext 3138
Fax	62 22 251 1575 250 0258
Email	sjarmidi@bi.itb.ac.id
Contact person 3	Prof. Dr. Soelaksono Sastrodihardjo, Laboratorium Entomologi
Phone	622 22-250 9172 ext3156
Fax	622 22-251 1575
Email	soel@bi.itb.ac.id
SEAMEO BIOTROP, Bogor	
Address	SEAMEO BIOTROP Jl. Raya Tajur Km 6 PO Box 116 Bogor 16000
Phone	62-251-323848
Fax	62-251-326851
E-mail	info@biotrop.org
Website	www.biotrop.org
Contact person 1	Dr. Sunjaya
Contact person 2	Ir Kasno

Central Research Institute for Food Crops, Bogor	
Address	Jl Cimanggu Kecil No.2 Bogor Indonesia
Contact person 1	Dr. Sri Suharni Siwi, Senior Researcher
Phone	62-251-347-923
Fax	62-251-312-755
Email	ssiwi@indo.net.id
Contact person 2	Ms Trisnaningsih
Dept of Plant Pests and Diseases, Bogor Agricultural University, Bogor	
Address	Jl. Pajajaran Bogor 16144 Indonesia
Contact person 1	Dr. Purnama Hidayat, Entomologist
Phone	62 251 629364
Fax	62 251 629362
Email	phidayat@ipb.ac.id
Contact person 2	Prof. Soemartono Sosromarsono, Professor of Entomology (retired)
Phone	62 251 322079
Contact person 3	Dr. Dewi Sartiami
Museum Zoologicum Bogoriense, Cibinong	
Address	Jl Raya Jakarta - Bogor, Km 46 Cibinong, 16911 Bogor, Indonesia
Contact person 1	Dr Yayuk Suhardjono
Fax	62-21-8765068
Email	yayukrs@indo.net.id
Contact person 2	Dr. Siti Nuramaliati Prijono, Director
Indonesian Agricultural Quarantine Agency, Jakarta	
Address	Indonesian Agricultural Quarantine Agency (IAQA) Gedung E, Lantai V Departemen Pertanian Jalan Harsono R.M. 3 Pasarmingu

	Jakarta 12550 Indonesia
Contact person 1	Mr Suwanda, Director
Contact person 2	Ms Rumenda Ginting
The Indonesian Institute of Sciences (LIPI)	
Section	Research Centre for Biology, Biodiversity Information Centre
Address	Widyasatwaloka Building, Zoological Division, Research Centre for Biology. Jl. Raya Bogor KM 46. Cibinong. Indonesia.
Contact person 1	Mr Roemantyo, Plant Ecologist/ Bioinformatics
Phone	62 21 8765070
Fax	62 21 8765068
Email	roemantyo@yahoo.com
Indonesian Institute of Science Research and Development Centre for Oceanology	
Address	Jl. Pasir Putih 1, Ancol Timur Jakarta 14430
Contact person 1	Rianta Pratiwi Afriadi
Phone	62 21683850
Fax	62 21681948
Email	P3o_lipi@jakarta.wasantara.net.id

LAOS

National Agriculture Forestry and Extension Service	
<i>Section</i>	Soil and Crop Extension Centre, Houiyang
Address	Ministry of Agriculture and Forestry Thagone Rd, PO Box 1640 Vientiane, Lao PDR
Contact person 1	Phousit Phoumavong
Phone	856 21 732309
Fax	856 21 812130
Email	ipmlaos@attglobal.net
<i>Section</i>	National Research Centre, NaPook
Address	
Contact person 1	
Phone	
Fax	
Department of Agriculture	
Section	Quarantine Section, Service of Agriculture and Forestry of Vientiane Municipality
Address	Ministry of Agriculture and Forestry Friendship Bridge
Contact person 1	Mr Thongsavanh Taipangnavong, Chief of Plant Quarantine and Provincial IPM Coordinator
Phone	856 21812162
Fax	856 21832083
Section	Plant Protection Centre, Salakham
Address	Ministry of Agriculture and Forestry PO Box 811/ PO Box 8914 Vientiane, Lao PDR
Contact person 1	Mr Saleumy Phithayaphone, Deputy Director
Phone	856 21 812110
Fax	856 21 812090
Email	doag@laotel.com

Contact person 2	Mr Viengsavay Sensourivong, Head of Plant Protection Section and National BUCAP Project Coordinator
Phone	020 507605
Fax	856 21 812090
Email	vsvbucap@laopdr.com
Contact person 3	Mr Tiangkham Vongsabouth
Phone	812 11 812164
Fax	856 21 812090
Number of specimens	Small
FAO IPM Program Office	
Address	GCP/ RAS/ 160/ Net Crop Protection Center Salakham, Vientiane, Lao PDR
Contact person 1	Mr Jan Willem Ketelaar, Team Leader, IPM Expert
Phone	856 21 812142
Fax	856 21 812130
Email	Jwkipm@attglobal.net

MALAYSIA

Centre For Insect Systematics, Universiti Kebangsaan Malaysia	
Address	Centre for Insect Systematics, Universiti Kebangsaan Malaysia 43600 Bangi Selangor, Malaysia
Contact person 1	Prof. Mohamed Salleh Mohamedsaid
Phone	603-8929 2872
Fax	603-8925 3357
Email	mohds@pkrisc.cc.ukm.my
Contact person 2	Ms Salmah Yaakop
Number specimens	100,000
Plant Protection Department, Universiti Putra Malaysia, Serdang	
Address	Universiti Putra Malaysia 43300 Serdang Selangor, Malaysia
Contact person 1	Dr. D. Zolkifli Omer
Email	zolkifli@agric.upm.edu.my
Contact person 2	Mr Mohd Salleh
Strategic, Environment and Natural Resource Research Centre, MARDI	
Address	Malaysian Agricultural Research and Development Institute (MARDI) Serdang, Selangor, Malaysia
Contact person 1	Dr Mohamed Rani Mat Yusoh, Research Officer
Phone	603-8943 7349
Fax	603-8948 7639
Email	mrmym@wardi.my
Number specimens	26,408

Crop Protection & Quarantine Division, Dept of Agriculture	
Address	Jalan Gallagher 50480 KUALA LUMPUR MALAYSIA
Contact person 1	Mr Yusof Bin Othman
Phone	603-26977137
Fax	603-26977205
Email	yusof@pq.doa.moa.my
Contact person 2	Ms Asna Booty Othman, Director
Number specimens	85,908
Forest Research Institute Malaysia (FRIM)	
Address	Kepong, 52109 Kuala Lumpur, Malaysia
Contact person 1	Dr Grace Tabitha Lim, Research Officer, Entomology
Phone	603-6279 7110
Email	grace@frim.gov.my
Number specimens	597,500
Agriculture Research Centre, Kuching	
Address	PO Box 977 93720 Kuching Sarawak, MALAYSIA
Contact person 1	Mr Ron Ah Goh
Phone	082-611171
Fax	082-611178
Email	ronag@sarawaknet.gov.my
Number specimens	21, 000 species
Contact person 2	Mr Stephen Leong Chan Teck, Entomologist
Phone	082-611171
Fax	082-611178
Email	Dragon8leong@yahoo.com
Contact person 3	Ms Megan Gumbok

Forest Research Center, Kuching	
Address	Forest Department Sarawak Km 10, Jalan Penrissen 93250 Kuching Sarawak, Malaysia
Contact person 1	Ms Lucy Chong, Assistant Director of FRC
Phone	60-82-615888
Fax	60-82-617953
Contact person 2	Mr Ernest Chai Oi Khun
Phone	60-82-615888
Fax	60-82-617953
Email	echai@tm.net.my
Contact person 3	Mr Ernest Chai Oi Khun
Contact person 4	Mr Paulus Meleng
Contact person 5	Mr Marfaisal Marzuki
Number of specimens	500,000
Institute of Biodiversity & Environmental Conservation, Universiti Malaysia Sarawak	
Address	Universiti Malaysia Sarawak, 94300 Kota Samarahan Sarawak Malaysia
Website	http://www.unimas.my http://www.unimas.my/en/ibec/index.htm (under construction, as at June 2002)
Contact person 1	Dr Fatimah Abang, Director
Phone	60 82 672318
Fax	60 82 671727
Email	fatim@ibec.unimas.my
Number specimens	Around 40, 000
Contact person 2	Dr Dennis Hill
Phone	60 82 671000 x255
Fax	60 82 671727
Email	dshill@ibec.unimas.my

Sabah Forest Department	
Section	Environmental Sciences Division, Forest Research Centre
Address	Forest Research Centre PO Box 1407 90715 Sandakan Sabah, Malaysia
Contact person 1	Dr Chey Vun Khen, Head Forest Entomologist
Phone	089 – 538202 ext. 31
Fax	089-531068
Email	frc@tm.net.my cheyvk@tm.net.my
Number of specimens	100,000
Agricultural Research Centre, Kota Kinabalu	
Address	Agriculture Research Centre PO Box 3 89207 Tuaran, Sabah
Contact person 1	Mr Jinius Jipanin
Phone	0060-88-788590
Fax	0060-88-788548
Email	Roo.11.@sabah.gov.my
Number of specimens	30,000
Malaysian Cocoa Board, Kota Kinabalu	
Address	Locked Bag 211, 88999 Kota Kinabalu, Sabah, Malaysia
Contact person 1	Dr. I. Azhar, Director General
Phone	6088-252572
Fax	6088-239575
Email	abi@koko.gov.my
Website	www.koko.gov.my
Contact person 2	Dr. Lee Ming Tong, Deputy Director General (Research)
Email	leemt@koko.gov.my
Contact person 3	Dr Lee Choon Hui
Phone	605-6488176
Fax	605-646489151
Email	chlee@koko.gov.my

Institute for Tropical Biology & Conservation, Universiti Malaysia Sabah	
Address	Locked Bag 2073, 88999 Kota Kinabalu, Sabah, Malaysia
Contact person 1	Prof. Maryati Mohamed
Contact person 2	Assoc. Prof. Mennon Schilthuizen
Phone	6088-320000 ext. 5610
Fax	6088-435311
Email	schilthuizen@excite.com
Website	www.ums.edu.my/ibtp
Number of specimens	32,000

MYANMAR

Myanmar Agriculture Service	
Section	Plant Protection Division
Address	Ministry of Agriculture & Irrigation Bayint Naung Rd, Insein P.O. 11011 Yangon. Union of Myanmar
Contact person 1	Mr Than Aye, Head of the Division
Phone	95-01-663397
Fax	95-01-667991
Email	Ppmas.moai@mptmail.net.mm
Contact person 2	Mrs Phyu Phyu Lwin, Entomology Section Head
Department of Entomology, Yezin Agricultural University	
Address	Yezin Agricultural University, Yezin, Myanmar
Contact person 1	Dr Myint Thaug, Professor
Phone	095-067-21098
Forest Department, Ministry of Forestry	
Address	Bayint Naung Rd, Insein P.O. 11011 YANGON Union Of Myanmar
Contact person 1	Dr U Shwe Kyaw, Director General
Phone	095-01-681754
Fax	095-01-665592
Email	Teaknnet@mptmail.net.mm

PHILIPPINES

University of the Philippines Los Baños	
Section	Plant Quarantine Support Laboratory National Crop Protection Centre
Address	College of Agriculture University of the Philippines Los Banos College Laguna 4031
Contact person 1	Dr. Eliseo P. Cadapan, Director NCPC & Prof. Dept. Ento.
Phone	049 536 0975
Fax	049 536 2409
Email	ncpc@mudspring.uplb.edu.ph
Contact person 2	Dr. Bonifacio Cayabyab
Contact person 3	Ms Jessamyn D. Recuenco-Adorada
Phone	049 536 2410
Fax	049 536 2409
Email	jdradorada@yahoo.com
Section	Dept of Entomology
Address	Department of Entomology University of the Philippines Los Banos College, Laguana Philippines 4031
Contact person 1	Dr. Virginia Ocampo
Contact person 2	Dr.S.G. Reyes
Section	Museum of Natural History
Address	University of the Philippines Los Banos College 4031, Laguna, Philippines
Contact person 1	Dr. Ireneo L. Lit, Entomologist
Phone	49 536 2864
Email	mnh@laguna.net
Contact person 2	Assoc. Prof. Lourdes B. Cardenas, Director
Website	www.laguna.net/uplbmuseum

Dept of Entomology, Benguet State University	
Address	Department of Entomology College of Agriculture Benguet State University La Trinidad, Benguet
Contact person 1	Assoc. Prof. Bonie S. Ligat
Number of specimens	small
College of Agriculture, Central Luzon State University	
Address	Central Luzon State Univesity, Nueva Ecija 3120 Philippines
Contact person 1	Dr. Elaida R. Fiegalan
Contact person 2	Ms Arlene G. Villameva
Number of specimens	Fewer than 10,000
Website	www2.mozcom.com/~clsu/
International Rice Research Institute (IRRI)	
Address	DAPO Box 7777 Metro Manila, Philippines
Contact person 1	Dr. Alberto T. Barrion
Phone	63-2 845-0563, 845-0569
Fax	63 2 845 0606
Email	irri@cgiar.org
Website	http://www.irri.org/index.htm

Philippines Rice Research Institute (Phil Rice)	
Address	Maligaya, Munoz 3119 Nueva Ecija Philippines
Contact person 1	Evelyn M. Valdez
Contact person 2	Gertrudo Arida
Website	http://www.philrince.gov.ph/
Bureau of Plant Industry, Dept of Agriculture, Manila	
Section	Crop Protection Division
Address	692 San Andres St Malate Manilla 1004
Contact person 1	George Paul S. Karganilla
Phone	524 07 65/ 525 81 88
Fax	521 76 50
Number specimens	~30,150
Contact person 2	Wilma R. Cuaterno, Chief
Phone	02 524-7353
Email	02 523 2426
National Museum of the Philippines, Manila	
Address	National Museum of the Philippines, P. Burgos St., Manilla, Philippines
Phone	527 12 15
Fax	527 03 06
Email	nmuseum@i-next.net
Contact person 1	Mr. Venancio, U. Samarita
Phone	400 32 39
Fax	527 03 06
Number specimens	~121,000
Contact person 2	Ms Elma Naqas

SINGAPORE

Zoological Reference Collection – Entomological Collection, Raffles Museum of Biodiversity Research	
Address	Department of Biological Sciences, National University of Singapore (NUS) Kent Ridge Singapore 119260
Website	http://rmbn.nus.edu.sg/collections/entomology.htm
Contact person 1	Mrs Yang Chang Man
Phone	0011 65 6874-5082/ 0011 65 6874-2875
Fax	0015 65 6774-8101
Email	dbsycm@nus.edu.sg
Number specimens	86,500
Entomology Laboratory, Agri-food & Veterinary Authority of Singapore (AVA)	
Address	Plant Health Centre Sembawang Research Station 17 km, Sembawang Rd Singapore 769193
Website	http://www.ava.gov.sg/JAVASCRIPT/main-ie.html
Contact person 1	Mr He Liansheng
Phone	0011 65 6752 9835
Fax	0015 65 6753 4626
Email	He_Lian_Shang@ava.gov.sg
Number specimens	4, 000
Environmental Health Institute, Ministry of the Environment	
Address	The Gemini Block 41 #03-24/28, Science Park II Singapore 117610
Contact person 1	Mrs Lam-Phua Sai Gek
Phone	0011 65 6771 9126
Email	PHUA_Sai_Gek@env.gov.sg
Number specimens	1460

Singapore Botanic Gardens, National Parks Board	
Address	1 Cluny Rd Singapore 259569
Website	www.nparks.gov.sg
Contact person 1	Ms Cheryl Chia Siew Wah – Research Officer
Phone	0011 65 6471 9945
Fax	0015 65 6475 4295
Email	Cheryl_CHIA@NPARKS.GOV.SG
Contact person 2	Ms Chew Ping Ting

THAILAND

National Biological Control Research Center (NBCRC)	
Section	NBCRC Headquarters, Kasetsart University
Address	P.O. Box 9-62 Chatuchak Bangkok 10900 Thailand
Website	http://www.wisard.org/wisard/shared/asp/generalinfoserver/intermediate.asp?InstitutionID=5780
Contact person 1	Ms Thitima Thongtab
Phone	66-0-2579-3649
Fax	66-0-2942-8252
Email	thitithong@yahoo.com
Number specimens	2,600
Contact person 2	Dr Banpot Napompeth – Executive Director NBCRC
Email	agrbn@nontri.ku.ac.th
Contact person 3	Dr Weerawan Amornsak
Section	NBCRC Central Regional Centre
Address	10/99 Kaset Nives, Chaeng, Watana 14 Thailand
Contact person 1	Mr Kosol Charearnson
Phone	66-0-3428 1265
Fax	66-0-3435 1881
Email	agrkok@ku.ac.th
Number specimens	7,540
Section	NBCRC Northern Regional Centre
Institution	Department of Plant Protection, Faculty of Agricultural Production, Maejo University
Address	NBCRC/ NRC Maejo University, P.O. Box 11, Sansai, Chiang Mai 50290 Thailand
Contact person 1	Mr Charnnarong Doungsa-ard, Assistant Professor
Phone	66-0-53-498243
Fax	66-0-53-4982
Email	Charn_nbcrc@yahoo.com

Section	NBCRC North Eastern Regional Centre
Address	Khon Kaen University PO Box 181 Khon Kaen 40002 Thailand
Contact person 1	Dr Nutcharee Siri, Director
Phone	66-43-343055
Fax	66-43-343055
Email	nutcharee@kku.ac.th
Number specimens	Around 630
Contact person 2	Dr. Manochai Keerati-kasikorn
Section	NBCRC Southern Regional Centre
Address	Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkla 90112 Thailand
Contact person 1	Dr Jiraporn Peteharat
Phone	074-213-063
Fax	074-213-063
Email	pjirapor@patree.psu.ac.th
Number specimens	Around 800
Entomology & Zoology Division, Dept of Agriculture, Bangkok	
Address	50 Paholyothin Rd Chatuchak, Bangkok 10900 Thailand
Website	entozoo@doa.go.th
Contact person 1	Mrs Vatana Charanasri, Senior Entomologist
Phone	622-579-4128 x176
Fax	662-9405396
Email	vatanac@doa.go.th
Contact person 2	Mrs Wipada Vungsilabutr
Phone	622-579-3053
Fax	662-9405396
Number specimens	Approx. 600,000

Forest Insect Group, Royal Forest Department, Bangkok	
Address	61 Paholyothin Rd Chatuchak, Bangkok 10900 Thailand
Website	http://www.forest.go.th/default_e.asp
Contact person 1	Mr Surachai Chondumrongkul
Phone	0-2561-4292 x439
Fax	0-2579-8775
Email	surach@forest.go.th
Number specimens	Approx. 17,400
Contact person 2	Dr. Chaweewan Hutacharern, Director of Division
Contact person 3	Mr Supachote Eungwijarnpanya
Dept of Plant Protection, Mae Jo University, Chiang Mai	
Address	Sunsai, Chiang Mai 50290 Thailand
Contact person 1	Dr Khayan Surwan – Head of Department
Phone	057-878089
Fax	053-878089
Email	Khayan@mju.ac.th
Number specimens	Around 1,550
Chiang Mai University	
Section	Dept of Entomology
Address	Faculty of Agriculture, Chiang Mai University 50200 Thailand
Website	http://www.kku.ac.th/kkuinfo/ag.html
Contact person 1	Assoc. Professor Sanit Ratanabhumma, Chairman of Dept
Phone	053-944026
Fax	053-944666
Email	headebt@chiangmai.ac.th
Number specimens	About 29,500
Contact person 2	Dr Hans Banziger

Phone	053-944026
Fax	053-944666
Contact person 3	Associate Prof. Vichian Hengsawad
Contact person 4	Dr Manas Titayavan
Section	Postgraduate Education and Research Development Project in Postharvest Technology
Contact person 1	Dr Vichian Hengsawad, Director
Phone	053-941449
Fax	053-941447
Email	vichianh@hotmail.com ; ageni004@chiangmai.ac.th
Contact person 2	Dr Manas Titayavan, Deputy Director
Phone	053-941448
Fax	053-941447
Email	ageni001@chiangmai.ac.th
Khon Kaen University	
Section	Dept of Entomology
Address	Faculty of Agriculture, Khon Kaen University Khon Kaen 40002 Thailand
Website	http://www.kku.ac.th/
Contact person 1	Dr Yupa Hanboonsong, Head of Department of Entomology and Director of Office of International Agriculture.
Phone	66 0 4323 7602
Fax	66 0 4324 4474
Email	Yupa_han@kku.ac.th
Contact person 2	Ms Chutinan Choosai
Email	chucho@kku.ac.th
Contact person 3	Dr Sivilai Sirimungkararat
Phone	66-043-362108
Fax	66-043-362108
Email	sivilai@mail.kku.ac.th
Number specimens	57,000

<i>Section</i>	Office of International Agriculture
Address	Department of Entomology, Faculty of Agriculture, Khon Kaen University
Contact person 1	Dr. Yupa Hanboonsong (as above)
Number specimens	Approx. 77, 140
Dept of Pest Management, Prince of Songkla University, Hat Yai	
Address	Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla 60112
Website	http://natres.psu.ac.th/
Contact person 1	Dr Sieng Kritsaneepaiboon, Dean for Faculty of Natural Resources
Phone	074-211-122
Fax	074-212-823
Email	ksieng@ratree.psu.ac.th
Contact person 2	Dr Prawit Towatana, Associate Dean for Research and International Relations
Phone	0-7428-2300
Fax	0-7421-1122
Email	tprawit@ratree.psu.ac.th
Contact person 3	Dr Surakra Permkam
Phone	074-212-844
Fax	074-212-823
Email	psurakra@ratree.psu.ac.th
Number specimens	Around 22, 000
Contact person 4	Dr. Aran Ngampongsai

Kasetsart University, Kamphaengsaen Campus	
<i>Section</i>	Dept of Pest Management
Address	Faculty of Agriculture, Kasetsart University Kamphaengsaen Campus Nakhon-Pathom 73140 THAILAND
Website	http://www.ku.ac.th/aboutku/thai/faculty/agr/mento.htm (in Thai) http://www.ku.ac.th/faculty/agri/indexe.html
Contact person 1	Weerawan Amornsak, Assistant Professor
Phone	66-2-579-0113 x3694
Fax	66-0-34 351-886
Email	agrwwa@notri.ku.ac.th agrwwa@ku.ac.th
Section	Dept of Entomology
Contact person 1	Assoc. Professor Chitapa Ketavan, Dept Head
Phone	66-2-561-3478
Fax	66-2-562-0985
Email	agrchk@nontri.ku.ac.th
Number specimens	More than 200,000

VIETNAM

National Institute of Plant Protection (NIPP)	
Address	National Institute of Plant Protection Ministry of Agriculture and Rural Development Dong Ngac Tu Liem Hanoi, Vietnam
Contact person 1	Prof. Nguyen Van Tuat
Phone	884-4-838 5578, 84-4-838 9724
Fax	84-4-836-3563
Email	Nipp.Vietnam@bdvn.vnmail.vnd.net tuat@hn.vnn.vn
Contact person 2	Dr. Nguyen van Cam, former Director
Phone	84-4-48 362 393
Fax	84-4-48 363 563
Email	Bio-nipp@hn.vnn.vn vietnam@bdvn.vnmail.vnd.net
Contact person 3	Dr. Pham van Lam, entomologist
Phone	84-4-8362393
Fax	84-4-8363563
Email	Bio-nipp@hn.vnn.vn
Contact person 4	Dr Quach Thi Ngo, Curator
Phone	84-4-8362393
Fax	84-4-8363563
Contact person 5	Ms Nguyen Thi Mai Chi
Number specimens	Approx. 40 000
Forest Science Institute of Vietnam	
Address	Dong Ngac Tu Liem Hanoi, Vietnam
Contact person 1	Mr Nguyen Van Do, Entomologist
Phone	84-48-362376
Fax	84-48-389722
Email	pbvr@hn.vnn.vn

Number specimens	14,270
Contact person 2	Dr. Nguyen Hoang Nghia, Deputy Director General
Phone	84-4-913 236028
Fax	84-4-8389722
Email	nhnghia@netnam.vn
Contact person 3	Dr Pham Quang Thu, Head of The Forest Protection Research Division
Phone	84-4-8362376
Fax	84-4-8389722
Email	pbvr@hn.vnn.vn
Hanoi Agricultural University	
Address	Trauquy Gialam Hanoi, Gia Lam District Hanoi, Vietnam
Contact person 1	Dr Nguyen Van Dinh, Head of Planning Division
Phone	84-4-8276473
Fax	84-4-8276473
Email	agronomy@hn.vnn.vn
Contact person 2	Prof. H.A Quang Hung
Phone	84-4-8 768039
Fax	84-4-8276554
Email	hunghuong@fpt.vn
Contact person 3	Dr. Nguyen Kim Van, Head Department of Plant pathology and Agro-Pharmacology
Phone	84-4-8 768 475
Fax	84-4-8 276 554
Email	agronomy@hn.vnn.vn vtman@hn.vnn.vn

Institute of Ecology and Biological Resources (IEBR)	
Address	Institute of Ecology and Biological Resources Nghia Do – Cau Giay, Hanoi, Vietnam
Contact person 1	Prof. Vu Quang Con, Director
Phone	84-4-8361441
Fax	84-4-8361196
Email	vucon@ncst.ac.vn
Contact person 2	Dr Le Xuan Canh, Vice Director
Phone	84-4-8360870
Fax	84-4-8361196
Email	Lxcanh@ncst.ac.vn
Contact person 3	Mrs Le Khuong Thuy
Contact person 4	Dr Tran Minh Hoi, Vice Director
Phone	84-4-7565942
Email	tranhoi@iebr.ncst.ac.vn
Contact person 5	Dr. Bui Tuan Viet
Email	btviet@iebr.ncst.ac.vn
Number specimens	In excess of 100,000