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Report of the

EXPERT CONSULTATION ON COCONUT BEETLE OUTBREAK IN APPPC MEMBER COUNTRIES

26-27 October 2004, Bangkok, Thailand

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
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Executive summary

The expert consultation was held in Bangkok from 26 to 27 October 2004 under the auspices of the FAO Regional Office for Asia and the Pacific. It was attended by 17 representatives from 11 countries, namely Cambodia, China, Indonesia, Lao PDR, Malaysia, Maldives, Myanmar, Pakistan, Sri Lanka, Thailand and Viet Nam. An international consultant from Fiji joined FAO technical officers to facilitate the expert consultation.

In his address to the participants of the expert consultation, He Changchui, the Assistant Director-General (ADG) and Regional Representative of FAO, reminded participants that in the past classical biological control of coconut pests were successful and, indeed, this ecologically sound approach to pest management is particularly important as FAO has designated 2004 as the Year of Biodiversity for Food Security.

Mr Liebregts described the achievements to date with classical biological control of *Brontispa longissima.* In some countries, the use of chemical insecticides was initiated but did not stop the outbreaks and the problem continued to spread. However, experiences in Viet Nam and the Maldives have shown that biological control works. The Viet Nam project has shown a return on investment of US$3 000 for every dollar invested in biological control.

Mr Ooi discussed the need to educate coconut farmers about Integrated Pest Management (IPM). Two examples of managing coconut pests were described and the need for developing a strong base for biological control was recommended. The outbreaks of *B. longissima* should help national programmes commit investment in developing capacity to face the challenges of managing invasive species.

B. longissima is reported in Cambodia, China, Lao PDR, Maldives, Myanmar, Thailand and Viet Nam. Sri Lanka, India, Bangladesh, Malaysia, Philippines and possibly some other Pacific Island countries are threatened. Indonesia is the centre of origin and will be a valuable source of additional natural enemies.

The participants discussed guidelines for introduction of beneficial organisms and also endorsed a set of recommendations that focused on:

- developing a regional programme to build national capacity to tackle invasive species;
- enhancing synergy of cooperation and catalysing sustainable use of natural resources through a regional programme;
- individual countries continuing to enhance their capacity to conduct classical biological control and cooperate with neighbouring countries;
- guidelines for safe and responsible introduction, production and release of biological control agents.

Participants visited the laboratory of the Department of Agriculture, Thailand to witness the rearing of parasitoids of *B. longissima*.

Report of the expert consultation on coconut beetle outbreak in APPPC member countries 26 to 27 October 2004, Bangkok, Thailand

I. Introduction

The expert consultation was held in Bangkok from 26 to 27 October 2004 under the auspices of the FAO Regional Office for Asia and the Pacific. It was attended by 17 representatives from 11 countries, namely Cambodia, China, Indonesia, Lao PDR, Malaysia, Maldives, Myanmar, Pakistan, Sri Lanka, Thailand and Viet Nam. An international consultant from Fiji joined FAO technical officers to facilitate the expert consultation.

The meeting was declared opened by He Changchui, Assistant Director-General (ADG) and Regional Representative for Asia and the Pacific. In his address, he pointed out that the main objective of the consultation was to exchange experiences and lessons learned among member countries of the Asia-Pacific Plant Protection Commission (APPPC) that are facing or may face coconut beetle outbreaks. It is important for countries affected or at risk of incursion to work together and FAO stands ready to facilitate the cooperation and provide technical assistance to build capacity to tackle this invasive insect.

In addressing the outbreaks, it is often unsustainable to rely on chemical insecticides. One successful approach in the past was to introduce effective biological control agents that attacked only the coconut beetle. This ecologically sound approach does little harm to the environment and helps restore the balance that contributes to sustaining a sound coconut ecosystem. The biological control approach is particularly important as FAO has designated 2004 as the Year of Biodiversity for Food Security. In this aspect, FAO has put forth specific guidelines to ensure successful and specific action of introduced species to control invader pests.

The ADG expressed confidence that the discussion would galvanize the member countries to work together proactively within a regional programme to prepare for the possible invasion of other pests and on other crops too. FAO has been successful in developing the IPM Farmer Field School (FFS) approach to help farmers manage their agro-ecosystem. This outbreak presents a unique opportunity for the member countries to recommit their agricultural development towards farmer education to sustain rural development and reduce poverty.

II. Presentations by resource persons

Impact and control of the coconut hispine beetle, *Brontispa longissima* gestro (Coleoptera: Chrysomelidae) by Wilco Liebregts

Brontispa longissima is one of the most serious pests of coconut in Asia and the Pacific. Recent estimates from Viet Nam indicate that, if left untreated, damage to the coconut industry there would have been in excess of one billion US$ over a 30-year period. *Brontispa* can be successfully brought under sustainable, environment-friendly

control by classical biological control, as shown in Samoa and other Pacific Island countries. FAO is supporting TCP projects in Viet Nam, Nauru and Maldives, which have seen the collection of the parasitoid *Asecodes hispinarum* from Samoa and its subsequent introduction in these countries. Initial surveys have confirmed the establishment of the parasitoid in Viet Nam and Maldives, where observations show that damage to young emerging leaves is reduced. The Viet Nam project has shown a return on investment of US$3 000 for every dollar invested by FAO in this project.

The pest has continued to spread in Southeast Asia, and is now found in different climate zones, where the effectiveness of *A. hispinarum* may be reduced. In this view, it is highly desirable to seek and identify additional species of natural enemies for study and selection to complement biocontrol efforts in the region. Such efforts should be accompanied by a revision of the genus *Brontispa* and of other relevant hispinae since confusion has arisen in the region on the presence of other coconut pests which show similarities in appearance and damage symptoms to coconut in the region.

Integrated Pest Management (IPM) of key coconut pests by Peter A.C. Ooi

Integrated Pest Management (IPM) concerns farmer education that empowers farmers to become more effective managers and decision-makers. The focus is about IPM by farmers and not IPM for farmers! In IPM, biological control and ecological principles are the founding principles. Through Farmer Field Schools (FFS), farmers develop skills in critical and informed decision-making. Experiences with IPM for the rhinoceros beetle and the coconut leaf moth demonstrated the need to educate farmers in IPM principles to sustain good coconut management practices. Farmers can learn to avoid disruption of biological control when they understand the ecological basis of pest outbreaks.

Besides *Brontispa longissima*, two other hispine beetles occur in the region and, indeed, *Promecotheca cumingii* may pose a serious threat to the coconut industry in areas where it does not yet occur. *Artona catoxantha* has the same ability to invade new areas and may cause outbreaks at the level currently caused by *B. longissima* and perhaps even worse. Lessons learned from the classical biological control of *B. longissima* point to the synergy of sharing information, experiences and beneficial agents between countries in the region. FAO can catalyze this through activities, such as this expert consultation. It is hoped that success in the biological control of *B. longissima* will encourage national programmes to enhance their capacity to face pest outbreaks and conduct classical biological control.

As invasive species transcend boundaries, it stands to reason that the sharing of information, especially through a regional entity such as FAO's Asia-Pacific Plant Protection Commission (APPPC) will greatly benefit the task of managing new pest situations. In this respect, a regional programme will allow countries in the region to enhance the readiness of national programmes to meet the challenges of invasive species and its control by introduced specific natural enemies. It is hoped that this expert consultation will discuss the possibility of setting up regional collaboration to address this important aspect of capacity enhancement. This is critical in the light of the outbreak of *B. longissima* and the possibility of new pests coming from within the region as well as from outside the region. For example, the coconut mite from Africa has already arrived in Sri Lanka and is spreading. The threat of the palm miner,

Coelanomenodera sp. from Africa to the oil palm is of concern to the region in the light of expanded air travel between continents. This is also true of pests from the region moving around, for example *Rhynchophorus* sp. invading the Middle East.

III. Summary of country reports

Cambodia

Brontispa longissima invaded Cambodia around 2001. Of the total 12.3 million coconut trees, 1.95 million trees or 16 percent were killed by *B. longissima*, 7.2 million trees or 58 percent were attacked. Due to lack of information about this invasive species, the country mounted an extensive chemical control campaign, incurring much expense but with negligible results. The representative at the meeting indicated the need for sustainable management of *B. longissima* in Cambodia.

China

The coconut leaf beetle was found in Hainan, Guangdong and Taiwan provinces, but the worse affected areas are in Hainan province.

In Hainan province, 11 species of host palm trees such as *Cocos nucifera, Areca catechu, Archontophoenix alexandrae, Roystonea regia, Washingtonia fllifera, Hyophorbe lagenicaulis, Washingtonia robusta, Liviston chinensis* and *Chrysalidocarpus lutescens* were recorded. The major host plant is *Cocos nucifer.* Dry periods favour the development of *Brontispa* populations. The long distance spread is aided by human activities.

Two biological agents, *Asecodes hispinarum* and *Metarhizium anisopliae*, are being intensively tested to manage this pest and promising results have been reported. Larger releases, especially of *A. hispinarum*, are being planned together with arrangements for monitoring its impact.

Indonesia

Brontispa longissima is one of the major pests in several provinces of Indonesia. There are three potential natural enemies for controlling *B. longissima*, namely: pupal parasitoid (*Tetrastichus brontispa*), entomopathogenic fungi (*Metarhizium anisopliae* var. *anisopliae* and *Beauveria bassiana*). *T. brontispa* has an important role as pupal parasitoid both under laboratory and field conditions. Percent parasitism of pupa under laboratory and field conditions ranged from 76.7 to 87.0 percent and 35.71 to 73.56 percent, respectively. Pathogenicity of *M. anisopliae* var. *anisopliae* and *B. bassiana* were examined under laboratory and field conditions. The results showed that these fungi could infect both larvae and adults of *B. longissima*.

Lao PDR

Brontispa longissima was reported in Lao PDR from 2001. A survey showed that six villages in two provinces are faced with damage from the coconut beetles. These included Namthon village in the Pakkading district of Bolikamxay province and the villages of Novilay, Vangboangtai, Vangboangnua, Fouang and Nabo in the Sepon district of Savannaket province.

With support from FAO, national plant protection staff are learning to rear *Brontispa* parasitoid in Viet Nam and will benefit from the experiences of classical biological control there. *A. hispinarum* will be released soon.

Malaysia

Coconut leaf-eating beetles, particularly *Plesispa reichei*, have become important pests in Malaysia. Frequent and sporadic infestations of *P. reichei* beetle have been reported on the coconut and ornamental palms throughout the country. As this pest was relatively unknown previously, little was known about its biology and ecology and effective control measures. More collaborative efforts among affected countries are required to develop effective short and long term control measures of this pest.

Maldives

It is most probable that the *Brontispa* infestation originated from adult or immature stages of the pest that were concealed in ornamental palms imported in 1999 from nurseries in Malaysia and Indonesia, as *Brontispa* is believed to be endemic to the Indonesian and Papua New Guinean region.

A survey confirmed that the beetle had spread from the known distribution range (Fenfushi, Tholhufushi, Nalaguraidhoo, Dhiffushi, Maamigili and Ariyadhoo) to islands further eastwards (Dhidhdhoo, Dhidhoofinolu and Dhigurah). The extent of infestation on Dhidhdhoo village indicated that the beetle had been present there at least for one year. Few infested palms were found on Dhidhoofinolhu and Dhigurah and it appears that the beetle reached the island at a later stage.

As in Cambodia, insecticides were recommended prior to introduction of biological control agents. While this measure afforded some relief, these were both expensive, polluting and provided only short term control of the pest. The parasitoid *A. hispinarum* was imported to the Maldives from Viet Nam. It was transferred to a semi quarantine laboratory at Sun Island resort for quarantine, mass rearing and field release to all infected islands of the Maldives. About 230 000 parasitoids have been released. Following its initial release in February 2004, the larval parasitoid *Asecodes hispinarum* now appears established on Sun Island. Parasitoid establishment on the inhabited islands of Maamigili and Fenfushi appears more difficult, despite the release of large numbers of adult parasitoids and mummies on both islands.

Myanmar

Brontispa longissima is a serious pest of coconut palms and it had been known to occur in Myanmar since early 2004. Plant protection teams of two states and four divisions have been assigned to conduct the specific survey for *Brontispa* with available support. There is an urgent need to build national capacity to address the problem of invasive pests to ensure sustainable development.

Sri Lanka

P. reichei is a minor coconut pest and *B. longissima* is not yet reported in Sri Lanka.

Thailand

Brontispa represents a threat to the coconut industry of the southern and central parts of Thailand with US$30 million production and 50 000 smallholder farmers. It is also a threat to the tourist industry of Koh Samui and Koh Pa-ngan.

Damage caused by *Brontispa* was first recorded in Narathiwas province, the border area near Malaysia, in 2000. Heavy infestation was first reported in February 2004 in southern provinces including Surat Thani (Samui Island and Pa-ngan Island) and Prachuap Khiri Kan.

It is reported that the total areas hit by the coconut beetle outbreaks amounted to 7 229 hectares.

Both the Department of Agriculture (DoA) and Department of Agricultural Extension (DoAE) are rearing *Asecodes hispinarum* from a shipment received from Viet Nam on 25 August 2004.

Other biological control agents are being reared by DoAE but, based on the results from Viet Nam, it would be more appropriate to educate farmers about the positive impact of *A. hispinarum*. Other biological control agents will be useful to educate farmers about biological control.

Viet Nam

Brontispa longissima was first detected in the Mekong Delta region in 1999. Despite extensive use of chemical insecticides to control this pest, the beetle spread and incurred losses estimated at US$17.8 million to the coconut industry by 2002. Indeed, the cost of insecticide use was estimated at US$722 323. These were not only expensive, they caused much damage to the environment and further exacerbated the problem of the *Brontispa* outbreak. The beetle continued to spread to new areas.

With the support of FAO, *A. hispinarum* was introduced from Western Samoa in June 2003 and these were reared under quarantine conditions and later released into the field in August 2003. By 2004, the parasitoid was released and became established in 15 provinces in South and Central Viet Nam. The parasitoids spread at the rate of 5-8 km in two months and, within four months, 60-90 percent recovery of palms was observed.

A quick economic analysis covering a time frame of 30 years puts a return of US$3 000 for every dollar invested. It is concluded that classical biological control of *Brontispa longissima* can be quickly, effectively and sustainably controlled by the introduction and releases of *Asecodes hispinarum*. However, this means that there is an urgent need to enhance the capability of national programmes in the areas of quarantine, biological control and IPM. In this respect, every country has to adhere to the guidelines contained in the International Standards for Phytosanitary Measures (ISPM) #2 and #3[1]. It is necessary that countries in the region strengthen their capability in addressing this issue of invasive species and ways and means to resolve them through sustainable methods that protect the biodiversity and ensure poverty reduction.

[1] International Standards for Phytosanitary Measures (ISPM) #2 and #3 can be found in this report as Annexes 8 and 9.

IV. Recommendations

Coconut plays a major role in the economies of many countries in the Asia and Pacific region directly by providing food and income from coconut products, and indirectly as an important component of the landscape where tourism plays a key role in the economy.

The expert consultation notes with great concern that these economies are threatened due to a serious outbreak of coconut chrysomelid hispine beetle, *Brontispa longissima*, that has spread to new areas at a rapid pace in the region. This invasive species demonstrates the need for strengthening the technical information base, quarantine and IPM capabilities within countries in the region.

The traditional pest management approach and strategy based on insecticide use has not been able to stop the spread and the damage continues unabated. Experiences from countries in the Pacific that were invaded years earlier as well as information from the country of origin of the insect demonstrates that the insect can be quickly, effectively and sustainably contained using classical biological control.

And whereas the paucity of knowledge of classical biological control is of concern and considering that the capacity of the countries in the region is substantially very low in dealing with the problem individually, the expert consultation recommends the following common strategies for the sustainable management of the coconut chrysomelid hispine beetle in the Asia-Pacific region:

1. Adopt a regional approach to develop a programme of coconut beetle management for the Asia-Pacific with FAO providing a coordinating forum to enable the experiences of the individual member countries, as well as neighbouring non-member countries, to plan and strengthen an ecologically sound IPM programme for the palm industry (including coconut). To further this objective, it is imperative that FAO, the Asian and Pacific Coconut Community, donor communities (including the Common Fund for Commodities) and member countries of the Asia-Pacific Plant Protection Commission work together to develop a comprehensive programme to ensure that the coconut industry will continue to be a symbol of a tropical agro-biodiversity haven that mirrors sustainable development for poverty alleviation through farmer education using an FFS approach.
2. It is duly noted by the meeting that a regional programme will speed up classical biological control implementation, reduce the cost of controlling the outbreak and enhance sustainability through optimizing resources, sharing of experiences and knowledge, avoiding pitfalls, exchanging biological control agents and promoting a better understanding between countries in Asia and Pacific.
3. The meeting further recommends that individual countries should strengthen their own database of crop pests and natural enemies, conduct independent impact assessments to facilitate an enabling environment for both biological control and IPM and further strengthen the regulatory framework of plant quarantine and pesticide management with concurrent activities for enhancing the capacity of extension staff.

4. The meeting appreciates the discussion on the rearing techniques for the biological control agent of *Brontispa longissima* and confirms compliance with the guidelines of the ISPM #2 and #3 and the guidelines for the rearing and release of *Asecodes hispinarum*. The need for greater awareness by the public and participation of farmers in classical biological control is highlighted. The meeting further concurs with the need to study the ecology of both insects to ascertain the impact of this biological control effort in each country, and that the results be incorporated in an overall regional IPM programme that may follow.

Annex 1

Opening address
by
He Changchui
Assistant Director-General and Regional Representative
for Asia and the Pacific

Chairperson
Distinguished experts and FAO colleagues:

On behalf of the Director-General of the Food and Agriculture Organization of the United Nations (FAO), Jacques Diouf, and on my own behalf, I have the honour and pleasure to welcome you to Bangkok for the expert consultation on the control of coconut beetle outbreak in APPPC member countries. I am delighted that as many as 17 representatives from 11 countries, namely Cambodia, China, Indonesia, Lao PDR, Malaysia, Maldives, Myanmar, Pakistan, Sri Lanka, Thailand and Viet Nam. An international expert from Fiji and FAO technical officers are participating in this important consultation.

The main objective of this consultation is to exchange experiences and lessons learned among the APPPC member countries that are facing the outbreak.

Coconut is an important source of food, fuel and wood for people living in the tropics. In recent times, with increased global travels, swaying coconut palms symbolizes exotic holidays and indeed tourism is a very important source of income for many tropical countries. However, the beautiful coconut palm is now under threat from an invasive pest that has moved from its centre of origin in Indonesia to other parts of the tropics and sub-tropics where it did not exist before. In its native country, this insect is often under natural biological control. When it spreads to another country, usually this insect arrives without its natural enemies and is able to multiply in large numbers unchecked. Besides reducing production or often killing palms, insect pests could possibly affect tourism as such symbols that foreign tourists seek are destroyed.

The insect that is of much concern is the coconut beetle that has spread to several countries, including Thailand. Such an introduction has affected the livelihood of people who depend on their livelihood on agriculture and tourism. Often, it is unsustainable to rely on chemical insecticides to reach the pest especially when tall palms are involved. In the past, whenever the coconut beetle arrived in a new country in the Pacific, the populations were successfully controlled by introducing effective parasitic insects that kill the pest. This ecologically sound approach does little harm to the environment and helps restore the balance that makes coconut a part of the ecosystem. In the last three years, the coconut beetle is on the march again and this is probably due to the frequent air travels between countries. Despite plant quarantine measures, invasive pests do get into the countries undetected. When this happens, it is important for the countries affected or will be affected to work together. In this respect, FAO stands ready to facilitate this cooperation and provide technical assistance to build capacity to tackle this invasive insect.

This approach is particularly important, for FAO has designated 2004 as the year of Biodiversity for Sustainable Development. This ecologically sound approach fits very well in the theme for protection of biodiversity, especially agro-biodiversity. FAO recognizes the problems of invasive species and indeed, in a biological control approach, we have put forth specific guidelines to ensure successful and specific action of introduced species to control the invader pest. The FAO looks forward to the concurrence from member countries to implement this code of conduct for importation of beneficial organisms. I am delighted to learn that as part of this expert consultation, the participants from all 11 APPPC countries will discuss this code of conduct. To enhance effective plant quarantine that will support successful introduction of beneficial organisms, FAO places much interest into the capacity building of expertise to handle classical biological control.

In the past, this coconut beetle has been successfully controlled by introduction of biological control agents that attack only the coconut beetle. Successful biological control has been reported from Solomon Islands, French Polynesia and Micronesia. In the Asian region, success appears to be in sight in Viet Nam and the experiences in Viet Nam will be shared with participants from other countries in today's expert consultation. I note that in this consultation, there is an element of Technical Cooperation between Developing Countries (TCDC) that Viet Nam is helping Lao PDR and Thailand in the biological control of this coconut beetle underlines the importance of working together and FAO is pleased to provide the umbrella for such collaboration.

Dear participants, I hope that this expert consultation is not focused only on the biological control of just this one pest. Indeed, I am confident that this experience will galvanize the member countries to consider working in a regional programme to prepare for the possible invasion of other pests and on other crops too. FAO has been successful in developing the IPM Farmer Field School (FFS) approach to help farmers manage their agro-ecosystem and this outbreak presents a unique opportunity for countries to recommit their agricultural development towards farmer education to sustain rural development and reduce poverty. In this respect, it is hoped that the consultation will come out with recommendations that will assist in a regional activity that will safeguard member countries from sudden and devastative invasion of pests.

I wish you a successful meeting and I look forward to the proceedings of the expert consultation.

Thank you.

Annex 2

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Annex 3

Timetable and Agenda

Tuesday 26 October 2004

08.30-09.15 hours	Registration

1. Opening session

09.15-09.30 hours	Opening address He Changchui, ADG/RR

2. Resource persons presentation

09.30-10.00 hours	Biological Control of *Brontispa* by Wilco J.M.M. Liebregts
10.00-10.30 hours	IPM of coconut pests by Peter A.C. Ooi
10.30-11.00 hours	Coffee break

3. Country report on *Brontispa* outbreak and management

11.00-11.15 hours	Cambodia
11.15-11.30 hours	China
11.30-11.45 hours	Indonesia
11.45-12.00 hours	Lao PDR
12.00-12.15 hours	Malaysia
12.15-12.30 hours	Maldives
12.30-14.00 hours	Lunch
14.00-14.15 hours	Myanmar
14.15-14.30 hours	Sri Lanka
14.30-14.45 hours	Thailand
14.45-15.15 hours	Viet Nam
15.15-15.45 hours	Coffee break

4. Working session

15.45-17.00 hours	Discussion on identifying guidelines for biological control of *Brontispa* and recommendations
17.00-18.30 hours	Discussion on strategy for coconut *Chrysomelid* beetle management and recommendations

Wednesday 27 October 2004

5. Reading, discussion and adoption of recommendations

08.30-09.15 hours	Reading of recommendations
09.15-10.30 hours	Discussion of recommendations
10.30-11.00 hours	Coffee break and revision of final recommendations
11.00-11.30 hours	Adoption of recommendations
11.30-12.30 hours	Lunch
12.30-18.00 hours	Visit to the laboratory for rearing parasitoids of *Brontispa*, the Department of Agriculture

Annex 4

Technical papers and presentations

Impact and control of the coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Chrysomelidae)*

Wilco Liebregts** and Keith Chapman***

Figure 1: *Brontispa* damaged coconut palm in southern Viet Nam

Abstract

The coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Chrysomelidae) is one of the most damaging pests of coconut and a range of ornamental palm species. Both larvae and adults of the beetle feed on tissues of developing, unopened leaves of the trees. The beetle can cause significant production losses, and high infestation levels may result in tree death. With assistance from FAO, the natural enemy *Asecodes hispinarum*, a larval parasitoid, has been collected in Samoa and introduced into affected countries in Southeast Asia and the Pacific to act as a biological control agent. The parasitoid has become established in Maldives and Viet Nam, and initial results indicate that pest populations and damage levels are declining.

* Parts of this paper were presented during the XLI coco technical meeting and coconut festival, 5 to 9 July 2004, Santo, Vanuatu, Asia and Pacific Coconut Community, Jakarta, and subsequently published in the report of the meeting.

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Introduction

The coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Chrysomelidae) is one of the potentially most serious pests of coconut palms. Both larvae and adults of the beetle inhabit the developing, unopened leaves of the coconut palm where they feed on leaf tissues. Where an attack is severe, complete defoliation of the palms may result. Prolonged attack, particularly to palms that are young or suffering from poor growing conditions, may result in death of the tree. With other palms productivity is severely affected by sub-lethal attacks.

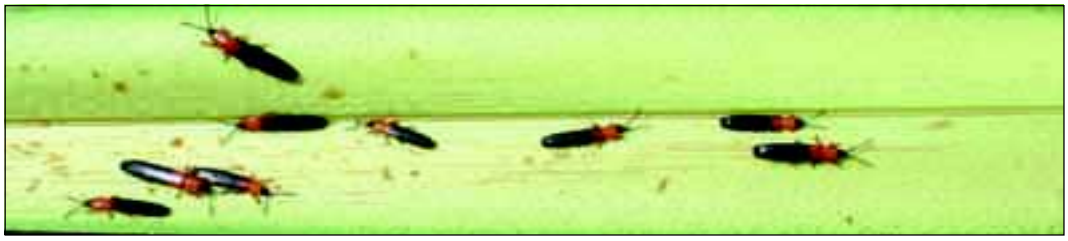

Figure 2: *Brontispa* adults on young coconut leaf

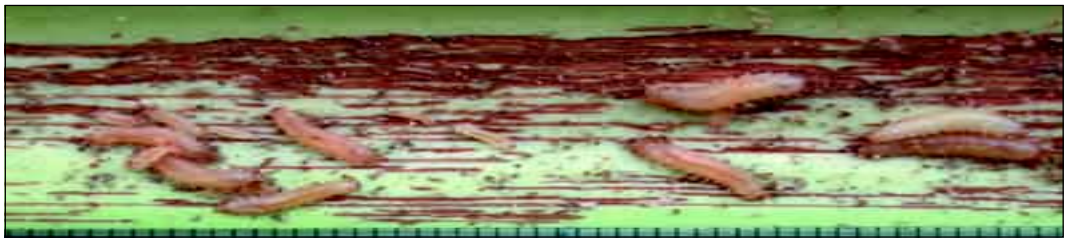

Figure 3: *Brontispa* larvae and feeding damage on coconut leaf

Brontispa longissima is believed to be endemic to Indonesia and possibly also to Malaysia, Papua New Guinea and the Solomon Islands. In the twentieth century the beetle was accidentally introduced in several other countries in Southeast Asia and the Pacific, and as a result has now become widespread there. The pest however was not recorded from continental Southeast Asian countries until the late 1990s when it was first detected in the Mekong Delta in Viet Nam.

Specialists suspect that this species was introduced into southern Viet Nam in shipments of ornamental palms. The pest spread rapidly northward and westward, causing significant losses to the coconut industry. The introduction of the beetle in Hainan Island in southern China, is believed to have occurred in a similar way with a shipment of ornamentals from the mainland or from Taiwan province. At around the same time, the pest was introduced into the Maldives. The pest was first noticed in Thailand in February 2004, and a few months later in Lao PDR and Myanmar. Singapore has also reported damage by the pest, but it is unclear if this is a new incursion. Although the pest has not yet been recorded from Cambodia, it is highly likely that the pest has reached these countries as well.

Importance of the coconut industry in recently affected countries

There are about 173 000 hectares of coconut grown in Viet Nam, that directly support about 70 000 families. Coconut is an important source of income for many households. Depending on the product, additional household incomes from the production of high-value products ranges from US$1-2.33 per person per day, US$34.50-62.10 per person per month, or US$42.20-55.25 per household per month. This income, in addition to the income from the coconut endosperm (kernel), can lift the coconut growing family above the poverty line. Since coconut oil is used domestically as cooking oil and as a raw material for oleochemicals, and the fiber and shell products are exported, coconut reduces vegetable oil imports and generates foreign exchange. Thus, loss of coconut palms may have serious macroeconomic and environmental impacts, as well as a microeconomic impact at the level of smallholder households as all family members get involved in producing the many coconut derived products.

Thailand's coconut industry consists almost exclusively of smallholders with just over 50 000 farmers involved; most of these farmers have an area of about 2.5 ha of palms. Yields are low at around 6.6 MT per hectare and incomes are low as the price per kg is only about TB 8. The total area under coconut is estimated at 328 000 hectares which produces about 1 146 million nuts or about 344 000 MT in copra equivalent, representing a total value of TB 902.16 million domestically and with exports of TB 512 330 million (TB 41 = US$ 1). The crop not only provides an important contribution to the economy and livelihoods of thousands of small holders, but provides a very significant land cover for poor coastal soil areas, and is a major feature of the country's tourist industry.

In Hainan province, China, the pest seriously affects coconut farmers, but also the rapidly developing tourism industry. In support of that industry, the island province has commenced a beautification campaign which includes the planting of coconuts and many ornamental species in cities and along major roads. Most of these palms have been affected by the beetle. In an attempt to control the pest and prevent it from spreading, host plants have been removed from a zone of 2 km around infested areas. In these areas, broad spectrum insecticides are applied to the crown, and sometimes injected in the trunk, but this appears to have had little effect in preventing further spread of the pest.

In the Maldives and Nauru, the coconut is perhaps the single most important plant and crop, as on these resource-poor atolls it is truly the 'tree of life', as it provides food, timber, and housing materials to the islanders. In the former, the tree is the most significant to the all-important tourist industry, which accounts for a large proportion of GDP.

Taxonomy

Species belonging to the genus *Brontispa* are mainly found in Southeast Asia and the western and northern Pacific. A number of species have been described, although several revisions of the genus have seen a considerable reduction in the number of species. The latest major revision of the subfamily *Hispinae*, to which the genus *Brontispa* belongs, was in 1957 and no further studies on the taxonomy of the genus *Brontispa* have been implemented since. The sudden and rapid spread of the pest into Southeast Asia, and the fact that there is considerable intra specific variation in

colour patterns within the species *B. longissima*, has caused confusion among plant protection specialists in the region, and now urgently warrants a revision of the genus *Brontispa*.

Impact of the pest in Southeast Asia and the Pacific

In 2001, a few years after its incursion into southern Viet Nam, surveys estimated that *Brontispa* affected some one million coconut palms in 150 000 ha of coconut in all 21 southern provinces. The beetle since advanced rapidly into the central provinces and in August 2002 was distributed over 30 provinces, where it infested an estimated six million coconut palms over a much larger area. Survey reports suggest that damage can be serious but that it varies among provinces, with the most severe damage recorded in Ben Tre province. It is now considered that some ten million trees are affected, and that the pest has reached the northern provinces, including the capital Hanoi.

Figure 4: *Brontispa* damage on young leaves
(Photo credit: Tran Tan Viet)

In the Maldives, an archipelago of some 1 000 islands south of India, the pest was first noticed in December 1999 on Sun Island resort on the island of Nalaguraidhoo in south Ari Atoll. It is likely that the introduction of the pest occurred with the importation in 1999 of ornamental palm trees from nurseries in Indonesia and Malaysia when developing the resort. The pest has since spread to nine nearby islands in the atoll, and was recently (April 2004) discovered at Hulhule Island, near Male. An eradication campaign is underway, and there are indications that it may be successful.

In Thailand the beetle was first reported from the southern provinces Prachuap Khiri Kan, Surat Thani in February 2004. Surveys showed that the pest was present in the southern provinces of Chumphon, Songkhla, Narathiwat and Pattani, as well as Bangkok. It is probable that the pest originated from Malaysia, and not from Viet Nam. The pest incursion shows considerable similarities with the one that occurred in Viet Nam, indicating that it will spread over the mainland and eventually to nearby islands.

In the Pacific, no further incursions of *Brontispa* occurred in the years following its establishment in (Western) Samoa in the early 1980s, until the beetle was detected in Nauru in April 2001. A brief survey suggested that the main infested areas were around the Buada lagoon, Ijuw, Anabar, Anabare and Yaren districts, where a considerable number of coconut palms showed heavy damage by the beetle.

The significant risk of the pest spreading to nearby countries such as India, Sri Lanka, Myanmar, Bangladesh is of major concern. These countries are at considerable risk, since the beetle will not be stopped at land borders: only natural barriers such as oceans and mountain ranges may halt the natural dispersal. For these countries, which have significant coconut industries, the pest incursion would be catastrophic. Quick action will see not only the reduction of damage levels, but also a slower rate of dispersal of the pest. Moreover, the natural enemies, once established, will follow

any further outward migration of the beetle, thus reducing the need for continuing releases in areas newly infested by the pest.

Control measures

With no viable alternative methods available, Viet Nam embarked on a massive campaign whereby the use of chemical pesticides was subsidized in an attempt to control the beetle outbreak and reduce its rate of spread. This campaign, and those implemented by provincial governments in the Mekong Delta already cost some US$300 000 by the end of 2002. In addition, it is estimated that farmers have spent a similar amount in pest control measures. That year, subsidy levels reached an estimated US$0.33 per coconut tree. With the invasion of the central provinces, the impact becomes even more serious as coconut palms are not cultivated intensively there, and farmers are much poorer than their southern colleagues, and are not able to pay for any chemical protection of their trees.

In the Maldives, management of Sun Island resort in June 2000 commenced a control programme that involved application of insecticides to the crown as well as stem injection of infested trees. In addition, seedlings were removed and destroyed on all islands. Estimates of direct economic losses between June 2000 and February 2003 amount to US$237 350 – for labour and insecticide application costs. In addition, losses in revenue from coconut sales, and coconut purchases for 'welcome' drinks for resort guests were estimated at US$32 800. The control programme, however, could not prevent the spread of the pest to nine neighbouring islands, and there continues to be a serious risk of further spread of the pest to other islands in Ari Atoll, and to other atolls in the country.

The use of pesticides in coconuts raises serious concerns about the health risks of the farmers, families and consumers. Coconuts generally sell for a low price, and pesticide application to trees for coconut beetle control is particularly hazardous. The trees are tall; applicators must climb up to the crown, and workers ask a high price for this dangerous task. They typically work without protective clothing, and are exposed to pesticide through the skin and via inhalation as they struggle to keep their balance while spraying beetle larvae in folded young leaves. Moreover, coconut plantations are often situated near homes, so that detrimental effects on the health and environment of households, fish ponds gardens and domestic animals due to pesticide exposure must be seriously considered.

Biological control

Complete control of *B. longissima* with high cost/benefit ratios has been achieved in several countries by importing and establishing parasitoids that attack immature stages of the pest. These successful locations include various Pacific and East and Southeast Asian countries. Known egg parasitoids include *Haeckeliana brontispa* Ferriere and *Trichogrammatoidea nana* Zehntner (Hymenoptera: Trichogrammatidae), and *Ooencyrtus* sp. (Hymenoptera: Encyrtidae). Several parasitoids in the wasp family Eulophidae attack the larval and/or pupal stages of *Brontispa*, including the larval parasitoid *Asecodes* sp. and the pupal parasitoid *Tetrastichus brontispa* Ferriere. A strain of the entomopathogenic green muscardine fungus *Metarhizium anisopliae* was isolated from *B. longissima* in China and formulated as a bioinsecticide. The fungus was also used in the 1980s in Samoa to control the pest on young coconut

Figure 5: The parasitoid *Asecodes hispinarum*
(Photo credit: Tran Tan Viet)

Figure 6: *Asecodes* parasitising *Brontispa* larva
(Photo credit: Tran Tan Viet)

seedlings in the field and in nurseries, but its application to larger, established trees was problematic and unfeasible.

FAO assistance

On request of the individual countries, the Food and Agriculture Organization of the United Nations (FAO) provided assistance to help developing control strategies of the pest in the affected countries. Bilateral Technical Cooperation Projects (TCP) to a value of more than US$650 000 are currently underway in Viet Nam (2003-2005), Maldives (2003-2005) and Nauru (2003-2004). Similar project proposals have been prepared for Thailand and PR China; a fast-track TCP was approved for the former in October 2004. Furthermore, technical assistance has been provided to Sri Lanka to increase awareness of this important pest. All projects seek to establish sustainable control of *Brontispa* through the development of an IPM programme based on classical biological control. For most countries, a public awareness campaign on the pest and the risk of it spreading further is also part of the project.

The larval parasitoid *Asecodes hispinarum* was collected in Samoa in 2003 and introduced, reared and released in Viet Nam, the Maldives and Nauru to combat the beetle. Although the parasitoid is established in the two former countries with promising prospects for achieving control of the beetle there, it is yet too early to determine its success in reducing beetle populations to sub-economic damage levels, as pest-parasitoid interactions and population dynamics fluctuate considerably in the first few years following introduction of the natural enemy. The effectiveness of the parasitoid is likely to be affected by environmental conditions, particularly in the various climate zones, and its impact on the pest may vary accordingly. In view of this, FAO recognizes the need for additional natural enemies to strengthen the biological control programme, and is seeking support for the implementation of exploratory surveys in Indonesia, Papua New Guinea and the Solomon Islands. The project also includes a taxonomic revision of the genus *Brontispa.*

Preliminary results

Results from Viet Nam confirm the establishment of the parasitoid in those provinces where it was released, and observations at and near release sites indicate that beetle damage has reduced considerably. It is expected that damage levels will be reduced to levels similar to those seen in Samoa, where *Brontispa* damaged palms are quite uncommon. Surveys have shown that the dispersal rate of the parasitoid from the release sites is some 5-8 km per two months.

In the Maldives and Nauru, field establishment of the parasitoid was confirmed after two and five months after initial field releases in February and November, respectively, but further recovery of the beneficials in Nauru has so far been irregular. In both countries, no significant reduction of damage has yet been observed that could be attributed to the impact of the parasitoid, although the newly emerging leaves appear to show less damage.

In Viet Nam, a recent study on the costs and benefits of the biological control programme has tentatively concluded, that by mid 2002, 9.4 million trees were infected by *Brontispa*. Up to mid 2004, the pest infestation has caused 30 percent fruit production loss, the death of 5 percent of trees (at an estimated cost of US$23.8 million), and has damaged 13 000 ornamental palms (at an estimated cost of US$838 000). The cost for pesticides applications amounted to approximately US$715 000, which was borne by the federal and provincial governments. This does not take into account the expenses and labour costs borne by the farmers and volunteers involved in the control programme. Overall, the cost of the FAO TCP Project (US$350 000) is very small in comparison with the losses caused by the pest. Using a unit price of US$0.10 per coconut (including husk), a tentative analysis of economical data points at a return of one billion dollars over a 30-year period, or a return US$2 000-3 000 for every dollar invested in the project. With prices currently near the US$0.50 mark, these returns have increased five-fold. Taking into account that much of the groundwork for the collection, identification, rearing and importation of *A. hispinarum* was done under the FAO-Viet Nam TCP, the cost-benefits are many times higher when taking into account the coconut industries for other Southeast Asian countries.

Integrated Pest Management (IPM) of key coconut pests

Peter Ooi*

Integrated Pest Management of Key Coconut Pests

Peter A.C. Ooi

Prepared for

Expert Consultation on the control of Coconut Beetle Outbreaks in APPPC countries, Bangkok, 26-27 October, 2006

IPM of Coconut Pests

1. What is IPM?
2. Coconut IPM
3. Chrysomelid beetles on coconut
4. Biological control of coconut pests
5. New Coconut Pests?

1 What is IPM?

WHAT IS IPM?

- Empowering farmers to become effective managers and decision-makers
- To be able to grow a healthy crop with the least disruption of the agro-ecosystem, thereby encouraging natural pest control mechanisms and minimizing pesticide usage and dependency
- IPM BY FARMERS, NOT FOR FARMERS

IPM IS KNOWLEDGE CAPITAL AND KNOWLEDGE MANAGEMENT

- BIOLOGICAL CONTROL AND ECOLOGICAL PRINCIPLES AS FOUNDATION
- FARMERS ANALYSIS AND DECISION-MAKING REVOLVE AROUND
  - Growing a healthy crop
  - Conserving natural enemies
  - Observing fields regularly

IPM IS HUMAN RESOURCE DEVELOPMENT: MAKING FARMERS EXPERT

- Develop critical and informed decision-making skills
- Develop new ways of thinking and problem-solving
- Help farmers organize themselves and their communities

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KNOWLEDGE MANAGEMENT STRATEGY: NON-FORMAL EDUCATION IN FFS

- DISCOVERY-BASED LEARNING TECHNIQUES
- EXPERIENTIAL LEARNING METHODS
- COOPERATIVE APPROACHES

SUSTAINABILITY OF IPM

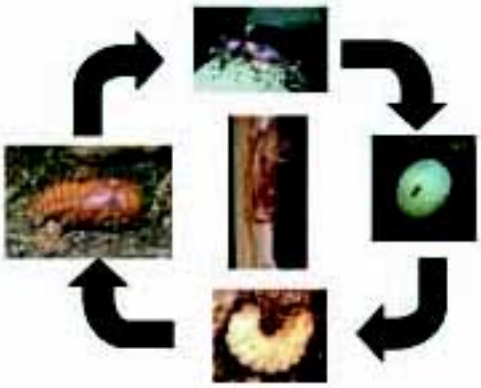
- STRONG TECHNICAL BASIS FOUNDED ON ECOLOGICAL PRINCIPLES
  - Farmers managing the ecosystem rather than controlling it
- PARTICIPATORY NF EDUCATION
  - Making farmers expert
- LOCAL COMMUNITIES OWNERSHIP OF IPM
  - Ensure communication, collaboration and continuous training

2 Coconut IPM

Case Study 1: *Oryctes rhinoceros*

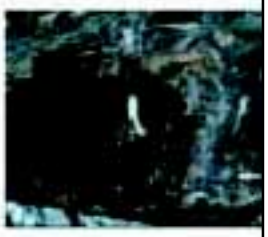
- Coconut Rhinoceros Beetle is a native to Southeast Asia
- It is often kept in check by the action of natural enemies, primarily *Baculovirus* and *Metarhizium anisopliae*
- Outbreaks of rhinoceros beetle are often associated with plentiful breeding sites for the beetle that allowed populations to escape and multiply rapidly

Oryctes rhinoceros



Essentials of rhinoceros beetle management - 1

1. Identify breeding sites of rhinoceros beetles in the village
2. Remove/reduce the breeding sites
3. Avoid leaving old tree/palm stumps that may serve as breeding sites
4. If old trees/palms trunks cannot be removed, grow cover crops over them



Essentials of rhinoceros beetle management - 2

1. Set up traps using compost heap, old tree trunks etc.
2. Inoculate breeding trap with *M. anisopliae* and *Baculovirus*
3. Trap rhinoceros beetles, inoculate them with *Baculovirus* and release them
4. Continue to monitor incidence of damage

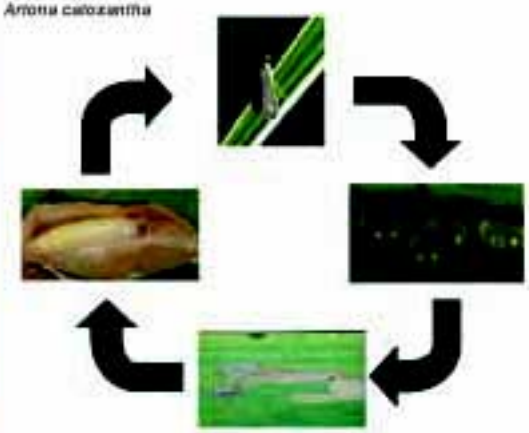
Case Study 2: *Artona catoxantha*

- This zygaenid moth is native to Malaysia and Indonesia and outbreaks seldom occur
- The insect is kept in check by the action of natural enemies, primarily *Bessa remota (Tachinidae)* and *Apanteles artonae (Braconidae)*
- Outbreaks of the coconut leaf moth are often associated with dry weather conditions and the onset of rain usually terminates such outbreaks.

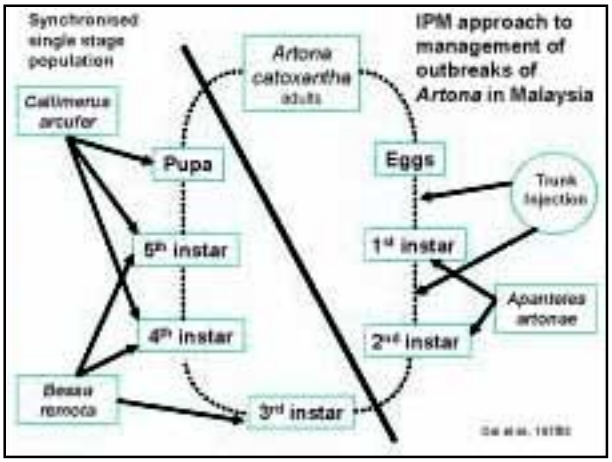
Essentials of leaf moth management

1. Outbreaks signal the breakdown of natural biological control
2. This is often associated with a "single-phase" population development
3. Once overlapping generations of moths are re-established, biological control will be restored
4. Trunk injection with systemic insecticides may be used to hasten re-establishment of biological control

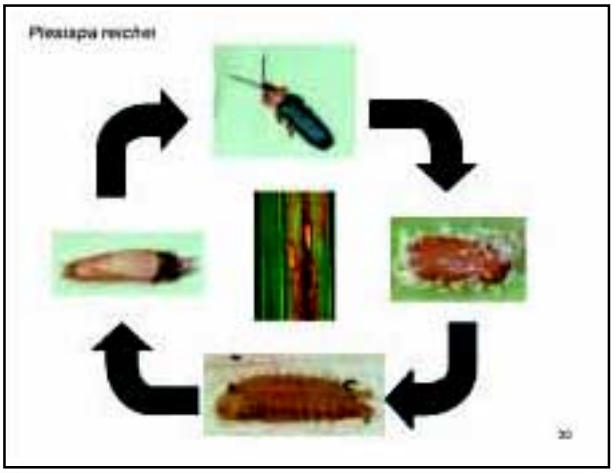
Artona catoxantha

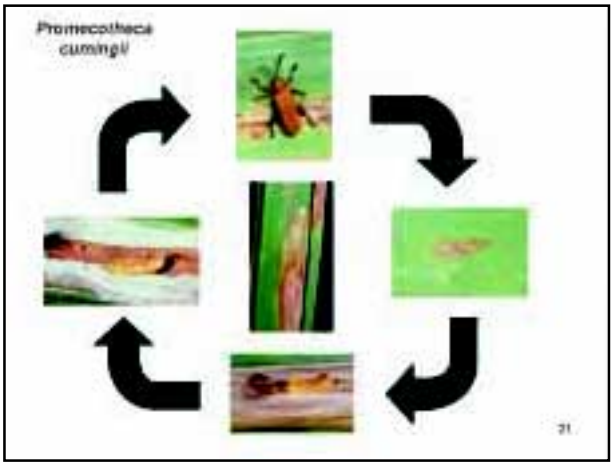


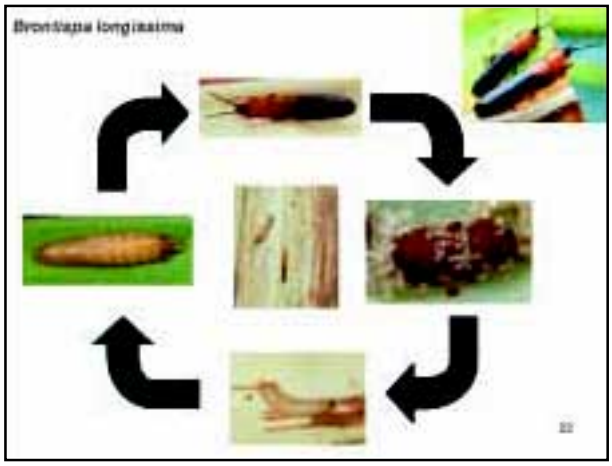
Natural Enemies of *Artona catoxantha*



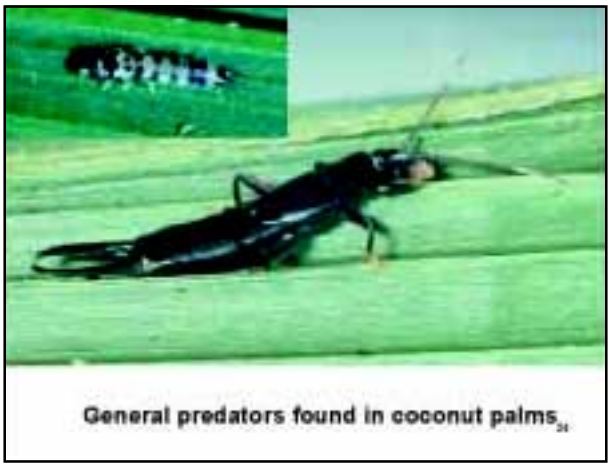
3 Chrysomelid beetles on coconut





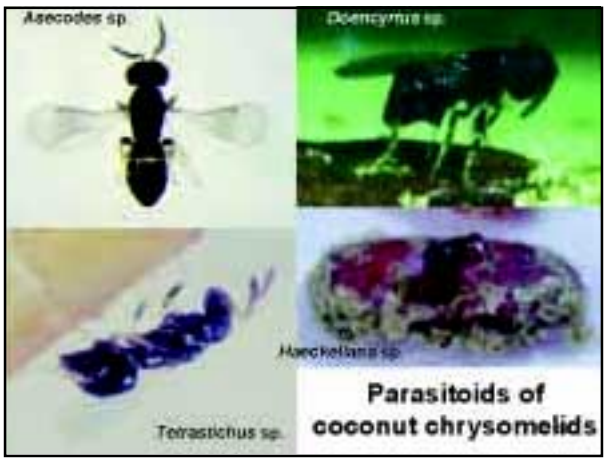


4 Biological control of coconut pests



General predators found in coconut palms

General predators found in coconut palms [20]



5 New coconut insect pests?

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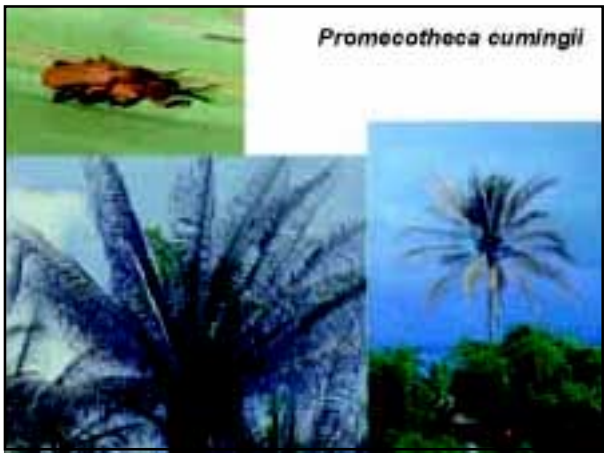

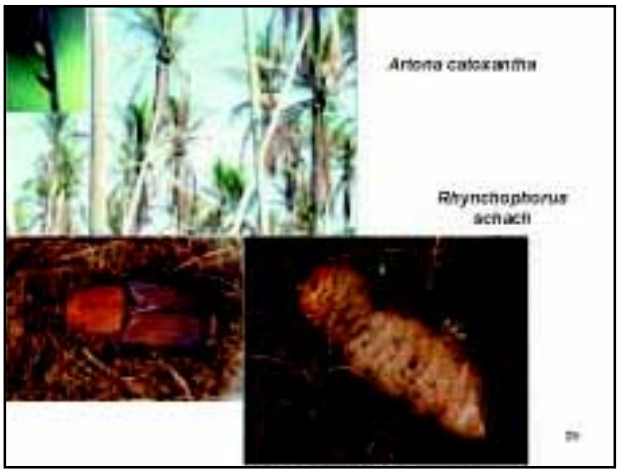

Coconut hispid beetle (*Brontispa longissima*): A new threat to coconut palms in Cambodia

Hean Vanhan*

KINGDOM OF CAMBODIA
Nation Religion King

Ministry of Agriculture, Forestry and Fisheries,
Department of Agronomy and Agricultural Land Improvement,
Plant Protection and Phytosanitary Inspection Office

Cambodia Presentation
at The Expert Consultation on Coconut Beetle Outbreak among APPPC Member Countries
Bangkok, Thailand (26-27 Oct. 2004)

Coconut Hispid Beetle
(*Brontispa longissima*)
A new Threat to Coconut Palms in Cambodia

by Dr. Hean Vanhan
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Background

NATIONAL AGRICULTURE DEVELOPMENT POLICY

Acknowledging that the achievement of increased economic growth and a significant reduction in rural poverty depends fundamentally on improvements in the agricultural sector; the government has accorded high priority to this sector. Its strategy is aimed at:

- improving food security and reducing reliance on the outside world (food aid),
- making sure that displaced persons can farm safely,
- increasing amenities and earnings,
- improving agricultural outreach services and the availability of inputs,
- developing agricultural lending locally and centrally, and
- developing the services and managerial skills of rural development institutions.

Background

Overview of the Industrial and Agricultural Sectors in Cambodia (2002)

Contribution to the GDP, %

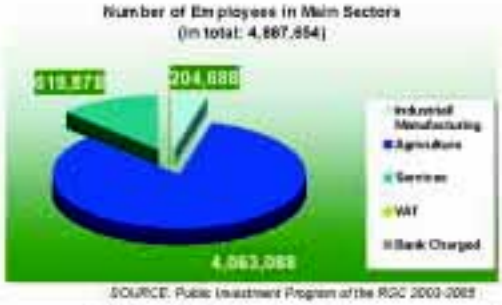
The estimated GDP real growth rate in 2003 was 5.5%.

SOURCE: Public Investment Program of the RGC 2003-2005

Background

Overview of the Industrial and Agricultural Sectors in Cambodia (2002)

Number of Employees in Main Sectors
(in total: 4,887,654)



SOURCE: Public Investment Program of the RGC 2003-2005

Background

Major Products in Agricultural Sector

- Rice, Maize, Cassava, Sweet Potato, Vegetable, Mung Bean, Peanut, Soya Bean, Sugarcane, Sesame, Tobacco, Jute, Castor Oil, Fruit and Permanent Crop, Animal Husbandry, Fish Products, Forest Products, Rubber Coffee, Tea.

The production of rice accounts for 13% of GDP

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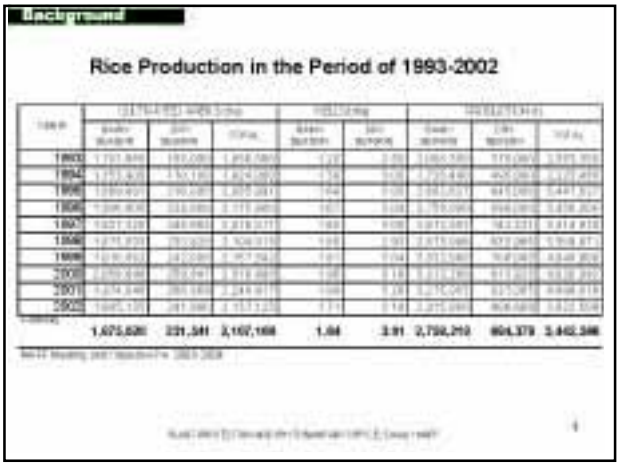
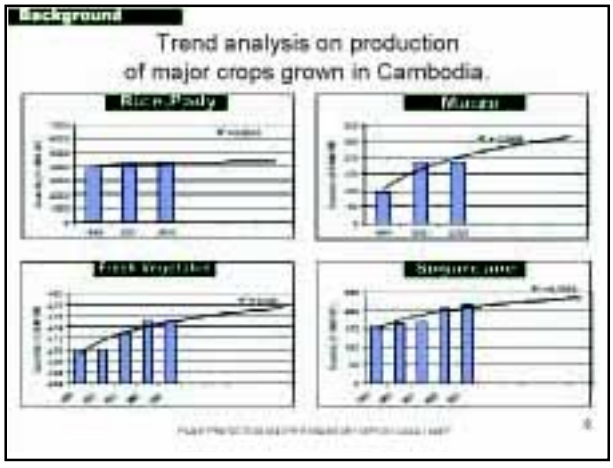
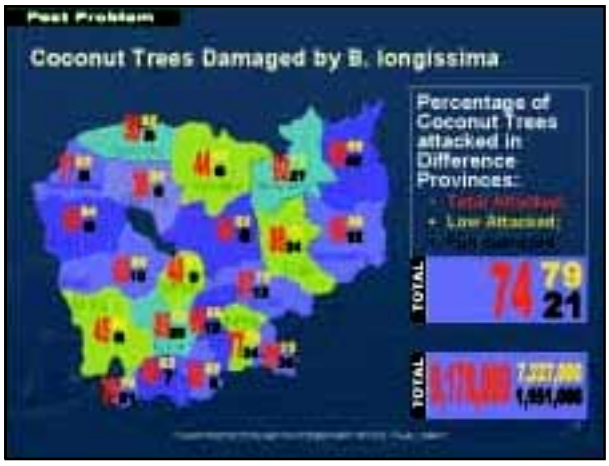

Background
Rice Production in the Period of 1993-2002


Background
Trend analysis on production
of major crops grown in Cambodia.

Background
Coconut Trees in Cambodia
(Number x 1000 Trees)
Mainly are family gardens;
Plantation are developing in North-East and South-West part;
No data support on production.
TOTAL
12,337

Pest Problem
New Incident of Pests:
Golden Apple Snail: In 1999 the Golden Apple Snails have been recorded as a new pest for Cambodia. They appear to be two species of apple snails in Cambodia: Pomacea maulerum and Pomacea canaliculata.
Palm Leaves Beetle (Brontispa longissima): In late of 2001 the Palm Leaves Beetle has been recorded as a new pest on coconut tree in Cambodia.


Pest Problem
Coconut Trees Damaged by B. longissima
Percentage of Coconut Trees attacked in Difference Provinces:
Low Attacked:
TOTAL
74 79
21
TOTAL

Pest Problem
Coconut Trees Damaged by B. longissima
Attacked Rate on Coconut Trees by B. longissima in Difference Region:
High Attacked:
Low Attacked:

Pest Problem

Coconut Trees Damaged by B. longissima

Pest Problem

Damaged Symptom, Caused by B. longissima

Pest Problem

Damaged Symptom, Caused by B. longissima

Pest Problem

Damaged Symptom, Caused by B. longissima

Pest Problem

Adults of B. longissima on coconut leaves

Control Measures

The Measures to Control in Cambodia

1. Phytosanitary Measure:

- Reduce the spread potential of the beetle to other regions by controlling the movement (transport) of coconut seedlings, coconut leaves (or items made from them), or ornamental and other palms from infested areas;
- Create national awareness on the pest and the danger of helping reach the beetle new areas.

Control Measures

The Measures to Control in Cambodia

2. Chemical Control (on Young coconut palms)

- Soluble powder of Cartap and Nereistoxin (11 g/300 g), packed inside filter paper bags of 30 grams, by putting on the top of trees. 1 bag per each tree, applied 1-2 times within 20-30 days.

Treatment	Effect (%) of Pesticides			
	10DAT	20DAT	30DAT	40DAT
Cartap	78.66	99.46	99.54	99.72
Nereistoxin	97.30	94.92	98.25	99.28

Control Measures

The Measures to Control in Cambodia

2. Chemical Control (on Young coconut palms)

- **Granule Formulation of Carbofuran 3G or Diazinon 10G**, by putting directly 30-40 gram or packed it inside tissue on the top of each trees, applied 1-2 times within 20-30 days.

Control Measures

The Measures to Control in Cambodia

2. Chemical Control (on adult coconut palms)

Actara 25WG (thiamethoxam): injected at 1 gram of product per palm, providing 100% control for up to 120 days and no residue are found in coconut milk at 7 DAT sampling (detection limit 0.01 ug/ml)

This will keep climbers away from danger, no poisoning for fishes in ponds, animal in surrounding farms and environmental pollution.

Control Measures

The Measures to Control in Cambodia

3. Biological Control:

- The Earwig as natural enemy, which native in Cambodia are under studying by plant protection and phytosanitary office.

Constrains & Perspective

Constrains in Controlling

Constrains:

- No experiences in controlling of S. longissima as new invasive alliance species;
- The infrastructure of natural enemies studies are not in place.

Perspectives:

- To continue on-going extension programs on beetle controls and Safety and Responsible Use of pesticide.
- Ask for collaboration and assistances from APPPC member countries, FAO and other donor agencies.

Occurrence and control of coconut leaf beetle in China

Fu Yueguan* and Xiong Yankun**

Coconut leaf beetle (*Brontispa longissima*) is classified as a species within the second class plant pest of forbidden entry to China. The beetle has been found in some places in Hainan, Guangdong and Taiwan provinces, especially in Hainan province. All levels of Chinese Government attached great importance to the epidemic. Many measures have been taken to prevent the beetle spreading, control the beetle and decrease its economic impacts. Details as the following:

1. Information about the beetle outbreak

1.1 Distribution

In China the coconut leaf beetle was first time found in Haikou city in Hainan province in June, 2002. The subsequent surveys of the beetle were conducted by Hainan province government for three times. The results of surveys indicated that the beetle occurred in 16 counties, infested about 817 thousand individual plants, endangered areas reached 40 thousand hectares or so, the beetle caused serious damage in Haikou and Sanya cities. Medium level attacks happened in Wenchang, Qionghai, Wanning and Tunchang, whereas light attacks took place in other occurring areas in Hainan province. In addition, the beetle was also found in few places in the Guangdong province.

1.2 Damage

The beetle attacks palms of all ages, especially damages young palm trees in nurseries and new leaves of palm trees, confining its damage to the tender unopened central leaves of palm trees. Neglected palms are more heavily attacked. The beetle sometimes occurred together with other palm pests. In some cases fruit shedding took place with loss of yield. In most cases all the central leaves were brown, newly-formed leaves were very small; the trees appeared ragged and may ultimately die. In Hainan province, 11 species of host palm trees such as *Cocos nucifera, Areca catechu*, *Archontophoenix alexandrae, Roystonea regia, Washingtonia fllifera*, *Hyophorbe lagenicaulis*, *Washingtonia robusta, Liviston chinensis,* and *Chrysalidocarpus lutescens* are found. The major host plant is *Cocos nucifer*.

1.3 Biology and ecology

The beetle laid eggs in groups between or inside the tightly folded leaflets covering each egg with excreta. The eggs hatch after an incubation period of about five days. The newly hatched larva begins to feed between and inside unopened leaflets. The number of instars varies from five to six. The larvae are fairly sedentary and avoid light. The larval period is 30-40 days, followed by a pre-pupal period of three days and a pupal period of six days. The development from egg to adult takes five to

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seven weeks. The adult beetles, which also seem to avoid light, are nocturnal. Adults feed among the young unopened leaflets. There is a pre-oviposition period of one to two months and 100 or more eggs may be laid. Dry periods favour the development of *Brontispa* populations. The beetle is only capable of weak flight, the main way of long-distance spread is migration aided by human activities.

2. Epidemic management

A leading group and experts group of controlling coconut leaf beetle were established to control and prevent the spread of beetle epidemic after its report in Hainan province. The leading group, directly managed by Deputy Chief General of Hainan province government, was responsible for organizing, commanding and inspecting all kinds of activities of controlling the beetle. Experts group, with responsibility for putting forward technical measures and policy advices on controlling beetle epidemic, consisted of plant protection experts and plant quarantine experts. Hainan province prepared and issued '*working programme on controlling coconut pests'*, with relevant arrangements for controlling coconut pest. Up to now, 85 percent infested plants have been restored. China undertook the following control measures.

2.1 Quarantine measures

Preventive measures, such as blockading and cutting off coconut trees, were taken to prevent the beetle from spreading out. In case of widespread epidemic occurrence, isolated areas were established, three kilometers from epidemic central spot to the outer; insecticide bags were hung on the palm trees in isolated areas. Transport of palm trees from other provinces to Hainan province, or from epidemic areas to other places was forbidden. Check points were established to enforce this regulation. Regulatory brochure *'method of inspecting coconut leaf beetle'* was developed and issued.

Epidemic survey was started immediately and epidemic survey spots were established at which highly susceptible hosts were planted. Regular surveys were carried out. A mechanism of reporting epidemic was established for timely action; the telephone number of epidemic reporting service was publicized. A '*manual of controlling coconut leaf beetle*' was developed and distributed to the public so that once anybody found the infesting beetles at any spot they could report it.

2.2 Chemical control

Initially chemicals were used to control the beetle after the report of epidemic in 2002. There are two periods of chemical control in China. Traditional chemical control measure was taken against the beetle in the first period, between June 2002 and December 2003. Broad spectrum insecticides such as *imidacloprid, cypermethrin*, *deltamethrin* and *matridine* were applied by spraying with high pressure applicator or elevator at intervals of three to four weeks. Some insecticides were injected to the trunk of infested palm trees. All of these treatments showed a certain degree of effectiveness in the period.

The second period was from December 2003 to July 2004 when a new pesticide powder, developed by South China Agriculture University, was mainly used. The insecticide powder was put into bags that were hung on the palm trees. Treatment

with this pesticide powder could not only effectively control the beetle with long effective duration and little damage to environment, but also effectively prevent the beetle from spreading. Satisfactory control could be achieved if insecticide bags were used in beauty spot, on sides of street and isolated areas. Up to now, 1.4 million insecticide bags have been applied and about 0.8 million palm trees saved; infested palm trees are beginning to recover from serious damage.

2.3 Biological control

Biological control is of primary importance for the sustainable control of the coconut leaf beetle, which is advocated by China. Two biological agents, *Asecodes hispinarum* and *Metarhizium anisopliae* were tested against the pest, and promising results have been obtained. Now these have been used in the field on a small scale.

Asecodes hispinarum

China organized expert group visit to study the biological control of coconut beetle with *Asecodes hispinarum* in Viet Nam in December, 2003. With the help of biocontrol specialist of FAO and Viet Nam experts and officials, *Asecodes hispinarum* was brought to Hainan in March 2004. Environment and Plant Protection Research Institute, Chinese Academy of Tropical Agricultural Sciences, headquartered in Hainan was responsible for study under isolated conditions. A series of related research has been conducted and much progress has been made. Results of studies showed that the imported *A. hispinarum* consignment did not bring dangerous microbes and parasites, and the agents did not parasitize other main native insects, such as lady bird beetle, silkworm, honeybee, moth. Now larvae of the coconut leaf beetle can be fed on preys or artificial or semi-artificial diets. *Asecodes hispinarum* has been released in the north (Haikou), the south (Sanya) and the east (Qionghai) of the island since August 2004, after safety evaluation of *Asecodes hispinarum* completed. A primary survey for the effects of the natural enemy release found that the number of coconut leaf beetle decreased greatly and infested trees recovered to a certain degree. Parasitization rate of 10-40 percent was recorded two months after the release. A special apparatus for the release of *Asecodes hispinarum* was invented. The habit and life history of *Asecodes hispinarum* has been surveyed. The effects of instar of the beetle larvae on parasitism and development of *Asecodes hispinarum*, the influences of temperature, humidity and photoperiod on the development of *Asecodes hispinarum*, have be investigated.

Metarhizium anisopliae

In total 11 strains of *Metarhizium anisopliae* were screened out from many fungal strains, of which ten strains were used for field trial in Haikou. Field trial revealed that two strains infected the beetle quickly with high mortality compared with others. Coconut trees turned green, a lot of beetles died in the field after these two strains formulations were sprayed. However, microbial control faced two problems. One is that new strains or formulations need to be screened out to suit the climatic conditions in South China, especially in Hainan province. The other is to develop spraying equipment that can deliver insecticide to high palm trees with low cost.

2.4 Study

A series of studies were carried out in China on *B. longissima*, including biological characteristics, biological control, and attractants.

Biological characteristics

The results of study indicated that the developmental threshold temperature and effective cumulative temperature of coconut leaf beetle were 11.08°C and 966.2°C respectively. Temperature between 24°C and 28°C was the favourable range for the growth of the beetle. Royal palms (*Roystonea regia*) and coconut were its primary hosts, while *Livistona chinensis* and oil palm were its secondary hosts. Field survey showed presence of ants and parasitic acarid, but no other parasitic natural enemies in Hainan. Beetles killed by *Metarhizium anisopliae* were also found in the field.

Biological control

The techniques for the mass rearing of the coconut leaf beetle and its parasitoid *Asecodes hispinarum* have been mastered by our research institutes. Factories for raising the beetle and *Asecodes hispinarum* were established, which could produce 2 000 coconut leaf beetles and 50 000 *Asecodes hispinarums* per day. *Tetrastichus brontispa* has been introduced from Taiwan province, and the study to use it as biological control agent is in progress.

Attractants

Some attractants have been found and one formulation is in the stage of field trial.

Biological control of *Brontispa longissima* (Gestro) in Indonesia

Meldy L.A. Hosang, Jelfina C. Alouw and H. Novarianto*

Abstract

Brontispa longissima is one of the major pests in several provinces of Indonesia. Biological control by using natural enemies such as parasitoids and entomopathogens has been proved as a promising method to control plant pests. There are three potential natural enemies for controlling *B. longissima* namely: pupal parasitoid *(Tetrastichus brontispa),* entomopathogenic fungi *(Metarhizium anisopliae* var. *anisopliae* and *Beauveria bassiana)*. *T. brontispa* has an important role as pupal parasitoid both under laboratory and field conditions. Percent parasitism of pupa under laboratory and field conditions ranged from 76.7 to 87.0 percent and from 35.71 to 73.56 percent, respectively. Pathogenicity of *M. anisopliae* var. *anisopliae* and *B. bassiana* were examined under laboratory, and field conditions. The results showed that these fungi can infect both larvae and adults of *B. longissima.* The effective concentration suggested to control *B. longissima* in the field is 5 x 10^5 konidia/µl. Mortality of larval and adult *B. longissima* caused by *M. anisopliae* var. *anisopliae* was 100 percent and 65 percent, respectively and by *B. bassiana was* 100 percent and 73.75 percent, respectively. Those entomopathogenic fungi can be applied by spraying conidial suspension twice-yearly at two weeks interval. Spraying the entomopathogenic fungi *M. anisopliae* var. *anisopliae* and *B. bassiana* reduced the pest population at about 90.37-95.0 percent.

Key words: Biological control, *Tetrastichus brontispa*, *Metarhizium anisopliae* var. *anisopliae*, *Beauveria bassiana*, *Brontispa longissima*

Introduction

Brontispa longissima Gestro (Coleoptera: Chrysomelidae) is one of the important pests in several provinces in Indonesia. Both larvae and adults attacked coconut leaves, particularly unfolded leaves. Therefore, the pest can decrease coconut production. The Chrysomelid beetles attack all ages of coconut, although more damage is found in coconut plantation between four to five years old, especially in drying areas. Severe damage of this pest would kill the palms.

Various strategies have been used to control *B. longissima*, but most of them strongly depend on the use of insecticides. This practice substantially increases cost of production besides threat to the ecosystem. Additionally, chemical control may not be a long-term solution because of (1) the possibility that pests would develop resistance against the commonly used insecticides and (2) the increasing likelihood of outbreaks of secondary pests. Integrated pest management is one promising approach for a sustainable management of coconut plantations and could be capable to control and reduce populations of *B. longissima*.

Biological control by using parasitoid, predator and entomopathogenic fungus has a good chance to depress population of *B. longissima* in the field. Pest control by

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using natural enemies is not as popular as using pesticide. Biological control would decrease the use of insecticides. Therefore, it has a good impact on the environment. Additionally, this practice has a long-term impact to depress or manage the pest population on coconut plantation in low level of palm damage.

Actually, pest control has no intention to eliminate the pest totally but to maintain the natural balances by keeping the pest population below economic threshold level. *Tetrastichus brontispa* (pupal parasitoid) and entomopathogenic fungi *Metarhizium anisopliae* var*. anisopliae* and *Beauveria bassiana* are promising natural enemies of *B. longissima*.

Study on the use of pupal parasitoid *T. brontispa* has been done by some researchers (Kalshoven, 1981; Lever, 1969; Tjoa, 1952). This parasitoid also attacks *Plesispa reichei* (Heroetadji, 1989; Ooi *et al.*, 1989). The use of entomopathogenic fungi to control *B. longissima* is still limited except for other pests. *Metarhizium anisopliae* isolated from *Oryctes rhinoceros* can also infect *B. longissima under* laboratory condition (Soekarjoto *et al*., 1994). *M. anisopliae* isolated from *B. longissima* in South Sulawesi was first reported by Hosang *et al.* (1996). This fungus attacks second instar larvae (L2) (100 percent) and adults (52.5 percent) under laboratroy condition. *B. bassiana* has intensively been used in managing several pests such as *Ostrinia nubilalis* (Hübner) (Bing and Lewis, 1991), *Leptinotarsa decemlineata* (Say), (Anderson *et al*., 1988), *Spodoptera exigua* (Hübner) (Barberchech and Kaya, 1991), *Cylas formicarius* (Burdeos and Villacarlos, 1989), and cotton pest, *Anthonomus grandis* Boheman (Wright and Chandler, 1992). This fungus is also found in the yellow rice-borer (*Tryporyza incertulas* (Walker), stem borer *Sesamia inferens* (Walker) (Kalshoven, 1981) and *Nilaparvata lugens* (Stal) (Domsch *et al.,* 1980). The efficacy of *B. bassiana* had been evaluated on the three coconut pests namely: *Tirathaba rufivena* Walker, *Promecotheca cumingii* Baly and *Plesispa reichei* Chapius. The experiment results proved that these fungi were effective on the pests (Gallego and Gallego, 1988). This information demonstrated the high potential of the three entomopathogenic fungi to be developed as promising natural enemies of *B. longissima*. In this paper we present the pest description and biology, palm damage, current status of coconut chrisomelid beetle, and biological control by using parasitoid *T. Brontispa*, entomopathogenic fungi *M. anisopliae* var. *anisopliae* and *B. bassiana.*

Description of *Brontispa longissima* (Gestro)

Coconut hispid, very destructive, 9 mm long in Indonesia, Malaysia, and Pacific Islands. It also occurs in other palms. Many local varieties have been described: *var. longissima* with brown elytra, original described in Wolan, one of the Aru Islands, and now common in Java; *var. froggatti* sharp with black elytra, from new Britain and Salomon Islands; *var. selebensis* Gestro with a spindle-shaped, black marking on the suture of the elytra, original from South and North Sulawesi, later also found near Bogor. Numerous forms, intermediate between the last two varieties occur in Sulawesi, the Moluccas and Irian. Fertile offspring from *'longissima'* and *'selebensis'* crosses could be produced in the laboratory.

The color of adults varies geographically from reddish-brown in Java to almost black in the Salomon Islands and Irian (Papua). Considerable overlapping of these forms, which were for long regarded as distinct species, occurs (Kalshoven, 1981).

Biology of *Brontispa longissima*

Eggs The eggs are brown and flat. They are laid singly or in groups of two to four on the still-folded heart leaves (Lever, 1979). An egg measures 1.4 mm in length and 0.5 mm in width (Tjoa, 1953). The incubation period reported by several researchers ranged from three to four days (Froggatt and O'Connor, 1941; Lever, 1979); five days (O'Connor, 1940; Waterhouse and Norris, 1987); four to seven days or four days on the average (Tjoa, 1953).

Larvae The newly hatched larvae are whitish, later turn to yellowish and have an average length of 2 mm. The older larvae have an average length of 8-10 mm. Larvae avoid light and have distally U-like hooks. *B. longissima* undergoes four larval instars (Froggatt and O'Connor (1941) or five to six larval instars (O'Connor, 1940). The total developmental period of larvae vary about 36 days (O'Connor, 1940); 30-40 days (Froggatt and O'Connor, 1941; Waterhouse and Norris, 1987); 23-43 days (Tjoa, 1953); or 35-54 days (Lever, 1979).

Pupae The newly formed pupae are yellowish-white and have an average length of 9-10 mm and a width of 2 mm. They have distally U-shaped hooks. The pupal period is six days (O'Connor, 1940; Waterhouse and Norris, 1987); four to five days (Tjoa, 1953); or four to six days (Lever, 1979).

Adult The adult male is generally smaller than the female and measures 7.5-10 mm long and 1.5-2 mm wide. They avoid light and stay inactive inside the still – folded heart leaf during day time and active fly and attack coconut plants at night. Female lays an average of 50-100 eggs (O'Connor, 1940) until 117 eggs (Tjoa, 1953). Pre-oviposition period is 74 days (O'Connor, 1940) or one to two months (Waterhouse and Norris, 1987). The adult longevity ranges from two and a half to three months (75-90 days) Tjoa (1953).

The development from egg to adult takes five to seven weeks. The beetles then mature in other two weeks. This species is one of the thoroughly studied pest in Indonesia, with work undertaken at Bogor, as well as Bulukumba and Manado (Kalshoven, 1981).

Palm damage caused by *B. longissima*

During 1919-1934, *B. longissima* had been recognized as a pest of coconut palm in five provinces in Indonesia namely: Central Java, East Java, D.I. Yogyakarta, South Sulawesi and North Sulawesi. According to Tjoa (1953), *B. longissima var. javana* was found in Java, Bali, Madura, Sumba and Papua; while *B. longissima var. selebensis* in South Sulawesi, North Sulawesi, Flores, Seram, Aru Island and Bogor. Recently, *B. longissima* has spread to several provinces. The pest was also found in Sumatera and Maluku. Suprapto (1983) reported that in 1980, *B. longissima* caused serious damaged in area of 2 000 ha in Lampung. Madry (1993) reported losses due to the pest in nine provinces of Indonesia namely; South Sumatera, Lampung, West Kalimantan, South Sulawesi, Maluku, Irian Jaya, Bali and D.I Yogyakarta amount to Rp 298 786 000.

B. longissima start attack coconut palm aged two to three years old. The older the palm the lower the infestation. No damage is reported in coconut palm aged eight to

nine years old due to the difficulties of the pest to penetrate unopened leaves to lay the eggs. In contrast, the less compact leaves are more susceptible to *Brontispa* attacks (Tjoa, 1953). Waterhouse and Norris (1987) concluded that the pest attacks all age stages of coconut palm with serious damage occurring in young coconut palm in the seedling and coconut palm at the age of four to five years in the field during dry season.

Light attack result in minor leaf injury, and a slight decrease in fruiting at the axils of the damaged leaves. Fruit production is significantly reduced if eight or more leaves are destroyed. Under prolonged outbreak condition, as occurred in South Sulawesi for several years, fruit-shedding takes places, newly-formed leaves remain small, the trees appear ragged, and may ultimately die (Tjoa, 1953; Kalshoven, 1981; Suprapto 1983). The newly produced leaves are favourable for the development of the pest. Population of *B. longissima* was higher in early infestation and was lower when severe damage takes place. This could be related to the food availability in the field.

Current status of the key coconut chrysomelid beetles

There are three chrysomelid beetles attacking coconut palm in Indonesia, namely *Brontispa longissima, Plesispa reichei* and *Promecotheca cumingii.* The distribution and losses caused by the pest are shown in Table 1, 2 and Figure 1. Attacked areas of *B. longissima* have decreased from about 34 289.72 ha in 1984 to 1 389 ha in 2004. It indicates that there is reduction of pest population in that area due to the action of the natural enemies and environmental factors that are not favourable for the development of the pest.

Table 1. Situation of coconut Chrysomelid beetles in Indonesia

No.	Pests	Attacked area (ha)	Locations (province)
1983/1984			
1.	*Brontispa longissima*	34 289.72	Lampung, West Java, Central Java, D.I. Yogyakarta, West Kalimantan, South Sulawesi, S.E. Sulawesi, Bali, Papua
1984/1985			
2.	*Promecotheca cumingii*	1 812.83	Central Sulawesi
1993			
1.	*Brontispa longissima*		South Sumatra, Lampung, West Kalimantan; South Sulawesi, Maluku, Papua, Bali, D.I. Yogyakarta
September 2004 (source: Dirjen Bina Produksi Perkebunan 2004)			
1.	*Brontispa longissima*	1 389.00	West Java, West Sumatera, Bangka Belitung, Papua, Nusa Tenggara Barat, East Java, Nusa Tenggara Timur, Central Java, D.I. Yogyakarta
2.	*Plesispa reichei*	99.65	Nusa Tenggara Barat, East Java, Gorontalo

Table 2. Coconut areas attacked by *Plesispa reichei* in West Kalimantan (July 2004)

Sub district	Area (ha)	Attacked area (ha)
Mempawah Hilir	4 992	278
Sungai Pinyuh	2 044	205
Sungai Kunyit	2 535	97
Siantan	2 885	85
Sui Kakap	10 188	55.8
Rasau Jaya	953	87
Sungai Raya	190	5
M.H. Utara	450	375
M.H. Selatan	1 478.5	4.9
Total	**25 715.5**	**1 192.7**

Source: Extention Service West Kalimantan.

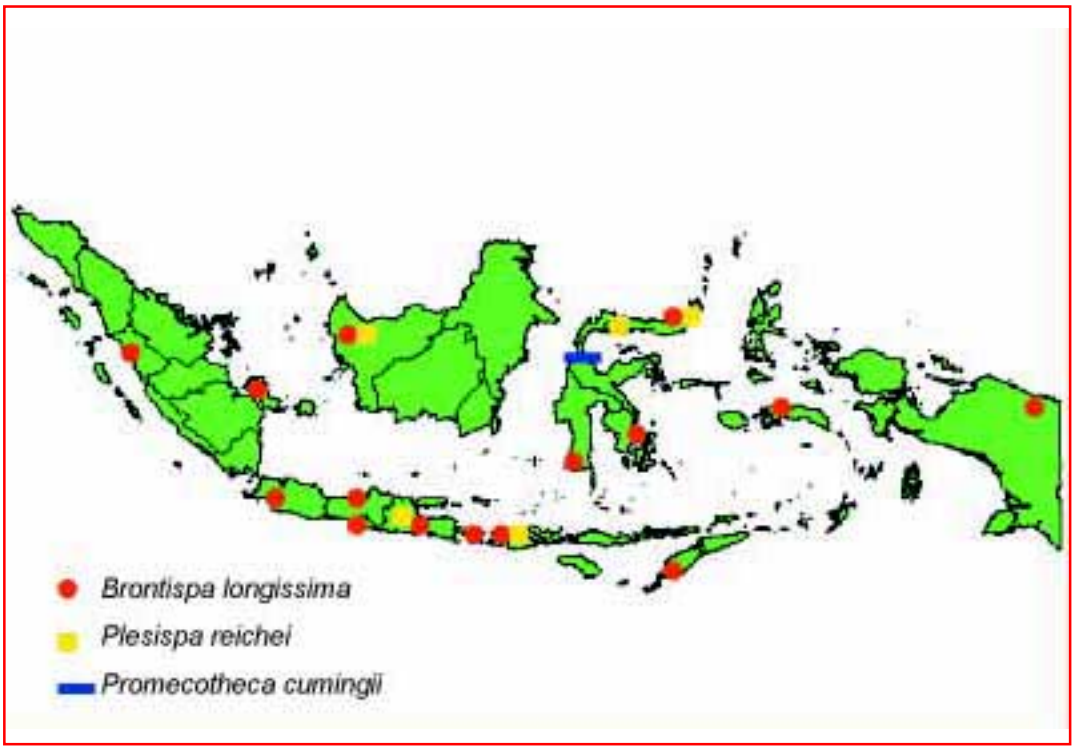

Figure 1: Distribution of Chrysomelid beetles in Indonesia

Promecotheca attacks are still limited to the areas of Central Sulawesi. The development of the pest was suppressed by the natural enemies as listed in Table 1. Generally, *P. reichei* attacks only young coconut palms, but it can also attack older palm as reported in West Kalimantan. About 5 percent (1 192.7 ha) of the coconut palm areas are attacked by the pest. In order to prevent the outbreaks and the spread of the pest to other coconut palm areas in Indonesia and even to other countries, the control of the pest should be done. Natural enemies of *B. longissima* can also be used as promising biological control agents to control *P. reichei*.

Biological control

Biological Control is the action of parasitoids, predators and pathogens in maintaining the pest population density at a lower average than it would occur in its absence. Biological control has recently been recognized as a promising and effective tool in the management of the most important pest on coconut palm (Sathiamma *et al*., 2001). Among the natural enemies used in biological control, information about predators against chrysomelid beetles is still limited. Waterhouse and Norris (1987) reported some earwigs preying on *B. longissima*. However, no research has been done to study the basic aspect of the predator and to develop them as an important potential biological agent of the chrysomelid beetles. This chapter presents the information regarding the parasitoids and entomopathogenic fungi of *Brontispa longissima.*

1. Parasitoids

The parasitoid complex of *B. longissima* comprises three egg parasites, *Haeckeliana brontispa* Ferriere, *Trichogrammatoidea nana* Zehntner (both Hymenoptera: Trichogrammatoidae) and a species of *Ooencyrtus* (Hymenoptera: Chalcidoidea), and a parasitoid of the larvae and pupae, *Tetrastichus brontispa* Ferriere (Hymenoptera: Eulophidae) (Lever, 1969). In Java, a complex of parasitoids occurs: (1) a strain of the trichogrammatid *H. brontispa*, with one wasp developing per *Brontispa* egg, and found on about 15 percent of *Brontispa* eggs in the field (Kalshoven, 1981) or 17 percent (Tjoa, 1952); (2) the encyrtid *Ooencyrtus podontiae* Gah. occurring on about 10 percent of the eggs (Kalshoven, 1980; Tjoa, 1952); (3) the eulophid *Tetrastichus brontispa* Ferr., found in 60-90 percent of the pupae and 10 percent of the larvae eggs (Kalshoven, 1980; Tjoa, 1952), developing in 18 days; about 20 specimens emerge from one *Brontispa* pupa. Hyperparasitoids have not been found. The same group of parasitoids could also be observed in 1940 in East Java near Kediri. *Tetrastichus* (= *Tetrastichodes*) which is a very distinctive parasitoid, is also found in other parts of Java, in Bali and Papua (Kalshoven, 1981). The *Tetrastichus* is the most effective parasitoid *of Brontispa*. Control of the beetle was achieved in Celebes by introducing this parasitoid from Java (see Lever, 1969).

1.1. Population of B. longissima and its parasitoid

Results of the pest collection done in West Java, Central Java and South Sulawesi in 1996 showed that population of *B. longissima*, natural enemies and palm damage in the three surveyed areas were in damaging stadium. Population of larvae and adults in West Java, Central Java and South Sulawesi were as follow: 57.42 percent and 17.98 percent; 35.86 percent and 38.34 percent; 63.63 percent and 18.93 percent, respectively (Hosang *et al.,* 1996).

Observation results obtained in district Selayar and Jeneponto (South Sulawesi) showed that the pest in the overlapping generation or in other words egg, larval, pupal and adult stages are available in the field (Hosang *et al.,* 1999). Total population of eggs, first instar larvae (L1), second instar larvae (L2), third instar larvae (L3), fourth instar larvae (L4), fifth instar larvae (L5), pupae and adults in seven regions of district Jeneponto were as follow 7.4 percent, 11.6 percent, 18.6 percent, 15.5 percent, 8.2 percent, 7.2 percent, 5.5 percent and 25.7 percent, respectively. So, the palm-damaging instars were 61.3 percent as larval instar (L1-L5) and 25.7 percent as

adults. This information is necessary for the decision making process to control the pest when outbreaks occur.

About 40 percent of 245 pupae collected in District Selayar and 2.7 percent of 113 pupae collected in District Jeneponto were parasitized by *Tetrastichus brontispa*. Percent parasitism varies in every location (Table 3). Hosang *et al.* (1996) reported that *T. brontispa* parasitizing in Pakuwon (West Java), Central Java and South Sulawesi were 36.4 percent, 11.1 percent and 50.6 percent, respectively. Level of parasitization is considered lower than that reported by Kalshoven (1981) that percent parasitism was 10 percent for larvae and 60-90 percent for pupae. The differences could be caused by environmental condition in every location, insect and plant biodiversity. In addition, larvae and adults collected in District Jeneponto were infected by *M. anisopliae* var. *anisopliae*, but no infections were found in larvae and adult collected in District Selayar. It indicates that *M. anisopliae* var. *anisopliae* does not evenly distribute in all attacked areas of *B. longissima* in South Sulawesi. All natural enemies were tested under laboratory and field condition.

Table 3. Population of healthy and parasitized/infected *B. longissima* in District Selayar and Jeneponto, South Sulawesi (Hosang *et al*., 1996)

Stages	Locations	
	Selayar	Jeneponto
Healthy Larvae (L4 dan L5)	725	271
M. anisopliae var. *Anisopliae* infected larvae	0	31 (10.3%)
Healthy pupae	147	110
T. brontispa parasitized pupae	98 (40%)	3 (2.7%)
Healthy adults	1 156	505
M. anisopliae var. *Anisopliae* infected adults	0	18 (3.4%)

1.2. The test of T. brontispa as pupal parasitoid under laboratory and field condition

Percent parasitism of *T. brontispa* ranged from 76.7 to 87.0 percent under laboratory condition (Table 4). The success of parasitoids much depends on the age of pupae to be parasitized. Pupae at the age of one to two days are more susceptible than the older one.

Table 4. Percentage of parasitized pupae by *T. brontispa* (Hosang *et al*., 1996)

Treatments	Percentage of parasitized pupae
1 parasitized pupae	76.7a
2 parasitized pupae	81.7a
3 parasitized pupae	83.3a
4 parasitized pupae	87.0a
5 parasitized pupae	80.0a

The parasitization level due to the release of *T. brontispa*-parasitized pupae in the field was 35.71-73.56 percent. The results demonstrated the high potential of *T. brontispa* to be developed as a biological control agent of *B. longissima*.

2. *Entomopathogenic fungi M. anisopliae var. anisopliae and B. bassiana*

2.1. *Test of different conidial concentrations of M. anisopliae var. anisopliae on different B. longissima stages*

Based on the analysis of variance for mortality of third instar larvae (L3), fourth instar larvae (L4), fifth instar larvae (L5) and adults at 20 days after treatments (day) showed that there were highly significant differences among treatments ($p < 0.01$). Results have shown that mortality of L3, L4 and L5 at concentration of 5×10^4, 5×10^5 was insignificantly different, but significantly different at the concentration of 5×10^2 and 5×10^3 conidia/µl. There was insignificant differences at the control and the concentration of 5×10^4 and 5×10^5, but significant differences were observed in adults at the concentration of 5×10^4 and 5×10^5. Significant difference was reported between concentration 5×10^4 and 5×10^5. Therefore, the lowest concentration of *M. anisopliae* var. *anisopliae* conidia that caused highest mortality of L3, L4 and L5 is 5×10^4 conidia/µl; while for adults is 5×10^5 conidia/µl (Table 5). This result was similar with *Beauveria bassiana* infecting *B. longissima* (Hosang, 1996). So, both fungi were subjected to tests in the next experiments in the screen cages.

The LC50 and LC95 values of conidial concentrations of *M. anisopliae* var. *anisopliae* on larvae and adults of *B. Longissima* at ten days are shown in Table 6. The result showed that for larvae, the LC50 values were 5.1×10^2 to 8.6×10^2 conidia/µl and 4.7×10^6 conidia/µl for adults.

Table 5. Mortality of L3, L4, L5 and adults at different conidial concentrations of *M. anisoliae* var. *anisopliae* at 20 days after treatment

Conidial concentrations (conidia/µl)	Larval stages			Adults
	3rd	4th	5th	
Control	1.25a (6.25)	2.00a (10.00)	2.75a (13.75)	1.75a (8.75)
5×10^2	13.75b (68.75)	17.75b (88.75)	14.25b (71.25)	1.75a (8.75)
5×10^3	18.50c (92.50)	18.00b (90.00)	16.50b (82.50)	2.75a (13.75)
5×10^4	20.00d (100.00)	20.00c (100.00)	20.00c (100.00)	7.50b (37.50)
5×10^5	20.00d (100.00)	20.00c (100.00)	20.00c (100.00)	13.00c (65.00)

– Means followed by different letters within a column are significantly different at 5 percent level.

– Percentage of mortality is in parentheses.

Table 6. The LC50 and LC95 values of *M. anisopliae* var. *anisopliae* on larval and adult stages of *B. longissima* at 10 days after treatments

Stadia	LC50 (conidia/µl)	LC95 (conidia/µl)
L3	5.1×10^2	2.0×10^4
L4	3.8×10^2	3.6×10^4
L5	8.6×10^2	6.2×10^4
Adults	4.7×10^6	2.6×10^9

2.2. Test of different conidial concentrations of B. bassiana on different B. longissima stages

Beauveria bassiana used in this experiment was isolated from coffee pest, *Hypothenemus hampei*. Result of the analysis of variance on mortality of first instar larvae (L1), second instar larvae (L2), third instar larvae (L3), fourth instar larvae (L4) and adults at 20 days after treatments showed that there were highly significant differences among treatments ($p < 0.01$). Mortality of L1 and L2 at the concentration of 5×10^3, 5×10^4 and 5×10^5 was not significantly different but the differences were observed at the control and 5×10^2 concentration. So, the lowest conidial concentration of *B. Bassiana* that caused highest mortality on L1 and L2 is 5×10^3 conidia/µl, 5×10^4 for L3 and L4 and 5×10^5 conidia/µl for adults (Table 7).

The LC50 and LC95 values of conidial concentrations of *B. bassiana* on larvae and adults of *B. longissima* at ten day are shown in Table 8 and the result showed that L1 was more susceptible than L2, L3, L4 and adults.

Table 7. Mortality of L1, L2, L3, L4, L5 and adults on different conidial concentrations of *B. bassiana* at 20 days after treatment (Hosang, 1996)

Conidial concentrations (conidia/µl)	Larval stages				Adults
	1st	2nd	3rd	4th	
Control	3.75a (18.75)	2.50a (12.50)	2.25a (11.25)	3.25a (16.25)	2.50a (12.50)
5×10^2	11.25b (56.25)	6.25a (31.25)	4.25a (21.25)	5.25a (26.25)	2.50a (12.50)
5×10^3	20.00c (100.00)	14.50b (72.50)	5.25a (26.25)	13.25b (66.25)	7.00ab (35.00)
5×10^4	20.00c (100.00)	20.00b (100.00)	14.25b (71.25)	19.75c (98.75)	7.75b (38.75)
5×10^5	20.00c (100.00)	20.00b (100.00)	20.00c (100.00)	20.00c (100.00)	14.75c (73.75)

– Means followed by different letters within a column are significantly different at 5 percent level.

– Percentage of mortality is in parentheses.

Table 8. The LC50 and LC95 values of *B. bassiana* on larval and adults stages of *B. longissima* at 10 days after treatment

Stages	LC50 (conidia/µl)	LC95 (conidia/µl)
L1	8.4×10^2	2.0×10^4
L2	3.1×10^3	6.6×10^4
L3	7.3×10^3	1.4×10^5
L4	5.8×10^3	8.4×10^4
Adults	8.8×10^5	4.7×10^8

This is probably caused by integument of L1 being softer and thinner than that of the older larvae and adults. Therefore, *B. bassiana* can easily penetrate and infect the L1. The same thing is also observed by Sivasankaran *et al*. (1990) on *Chilo infuscatellus* where the second and third instar larvae of the pest were more susceptible to infection of *B. bassiana* than the older larvae.

Conidial concentration(s) used to control larvae of *B. longissima* in the field are 5×10^3 and 5×10^4 conidia/µl, while for adults is 5×10^5 conidia/µl. Therefore, effective concentration to control the pest in the field is the concentration that caused the highest mortality for both stages, 5×10^5 conidia/µl. This indicates that higher the conidial concentration, higher the pest mortality. Barson (1977) showed that mortality of *S. scolytus* larvae depends on the *B. bassiana* concentrations; lower the conidial concentrations, lower the larval mortality. The results demonstrated high potential of *B. bassiana* to be developed as a biological control agent of *B. longissima* in either partial or integrated control.

2.3. Experiment in the screen cages

The experiments adopted a completely randomized design (CRD) involving seven different application frequencies as treatments and replicated three times. The treatments were as follows: (1) spraying of *B. bassiana* suspension twice-yearly at two weeks interval, (2) spraying of *B. bassiana* suspension at two months interval, (3) spraying of *B. bassiana* suspension at three months interval, (4) spraying of *M. anisopliae* var. *anisopliae* suspension twice-yearly at two weeks interval, (5) spraying of *M. anisopliae* var. *anisopliae* suspension at two months interval, (6) spraying of *M. anisopliae* var. *anisopliae* suspension at three months interval and (7) control (Hosang *et al*., 1999).

The result showed that larval and adult population in the cages sprayed with the fungi suspensions were lower than that in the control. This result indicated that both *M. anisopliae* var. *anisopliae* and *B. bassiana* can be used to control *B. longissima* population in the field. Low population of the pest in the field is mainly caused by high rain fall. Kalshoven (1981) reported that dry season could trigger the development of population of *Brontispa* spp. in the field.

Based on the analysis of variance, there were significant differences among treatments at two to six weeks after treatments. Spraying of *M. anisopliae* var. *anisopliae* suspension twice at two weeks interval was different from the control but insignificant with the others. The result showed that these fungi can regulate the development of pest population in the field if field conditions are favourable for the growth and

development of fungi. High rain fall not only affects the development of *Brontispa* but also the growth and development of *M. anisopliae* var. *anisopliae* and *B. bassiana* in order to control the pest in the field.

2.4. The effect of M. anisoplia var. anisopliae and B. bassiana on B. longissima in the field

Test of the effectiveness of *M. anisoplia* var. *anisopliae* and *B. bassiana* had been done in 1997-1998 and 1998-1999 in District Jeneponto, South Sulawesi. The experiments adopted a grouped randomized design with five treatments and replicated three times. The treatments were as follows: (a) spraying of *M. anisopliae* var. *anisopliae* suspension twice-yearly at two weeks interval and (b) spraying of *M. anisopliae* var. *anisopliae* suspension at three months interval, (c) spraying of *B. bassiana* suspension twice-yearly at two weeks interval, (d) spraying of *B. bassiana* suspension at three months interval and (e) without spraying of fungi, control.

Each plant was sprayed with fungi suspension at around ±100 ml. The unopened young leaves were subjected to spray because that part is usually attacked by *Brontispa.*

The preliminary observation was done by taking pest samples in the field. Result showed that all of the pest stages, eggs, larvae, pupae and adults were available in the field. The mean of *B. longissima* population were different at each plant. The total number of eggs, larvae, pupae and adults per plant were 0.87-4.73, 42.25-132.20, 3.77-10.93 and 13.87-47.47, respectively. The population of the pest highly reduced after treatments. The population of eggs, larvae, pupae and adults per palm per treatment four months after application (second observation) were as follows: A (0.47); B (1.66); C (12.54); D (1.77); and E (15.39). The next seven months, the pest populations were lower, except in control. Both *M. anisopliae* var. *anisopliae* and *B. Bassiana* are recommended to be used to control *B. longissima*. Introduction of these fungi reduced both pest population and plant damage. Spraying of these entomopthagenic fungi reduced the pest population at around 90.37-95.0 percent (Tumewan and Hosang, 1998). Pest population can be affected by rainfall, temperature and relative humidity. Dry season was occurred one month after treatment for four months, daily temperature was 26.35-31.15°C and relative humidity was 70-79 percent. Spraying of *M. anisopliae* var. *anisopliae* and *B. bassiana* suspension twice-yearly at two weeks interval or three months gave the same effect on the population of *B. longissima* in the field. In terms of the efficiency of spraying, the spraying of *M. anisopliae* var. *anisopliae* and *B. Bassiana* suspension twice-yearly at two weeks interval was suggested to regulate *B. longissima* in the field.

Conclusion

1. Pupal parasitoid, *T. brontispa* has high potential to be developed as a biological control agent of *B. longissima*. This parasitoid efficiently attack the pupae of *B. longissima* both in the laboratory and in the field. The percent parasitism under laboratory condition and in the field ranged from 76.7-87.0 percent and 35.71-73.56 percent, respectively.

2. Entomopathogenic fungi, *M. anisopliae var. anisopliae* and *Beauveria bassiana* can be used to control *B. longissima*.

3. *M. anisopliae* var. *anisopliae* can infect 100 percent larvae and 65 percent adults; while *B. bassiana* can infect 100 percent larvae and 73.75 percent adult under laboratory condition. Larval stage is more susceptible than the adult. The effective conidial concentration used to control *B. longissima* in the field is 5×10^5 conidia/µl. There is reduction of population in the field due to action of its natural enemies.

4. Spraying of *M. anisopliae* var. *anisopliae* and *B. bassiana* suspension can inhibit the development of *B. longissima* in the field. Spraying of *M. anisopliae* var. *anisopliae* and *B. bassiana* suspension twice-yearly at two weeks interval efficiently control *B. longissima* in the field. The level of palm damage can be reduced until about 90.37 to 95.07 percent seven months after application.

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The status of *Brontispa longissima* coconut beetle outbreak in Lao PDR

Vilaysouk Khennavong*

1. Country background

Lao PDR is located in the heat of the Indochina Peninsular, in Southeast Asia, latitude 14 to 23 degree north and latitude 100 to degree east.

Lao is landlocked country. It shares 505 km border with China to the north, 435 km with Cambodia to the south, 2 069 km with Viet Nam to the east 1 835 km with Thailand to the west, and 236 km with Myanmar to the north east. Lao PDR covers a total of 236~850 square kilometres three-quarters of which is mountain and plateau. The country has three distinct regions.

Coconut has been planted in Lao since ancient times until today. Even though, coconut cultivation is still not economic crop yet, it is a source of an additional income for farmers. Coconut is traditionally planted in villages and rural area around houses and big plantation for coconut is rare.

According to the weather condition and the experience of farmers, Lao has high potential to grow coconut in accordance with agro-processing industry. Therefore, for the last two years the Government has a policy focused on promoting coconut cultivation as economic crop for consumption and raw material for local agro-processing industry. In 2003-2004, the Government of Lao PDR has officially imported some coconut seed to grow in Champasack and Khammoun provinces.

2. Appearance and cause of *Brontispa longissima* outbreak on coconuts in Lao PDR

The coconut leaf beetle, *Brontispa* is native to Indonesia and it had been reported in other locations in the Asia-Pacific region. It is believed that this pest was introduced into southern Viet Nam a few years ago in shipments of ornamental palms. The beetle advanced rapidly into central and northern region of Viet Nam.

Since this report from Viet Nam, *Brontispa* has been reported in Hainan province in PR China, and Cambodia reported that the pest was found in late 2001 attacking coconut palms in provinces bordering Viet Nam. As in case of Lao PDR, the pest was found in the district bordering Viet Nam about 30 km and spread to other districts nearby.

After the coconut beetle outbreaks, Ministry of Agriculture and Forestry sent Lao and FAD technical team for field assessment. The survey showed that six villages in two provinces are facing the coconut beetles (*Brontispa longissima*) outbreak; these included Namthon village in Pakkading district of Bolikamxay province and villages Novilay, Vangboangtai, Vangboangnua, Fouang and Nabo in Sepon district of Savannaket province (Figure 1).

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The losses due to coconut beetle outbreak in Lao PDR have not been estimated so far because of traditionally scattered nature of cultivation. However, it appears that coconut palms in Savannaket province have serious infestation. Therefore, close- by areas in Salavan, Champasack, Khammoun provinces and Vientiane capital are at high risk (Figure 2).

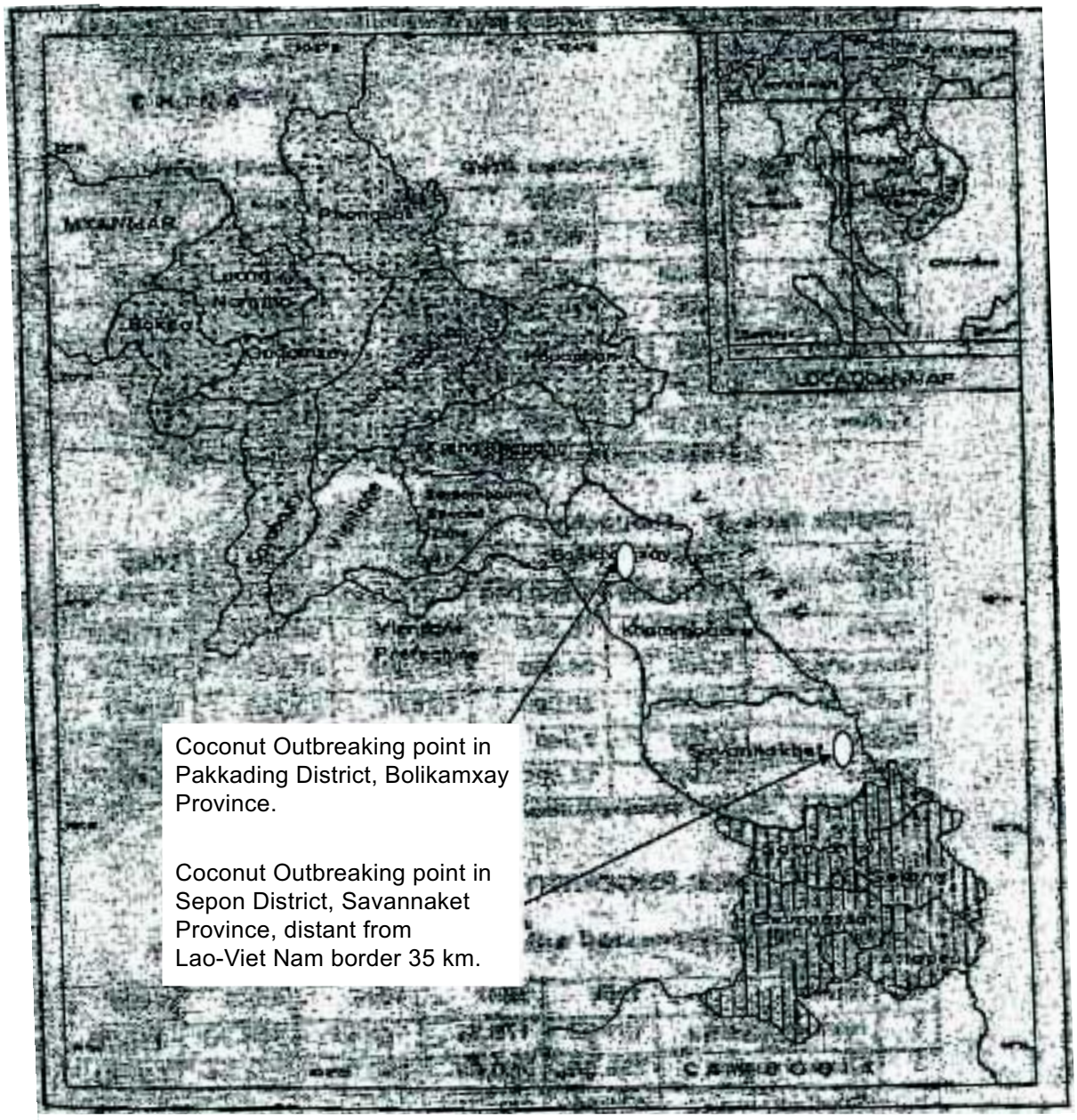

Figure 1: Sites of *Brontispa longissima* outbreak in Lao PDR

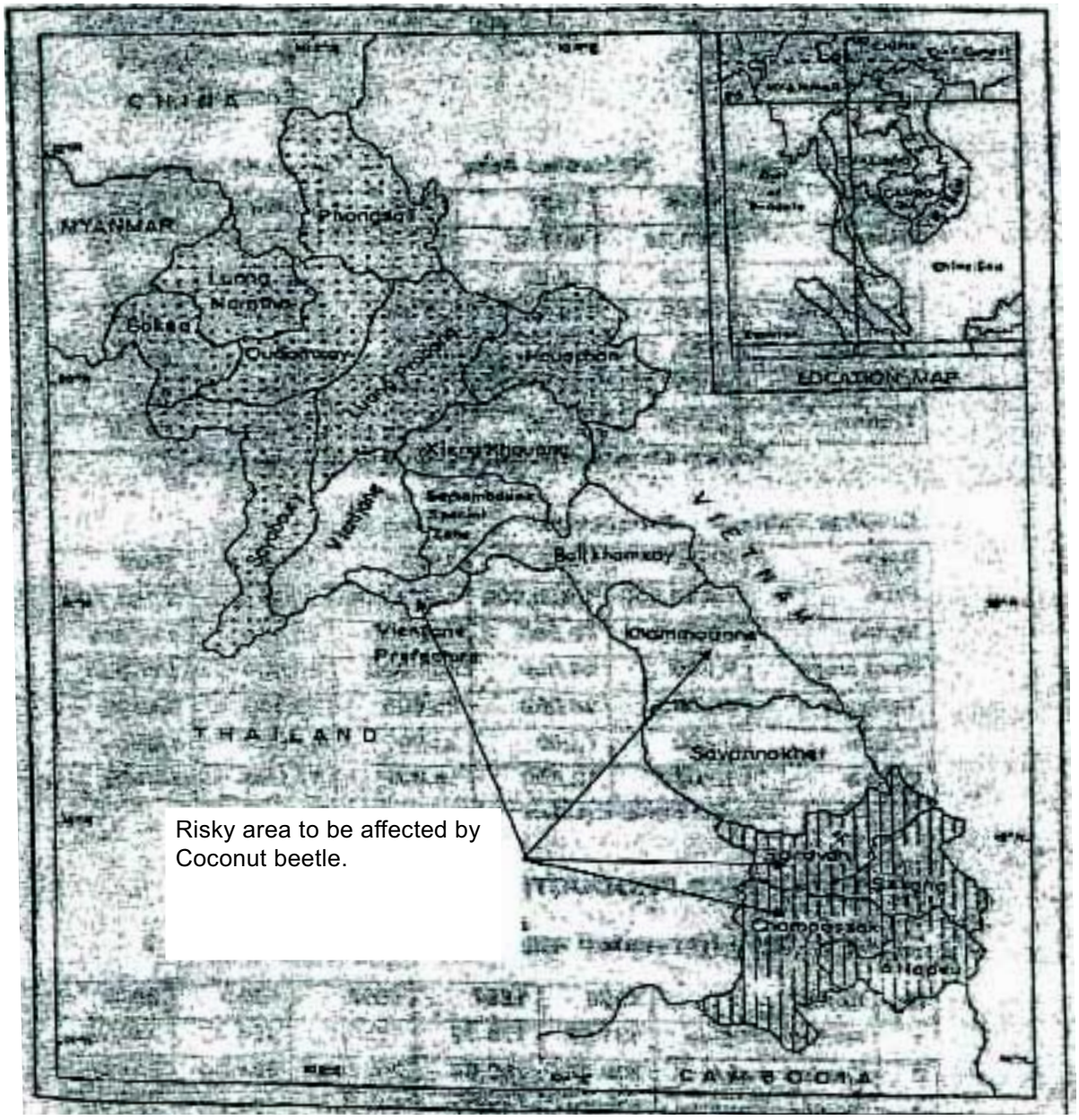

Figure 2: Areas threatened by spread of the coconut beetle

3. The main cause of *Brontispa longissima* outbreak in Lao PDR

The cause of beetle coconut outbreak (*Brontispa longissima*) in Lao is not clear. It is believed that some palm and coconut trees are imported illegally and these may have some infestation. The plant quarantine along the border is not so strict, which is primarily due to poor knowledge of the technical staff responsible for inspection of diseases and pests as well as the lack of equipment.

4. Some measures undertaken to overcome the coconut beetle outbreak in Lao PDR

Minister of Ministry of Agriculture and Forestry (MAF) announced to director of provincial, capital and special zone of agriculture and forestry to take following measures to combat the spread of coconut beetle outbreaks:

- Pay attention to implement plant quarantine at every import and export check points around country as well as improve the capacity and knowledge of plant quarantine officials to inspect systematically.
- Designate Bolikamxay and Savannaket province to be coconut beetle outbreak zone. No movement of plant material, especially palms or products of coconut and other palm from this area.
- Facilitate plant protection technical implementation and inspect individual or concern sectors that are involved in coconut seeds, coconut palms or any plant related to palms passing Bolikamxay and Savannaket provinces must have certified paper from Provincial Agriculture and Forestry Department to certify origin *or* sources of product.
- Province, Vientiane capital and special zone where no outbreak of coconut beetle has been noted, the Division of Agriculture must coordinate with local authority to monitor and conduct survey of coconut cultivation areas regularly and if any unexpected pests are detected these must be reported to MAF.

In order to overcome this pest, Ministry of Agriculture and Forestry has proposed and submitted letter to government regarding import of *Asecodes hispinarum* parasitoid. According to letter number three of International Phytosanitary Standard Measures (IPSM) of International Plant Protection Convention (IPPC), the Prime Minister office has allowed official notification to import, test, and introduce the natural enemy *Asecodes hispinarum* parasitoid from Viet Nam to rear and propagate in Plant Protection Centre, then release and inoculate to Pakkading district Khammoun province and Sepon district Savannaket province. Later, the Government will set an establishment of *Asecodes hispinarum* parasitoid in the two infested provinces. Moreover, MAF has requested emergency technical assistance from Viet Nam and international organizations in order to stop the coconut beetle outbreak in infested provinces and prevent further spread to other provinces.

Current status of coconut Chrysomelid beetles in Malaysia

Mat Hassan Othman*

1. Background

The coconut industry ranks fifth after oil palm, rubber, paddy, and fruits in terms of hectarage. However, it occupies only 2.4 percent or 151 044.7 of 6 269 909.9 hectares of the total cultivated land under the main crops in Malaysia. The coconut area is continually declining. It dropped from 213 14.0 hectares in 1985 to 151 044.7 hectares in 2001. The principal reason for the decline in hectarage being the low profitability. Many smallholders have changed over from coconut to oil palm mainly because of the poor returns.

Among the coconut holdings, about 69 percent are in Peninsular Malaysia, while the rest are in Sarawak (17 percent) and Sabah (14 percent). In Peninsular Malaysia, 70 percent coconut areas are located in the coastal region, cultivated mainly on alluvial soils of the west coast in Johore, Perak and Selangor and on bris (sandy) soils of the east coast.

About 92 percent or nearly 139 306 ha of coconut area are operated by smallholders and the average size of holding is about 1.1 ha. Due to the small size of holdings coupled with low yield and poor farm management, income received by the coconut smallholder has been very low. The net income being about RM 607 per year. In Malaysia, planting coconut as a mono-crop regardless of variety and management practices is not profitable enterprise.

2. Brief overview of coconut pests

The coconut palm is susceptible to attack of a large number of insects. In Malaysia, about 164 insects species have been associated with coconut palm (Ahmad Yunus and Ho Thian Hua, 1980). However, only a few of them are capable of causing considerable damage to the palm resulting in reduced growth and yield (Table 1). These pests include the Rhinoceros beetle (*Oryctes rhinoceros* Linnaeus), leaf-eating beetle (*Promecotheca cumingii* Baly and *Plesispa reichei* Chapuis), *Artona catoxantha,* nettle caterpillars (*Setora nitens* Walker and *Thosea sinensis* Walker), coconut spike moth (*Tirathaba rufivena* Walker), coconut skipper (*Hidari irama*), the Red Palm Weevil (*Rhyncophorus schach* Olivier), *Parasa lepida* Cramer, and coconut bagworms (*Cremastopsyche pendula* Joannis, *Metisa plana* Wlk, *Mahasena corbetti* Tams). The Rhinoceros beetle (*Oryctes rhinoceros* Linnaeus), leaf-eating beetle (*Promecotheca cumingii* Baly and *Plesispa reichei* Chapuis), *Artona catoxantha* are the major pests of concern. Widespread outbreaks are rare, but frequent localized and sporadic outbreaks of these pests have been reported (Tables 2, 3 and 4). During the outbreaks, serious damage has been observed on individual palm and small groups.

In general no control or minimum control measures were implemented when localized outbreaks occurred on mature palms. Surprisingly these pests disappeared after a time. Weather is one of the regulating factors. It was generally observed that most

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Table 1. List of common pests of coconut in Malaysia

No.	Pest	Pest Status						Distribution					
		Major			Minor			Wide spread			Limited		
		PM	SR	SA	PM	SR	SA	PM	SR	SA	PM	SR	SA
1	Rhinoceros beetle (*Oryctes rhinoceros* L)	✓	✓	✓				✓	✓	✓			
2	Two color coconut beetle, *(Plesispa reichei* Chapuis)	✓	✓	✓				✓	✓	✓			
3	Coconut leaf moth (*Artona catoxantha)*	✓				✓	✓	✓			✓	✓	✓
4	Coconut leaf beetle *Promecotheca cumingii*	✓	✓				✓				✓	✓	✓
5	Red stripe weevil, *(Rhynchophorus schach* Oliv.)				✓	✓	✓				✓	✓	✓
6	Nettle caterpillar, *(Setora nitens, Thosea* sp.)				✓	✓					✓	✓	✓
7	Coconut skipper, *Hidari irava*				✓	✓	✓				✓	✓	✓
8	Coconut spike moth, *Tirathaba rufivena*				✓	✓	✓				✓	✓	✓
9	Bagworm, *Cremastopsyche pendula*, *Metisa plana* Wlk, *Mahasena corbetti* Tams				✓	✓	✓				✓	✓	✓
10	Coconut scale insect, *Aspidiotus destructor*				✓	✓	✓				✓	✓	✓

Note: PM – Peninsular Malaysia; SR – Sarawak; SA – Sabah

severe infestations become obvious in the dry season, and end with the onset of a wet season. Besides that, numerous natural enemies were recorded on various coconut pests and were assumed to play a major role in regulating coconut pest populations.

3. Leaf-eating beetles

Currently two species of leaf-eating beetles, coconut leaf beetle (*Plesispa reichi* Chapuis) and Philippine leaf-miner (*Promecotheca cumingii* Baly) which belong to the sub-family hispinae of the family Chrysomelidae are the major pests of palms in Malaysia.

(a) Philippine leaf-miner Promecotheca cumingii Baly

Occurence and outbreaks

The Philippine leaf-miner was not recorded in Malaysia until the first outbreak of this pest on coconut palms occurred in Malacca in 1917 (Lever, R.A.W. 1951). The palms were badly attacked over considerable area but the beetle disappeared after a time (Gater, B.A.R. 1925). Since then no mention has been made of its presence until May 1972 when a major outbreak of the beetle on about 10 000 acres of coconut

Table 2. Record of outbreaks/infestations of Rhinoceros beetle 1999-2003

Pest	Year or date	Host (Age of host)	Status of infestation		Location
			Planted area (Ha)	Number Infested host	
1. *Oryctes rhinoceros* L	11/6/1999	Coconut (30 years)	15 ha	15 palms	Hilir perak
	10/4/2000	Oil Palm (20 months)	0.8 ha	0.08 ha	Perak Tengah
	24/4/2000	Coconut (5 months)	0.8 ha	50 palms	Dungun
	7/2/2001	coconut (10 years)	0.5 ha	10 palms	Kuala Muda
	2/4/2001	Coconut (15 years)	0.5 ha	10 palms	Kula Muda
	3/4/2001	Coconut (3 years)	0.75 ha	NA	Alor Gajah, Melaka
	18/6/2001	Coconut (2 years)	1 ha	40 palms	Kulim, Kedah
	24/9/2001	Coconut (1 year)	2 ha	20 palms	Temerloh, Pahang
	3/5/2002	coconut (2 years)	13 ha	NA	Raub
	5/2/2002	Coconut (30 years)	2.4 ha	NA	Perak Tengah
	16/12/2002	Coconut (25 years)	0.4 ha	0.3 ha	Perak Hilir
	8/1/2003	Coconut (2.5 years)	2 palms	2 palms	Kulim
	20/3/2003	Coconut (1 year)	5.8 ha	3 palms	Kota Bharu
	31/3/2003	Oil palm (10 years)	76 ha	38 ha	Seberang Perai
	31/3/2003	Coconut (3 years)	20 ha	NA	Kinta
	22/7/2003	Coconut (2 years)	4 ha	NA	Kerian
	30/12/2003	Coconut (4 years)	60 palms	40 palms	Rembau

Note: NA – Not available.

Table 3. Record of outbreaks/infestations of leaf-eating beetle

Pest	Year or date	Host (Age of host)	Status of infestation		Location of infestation
			Planted area (Ha)	Number Infested host	
2. *Plesispa reichei* Chapuis	4/3/2000	Coconut (7 years)	30 ha	20 palms	Telipot Kota Bharu, Kelantan
	7/4/2000	Coconut (20 years)	15 ha	15 palms	Pekan, Pahang
	22/6/2000	Coconut (20 years)	0.4 ha	30 palms	Pekan, Pahang
	12/6/2000	Coconut (5 years)	0.6 ha	30 palms	Kg. Kelulut, Marang, Terengganu
	26/7/2000	Coconut (2.5 years)	0.8 ha	10 palms	Marang, Terengganu
	2000	Coconut	NA	NA	Tuaran, Sabah
	15/1/2001	Coconut (1 year)	0.2 ha	20 palms	Pasir Mas Kelantan
	16/2/2001	Coconut (10 years)	0.2 ha	6 palms	Rompin Pahang
	11/7/2001	Coconut (2 years)	5 ha	5 palms	Pekan, Pahang
	2001	Coconut	NA	NA	Likas, Sabah
	22/1/2002	Coconut (1.6 years)	50 ha	NA	Raub, Pahang
	29/1/2002	Coconut (1 year)	1 ha	NA	Kluang Johor
	3/5/2002	Coconut (2 years)	13 ha	NA	Raub, Pahang
	17/10/2002	Coconut (2 years)	3 ha	52 palms	Pasir Mas, Kelantan
	23/1/2002	Coconut (2 years)	2 ha	NA	Temerloh, Pahang
	23/1/2002	Coconut (20 years)	200 ha	2 000 palms	Sabak Bernam, Selangor
	18/4/2002	Coconut (30 years)	34.4 ha	1 800 palms	Sabak Bernam, Selangor
	24/1/2002	Coconut	200 ha	25 ha	Labuan, Sabah
	30/10/2003	Coconut (3 years)	0.5 ha	100 palms	Bera Pahang
	23/11/2003	Coconut (3 years)	7 palms	6 palms	Kota Star, Kedah
	29/11/2003	Coconut	40 palms	15 palms	Kuala Lumpur
	29/11/2003	Manila palm	35 palms	10 palms	Serdang, Selangor
	29/11/2003	Manila palm	30 palms	20 palms	Bukit Jalil, Selangor
	29/11/2003	Manila palm	15 palms	5 palms	Bandar Tun Razak, Kuala Lumpur
3. *Promecotheca cumingii*	1917	Coconut	NA	NA	Malacca
	1972	Coconut	NA	10 000 acs	Pulau Pinag
	1995/1996	Sago & Coconut	13 115	Serious	Sarawak

Note: NA – Not available.

Table 4. Record of outbreaks/infestations of *Artona catoxantha* (2000-2003)

Pest	Year or date	Host (Age of host)	Status of infestation		Location
			Planted area (Ha)	Number Infested host	
4. *Artona catoxantha*	23/5/2000	Coconut (20 years)	0.4 ha	10 palms	Pekan, Pahang
	1/6/2000	Coconut (30 years)	50 ha	50 palms	Kota Bharu, Kelantan
	14/6/2000	Coconut (20 years)	0.8 ha	40 palms	Rompin, Pahang
	7/7/2000	Coconut	20 ha	NA	Mersing, Johor
	19/7/2000	Coconut	16 ha	NA	Mersing, Johor
	6/2/2001	Coconut (20 years)	100 ha	70 palms	Manjung, Perak
	1/8/2001	Coconut (25 years)	NA	NA	Kuala Selangor, Selangor
	31/7/2002	Coconut (20 years)	1.5 ha	1.5 ha	Kuala Selangor, Selangor
	5/3/2003	Coconut (40 years)	20 ha	20 ha	Kluang, Johor
	8/10/2003	Coconut (30 years)	40 ha	0.4 ha	Muar, Johor
	3/11/2003	Coconut (20 years)	1.8 ha	1.8 ha	Pontian, Johor

Note: NA – Not available.

palms took place in province Wellesley and the southernmost part of Kedah (Ding, S.M. 1975). The infested palms were exclusively found on small land holdings. In this outbreak, it had been observed that the beetle besides infesting coconut palms also attacked nipah palm, oil palm, royal palm. The infestation on nipah was the most severe.

Another major outbreak of *Promecotheca cumingii* occurred in Kuching and Samarahan districts in Sarawak in 1996 (Gumbek, M.,1999). About 13 000 hectares of coconut palms and 10 000 hectares of nipah palms were affected. The affected palms were located in the coastal areas and along Samarahan river. The initial pest infestation occurred on nipah palm (*Nipa fruticans*), but later it had spread to coconut palms (*Coccos nuciferae*), oil palms (*Elaeis guineensis*), sago palms (*Metroxylon sagu*), ornamental palms and other jungle palms.

Damage

The damage on the coconut palm is resulted from the feeding activity of both adult beetle and the larva on the leaflets. The adult beetles feed on the spongy tissue of the coconut leaflet by chewing a series of fine grooves on the lower surface, sparing a thin layer of the upper epidermis. Normally unattacked tissues in between the grooves die. In severe infestation, leaftips generally turned brown, shriveled and

Table 5. Record of outbreaks/infestations of *Promecotheca cumingii* in Malaysia

No.	Pest	Year	Host (Age of host)	Status of infestation		Location
				Planted area (Ha)	Number Infested host	
1	*Promecotheca cumingii* Baly	1917	Coconut	NA	NA	Malacca
		1972	Coconut	NA	10 000 acs	Pulau Pinag
		1995/1996	Sago & Coconut	13 115	Serious	Kuching/ Semarahan Sarawak

Note: NA – Not available.

curled downward giving the palms a scorching appearance. All fronds are attacked but the older ones are more susceptible. The larva feeds and mines inside the leaf. It feeds on the parenchymatous leaving the upper and lower epidermis intact. In severe cases the coalescence of the larval mines and the adult feeding scars together with the natural drying up of unattacked tissue resulted in the death of extensive area of the leaflets. After a few generation of attack, the whole leaflet may be killed. In very severe infestation, except for a few young fronds, the whole palm assumed a burning appearance. Damaged leaflets consequently weaken the palm and reduce the yield. Premature fruit fall also occurred.

Cause of the outbreak

The *Promecotheca cumingii* is found in Malaysia since 1917. Except for three outbreaks reported in 1917, 1975 and 1996 respectively, the beetle has been otherwise under good natural control. It was suggested that outbreak could arise through several factors which are believed to upset the host-parasitoid equilibrium. These factors include favourable environmental conditions for beetle to multiply and low level or absence of natural enemies. When this occurs, rapid increase of beetle population takes place, resulting in outbreak.

Control measures

(i) Natural control

Outbreak of *Promecotheca cumingii* occurred occasionally and between outbreaks it would be difficult to determine the presence of this beetle. It is believed that natural control, particularly natural enemies seem to play the primary role in suppressing or terminating outbreaks and kept the pest in check. For example, in 1917 and 1975 outbreaks, the beetle died down or disappeared after a time without any chemical control (Gater, B.A.R., 1925; Ding, S.M., 1975).

Numerous natural enemies had been found to attack *P. cumingii* during the outbreak in province Wellesly in Peninsular and in Sarawak (Table 6). Of these natural enemies, *P. parvulus* and *S. javanicus* were the most common parasitoids. Of the two, *S. javanica* is normally present in numbers far exceeding that of *P. parvulus* and is most effective (Ding, K.M., 1975). It has attacked all the larval instars of the host while *P. parvulus* attack was limited mainly to the second and third instar larvae and

pupae. During the outbreak it probably played an important role in suppressing the leaf-eating beetle.

During the outbreak in province Wellesley, it was found that unknown factors had caused a high larval mortality than the parasitoids (Ding, S.M., 1975). Adverse environmental conditions and overcrowding were attributed to the premature death of larvae.

(ii) Other control measures

Apart from natural control, the following measures have been employed for the control of the coconut leaf beetle:

- Removal of attacked hosts/fronds

  The destruction of heavily infested hosts/fronds (cut and burn) would reduce the population of the next generation.
- Spraying and fogging

Table 6. Parasitoids of *P. cumingii* in Malaysia

No.	Parasitoid Family	Species	Remarks	Distribution	
				PM	SR
1	Eulophidae	*Sympiesis javanica*	Ectoparasitoid for larval stage, very common and most effective	✓	✓
		Pediobius parvulus	Endoparasitoid for larval and pupal stages, very common	✓	✓
		Achrysocharis promecothecae	Egg parasitoid (Peninsular)	✓	–
		Pediobius anomalus	Egg parasitoid, less common (Sarawak)	–	✓
		Closterocerus sp.	Egg parasitoid, less common (Sarawak)	–	✓
2	Brachonidae	*Adesha* sp.	Larval parasitoid	–	✓
3	Cleridae	*Callimerus arcutifer*	Predator. Attack egg, larva, pupa	✓	–
4	Hyphomycetes	*Beauveria bassiana*	Entomogenous fungus	✓	✓

Note: PM – Peninsular Malaysia; SR – Sarawak

Ground spraying was not carried out during the outbreaks as it was difficult and not practical as most infested palms were very tall. In Sarawak, most of the infested areas, especially nipah palms could not be accessed through ground roads. Only fogging using propuxur was carried out in seriously infested coconut holding and the periphery of nipah areas.

- Trunk injection

  In Sarawak, trunk injections with 10 ml of methamidophos were carried out in areas with low infestation and the buffer zones.

- Aerial spraying

  Due to extensive areas infested, aerial spraying with Dipterex 95 Sp was carried out to control the outbreak in Sarawak. The spraying operation covered an area of 15 670 hectares. It was found to be effective in containing the pest infestation (Gumbek *et al*., 1996).

(b) Two coloured coconut leaf beetle (Plesispa reichei Chap.)

Occurrence and outbreak

The earliest record of *P. reichei* occurrence on coconut in Malaysia was in Johore in 1912 (Corbett, G.H., 1923). This species was found in abundance in Johore and elsewhere in Malaya. Both adults and larvae feed on the surface of the unopened leaf of coconut. Their attack is confined between the folds of tender leaves whilst they are still partially folded up.

Since it was first found, the *P. reichei* remained an insignificant pest as it was never reported to cause economic damage to coconut palms. But it has emerged as a major pest of coconut after the year 2000. The presence of this pest was reported throughout the country and sporadic outbreaks have occurred in various places on coconut and other ornamental palms (Table 3). In areas where an outbreak occurred, a serious damage has been observed on individual palm and small groups.

Damage

Both adults and larvae live and feed on partially unfolded coconut leaflets. The damage on the coconut palm is the result from the feeding activity of both adult beetle and the larva on the leaflets. They remove strips of tissue from both sides of the leaves. They feed in a straight line and parallel to each other. Later, these feeding lines mingle with each other so that the remaining tissue dries and rots. In severe infestation, leaflets generally turn brown giving the palms a scorching appearance. When the attack is severe and of long duration, the palms may die.

Cause of the outbreak

P. reichei is found in Malaysia since 1917. Only recently, this pest has emerged as serious pest of coconut palms. Ornamental palms, particularly coconut and Manila palms that are planted for landscape in cities and golf courses were severely attacked. The emergence of this pest could arise through several factors which are believed to upset the host-parasitoid equilibrium. These factors include favourable environmental conditions for beetle to increase and low level or absence of natural enemies. When this occurs, rapid increase of beetle population takes place, resulting in outbreak.

Control measures

(i) Natural control

It is believed that natural control, particularly natural enemies is playing the primary role in suppressing outbreaks and keeping the pest in check. In many outbreaks, it has been observed that the infested plants recovered and the beetle died down or disappeared after a time without any control action. So far there is no information available on the natural enemies attacking this pest in Malaysia.

(ii) Cultural practices

Cutting and burning of heavily infested fronds may reduce pest population.

(iii) Chemical application

During severe infestation, insecticide application is required to help quick knockdown of pest. Following are the commonly used control methods:

- Insecticide spraying

  Sprays were generally effective for young palms (shorter than 2.5 metre). Foliar spraying with dimethoate or mixture of chloropyrifos and cypermethrin were found to be effective against leaf beetle (Choo-Toh,1999; Sivapragasam *et al.,* 2004).

- Soil drenching

  For tall palms soil drenching or trunk injection with systemic insecticides were recommended to control the pest. Drenching around the palm base with imidacloprid at 10 ml in 2000 ml water/palm was found to be the most effective. The palms begin to produce healthy new fronds after 30 days of treatment.

- Trunk injection

  10-15 ml of systemic insecticides such as monocrotophos or methamidophos is injected undiluted into a hole (10-15 cm deep and 1.5 cm wide) bored in the palms trunk half a metre above the ground. After the injection, the hole is sealed up with clay or bitumin.

4. Proposal

Coconut leaf-eating beetles particularly *P. reichei* have become important pests in Malaysia. Frequent and sporadic infestations of *P. reichei* beetle have been reported on the coconut and ornamental palms throughout the country. This beetle is becoming a serious pest in other countries in this region particularly in Singapore. As this pest was relatively unknown previously, very little is known about biology and ecology and effective control measures. More collaborative efforts, among affected countries, are required to develop effective short and long terms control measures of this pest.

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Integrated control of coconut hispid beetle *Brontispa longissima* (Gestro) in the Maldives

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Introduction

The Republic of Maldives consists of 1 192 coral islands, which form a chain 820 km in length and 130 km at its widest point, set in an area of 90 000 sq km of the Indian Ocean, extending from equator to latitude 8-degree north. The islands are grouped in to units called as atolls for the purposes of administration.

Coconut plays a major role in the economy of Maldives directly by providing food and income from coconut products, and indirectly as an important component of the landscape, where tourism plays a key role in the economy. The pest *Brontispa* was first noticed in December 1999 on Sun Island resort (local name: Nalaguraidhoo; 1 600 by 380 meters) in South Ari Atoll, but uncertainty about the potential impact of the pest delayed its reporting by resort management to Ministry of Fisheries, Agriculture and Marine Resources (MFAMR) until early 2000.

Discussions between MFAMR staff and management of Sun Island resort found that ornamental palms were imported in 1999 from nurseries in Malaysia and Indonesia. In the absence of adequate legislation stipulating quarantine intervention and its enforcement, the introduction of ornamentals into the Maldives is allowed provided a phytosanitary certificate is obtained from state authorities in the exporting country. However, the importation of coconuts and coconut planting materials from any country is prohibited by law. It is most probably that the *Brontispa* infestation originated from adult or immature stages of the pest that were concealed in these palms, as *Brontispa* is believed to be endemic to the Indonesian and Papua New Guinean region.

The pest has since known to spread to neighbouring inhabited island of Fenfushi and to Holiday Island resort (Dhiffushi, as well Maamigili [inhabited] and Ariyadhoo [uninhabited]) island within a couple of years.

Sun Island resort management in consultation with regional experts and MFAMR initiated chemical control measures for the pest starting from June 2000. These measures included cutting of infested leaf spears and application of insecticide (Carbamate 'Sevin') as a topical application on the cut leave stumps and central crown and injection of systemic insecticide (Monocrotophos) into the trunk of infested trees. In addition, recommendations were made to remove and burn seedlings. This was an emergency measure as infestation was very serious in the island.

Information provided by Sun Island resort management indicated direct economic losses between June 2000 and February 2003 at US$237 350.

Control of the beetle heavily depended on toxic insecticides. However, chemical insecticides pose serious health risks and damage to the environment. Nevertheless, the control programme, could not prevent the spread of the pest to five neighbouring

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islands (Holiday Island resort: Dhiffushi), the inhabited Maamigili and Fenfushi Islands, and the uninhabited islands of Tholufushi and Ariyadhoo. There is a serious risk of further spread of the pest to other islands in Ari Atoll, and to other atolls in the country. Many farmers from these islands and from Ari Atoll depend on coconut for food and income from coconut product sales to the resorts and tourists. Coconuts palms are also an important component of the landscape, contributing to the aesthetic beauty of many of the islands where tourism plays a key role in the economy.

Introduction of the pest into new areas will have a serious impact on production levels of coconuts for local consumption or for sale to nearby tourist resorts and markets in major population centres such as the capital Male'. The imposition of internal quarantine restrictions on the export of leaves for roof thatch or other tourist products made from leaves from *Brontispa* infested islands further affects the income of the local population.

However, the impact of the pest is as much feared for its direct impact on the tourist industry: the damaged leaves affect the aesthetic appearance of the palm trees which forms a major attraction for tourists. With the national economy heavily dependent on the tourism industry – the majority of the Maldivians directly or indirectly depend on this sector – the risk of spread and potential impact of the pest is a major concern for the government. *Brontispa* is therefore a serious threat to the continued income generation and as such, the country's food security.

Of major international concern, however, was the significant risk of the pest spreading to nearby countries such as India and Sri Lanka. This risk will increase with the progressive invasion of the pest of other islands and atolls within the Maldives. Both India and Sri Lanka have a very large coconut industry and damage to the industry would be catastrophic. Coconut is also a very important crop that provides food security to thousands of people, and to the processing industry that is vital to both the economies of these countries. The effects of a *Brontispa* introduction to Sri Lanka and India will be much more severe and far-reaching than those seen in the Maldives. This provides further support to the need for immediate and concerted action for control in the Maldives.

Due to the seriousness of the pest and the failures in attempted control measures, the MFAMR requested Food and Agriculture Organization of the United Nations (FAO) for special assistance and the project: TCP/MDV/2904(A) Integrated Pest Management of Coconut Hispid Beetle; *Brontispa longissima* was launched in September 2003, to address the pest problem in the Maldives. The overall objective of the project is:

"Livelihoods of the people of the Maldives secured by reviving the productivity and attractiveness of coconut palms through management of the destructive introduced coconut hispid beetle with ecologically-friendly Integrated Pest Management (IPM) practices, focusing on biological control through the introduction of natural enemies".

The immediate/specific objectives focused on:

1. Authoritative identification to species level of the coconut leaf beetle that is causing problems in the Maldives, and of any principal natural enemies (parasitoids, predators, pathogens).
2. Collection of natural enemies (parasitoids, predators and pathogens) of coconut leaf beetle from semi-quarantine rearing facilities in Viet Nam

and/or Nauru, and their importation into the Maldives, with due consideration of established international guidelines and procedures pertaining to quarantine requirements.

3. Introduction and successful rearing of exotic parasitoids of *Brontispa* in captivity in the Maldives.
4. Release of exotic natural enemies in the infested areas.
5. Assessment of effectiveness of exotic natural enemies in controlling *Brontispa.*
6. A control strategy developed and recommended for the control of *Brontispa* in coconut in the Maldives, including appropriate improved agronomic practices that ensure good plant health.
7. A training programme developed and implemented for researchers, extension officers and farmers in the control of *Brontispa* in coconut.
8. Development and implementation of an awareness-raising programme to educate the people about coconut leaf beetle IPM, focusing on the biology and impact of natural enemies of the leaf beetle as well as the value of natural enemies for suppressing pests in other crops.

Main project activities

1. Identification of the pest

In 2002, Ministry of Fisheries, Agriculture and Marine Resources tentatively confirmed the identity of the pest. Samples of the beetle collected in February 2003 were identified by Dr Peter Maddison, of Field Studies, Auckland, New Zealand, as the “Coconut Hispid Beetle” *Brontispa longissima* Gestro.

2. Survey of coconut hispid beetle distribution

Two FAO consultants Mr Allan Chambers (Quarantine Specialist) and Mr Wilco Liebgrets (Project Team Leader) and a technical team from MFAMR (Ms Aminath Shafia – Project National Coordinator, Mr Mohamed Firsah – Project Local Counterpart) surveyed all islands of North and South Ari Atoll for the presence of the pest and its natural enemies.

The survey team visited all islands including resorts and villages. Coastal coconut palms on small uninhabited islands were surveyed from the boat with a high powered binocular for signs of characteristic pest damage.

The survey confirmed that the beetle had spread from the known distribution range (Fenfushi, Tholhufushi, Nalaguraidhoo, Dhiffushi, Maamigili and Ariyadhoo) to islands further eastwards Dhidhdhoo and Dhidhoofinolu and Dhigurah. The extent of infestation on Dhidhdhoo village indicated that the beetle had been present there at least for one year. Few infested palms were found on Dhidhoofinolhu and Dhigurah and it appears that the beetle reached the island at a later stage.

The survey also confirmed that the beetle had not spread to the northern parts of the atoll, however infestation of rhinoceros beetle, *Oryctes rhinoceros* was observed from many islands. The project team did not find any effective biocontrol agents of the pest from any surveyed island. Hence, it was concluded that a biological control agent need to be identified from other countries where successful biological control of coconut hispid beetle has been achieved. Furthermore, based on the survey and the available literature, the team concluded that only one species of *Brontispa* cause damage to the coconuts and other palms species in the Maldives.

The dispersal of the beetle over the islands in southern Ari atoll was not unexpected: the islands are located within very short distances, and it must be assumed that the pest can cross between these islands by flight. However, the distances between the infested island of Fenfushi in the south west and Huruelhi and Hukurudhoo in the south east, and between Dhigurah and Dhangethi in the east are quite considerable and are likely to provide a significant barrier to the further dispersal by flight of the beetle northwards in Ari atoll. Quarantine measures therefore are of the highest importance to prevent spread of the pest with coconut seedlings, palm trees and leaf materials that may be transported by the people.

The opportunity was used to distribute leaflets on the pest to island authorities and resort management staff to create awareness and stress the need for quarantine to reduce the risk of its further dispersal.

3. Chemical treatment

Until the identification of a biological control agent, a more effective and a less toxic chemical DIAZINON 10 percent GRANULES trade name DIAPHOS was introduced. The product is known to be a more effective product for coconut hispid beetle. The application method is also more suitable and less laborious compared to the previously used chemical 'Sevin'. (Sevin has to be applied to the palm by pouring a considerable amount of chemical into the cut palm frond).

Diaphos 10 gram bags, were inserted at the base of the sheath of un-opened leaf. Diaphos packet of 30 G per tree was enough for controlling the beetles efficiently for two to three months. To avoid re-infection, Diaphos was applied to all palms at the same time.

4. Identification and importation of a biological control agent

The parasitoid wasp *Asecodes hispinarum* was identified by the international project consultant from W. Samoa. This wasp was the major biological control agent that controlled the pest in Western Samoa during the 1980s. *A. hispinarum* was also found to be successful in the control of CBH in Viet Nam.

The parasitoid, *Asecodes hispinarum,* was imported to the Maldives as a pure culture that was reared for ten generations in the quarantine facility of Nong Lam University, Ho Chi Minh City (HCMC), Viet Nam. The parasitoid was transferred to semi quarantine laboratory at Sun Island resort (Nalaguraidhoo) for quarantine, mass rearing and field release to all infected islands of the Maldives.

A total of 150 mummies were introduced from Viet Nam, which was parasitized over a period of five days and isolated into individual glass vials prepared for shipment. A cardboard box containing the parasites in a dormant phase of development was hand-carried by the TCDC specialist from Viet Nam over Singapore to Maldives on 5 December. Upon arrival the package was kept in custody by MFAMR, until it was delivered to the semi-quarantine facility at Sun Island resort a day later.

International protocols for importing biological control agents were strictly followed. A dossier was prepared and all necessary authorization was obtained from relevant ministries.

5. Mass rearing of biological control agent at laboratory condition

At the laboratory provided by the management of Sun Island resort, mass rearing of the parasitoid began upon arrival of the parasitoids. To mass rear the parasitoids, the coconut hispid beetle was also required to be reared. Both these activities were carried out at Sun Island by MOFAMR staff assisted by resort staff.

The rearing procedure developed by Long Nam University, Viet Nam was followed.

Following the exposure of the first generation of parasitoids (i.e. those that emerged from the mummies imported from Viet Nam) to *Brontispa* host larvae for parasitization, a representative sample (some 100 dead parasitoids preserved in a vial with 80 percent ethanol) were sent to the Natural History Museum, London, United Kingdom, for verification and confirmation of the identity of *A. hispinarum*. This follows international protocols to ensure that the only the desired species is imported and used for mass rearing in the recipient country.

6. Release of parasitoids

The Executive Director MOFAMR, Mr Jaadullah Jameel, initiated the first official release of parasitoids on 9 February, during the official ceremony held on both Sun Island resort and Fenfushi Island. The ceremonies were attended by senior officials from FAO, Maldives Customs, MOFAMR and other relevant ministries. The team

was complemented by national news papers, Voice of Maldives and Television Maldives. Most members of the Project Coordinating Committee attended the ceremony. The parasitoid was released as adults by letting them fly into the environment and also the parasitized mummies of CHB were hung on trees for natural emergence and release. Parasitoid release had been continuously undertaken and the approximate number of parasitoids released is provided in Table 1.

Table 1. Details of the numbers and locations where parasitoids have been released to-date

***Brontispa infested* Island**	**Palm infestation (%) February 2004**	**No of adult parasitoids released**
1. Nalaguraidhoo (Sun Island resort)	23	140 420
2. Dhiffushi (Holiday Is. resort)	1	10 200
3. Dhidhdhoofinolhu (White Sands resort)	1	7 500
4. Maamigili	45	56 020
5. Fenfushi	40	44 640
6. Dhidhdhoo	1	5 000
7. Dhigurah	1	6 600
8. Ariyadhoo	10	28 900
Total		**299 280**

7. Awareness and quarantine programme

In view of the high risk of spread of the beetle to other islands within the atoll and to other atolls, a quarantine awareness campaign was launched to educate the public on the pest and the most likely methods of dispersal to new areas.

The *Brontispa* awareness programme started in March 2003 and has been very successful in increasing awareness on *Brontispa* among the local population.

Radio broadcasts on the threat of the coconut hispid beetle are frequent, and have contributed significantly to increase public awareness on the pest.

A special radio programme and a television programme were aired to inform people about the pest status in the country. Full colour posters containing important information regarding the pest was printed in both A2 and A3 formats; made in English and Dhivehi languages. The posters have been distributed to all inhabited islands, resorts, relevant ministries, schools, and the general public, to achieve maximum awareness. A leaflet of the pest is also prepared in local (Dhivehi) language and being distributed to the general public.

A workshop involving a broad cross-section of the Maldivian community was conducted in Male' as an initial awareness raising activity. After raising their awareness of the pest, attendees developed action plans aimed at dealing with the current situation and in the development of longer term strategies for preventing similar problem in the future.

The quarantine regulation imposed under this campaign is to prohibit inter island movement of fresh coconut leaves/fronds, mature coconut palms and coconut seedlings from a *Brontispa* infected island.

The programme also involves a *Brontispa* reporting mechanism. When the island community suspects the beetle in the island, they are requested to report MOFAMR. Upon reporting a scrutinizing team consisting of professionals who could identify symptoms, adults and young stages of hispid beetles visit the island and verify the situation. So far none of the reported islands is infected with the beetle.

8. Training

The training exercise is on-going and will be continued until end of project in August 2005. The availability of the posters and leaflets will enable the implementation of Train-the-Trainers for Community Awareness. MOFAMR staff was trained by the National Project Coordinator and the training programmes are underway. To-date training has been conducted in five atolls.

9. Assessment of effectiveness of A. hispinarum in controlling B. longissima

Assessment of the effectiveness of *A. hispinarum* in controlling the beetle is on-going. The data collected from the island after four months of parasitoid release indicated very low (less than 3 percent) parasitization in Sun Island resort while in other islands it was nil. However, this information provided confirmation that *Asecodes hispinarum* can survive and establish in the field conditions in the Maldives.

Further studies conducted in September 2004, revealed that the parasitization level is increasing. This survey was only carried out from Sun Island resort, however, depending on the data further islands will be selected for surveying. The surveyed palms showed that parasitization level is increasing (Table 2), compared to that of earlier studies. The studies also looked into detail counts of different stages of the parasitoid on palms showing *Brontispa* infestation.

Table 2. Parasitization level of *Brontispa*

	Average No. of Adult beetles	Average No. of L3 & L4 larvae	Total larvae/palm	% parasitised
Palms with no parasitoids	100	119	186	0
Palms with parasitoids	44	53	84	27.6

Although the number of surveyed palms were low (n = 5), palms infested with *Brontispa* with no parasitization shows higher numbers of adults and larvae. There is a two to three fold increase in the number of beetles and larva without the presence of the biological control agent. The conclusion from the on-going assessment studies include:

1. Following its initial release in February 2004, the larval parasitoid *Asecodes hispinarum* now appears established on Sun Island.
2. Observations indicate that many young, emerging coconut leaves show less damage.
3. There is yet no indication of a reduction in the number of trees damaged by *Brontispa*.
4. *Brontispa* and parasitoid populations vary considerably between individual trees, and it appears that they both are in a 'flux', typical of population dynamics in a host-parasitoid interactions, when the beneficial is increasing in numbers.
5. Parasitoids distribution appears somewhat 'clustered' to specific trees, and not spread evenly over the island.
6. It is yet too early to determine the effectiveness of parasitoids in controlling *Brontispa*.

Parasitoid establishment on the inhabited islands of Maamigili and Fenfushi appears more difficult, despite the release of large numbers of adult parasitoids and mummies on both islands. A possible reason is the harsher environment on these islands: there is little free water, less greenery, and greater areas of brighter surfaces (white sand on roads; white/grey houses; generally less shade; and less flowering plants. In contrast, Sun Island is fully cultivated with flowering ornamentals, lawns, coconut palms and banana, and is frequently watered. There are less bright surfaces that reflect sunlight. These conditions are more conducive to parasitoid establishment.

Current status of *Brontispa* infestation in Myanmar

Kyu Kyu Swe Tin*

Preamble

Brontispa longissima is a serious pest to the coconut trees and it has been known to occur in Myanmar since early 2004. It was introduced by unknown path way and the situation is under investigation. The FAO Resident Representative office is encouraged to investigate the infestation at the Department's earliest convenience and notify the scientists concerned from the FAO Regional Office for their information and requesting technical advice.

It was suggested by the Industrial Crop Officer from FAO Regional Office that the investigation should commence as soon as possible and also advised to acquire public awareness for the existence of this serious pest and seeking for appropriate control measures.

Work programme

Plant Protection Division of the Myanmar Agriculture Service had organized a workshop to initially investigate where the infestation of *Brontispa* occurred in Myanmar. The plant protection team leaders from Kayin State, Mon State and Tanintharyi Division sharing borders with Thailand had attended. Apart from those, other plant protection team leaders from Yangon Division, Bago Division and Ayerwady Division where coconut trees and ornamental plants are widely produced also participated.

Technical staff from Plant Protection Division had discussed the detailed features of the pest and its natural enemies, control strategies, etc. from the experiences of some other nations. A specific survey in line with International Standards for Phytosanitary Measures (ISPM) No. 8 has been planned to be conducted in some designated States and Divisions.

Observation of naturally infested coconuts and other related species of plants are very critical for the Plant Protection Division due to inadequate information sources, expertise and equipments. Therefore, plant protection teams of two states and four divisions have been assigned to conduct the specific survey for *Brontispa* with available support.

Future aspects

Coconut has not been an important industrial crop to the country. However, oil palm is gaining significance with the emergence of oil palm industry in line with the country's ambition to produce sufficient amount of edible oil. The survey will be done in a few months for infestation of *Brontispa* in areas of oil palm lands. The plant protection team Leaders from those areas have reported problems other than *Brontispa* infestation that require further specific survey.

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Control measures

Chemical control is not practicable in some coconut farms due to the height of the plants. For some smaller coconut trees and ornamental plants nearby, some sort of basal application of systemic insecticides is used. In the context of biological control thorough investigation on the use of entomo-pathogens like *Metarhizium anisopliae* is to be done. In 1990s, Plant Protection Division had some experiences in the application of *Metarhizium anisopliae* to control groundnut chafer beetle *Anomala antiqua*. Some cultures were still maintained in the biological control laboratory of IPM section; however research will be needed to verify the effectiveness of available strains against *Brontispa.*

Myanmar's perspective

Like some other nations in this region, Myanmar would like to share experiences and knowledge in this particular pest from any national or international agencies and has suggested obtaining opportunity for implementing regional TCP programme for coconut hispine beetle, *Brontispa*.

Current status of key coconut Hispine beetles in Sri Lanka

M.A.K. Wijesinghe*

Introduction

Sri Lanka grows coconut as a main plantation crop. It occupies 440 000 ha of coconut lands in the country (Liyanage, 1999). Coconut plantations in Sri Lanka face many types of pest and disease problems. Among the pests, infestation of *Chrysomelid* beetles is one of the problems to coconut industry. Mainly two types of *Chrysomelid* beetles, *Brontispa longissima* and *Plesispa reichei* are reported to be attacking coconut palms in the world. However, *P. reichei* is still considered as a minor coconut pest whereas *B. longissima* is not reported in Sri Lanka (Fernando, 2004).

The pest, *P. reichei* was first reported from Walpita area (western province) (Anon, 1999) and now it is spreading to other coconut areas slowly. *P. reichei* attacks seedlings in the nursery as well as those established in the field.

Damage symptoms

Both adults and larvae damage the leaflets of young unopened fronds by feeding on tissues. The symptoms are prominent when the affected leaves become unfolded and green. Small brown patches of varying sizes and light brown streaks, which are typically parallel to the midrib could be observed in the opened green leaflets. The brown areas shrivel and curl, giving the leaf a characteristic scorched, ragged appearance.

Figure 1: Damaged shoot (left) **Damaged leaves of a seedling** (right)

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Life cycle and morphology of the pest

No studies have been conducted on life cycle and other aspects the biology of this pest in Sri Lanka. However, literature shows that lifespan of the adult is about six to eight months. Head and thorax of the pest are brownish orange in colour while the abdomen is black. Males (about 6.5 mm long) are comparatively smaller than females (about 7.5 mm).

Figure 2: Adult (left) **and larva** (right) **of *P. reichei***

The pest is now spreading to other coconut growing areas slowly. Further, it is noted that the stage of the damage, symptoms and morphology of the pest reported as *P. reichei,* is quite similar to those of *B. longissima*. Since *B. longissima* is present in our neighbouring island Maldives and many exchanges occur in between both countries daily, chances are higher to introduce the pest to our country. This suggests the necessity of re identification of the pest. If the pest *B. longissima is* already present, great care has to be taken to prevent its spread to other coconut growing areas as its damage is fatal.

A study has been conducted to screen some botanicals and synthetic insecticides against *P. reichei* at Coconut Research Institute, Lunuwila, Sri Lanka. Chemical insecticides Marshal 20 percent EC and Chloropyrifos 20 percent EC have shown more promise in controlling the pest (Anon, 1999).

Other than chemicals, no possible IPM or biological control measures have been attempted yet. In adopting IPM and biological measures, biology, ecology and other relevant factors of the pest should be studied properly.

It does not matter if the pest is *B. longissima* or *P. reichei*, but it is interesting to note that the pest is spreading slowly. This may be attributed to the tolerance of palms, occurrence of natural enemies and some other unknown factors prevails in Sri Lanka. These should be explored and the findings could be exploited to control the pest under Sri Lankan conditions. The information could be very useful in formulating a sustainable IPM programme against *B. longissima* in other countries too, as both pests belong to the same family.

Pertinent litérature on *B. longissima*

Host range

B. longissima attacks several species of palmae (*Arecaceae*), however, coconut is the primary host. In addition, *B. longissima* attacks sago palms, areca or betel palm (*Areca catechu*), royal palms (*Roystonea regia*), oil palm and ornamental palms in Papua New Guinea. In northern Australia, hosts include areca palms (*A. catechu*), nicobar palm (*Bentinckia nicobarica*), carpentaria palm (*Carpentaria acuminata*) and fish tail palm (*Caryota mitis*). In Hong Kong, it is also reported from ivory nut palm (*Phytelephas*), petticoat palm (*Washingtonia robusta*), king palm (*Archontophoenix alexandrae*) and dwarf date palm (*Phoenix roebelenii*). (Crop Protection Compendium, CABI International 2002).

Geography

B. longissima was originally described from the Aru Islands. It is native to Indonesia, possibly to Irian Java, and also to Papua New Guinea, including the Bismarck Archipelago, where it seldom causes serious problems. It was reported from the Solomon Islands in 1929 and from Vanuatu in 1937 (Risbec, 1942). Risbec (1942) stated that it had been present in New Caledonia for several years. *B. longissima* was reported from New Caledonia (Tahiti) (Cohic, 1961), American Samoa (Long, 1974) and Western Samoa (Anon, 1981). It is also present in northern Australia (Fenner, 1984) and Taiwan (Shiau, 1982).

B. longissima Gestro, was first found in Pingtung, Taiwan in 1975 (Anon 2004a). Later, it spread to north and east Hualien and Taitung, and has since become a serious pest to coconut palms.

B. longissima was detected in Hong Kong in 1988 infesting 30 petticoat palms in a nursery (Lau, 1991). Though it was eradicated, some reports show its establishment in Hong Kong and suspected that *B. longissima* was introduced from China, probably from the Shenzhen area of Guangdong province.

In Nauru, the pest was detected first in April 2001 (Anon 2004b). The pest has been reported in Maldives Island very recently (Anon 2004c).

Natural enemies of *B. longissima*

Three wasp parasitoids of *B. longissima* are known in Java. Two of these are egg parasitoids: the trichogrammatid *Hispidophila brontispa*; and the encyrtid *Ooencyrtus pindarus*. One *H. brontispa* wasp develops per *Brontispa* egg, producing about 15-17 percent parasitism (Kalshoven, 1981; Waterhouse and Norris, 1987), and *O. pindarus* produces about 10 percent parasitism (Kalshoven, 1981). The eulophid, *Tetrastichus brontispa*, which is found in 60-90 percent of the pupae (Awibowo, 1934) and 10 percent of the larvae, develops in 18 days; about 20 specimens emerge from one *Brontispa* pupa.

Parasitized larvae may die before pupation, but parasitoids will emerge. However, the level of parasitization by *T. brontispa* is not always high and Lange (1950) recorded an average of only 16 percent in pupae. The life cycle of *T. brontispa* is 16-21 days (Lever, 1936a, b; Lange, 1953). *Tetratichus brontispa* (Fern.) was introduced to Taiwan from Guam to control *B. longissima* in 1983. The percentage of parasitism recorded from field recoveries made in Chen-chin-hu and Lin-bien were 21.2-79.2 percent and 9.3-36.2 percent, respectively. (http://www.fftc.agnet.org/library/article/eb224a.html).

Two native wasp parasitoids are known in the Rabaul district of Papua New Guinea: the non-specific egg parasitoid, *Trichogrammatoidea nana,* and the eulophid larval parasitoid, *Chrysonotomyia* sp. A large percentage of *Brontispa* eggs are attacked by *T. nana*, which has also been bred from *Brontispa* eggs in the Solomon Islands. *Chrysonotomyia* sp. is comparatively rare.

Occasionally, *Brontispa* larvae have been killed by a bacterial disease (Froggatt and O'Connor, 1941; O'Connor, 1940) or by the fungus *Metarhizium anisopliae* in Papua New Guinea (Waterhouse and Norris, 1987). The fungus which was found to affect

larvae, pupae and adult of *Brontispa* (Maddison, 1983) may be effective in managing *B. longissima*. *M. anisopliae* caused 15-20 percent mortality of both adults and larvae of *Brontispa* in American Samoa (Waterhouse and Norris, 1987).

In Australia, large numbers of torn, empty egg shells of *Brontispa* have been found in a nest of the ant, *Tetramorium simillimum*, but the significance of this ant in influencing numbers of the pest is unknown (Fenner, 1984). The ant *Pheidole megacephala* attacks *T. brontispa* in New Caledonia and both young larvae and parasitized pupae of *Brontispa* (Cochereau, 1965).

The earwig *Chelisoches morio* has been reported as a predator of *B. longissima* in Vanuatu (Risbec, 1933).

Metarhizium anisopliae is available in Sri Lanka. The natural enemies listed here and some other new natural enemies which are highly effective in controlling *B. longissima* could be present in Sri Lanka and other counties. These natural enemies and their role in manipulating the pest level below economic injury level could be explored and it would be much useful in formulating a suitable IPM package to control *B. longissima.*

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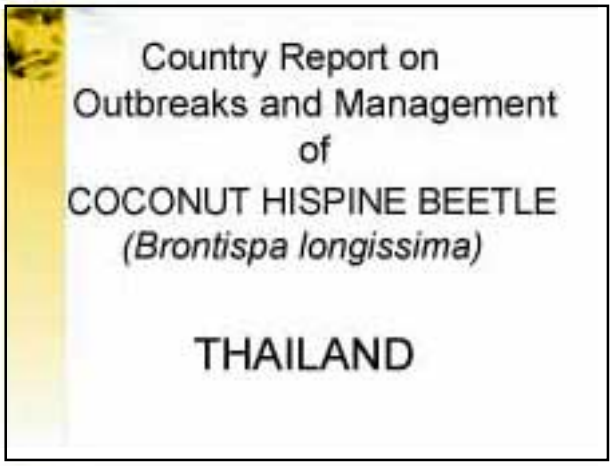
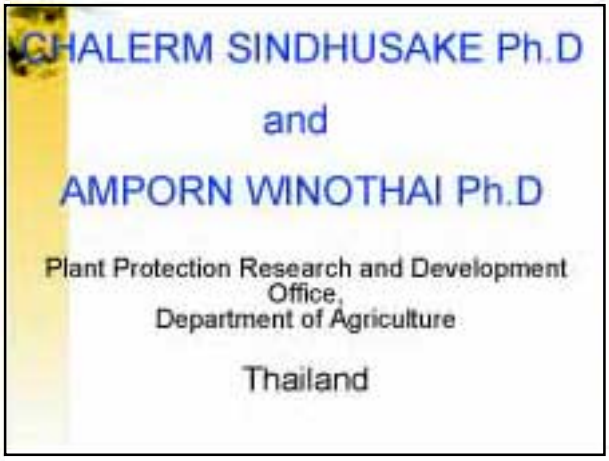
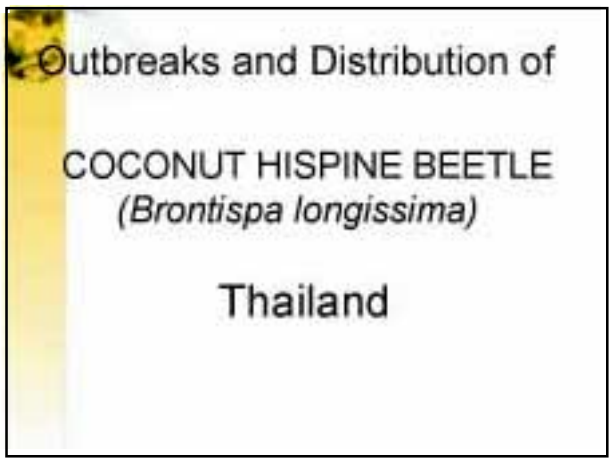
Outbreaks and management of coconut hispine beetle *(Brontispa longissima)* Thailand

Chalerm Sindhusake* and Amporn Winothai**







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** Plant Protection Research and Development Office, Department of Agriculture, Bangkok, Thailand.

View of Samui Port

Outbreaks

- First record of *Brontispa* damage at Narathiwas province, border area near Malaysia in 2000
- First report on heavy infestation from southern provinces at Surat Thani (Samui Island, Pa-ngan Island), and Prachuap Khiri Kan in February 2004

Outbreaks

- Survey on distribution and degree of infestation on *Brontispa* was done in coconut plantation areas in Thailand

Distribution of *Brontispa*

How do you know the *Brontispa* distribution and degree of infestation in Thailand?

- 4 Working Groups surveyed in the infestation areas
- 100 coconut trees along the road were counted every 50 km in the Central Plain, Eastern, Upper South and Lower South
- GPS as the tool for identify *Brontispa* at infested areas and recorded degree of infestation in each sites

Distribution of *Brontispa*

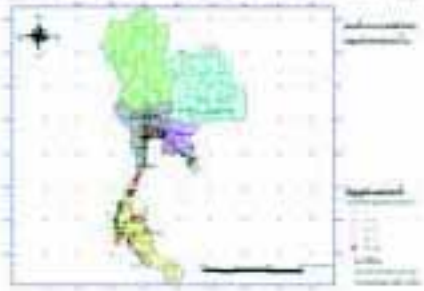
Distribution of *Brontispa* in Southern Thailand

Distribution of *Brontispa*

Distribution of *Brontispa* in Central Thailand

Distribution of *Brontispa*

Distribution of *Brontispa* in overview of Thailand



Control Strategies Programme in Thailand

1. Follow up procurement, importation and release procedures of international regulations:

• Code of Conduct for the Import and Release of Exotic Biological Control Agents – Part 1: Import Regulations. International Standards for Phytosanitary measures. FAO, Rome. 1996.

Control Strategies Programme in Thailand

1. Follow up procurement, importation and release procedures of international regulations (Con't):

• Guideline for Biological Control Projects in the Pacific. Information Document No. 57 ACIAR and South Pacific Commission, Noumea, New Caledonea. 1997.

Control Strategies Programme in Thailand

2. Mass rearing *Brontispa in laboratory*

Control Strategies Programme in Thailand

3. Mass rearing of *Asecodes hispinarum* parasitoid in semi-quarantine room

• Allowed import permit from DoA

• Introduced of parasitoids as the mummifies (dead larvae) from Nong Lam Univ., Vietnam

• Mass rearing of parasitoid with *Brontispa* in semi-quarantine room at Biological Control Res. Group as pure culture w/o any contaminants

Mass rearing *Asecodes hispinarum* in semi-quarantine rearing facility at Biological Control Section, PPRDO

• August 25, 2004: Amount of 100 mummied from Vietnam obtained only 88 parasitoid mummies and given 4,400 parasitoids

Mass *Asecodes hispinarum* in semi-quarantine rearing facility at Biological Control Section, PPRDO

Date	Larvae	Mummies	Parasitoid mummies	Parasitoid
Aug 31	560	399	152	
Sept 1	930	497	196	
Sept 2	600	332	197	
Total			633	31,650

Mass *Asecodes hispinarum* in semi-quarantine rearing facility at Biological Control Section, PPRDO

Date	Larvae	Mummies	Parasitoid mummies	Parasitoid
Sept 19	280			
Sept 20	1,920			
Sept 21	1,640			
Sept 22	1,115			
Sept 23	227			
Total	4,902		2,395	119,750

Control Strategies Programme in Thailand

4. Analysis of host specificity

- Host specificity has been tested on larvae of flour beetle *(Tenebrio molitor)*, leaf beetle *(Harmonia convergent)*, common cutworm *(Spodoptera litura)* and larvae of lacewing predators *Mallada basalis*, and *Chrysoperla carnea*

Control Strategies Programme in Thailand

4. Analysis of host specificity (Con't)

- Results were confirmed parasitoid does not attack these species
- Proven to be highly specific, survive only on *Brontispa longissima*

Control Strategies Programme in Thailand

5. Survey and identification of native natural enemies in Thailand

Parasitoid

- Larval parasitoid *Tetrastichus sp.* (Hymenoptera: Eulophidae) and unknown parasitoid at Songkhla Field Crop Research Center, Southern province
- Unknown egg parasitoid Encyrtid (Hymenoptera: Encyrtidae) at Prachuap Khiri Kan

Control Strategies Programme in Thailand

5. Survey and identification of native natural enemies in Thailand (Con't)

Predator and pathogen

- Predator earwigs at Prachuap Khiri Kan, Chachoengsao and BKK
- Fungus *Metarhizium anisopliae* at Prachuap Khiri Kan, Chachoengsao, BKK and Surat Thani

Training course

- Provide training course for farmers and hotel owners at Koh Samui, Surat Thani

Training course

- Parasitoid releasing tool was adapted from fruit-fly pheromone trap set up at the coconut plantation

Control Strategies Programme in Thailand

Research programme

- Implementation and evaluation of *Brontispa* parasitism in the farmers' fields
- *Brontispa* ecology and alternate host plants
- Identify of the native natural enemies
- Make control strategies for sustainable control of *Brontispa* IPM and IPM on other coconut palm pests

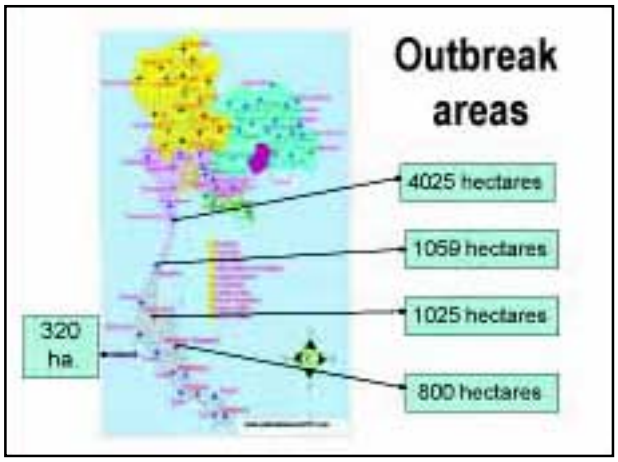
Control Strategies Programme in Thailand

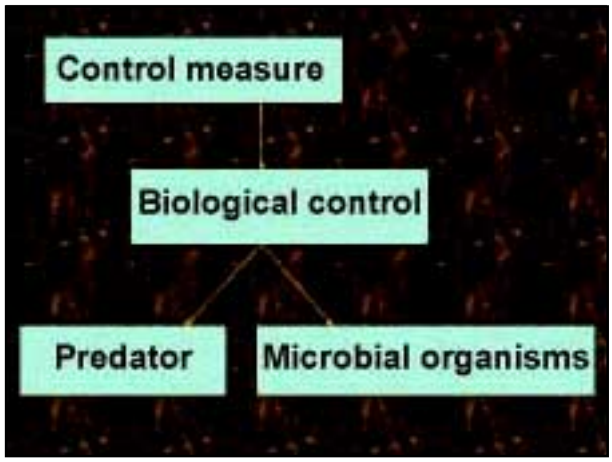
Implementation programme

- Arranging training courses (TOT) for at lease 100 DoA and DoAE plant protection officials at the infestation areas in technology transfer
- Arranging Farmer Field Schools in infestation areas
- Kick-off campaign on awareness of move out of palm seedlings with pests to other non-infested areas

Coconut beetle control

Patcharee Menakanit*





* Director of Pest Management Division, Bureau of Agricultural Product Quality Development, Department of Agricultural Extension (DoAE), Bangkok, Thailand; e-mail: patcharee@doae.go.th

WORK PLAN
Activity
Duration
1 Pest and natural enemy monitoring
Oct 04 - Sept 05
2 Mass rearing of bio agents
Oct 04 - Sept 05
3 Training Field technicians Farmers
Dec 04 - Feb 05 Jan 05 - Apr 05
4 Field release
Oct 04 - Sept 05
5 Communication campaign
Mar 05 - July 05

Pest Management Center
THAILAND
- Chiangmai
- Pitsanulok
- Khon Kan
- Nakorn Rachasima
- Chainat
- Chol Buri
- Supanburi
- - Pran Buri
- Surat Thani
- Songkla

Chelissoches

Beauveria bassiana

Mass rearing of Brontispa longissima

Metarhizium anisopliae

Classical biological control of coconut hispine beetle with the parasitoid *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae) in Viet Nam

Tran Tan Viet*

TCP/VIE/2906-FAO Project

Classical Biological Control
of Coconut Hispine Beetle with the Parasitoid
Asecodes hispinarum Boucek (Hymenoptera:
Eulophidae)
in Viet Nam

TRAN TAN VIET
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Faculty of Agronomy
Nong Lam University, HCMC, Viet Nam
trantanviet@hcm.vnn.vn

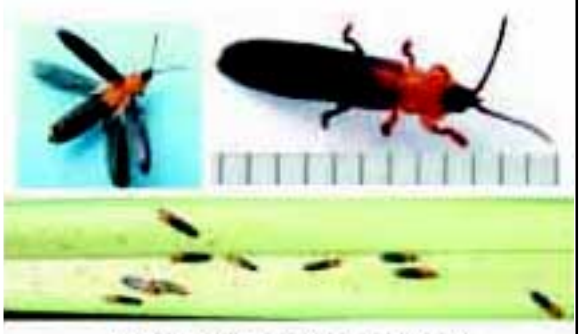
Contents:

- Importance of Coconut Palms and the Pest
- Pest History
- Control Measures
- Classical Biological Control

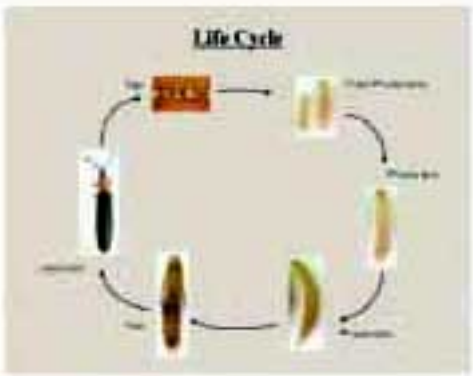
1. The Importance of Coconut and the Coconut Hispine Beetle (CHB)

- **210,000 ha of Coconut Palms, value at $US 87 millions/year (nuts).**
- **Yield loss: 30%**
- **Cost due to dead trees: $US17.8 millions**
- **Cost due to damage to ornmamental palm trees: $US838,000**
- **Cost for pesticides applications: $USD 722,323**

(Source: PPD's reports July 2002, February 2003, MARD 2003)



Adults Longevity (180-220 days)



2. The pest, *Brontispa longissima* Gestro (Coleoptera: Chrysomelidae)

- Developmental time: 29,9±2 days (at 28°C)
- Adult longevity: 223±15 days
- Total eggs laid: 153±20 to 431±108 (depend on food plants)
- Sex ratio = 1:0.5 (female/male)
- Both larva and adult eat on young coconut leaf
- Host ranges: attacking 17 species of two families Palmae and Cycadaceae

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HOST RANGE
17 Plant Species of Palmae and Cycadaceae

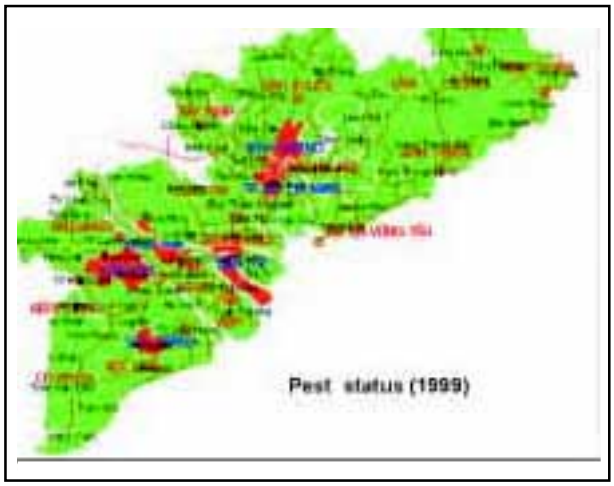
Coconut Palm | Oil Palm | Ornamental Palm

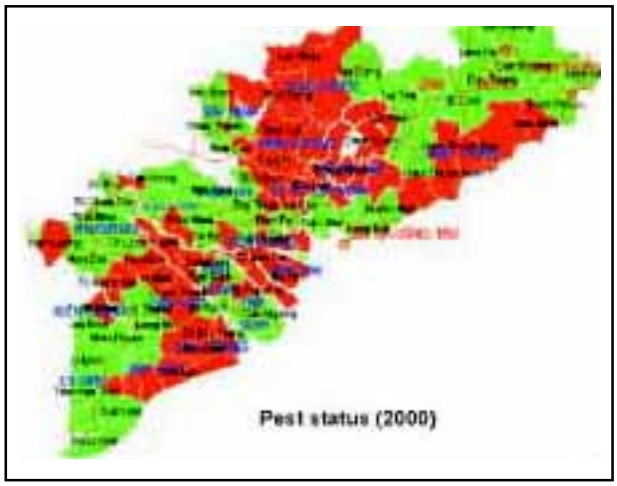
Including NIPA PALM

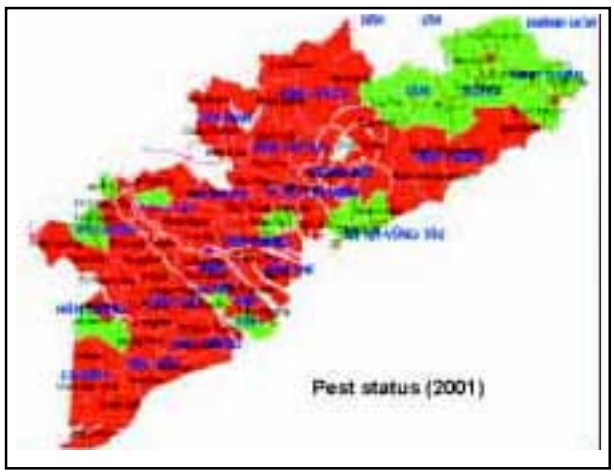
Cycas

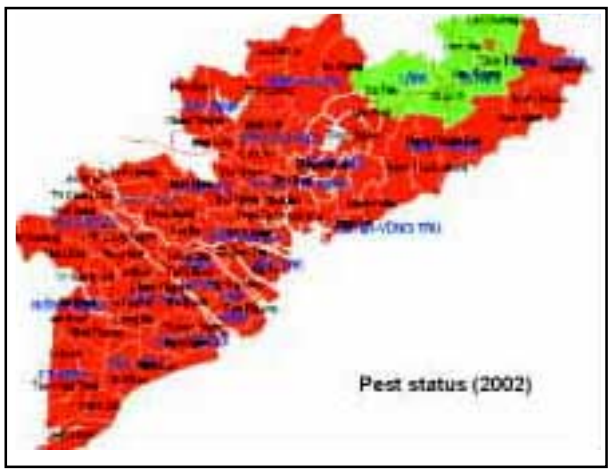
4. History of the CHB in Viet Nam

- April 1999, recorded first time in Dong Thap Province in with a few plants infected
- July 2000, Found 18/30 Provinces of the Southern infected
- August 2001 found 30/30 Provinces (3 millions plants infected)
- August 2002, found any where in Viet Nam (5.6 millions plants infected)
- 2003, about 9 millions plants infected


Pest status (1999)


Pest status (2000)


Pest status (2001)


Pest status (2002)

Attack in nursery

At a resort

Looking

Eat on leaflet
...and kill

At Tra Vinh Province 2002

Symptoms of damage

5 Symptoms of damage

5. Control measurements

- Chemical Insecticides Spraying:
  - Fastac, Karate, Sherpa
  - Labour-consuming and costly (0.35US Cents/plant)
  - Endanger to environment and labour
  - Low accessibility to the pest
  - Short effective period
  - Should be treated repeatedly

5. Control measurements:

- **Chemical insecticides "trunk injection":**
  - Controversial effectiveness, mostly say ineffective
  - Costly
  - Labour consuming
- **Chemical insecticides in "Tea-bag":**
  - Effective
  - Acceptable
  - Easy to apply
  - Should be used repeatedly
  - Harmful to environment

Chemical Control: Spraying Insecticides

Placing "Tea Bag"

Hanging "Tea Bag" in the Plant

5. Control measurements:

Bio-insecticides: *Metarhizium anisopliae*

- Labour consuming
- Weather depending
- Limit effective

Metarhizium anisopliae

5. Control measurements:

- Mechanical control: Cutting the spears
- Cultural Control: Fertilising and watering

Mechanical Control

5. Control measurements:

Native natural enemies conservations:

+ Yellow ants
+ Other ants colonied in plants
+ Earwigs
+ Small animals

The Parasitoid *Asecodes hispinarum* Boucek

- Larval endo-gregarious parasitoid
- Number of individuals produced per host: 30-160

5. Control measurements:

- **Classical biological control:**
  - Importation of *Asecodes hispinarum* from Western Samoa in June 2003
  - Subjected into quarantine procedures in Samoa and Viet Nam
  - First official release made on August 2003
  - The parasitoid has been released at 15 Provinces in the Southern and Central Viet Nam

A. hispinarum:

- Developmental time: 17±1 days (at 28°C)
- Adult longevity: 3.4 days (female); 4.1 days (male)
- Host stage selection (table 1)

Host Stage Suitability (non-choice test)

Stage	No. host tested	% Parasitism	No. Parasitoids emerged per a host	Sex ratio (M/F)
Eggs	30	0.0	-	-
1st instar	30	13.3	4.0	1:1
2nd instar	30	40.0	9.6	1:1
3rd instar	30	93.3	25.6	1:2
4th instar	30	96.7	60.9	1:3
Prepupae	30	20.0	40.8	1:5
Pupae	30	3.3	59.0	1:4

Host Stage Preference (choice test)

Stage	No. Host tested	% Parasitism	No. Parasitoids emerged per a host	Sex ratio (M/F)
1st instar	20	0	-	-
2nd instar	20	5	5	1:1.5
3rd instar	20	30	24.8	1:1.8
4th instar	20	35	57.7	1:3.9
Prepupae	20	0		
Pupae	20	0		

Parasitization

Host stage preference

Symptoms of parasitization

Parasitoids emerged from parasitised larva

6. Parasitoid release

- Equipments for release:
  - Plastic boxes
  - Paper boxes
- Density of parasitoids: 5 mummies/box at each 200 m, or 500 m apart.

Collecting hosts for assessment

6. Parasitoid releasing methods:

- Adult stage:
  - Consuming labour
  - Ineffective (failed in Naruu)
- Developmental stages: It was found that the parasitoid can be released in form of mummies since 7 to 17 days after parasitization.
- Sites of release: close to infected areas

Release as mummified hosts in plastic box

Release Site: Outdoor

Release of parasites

Rate of spread in southern Viet Nam:

5 (- 8) km per 2 months

Official Ceremony for First Release (August 2003)

Some Recent Results:

- Established at 15 Provinces where the parasitoids were released.
- Speech of spread: 5-8 km in 2 months from the releasing sites.
  (in BT province found 34 km down wind direction)
- Recovery of palm trees after 2-4 months release: 60-90%
- Pesticides companies failed to sell any insecticides to treat CHB since the project implementation

Annex 5

Working session 1: Discussion on biocontrol guidelines

Participants were given a questionnaire to determine the availability of various procedures and facilities in their respective countries. Results (Table 1) showed that overall, about half the requirements were available. Most of the counties had updated information on their coconut pest situation, quarantine facilities, national biocontrol skills and access to pest information. Least available were access to taxonomic resources, national funding support and economic and environmental impact assessment capacities. The countries best prepared were Thailand and Viet Nam, while Cambodia and Maldives needed the most help.

Regarding the flowchart for *Brontispa* classical biological control (Figure 1), several suggestions were made such as: early and continuous public awareness and involvement, cumulating in Farmer Field School (FFS)-type farmer education activities during release and control phase; inspecting for natural enemies while conducting pest surveillance; conduct of host range and other studies during quarantine; inform APPPC parallel to planning for biocontrol; point out parallel processes and decision points; reconfirm identity of biocontrol agent prior to release; or advocacy by researchers for support from policy-makers. It was pointed out that there should be separate permits for the import and release of biocontrol agents, and inundative releases should be preceded by a pilot release on a smaller scale. Farmers should be discouraged to use counterproductive measures such as pesticides during the establishment period; this can best be achieved if they are aware of the biocontrol activities and have studied the live cycles of the pest and natural enemies.

To follow the spirit of ISPM #3, biocontrol management should consider different ecological zones separately. This would mean that neighbouring countries in the same eco-zone should work together and conduct the pest risk assessment jointly, while large countries like China and Indonesia should consider separate procedures for different eco-zones even though ISPM does not require that.

Suggestions:

1. Classical biocontrol of *Brontispa* should follow the guidelines specified in ISPM #2[1] and ISPM #3[2].
2. Following the spirit of ISPM #3, biocontrol management should consider different ecological zones separately. This would require closer regional cooperation between neighbouring countries of the same eco-zone, while large countries should consider separate procedures for different zones.
3. Recognizing the importance of public awareness and farmer education for the success of biocontrol efforts, parallel activities should start after the surveillance phase by informing the public of the outbreak and control options, and should cumulate in FFS-type farmer education activities where farmers learn about the life cycle of the pest and natural enemies.

[1] International Standards for Phytosanitary Measures – Guidelines for pest risk analysis Publication No. 2, February 1996 FAO, Rome. 19 pp.

[2] International Standards for Phytosanitary Measures – Code of conduct for the import and release of exotic biological control agents Publication No. 3, February 1996 FAO, Rome. 19 pp.

Table 1. Questionnaire results

	Availability of …	Cambodia	China	Indonesia	Lao PDR	Malaysia	Maldives	Myanmar	Sri Lanka	Thailand	Viet Nam		
1	updated country information on coconut pests (inc. distribution, impact, importance, control measures)	▒	■	▒	▒	▒	■	■	■	▒	■	5	0
2	access to pest info (literature, database/web)		▒	▒	▒	▒	■	■	▒	▒	■	3	1
3	access to taxonomic resources (ID to species)		▒	■		▒			▒		▒	1	5
4	national insect reference collection		■	▒	■	▒	▒	■	■	■	■	6	1
5	protocol for informing pest incursions to APPPC	▒	■		▒	■		■			▒	3	4
6	national legislation/regulations for biocontrol	▒	▒	▒	▒	■	▒	■		■		3	2
7	national biocontrol skills and expertise		▒	▒	▒	▒	▒	■	■	■	▒	3	1
8	pest risk assessment capacities (PRA)		■	▒	▒	▒		■	▒	▒	■	3	2
9	quarantine facility	▒	■	■	▒	■			■	■	▒	5	2
10	mass rearing facility		▒	▒	▒		▒		▒	■	■	2	3
11	regulations and enforcement of domestic quarantine	▒	■	▒	▒	■	▒		▒	■		3	2
12	national funding support for biocontrol activities		▒	▒		▒			▒	▒	▒	0	4
13	economic and environmental impact assessment capacity		▒	▒			▒	■	▒	▒	■	2	3
		8	0	1	3	1	5	5	2	2	2		

■ Yes ▒ Partial □ No

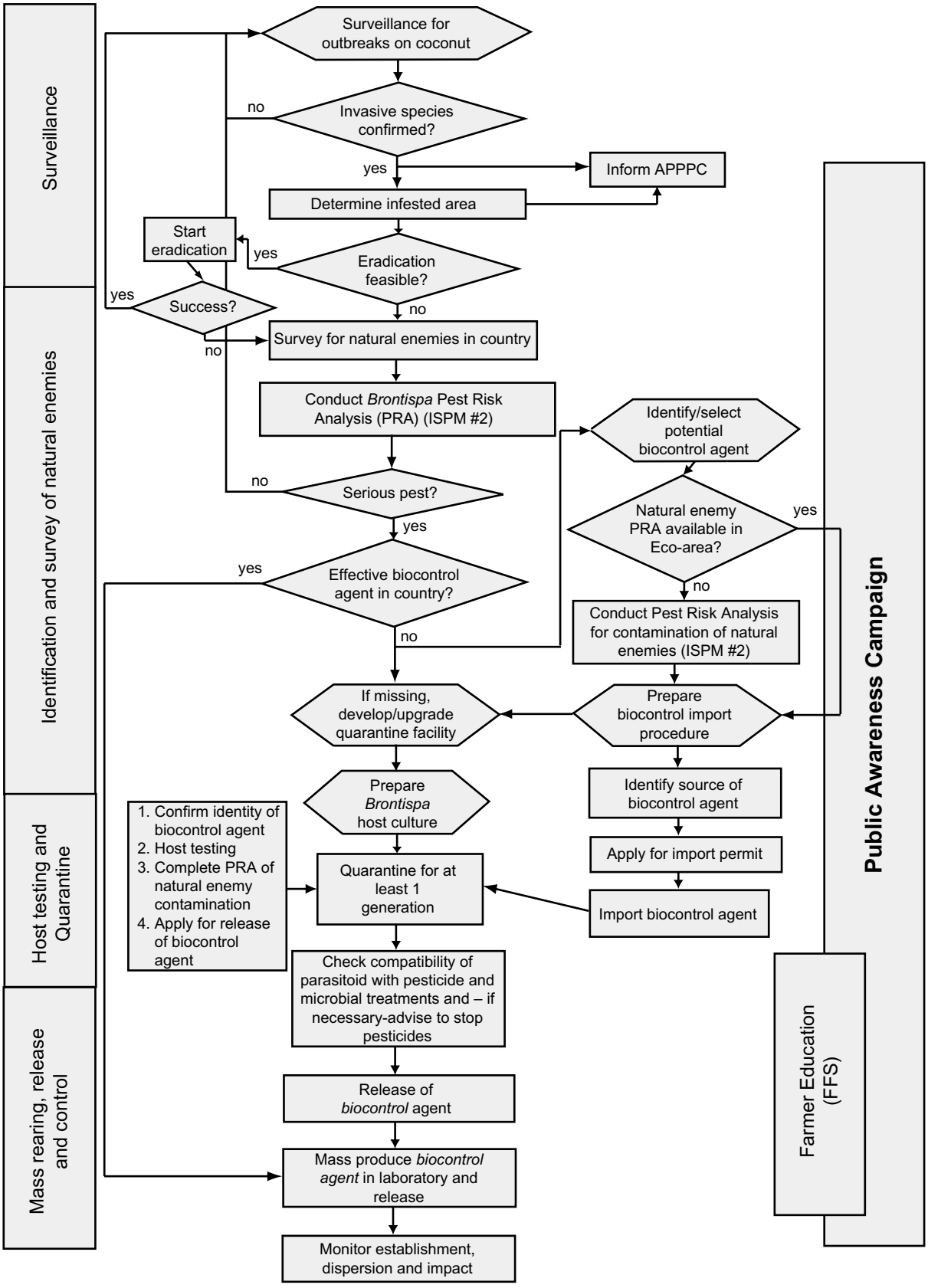


Figure 1: Flowchart for *Brontispa* classical biological control*

* For more details please refer to ISMP #3.

Annex 6

Working session 2: Questions and answers

In this session, participants are invited to respond to the four questions posed by the facilitator and the answers are listed:

Q. Why does it take so long to initiate biological control for an introduced pest like Brontispa?

Answers:

1. Lack of information.
2. Lack of expertise/experience.
3. Importance of the pest not understood.
4. Infrastructure/capacity.
5. Over-emphasis of chemical control.
6. Governmental management systems of controlling and reporting invasive pests.
7. Mindset for easy option (quick fix by use of chemical control).
8. Policy advocacy.

Q. Are national programmes sufficiently ready and capable to carry out classical biological control?

Answers:

1. Training of quarantine and plant protection as well as harmonizing knowledge.
2. Expert knowledge and practical experience.
3. Financial requirements for mass application.
4. Capacity building and facilities.
5. Specificity of biological control agent requires high level expertise.
6. Sharing of experiences.
7. Strengthen quarantine.
8. Farmer Education.
9. Public awareness and publicity.

Q. What is the benefit of regional collaboration and regional programme in classical biological control of coconut pests?

Answers:

1. Speeds up the activity implementation.
2. Reduces costs and increases sustainability.
3. Optimizes resources.
4. Shares experiences/knowledge and avoids bad lessons/pitfalls.
5. Facilitates exchanges of biological agents.
6. Promotes understanding between countries.

Q. What would you recommend to strengthen and enhance the capacity to implement classical biological control?

Answers:

1. Database of crop pests and natural enemies (coconuts and other crops).
2. National project/programme setting.
3. Impact assessment as part of the programme.
4. Enhance the capacity of extension staff.
5. Advocacy/meetings.
6. Strengthening regulatory framework of pesticides.

Annex 7

Manual for mass-rearing *Asecodes Hispinarum*, a parasitoid of hispine beetle, *Brontispa Longissima*

Nguyen Thi Thuy Oanh, Nguyen Huu Truc, Le Cao Luong

Introduction

The hispine beetle, *Brontispa longissima* Gestro is spreading in many countries of Southeast Asia and the Pacific. Recently, it was recorded to have appeared in Viet Nam, Maldives, Singapore, China and Nauru.

Both larvae and adults feed on the leaves of coconut palms and other species of the family Palmae. The damage caused by the insect leads to leaf burn, yield loss and in many cases, plant death. According to scientific literature, this insect pest can be completely controlled at low cost by using natural enemies, especially parasitoids.

The project TCP/VIE/2905, funded by FAO, commenced in Viet Nam in February, 2003. In June, the parasitoid *Asecodes hispinarum* was imported from Samoa, subjected into quarantine and released in August, 2003. Field surveys confirmed that the parasitoid was established in many areas of Viet Nam. To help the parasitoid spread over the country, local parasitoid rearing and release is desirable. This document is designed to support training programmes for that purpose.

Biology of *Brontispa*

1. Adults lay one to five eggs per day and live up to 220 days during which they can lay 100 eggs. The adults hide from daylight and move slowly mostly at night time.

2. Eggs are laid in clusters of 1-5 eggs and hatch after five days.

3. Larvae chew leaf surfaces. There are four instar larval stages with a duration of 30 to 40 days. Larvae are less active.

4. *Brontispa* normally chewes on un-opened leaves. The damaged leaves become dry.

Mass-rearing *Brontispa* Since *A. hispinarum* is a specific parasitoid which only parasitizes its host – the hispine beetle should be mass-reared to provide a host for the parasitoid.

5. Preparing boxes for rearing: Plastic boxes of different sizes can be used. This picture shows plastic boxes with the dimension: 30 x 10 x 6 cm (L x W x H). The lid is cut and replaced by a piece of fine cloth fixed by glue for ventilation.

6. Leaflets of coconut spears are cut into small pieces of 5-7 cm length. Make sure that the leaf is not contaminated with any insecticides.

7. Place 50-60 female adult *Brontispa* into a box containing small pieces of leaf on which the females will lay eggs.

8. Prepare a new box with fresh leaves every two days and transfer the adult *Brontispa* into the new box. It is necessary to add some new adult *Brontispa* to replace dead ones.

9. The eggs will hatch between four to five days after being laid. Transfer 100 larvae each in to a box with small pieces of leaf which are replaced every three to four days.

10. This picture shows how to transfer larvae into new boxes.

11. This picture shows how to transfer larvae into new boxes.

12. Keep pupae in boxes with 2-3 pieces of leaf which provide as food when pupae become adult.

Mass-rearing parasitoid

Biology:

- Life cycle: from egg to adult emergence: 18-20 days at 28°C.
- Adult stage: females live for seven to ten days, while males live only two to three days; normally they die soon after mating.
- Females attack 4th instar larvae of *Brontispa.*
- Foods of adults: honey, honey dew, nectar.

13. The parasitoid can be reared in boxes or plastic or glass tubes.

Rearing in plastic boxes

14. Size of box: 6 x 12 x 5 cm (W x L x H). The lid is removed and replaced by a fine cloth fixed by glue. In one side of box a hole of 0.5 cm diameter is made. The adult parasitoids will be introduced into the box through this hole.

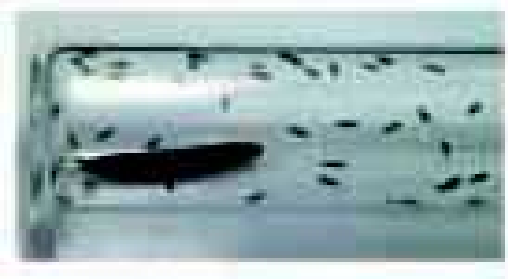
15. Place five to seven small pieces of leaf and 10-20 larvae of the 4th instar per box. A piece of tissue paper soaked into honey solution (30 percent) is pasted on wall to provide food for adults.

16. Introduce about 100 adult parasitoids into the box by inserting a tube containing parasitoids into the hole.

    After 24 hours, transfer the parasitoids into the new box.

17. The parasitized hosts become less active and turn brown in color after six days.

18. Parasitized hosts are then isolated individually in small vials (0.4 cm in dia., 7 cm long).



19. The parasitoid will emerge after 18-20 days of incubation.

Rearing parasitoid in glass tubes

20. Glass tubes of 3 cm diameter and 13 cm length can be used.

    Place 3-4 pieces of leaf in a tube and 10 larvae of *Brontispa*.

21. A piece of tissue paper soaked in honey solution (30 percent) is pasted on the wall of the tube.

22. Introduce parasitoids into the tube by inserting a vial containing newly emerged adults.

23. Fix the tube with a thick cloth.

After 24 hours, transfer the parasitoids into a new tube by connecting it with the old one which is covered by black paper. The parasitoids will move to the new tube as they are attracted by light.

The parasitized hosts are reared with the same procedure as above but in glass tube.

Releasing parasitoids

24. Releasing adult parasitoids:

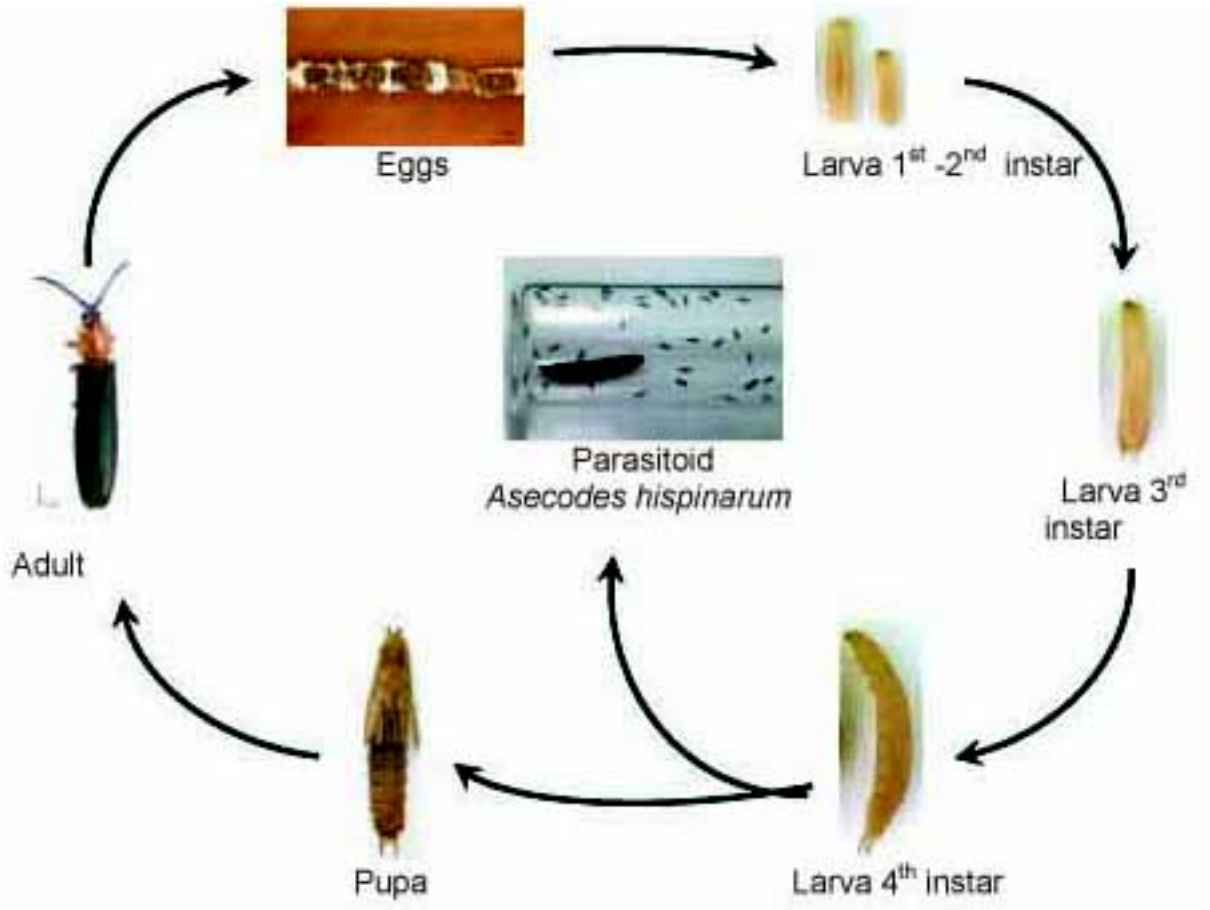
Open the lid and the parasitoids will fly out after some minutes. It is better to release them in early morning or late afternoon. It is recommended to feed them well before releasing.

25. Releasing developing stages:

The parasitoids are placed inside a plastic box three days before adult emergence. Several holes are made in the walls of box to provide exit places for parasitoids.

26. Hang the box on a tree which is close to coconut palms damaged by *Brontispa*.

Flow chart for mass-rearing *Brontispa* and parasitoid



Acknowledgement

This work has been done with support from the FAO project TCP/VIE/2905 on "Integrated pest management of hispine beetle *Brontispa longissima* in Viet Nam".

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Annex 8

International Standards for Phytosanitary Measures No. 2: Guidelines for pest risk analysis

Secretariat of the International Plant Protection Convention
Food and Agriculture Organization
of the United Nations
Rome, 1996

Review and amendment

International standards for phytosanitary measures are subject to periodic review and amendment. The next review date for this standard is 2001, or such other date as may be agreed upon by the Commission on Phytosanitary Measures.

Standards will be updated and republished as necessary. Standard holders should ensure that the current edition of this standard is being used.

Distribution

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- Asia and Pacific Plant Protection Commission
- Caribbean Plant Protection Commission
- Comité Regional de Sanidad Vegetal para el Cono Sur
- Comunidad Andina
- European and Mediterranean Plant Protection Organization
- Inter-African Phytosanitary Council
- North American Plant Protection Organization
- Organismo Internacional Regional de Sanidad Agropecuaria
- Pacific Plant Protection Organization.

Introduction

Scope

This standard describes the process of pest risk analysis for plant pests for the purpose of preparing phytosanitary regulations by National Plant Protection Organizations.

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International Plant Protection Convention, 1992. FAO, Rome.
Principles of plant quarantine as related to international trade, 1995. ISPM Pub. No. 1, FAO, Rome.

Definitions and abbreviations

Area	An officially defined country, part of a country or all or parts of several countries.
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss.
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled.
Entry potential	Likelihood of the entry of a pest.
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry.
Establishment potential	Likelihood of the establishment of a pest.
Introduction	Entry of a pest resulting in its establishment.
Introduction potential	Likelihood of the introduction of a pest.
IPPC	International Plant Protection Convention, as deposited in 1951 with FAO in Rome and as subsequently amended.
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC.
Official	Established, authorized or performed by a National Plant Protection Organization.

* The terms and definitions published in 1996 in this standard conform to this edition of the *Glossary of phytosanitary terms*.

Pest	Any species, strain or biotype of plant or animal or any pathogenic agent, injurious to plants or plant products.
Pest free area	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained.
Pest risk analysis (PRA)	Pest risk assessment and pest risk management.
Pest risk assessment	Determination of whether a pest is a quarantine pest and evaluation of its introduction potential.
Pest risk management	The decision-making process of reducing the risk of introduction of a quarantine pest.
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests.
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, by regulating the production, movement or existence of commodities or other articles, or the normal activity of persons, and by establishing schemes for phytosanitary certification.
PRA area	Area in relation to which a pest risk analysis is conducted.
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.
Spread	Expansion of the geographical distribution of a pest within an area.
Spread potential	Likelihood of the spread of a pest.

Outline of requirements

Pest risk analysis (PRA) consists of three stages: initiating the process for analyzing risk, assessing pest risk, and managing pest risk (see Figures 1-3).

Initiating the process involves identification of pests or pathways for which the PRA is needed. Pest risk assessment determines whether each pest identified as such, or associated with a pathway, is a quarantine pest, characterized in terms of likelihood of entry, establishment, spread and economic importance. Pest risk management involves developing, evaluating, comparing and selecting options for reducing the risk.

PRA is only meaningful in relation to a defined “PRA area” considered to be at risk. This is usually a country, but can also be an area within a country, or an area covering all or parts of several countries (e.g. the area covered by a Regional Plant Protection Organization [RPPO]).

General requirements for pest risk analysis (PRA)

1. Stage 1: Initiating the PRA process

There are generally two initiation points for a pest risk analysis (see Figure 1):

- the identification of a pathway, usually an imported commodity, that may allow the introduction and/or spread of quarantine pests
- the identification of a pest that may qualify as a quarantine pest.

Either can involve pests already present in the PRA area but not widely distributed and being officially controlled, as well as pests absent from the PRA area, since both are covered by the quarantine pest definition.

Stage 1: Initiation

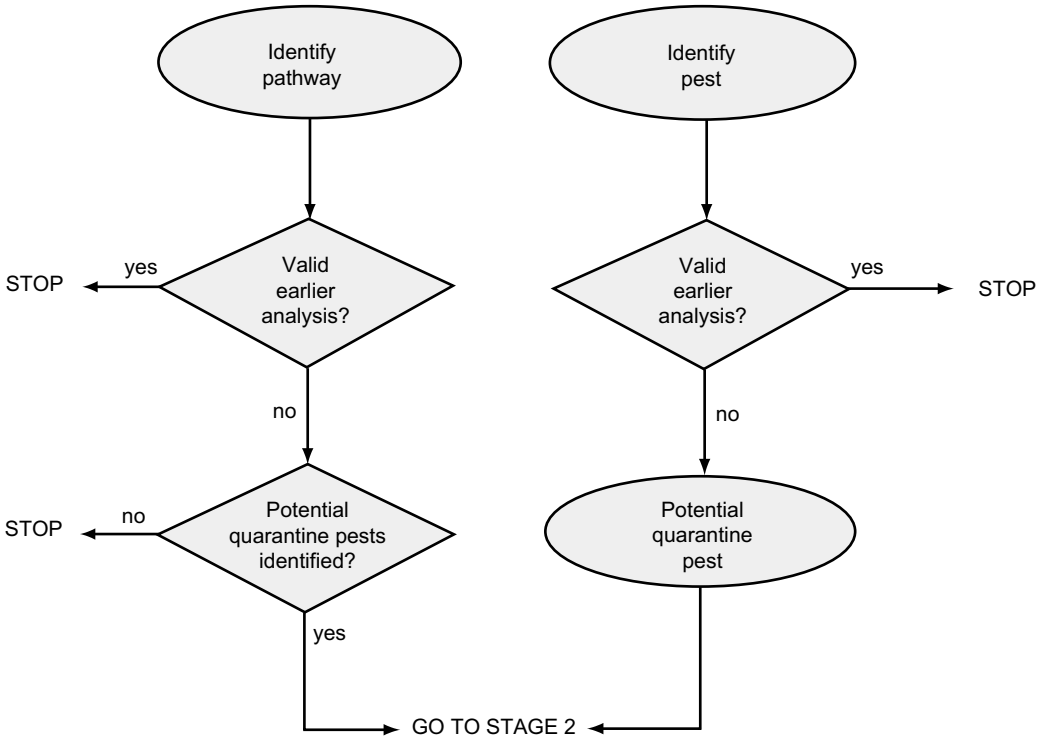

Figure 1: Pest risk analysis

1.1 PRA initiated by a pathway

A requirement for a new or revised PRA originating from a specific pathway will most frequently arise in the following situations:

- International trade is initiated in a new commodity (usually a plant or plant product) or a commodity from a new origin. The PRA may be triggered by a request for import, or by the appearance in trade of consignments of a commodity. The pathway may concern a single area of origin or several.
- New plant species are imported for selection and scientific research purposes
- A pathway other than commodity import is identified (natural spread, mail, garbage, passenger's baggage etc.)
- A policy decision is taken to establish or revise phytosanitary regulations or requirements concerning specific commodities
- A new treatment, system or process, or new information impacts on an earlier decision.

The pests which are likely to follow the pathway (e.g. be carried by the commodity) are then listed, and each is then subjected to Stage 2 in the PRA process.[1] If no potential quarantine pests are identified as likely to follow the pathway, the PRA stops at this point.

1.2 PRA initiated by a pest

A requirement for a new or revised PRA originating from a specific pest will most frequently arise in the following situations:

- An emergency arises on discovery of an established infestation or an outbreak of a new pest within a PRA area
- An emergency arises on interception of a new pest on an imported commodity
- A new pest risk is identified by scientific research
- A pest is introduced into a new area other than the PRA area
- A pest is reported to be more damaging in a new area other than the PRA area itself, than in its area of origin
- Audits reveal that a particular pest is repeatedly intercepted
- A request is made to import, as such, an organism, for example by researchers, educators, biological practitioners, businesses (pet store owners), the food industry (snails for consumption) or hobbyists (aquatic plants for aquaria)

[1] The list of pests may be generated by any combination of databases, literature sources, or expert consultation. Once the list of pests has been established, it is preferable to prioritize it by using expert judgement before the next step. According to the results obtained, it may or may not be necessary to conduct a risk assessment on all pests on the list.

- A policy decision is taken to revise phytosanitary regulations or requirements concerning specific pests
- A proposal is made by another country or by an international organization (RPPO, FAO)
- A new treatment system, process, or new information impacts on an earlier decision.

The specific pest identified is then subjected to Stage 2 in the PRA process.

1.3 Review of earlier PRAs

Prior to proceeding with a new PRA, a check should be made as to whether the pathway or pest has already been subjected to the PRA process, either nationally or internationally. If a PRA exists, its validity should be checked as circumstances may have changed. The possibility of using a PRA from a similar pathway or pest, that may partly or entirely replace the need for this PRA, should also be investigated.

1.4 Conclusion for Stage 1

At the end of Stage 1, pests have been identified as potential quarantine pests, individually or in association with a pathway.

2. Stage 2: Pest risk assessment

Stage 1 has identified a pest, or list of pests (in the case of initiation by a pathway), to be subjected to risk assessment. Stage 2 considers these pests individually (see Figure 2). It examines, for each, whether the criteria for quarantine pest status are satisfied:

> "a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled."

In this context, "area" should be understood to mean:

> "an officially defined country, part of a country, or all or part of several countries,"

and "endangered area" should be understood to mean:

> "an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss."

In doing so, the PRA considers all aspects of each pest and in particular actual information about its geographical distribution, biology and economic importance. Expert judgement is then used to assess the establishment, spread and economic importance potential in the PRA area. Finally, the potential for introduction into the PRA area is characterized.

Stage 2: Assessment

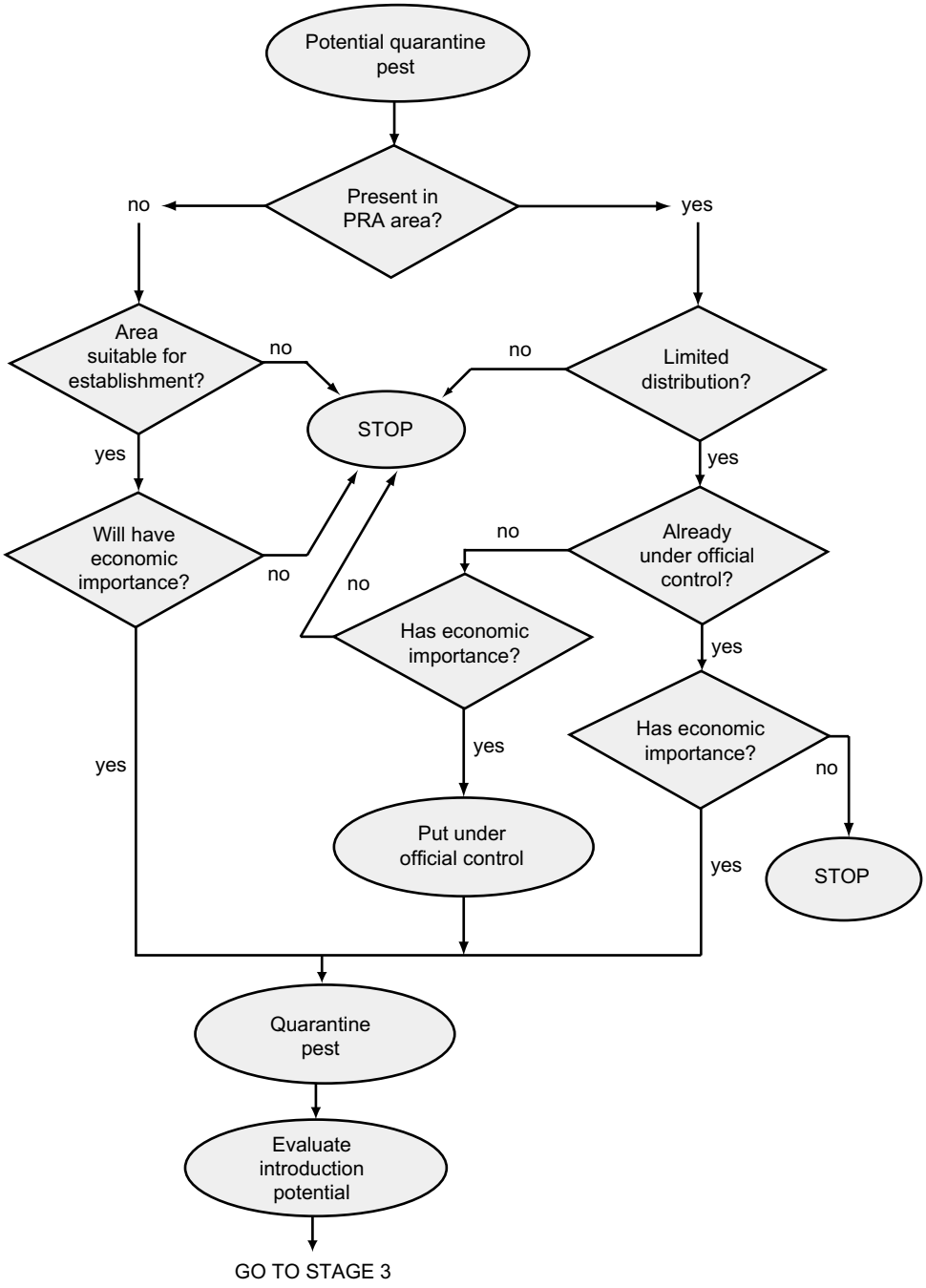

Figure 2: Pest risk analysis

In characterizing the risk, the amount of information available will vary with each pest and the sophistication of the assessment will vary with available tools. For example, one country may have elaborate pest databases and geographical information systems, another may depend on books, printed soil maps, and climate maps. In some cases, virtually no information may be available, or research may be needed to obtain it. Assessments will be limited by the amount of information available on the biology of a particular pest. Countries where the pest is present may provide available information for the country conducting the PRA, on request.

2.1 Geographical and regulatory criteria

For each pest subjected to the PRA process, the geographical and regulatory criteria in the quarantine pest definition should be considered:

- If the pest is present in the PRA area and has reached the limits of its ecological range (i.e. is widely distributed), then the pest does not satisfy the definition of a quarantine pest and the PRA for the pest stops at this point
- If the pest is present in the PRA area and has not reached the limits of its ecological range (i.e. not widely distributed), and the pest is subject to official control in the PRA area, then the pest satisfies this aspect of the definition of a quarantine pest
- If the pest is not widely distributed but is under consideration of future official control in the PRA area, then the PRA will determine whether the pest should be placed under official control. If the conclusion is reached that the pest should be subject to official control, then the pest satisfies this aspect of the definition of the definition of a quarantine pest
- If the pest is not widely distributed but is not subject to official control or consideration of future official control in the PRA area, then the pest does not satisfy the definition of a quarantine pest and the PRA for the pest stops at this point
- If the pest is absent from the PRA area, then it satisfies this aspect of the definition of a quarantine pest.

2.2 Economic importance iriteria

For potential economic importance to be expressed, a pest must become established and spread. Thus the risk of a pest, having entered, becoming established and spreading in the PRA area must be characterized. The factors to be considered are set out below.[2]

2.2.1 Establishment potential

In order to estimate the establishment potential of a pest, reliable biological information (life cycle, host range, epidemiology, survival etc.) should be obtained from the areas where the pest currently occurs.

The situation in the PRA area can then be carefully compared with that in the areas where it currently occurs and expert judgement used to assess the establishment potential. Case histories concerning comparable pests can usefully be considered. Examples of the factors to consider are:

- availability, quantity and distribution of hosts in the PRA area
- environmental suitability in the PRA area

[2] Fuller checklists of information which can usefully be considered in assessing the potential for establishment, spread and economic importance, are available from national and international sources.

- potential for adaptation of the pest
- reproductive strategy of the pest
- method of pest survival.

If a pest has no potential for establishment in the PRA area, then it does not satisfy the definition of a quarantine pest and the PRA for the pest stops at this point.

2.2.2 Spread potential after establishment

In order to estimate spread potential of the pest, reliable, biological information should be obtained from areas where the pest currently occurs.

The situation in the PRA area can then be carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the spread potential. Case histories concerning comparable pests can usefully be considered. Examples of the factors to consider are:

- suitability of the natural and/or managed environment for natural spread of the pest
- movement with commodities or conveyances
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

The information on spread potential is used to estimate how rapidly a pest's potential economic importance may be expressed within the PRA area. This also has significance if the pest is liable to enter and establish in an area of low potential economic importance and then spread to an area of high potential economic importance. In addition it may be important in the risk management stage (see Figure 3) when considering the ease with which an introduced pest could be contained or eradicated.

2.2.3 Potential economic importance

The next step in the PRA process is to determine whether the pest is of potential economic importance in the PRA area.

In order to estimate the potential economic importance of the pest, information should be obtained from areas where the pest currently occurs. For each of these areas, note whether the pest causes major, minor or no damage. Note whether the pest causes damage frequently or infrequently. Relate this, if possible, to biotic and abiotic effects, particularly climate.

The situation in the PRA area can then be carefully compared with that in the areas where the pest currently occurs. Case histories concerning

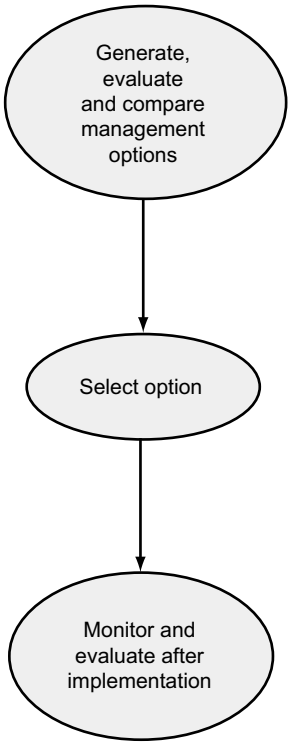

Figure 3: Pest risk analysis

comparable pests can usefully be considered. Expert judgement is then used to assess the potential for economic importance. Examples of the factors to consider are:

- type of damage
- crop losses
- loss of export markets
- increases in control costs
- effects on on-going integrated pest management (IPM) programmes
- environmental damage
- capacity to act as a vector for other pests
- perceived social costs such as unemployment.

If a pest has no potential economic importance in the PRA area, then it does not satisfy the definition of a quarantine pest and the PRA for the pest stops at this point.

2.3 Introduction potential

The final stage of assessment concerns the introduction potential which depends on the pathways from the exporting country to the destination, and the frequency and quantity of pests associated with them. Documented pathways for the pest

to enter new areas should be noted. Potential pathways which may not currently exist should be assessed if known.

The following is a partial checklist that may be used to estimate the introduction potential divided into those factors which may affect the likelihood of entry and those factors which may affect the likelihood of establishment.

Entry:

- opportunity for contamination of commodities or conveyances by the pest
- survival of the pest under the environmental conditions of transport
- ease or difficulty of detecting the pest at entry inspection
- frequency and quantity of pest movement into the PRA area by natural means
- frequency and number of persons entering from another country at any given port of entry.

Establishment:

- number and frequency of consignments of the commodity
- number of individuals of a given pest associated with the means of conveyance
- intended use of the commodity
- environmental conditions and availability of hosts at the destination and during transport in the PRA area.

2.4 Conclusion for Stage 2

If the pest satisfies the definition of a quarantine pest, expert judgement should be used to review the information collected during Stage 2 to decide whether the pest has sufficient economic importance and introduction potential, i.e. sufficient risk, for phytosanitary measures to be justified. If so, proceed to Stage 3; if not, the PRA for the pest stops at this point.[3]

3. Stage 3: Pest risk management

Pest risk management (see Figure 3) to protect the endangered areas should be proportional to the risk identified in the pest risk assessment. In most respects it can be based on the information gathered in the pest risk assessment. Phytosanitary measures should be applied to the minimum area necessary for the effective protection of the endangered area.

3.1 Risk management options

A list of options for reducing risks to an acceptable level should be assembled. These options will primarily concern pathways and in particular the conditions for permitting entry of commodities. Examples of the options to consider are:

[3] Decision-making schemes, or expert systems, may be useful at this stage to assist expert judgement.

- inclusion in list of prohibited pests
- phytosanitary inspection and certification prior to export
- definition of requirements to be satisfied before export (e.g. treatment, origin from pest free area, growing season inspection, certification scheme)
- inspection at entry
- treatment at point of entry, inspection station or, if appropriate, at place of destination
- detention in post-entry quarantine
- post-entry measures (restrictions on use of commodity, control measures)
- prohibition of entry of specific commodities from specific origins.

They may also, however, concern ways of reducing the risk of damage, for example, introduction of a biological control agent, or ease of eradication or containment.

3.2 Efficacy and impact of the options

The efficacy and impact of the various options in reducing risk to an acceptable level should be evaluated, in terms of the following factors:

- biological effectiveness
- cost/benefit of implementation
- impact on existing regulations
- commercial impact
- social impact
- phytosanitary policy considerations
- time to implement a new regulation
- efficacy of option against other quarantine pests
- environmental impact.

The positive and negative aspects of the options should be specified. While it is recognized that countries according to the sovereignty principle may exercise their sovereign right to utilize phytosanitary measures, countries should also take particular note of the "**Minimal impact**" principle:

> *Phytosanitary measures shall be consistent with the pest risk involved, and shall represent the least restrictive measures available which result in the minimum impediment to the international movement of people, commodities and conveyances*.

Article VI.2(f) of the International Plant Protection Convention makes a similar but less comprehensive provision. Phytosanitary measures recommended should be based on all of the above factors.

In order to determine which options are appropriate, it may be advisable to communicate with interested and affected groups within and outside the PRA area.

3.3 Conclusion for Stage 3

At the end of Stage 3, the appropriate phytosanitary measures concerning the pest or pathway have been decided. Completion of Stage 3 is essential; it is in particular not justified to complete only Stages 1 and 2 and then take phytosanitary measures without proper assessment of risk management options. After implementation of the phytosanitary measures, their effectiveness should be monitored and the risk management options should be reviewed, if necessary.

4. Documenting the PRA process

A PRA should be sufficiently documented so that when a review or a dispute arises, the PRA will clearly state the sources of information and the rationales used in reaching a management decision regarding phytosanitary measures taken or to be taken.

For further information on international standards, guidelines and recommendations concerning phytosanitary measures, and the complete list of current publications, please contact the:

Secretariat of the International Plant Protection Convention

By mail: IPPC Secretariat
Plant Protection Service
Food and Agriculture Organization of the United Nations (FAO)
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http://www.fao.org/WAICENT/FaoInfo/Agricult/AGP/AGPP/PQ/Default.htm

Annex 9

International Standards for Phytosanitary Measures No. 3: Code of conduct for the import and release of exotic biological control agents

Secretariat of the International Plant Protection Convention
Food and Agriculture Organization
of the United Nations
Rome, 1996

Review and amendment

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- InterAfrican Phytosanitary Council
- North American Plant Protection Organization
- Organismo Internacional Regional de Sanidad Agropecuaria
- Pacific Plant Protection Organization.

Introduction

Scope

This standard describes the Code of Conduct for the Import and Release of Exotic Biological Control Agents. It lists the responsibilities of the authorities of governments, and the responsibilities of the exporters and importers of biological control agents.

The Code addresses the importation of exotic biological control agents capable of self-replication (parasitoids, predators, parasites, phytophagous arthropods and pathogens) for research and/or release into the environment including those packaged or formulated as commercial products.

Governments that are already fulfilling the objectives of this Code by regulation or other equivalent means may consider adapting their existing systems in the light of this Code.

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Definitions and abbreviations

Antagonist	An organism (usually pathogen) which does no significant damage to the host but its colonization of the host protects the host from significant subsequent damage by a pest.
Area	An officially defined country, part of a country or all or parts of several countries.
Authority	The National Plant Protection Organization, or other entity or person officially designated by the government to deal with matters arising from the responsibilities set forth in the Code.
Biological control (Biocontrol)	Pest control strategy making use of living natural enemies, antagonists or competitors and other self-replicating biotic entities.
Biological control agent	A natural enemy, antagonist or competitor, and other self-replicating biotic entity, used for pest control.
Biological pesticide (Biopesticide)	A generic term, not specifically definable, but generally applied to a biological control agent, usually a pathogen, formulated and applied in a manner similar to a chemical pesticide, and normally used for the rapid reduction of a pest population for short-term pest control.
Classical biological control	The intentional introduction and permanent establishment of an exotic biological agent for long-term pest control.

Competitor	An organism which competes with pests for essential elements (e.g. food, shelter) in the environment.
Ecoarea	An area with similar fauna, flora and climate and hence similar concerns about the introduction of biological control agents.
Ecosystem	A complex of organisms and their environment, interacting as a defined ecological unit (natural or modified by human activity, e.g. agroecosystem), irrespective of political boundaries.
Establishment (of a biological control agent)	The perpetuation, for the foreseeable future, of a biological control agent within an area after entry.
Exotic	Not native to a particular country, ecosystem or ecoarea (applied to organisms intentionally or accidentally introduced as a result of human activities). As this Code is directed at the introduction of biological control agents from one country to another, the term "exotic" is used for organisms not native to a country.
Import permit (of a biological control agent)	An official document authorizing importation (of a biological control agent) in accordance with specified requirements.
Introduction (of a biological control agent)	The release of a biological control agent into an ecosystem where it did not exist previously (see also "establishment").
Inundative release	The release of overwhelming numbers of a mass-produced, invertebrate biological control agent in the expectation of achieving a rapid reduction of a pest population without necessarily achieving continuing impact.
IPPC	International Plant Protection Convention, as deposited in 1951 with FAO in Rome and as subsequently amended.
Legislation	Any act, law, regulation, guideline or other administrative order promulgated by a government.
Micro-organism	A protozoan, fungus, bacterium, virus or other microscopic self-replicating biotic entity.
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC.
Natural enemy	An organism which lives at the expense of another organism and which may help to limit the population of its host. This includes parasitoids, parasites, predators and pathogens.

Naturally occurring	A component of an ecosystem or a selection from a wild population, not altered by artificial means.
Organism	Biotic entity capable of reproduction or replication; vertebrate or invertebrate animals, plants and micro-organisms.
Parasite	An organism which lives on or in a larger organism, feeding upon it.
Parasitoid	An insect parasitic only in its immature stages, killing its host in the process of its development, and free living as an adult.
Pathogen	Micro-organism causing disease.
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products.
Predator	A natural enemy that preys and feeds on other animal organisms, more than one of which are killed during its lifetime.
Quarantine (of a biological control agent)	Official confinement of biological control agents subject to phytosanitary regulations for observation and research, or for further inspection and/or testing.
Release (into the environment)	Intentional liberation of an organism into the environment (see also “introduction” and “establishment”).
Specificity	A measure of the host range of a biological control agent on a scale ranging from an extreme specialist only able to complete development on a single species or strain of its host (monophagous) to a generalist with many hosts ranging over several groups of organisms (polyphagous).

Outline of the code

The Code is concerned with the importation of exotic biological control agents capable of self-replication (e.g. parasitoids, predators, parasites, phytophagous arthropods and pathogens) for research, and field release of control agents used in biological control and those used as biological pesticides. Currently used formulations of live pathogens are included because they possess the potential for multiplication and persistence in the environment. Naturally occurring strains (genetically, if not morphologically distinct entities) of natural enemies may show notable differences in specificity and infectivity, for example strains of *Bacillus thuringiensis* (Bt), and if exotic, fall within the terms of reference of this Code.

It is recognized that it may often be difficult to know whether the agent in a biological pesticide is exotic or not. For that reason many biological pesticides may have to be treated as though they were exotic.

The Code does not deal with other pest control techniques, that are also sometimes referred to as “biological controls”, notably, autocidal methods, resistant host plants, as well as behaviour-modifying chemicals and other novel biological products. For toxic products of microbes used as pesticides which cannot reproduce and which are similar to conventional chemical pesticides, refer to the FAO International Code of Conduct on the Distribution and Use of Pesticides where they are covered in detail.

Procedures governing the handling and release into the environment of strains of organisms created artificially by genetic engineering are currently being examined by various international organizations and by national programmes. If required this Code could be applied to these organisms.

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

Thus the Code deals with:

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

It does this by:

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

Code of Conduct for the import and release of exotic biological control agents

1. Objectives of the Code

1.1 The objectives of the Code are to:

- facilitate the safe import, export and release of exotic biological control agents by introducing procedures of an internationally acceptable level for all public and private entities involved, particularly where national legislation to regulate their use does not exist or is inadequate;
- describe the shared responsibility of the many segments of society involved and the need for cooperation between importing and exporting countries so that:
  - benefits to be derived are achieved without significant adverse effects,
  - practices which ensure efficient and safe use while minimizing health and environmental concerns due to improper handling or use are promoted.

Standards are described that:

- encourage responsible and generally accepted trade practices,
- assist countries to design regulations to control the suitability and quality of imported exotic biological control agents and to address the safe handling, assessment and use of such products;
- promote the safe use of biological control agents for the improvement of agriculture, and human, animal and plant health;
- allow all those involved in the import or release of exotic biological control agents to determine if, in the context of the International Plant Protection Convention and other relevant conventions and legislation, their proposed actions and the actions of others constitute acceptable practices.

1.2 Responsibilities are outlined for the entities which are addressed by this Code, including governments, individually or in regional groupings; international organizations; research institutes; industry, including producers, trade associations, and distributors; users; and public-sector organizations such as environmental groups, consumer groups and trade unions. All references in this Code to a government or governments shall be deemed to apply equally to regional groupings of governments for matters falling within their areas of competence.

2. Designation of authority responsible

2.1 Governments should designate the competent authority empowered (normally the National Plant Protection Organization) to regulate or otherwise control and, where appropriate, issue permits for the importation and release of biological control agents. The authority may exercise its powers by using an internationally

accepted standard (such as this Code) for guidance or by applying national legislation (which should be aligned with this Code). Importations of biological control agents should only be carried out with the consent of the authority.

2.2 The authority needs to:

2.2.1 Consider the legislation and regulations for the import and release of biological control agents.

2.2.2 Establish procedures for the assessment of the dossiers specified in section 4 and for establishing conditions appropriate to the assessed risk for the importation of biological control agents either with confinement in quarantine or directly to the importing agent without such requirement.

2.2.3 Maintain appropriate communication with and advise affected parties, including, where appropriate, other authorities on:

- despatch and handling procedures,
- release and evaluation of agents,
- distribution, trade and advertising factors,
- labelling, packaging and storage,
- information exchange, and
- occurrence of unexpected and/or deleterious incidents, including remedial action taken.

3. Responsibilities of authorities prior to import

3.1 The authority of an importing country should:

3.1.1 Endeavour to promote compliance with the Code or use specific powers or introduce necessary legislation to regulate the import, distribution and release of biological control agents in their countries, and make provision for effective enforcement.

3.1.2 Evaluate the dossiers specified in section 4 on the pest and the candidate biocontrol agent supplied by the importer in relation to the degree of acceptable risk and establish conditions for importation, containment or release appropriate to the assessed risk.

3.1.3 Issue regulations and/or import permits stating conditions to be fulfilled by the exporter and importer. As appropriate, these should include the:

- requirements to ensure authoritative identification of the agent,
- specified source of the biocontrol agent,
- precautions to be taken against inclusion of natural enemies of the agent,
- measures required for the exclusion of contaminants (especially quarantine pests),

- nature of the packaging to provide appropriate security,
- measures to allow inspection without escape of contents,
- point of entry,
- person or organization to receive the consignment,
- conditions under which the package may be opened,
- facilities in which the biological control agent may be held.

3.1.4 Ensure that procedures are available for the full documentation of the importation (identity, origins), release (numbers/quantities, dates, localities), impact of each particular biological control agent in each country and any other data relevant to assessing the outcome, and make records are available to the scientific community and the public, as may be appropriate, while protecting any proprietary rights to the data.

3.1.5 If appropriate, ensure entry and where required, processing through quarantine facilities or consider where a country does not have secure quarantine facilities, the importation through an accredited intermediate quarantine station in a third country.

3.1.6 Ensure the deposition in appropriate collections of authoritatively identified voucher specimens of the pest(s) and imported biological control agent where they will be available for reference and study.

3.1.7 Consider the necessity to require culturing of imported control agents in quarantine before release. Culturing for one generation can help in ensuring purity of the culture, authoritative identification, freedom from hyperparasites and pathogens or associated pests. This is especially advisable when wild collected agents are involved.

3.1.8 Decide if after a first import, further imports of the same biological control agent can be exempted from some or all of the requirements for import.

3.1.9 Maintain appropriate communication with and advise affected parties, including, where appropriate, other authorities on:

- despatch and handling procedures,
- release and evaluation of agents,
- distribution, trade and advertising factors,
- labelling, packaging and storage,
- information exchange, and
- occurrence of unexpected and/or deleterious incidents, including remedial action to be taken.

3.1.10 Ensure, in the case of repeat imports of a biological control agent for use in biocontrol or as a biopesticide, that documentation of the

certification system permitting entry and release is such that only imports of at least equivalent standard to the approved import are released.

3.1.11 Take action to inform and educate local suppliers of biological control agents, farmers, farmer organizations, agricultural workers' unions, and other interested parties on the appropriate use of biological control agents.

3.1.12 Consult with authorities in neighbouring countries within the same ecoarea and with relevant regional organizations to clarify and resolve any potential conflicts of interest that may arise between countries.

3.2 The authority of an exporting country, to the extent possible, should:

3.2.1 Ensure that regulations of the importing country relevant to the Code are followed in the export from their countries of biological control agents.

3.2.2 Follow, where the importing country has no or limited legislation concerning the import of biological control agents, the elements of the Code concerning the export of agents.

3.2.3 Ensure that arrangements are made for the taking and storing of voucher specimens of the exported material.

4. Responsibilities of importer prior to import

4.1 At the first importation, the importer of biological control agents for any purpose should prepare dossiers for submission to the authority with information on the pest to be controlled, including:

4.1.1 Accurate identification of the target pest, its world distribution and probable origin,

4.1.2 Assessment of its importance,

4.1.3 Its known natural enemies, antagonists or competitors already present or used in the proposed release area or in other parts of the world.

4.2 At the first importation, the importer of biological control agents for any purpose should prepare dossiers with information on the candidate biological control agent including:

4.2.1 Accurate identification or, where necessary, sufficient characterization of the agent to allow its unambiguous recognition,

4.2.2 A summary of all available information on its origin, distribution, biology, natural enemies and impact in its area of distribution,

4.2.3 An analysis of the host specificity of the biological control agent and any potential hazards posed to non-target hosts,

4.2.4 Natural enemies or contaminants of the candidate agent and procedures required for their elimination from laboratory colonies including, if appropriate, procedures to accurately identify and, if necessary, eliminate from the culture the host upon which the agent was cultured.

4.3 At the first importation, the importer of biological control agents for any purpose should also prepare a dossier for presentation to the authority which identifies potential hazards analyses the risks posed thereby and proposes mitigating procedures with respect to:

- those who may be handling biological control agents under laboratory, production and field conditions,
- human and animal health following introduction.

4.4 The importer of candidate biological control agents proposed for research in quarantine only should include information on the above points, plus the:

- nature of the material proposed for importation,
- security of quarantine (based on a description of the facilities and the qualifications of the staff).

4.5 The importer of biological control agents for import and release and use as biological pesticides should include in the dossier specified in 4.3 above, an analysis of the risks posed to possible non-target organisms and to the environment generally and should detail available emergency procedures should the biological control agent after release display unexpected adverse properties. The dossier should also contain a report detailing laboratory tests, and/or field observations and any other appropriate data to indicate the known or probable host range of the candidate agent. Testing should be based on recommended procedures and approved by the authority. These tests should relate to the candidate agent only and different procedures should apply to any additives used in formulations of products which contain biological control agents.

5. Responsibilities of exporter prior to export

5.1 Exporters of biological pesticides and other biological control agents for inundative release should:

5.1.1 Take all necessary steps to ensure that exported biological control agents conform to relevant regulations of importing countries, FAO and World Health Organization specifications concerning labelling, packaging and advertising, in particular the International Code of Conduct on Distribution and Use of Pesticides, as applicable, and this Code.

5.1.2 Ensure that biological control agents used in biological pesticides and for inundative release are evaluated for safety as provided for in section 4.3.

5.1.3 Ensure that all biological pesticides and other biological control agents for inundative release are evaluated for safety to human health and the environment and freedom from contaminating organisms.

5.2 The exporter of biological control agents for any purpose should ensure that:

5.2.1 All conditions specified in the regulations of the importing country or on the import permit are complied with.

5.2.2 Consignments, upon export, are accompanied by appropriate documentation:

- specifying that the contents are in compliance with the legislative provisions of the importing country and the permit provisions for that consignment,
- including information on the identity and recognition, safety, rearing or culture, and handling methods of the agent, and on possible contaminants, their recognition and elimination.

5.2.3 Packaging be sufficiently robust and consists of inert material secured in such a way that it can be inspected without escape of the contents. Wherever possible, organisms should be transported without their hosts (to reduce quarantine risks) and/or when they are in a dormant, inactive stage that is least likely to escape from packaging.

5.3 The exporter of biological control agents for research or classical biological control should also ensure that:

5.3.1 The import permit and all other documentation required in association with it are available prior to dispatch of the agent.

5.3.2 Packages are properly labelled in the official language of the importing country as to their contents and handling both in transit and on receipt in the receiving country. The information should include instructions to handlers and officials at the point of entry on how the package should be treated to avoid damage to the contents and on action to be taken if the packaging is breached. It should also indicate whether it may be opened for customs inspection or must be sent directly into quarantine before opening.

5.3.3 Advance notice with full details of routing is provided to the receiver to minimize delays and to alert officials at the point of entry.

6. Responsibilities of authorities upon import

6.1 Authorities should:

6.1.1 Ensure that, where required (see section 3.1.5), all imports of classical biological control agents for research or biological control, after completion of import requirements at the point of entry, are taken directly to the specified quarantine facility for inspection or other required procedure. All dead, diseased or contaminated material, as well as extraneous material and packaging material should be sterilized or destroyed in quarantine.

6.1.2 Ensure that biological control agents for which it is considered necessary (see section 3.1.6) are cultured in quarantine as long as has been specified by the authority.

6.1.3 Allow certain biological control agents to be passed directly for release providing all conditions have been complied with and appropriate documentary evidence is made available (see section 3). In all cases where identification or compliance is to be checked, this should be undertaken in a secure laboratory (i.e. a closed room with facilities for sterilizing or autoclaving extraneous or suspect materials).

7. Responsibilities of authorities before and upon release

7.1 Authorities should:

7.1.1 *If not already agreed under the terms of the import permit:*
Consider for approval for release following critical assessment of the submitted dossier on the agent and the establishment of appropriate conditions to reduce the assessed risk to an acceptable level. Assessments should be made using the types of procedures established in the ISPM *Guidelines for pest risk analysis* (e.g. to assess risks to non-target organisms and to identify risk-mitigating procedures). This may require information from specified additional tests.

7.1.2 Ensure full documentation of novel importations and their release programme as to identities, origins, numbers/quantity released, localities, dates, location of voucher specimens and any other data relevant to assessing the outcome, and maintenance of records of appropriate information with regard to other repeated releases of the same species.

7.1.3 Encourage the monitoring of the release of biological control agents in order to assess the impact on the target and non-target organisms.

7.1.4 Where problems (i.e. unexpected deleterious incidents) are identified, consider, and where appropriate, ensure corrective action is taken and inform all relevant interested parties.

8. Responsibilities of importer after import and release

8.1 The importer should:

8.1.1 Ensure that persons involved in distribution of their biological control agents are trained adequately, such that they are capable of providing a user with advice on efficient use.

8.1.2 Make information relating to the safety and environmental impact of biological control agents publicly available, and maintain a free and frank exchange of information, not subject to commercial confidentiality, with exporters, authorities other importers and operators of programmes involving biocontrol agents.

8.1.3 Consider publication of the results of each first importation and release programme in an international journal. Such publication should include details of the programme and its economic and environmental impact as soon as practicable after the release of the agent.

8.1.4 Notify the authorities when problems occur and voluntarily take corrective action and, when requested by authorities, help to find solutions to difficulties.

8.1.5 Ensure application of the provisions of Article 11 of the International Code of Conduct on the Distribution and Use of Pesticides with respect to the advertising of commercial preparations of biological control agents for sale to the public.

9. Observance of the Code

9.1 This Code should be observed through collaborative action on the part of: governments, individually or in regional groupings; international organizations; research institutes; industry, including producers, trade associations, and distributors; users; and other organizations such as environmental groups, consumer groups and trade unions.

9.2 The Code should be interpreted so that the requirements of other relevant codes or treaties are respected.

9.3 All parties addressed by this Code should observe this Code and promote the principles and ethics expressed, irrespective of other parties' ability to observe the Code.

9.4 The parties involved in providing biological control agents should retain an active interest in following their products, keeping up to date with major users and with the occurrence of problems arising in the use of their products.

9.5 FAO Members should periodically review the relevance and effectiveness of the Code. The Code should be considered a dynamic text which must be brought up to date as required, taking into account technical, economic and social progress.

9.6 Authorities should monitor the observance of the Code and report on progress made to the Director-General of FAO.

For further information on international standards, guidelines and recommendations concerning phytosanitary measures, and the complete list of current publications, please contact the:

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