COASTAL SANDY SOIL MANAGEMENT THROUGH INTERCROPPING/ ALLEY CROPPING OF GLYRICIDIA IN THE COCONUT GARDEN

P. Subramanian, R. Dhanapal, C. Palaniswam and HP Maheswarappa

The coastal sandy tracts with fairly high water table (1 m to 2.5 m) are well defined zones on the west and east coasts of the Peninsular India lying mostly in Kerala, Karnataka, Andra Pradesh and Tamil Nadu, where coconut is the major crop. The general weather prevailing along the coast is conducive for growing coconut economically. However, coconut productivity is very low in the coastal sandy soils, mainly due to poor physico - chemical properties of the soil. Coastal sandy soils are characterized by the poor water retaining capacity, excessive infiltration (due to the porosity of sands), easy leaching and low inherent fertility status. These soils have a field capacity in the range of 4-6 per cent and permanent wilting point 0.2 to 0.6 per cent, and bulk density of 1.6 –2.0 $g.cm^{-3}$. The mechanical analysis revealed that the sand fraction is very high (94 - 99 per cent), where as silt (0.2 – 2.0 per cent) and clay (0.6 to 2.8 per cent) fractions are low in all the layers of the soil profile. Because of low clay and organic matter, these soils have small specific surface area, cation exchange capacity as low as 1.5-2.4 centimol. Besides, the soil available nutrient status viz, Nitrogen, Phosphorous and Potassium are also low.

The nutritional deficiency in sandy soils has been considered an important factor for the poor productivity of coconut palms. It is also a cause attributed to the incidence of barrenness, underdeveloped nuts and poor quality copra. The nutritional and water deficiencies in sandy soils often cause poor setting and severe shedding of nuts. The trees grown with little care and management are prone to the attack of several pests and diseases, as applied water moves downward easily and the soil needs frequent irrigation at short intervals. Such conditions aggravate the loss of nutrients through the water.

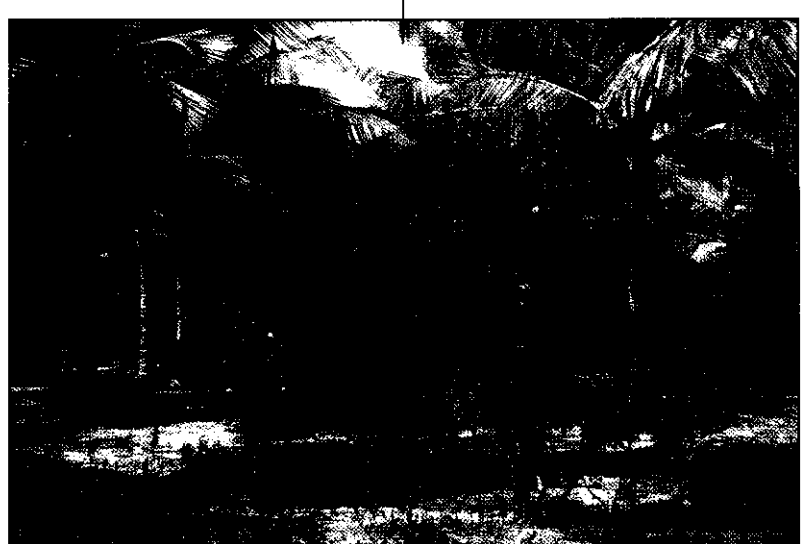
Under these conditions soil management practices that improve the soil fertility status apart from increasing the water holding capacity, hold the key for increasing the productivity.

Sandy Soil Management

A few technologies developed over a period of time which has helped increase the productivity are detailed here. The organic matter status of the soil can be maintained by the addition of green leaves, compost or farm yard manure (FYM). Earlier studies revealed that addition of blended organic sources, like forest leaves and cattle manure markedly enhanced the growth and vigour of coconut palms as compared to palms treated with NPK fertilizers alone. However, in many coconut gardens, farmers are unable to apply the required quantity of compost or FYM because of inadequate availability and high cost involved. This necessitates the *in situ* production or alley cropping of green manure crops.

Alley cropping/ intercropping of glyricidia in coconut gardens

Even though coconut is a widely spaced crop, the interspace cannot be utilised economically for growing commercial intercrops in sandy soils without adopting soil and water conservation measures and



Glyricidia as intercrop in coconut garden

irrigation. Under these situations, permanent coconut-tree legume intercropping may be well suited under costal sandy soils with minimum water for establishment in the begining. Glyricidia has a great potential as multipurpose tree in agroforestry, which fits well in marginal and sub marginal soils. Keeping the above points in mind, investigations on the feasibility of growing glyricidia in coconut gardens were carried out at the Central Plantation Crops Research Institute (CPCRI), Kasaragod. It has been proved that glyricida can be successfully grown as intercrop in the coconut garden in littoral sandy soil, where no other green manure can establish, thrive and supply green manure permanently especially the annual green manure crops.

Glyricidia can establish and grow well in different types of soils including coastal sandy soil and different agro climatic conditions. Either stem cuttings or seedlings raised from seeds can be used for planting. Seedlings can be raised in poly bags/raised beds. It is preferred that the planting season coincides with monsoon season (South West monsoon/North East monsoon) for better establishment. During initial period (for six months) protective irrigation should be given for the establishment of glyricidia seedlings/cuttings either through hose/sprinkler/ drip/pot watering wherever it is necessary. Spacing of 1 x 1 m can be adopted (between row to row and plant to plant). Two or three rows of glyricidia can be planted in between two rows of coconut. Planting can be done as depicted in the schematic representation of glyricidia in coconut gardens (fig.1). One meter long stem cuttings / seedlings should be planted in an upright position in the pits of 30 cm ^{3}. For better

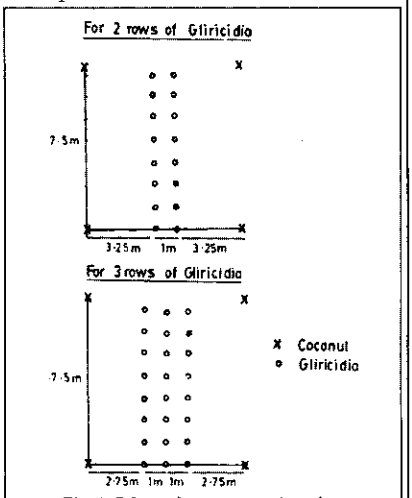


Fig. 1. Schematic representation of gliricidia planting in coconut gardens.

establishment, a basal dose of 50 kg of phosphorus/ha can be applied. Pruning height should always be maintained at 1 m height. Glyricidia intercropping suppresses the weed growth, hence weeding may not be a major problem. However, in certain cases weeding can be done manually if required. Pest and disease of glyricidia is not a major problem and no plant protection measures are required.

Pruning can be started after one year of planting. Three rows of glyricidia in between two rows of coconut with three prunings per year (February, June and October) resulted in higher biomass yield of 7970 kg ha^{-1}. The coconut growth was not affected by intercropping of glyricidia. Application of the glyricidia prunings from interspace of one hectare of coconut garden to the coconut palms could meet a major portion of nitrogen (90 per cent), part of phosphorous (25 per cent) and potassium (15 per cent) requirement of coconut palms (Table 1). The *in situ* planting of Nitrogen fixing tree species like glyricidia between the coconut rows can supply the micronutrients such as Copper, Zinc and Boron. Further, *in situ* availability, easy decomposability and low cost green manure are the added advantages. In addition to this, the microclimate condition in the coconut garden also is improved.

Table 1: Nutrient substitution through gliricidia loppings in coconut

....	N	P	K
Coconut			
Fertilizer recommendation (g/palm/year)	500	120	1200
Total fertilizer nutrient needs (175 trees; kg/ha)	87.5	21.0	210
Gliricidia			
Nutrient content of loppings (%)	3.38	0.247	1.165
Nutrient availability through gliricidia biomass from 1 ha glyricidia intercropped coconut garden	77.74	5.68	26.80
Fertilizer nutrient substitution by gliricidia			
% substitution	**88.0**	**27.0**	**13**

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SLUG OR NETTLE CATERPILLAR PESTS OF COCONUT

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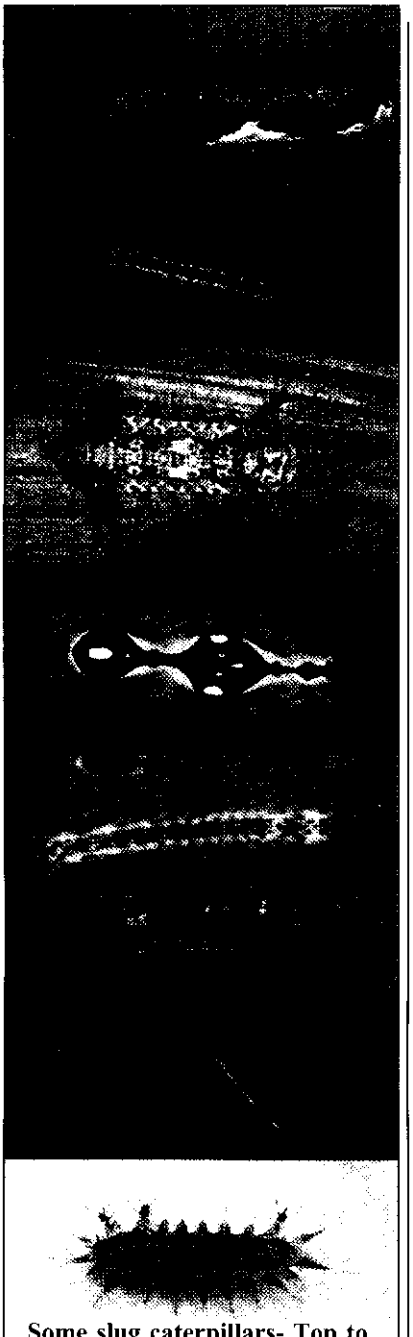
Larvae belonging to lepidopteran family Limacodidae are fleshy, slug-like and have a series of tufts of spines highly irritating and painful to touch, hence called 'slug larvae or caterpillars' or 'nettle larvae or grubs'. In Indonesia they are locally known as *ulat bulu.*

The moths of limacodids are small to medium-sized, stout-bodied and covered with dense setae, giving them a woolly appearance. Their basic colour is most often brown, and the wings often have characteristic green patches. They are nocturnal. The dorsoventrally flattened eggs are laid singly or in overlapping clusters.

The head of the slug like larvae is retracted into the thorax. Thoracic legs are small. Suction discs are present ventrally on the abdomen, which in crawling are coordinated to produce a slow gliding motion. They are brightly coloured, mostly bluish or greenish in colour, and sometimes with stripes. The pupae, usually are thick and robust looking, enclosed in a hard, ovoid cocoon with a trapdoor exit.

Limacodid larvae usually feed on the abaxial surfaces. The larvae of early instars consume only the outer surfaces of leaf tissue, leaving the adaxial surface intact. This results in elongated parallel-sided window like scars. Beginning with the fourth instar, the larvae may perforate these scars, so that the ultimate damage consists of holes all the way through the laminar tissue.



Some slug caterpillars- Top to bottom: *Darna trima, Pseudonirmides sola, D. diducta, Setothosea asigna, Parasa lepida, Thosea vetusta* and *Susia malayana*

Limacodid larvae typically consume the equivalent of one or two leaflets per larva during their development. An estimated 95% of the consumption of leaf tissue by limacodid larvae is by the three last larval instars.

Limacodids prefer monocotyledons, many species are highly polyphagous. In addition to palms, limacodids are among the most important defoliators of bananas, plantains and other crops. In tropical countries, dicotyledonous host plants of limacodids include crops, and fruit trees, such as citrus, coffee, cacao, guava, lychee, etc.

Normally they do not cause any economic damage but at times under inadequate biological or environmental regulations they multiply in enormous proportions and cause serious damage.

Limacodid population reaching outbreak levels on palms require artificial (i.e. chemical) control in Asia, Africa and tropical America. Outbreaks of limacodids tend to spread slowly, indicating low dispersal abilities.

The treatment thresholds may be expected to vary from 10 to 20 larvae per frond for large species and from 30 to 80 larvae for small species.

For management of slug caterpillars, mechanical removal of the pest, cutting and burning of highly infested leaves,

conservation and use of some bacterial, viral and fungal pathogens, predators, parasitoids and chemical insecticides have been attempted from time to time. Progressive farmers use 'Tree sprayer' for faster coverage. Root absorption of systemic insecticides and application of viruses are considered appropriate for the management of slug larvae.

Pest Distribution

About three dozen species of slug caterpillars have been recorded infesting coconut in different countries. Slug caterpillars recorded on coconut include *Acharia fusca* from tropical South America; *A. stimulea* from south-eastern USA; *Casphalia extranea* from Cote d'Ivoire; *Chalcocelis albiguttata* from Malaysia (Sarawak), Indonesia and Vietnam; *C. fumifera* from Malaysia and Myanmar; *Contheyla rotunda* from India and Indonesia; *Darna catenatus* from Malaysia (Sarawak) and eastern Indonesia; *D. diducta* from South-East Asia; *D. furva* from Thailand, north-eastern India, southern China and Taiwan (China); *D. mindanensis* from Philippines; *D. nararia* (=*Macroplectra nararia*) from India and Sri Lanka; *D. sordida* from Indonesia, Malaysia and Thailand; *D. trima* from Malaysian Peninsula (Sarawak, Borneo), Indonesia (Sumatra, Java); *Narosa conspersa* from Indonesia, Sri Lanka, India and Taiwan (China); *Parasa darma* from Myanmar, Malaysia, Indonesia, Thailand and Taiwan (China); *P. lepida* from Indo-Malaysian region; *P. philipida* from Philippines; *P. viridissima* from Nigeria; *Pectinarosa alastor* from Indonesia ; *Penthocrates rufofascia* from Philippines; *Penthocrates zelaznyi* from Philippines; *Setora cupreiplaga* from Indonesia (Borneo and Natuna Islands); *S. kelapa* from Indonesia; *S. nitens* from Malaysia (Sarawak), Indonesia (Java, Sumatra) and Vietnam; *Setothosea asigna* from Indonesia, Malaysia and Philippines; *Thosea andamanica* from India; *T. aperiens* from Sri Lanka; *T. chrysoparala* from Ghana; *T. cineteomarginata* from Philippines; *T. loesa* from Thailand; *T. lutea* from Malaysia and Indonesia; *T. molluccana* from Indonesia; *T. monoloncha* from Indonesia and Papua New Guinea; *T. sinensis* from Indonesia; *T. vetusa* from South-East Asia and *Trichogyia albistrigella* from Indonesia and Thailand.

Slug caterpillars recorded from oil palm include *Acharia fusca* from tropical South America; *A. nescea* from Brazil and Argentina; *Casphalia extranea* from Cote d'Ivoire; *Darna diducta* from South-East Asia; *D. furva* from Thailand, north-eastern India, southern China and Taiwan (China); *D. sordida* from Indonesia, Malaysia and Thailand; *D. trima* from Malaysia (Sarawak, Borneo), Indonesia (Sumatra, Java); *Epsibine intensa* from Guyana and Colombia; *E. sibinides* from Peru; *Euclea diversa* from Mexico to Peru; *Euprosterna eleasa* (=*Darna metaleuca*) from Mexico through tropical South America; *Natada subpectinata* from Trinidad and tropical South America; *Parasa viridissima* from Nigeria; *Pseudonirmides sola* from Philippines; *Setora cupreiplaga* from Indonesia (Borneo and Natuna Islands); *Setora nitens* from Malaysia, Indonesia and Vietnam; *Setothosea asigna* from Indonesia, Malaysia and Philippines; *Susia malayana* from Philippines and *Thosea lutea* from Malaysia and Indonesia.

Occasional outbreaks of limacodid larvae on oil palm, notably in Malaysia (Sabah), Indonesia (Sumatra) and the Philippines are easily controlled by a policy of minimum insecticidal intervention.

The best-known limacodids, of course, are species that have frequently undergone outbreaks and caused the greatest economic damage to economically important palms. Some significant limacodids of major regions are discussed below.

Contheyla rotunda

Contheyla rotunda is a sporadic pest occasionally causing serious damage in west coast of India and some parts of Indonesia. The adult *C. rotunda* is a small inconspicuous moth about half a centimetre in length and having a wing span of about 20 mm in the female and 16 mm in the male. The moth is greyish-brown to dark grey in colour. The wings are kept roof like over its body while resting on the leaves. Antennae are plumose in males and filiform in females. Adult males live for 4-6 days and females for 5-6 days. Adults mate on the day of their emergence, and oviposition began on the same night or the following day. Females mate in the morning and lay small, scale-like, elliptical and compressed eggs singly on the underside of leaflets in small batches of 5-10. Oviposition continued for four days, the number of eggs laid decreasing progressively, a mean of 215 (62 to 420) eggs is laid on the abaxial surfaces of fronds. Eggs hatch in about five to seven days with a viability of 83% and the young larvae come out of the egg shells by bursting them open.

The larvae are slug like, with marginal tubercles bearing long spines and dorsal tubercles with short spines. They vary in colour from pale yellow, ash-grey, greyish brown to almost brick-red, with two narrow grey dorsal stripes. The larva is sticky and

soft on the ventral side and moves sluggishly. The larval instars last 4 (3-5), 5.5 (5-6), 8.2 (7-10), 6.1 (5-7) and 7.5 (6-10) days. The entire larval period lasts for 34 days (25-45) days reaching a size of 1.0-1.5 cm in length.

On completion of larval period they migrate to the leaf axil or to the soil, remain inactive for 12-24 h and spin round shell like dense cocoons of brown silk impregnated with a loose white powdery substance. The ovoid 8–15 mm long cocoon is attached firmly to the surface of the affected leaflets. The pupal period varies from 10 to 15 days. The adult moth comes out from the cocoon by pushing aside the opercula. The total duration of life cycle of *C. rotunda* varies from 42 to 60 days with an average of 52 days.

C. rotunda usually causes little damage and passes unnoticed, but occasionally it reaches outbreak proportions. The young larvae scrap the green chlorophyll tissues in small round patches by remaining on the undersurface of leaves. The grown up larvae feed on the margin of leaflets causing irregular feeding damage up to leaf tip. The patches of scrapping get dried and feeding holes are even visible from the ground level on the affected leaves. The larvae damage not only the leaves but also the green petioles, spathes and nuts of coconut palm and even the foliage of other crops grown beneath the palms, giving a scorched appearance to the whole plantation. Older and tall trees are highly preferred by the pest. The intensity of attack varied from 1-15 larvae/leaflet and on an average 250-500larvae/frond. Saw dust like fecal pellets is spread in large quantity all over the field on the ground due to feeding. Adult moths, larva and fecal matter when falling on the skin cause itching on people working inside the garden.

The first report of the pest attack in coconut palms in India was made in south Malabar during February 1916. This pest was subsequently recorded as a minor pest in 1920-1930 in Kochi (Cochin) and Malabar Coast in Kerala, and few places in Andhra Pradesh and Tamil Nadu. In an outbreak in 1936/37 in Edavanakad, Kerala, India all but the youngest fronds of 10,000 coconut palms were stripped, and the larvae even fed on surfaces of petioles. Severe outbreak was reported in 1954 in Ashtamudy area of south Kerala, India. During a severe outbreak, the larvae of the pest can cause severe defoliation, resulting in yield reduction by 75%.

In 1969 (February/March) an outbreak of *C. rotunda* was reported along the Rambungan coastal coconut plantations of the First Division, Sarawak, Malaysia, in an estimated area of 500 acres or more.

In second fortnight of February 1997 an outbreak of *C. rotunda* was recorded in Muthianvalasu, Nathakadaiyur, Kuttappalayam, Kolanelli, Unjalur, Ilamathur, Payakottai, Maruthurai, Mudakurichi and Sivagiri villages of Periyar District, Tamil Nadu, India to an extent of 10-90% infestation. The outbreak was noted in 21 villages of Periyar district affecting coconut plantations on 400 hectares of land. The occurrence of the pest attack was very pronounced in Erode and Kangeyam blocks. The sudden outbreak of this pest created panic among the coconut growers of this district.

In March, 2006 a sudden outbreak of *C. rotunda* was observed in the village Bala Marthandapuram of Kanniyakumari district in Tamil Nadu, India devastating about 200 ha and creating panic among coconut growers. Dr. P. Rethinam, Executive Director, APCC who is instrumental to form a committee also accompanied the Committee for accessing the impact of this outbreak and recommended providing necessary awareness for the Agricultural Field Officers and Coconut farmers of the locality for prompt action. The awareness programme for Agricultural Officers from Kanniyakumari and Tirunelveli Districts (15 officers from each district) and the progressive farmers from both the districts (10 from each district) has been conducted in mid March, 2006 with close association of the Scientists and Officials from Central Plantation Crops Research Institute, Coconut Development Board (CDB), Tamil Nadu Agricultural University and Department of Agriculture, Tamil Nadu. As an immediate step, Joint Director of Agriculture, Nagercoil and Joint Director of Agriculture, Tirunelveli were requested to take up the control measures at field level as per the recommendations in the affected coconut areas and nearby gardens. Request was made to CDB to provide necessary financial support to distribute the pesticide in the affected area and for the training programme of the Departmental Officials. Farmers were advised to take up necessary precautionary steps while taking up spraying to avoid any side effect on the non-target areas like wells, water bodies, intercrops, animals, poultry, etc.

The preferred host plant of *C. rotunda* is coconut palm; relatively tall palms being most frequently attacked. When high populations have developed on taller palms, the insects may attack younger palms and seedlings.

In severe outbreaks, *C. rotunda* attacks leaves of plantains and several other crops such as arrow-root

***Contheyla rotunda*-Top: Severe damage caused to coconut palm; Second Row – Left to Right: Close up of the damage caused by larvae, Nuts showing scrapping by larvae, Larvae collected from below the palm canopy**

(*Curcuma angustifolia*), wild arrow root (*Maranta* sp.), areca palm (*Areca catechu*), banana (*Musa paridasiaca*), cacao (*Theobroma cacao*), cover crop (*Pueraria javanica*), tea (*Camellia sinensis*) and grass in addition to coconut (*Cocos nucifera*).

In the south-west coast of India during monsoon, the heavy rains may cause catastrophic mortality to the weak, clumsy adult moths of *C. rotunda.*

Population of *C. rotunda* is regulated by a complex of hymenopteran parasitoids of larvae and pupae. Among the natural enemies, parasitoids-braconid *Rogas* sp., ichneumonid *Goryphus* sp., chalcidids *Antrocephalus* sp. & *Aroplectrus contheylae* & chrysidid *Chrysis* sp., and bacterial and fungus diseases during the rainy seasons are recorded as parasitizing *C. rotunda. Chrysis* was found parasitising 15-30% of the pupae. Release of predatory pentatomid bug, *Eocanthecona furcellata* is found effective in managing the pest. During the rainy season, quite often, severe outbreaks are brought under control by bacterial and fungus pathogens.

The common method of artificial control is to cut off and burn heavily infested palm leaves that are too badly damaged to be functional. Cutting and burning infested leaves will check the spread of the pest.

In chemical control, earlier, spray of BHC [HCH] 0.1% and DDT 0.1% were used. BHC 0.1% was the most economical for large-scale control; in severe outbreaks, monthly applications were given to reduce the pest population level below the economic threshold. Subsequently, 0.05% carbaryl, quinalphos, carbaryl, endosulfan, chlorpyriphos, monocrotophos and trichlorfon were evaluated successfully.

In India committees were formed after every major outbreak, which recommended the following measures from time to time for the management of *C. rotunda.*

1. Adoption of proper sanitary measures including cutting and burning of severely affected leaves in a co-operatives manner simultaneously by all the farmers in an area after identifying pest and its stages. While cutting the leaves a petiole length of one metre shall be retained. If feasible, collection and destruction of eggs, larvae, pupae and affected leaves be followed.
2. Light traps could be set up one per 500 trees to monitor and trap adult moths. Water pan with little quantity of kerosene can be used to kill the moths attracted to light.
3. Chemicals recommended included spraying with monocrotophos coupled with root feeding of dichlorvos, spraying carbaryl 0.1% (2 grams/litre of water) on the under-surface of the leaves to give thorough coverage of the entire canopy of the palm including the inner leaves. Spraying severely infested trees with dichlorvos (Nuvan) at 2.0ml/l of water using pedal pump or rocker sprayer or tractor mounted H.T.D. pump and spray gun. Sticker or neem oil at 10ml/20 lit of spray fluid can be added to enhance sticking. Since there is a possibility of a second build up of the pest due to heavy incidence it is desirable to give a second round of pesticide application after 20 days of first round. Pesticide application may be done only

after proper monitoring of the pest population and determining the need for such action.

4. Root feeding with monocrotophos (Nuvacron) 10ml + 10ml water selecting a feeder root at 3 feet away from the trunk. Observe the minimum waiting period of 30-45 days for using coconut for consumption.
5. Biological control of the pest needs further investigation but simple natural enemy conservation methods may be adopted on a regular basis.
6. The weeds in the coconut gardens also have been seen to serve as the collateral hosts of the pest. Hence weed control may also be taken up.
7. Farmers should be trained to take up monitoring of pest incidence by cutting sample green leaves or 50-100 leaflets in their garden to identify periodically and report immediately to the nearest Staff of Department of Agriculture or Scientists of the Agricultural University if noticed. By integrated and community approach, the pest outbreak can be reduced to manageable level. Monitoring of palms in the immediate vicinity of affected gardens is also necessary to take adequate control measures in time, if pest is noticed.
8. The pest affected palms require special care such as need based irrigation and organic manure application for the speedy recovery. As the pest attack is contiguous, involvement of the farming community of entire village is essential for the management of the pest.

Parasa lepida

Parasa (*Latoia*) *lepida* is commonly called as nettle larva; blue-striped nettle grub; nettle grub green striped or castor slug larva. *P. lepida* is common throughout Indomalaysia, from India and Sri Lanka to Malaysia and the Indochinese peninsula (mainly Vietnam), Indonesia and as far out as Papua New Guinea. In Indonesia, it is very frequent in south Sumatra in the Lampung region, and also in Java. The species is one of the most highly polyphagous limacodids, attacking monocotyledons and dicotyledons of diverse families but showing a strong preference for coconut palm. *Parasa lepidula* is distributed in China and Japan and *P.media* in mainland and insular South-East Asia as far East as Bali (Indonesia).But *P. lepida* is the most serious during outbreaks.

***Parasa lepida*-Top to bottom: Adult in resting position, Adult showing wing expense, Larva, Pupa, Close up of the damage by larvae, Nymphs of *Eocanthecona furcellata* feeding on larva**

The wing span of *P. lepida* male measures on an average 30 mm, and females 40 mm with a much sturdier body. Both the sexes are similar in colour. The head and thorax are yellowish green, and on the latter there is a large reddish brown dorsal patch narrowing to the fore and edged with a darker line. The abdomen is reddish-brown, and the legs are dark red-brown with well-developed tufts of bristles. The forewings are largely dark brown at the base. A brownish, sinuous line starts at the costal edge two-thirds of the way down the wing and crosses it obliquely to the middle of the lower edge, marking off at the rear a light brown zone with reddish glints darker than the fore and middle parts, which are yellowish green. A brownish fringe surrounds the outer edge of the wing. The rear wings are light brown at the base, darkening towards the distal area. The colouring of the undersides of the wings is fairly similar but

the pattern is only faintly marked.

Adult emergence coincided with the onset of the rains. The adults usually emerge from the cocoons in the evening and are active at twilight. During the day, they rest on the tips of dried up leaves on the lower part of the tree. Mating takes place on the second day after adult emergence, and oviposition begins the next day, the adults live for 4-10 days.

The females lay about 350 eggs in 3-5 days, but one female produced 660 eggs. Two mm long oval, yellowish, translucent and very much flattened eggs are laid in batches of 10-50, glued to the substratum on the undersides of leaves, and hatching occurrs after 5-7 days.

Newly hatched larvae are 4-5 mm long and last instar fully developed larvae are 20-25 mm long. The overall colour is yellowish green, with a characteristic wide, pale blue band bordered by a dark brown line running down the middle of the back. In the first instars the protuberances are very marked to the fore and rear of the body; from the fifth instar onwards they are practically the same size; in the first two they are completely yellow, and it is in the third instar that a band of indefinite outline and a diffused blue colour appears along the back, to become more distinct in the fourth and take on its final shape and tint in the fifth. The characteristic velvety-black anal patches develop in the sixth stage. Larvae are gregarious during early development but disperse subsequently. It is not uncommon for them to go from one frond to another in procession. The entire larval stage, which consisted of 6-8 instars, lasts 40 days (30-48).

After the pre-pupal stage the larvae pupate in a cocoon glued to the ventral surface of the leaf on the leaf bases in the crown, on the stem under the fibres or, on young coconuts, at the collar; the cocoons are all clustered closely together. The cocoon is longer than it is wide, perfectly hemispherical, and covered with a fine web, especially along the sides. The average measurement is 12.7 mm long (12.2-13.5 mm) by 8.4 mm wide (7.6-9.0 mm). When newly-formed it is reddish brown but quickly darkens to blackish-brown as it dries. The oldest cocoons are grayish-looking. The pupal stage lasts about 20-24 days. Each generation is completed in about 68 (55-77) days.

As soon as they hatch the young larvae feed on the underside of the epidermis, stripping it off the leaflets, often at the tip where the eggs are laid. Then they start eating the edges of the leaflets and devour larges areas of the lamina. When they have finished devouring the whole leaflet will have been consumed systematically from tip to base, leaving only the midrib, the notched indentations left by the larvae are visible.

The first outbreaks of *P. lepida* are usually localized; a few trees only are preferentially defoliated and easy to spot. But if nothing is done, the infested area may enlarge rapidly in the course of the next generation.

P. lepida attacks seedling stage, vegetative growing stage, flowering stage, and fruiting stage of the palm. It causes severe damage to adult coconut palms, and young palms may be completely defoliated. A marked reduction in net production of coconut palm was observed during the first six months following a severe defoliation by *P. lepida.* In Indonesia infested palms produced no coconuts in the ensuing 20 months, and did not fully recover production until after 40 months following defoliation.

In an outbreak of *P. lepida* on coconut in Kerala, India, in August 1986, many diseased and dead larvae were found on the lower surface of the leaves.

P. lepida is highly polyphagous and attacks a variety of crops particularly banana (*Musa paridasiaca*), orchid tree (*Bauhinia* spp.), palmyra palm (*Borassus flabellifer*), cacao (*Theobroma cacao*), siamese senna (*Cassia siamea*), castor (*Ricinus communis*), citrus (*Citrus* sp.), coconut (*Cocos nucifera*), coffee (*Coffea* sp.), gandhraj tree (*Gardenia* sp.), gliricidia (*Gliricidia sepium*), gamhar (*Gmelina arborea*), jungleflame (*Ixora parviflora*), kachnar (*Bauhinia variegata*), kaghazi lime (*Citrus aurantifolia*), kusum or Indian lac tree (*Schleichera triguga*), litchi (*Litchi chinensis*), mango (*Mangifera indica*), sago palm (*Metroxylon* sp.), mulberry (*Morus alba*), neem (*Azadirachta indica*), rambutan (*Nephelium lappaceum*), nypa palm (*Nypa fruticans*), oil palm (*Elaeis guineensis*), pear (*Pyrus pyrifolia*), pepper (*Piper nigrum*), pineapple (*Ananas comosus*), pomegranate (*Punica granatum*), rice (*Oryza sativa*), rose (*Rosa* sp.), tamarind (*Tamarindus indica*), tea (*Camellia sinensis*), winged bean (*Psophocarpus tetragonolobus*), wood apple (*Limonia acidissima*) and bush legumes but not African oil palm.

Parasitoids reared from *P. lepida* include- braconids- *Apanteles parasae, Apanteles* sp. & *Clinocentrus* sp., ichneumonids *Goryphus oxymorus,* chrysidids *Chrysis* (*Pentachrysis*) *shanghaiensis* & *Stilbum splendidum,* eulophids *Pediobius detrimentosus* (=*Pediobius imbrues*) & *Pediobius* sp., chalcidid *Stomatoceras ayyari,* elasmid *Elasmus albomaculatus,* eupelmid *Eupelmus catoxanthae,*

eurytomid *Eurytoma monetna,* tachinids *Bessa remota* , *Chaetexorista javana, Chaetexorista* sp. & *Exorista sorbillans,* sarcophagid *Seniorwhitea orientalis*, and calliphorid *Sarcophaga* (*Sarcorohdendorfia*) *antelope.*

Among predators- pentatomids *Eocanthecona concinna*, *E. furcellata* and reduviid *Isyndus obscurus* have been recorded on *P. lepida* from different countries. An interesting predatory larva *Phycita dentilinella (*Phycitidae) has been recorded inside the cocoon of the pest destroying the pupae. *P. dentilinella* may also pierce the surface of the cocoon, thus opening the door to numerous pathogens or predators.

Entomopathogens such as *Aspergillus* sp., *Cordyceps* sp., *Cordyceps sinensis, Beauveria bassiana,* granulovirus, a multiple embedding virus and small icosohedral virus have been reported from *P. lepida.* In Sandhiyur, Tamil Nadu, India, approximately 25% of the larvae were naturally infected with a local strain of entomopathogenic bacterium *Bacillus thuringiensis*. Granulovirus was found to be important in controlling larval populations under natural conditions. Natural incidence of virus diseases was 20% (average). *Bacillus thuringiensis* subsp. *japonensis* was highly toxic to larvae of *P. lepida.*

During the rainy season population of *P. lepida* is frequently decimated by a virus disease, the efficacy of which is reinforced and the dispersal ensured by *Forcipanyia* sp. (Diptera: Ceratopogonidae). This insect sucks haemolymph of sick and then healthy larvae, thus vectoring and disseminating the disease and limiting the spread of the pest.

In young plantings, when the fronds are accessible and the attacks confined to a few trees, the larvae in gregarious phase and cocoons can be collected by hand and destroyed. When the trees are older and the leaves out of reach, or when the infestation is general, with a population above the critical threshold and no adequate biological control, chemical treatment may be given. The chemicals evaluated earlier were DDT or HCH, lead arsenate and Derris. Subsequently several chemicals such as azinophos-methyl, dichlorvos, monocrotophos, quinalphos, triazophos, carbaryl, trichlorphon, dichlorvos, malathion and fenitrothion at 0.05% were evaluated; although effective, these insecticides are not very selective. The most effective products for use in sprays were carbaryl at 1.2 kg/ha or a preparation of *Bacillus thuringiensis* at 1 kg /ha for small localised foci and the pyrethroids- deltamethrin (Decis) at 10 g/ha, permethrin at 30 g/ha or fenvalerate at 20 g/ha for larger areas. As mentioned earlier sprays of granulovirus gave effective control of larvae.

For management decision making periodical checks is necessary with sampling of two trees/ha and a count of larvae on a leaf of average level, 9 to 14 or 19, depending on the age of the palms. The critical threshold is 10 larvae on the most infested frond in young trees and 20-35 in mature ones.

Parasa viridissima

Parasa viridissima is a pest of coconut palms and African oil palms in Nigeria, West Africa. The moths are green, with brown markings. The adult measures 30-40 mm. The larvae are green, with regularly spaced tufts of spines and two tufts of red-orange bristles posteriorly. The larval stage may last up to about 3 months. The spheroid cocoons are spun of whitish silk with incorporated spiny exuviae. The development cycle takes 3-4 months. During outbreaks, 90% of the palms in a plantation may be infested by *P. viridissima.*

Natural enemies attacking the larvae of *P. viridissima* included two species of Braconidae, one of Eulophidae and a species of nematode, *Agamerimis* sp. (Mermithidae). Two species of Chalcidoidea, one of Ichneumonidae and one of Bomhyliidae parasitize the pupae. A fly, *Palexorista* sp. (Diptera:Tachinidae), parasitizes both the larvae and the pupae and was the most abundant in samples of parasitoids of this larva, 17.8% of the larvae in 1980 and 11.1 % in 1981 were parasitized, and each year most of the larvae were parasitized by the tachinid fly. A virus, which may infect any larval stage, is a principal natural control agent. Spiders and mantids play additional roles in regulating populations of *P. viridissima.*

Predation and microbial infection of the first two instars were the major factors that regulated generation to generation population growth.

Another important limacodid on coconut palm and, to a lesser extent, on African oil palm in West Africa is *Parasa pallida.* Its bionomics and control are similar to those of the above mentioned *Parasa* species.

Darna* (*Macroplectra*) *nararia

Darna nararia is a sporadic pest occasionally causing serious damage. *D. nararia* occurs commonly in Godavari district of Andhra Pradesh and during May 1995, it severely defoliated about 8 per cent of trees in 15 coconut gardens in Devanahalli, Bangalore, Karnataka, India. On the east coast of India, *D. nararia* occasionally attacks the coconut palms and cause extensive damage to leaves.

Adult of *D. nararia* is pale brownish coloured moth. The

basal two third portion of fore wing is red in colour while the border is brown. The tiny scale-like eggs are laid singly on both sides of the leaves, which hatch in 4-5 days. The fully grown larva is 8-11 mm long and is yellowish green on the upper side and pinkish on the underside. A series of red tipped tubercles increasing in length towards the hind end with very short spines are present on the upper side. The larva is strongly mandibulated and devoid of prolegs. The larval period is on an average 31 days. Pupa is enclosed in a 5-7 mm round, brownish shell which is covered sparsely by light yellowish brown silk.

Larvae are mostly confined to lower surface of leaves. Severely affected palms are devoid of green parts of leaflets. *D. nararia* is polyphagous pest capable of feeding on a widely unrelated plant species like jack fruit (*Artocarpus heterophyllus*), pongamia (*Pongamia pinnata* =*Pongamia glabra*), erythrina (*Erythrina indica*), papaya (*Carica papaya*), citrus (*Citrus* sp.), eucalyptus (*Eucalyptus* spp.), ficus (*Ficus* sp.), cotton (*Gossypium herbaceum*), hibiscus (*Hibiscus* sp.), Arabian jasmine (*Jasminum sambae*), mulberry (*Morus alba*) and curry-leaf (*Murraya koenigii*). Its ability to feed on eucalyptus is interesting as a few specialized feeders only are capable of feeding on this plant.

An unidentified braconid parasitoid was found parasitizing the larvae, 6-8 pupae (in two rows) of the parasitoid were found loosely attached to the leaflet beneath the larval cadaver. Pentatomid predator *Eocanthecona furcellata* preyed on larvae of *D. nararia* in large numbers. During the rainy season, this pest is attacked in nature by fungi such as *Aspergillus flavus* and *A. niger*. In Sri Lanka, a suspension of a granulosis virus has been applied in an attempt to suppress the pest. Few species of eulophids parasitoids have been recorded on it in Sri Lanka. Of these, the commonest and most effective is *Euplectrus maculates*. Four new species of chalcid parasitoids i.e. *Eurytoma tatipakensis*, *Euplectromorpha natadae*, *Secodes nararіae* and *Euderus natadae* were recorded from *D. nararia* from Tatipaka, Andhra Pradesh, India.

If the defoliation is very severe and natural enemies are not effectively reducing the pest population, spraying either chlorpyriphos or monocrotphos 0.05% is done. Since the insect pupates in the axils at the base of the fronds in large numbers, packing this space with a 1:1 mixture of sand and carbaryl is also undertaken.

***Darna catenatus* (=*Orthocraspeda catenatus*)**

Darna catenatus is distributed in South-East Asia-Indonesia (Sulawesi), and Papua New Guinea. The forewings of adult moths are brown to ochre; the male (8-14 mm) has a darker brown border. The larva at the end of its development is 15 mm long, whitish green with discontinuous black lines on its back. The development cycle is completed in 6-7 weeks. The cocoons are fixed near to the central vein of the leaflet. It is attacked by hymenopteran: *Euplectrus* sp. (Chalcididae), *Apanteles* sp. (Braconidae) & *Chrysis* sp. (Chrysididae); and by dipteran, *Chaetexorista* sp. and *Bessa* sp. (Tachinidae). A virus disease limits the population.

D. catenatus is known to feed on palms (coconut and areca), pasture and ornamental grasses, weeds, and foliage plants. Fecal pellets on the leaves are signs of presence of the larvae.

A cytoplasmic polyhedrosis virus, trichogrammatid wasp, ultraviolet light traps with a bucket of soapy water directly beneath it to capture fallen moths has good potential. Some pesticides (pyrethroid, organophosphate, carbamate, and microbial types including *Bacillus thuringiensis*) could also be effective against the larval stage.

Another species of *Darna*, *D. trima* is recorded from Malaysian Peninsula (Sarawak, Borneo) and Indonesia (Sumatra, Java). Up to 2000 larvae of *D. trima* per frond have been observed during an outbreak. Three types of viral particles were identified from *D. trima* with a natural incidence of 24%.

Setora nitens

Setora nitens is a major limacodid pest of palms in the Malaysian Peninsula, Java and Sumatra (Indonesia). A highly polyphagous insect, its host plants include coconut palm, African oil palm, sago palm, nypa palm, bananas and diverse dicotyledonous trees, including cacao, cinchona, citrus, coffee, tea and others.

The adult moth is brown, with dark reddish-brown bands on the wings, and has the typical woolly appearance of limacodids. The wing expanse of the female is 30—35 mm and that of the male about 15 mm. The moths are nocturnal. The females lay eggs in rows on the abaxial surfaces of the more mature fronds, often near the tips of leaflets. One female lays 250-350 eggs, which are oval in shape and measuring 2 mm X 3 mm. The eggs hatch in about a week.

First-instar larvae are 3-4 mm long. Fifth-instar (i.e. mature) larvae are over 20 mm long, with large female mature instars up to 39 mm long. The larvae are typically green, but there are orange, red and other colour forms with a purple band in the middle. The body has an

abundance of warts covered with itching hairs.

First-instar larvae feed only on the epidermis, forming translucent window-like areas. Larvae of later instars feed from the margin of the lamina inward, leaving the midvein. *S. nitens* larvae attack the more mature fronds and, as population densities increase, move to even younger fronds. Larval development takes 3-7 weeks. Larvae crawl down to the base of the trunk or among herbaceous vegetation to spin cocoons and pupate. Smooth and spheroid light brown cocoons are, about 15 mm X 17 mm in females and 13 mm X 15 mm in males. The pupal stage lasts 2.5 and 4 weeks.The development cycle is completed in two months.

S. nitens may remain for long periods at low population levels, undergoing occasional devastating outbreaks. In north Sumatra (Indonesia), it occurs in the drier months of February and March, causing up to 60-90% defoliation. They are particularly severe pests of African oil palms of 2-8 years of age. Some larvae grow to be relatively large, and thus their consumption of foliage is correspondingly great. In addition to direct damage to palms, *S. nitens* is a nuisance in plantations because the venom of their urticating spines causes exceptionally painful reactions.

Parasitoids of *S. nitens* include trichogrammatid *Trichogrammatoidea thoseae* on the eggs; Eulophid *Euplectromorpha malayensise* on the young larvae, and braconid *Spinaria spinator* on the older larvae and tachinid *Chaetexorista javana* on the cocoons. But there are also several hyper-parasites. The reduviid bug *Sycanus leucomesus* and pentatomid *Eocanthecona furcellata* are active predators of the larvae and a virus on the larvae and fungus (*Cordyceps* sp.) on the pre-pupae. Diagnostic tests using molecular technology have been developed for detecting viruses. These can be used to monitor infection levels in the larval populations. *C. javana* has been reported to be the most effective parasitoid. Since the duration of its life cycle is about half of that of S. *nitens,* this fly species potentially multiplies rapidly compared with *S. nitens.*

Because *S. nitens* first attacks the older fronds, moving progressively to younger fronds, coconut farmers have sometimes removed the infested fronds, even when this means removing all opened fronds. Severe pruning resulted in a 76% reduction of fruits in the year following pruning. Palms that were severely infested with S. *nitens,* but not mechanically pruned, suffered a 14.3% reduction in fruits. The effects of severe pruning are thought to be due not only to the reduction of the palm's photosynthetic area, but also to damage to young fruits exposed to full sun. Thus, severe pruning to control these larvae does more damage than the caterpillars themselves. In Indonesia, the new fronds produced after an attack on young palms were stunted, but by the time they had produced eight new fronds the palms had appeared to recover and resumed production of normal fronds.

There were fewer larvae of *S. nitens* on fronds of tall varieties ('Bali', 'Palu' and 'Tenga') than on 'Nias Yellow Dwarf'. Both stomata and trichomes on abaxial frond surfaces were denser on the dwarf variety than on the tall varieties. The head capsule of a recently eclosed larva of *S. nitens* is no larger than a trichome and hence the trichomes could serve as obstacles to the establishment of young larvae.

Mechanical control i.e. manually removing the larvae from the palms is particularly appropriate for nurseries and small landscape plantings. Control of *S. nitens* on tall palms consists of knocking the larvae off the foliage with a stiff brush of coconut fibre on a long pole. Cultural practice may enhance biological control. Maintaining a ground cover as habitat for natural enemies of limacodids is recommended.

Thosea andamanica

An outbreak of *Thosea andamanica* on coconut was recorded in the South Andaman Islands, India. A 68-ha coconut plantation was severely affected by *T. andamanica* in February 1992. Treatment of the plantation with cypermethrin and malathion sprays, both at 0.2% concentration, drastically reduced the larval population.

Another species of *Thosea, T. vetusta* is distributed in South-East Asian countries. A single larva of *T. vetusta* consumes the equivalent of two leaflets of African oil palm.

Acharia fusca (= *Sibine fusca*)

Acharia fusca, a highly polyphagous larva, is a pest of African oil palm and coconut palm distributed in northern South America. Adult moths have reddish-brown forewings and light brown hind-wings, with wing-spans of 48–54 mm in the female and 34–38 mm in the male. Larvae are pale green in early instars; after the fifth instar, the head and thorax are blue and the abdomen yellow.

The larval stage of *A. fusca* consists of ten instars

and lasts from about six to nine weeks. In the first eight instars, the larvae live gregariously in colonies of ten to sixty individuals. They are more dispersed in the last two instars and then regroup at the leaf bases to form cocoons and pupate. Specialized deciduous spines are incorporated in the cocoon covering. The pupal stage lasts about four to over 5 weeks.

A. fusca has a wide host range, in addition to palms; it attacks citrus and other dicotyledonous trees. Because *A. fusca* occurs gregariously and each larva consumes the equivalent of 1.5 leaflets of a coconut palm, damage by this species can be severe. Natural enemies include species of Braconidae, Chalcididae, Bombyliidae and Tachinidae. Tachinid *Palpexorista coccyx* has been observed to parasitize 35–75% of the larvae of some populations. Braconidae *Apanteles* sp. (*glomeratus* group) parasitizes up to 30–35% of the larvae. Bombyliid *Systropus nitidus* parasitize up to 65% of the cocoons.

A. fusca is susceptible to a densonucleosisvirus disease, which causes a decrease in activity of the larvae within days after infection. The larvae lose their gregarious habit, become more dispersed and stop feeding. Symptoms of infection include buccal and anal secretions, softening of the larvae and a change in colour in young larvae from green to yellow and then brown. The disease sometimes decimates populations within about 2 weeks. Larger larvae drop to the ground, while younger larvae die stuck to the frond surfaces.

The larvae can be controlled with an artificial application of this virus. To prepare this biological pesticide, larvae are collected while showing initial symptoms of the viral disease. These are ground up and liquefied in distilled water. Few grams of ground infected larvae per ha were sufficient to initiate an epizootic of the virus. The rapidity with which the virus spreads is greater with higher dosages and in populations consisting of earlier-instar larvae. It presumably spreads faster in dense populations. The virus apparently has the advantage of high specificity to *A. fusca.* The virus solution can be stored at 4°C for at least two years and be applied as needed, including by aerial applications.

Acharia nesea

Acharia nesea is a pest of African oil palm and has been reported from dicotyledonous crop trees, such as cashew, mango and citrus. It is distributed in Brazil and Argentina. The highly gregarious colonies of 80–100 individuals can cause extensive defoliation.

Casphalia extranea

Another important limacodid on coconut palm and, to a lesser extent on African oil palm in West Africa is *Casphalia extranea.* Its bionomics and control are similar to those of the above species. A densovirus that infects *C. extranea* has been investigated.

Setothosea asigna

Setothosea asigna a larger South-East Asian limacodid consumes leaf area, the equivalent of four to five leaflets, during development.

Virus diseases are prevalent in most of the limacodids. Symptoms of viral diseases infecting the limacodid *S. asigna* are described from Indonesia. A cytoplasmic polyhedrosis virus and another virus have been found in this species.

Health concern

The larvae are also a health concern due to their spines which cause burning and itching sensations to the skin. The nettle larva's stinging, spiny hairs have a physical effect on human skin similar to that of fiberglass. In addition, the spines release an irritant (a mixture of histamines) produced by a poison gland. The irritant causes the skin to burn and itch. Noticeable swelling may occur and welts may form that can last for several days followed by a persistent rash lasting for weeks. If spines get into the eyes, the irritation can be acute; requiring medical attention. Similarly if there are any severe symptoms such as difficulty in breathing, seek medical help immediately.

What to do if you are stung

- Avoid further contact with the larva's spines.
- Wash the area immediately with soap and water to reduce initial pain.
- An oral antihistamine may stop itching and swelling.
- Hydrocortisone cream may also stop itching and swelling.
- **Get medical attention immediately if you experience difficulty breathing or are stung in the eye.**

Conclusion

Normally limacodid do not cause any economic damage but at times under inadequate biological or environmental regulations they multiply in enormous proportions in outbreak forms and cause serious damage.

Limacodids are pests of coconut and other palms, some

species are highly polyphagous. The larvae are of major concern because of their painful irritation, voracious appetite, lengthy larval feeding and wide host range.

In general, the numerous parasitoids, predators as well as epizootic of entomopathogenic organisms are limiting factors for the spread of the slug caterpillars, which in spite of the gregarity and high fertility does not very often form big populations. But in pest outbreak years the palms are severely attacked, notably those in young stands, are completely defoliated, and on mature palms the damage can spread and cause yield losses over a period of four years. Pests in such scenario have to be controlled not only on coconut or oil palm but also on other palms and alternate hosts. Surveillance should be stepped up to find the foci and reduce them by hand collection of the larvae and cocoons or by chemical treatments if the first method cannot be used.

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