Occurrence and control of coconut leaf beetle in China

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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

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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.

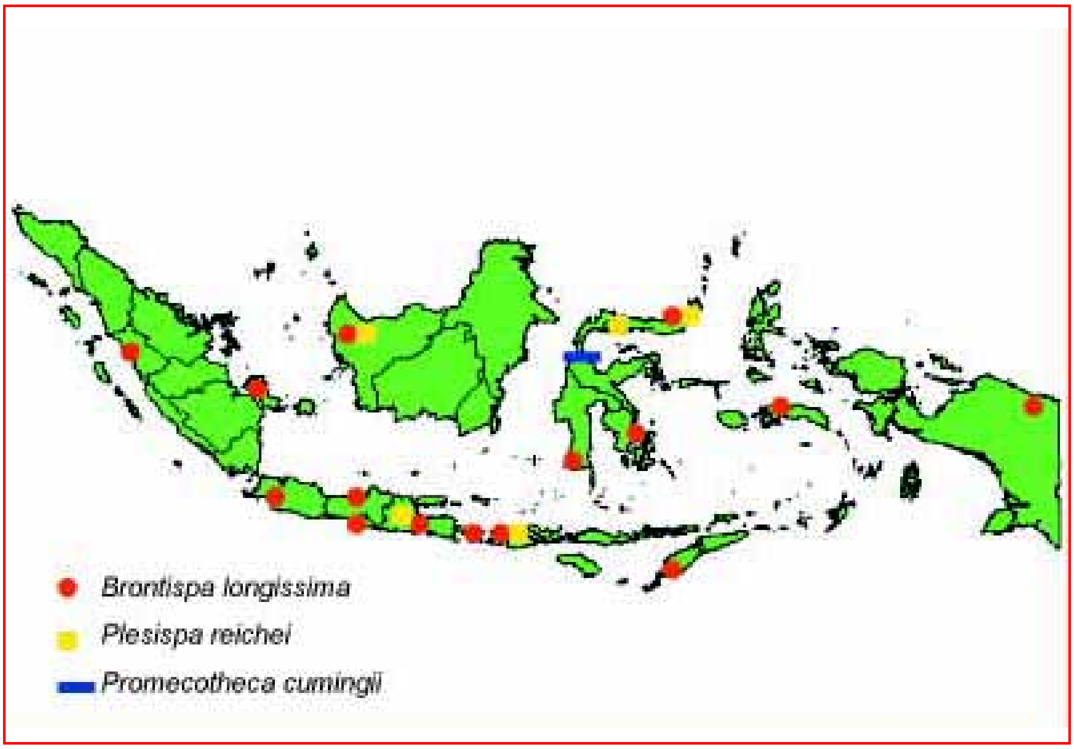

Figure 1: Distribution of Chrysomelid beetles in Indonesia

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 x 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).

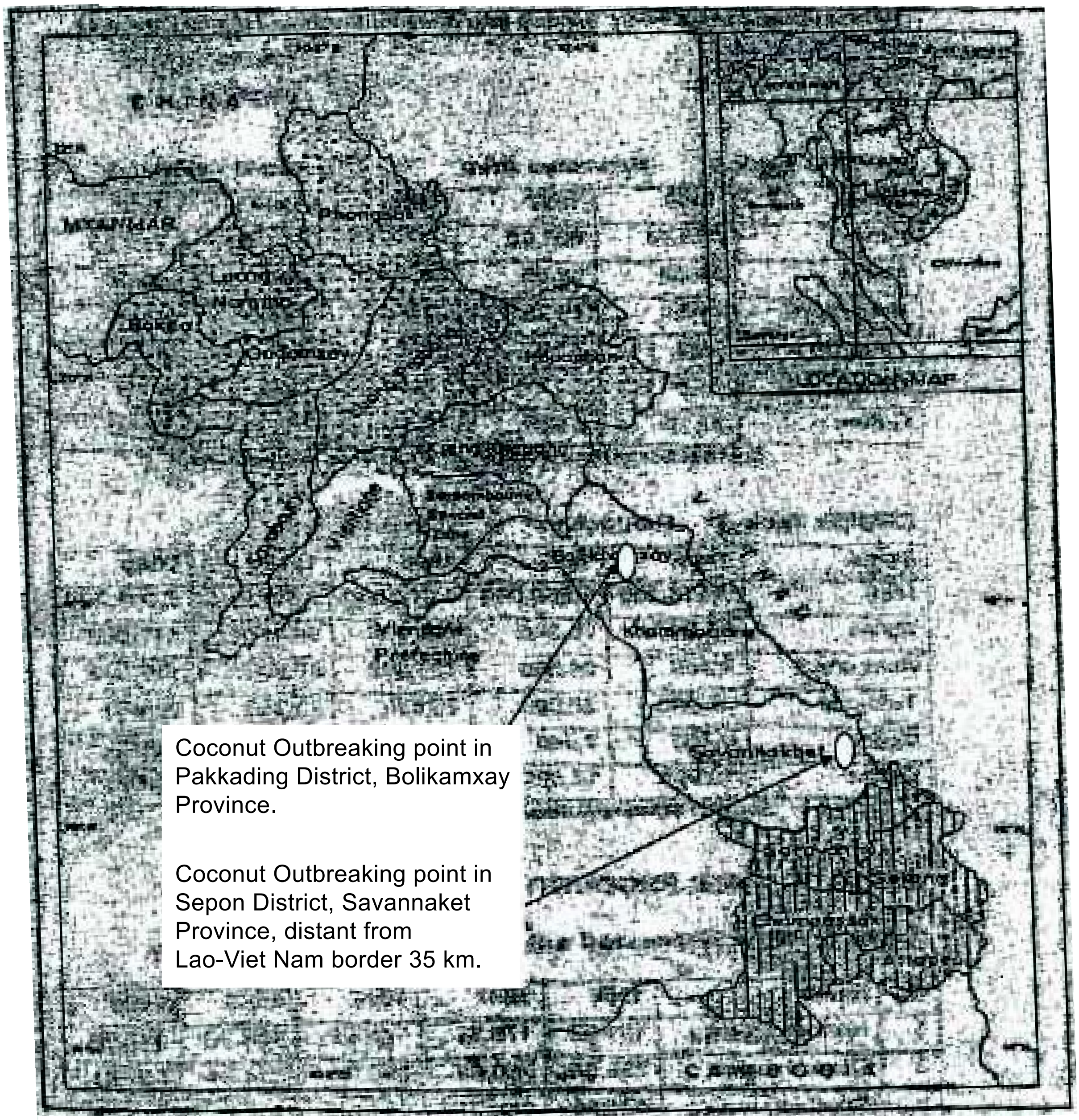

Figure 1: Sites of *Brontispa longissima* outbreak in Lao PDR

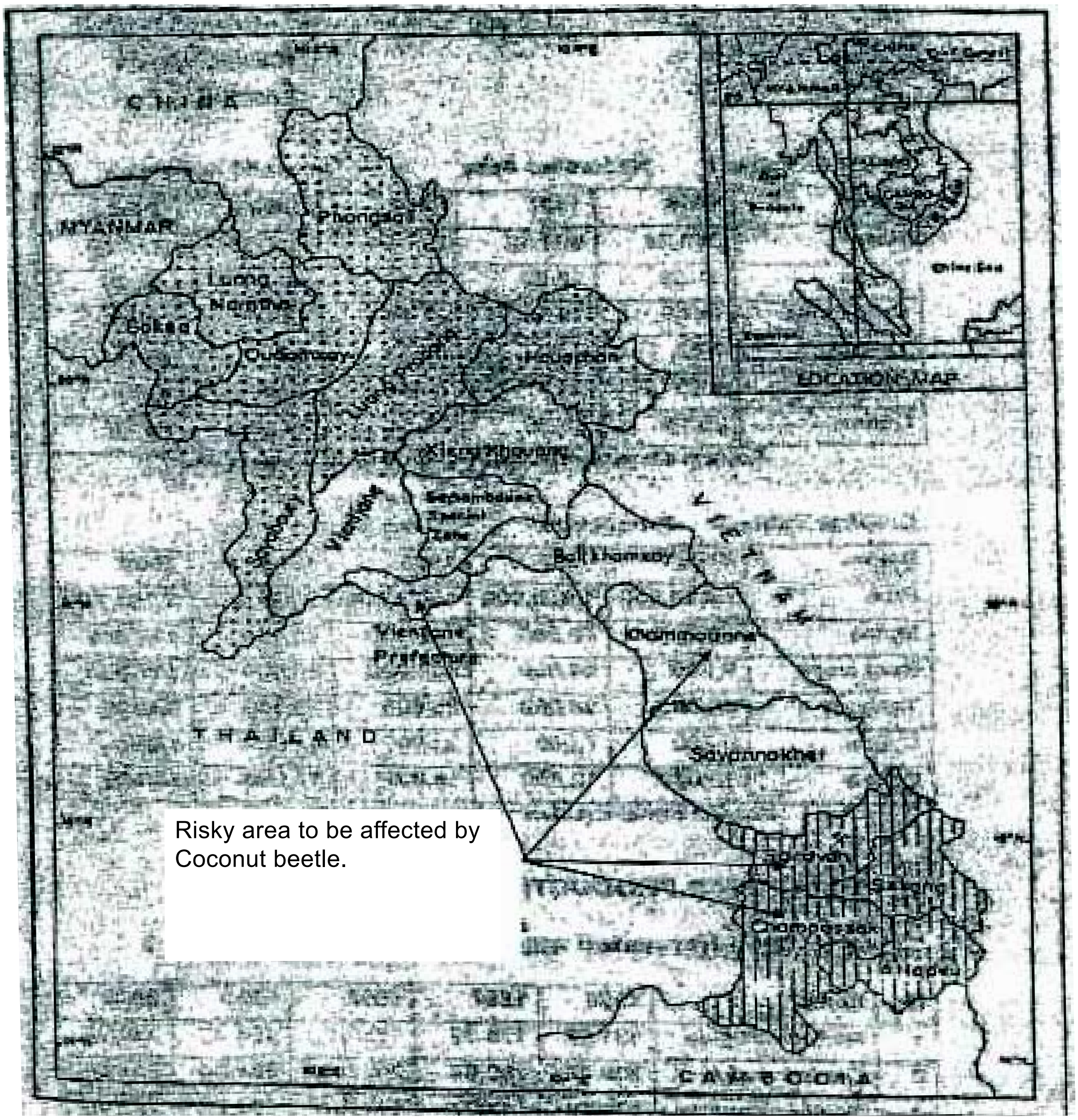

Figure 2: Areas threatened by spread of the coconut beetle

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

Aminath Shafia*

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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