

Pests of Cocoa

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1. INTRODUCTION

Cocoa (*Theobroma cacao* Linn.) is cultivated in India on a large scale for the last 20-25 years. It is grown mainly in Kerala, Karnataka and Tamil Nadu, mostly as a component of mixed crop with arecanut or coconut. In few instances, it is grown in forest clearings with few forest trees retained as shade trees. In the last 25 years of cultivation in India, the cocoa plant is liked/disliked by most of the polyphagous insect pests of this part of the country; but none of them have evolved to a status which warranted regular chemical control. Probably this 20-25 years period is not enough for these insects to acclimatise to this crop. Another reason is the slow increase in area under this crop. But within a short period, one group of pests have become a major threat to this crop economically, they are the rodents. The reason for this sudden acclimatisation of rodents to cocoa pods may be the reduction in number of their traditional fruit crops.

Of course, few of the insects could cause severe damage during the initial years of the plant and few sucking insects could cause direct loss of the crop by feeding on young and maturing cocoa pods. In this chapter is presented the available information on the insect and other pests of cocoa in India. The insects are grouped according to the damage they cause to the crop.

2. INSECT PESTS

2.1 Sucking Insects

2.1.1 Mealy Bugs

This cosmopolitan group of insects with exceptional powers of dispersal are seen colonising cocoa from the initial years of introduction to India.

2.1.1.1 Cocoa mealy bug, *Planococcus lilacinus* (Ckll.) (*Pseudococcidae*): It is reported as a serious pest from India in the seventies. It ranks as the most important pest causing damage to cocoa and is present in all cocoa tracts of the country. This occurs consistently on the crop and is present throughout the year (CPCRI, 1977). This infests the tender parts of the plant, such as the growing tips of the shoots, the terminal buds, the flower cushions, the young cherelles and the mature pods. Mealy bug feeding on tender apical

shoots results in reduced growth and they become deformed into slender hair-like processes giving the appearance of a brush. When the flower cushions are attacked, the growth of flowers is totally suppressed and the cushions ultimately wither and dry up. Radhakrishnan Nair (1981) reported 85.35 per cent cherelle wilt due to mealy bug attack from a study on 10 cacao trees. Though minute irregular cracks and pittings are observed on the pod surface, there is no injury to the beans inside the pod.

The adult female bug is oval in shape measuring 3.9 mm in length and 2.25 mm in width. Body colour is chocolate brown and the dorsal body surface is covered with a thick waxy covering. The male is winged and free living. The life cycle is completed in 20 to 25 days in the case of female mealy bugs and 17-20 days in the male. Eggs laid in a cottony envelope hatch within 6 h into crawlers. A female produces 47-286 eggs (Radhakrishnan Nair, 1981).

Population of this mealy bug is lowest in June, July and August. Then the build-up of the population starts with a peak in April and May. High maximum temperature ranges were favourable for population build-up of the mealy bug. Population was positively correlated with temperature and negatively correlated with rainfall and relative humidity (Radhakrishnan Nair, 1981).

- a) *Association of ants:* Seven species of ants were reported to be associated with mealy bugs (Radhakrishnan Nair, 1981). They are the red ant, *Oecophylla smaragdina* (Fab.), *Technomyrmex* sp., *Solenopsis geminata* (Fab.), *Camponotus compressus* F., *Monomorium* sp., *Anoplolepis longipes* J. and *Myrmicaria brunnea* S. Of these, *O. smaragdina* was the most common. They sometimes build webs over the mealy bug colonies on shoots and pods. *Technomyrmex* sp. was more prevalent on flower cushion colonies of mealy bugs. Of these ants, only *O. smaragdina* and *Technomyrmex* are seen as mealy bug tending at Vittal cocoa plots.
- b) *Predators:* Native natural enemies of this mealy bug included a coccinellid beetle *Pullus* sp. and caterpillars of the lycaenid moth *Spalgis epius* Westw. These predators were more prevalent in summer months. Trials with exotic predatory beetle, *Cryptolaemus montrousieri* did not give any positive results (CPCRI, 1986).
- c) *Control:* Radhakrishnan Nair (1979) tried the relative efficacy of seven insecticides in controlling the population of *P. illacinus* by counting the reduction in percentage of shoots and pods infested. There was no significant difference in their relative efficacy. Results of field studies on chemical control tried at Kottayam, Kerala and at Vittal, Karnataka by Radhakrishnan Nair (1981) indicated that foliar spraying of 0.05 per cent fenthion, monocrotophos, quinalphos or dimethoate was effective. This could even be applied as spot spray whenever the mealy bug population was over 15 per cent and this was highly effective in maintaining the population at

a low level. Studies on trunk implantation of insecticides showed that monocrotophos and phosphamidon at 1.5 and 3.0 g a.i. per plant and dimethoate at 3.0 g a.i. per plant were effective in controlling the mealy bug population up to 45 days. Drenching experiments using systemic insecticides indicated that dimethoate, monocrotophos, and phosphamidon at 1.5 and 3.0 g a.i. per plant were effective in controlling the mealy bug infestation in young plants. Application of systemic insecticides as granules in soil was not effective in controlling the mealy bug infestation.

2.1.1.2 *The Citrus mealy bug, Planococcus citri* (Risso) : This is reported on cocoa from Nilgiris (Ayyar, 1940; Abraham and Padmanabhan, 1967) and in Kerala by Abraham and Remamony (1979). This also infests cocoa shoot tips, flower stalks, foliage, stem tissue, cherelles and pods. The cherelles are severely attacked and they dry up. Infested mature pods develop irregular sunken necrotic lesions. Population peak occur during July-October (Abraham and Remamony, 1979). These mealy bugs also are tended by the ant *O. smaragdina*.

2.1.1.3 *Rastrococcus iceryoides* Green (*Pseudococcidae*) : A polyphagous species reported from Tamil Nadu on cacao. Abraham and Padmanabhan (1967) reported this as occurring heavily on young shoots, pod stalks and pods. This is attended by *O. smaragdina*.

2.1.1.4 *Drosicha mangiferae* Green (*Margarodidae*) : Nymphs and female adults of this insect cluster on tender shoots and desap the tissues resulting in drying of the shoots (Abraham and Remamony, 1979).

Abraham and Remamony (1979) reported *D. stebbingi* Gr., the mango mealy bug, as infesting tender cocoa shoots. The infestation is observed in November-December. The bugs are attended by the black ant, *Camponotus compressus* F.

2.1.2 *Citrus Black Aphid, Toxoptera aurantii* B.de.F. (*Aphididae*)

This dark brown to black aphid colonises the tender leaves, shoots, flower cushions and tender cherelles. Severe feeding by aphids result in crinkling of leaves and shedding of flower buds. On flowers, they colonise the flower stalks and on cherelles, stalk and cherelle surface are colonised. Aphid colonies could be found on the plant throughout the year, but highest infestation is noticed from July to January (Radhakrishnan Nair, 1981).

The ants *Camponotus* sp. and *Crematogaster* sp. were found attending the aphid colonies. Abraham and Remamony (1979) reported the ant *Prenolepis* sp. as attending the aphid colonies.

Natural enemies of this aphid are well represented in the field and they exert a good control of this insect. These include mostly predators of the families Syrphidae, Chrysopidae, Hemeroibiidae and Coccinellidae.

2.1.3 Cotton Aphid, *Aphis gossypii* Glover

This green aphid infests young shoots and flowers.

2.1.4 Cow Bugs

Gargara mixta Buckt and *Gargara* sp. (Membracidae). The greenish nymphs and adults of *G. mixta* infest tender shoots. The female lays eggs in the slits made on tender shoots. This membracid is attended by *O. smaragdina*. Adults of *Gargara* sp. are dark brown. They measure 3-5 mm in length. They produce small brown lesions on tender shoots. This is seen in Kerala.

The mango hopper *Idioscopus clypealis* (Leth.); *Bothrogonia* sp., *Krisna* sp., *Kurtara brunnescens* Dist., *Balocha* sp. and *Coclidia* sp. (Cicadellidae). These leaf hoppers found on cocoa suck the plant sap from green shoots and cherelle and pod surface. *Phymatostetha deschampes* Linn. and *Peuceptyellus sigillifer* Wlk. (Cercopidae) also infest cocoa plants.

2.1.5 Tea mosquito Bug, *Helopeltis antonii* Sign. (Miridae)

This is found infesting cocoa in Kerala, Tamil Nadu (Abraham and Remamony, 1979; Abraham and Padmanabhan, 1967) and Karnataka (CPCRI, 1989). The nymphs and adults of this bug infest cherelles, pods and tender shoots. Characteristic circular water soaked lesions develop on cherelle and pod surface which blacken after few hours of feeding. Tender shoots with linear lesions dry up in course of time. The attacked cherelles dry up. Severe infestation may lead to deformation of pods (Abraham and Remamony, 1979).

2.1.6 Red-banded Thrips, *Selenothrips rubrocinctus* (Giard) (Thripidae)

Ayyar (1940) had stated that this thrips infesting cashew might adapt itself to cocoa. These thrips colonise the mature leaf surface and pods. Infested leaves turn brown and dry up and on pod scabby patches develop.

2.2 Leaf Feeding Caterpillars**2.2.1 Lymantriid Caterpillars (Lymantriidae)**

Lymantria ampla Walk. Caterpillars of this moth are the most commonly encountered leaf feeding insect of cocoa. The caterpillars feed on tender leaves and on the surface of cherelles and green pods. Premkumar (1974) reported *L. obfuscata*, the Indian gypsy moth as damaging cacao but Ramaseshiah and Ramesh Bali (1987) have pointed out the record of *L. obfuscata* on cocoa as erroneous. *L. obfuscata* is mainly confined to North India, feeding on fruit trees of temperate regions. The studies being conducted at CPCRI also confirm the work of Ramaseshiah and Ramesh Bali. The early instars of *L. ampla* feed on leaves or pod surface during day and night, but mature caterpillars

are nocturnal in habit, they hide during day time on the fallen leaves at the base of the tree or on the basal surface of the main stem (Premkumar and Radhakrishnan Nair, 1982). The eggs laid in a cluster at the site of pupation hatch in 9 days. The larval period lasts for 31-38 days for females which have five instars and 27-34 days for males with four instars. The caterpillars are seen in large number in the field after monsoon showers. The caterpillars cause severe leaf damage, especially in young plants. *Aspergillus flavus* Link. is reported as a fungal parasite of this (Radhakrishnan Nair and Prem Kumar, 1974).

2.2.2 *Euproctis* spp.

E. subnotata Walk. and *E. guttata* Walk. Caterpillars of these yellow shaded moths feed on tender leaves and cherelles and green pod surface. Life cycle is completed in one month in *E. subnotata*. Eggs are laid in groups of 8-10 on lower leaf surface. Egg masses are covered with hairs. The egg, larval and pupal stages last 5, 14-17 and 8-10 days respectively. Life cycle is completed in 35-45 days. In *E. guttata*, egg stage is from 6-8 days, larval 18-27 days and pupal stage 9-15 days. A sporadic high population could cause severe tender leaf damage on cocoa. During a survey it was found that the caterpillars of both these species together cause about 28 per cent damage to pods. The period of infestation is June-July (Prem Kumar and Radhakrishnan Nair, 1982).

2.2.3 *Dasychira mendosa* Hb.

Hairy and brightly coloured caterpillars of this moth also feed on tender leaves, buds and surface of tender pods. Abraham and Remamony (1979) reported this from Trichur during August-November. The larvae occur in groups of 2-3 and feed voraciously on the foliage. The eggs are laid in masses.

2.3 Loopers (Geometriidae)

2.3.1 *Hyposidra talaca* Walk.

This is sporadic in nature and cause extensive defoliation of nursery seedlings and young trees. Eggs are laid in groups on leaves and on an average 250 eggs are laid. Incubation period is four days and larval period lasts 17-24 days. Early instar larvae are black. When full grown, it is pale brown with orange dots laterally. Pupation is on fallen leaves. Total life cycle is completed in 30-35 days. Adult moth is dirty pink brown (Prem Kumar and Radhakrishnan Nair, 1982). This was present in all cocoa growing areas surveyed.

2.3.2 *Oenospila quadraria* Guen.

The greenish looper caterpillars were observed as minor pest of foliage in Trichur district of Kerala.

2.3.3 *Pingasa ruginaria* Guen.

This is another geometriid found on cocoa.

2.4 Hairy Caterpillars

2.4.1 *Pericallia ricini* F. (Arctiidae)

This polyphagous caterpillar feeds on cocoa leaves in large numbers both on nursery and field plants. In severe cases, all the tender leaves are eaten. The egg period lasts for 4 days, the larval period is 30 days and pupation in cocoons lasts for 10 days. Prem Kumar (1974) tested the effect of some antifeedants on these caterpillars. Triphenyl tin acetate at 0.2 and 0.1 per cent and triphenyl tin chloride at 0.2 per cent were most effective in checking the leaf consumption by caterpillars and causing maximum mortality of caterpillars.

2.4.2 Bihar Hairy Caterpillar, *Diacrisia obliqua* (Walk.) (Arctiidae)

Recorded on cocoa from Karnataka (Premkumar and Radhakrishnan Nair, 1982), these caterpillars feed on tender leaves. They are orange coloured caterpillars with brown hairs and bands on the body. Adult is a pale buff coloured moth with black dots on the wings. Abdomen is crimson red with black spots.

About 600 eggs are laid on an average. Egg, larval and pupal periods last for 5, 5-18 and 7 days respectively. This insect is sporadic in nature, mainly appearing in September-October.

2.4.3 *Amsacta gangis* Linn. (Arctiidae)

These are black-brown hairy caterpillars feeding on leaves (Nair, 1986).

2.4.4 *Spodoptera litura* (F.) (Noctuidae)

The polyphagous caterpillars cause serious damage to the nursery plants by completely defoliating seedlings and feeding on growing buds. Feeding mainly takes place during night. Due to frequent defoliation by the larvae, the seedlings show a tendency for premature branching. It is absent in the field during summer.

Eggs laid on the leaves are covered with buff coloured hairs. About 500 eggs are laid by a female insect. Egg period lasts for 5 days, larval period for 16 to 18 days and pupal period for 8 to 14 days.

At CPCRI Regional Station, Vittal Farm, 42 per cent of the seedlings in nursery were found damaged by this pest in 1976.

2.4.5 *Castor Semilooper, Achaea janata* Linn. (Noctuidae)

The caterpillars feed voraciously on leaves, leaving behind only midribs and stalks of leaves.

Eggs are laid singly on the leaves. The egg period, larval period and pupal period last for about 4, 20 and 8 days respectively. They pupate inside leaf folds.

2.4.6 Leaf Webber, *Adoxophyes privitana* Walk. (Tortricidae)

Prem Kumar and Radhakrishnan Nair (1982) recorded this on cocoa from India. The caterpillars of this moth web together the young leaves and feed from within, making irregular holes on them.

The small moth lays eggs on tender shoots which hatch in about six days. The larval period is completed in 16-20 days and the pupal period in 4 days. Pupation is within the webbed leaves. Total life cycle is completed in 26-30 days. This is found in all cocoa growing areas and the maximum infestation is recorded during January-March. On an average, leaves in about 28 per cent of the shoots are infested by the caterpillars during heavy infestation.

Other leaf eating caterpillars of minor importance include *Helicoverpa armigera* (Hub.) (Noctuidae); *Metanastria hyrtaca* Cram. (Lasiocampidae); the slug caterpillar *Latoia lepida* Cr. (Limacodidae); and *Argina cribraria* Cl. and *A. syringa* Cl. (Hypsidae) (Nair, 1986).

2.5 Leaf Eating Beetles

2.5.1 *Popillia complanata* Newm. (Scarabaeidae)

Adult beetles damage the leaves severely and they prefer tender leaves. A single beetle eats an average of 176.5 cm² leaves during its life time (Premkumar, 1974).

Beetles are very active, swift fliers and feed on leaves remaining on the underside of leaves. Initial feeding results in small circular holes which coalesce later and the leaf is heavily damaged by irregular perforations. The midrib region of the leaf is not eaten.

This insect is found throughout the year but the incidence is more during August-September.

2.5.2 Flea Beetle, *Monolepta longitarsus* J.G. (Chrysomelidae)

Premkumar and Radhakrishnan Nair (1982) recorded it on cacao. This is a small reddish beetle feeding on cocoa leaves. Beetles cut small circular holes on the leaves. A large number of beetles feed on a single leaf. With the slightest disturbance, they jump. In severe infestations, the tender leaves are riddled with feeding holes and tender shoots are also eaten.

2.5.3 Ash Weevils, *Mylocherus viridanus* Fab. and *M. maculosus* Desb. (Curculionidae)

Abraham and Padmanabhan (1967) reported *M. viridanus* on cacao in the Nilgiris and Yercaud regions. This occur throughout Kerala as a major pest, while *M. maculosus* is found in a few gardens as a minor pest.

Adults occur in large numbers on the under surface of leaves and feed on the interveinal tissues leaving the veins intact. The flaccid tender flushes are not preferred for feeding. Population peak is observed in July-September. Infestation is relatively severe on young plants and quite often, the entire foliage of such plants are skeletonised leading to growth retardation.

Prophylactic application of fenitrothion (0.05%), quinalphos (0.05%) or fenthion (0.05%) is essential to afford absolute protection. It has to be ensured that the insecticidal films thoroughly cover the under surface of leaves.

Leaf feeding beetles of minor importance include *Metriona circumdata* Hebst. and *Aspidomorpha miliaris* Fab. (Chrysomelidae) (Prem Kumar and Radhakrishnan Nair, 1982).

2.6 Stem Boring Caterpillars and Beetles

2.6.1 Red-borer of Coffee, *Zeuzera coffeae* Nietn. (Cossidae)

Sathiamma and Shama Bhat (1974) recorded this on cocoa from Vittal, Karnataka, as damaging 3-4 years old cocoa plants grown as an intercrop in arecanut gardens. The caterpillars make unramified hollow tunnels inside the stem. The external symptoms of attack are a round hole on the stem, drying of the upper portions above the hole, and excreta and chewed up fibres strewn out on the ground. When the main stem is attacked, the plant dies. When branches are attacked, only these branches dry up.

Adult moths are white in colour with dark spots. They are sexually dimorphic, the male moth is smaller (21 mm in length) with the antenna bipectinate up to the middle and filiform distally. The female moth is large (32 mm in length) with filiform antennae and is provided with a well developed ovipositor.

Eggs are yellowish and are laid in groups. Full grown larva is reddish-brown and measures 42 mm in length. Larval period lasts 60-100 days. Pupa is reddish-brown with a hard spine-like projection at the anterior region. Pupa measures 27-32 mm in length and 3-5 mm in width. Pupal period lasts 9-13 days. Life cycle takes about 4-5 months for completion.

Attack is more severe during post-monsoon months. Young caterpillars make galleries in the newer portion of branches and fan shoots and then progress to more mature parts. The galleries are long and irregular.

2.6.2 *Sinoxylon* sp. (Bostrychidae)

Prem Kumar and Radhakrishnan Nair (1982) reported this on cacao. Adult beetles bore into green shoots and twigs. They infest young seedlings just planted in the field. Beetles make horizontal tunnels. Grubs also bore into the twigs of mature plants and remain in galleries which are circular and tightly packed with saw dust-like material. Dried leaves on the plant is a symptom of attack by this insect.

2.6.3 Trunk Borer, *Glenea* sp. (Cerambycidae)

Prem Kumar and Radhakrishnan Nair (1982) reported this from India on cocoa. Beetle occurs in neglected plantations. Usually more than one grub is present in a stem. Attack is mostly on lower trunks and the branches are rarely attacked.

The grub tunnels into the trunk and penetrates deeper, making galleries within. Wood as well as bark tissues are eaten. Adults are found inside dried up wood. Girdling of stem and branches is noticed sometimes.

2.6.4 Stem Girdler, *Sthenias grisator* Fab. (Cerambycidae)

Abraham (1958) reported this for the first time from India on cocoa. Abraham and Remamony (1979) reported this stem girdler from Idukki, Kottayam, Kollam and Kozhikode districts of Kerala. Infestation is relatively severe in gardens bordered by wild vegetation. The stout beetles girdles the main stem as well as thick fan branches and causes breakage at the ringed region. Control of this borer is very difficult.

Other stem boring beetles found on the dying and dead shoots are *Pterolophia annobonae* Aur. (Cerambycidae); *Brytax tuberculatus* Cora, and *Ceropria induta* Weid. (Tenebrionidae); *Epistictia weisei* Spaeth. and *Hyperaxis fulvohirsuta* Jac. (Chrysomelidae); *Lepropus oculus* Heller, and *Crinorrhinus crassirostris* Fst. (Curculinoidae); *Rhychites* sp. (Attelabidae).

2.7 Root Feeding Grub

2.7.1 Cockchafer Beetle, *Leucopholis* sp. (Melolonthidae)

Roots of young and grown up plants interplanted with coconut in parts of the Malappuram district were found damaged by the grubs of *Leucopholis* sp. (Abraham and Remamony, 1979). The grubs feed on the surface root mat and parts of the tap root causing yellowing and dropping of leaves. Pest incidence was observed in March-April after premonsoon showers.

2.8 Pod Boring Insects

2.8.1 Shoot and Capsule Borer, *Dichocrocis punctiferalis* Guen. (Pyralidae)

The caterpillars damage flower cushions and bark in Kerala and bores into pods in Tamil Nadu. Caterpillars bore into tender pods making tunnels below the pod surface (Chandramohan and Harishu Kumar, 1975).

2.9 Mammalian Pests

Mammalian pests, mostly rats, squirrels and palm civets inflict direct loss of the crop by feeding on pods. These small mammals are considered the major non-insect pests of cocoa in India.

2.9.1 Rodents : Rats and Squirrels

These animals damage the pods and the attack follows a fairly constant pattern. Ripe pods are usually chosen and a large hole is bitten through the pod husk. The beans are then extracted and after the sweet mucilage has been eaten, these are discarded.

Two years survey work in South India by Keshava Bhat *et al.* (1981) revealed three rodent species as the most important vertebrate pests of cocoa. They are the Western Ghats squirrel, *Funambulus tristriatus* Waterhouse, the South Indian palm squirrel, *F. palmarum* Linnaeus and the black rat, *Rattus rattus* Linn. Of these, the Western Ghats squirrel and black rat are the major pests occurring in arecanut-cocoa and coconut-cocoa mixed gardens and pure gardens of cocoa. The squirrel is the most serious pest of cocoa in India (Keshava Bhat, 1978).

All rodent species while feeding on cocoa pods leave tooth marks on pods. The tooth marks on pods that had been damaged by rats could not be distinguished from those of squirrels. The tooth marks on pods by one of the rodent species were distinguishable from the marks on the pods that had been attacked by either monkeys or civet cats.

A study on rodent damage to cocoa pods revealed that squirrels have the tendency to make oval holes either in the central or in the terminal portion of pods; (Fig. 1) while rats make oval or round holes near the stalk region for feeding (Fig. 2).



Fig. 1 : Squirrel attacked cocoa pods.

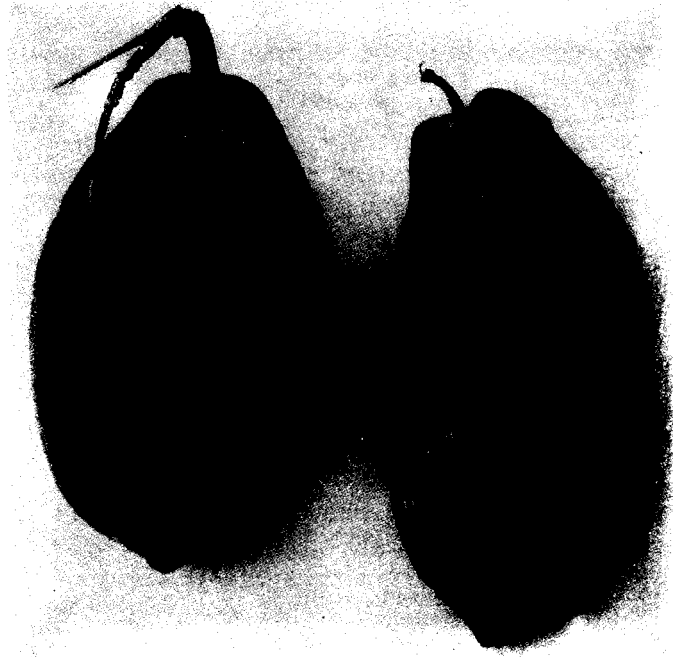


Fig. 2 : Rat attacked cocoa pods.

Squirrels damage the pods during day time and rats during night time. Squirrels damage ripe pods and rats damage both ripe and unripe pods. Among the rodent damaged pods collected from the field during day time significantly more number of pods had the damage away from the stalk region. Further, in these pods oval type of holes was more frequently observed than other types. The results obtained from the pods damaged by rodents during day time were on par with that of the pods damaged by squirrels in captivity. Among the pods damaged by rodents during night time, significantly more number of pods had the damage hole near the stalk portion and in most of the pods the shape of the hole was round (Keshava Bhat, 1980; Table 1).

Out of 30 per cent of mature cocoa pods that were damaged in an year by mammals in four Dakshina Kannada cocoa gardens, 29 per cent was by rodents. Squirrel population is about 4-5 numbers per hectare. The home range is 2 ha. Squirrels are very active during early morning and late evening hours. Rats are nocturnal and they are good climbers. Rat population is about 25-30 per hectare and home range is 0.5 ha only.

A study on the species composition of small mammals in coconut-cocoa gardens in Kerala using live traps on the branches as well as ground revealed the presence of six species of rodents. *Rattus rattus wroughtoni* was the most predominant species followed by *Mus booduga*. These were followed by *Vandeleuria oleracea*, *F. tristriatus*, *R.r. rufescens* and *Suncus murinus* (Table 2) (Keshava Bhat and Sujatha, 1986).

Table 1 : Position and shape of the nibbled hole on cocoa pods damaged by rodents during different times of the day (in field)

Characteristics of the nibbled holes on the pods	No. of damaged pods during		Percentage of total	
	Day	Night	Day	Night
Position				
Near the stalk	4	119*	3.4	90.8
Away from the stalk	115*	12	96.6	9.2
Shape				
Oval	95*	18	79.8	13.7
Round	17	73*	14.3	55.7
Triangular	2	14	1.7	10.7
Irregular	5	26	4.2	19.8

*Significant at $P = 0.01$ (Keshava Bhat, 1980).

Table 2 : Relative abundance of small mammals in coconut-cocoa mixed habitat

Species	Total animals trapped on different levels			Relative abundance* (%) on different levels		
	Total	Branches	Ground	Total	Branches	Ground
Rodentia						
<i>R.r. wroughtoni</i>	214	177	37	44.6	64.8	17.9
<i>M. booduga</i>	145	0	145	30.2	0	70.1
<i>R.r. rufescens</i>	17	13	4	3.5	4.8	1.9
<i>F. tristriatus</i>	32	29	3	6.7	10.6	1.4
<i>V. oleracea</i>	55	54	1	1.5	19.8	0.5
<i>T. indica</i>	2	0	2	0.4	0	1.0
Insectivora						
<i>Suncus murinus</i>	15	0	15	3.1	0	7.2
Total	480	273	207	100.0	100.0	100.0

*In 20 wooden and 20 Sherman traps set for 15 consecutive days; each two months period from January-December, 1985.

(Keshava Bhat and Sujatha, 1986).

Though the population of *R. rattus* was about seven times that of *F. tristriatus*, it was observed that the intensity of squirrel damage to cocoa was nearly three times more than that caused by rats (Keshava Bhat *et al.*, 1981; Keshava Bhat, 1982). This was mainly because of the greater capability of squirrels to damage cocoa pods.

V. oleracea, an arboreal species present in cocoa gardens is not found so far feeding on cocoa pods. This is a potential pest of cocoa.

2.9.1.1 Control : Baiting and trapping : The detailed studies conducted at CPCRI on the different trapping and baiting methods concludes that for squirrels the best control measure is judicious trapping using traps.

Wiremesh live box traps were the most effective traps for squirrels. 'Wonder' and 'snap' traps were less effective (Keshava Bhat and Mathew, 1983). These traps have to be set up in the early hours of the day since the squirrel feeding activity was on its highest in the morning hours (Keshava Bhat and Mathew, 1984).

Paddy was consumed most, followed by *jowar* in a bait preference study for squirrels with seven food grains. They were not attracted by oil, sugar and salt. Plain whole grain was the most preferred bait (Keshava Bhat, 1979).

Another bait preference study was conducted in 1985 by Keshava Bhat and Mathew for attracting the Western Ghats squirrel. Eleven wet baits were compared with paddy grains. For convenience, the baits were randomly divided into four groups of four baits. Each bait was kept in a separate 'wonder' trap and all the four traps in a particular group were kept side by side in each bait station so as to give ample chance for squirrel to exercise the preference. A total of four permanent baiting stations were selected for each group and in each group trapping was counted for 20 days. The results are given in Table 3. Though jack fruit bait captured more squirrels than paddy the latter because of its easy availability and good keeping qualities is considered a better bait.

Multiple dose anticoagulants like warfarin and fumarin are very effective in controlling rats in cocoa gardens. Baiting with rice-flour and jaggery during summer months and rainy season added with paraffin wax, these poison baits are good for rat control. Since cumulative feeding for 9-10 days are required for these rodenticides, second generation single dose anticoagulants are available now. Brodifacum, one of these single dose rodenticides was evaluated in a recent study against the black rat, *R. wroughtoni*. Laboratory feeding trails using brodifacum (0.05%) wax blocks showed cent per cent mortality in these rats by one day feeding. One, two and three baitings with brodifacum baits at intervals of 10 days between baitings reduced the rat population by 76, 95 and 97 per cent respectively in cocoa gardens. Moreover, cent per cent reduction in damage was achieved by two baitings itself (Keshava Bhat and Sujatha, 1989).

2.9.2 Palm Civet, *Paradoxurus hermaphroditus* Pallas (Carnivora)

Known otherwise as toddycat, damage by this to cocoa pods had been reported earlier by Abraham and Padmanabhan (1967). Keshava Bhat *et al.* (1981) reported about 12.8 per cent damage by this in Kerala. The palm civet, as big as a small dog, has a slightly pointed snout and a hairy tail, measuring about 45-60 cm with a tail of equal length. The palm civet is nocturnal and arboreal in habit.

The palm civet bite and break the husk of cocoa pods. The piece of broken chunks are 2.0 to 3.0 cm in diameter. There is no distinct pattern for the damage (Fig. 3). In some pods the terminal half is removed, whereas in some others, only one side is

Table 3 : Number of Western Ghat squirrels trapped in cages with various baits

Group	Baits	Number of squirrels trapped		
		Actual no.	Percentage	Rank
1	Jack fruit (<i>Artocarpus integrifolia</i> Anth.)	35*	42.2	2
	Cocoa pod (<i>Theobroma cacao</i> Linn.)	5	6.0	4
	Paddy grains (<i>Oryza sativa</i> Linn.)	37	44.6	1
	Banana fruit (<i>Musa paradisiaca</i> Linn.)	6	7.2	3
2	Cashew apple (<i>Anacardium occidentale</i> Linn.)	43	60.6	1
	Papaya fruit (<i>Carica papaya</i> Linn.)	14	19.7	2
	Cassava tuber (<i>Manihot utilissima</i> Rohl.)	10	14.1	3
	Coconut kernel (raw) (<i>Cocos nucifera</i> Linn.)	4	5.6	4
3	Mango fruit (<i>Mangifera indica</i> Linn.)	42*	57.5	1
	Pineapple fruit (<i>Ananas sativas</i> Schult)	7	9.6	4
	Sweet potato tuber (<i>Ipomea batatas</i> Lan.)	13	17.88	2
	Coconut kernel (roasted)	11	15.1	3
	Jack fruit	23	30.3	1
	Paddy grain	20	26.3	2
	Cashew apple	18	23.7	3
	Mango fruit	15	19.7	4

*Significantly more from the general mean for that group $P=0.01$.
(Keshava Bhat and Mathew, 1985).

broken. while feeding, the civets are known to swallow the beans also and as such no trace of beans is visible directly under the tree. Instead, piles of defecated beans are seen scattered around in cocoa plantations

2.9.2.1 Control : Palm civets could be easily controlled by poison baiting with carofuran granules using ripe bananas as baits. Through a longitudinal slit in the banana, 0.5 g of carbofuran was added to it and closed properly. Two such bananas were tied on the trunk/jorquette of five to six cocoa trees per hectare (Keshava Bhat *et al.*, 1987).



Fig. 3 : Palm civets attacked cocoa pod.

2.9.3 Monkeys

Bonnet monkey, Macaca radiata Geoffroy was observed feeding on cocoa pods in Karnataka (Keshava Bhat *et al.*, 1981). The monkey damage on cocoa pods could be easily distinguished by their 5 mm wide incisor teeth marks around the periphery of the gnawed hole. Monkeys remove the bark portion of the tree along with the pods and its damage was only 0.3 per cent of the total 30 per cent damage by mammals in four Dakshina Kannada gardens.

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