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Integrated Pest Management of Important Insect Pests of Coconut[1]

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Abstract

IPM or Integrated pest management is a strategy that integrates various methods of cultural, physical, mechanical, biological control and selection of pesticides as the last option. IPM is not only cost effective but simultaneously prioritized human and environmental safety. IPM is based on farmer's local knowledge, acceptance and education. Several insects were reported as coconut pests in Asia and Pacific region. Among these pests, rhinoceros beetle, red palm weevil, coconut hispine beetle, coconut black headed caterpillar and coconut scale currently causing severe damage to coconut palms in the region. Rhinoceros beetle, *Oryctes rhinoceros* Linnaeus (Coleoptera: Scarabaeidae) is native to South Asia and Southeast Asia. Management of this pest is a combination of sanitation in plantations and surrounding, biological control by using *Metarhizium anisopliae*, *Oryctes* virus and pheromone trapping. Red palm weevil, *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) outbreaks usually occur after infestation of rhinoceros beetle. Keeping the rhinoceros under control results in keeping the red palm weevil under control too. Pheromone trapping is also developed for reduction of this pest. Coconut hispine beetle, *Brontispa longissima* (Gestro) (Coleoptera: Chrysomellidae), is an invasive pest occurs in Southeast Asia and Pacific region. Biological control of the pest is recommended by releasing two species of parasitoids, *Asecodes hispinarus* Boucek (Hymenoptera: Eulophidae) and *Tetrastichus brontispae* Ferriere (Hymenoptera: Eulophidae). Coconut black headed caterpillar, *Opisina arenosella* Walker (Lepidoptera: Oecophoridae) is one of the key pests of coconut in South Asia and invaded Thailand in 2008. Management of this pest in its native region consisted of: 1) removing and burning of the infested leaves; 2) biological control by releasing parasitoids such as *Goniozus nephantidis* (Muesebeck), *Bracon brevicornis* (Wesmael), *Brachymeria nephantidis* Gahan; and 3) chemical control by trunk injection and applying systemic insecticides in the holes. *Bacillus thruringiensis* has been recommended for biological control of the black headed caterpillar in Thailand. Coconut scale, *Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) has been reported as a serious in Philippines. Predators are significant biological control agents in limiting *A. destructor* populations. The most common natural enemies associated with the coconut scales are the coccinellid beetles *Chilocorus* spp., *Azya trinitatis*, *Cryptognatha nodiceps*, *Rhyzobius lophanthae* and *Pentilia castanea*. Local parasitoids, *Comperiella*, *Aphytis* and *Encarsia* also play important roles in keeping the pest under control. Application of insecticides could inducee the infestation of the scale. Biological controls is recommended for suppression of other coconut pests, such as slug caterpillars (Lepidoptera: Limacodidae) such as *Parasa lepida* Cramer; coconut leaf moth, *Artona catoxantha* Hampton (Lepidoptera: Zygaenidae); and coconut leafminer, *Promecotheca cumingii* Baly (Coleoptera: Chrysomelidae).

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Introduction

Coconut is an economic crop that plays an important role in social and cultural activities in Asia and Pacific. People in these regions know how to make use of coconut as food, traditional medicines, cosmetics and as raw material for several industrial products. Coconuts are produced in 92 countries worldwide on about 12 million hectares. World production has been estimated at 59.98 million tons (FAO, 2012).

Table 1. Top ten coconut producing countries in the world in 2012

Rank	Country	Area Harvested (Ha)	Yield (Kg/Ha)	Production (tones)
1	Philippines	3,573,806	4,439	15,862,386
2	Indonesia	3,000,000	6,000	18,000,000
3	India	2,132,240	4,953	10,560,000
4	Sri Lanka	395,000	5,063	2,000,000
5	Vietnam	145,000	8,621	1,250,000
6	Thailand	217,000	5,069	1,100,000
7	Papua New Guinea	223,000	4,036	900,000
8	Solomon Islands	53,000	7,698	408,000
9	Vanuatu	97,000	4,124	400,000
10	Fiji	60,000	3,500	210,000
	Total	9,929,046		50,972,386
	World	12,002,505	4,998	59,983,908

There are 750 pest species attacking coconuts all over the world. Among these pests, insects pests are the most destructive, causing severe damage to coconut palms when outbreaks occur, affecting coconut yield and quality. An estimated one fifth of these species cause damage directly to the coconut. Damage caused by insect pests reduces production in both number and size of coconuts.

Pest management decisions require information on the pests' biology, behavior, ecology, natural enemies, economic loss and resources available. Insect pests of coconut can be divided into major pests and minor pests. The current important insect pests of coconut in Asia and Pacific are rhinoceros beetle, red palm weevil, coconut hispine beetle and black-headed caterpillar. Some insect pests which usually have their populations suppressed by natural enemies are formally reported as major pests in some references. They are coconut leaf moth (*Artona catoxantha*), four-spotted coconut weevil (*Diocalandra frumenti*).

Oryctes rhinoceros (Linnaeus)

Common name: Asiatic rhinoceros beetle

Family, Order: Scarabaeidae, Coleoptera

Host: coconut, oil palms date palms, ornamental palms

Damage: Coconut orchards that have been attacked by rhinoceros beetle show reduced leaf area of the palms, which influences nut production, with attack greater on tall, mature trees, from about 5 years of age onwards. Serious attacks on coconut were also observed in areas adjacent to a breeding site with a high beetle population, especially in the coastal region. Zelazny (1979) reported 5-10% damage resulting in 4-9% yield reduction; similarly 30% damage resulted in 13% yield reduction.

Pest status: There are 2 species of the genus *Oryctes* attacking coconut in Asia and Pacific region. They are *Oryctes rhinoceros* (Linnaeus) and *Oryctes gnu* Mohner. Adults are dark brown to black, shiny in colour, with a prominent horn on the head. The males have a relatively longer horn than the female. The males can be separated by having a rounded shiny terminal abdominal segment while the female has a relatively hairier posterior abdominal segment. The strikingly similar but larger species, *O.gnu* has three tubercles (trituberculatus) on thoracic ridge, while there are two in *O. rhinoceros* (Endrödi, 1985).

The destructive stage of this insect is the adult. They feed in the crown region of coconut, bore through petiole bases into the central unopened leaves. This causes tissue maceration

Table 2. Insect Pests of Coconut around Asia and the Pacific base on Lever 1969, Krantz *et al.* 1978 and Red Ring Research Division 1983

Order and species	Distribution
Seedling leaf attacked	
Coleoptera	
Adoretus celogaster Arrow G.J. (Rutellidae)	Sri Lanka
A. compressus Weber (Rutellidae)	Fiji, Malaysia
Chalcosoma atlas L. (*Scarabaeidae*)	Philippines, New Guinea
Protocerius colossus Schoenherr (Curculionidae)	Indonesia
P. praetor Faust (Curculionidae)	Indonesia
Lepidoptera	
Agonoxena miniana Meyrick (Agonoxenidae)	Indonesia
Telicota bambusae Moore (Hesperiidae)	New Guinea
Thosea cineteomarginata Banks (Limacodidae)	Philippines
Chalcocelis albiguttata Snellen (Limacodidae)	Malaya, Indonesia, Vietnam
C. fumifera Swinhoe (Limacodidae)	Malaysia, Myanmar
Contheyla rotunda Hampson (Limacodidae)	India
Darna carenatus Snellen (Limacodidae)	Indonesia
D. trima Moore (Limacodidae)	Indonesia, Malaysia
Narosa conspersa Walker (Limacodidae)	Indonesia, Sri Lanka, India, Taiwan
Parasa lepida Cramer (Limacodidae)	Indo-Malayan region
Ploneta diducta Snellen (Limacodidae)	Indonesia
Setora nitens (Limacodidae) Walker	Malaysia, Indonesia, Vietnam
Thosea aperiens Walker (Limacodidae)	Sri Lanka
Thosea loesa Moore (Limacodidae)	Thailand
Thosea molluccana Roepke (Limacodidae)	Indonesia
Thosea sinensis Walker (Limacodidae)	Indonesia
Trichogyia (= *Olona*) *albistrigella* Snellen (Limacodidae)	Indonesia, Thailand
Mature plant leaf eaters	
Coleoptera	
Aphanisticus altus Kerr. (Buprestidae)	Indonesia
Barystethus cletussi Heller (Curculionidae)	New Guinea
Botryonopa sanguinea Guérin-Méneville (Chrysomelidae)	Indonesia
Brontispa longissima Gestro (= *B. forgatti* Sharp.) (Chrysomelidae)	Indonesia, Philippines
Brontispa chalybeipennis (Zacher) (Chrysomelidae)	Micronesia
B. mariana Speath (Chrysomelidae)	Pacific Is.
B. palauensis (Chrysomelidae)	Micronesia
B. selebensis Gestro (Chrysomelidae)	Indonesia
B. simmondsi Mlk. (Chrysomelidae)	New Guinea
B. yoshinol (Chrysomelidae)	Micronesia
Diocalandra stigmaticollis Gyll.	India, Indonesia, Sri Lanka
(= *Diocalandra frumenti* F.) (Curculionidae)	Philippines, Zanzibar, Pacific Is.
Exopholis hypoleuca Wiedemann (Scarabaeidae)	Indonesia, Pacific Is.
Oryctes gnu Mohn (Scarabaeidae)	Indonesia, Malaysia, Thailand

Order and species	Distribution
O. rhinoceros L. (Scarabaeidae)	Widespread
Phyllognatus dionysius F. (Dynastidae)	Sri Lanka
Plesispa cacotis Manlik (Chrysomelidae)	New Caledonia
P. reichei Chapuis (Chrysomelidae)	Malaysia, Indonesia, Philippines
Promecotheca caeruleipennis Blanchard (= *reichei* Baly) (Chrysomelidae)	Pacific Is.
P. cumingii Baly (Chrysomelidae)	Philippines, Borneo, Malaysia
P. opacicollis Gestro (Chrysomelidae)	Pacific Is.
P. papuana Csiki (Chrysomelidae)	New Guinea
P. soror Maulik (Chrysomelidae)	Indonesia
Scapanes australis (Boisduval) (Dynastidae)	New guinea, Philippines
Wallaceana palmarum Gestro (Chrysomellidae)	Indonesia
Xylotrupes gideon L. (Scarabaeidae)	Malaysia, India, Indonesia, New Guinea, Philippines, Solomon Is.
Lepidoptera	
Acanthopsyche cana Hampson (Psychidae)	Sri Lanka
A. lypotenca Hampson (Psychidae)	Sri Lanka
Agonoxena (= *Haemolytis*) *miniana* Meyrick (Agonoxenidae)	Indonesia
Amathusia phidipus phidiipus L. (Nymphalidae)	Indonesia, Philippines, Vietnam
Artona cartoxantha Hampson (Zygaenidae)	Indonesia, Malaya, Pacific Is., Philippines, Thailand
Brassollis sophorae L. (Nymphalidae)	Thailand
Chalcocelis albiquttata Snellen (Limacodidae)	Malaysia, Indonesia, Vietnam
C. fumifera Swinhoe (Limacodidae)	Malaysia, Myanmar
Contheyla rotunda Hampson (Limacodidae)	India
Darna catenatus Snellen (Limacodidae)	Indonesia
Darna (*Ploneta*) *diducta* Snellen (Limacodidae)	Indonesia
D. trima Moore ((Limacodidae)	Indonesia, Malaysia
Elymnias hypermnestra fraterna Butler (Nymphalidae)	Sri Lanka
Erionota thrax L. (Hesperidae)	Indo-Malaysian region
Gangara thrysis (F.) (Hesperiidae)	Indo-Malaysian region
Gangara panda Moore (Hesperi	Indonesia
Hidari irava Moore (Hesperiidae)	Malaysia, Indonesia
Levuana iridescens Bethune-Baker	Fiji
Mahasena corbetti Tams (Psychidae)	Malaysia, Indonesia
Opisina arenosella Walker (=*Nephantis serionopa* Meyrick) (Oecophoridae)	India, Sri Lanka, Myanmar
Narosa conspersa Walker (Limacodidae)	Indonesia, Sri Lanka, India, Taiwan
Parasa lepida Cramer (Limacodidae)	Indo-Malayan region
Psyche albipes Moore (Psychidae)	Sri Lanka
Setora nitens Walker (Limacodidae)	Malaysia, Indonesia, Vietnam
Spodoptera mauritia Boisduval (Noctuiidae)	Sri Lanka
Thosea aperiens Walker (Limacodidae)	Sri Lanka
T. loesa Moore (Limacodidae)	Thailand
T. molluccana Roepke (Limacodidae)	Indonesia
T. sinensis Walker (Limacodidae)	Indonesia

Order and species	Distribution
Trachycentra calamias Meyrick (Tineidae)	Fiji
Trichogyia (= *Olona*) *albistrigella* Snellen	Indonesia, Thailand
Valanga nigricornis zehneri Krauss (Acrididae)	Indonesia
Homoptera	
Aleurodicus destructor Mackie (Aleyrodidae)	Indonesia, Malaysia, New Guinea, Philippines
Aspidiotus destructor Signoret (Diaspididae)	Widespread
A. destructor rigidus Reyne (Diaspididae)	Indonesia
Assamia moesta West.	Sri Lanka
Ceroplastes actiniformis Green (Coccidae)	India, Sri Lanka
Chionapsis dilatata Green (Diaspididae)	Sri Lanka
Chrysomphalus aonidum L. (Diaspididae)	Philippines
C. aurantii Maskell (Diaspididae)	Philippines
Chrysomphalus bifasciculatus Ferris (Diaspididae) missed identification as *C. ficus* Ashmea	Widespread
Coccus hesperidum L. (Coccidae)	India, Fiji
C. maniferae Green (Coccidae)	Indonesia, Philippines
Eucalymnatus tessellatus Signoret (Coccidae)	Fiji
Fiorinia fioriniae (Targioni Tozzetti) (Diaspididae)	Sri Lanka, Philippines
Ischnaspis longirostris Signoret (Diaspididae)	Sri Lanka, Papua New Guinea, Malaysia
Nipaecoccus nipae (Maskell) (Pseudococcidae) (Syn: *Pseudococcus nipae* (Maskell)	Vietnam
Prococcus acutissimus (Green) (Diaspididae) *(Synonym: Lecanium acutissimum* Green)	Sri Lanka
Psendococcus Sp. (Pseudococcidae)	Indonesia
Stephanitis typicus Distant (Tingidae)	India
Orthoptera	
Cardiodactylus novae-guineae Haan (Gryllidae)	Solomon Is., Papua New Guinea
Valanga nigricornis Burmeister (Acrididae)	Malaysia
V. nigricornis sumatrensis Uvarov (Acrididae)	Indonesia
V. translens Walker (Acrididae)	Indonesia
Stem borers	
Coleoptera	
Diocalandra taitensis Guerin (Curculinidae)	Pacific Is.
Panglyphyra woodlarkiana Montr. (Scarabaeidae)	Indonesia
Rhabdoscelus obscurus (Boisduval) (Curculinidae) (Syn.: *Rhabdocnemis maculatus* Schaufuss)	Sri Lanka
Rhabdoscelus lineaticollis Alonso-Zarazaga & Lyal (Syn.: *Rhabdocnemis lineaticollis* Heller) (Curculionidae)	Philippines
Rhynchophorus ferrugineus Olivier (Curculionidae)	India, Sri Lanka, Philippines, Myanmar, Indonesia, Thailand, Vietnam
R. kaupi Schaufuss (Curculionidae)	New Guinea

Order and species	Distribution
R. papuanus Kirsch (Curculionidae)	New Guinea
R. schach Olivier (Curculionidae)	Malaysia, Philippines, Indonesia, Thailand, Pacific Is.
Xyleborus perforans (Wollaston) (Scolytidae)	Sri Lanka
Isoptera	
Coptotermes ceylonicus Holmgren (Rhinotermitidae)	Sri Lanka
Hymenoptera	
Dorylus orientalis Westwood (Formicidae)	India, Myanmar, Sri Lanka, Pakistan
Flower/Nut Borers	
Coleoptera	
Dorcus (= *Eurytrachelus*) *egregius* Mollenkamp (Lucanidae)	New Guinea
Eurytrachelus sp. (Lucanidae)	Indonesia
Nodocnemis uniformis Marshall (larvae) Curculionidae)	Solomon Is.
Odontolabis bellicosa (Castelnau) (Lucanidae)	Indonesia
Lepidoptera	
Acritocera neglingens Butler (Cossidae)	Malaysia, Fiji
Batrachedra arenosella Walker (Gelechiidae)	India, Indonesia, Malaysia
Coconympha iriarcha Meyrick (Gelechiidae)	India
Coleoneura trichogramma Meyrick (Pyralidae)	Fiji, Tonga
Harpagoneura complexa Butler (Pyralidae)	Fiji
Hydelepta (*Phostria*) *blackburni* Butler (Pyralidae)	Hawaii
Stathmopoda mucivora Meyrick (Yponomeutidae)	Solomon Is.
Tirathaba rufivena Walker (Pyralidae)	Malaysia, New Guinea, Indonesia, Solomon Is., Thailand
Heteroptera	
Amblypelta cocophaga Brown (Coreidae)	China, Solomon Is
Root Feeding	
Coleoptera	
Lepidiota stigma F. (Scarabaeidae)	Indonesia
Lepidoderma pica Arrow (Larvae)	Indonesia
Lenchopholis corneophora Surm.	India
Isoptera	
Odontotermes obensus Ramb. (Termitidae)	India
Hymenoptera	
Dorylus orientalis Westwood (Formicidae)	India, Myanmar, Sri Lanka, Pakistan
Oecophylla smargdina F. (Formicidae)	Indo-Australian region

and the presence of a fibrous frass inside the feeding hole is an indication of their activity within. A single attack is often followed by others on the same palm (Young, 1975; Barlow and Chew, 1970). These attacks subsequently produce fronds which have the characteristic of serrated cut or fan-shaped fronds.

Biology: The mated female adult lays eggs in rotting palm or other organic substrates including trunks, tree stumps, compost heaps, sawdust or rotting garbage. The eggs hatch in 10-12 days and the all larval stage developed inside the breeding sites. Total development of the larvae range from 80-150 days. The larvae start the prepupal stage that take 8-13 days, subsequently pupating within a pupal chamber made from the food substrate. The pupal stage ranges from 23-28 days. Adult longevity is up to 6 months or more (Khoo *et al*., 1991).

Life cycle of *O. rhinoceros* shows a wide range in the duration of the third instar larvae (60-165 days), compared to the other stages. Dry climate or low nutritional conditions will delay larval development of *O. rhinoceros*, which can be extended to as long as 14 months, giving rise to smaller-sized adults (Catley, 1969). Wood (1968a) demonstrated that the larvae required about 5-7 months to mature in oil palm log tissue, while a shorter maturity period of 4-5 months was observed in a habitat mixture of cow dung and sawdust. Conditions suitable for larval development are temperature 27-29°C and RH 85-95% (Bedford, 1980). The adult beetles feed on the growing points of coconut palms and this is the primary cause of crop damage leading to loss of yield and death in young palms. The larvae feed on dead wood; dead palm logs are a primary breeding site. *O. rhinoceros* is thought to have spread throughout Asia and Pacific region. The pest has also been found in air cargo and may be transported to new areas in decaying organic materials such as compost and sawdust, and in nursery pot plants.

Management:

1. Sanitation within and surrounding the plantations, especially destruction of the potential or existing breeding sites of this pest, provides an important basis for its control. Manure heaps have to be covered or turned regularly for the removal of the grubs. The establishment of a good, fast-growing ground cover provides a vegetative barrier that hampers the movement of the adult beetle looking for suitable breeding sites.

2. Removal of the adults from the point of attack in young palms by using a hooked piece of wire (winkling) can be considered a common mechanical control technique to reduce the number of adults in an infested area. This measure is often costly, labor intensive and needs to be conducted regularly.

3. Pheromone Trapping: A synthetic aggregating pheromone, ethyl 4-methyloctanoate, has been developed for *O. rhinoceros*. The pheromone is stored in a small, heat-sealed, polymer membrane bag and placed on top of winged vanes traps, mounted on a plastic bucket. The beetles attracted by the pheromone are trapped inside the bucket. The pheromone shows some promise as a monitoring tool and as an economical control method, when placed at a density of one trap for every 2 ha.

4. Green muscardine fungus or *Metarhizium anisopliae*: A log pit is prepared filled with coconut husk, animal dung and other organic matter, then moisture is added and the mixture is left to decay. Decayed material in log pits is attractive to female rhinoceros beetles for oviposition. Once the beetle larvae are observed the Green Muscardine Fungus is applied onto the organic material and mixed. The larvae will be killed; the fungus will multiply and destroy any larvae breeding in the log pit.

5. *Oryctes* virus: The entomopathogenic *Oryctes rhinoceros* virus was first discovered in Malaysia. It was successfully introduced into many South Pacific countries to control *O. rhinoceros* on coconut. In Malaysia, the infection of *Oryctes* virus is common on adults and less frequent on larvae. An infected adult has a swollen gut and an infected larva becomes transparent when viewed against light. It is hoped that the successful control of *Oryctes* by virus could reduce the use of pesticides.

Rhynchophorus ferrugineus (Olivier)

Common name: Asiatic red palm weevil

Family/Order: Curculionidae/ Coleoptera

Host: Coconut, oil palms, date palms, sago, other species of Palmae

Distribution: India, Pakistan, Sri Lanka, S.E. Asia, China, Taiwan, Saudi Arabia, the United Arab Emirates, and the Solomon Islands

Damage: The feeding larvae bore into the crown of coconut and destroy it. Initially the outer leaves turn chlorotic and die, this gradually spreads to the innermost leaves. Later the trunk becomes tunneled and weakened, and may break.

Pest status: Red palm weevil is a serious pest of coconut. Two species of this genus are found attacking coconut palm, *R. ferrugineus* and *R. vulneratus*. It is very difficult to detect red palm weevil in the early stages of infestation. It is generally detected only after the palm has been severely damaged. Careful observation may reveal the following signs which are indicative of the presence of the pest. Observation on infestation of red palm weevil can be done by monitoring of some holes in the crown or trunk from which chewed-up fibres are ejected. This may be accompanied by the oozing of brown viscous liquid, crunching noise produced by the feeding grubs can be heard when the ear is placed to the trunk of the palm and looking for a shriveled bud or crown.

Biology: Eggs are laid singly in the wounds or holes made by rhinoceros beetles. The eggs are creamy white, oblong and shiny. The average size of an egg is 2.62 mm long and 1.12 mm wide. Eggs hatch in 2-3 days and develop larger in size before hatching. The larvae can grow up to 3.5 cm long and can be recognized by the brown head and white body. Mouthparts are well developed and strong. When about to pupate, larvae construct an oval-shaped cocoon of fibre. Total larval stages range from 61-109 days. The pupal case length range from 5-9.5 cm and 2.5-4 cm. wide. The prepupal stage lasts for 3 days and the pupal duration varies from 9-25 days. Adult longevity ranges from 61-169 days. Adult weevils are reddish brown, about 3.5 cm long and 1 cm wide and are characterized by a long curved rostrum or snout. Dark spots are visible on the upper side of the middle part of the body. The head and rostrum is one-third of the total length. In the male, the dorsal apical half of the snout is covered by a patch of short brownish hairs, the snout is bare in the female, more slender, curved and a little longer than the male.

R. ferrugineus is a serious pest of coconut palms in India and Sri Lanka. Ganapathy et al. (1992) observed its damage in 34% of coconut groves in Cochin, India. Red palm weevils are also major pests of the oil palms, sago palms, date palms, and ornamental palms everywhere it presented.

Management:

1. Most infestations of red palm weevils occur after the attack of rhinoceros beetle. Reduction of the rhinoceros beetle population results in reduction of red palm weevil populations.

2. Mass trapping by aggregation pheromones has been used to detect adult weevils. Application of pheromone trapping together with food bait obtains higher catches of the weevil. Hallett et al. (1999) found that trap catches were maximized by placing the traps at ground level or a height of 2 m and that vane traps were superior to bucket traps.

Brontispa longissima (Gastro)

Common name: Coconut hispine beetle

Family/Order: Chrysomelidae/Coleoptera

Host: Coconut, areca or betel palm, royal palms (Roystonea regia), oil palm, ornamental palms and cat tail (*Typha angustifolia* L.)

Distribution: Papua New Guinea, the Solomon Islands Vanuatu, New Caledonia, American Samoa, Western Samoa, northern Australia, Taiwan, Fiji, Tonga, Hong Kong, China, S.E. Asia, Maldives.

Pest status: Coconut hispine beetle or *Brontispa longissima* (Gastro) is an insect pest native to Indonesia and CABI, 2013 reported that this insect was originally described from the Aru Islands. It is native to Indonesia, possibly to Irian Jaya, 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. Cohic (1961) was the first to record *B. longissima* from New Caledonia (Tahiti), Long (1974) for American Samoa and for Western Samoa. It is also present in northern Australia (Fenner, 1984) and Taiwan.

B. longissima was detected for the first time in Hong Kong in 1988 infesting 30 petticoat palms in a nursery (Lau, 1991). This outbreak was eradicated, but in late 1991, a few mature coconuts (>30 years old) were affected, indicating that the pest may be established in Hong Kong. Since most of the locally grown ornamental palms, including petticoat palms, king palms and dwarf date palms were imported from China in recent years, it is suspected that *B. longissima* was introduced from China, probably from the Shenzhen area of Guangdong Province. The beetle is an invasive pest that causes serious damage to both young and mature coconuts and ornamental palms, drying the young shoots and eventually killing the whole tree. Both larvae and adults are destructive, inhabiting the developing and unopened spear leaves of the coconut palms where they feed on the leaf tissues. Damaged palms appear burnt at a distance. *B. longissima* has spread to Singapore, Vietnam, Nauru, Cambodia, Laos, Thailand, Maldives, Myanmar and Hainan Island, China (Rethinam and Singh, 2007). It is feared that it will spread from the Maldives to Sri Lanka and southern parts of India.

Biology: The eggs are laid singly or in groups, end to end, in a furrow chewed in the leaf by the adult, between or inside the tightly folded leaflets. The beetle covers each egg with excreta. The newly hatched larva begins to feed inside unopened leaflets. The number of instars varies from five to six. The beetles, which also seem to avoid light, are nocturnal and fly well. The adults feed among the young unopened leaflets, their cumulative damage greatly exceeds that of the larvae. Winotai, et al. (2007) reported that *B. longissima* invaded and caused severe damage to coconut plantations in the south of Thailand since 2004. Biological control was the most suitable measure to manage the problem. Both larvae and adults feed on unopened leaves of coconut. Studies on the life cycle of *B. longissima* fed young coconut leaves concluded that eggs were laid singly or in groups of 2-5 eggs/group. Adult females laid 56-264 eggs/female, averaging 69.29 eggs/female. The egg stage ranged from 2-6 days, averaging 4.20 ± 0.98 days. The larvae which developed 4 larval stages of 3 - 5, 3 - 9, 2 - 8 and 4 -13 days, respectively, averaging 4.13, 4.27, 5.10, and 9.47 days. When the larvae developed a 5th larval stage, it took 1-9 days, averaging 6.33 days. The total larval stages which developed 4-5 larval stages ranged from 18 - 26 days, averaging 23.60 days. The pupal stage took 2-7 days, averaging 4.97 days. The female adult longevity was 13-113 days, averaging 56.79 days. The male adult longevity was 21-110 days, averaging 65.18 days.

B. longissima attacks palms of all ages. Neglected palms are more heavily attacked than those under care. Coconut plantations in South Sulawesi, Indonesia, which were in poor condition due to poor soil conditions, with infestations by coconut whitefly or with inadequate maintenance were more susceptible to attack by *B. longissima*. Severe *B. longissima* attacks were reported in nearly all regions of south-east Sulawesi in 1929. The hispid sometimes occurred together with whitefly, *Oryctes* beetles and the red palm weevils, which

together killed numerous palms, while other palms were in poor condition that they did not produce fruit for many years. Fruit production is significantly reduced if eight or more leaves are destroyed. Under prolonged outbreak conditions, fruit-shedding takes place, newly-formed leaves remain small, and the trees appear ragged and may ultimately die.

Management: Experience from dealing with coconut hispine beetle concluded that biological control can keep this pest under control. Natural enemies of *B. longissima* consist of 8 species of insect natural enemies and 2 species of fungus diseases. The insect natural enemies are:

1. *Asecodes hispinarum* Boucek
2. *Chelisoches morio* (Fabricious)
3. *Chrysonotomyia* sp. (Hymenoptera: Eulophidae)
4. *Hispidophila brontispae* (Hymenoptera: Trichogrammitidae)
5. *Oecophylla smaragdina* (Hymenopetra: Formicidae)
6. *Ooencyrtus pindarus* (Hymenoptera: Encyrtidae)
7. *Ooencyrtus podontiae* (Hymenoptera: Encyrtidae)
8. *Tetrastichus brontispae* (Hymenoptera: Eulophidae)

Fungus diseases found attacking *B. longissima* are *Beauveria bassiana* and *Metarhizium anisopliae*

A. hispinarum is a larval exotic parasitoid that FAO expert together with Vietnamese scientists found in Western Samoa and used in several countries such as Fiji, Maldives, Malaysia, Cambodia, Vietnam and Thailand. Winotai, A., *et.al.* (2006) studied the biology and rearing of *A. hispinarum* reported that the parasitoid, *A. hispinarum* Boucek attacks all stages of the *B. longissima* larvae. The parasitized larvae move slowly, feed less, finally die and become mummies. The total duration from parasitization to mummification was 6-10 days, averaging 7.01 days. The time taken from parasitization until adult parasitoids emerged ranged from 17 - 20 days, averaging 17.7 days. The 4^{th} -5^{th} larvae are suitable for mass rearing *A. hispinarum* in the laboratory because they can produce 23-129 parasitoids per mummy, averaging 50.20 parasitoids per mummy. Studies on the effect of temperature on parasitoid mass rearing concluded that the highest parasitization was found at 28°C. Mass rearing procedures were developed for both the pest and parasitoid, rearing technology has been transferred to DOA-Research and Development Centers and Department of Agricultural Extension insectaries located in areas where the pest presently occurs. Both *A. hispinarum* and *B. longissima* were cultured in laboratories. Mature coconut leaves were offered as food for rearing the larvae of *B. longissima* while adults were fed with young leaves. The 4th instar larvae of the host are suitable for producing *A. hispinarum*. The larvae of *B. longissima* (80–100 nos.) were exposed to 50 adults of *A. hispinarum* in a plastic container (10x14x6 cm) for parasitization. Honey solution (20%) smeared on tissue paper was provided as food for the parasitoid adults. Around 10 days after parasitization, the larvae of the coconut hispine beetle are killed and mummified larvae or mummies are observed. The mummies are then collected and released. About 10% of the mummies are needed to maintain the parasitoid culture and the remaining 90% can be used for release purposes. Releasing 30–60 mummies/ hectare three times at 7–10 day intervals is recommended for effective pest control.

In Thailand, *T. brontispae* is a natural enemy found in the south of Thailand. Weijaroen, et al. (2010) studied on biology and mass rearing techniques reported that the parasitoid *T. brontispae* culture rearing at DOA laboratory was collected from Pattalung, a province in the South of Thailand.

Two different Eulophid wasps emerged from the mummies collected. One was a Eulophid with flat thorax, while the other had a thicker thorax. A sample of both parasitoids were collected and sent to Dr. John LaSalle, Australian National Insect Collection, Australia, under collaboration with USDA-Australian Biological Control Laboratory, Brisbane, Australia. 90% of the wasps emerged from the mummies collected were Eulophid with flat thorax was identified as *T. brontispae* while

another Eulophid with thicker thorax was *Tetrastichus* sp. Studying the life cycle of the parasitoid revealed that the parasitoid preferred attacking prepupal stage of *Brontispa longissima*, but the parasitoid also attacked the last instar larvae and 1 day-old pupae of the coconut hispine beetle. Developmental period was studied under laboratory conditions of 28°C and 75% R.H.

T. brontispae was an endo-parasitoid attacking prepupae, pupae and last instar larvae of *B. longissima*. Weijaroen, et al. (2010) studied the biology and mass rearing techniques and reported that *T. brontispae* was a pupal parasitoid of *B. longissima*. Egg stage was 1-2 days, larval stage 6-8 days, pupal stage ranged from 10-13 days. Total life cycle took 18-25 days, with an average of 19.98 days. The average per cent parasitization was 62.84 and the per cent adult emergence was 91.33. The average number of wasps that emerged from each mummified pupae was 23.09 with a sex ratio of 1.8. Adult longevity when fed with 10% honey range from 7-26 days, and each female can attack 1-4 *B. longissima* pupae, and produce 11-57 wasps.

Opisina arenosella Walker

Common name: Black headed caterpillar

Family/Order: Oecophoridae/Lepidoptera

Host: Coconut, oil palms, date palms, betal nuts, ornamental palms, banana

Distribution: India, Sri Lanka, Burma, Thailand

Damage: Severe damage often results in reduction of yield. Massive damage to the crown of leaves affects the thatching quality of leaves, in addition to decline in yield in years following the outbreak of the pest. In severe outbreaks thousands of palms are affected and all fronds are destroyed. In the following year, coconut production may be halved due to reduction of flower spike, increase in premature nut fall, constriction of the trunk and retardation of growth. In Sri Lanka, Climate factors play a major role in population dynamics of this pest (Perera *et al*. 1988).

Pest status: *O. arenosella* was declared a pest in Sri Lanka in 1924 when it became a legal requirement to report any outbreaks to the agricultural authority (since 1956 to the Coconut Research Institute (Perera *et al*. 1989). Since then it is the most important coconut pest in India and Sri Lanka. It is also reported from Myanmar and Bangladesh. This species is long known as *Nephantidis serinopa* Meyrick (Ramachadran *et al*., 1979).

Biology: Description of this species can be observed from the adults. The moth has a wing span of 20-30 mm, pale grey speckled with black. The caterpillars are pink with a black head and dark thoracic plates.

The female moth lays 49-490 egg, on apical section of old fronds. Incubation period is 4-5 days. The caterpillars mostly develop 6 larval instars, some larvae can develop up to 10 larval instars. Total larval stages take 32-48 days. Caterpillars live in galleries made of silk and frass in the underside of the mature leaves and feed on green tissue. Natural enemies that affect the population dynamics of black headed caterpillars were studied and reported by Nadarajan and Channa Basavanna (1980).

Management: In India, coconut black headed caterpillars have many insect natural enemies as show in Table 2.

In India there are 43 species of parasitoids and 51 species of predators that have been reported attack coconut black headed caterpillars. Among these the larval parasitoid, *Goniozus nephantidis* (Muesebeck) (Hymenoptera: Bethylidae) is the dominant species and responsible for the reduction of *O. arenosella* population (Dharmaraju, 1963; Cock and Perera, 1987). It is a gregarious larval ecto-parasitoid. In India it occurs throughout the year, peak activity was observed in February. Its

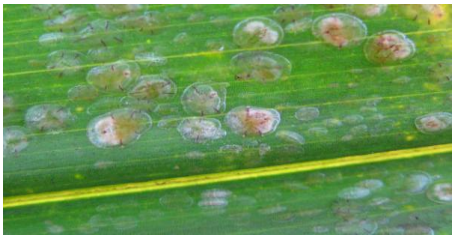
Table. 2 Natural enemies of *Opisina arenosella* Walker recorded from India

Scientific Name	Family	Notes
1. *Brachymeria nephantidis* Gahan	Chalcididae	Pupal parasitoid
2. *Brachymeris nosatoi* Habu	Chalcididae	Pupal parasitoid
3. *Brachymeria latus* Walker	Chalcididae	Pupal Parasitoid
4. *Bracon hebetor* Say	Braconidae	Larval ecto-parasitoid
5. *Bracon brevicornis* Westmeal	Braconidae	Larval ecto- parasitoid
6. *Trichospilus pupivora* Ferriere	Eulophidae	Pupal endo-parasitoid
7. *Anthocephalus hakonensis* Ashmead	Chalcididae	Pupal parasitoid
8. *Elasmus nephantidis* Rohwer	Elasmidae	Larval ecto-parasitoid
9. *Goniozus nephantidis* (Muesebeck)	Bethylidae	Larval ecto-parasitoid
10. *Apanteles taragamae* Vierick	Braconidae	Larval endo-parasitoid
11. *Eriborus trochanteratus* (Morley)	Ichneumonidae	Larval endo-parasitoid
12. *Goryphus* sp.	Ichneumonidae	Pupal parasitoid
13. *Meteoridea hutsoni* Nixon	Braconidae	Larval parasitoid
14. *Tetrastichus isaraeli* (Mani and Kurian)	Eulophidae	
15. *Stomatomyia bezziana* Baranoff	Tachinidae	Larval parasitoid
16. *Cardiastethus exigruis* Popius	Eggs, and small larvae	Predator

development is positively influenced by warm and dry weather, generally low parasitism is observed during humid months. The female wasps behavior shows maternal care of their eggs and the hatching larvae. Female *G. nephantidis* paralyzed the host larvae and feed on the host body fluid. The parasitoid is capable of suppressing part of the pest population by stinging and paralyzing 1st to 2nd instar larvae (Sundaramurthy and Santhanakrishnan, 1978, 1979). The total developmental period is 10-12 days. The egg stage is about 1 day, larval period is 2-3 days, pupal stage ranges from 7-8 days. Female progeny ranges from 85-90%. Female longevity ranges from 44-61 days. Fecundity varies from 65-79.5. The adult female is known to have three cycles of oviposition and brood care, each lasting for 12-13 days and separated by 4-5 days. Each female can parasitize 6-8 larvae.

Occurrence of *G. nephantidis* throughout the year with higher proportion of female progeny, greater host searching ability, high temperature tolerance and maintenance of density in relation with that of the pest population makes it a versatile parasitoid for the management of *O. arenosella*. In India, different levels of parasitism by *G. nephantidis* have been recorded in various states. *C. cephalonica* larvae are used as host for mass rearing of *G. nephantidis*. A vigorous and healthy *C. cephalonica* colony is a pre-requisite for continuous production of *G. nephantidis*.

***Aspidiotus destructor* Signoret**



Common name: coconut scale insect

Family/Order: Diaspididae/Hemiptera

Host: *A. destructor* is a highly polyphagous species. Davidson and Miller (1990) recorded it from hosts belonging to 75 genera in 44 plant families. The common host plants found this scale insect feeding on are coconut, other palm, mango, banana, citrus, ginger, guava, papaya, sugarcane

Damage: Coconut is its favorite host; the undersurface of the leaves is mainly attacked, but frond stalks, flower clusters and young fruit can also be affected. Older trees (over 4 years) or trees on well-drained soil are seldom seriously infested. On leaves, *A. destructor* causes yellow spots to develop beneath the insects, due to the toxicity of saliva injected in to plant tissues while feeding. Entire leaves may turn yellow to brown and fall, and fruits may be discolored, stunted or fall prematurely. The bright yellow color of affected coconut palms is clearly visible from a great distance. The undersurface of the leaves is mainly attacked, but frond stalks, flower clusters and young fruit can also be affected. In extreme cases, the leaves dry out, entire fronds drop off and the crown dies.

Distribution: Pantropical, Iran, Japan, California, South Australia, S.E. Asia

Pest Status: One of the most serious pests of coconuts and other crops. Especially in the orchards where chemicals insecticides are applied

Biology: The body of *A. destructor* adult is bright yellow, nearly circular in outline, and covered with a flimsy, semitransparent, slightly convex scales. The scale diameter ranges from 1.5-2 mm. They reproduce sexually. Males are much smaller, bodies are reddish, on attaining maturity the male insect has a pair of wings, motile, and leaves the scale. The eggs are yellow, tiny, and laid under the scale around body of female. Incubation period ranges from 7-8 days. After hatching the first instar nymph or clawler leaves the maternal scale and takes up a position on the leaf and starts feeding. The nymphs remain on this site throughout their nymphal stages. If they are females, they also stayed there throughout their adult life. The male nymphs moult three times, while the females only twice. Life cycle of *A. destructor* typically lasts for 32-34 days. Each female deposits 20-50 eggs under the scale cover over a few days. The dispersal phase of A. destructor is the first instar, or crawler, which has legs. Crawlers can walk up to perhaps 1 m, but can be distributed across much greater distances by wind, flying insects and birds and transport of infested plant material by man.

Management: Predators play a significant part in limiting *A. destructor* populations. The most common are the coccinellid beetles: *Chilocorus* spp., *Azya trinitatis*, *Cryptognatha nodiceps*, *Rhyzobius lophanthae* and *Pentilia castanea*. Parasites of local significance include *Comperiella*, *Aphytis* and *Encarsia*. A number of parasitoids and predators of *A. destructor* are described by Rosen (1990). Natural enemies of A. destructor have been described from Sri Lanka (Sinnathamby, 1980), China (Zhou *et al*., 1993) and Taiwan (Wu and Tao, 1976). Gordon (1978) describes coccinellid predators from the West Indies. Mariau and Julia (1977) report that predation by coccinellids was usually sufficient to maintain scale populations below the economic level in coconuts in Ivory Coast. The coccinellid *Cryptognatha nodiceps* is a particularly effective predator (Rosen, 1990).

***Plesispa reichei* Chapei**

Common name: Coconut leaf palm hispid

Family/Order: Chrysomelida/Coleoptera

Host: coconut

Distribution: S. Asia, and S.E. Asia

Damage: *P. reichei* or coconut leaf palm hispid is mostly found attack young palms around 3-4 years old. Damage cause by this hispid occur by both adults and larvae feed on young unopened leaflets and make feeding scars paralleled to the main vein, as the leaflets open the damaged tissue dies and the leaflets are easily shredded and wind action. Seedling growth is impaired and the plants may be killed. On mature palms the beetles attack the tips of recently unfolded leaflets. The leaf tip folds over and make a small chamber where the eggs are laid and larvae develop. Occurrence of this pest regularly happen on coconut palm in Southeast Asia but occasionally is serious done. In most case the pest is kept under control by its natural enemies.

Pest status: Minor pest of coconut

Biology: The beetles have an orange-yellow head and pronotum. Elytra are black and about 7-8 mm. long. Female is slightly larger than male. 50-100 eggs are laid singly or in groups, side to side. Incubation period is about 10 days, total larval period ranges from 30-40 days, and pupal stage range from 6-11 days. The total developmental time is 40-64 days.

Management: Damage of *P. reichei* is seldom serious, most populations of this pest are usually kept under control by a wide range of natural enemies.

Promecotheca cumingii Baly

Common name: Palm leafminer

Family/Order: Chrysomelidae/Coleoptera

Host: Coconut, other palms

Distribution: Indonesia, Malaysia and Philippines, no record of this species in Thailand

Damage: This species mainly attacks coconut palm and oil palm. Young larvae mine in the leaflets of mature leaves, and make tunnels around 10 cm long and 1 cm wide. Adults make long narrow feeding scars on the leaflets. The overall result is the foliage withers and appears scorched, the palm seldom dies but the crop yield will be reduced for usually a year and a half. When pest population explosions occur, damage is extensive and widespread. This is thought to occur when the natural enemies are reduced in number, and fruit shedding can be common and many trees may die. Leaf damage is often associated with fungal attack.

Pest status: Minor pest of coconut or occasional pest.

Biology: Eggs are laid singly in small cavities on the undersides of leaflets. Incubation period takes 13-24 days, each female lays about 120 eggs over 8-15 weeks. The larvae mine the leaflets make long blotch mines. Pupation takes place at the end of the mine. They are slow moving and do not fly far, and usually develop several overlapping generation per year.

Management: Because this insect occurs seasonally, and several natural enemies are found on this species, biological control is the major mechanism keeping the pest under control.

***Parasa lepida* (Cramer)**

Common name: Nettle or slug caterpillars

Family/Order: Limacodidae/Lepidoptera

Host: coconut, other palm such as Borassus, Metoxylon and Nypha palms, coffee, cacao, tea, peppers, bananas, mangoes, Eugenia, Nephelium, Cassia, Gliricidia, Gardenia and Rose.

Distribution: S.E. Asia, South Asia, China, India, Japan

Damage: As soon as they hatch on the host leaves, the young caterpillars feed on the underside of the epidermis, stripping it off the leaflets; often beginning at the tip where the eggs were laid. They then eat the edges of the leaflet and devour large areas of the lamina. When they have finished developing, the whole leaflet will have been consumed systematically from tip to base, leaving only the midrib, along which the notched indentations left by the caterpillars are visible.

P. lepida can severely attack coconut soon after field planting. The first outbreaks of P. lepida are usually localized with only a few trees defoliated and the infestation is thus easy to identify. However if no control measures are instituted, the infested area may enlarge rapidly

in the course of the next pest generation. Older coconuts in adult stands can also be heavily attacked, and sometimes the whole crown is affected. After such defoliation, the palms produce fewer nuts for the first 6 months, then practically none at all for the next 20 months, and yield does not return to normal until the end of month 40.

Pest status: Minor pest of coconut.

Biology: *P. lepida* develops seven larval stages. Total developmental period from egg to adult ranges from 58-77 days. Eggs are laid on the underside of the fronds. The females lay about 350 eggs in 3-5 days, one female can produce 660 eggs. Incubation lasts 5-7 days. After hatching, the caterpillars are gregarious and remain so throughout their life. Even if, at the end of their development, they scatter over the leaflets, they always stay closely grouped. It is not uncommon for them to go from one frond to another in procession.

Pupation takes place on the leaf bases in the crown, on the stem under the fibres or, on young coconuts, at the collar. All the cocoons are clustered closely together. Pupation occurs in July and August in West Java and lasts an average 21-22 days for males and 22-24 days for females. Pupation can last much longer in a dry period, with the adults appearing only when the rains start.

The adults emerge from the cocoons. The adults are active at night, during the day they hide by clinging to the tips of the more or less dried-up leaflets on the lower fronds, with their wings folded up in a ridge.

Management: The natural enemies of *P. lepida* in South-East Asia are reviewed by Cock et al. (1987). *P. lepida* has many parasites, the most common being the Braconid, *Apanteles parasae*, at most larval stages, and the tachinid, *Chaetexorista javana*.

In young plantings, where the fronds are accessible, the attacks are confined to a few trees and the *P. lepida* caterpillars are closely grouped, and they can be collected by hand and destroyed.

Chemical treatment is required if the trees are older and the leaves out of reach, or if the infestation is general, with a population of *P. lepida* above the critical threshold and no adequate biological control. Caterpillars of *P. lepida* are very sensitive to rotenone (derris solution). *Bacillus thuringiensis* has been used successfully against *P. lepida*.

Artona catoxantha Hampson

Common name: coconut leaf moth

Family/Order: Zygaenidae/Lepidoptera

Host: Coconut

Distribution: Myanmar eastwards throughout Malaysia, Singapore, Indonesia and the Philippines, Thailand and Papua New Guinea.

Damage: *A. catoxantha* has been recorded as a pest on coconut palm trees by various authors (Tothill *et al.*, 1930; Kalshoven, 1981). Outbreaks have been known since 1892. Serious damage is reported especially from Malaysia and Indonesia. Outbreaks are comparatively rare and never begin during the wet season. Moreover, they are always controlled by natural enemies, and usually before serious damage is done to the leaves of the trees. The lower leaves of the trees are attacked first and are killed in most cases. The coconut palms are weakened and the growth of the coconuts is diminished but the trees are rarely killed. There is no clear regular periodicity in the occurrence of the outbreaks. Normally, *A. catoxantha* is a rare species restricted to tropical climates and hardly ever observed in the field. Presumably the populations survive in small aggregations in the dense rain forests. Both sexes are day flying. Copulation and oviposition takes place in bright daylight.

Biology: The eggs are laid on the underside of coconut leaflets. They are deposited singly. The egg is yellowish in color and hatches in about 3-5 days. The caterpillar feeds on the undersurface of the leaflets. The feeding marks are characteristic in that they brownish, ladder-like marks running longitudinally along the leaflets. This is caused when the caterpillar eats away the epidermis. The old caterpillar may eat the edges of the leaflet. Pupation takes place in an oval, grayish-yellow, dense cocoon on the underside of the leaves of the host plant, mainly close to the veins of the leaves, sometimes together in clusters. The pupa in the cocoon is always facing the surface of the leaf. Under tropical conditions *A. catoxantha* is able to produce 8-9 generations per year. The pupal stage ranges from 8-10 days. Female adult moth is slightly larger than male, and the antennae are thread like while the male antennae are comb-like (Ooi, 1977). Adults rest at an angle of approximately 60° to the surface, the head high up, touching the leaf with the tip of the abdomen, gripping the surface with the hind legs only. Vertically hanging leaves are preferred for resting. The adults take nectar from the inflorescences of the palm trees. The females normally do not leave the host plants and rest close to the place where they have emerged from the pupae, waiting for males. Males have been observed flying in great numbers around the crowns of the trees searching for females. Copulation takes place on the leaves, but observations are recorded that mating also takes place during flight, which is very unusual for Procridinae (Kalshoven, 1981). Oviposition starts in the early afternoon and lasts until early evening. *A. catoxantha* adults have been observed several times on short-distance migration flights between coconut plantations, flying over distances of 1-1.5 km across open country (van der Vecht, 1950). The preferred host plants are Arecaceae, such as coconut palm and sago palms, but ornamental palms are also known to suffer severe damage. Banana (*Musa* spp.) and Poaceae such as sugar cane (*Saccharum* spp.), may serve as temporary hosts for later-instar larvae.

Pest status: Minor pest of coconut

Management: Control of *A. catoxantha* by cutting and burning infested leaves is regularly recommended. This method was only partly successful as the owners found cutting of only partly infested leaves unnecessary and refused to cooperate. Biochemical control with rotenone was practiced. This method is successful when larger numbers of larvae can be killed by spraying heavily infested trees (Kalshoven, 1981; Ooi, 1978). Trunk injection technique, was introduced by Ooi et al. (1975). Control of *A. catoxantha* by natural enemies is the preferred method of control (Kalshoven, 1981; Tothill et al., 1930).

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