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Pests of Spice Crops

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1. INTRODUCTION

Infestation by insect pests has been identified as one of the main factors responsible for low productivity of spices in the country. The major spice crops are infested by various insects and some of them cause heavy economic losses. These include 'pollu' beetle on black pepper, thrips on cardamom and shoot borer on ginger and turmeric. The tree spices, viz., cinnamon, clove, nutmeg and allspice are relatively free of major pest infestation. The information available on distribution, nature and extent of damage, life history, seasonal abundance, natural enemies, alternate hosts and control measures of various insect pests infesting spice crops in India is reviewed.

2. BLACK PEPPER (*PIPER NIGRUM* L.)

2.1 Major Pests

2.1.1 *'Pollu' Beetle (Longitarsus nigripennis Mots.)*

The 'pollu' beetle is the most destructive pest of black pepper in India (Fig. 1). The incidence of the pest was reported to be high (20-30 per cent) in the plains of Malabar area and low (5-10 per cent) in Wynad and Travancore areas of Kerala (Anon., 1954). Abraham (1959) reported that loss from 'pollu' was 6-21 per cent. Rehiman and Nambiar (1967) reported that 30-40 per cent of the yield was lost due to pest attack in Kerala. Premkumar (1980) reported that 10-30 per cent of the berries were damaged by the pest in the districts of Cannanore, Calicut and Kottayam in Kerala. The incidence of the pest was higher in the plains and at altitudes below 300 m; no damage was observed in areas above 900 m.

Studies on the nature of damage and life history of 'pollu' beetle were conducted by Ayyar (1920a), Ayyar *et al.* (1921), Rao and Ramaswamiah (1927), and Premkumar (1980). The adult beetles were described by Maulik (1926). Vidyasagar *et al.* (1988) have described an easy method for sexing live adults. The adults are small, measuring about 2.5 mm in length, the head and thorax being yellowish brown and the abdomen (elytra) black. The femur of the hind pair of legs are considerably enlarged and adapted for jumping. The eggs are laid on tender berries which hatch into creamy-white grubs

in 5-8 days. The grubs bore within the tender spikes and berries and damage them by feeding on the internal contents. The infested berry turns yellow and finally black and easily crumble when pressed (the term 'pollu' denotes the hollow nature of the infested berries in Malayalam language). The grub stage lasts for 20-32 days and during this period a single grub destroys 4-5 berries. Fully grown grubs measure about 5 mm in length. Pupation occurs in the soil in oval earthen cocoons; pupal period last for 6-7 days. There are four or five generations in a year. The adults feed on tender shoots, leaves and spikes by scraping the tissues. During December to May, when berries are not available on the vines and egg laying does not occur, the adults remain in the field and feed on mature leaves. The pest infestation is generally more severe in shaded gardens.

Studies on the seasonal abundance of adult 'pollu' beetle conducted at Calicut and Kottayam districts in Kerala indicated that pest population was high during July-January at Calicut. At Kottayam, pest population was high during May-September. Rainfall induced the plant to put forth new flushes and spikes which provided adequate feeding material and breeding sites. A positive and significant correlation existed between rainfall and population. The correlation between relative humidity and population was, however, not significant. The correlation between temperature and population was negative and significant (Premkumar and Nair, 1985).

Apart from an unidentified species of a predaceous spider on adults (Premkumar, 1980), no other natural enemy of 'pollu' beetle has been reported. No alternate host of the pest has been recorded.

Field observations indicate the wide variability of various cultivars of black pepper in their reaction towards 'pollu' beetle. Pillai and Abraham (1979) screened 44 cultivars maintained at the Pepper Research Station, Panniyur, Kerala and found that the hybrid Panniyur-1 was the most susceptible and Kalluvally Type-II, the least. Similar results have also been reported by Premkumar (1980).

Evaluation of insecticides for the control of 'pollu' beetle has drawn the attention of various workers. Nambiar and Kurien (1962), and Rehiman and Nambiar (1967) recommended spraying of DDT (0.2%) for the control of the pest. Pillai and Abraham (1974) found that spraying of dimethoate, quinalphos or endosulfan (0.1% each) twice a year, during July and October was effective. Premkumar (1980) found that endosulfan, quinalphos, methyl parathion, monocroptophos, methamidophos and isofenphos (0.05% each) were also effective when sprayed twice a year during June and September. Premkumar and Nair (1986) reported that, among the nine insecticides tested, endosulfan (0.05%) was the most effective giving significant control of adults up to 51 days of application of the insecticides. Multilocation field trials conducted at Calicut and Kottayam districts indicated that endosulfan and quinalphos (0.05% each) were more effective when sprayed twice a year during July and October (Premkumar *et al.*, 1986). Premkumar and Nair (1987a) evaluated nine insecticides at Calicut and Kottayam, and found that all were effective when sprayed during late June and early September; endosulfan

(0.05%) gave the best result. Nandakumar *et al.* (1987) reported that three rounds of spraying of endosulfan (0.05%) during May, July and September was the most effective treatment. Balakrishnan *et al.* (1984) have worked out the economic viability of spraying endosulfan, quinalphos and methyl parathion in the control of pest taking into consideration the cost of spraying, levels of pest infestation and yield potential of the vines.

2.1.2 *Top Shoot Borer (Cydia hemidoxa Meyr.)*

The top shoot borer (Fig. 2) is also a serious pest of black pepper, especially in younger plantations. Visalakshi and Joseph (1965) reported that the pest occurs throughout Kerala and is more serious in the Malabar area. Pillai (1978) reported that up to 48 per cent of the shoots were damaged in an one year old plantation in South Kerala.

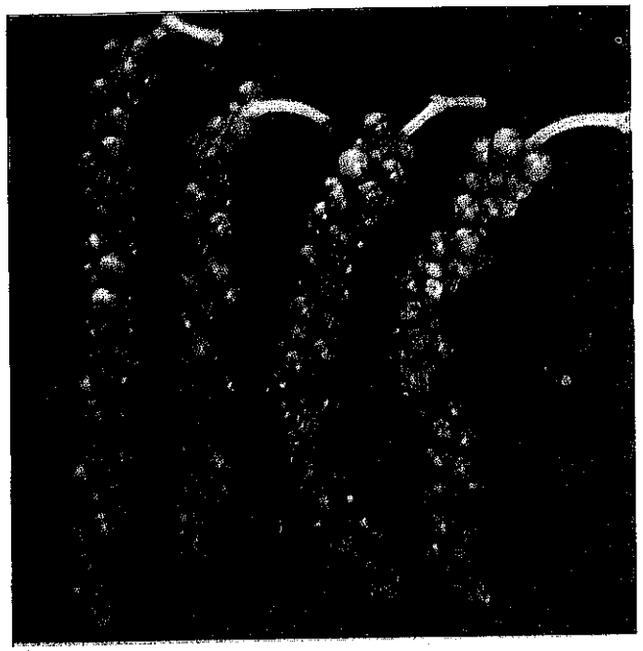
The nature of damage and life history of top shoot borer was studied by Visalakshi and Joseph (1965). The adults were described by Meyrick (1931). Adults are small with a wing of span of 10-15 mm, the forewings being crimson-red and yellow and the hind wings grey. The earlier instars of the larvae live within the silken webs on the tender shoots and scrape and feed on them. Later, the larvae bore into the tender shoots and feed on the internal contents resulting in drying up of the same. Repeated infestations of new shoots affect the growth of the vine. Up to 57 per cent reduction in growth was observed on 1 year old vines when there were three repeated infestations during an year (Devasahayam and Koya, 1993). Fully grown larvae are greyish-green and measure 12-14 mm in length. The larval period lasts for 14 days. Pupation generally occurs within the infested shoots and sometimes outside. The pupal period lasts for 8-10 days. The pest is relatively abundant in the field during August-December.

Three hymenopteran parasites, viz., *Apanteles* sp. (Braconidae), *Eudederus* sp. (Eulophidae) and *Goniozus* sp. (Bethylidae) have been reported to parasitise the larvae of top shoot borer (Visalakshi and Joseph, 1965). No alternate host of the pest has been recorded.

Very few field trials have been conducted for the control of top shoot borer. Banerjee *et al.* (1981) conducted field trials with nine insecticides and found that endosulfan (0.05%) was the most effective in controlling the pest. They have also mentioned that since the incidence of the pest coincides with the abundance of 'pollu' beetle, the spray given for the latter would be sufficient to control the top shoot borer. Recently, spraying monocrotophos (0.05%) during June and September was found effective in controlling the pest infestation (Anon., 1990).

2.1.3 *Leaf Gall Thrips (Liothrips karnyi Bagn.)*

Leaf gall thrips infest leaves of black pepper (Fig. 3) and induce the formation of tubular marginal leaf galls within which they live. The pest infestation is generally



⇐**Fig. 1 :** Black pepper berries damaged by 'pollu' beetle.

Fig. 3 : Black pepper leaves infested with leaf gall thrips.

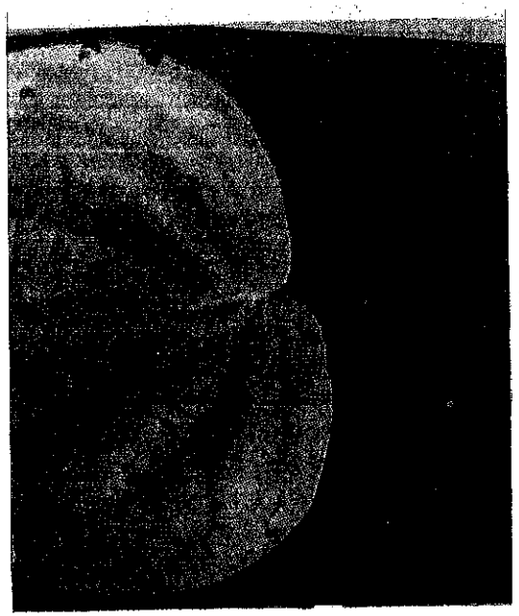


Fig. 2 : Terminal shoot of black pepper damaged by top shoot borer.

serious at higher altitudes and also in nurseries in the plains. Visalakshi and Joseph (1967) considered leaf gall thrips as a persistent pest occurring throughout Kerala. Banerjee *et al.* (1981) reported that leaf gall thrips were the most important pest of black pepper in South Wynad area of Kerala.

The adults of leaf gall thrips were described by Ananthakrishnan (1960). Visalaskhi and Joseph (1967) studied the nature of damage and life history of the pest. Raman and Ananthakrishnan (1983) studied in detail the anatomical changes induced by the pest infestation on the leaves. Apart from the formation of marginal leaf galls, the pest infestation results in reduction in size, crinkling and malformation of the infested leaves. In severe cases of infestation, the growth of the vine and sometimes the formation of spikes may be adversely affected. The adults are black and measure 2-3 mm in length. The larvae and pupae are creamy-white. The eggs are laid within the galls and they hatch in 6-8 days. The two larval stages, prepupal stage and two pupal stages lasts for 4-7, 4-6, 2, 2-3 and 2-3 days, respectively.

Montandoniola moraguesi Puton (Anthocoridae) and *Androthrips flavipes* Schmutz (Phlaeothripidae) were recorded as predators of leaf gall thrips (Ananthakrishnan, 1978). Visalakshi and Joseph (1967) reported that an unidentified species of anthocorid and a mite predate on juvenile stages of the pest. The life cycle and predatory potential of *M. moraguesi* was studied (Devasahayam, 1991).

Nair and Christudas (1976) reported that among the five insecticides tested for the control of leaf gall thrips, monocrotophos (0.02%) was the most effective, followed by dimethoate (0.03%) and phosphamidon (0.05%). Vivekanandan *et al.* (1981) reported that among the six insecticides tested, fenvalerate and methamidophos were relatively more effective in controlling the pest infestation when sprayed at 30-60 days interval. Studies on residual toxicity of nine insecticides against the pest indicated that residual toxicity was maximum in monocrotophos (0.05%) (Devasahayam, 1989). Devasahayam (1990) also evaluated six insecticides in the field and found that monocrotophos (0.05%) and dimethoate (0.05%) were effective in controlling the pest.

2.1.4 *Scale Insects*

Scale insects sometimes cause severe damage to black pepper vines in certain areas especially at higher altitudes. The infestation is seen in the form of encrustations on stems, leaves and berries and generally becomes more severe during summer months. Scale insects suck the plant sap resulting in yellowing and withering of infested shoots and in severe cases the vines dry up. The pest infestation is sometimes very severe in the nursery especially in older cuttings. Among the various species recorded on the crop, *Lepidosaphes (Mytilaspis) piperis* Gr. and *Aspidiotus destructor* Sign. are important; these were first recorded by Lefroy (1909) and Fletcher (1914), respectively. The former is elongated and dark brown and the latter oval and pale yellow. Scale insects can be controlled by spraying dimethoate (0.05%) (Anon., 1989a).

2.2 Minor Pests

2.2.1 *Sap Feeders*

Gautam (1980) reported the occurrence of *Toxoptera aurantii* (B. de F.) on black pepper at Sultan's Battery (Wynad district) and Koothali (Calicut district) areas. The aphid colonies were found on the ventral surface of leaves which exhibited yellowing symptoms.

Colonies of mealy bugs are sometimes seen on tender shoots and berries. The species recorded on black pepper include *Ferrisia (Pseudococcus) virgata* Ckll. (Rao, 1926) and *Planococcus citri* (Risso) (Nayar *et al.*, 1976).

Apart from the scale insects mentioned earlier, *Hemichionaspis aspidistrae* Sign. (Ayyar, 1919), *Pinnaspis aspidistrae* Sign. (Rao, 1926), *Marsipococcus (Lecanium) marsupiale* (Gr.) (Fletcher, 1914), *P. marchali* Ckll. and *Chionaspis raricosa* Gr. (Nair, 1975) have also been recorded on black pepper. Rao (1926) mentioned that spraying of bordeaux mixture for the control of 'pollu' disease resulted in infestation by *P. virgatus* and *P. aspidistrae* on the treated vines. Abraham (1959) also mentioned that vines sprayed with resin-bordeaux mixture were attacked during the subsequent summer months by mealy bugs.

Devasahayam *et al.* (1986) reported the occurrence of *Helopeltis antonii* Sign. infesting tender shoots and leaves of young black pepper vines at Kottaparamba (Calicut district). The pest infestation resulted in the formation of necrotic lesions on the affected tissues; when very young shoots were attacked they dried up completely.

The other sap feeders recorded on black pepper include *Amrasca devasatans* (Dist.), *Disphinctus maesarum* Kirk. (Hill, 1983), *Cyclopelta siccifolia* Westw. (Nayar *et al.*, 1976) and *Aleurocanthus piperis* Mask. (Nair, 1975).

2.2.2 *Leaf Feeding Caterpillars*

Gautam (1980) recorded *Spodoptera litura* F. damaging 2-3 year old black pepper vines and young seedlings in the nursery at Peruvannamuzhi (Calicut district). About 53 per cent of the leaves were damaged in a sample of 50 vines during May 1979.

Premkumar and Devasahayam (1989) observed *Synegia* sp. damaging tender shoots, leaves and spikes of black pepper at Peruvannamuzhi. The infestation was more common on younger vines. In a sample survey on 100 young vines, about 52 per cent of the leaves were observed to be damaged; on adult vines, about 17 per cent of the spikes were damaged.

The other leaf feeding caterpillars recorded on black pepper include *Latoia (Parasa) lepida* Cram. (Fletcher, 1914), *Cricula trifenestrata* Helf. (Ayyar, 1940) and *Thosea sinensis* Wlk. (Hill, 1983).

2.2.3 *Leaf Feeding Beetles and Weevils*

The leaf feeding flea beetles recorded on black pepper include *Neculla pollinaria* B. and *Pagria costatipennis* J. in Kerala (Nair, 1975), *Hermaeophaga* sp. in Trivandrum and Kottayam districts and *Lanka* sp. in Lakkidi in Wynad district (Premkumar and Nair, 1987b).

The weevils infesting foliage of black pepper include *Eugnathus curvus* Faust (Nair, 1975) and *Myllocerus* sp. (Pillai, 1978).

2.2.4 *Stem Borers*

Abraham (1959) reported that stems of black pepper vines were attacked by a stem borer (unidentified) in Cochin and Coorg regions resulting in their wilting and drying up. Dubey *et al.* (1976) reported the occurrence of *Diboma procera* Pasc. and *Pterolophia annulata* Chevr. in Cannanore and Calicut districts. The pest incidence was as high as 50 per cent in some gardens. The grubs were observed to tunnel into and feed on the central core of the stem around the collar region. Though the grubs were observed in older living vines, they had a preference for dead and drying tissues.

2.2.5 *Gall Thrips*

Apart from *L. karnyi*, two other species of *Liothrips* were also reported on black pepper. Mani (1973) reported that infestation by *L. chavicae* Z. resulted in epiphyllous inrolling of leaf margins, thickening of leaf blade and crinkling of leaves; the thrips were recorded from the hilly tracts of the former Travancore-Cochin state which now forms part of Kerala. Nair (1975) also reported the occurrence of *L. pallipes* Karny on black pepper in South India.

2.2.6 *Gall Midges*

The occurrence and life history of *Cecidomyia malabarensis* Felt. on black pepper has been reported by Rao (1925, 1928). The maggots develop within the berries, leaf stalks and shoots resulting in swelling of the infested tissues. *Polygaster* sp. was observed to parasitise the maggots. Mani (1973) reported the occurrence of two unidentified species of cecidomyiids causing hypophyllous globose solitary pellet shaped galls on the leaf and minute irregular rinden galls on the stem.

3. GINGER (*ZINGIBER OFFICINALE* ROSC.) AND TURMERIC (*CURCUMA LONGA* L.)

3.1 Major Pests

3.1.1 *Shoot Borer (Conogethes punctiferalis Guen.)*

The shoot borer is the most important pest of ginger and turmeric, and was first recorded on these crops by Fletcher (1914). The adult is a small moth with orange-

yellow wings with small black spots. The larvae bore into pseudostems and feed on the growing shoot resulting in yellowing and drying of infested shoots. The presence of bore holes in the pseudostem through which frass is extruded and the withered central shoot are characteristic symptoms of pest infestation. Studies on yield loss caused by the pest indicated that when 50 per cent of the pseudostems in a clump were affected, there was a reduction of 38 g of yield per clump (Koya *et al.*, 1986).

The nature of damage and life history of shoot borer on turmeric was studied by Jacob (1981). At Kasaragod (Kerala), under laboratory conditions (temperature range 30-33°C; relative humidity range 60-90%), the egg period lasted for 3-4 days. There were five larval instars and they lasted for 3-4, 5, 3-7, 3-8 and 7-14 days, respectively. Fully grown larvae were light brown and 16-26 mm in length. The prepupal and pupal periods lasted for 3-4 and 9-10 days, respectively. Adult females laid 30-60 eggs during its life span. In the field, 6-7 generations were completed during a crop season.

The natural enemies and alternate hosts of the shoot borer have been furnished under cardamom. The shoot borer is highly polyphagous; Jacob (1980) has listed its alternate hosts.

The reaction of various ginger and turmeric types to shoot borer in the field was studied. Nybe and Nair (1979) reported that among the 25 cultivars of ginger screened, pest infestation was minimum in Rio-de-Janeiro and maximum in Valluvanad. Sheila *et al.* (1980) reported that among the 13 turmeric types observed, Dindigam Ca-69 was least susceptible and Amruthapani Kothapeta C11-317 most susceptible. Philip and Nair (1981) reported that among the 19 turmeric types screened, Mannuthy local was most tolerant.

Very few field trials have been conducted for the control of shoot borer on ginger and turmeric. Koya *et al.* (1988) found that monthly spraying of malathion (0.1%) during July-October was the most effective among the six insecticides tested in field trials on ginger. Koya *et al.* (1986) have evolved a sequential sampling strategy for monitoring the level of pest infestation in a field of ginger as a guidance for undertaking control measures.

3.1.2 *Leaf Roller (Udaspes folus Cram.)*

The leaf roller was first recorded on ginger and turmeric by Lefroy (1906, 1909). The larvae cut and fold the leaves, remain within and feed on them.

The nature of damage and life history of leaf roller was studied on ginger and turmeric at Kasaragod under laboratory conditions (temperature 26-35°C; relative humidity 41-100%) by Abraham *et al.* (1975). Adults are medium sized with brownish-black wings with large white spots. The egg, larval and pupal periods lasted for 4-5, 13-25 and 6-7 days, respectively on ginger; on turmeric the various stages lasted for 3-4, 12-21 and 6-7 days, respectively. There were five larval instars; fully grown larvae were dark green and about 36 mm in length. The pest was abundant in the field during August-October.

The natural enemies recorded on leaf roller include *Ceromyia* sp. (Tachinidae), *Apanteles* sp. (Vipionidae), *Sympiesis* sp. (Eulophidae), *Brachymeria coxodentata* (Chalcidae) and mermithid nematodes; the overall mean percentage of parasitisation of caterpillars in the field during the entire season went up to 26.4 per cent (Anon., 1975a, 1976, 1977). *Enterobacter cloacae* and *Pseudomonas* sp. were also isolated from diseased larvae (Anon., 1974).

The leaf roller has been recorded on wild lilies (Fletcher, 1914), arrowroot, *Curcuma angustifolia* (Ayyar, 1940), *Elettaria cardamomum, Aframomum melegueta, C. amada* and *Headychium* sp. (Abraham *et al.*, 1975).

Very few field trials have been conducted for the control of leaf roller. Spraying of carbaryl (0.1%), dimethoate or phosphamidon (0.05% each) was recommended for the control of the pest (Anon., 1985b).

3.1.3 *Rhizome Scale (Aspidiella hartii Ckll.)*

The rhizome scale infests rhizomes of ginger and turmeric (Fig. 4) both in field and in storage. The pest was first reported on turmeric by Ayyar (1940). In the field, in severe cases of infestation, the plants wither and dry. In storage, the pest infestation results in shrivelling of buds and rhizomes; when the infestation is severe, it adversely affects sprouting of rhizomes.

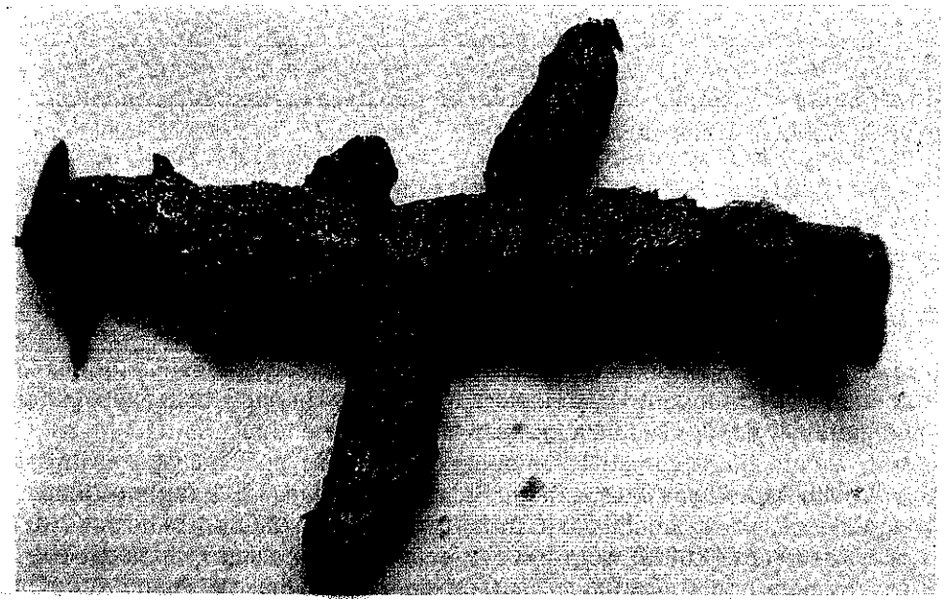


Fig. 4 : Turmeric rhizome infested with scale insects.

The nature of damage caused by rhizome scale on turmeric and brief description of the same was given by Jacob (1982). The adult females are minute, circular and light brown to grey. Females are ovo-viviparous and also reproduce parthenogenetically; about 100 eggs are laid by a single female.

The natural enemies recorded on rhizome scale include *Physcus comperei* Hayat (Aphelinidae) (Anon., 1985), *Adelencyrtus moderatus* Howard (Encyrtidae) and two types of mites (Jacob, 1982).

Rhizome scales were also recorded on *Amorphophallus companulatus* (Regupathy *et al.*, 1976), *Dioscorea alata* and *Xanthosoma sagittifolium* (Anon., 1985a). Regupathy *et al.* (1976) studied the field reaction of 191 turmeric types to rhizome scale and found that 87 were free from infestation.

Regupathy *et al.* (1977) reported that in trials involving 12 insecticides, dipping seed rhizomes in aldicarb sulfone, DDVP, monitor, phosalone, monocrotophos and leptophos (0.05% each) for 15 minutes was relatively more effective in controlling the infestation of rhizome scales on turmeric. Dipping the seed rhizomes of turmeric in quinalphos (0.1%) for 5 minutes after harvest and before planting was also effective in controlling the pest infestation (Anon., 1985a).

3.2 Minor Pests

3.2.1 *Sap Feeders*

The occurrence of *Stephanitis typica* Dist. on turmeric leaves was first reported by Fletcher (1914). The foliage of infested plants turn pale and dry up. Thangavelu *et al.* (1977) found that spraying of dimethoate or phosphamidon (0.05% each) was more effective in controlling the pest.

Aspidiella curcumae Gr. on turmeric in Maharashtra (Nair, 1975), *Pentalonia nigronervasa* Coq. on ginger (Hill, 1983) and unidentified mealy bugs on both (Vevai, 1971) are the other sap feeders recorded on these crops.

3.2.2 *Thrips*

Ayyar (1920b) included *Panchaetothrips indicus* Bagn. infesting turmeric in his list of economically important Thysanoptera from India. The infested leaves roll up, turn pale and gradually dry up. The development of rhizomes is reduced when the infestation is severe. Ananthakrishnan (1973) mentioned that this species was always found associated with *Asprothrips indicus* Bagn. Balasubramanian (1982) reported that in trials involving 12 insecticides, dimethoate (0.06%), fenpropathrin (0.02%), bendiocarb (0.08%) and methyl demeton (0.05%) were more effective in controlling *P. indicus*. The other thrips recorded include *Thrips tabaci* Lind. on ginger (Chadha, 1976) and *Anaphothrips sudanensis* (Trybom) on turmeric (Ananthakrishnan, 1973).

3.2.3 *Leaf Feeders*

Meyrick (1931) described *Acrocercops irradians* Meyr. as a pest of ginger in Bombay. Ramakrishna and Raghunath (1982) reported a heavy incidence of *Creatonotus gangis* (L.) on turmeric in Andhra Pradesh causing severe defoliation. Studies on the biology of the pest were also conducted by them. Khan (1983) has suggested the use of light traps, collection and destruction of egg masses, digging trenches around the field and dusting BHC (10%) for the control of Bihar hairy caterpillar (*Diacrisia obliqua* Wlk.) on turmeric. The other leaf feeding caterpillars recorded include *Catopsila pomona* F. and *Bombotelia nugatrix* Gr. on turmeric (Anon., 1977) and *Spodoptera litura* (F.) on ginger (Hill, 1983).

Leaf feeding beetles such as *Lema praeusta* Fabr., *L. signatipennis* Jac. and *L. semiregularis* Jac. were recorded on turmeric in Orissa (Sengupta and Behura, 1955). Both adults and larvae feed on leaves. The life histories of *L. praeusta* and *L. semiregularis* was also studied (Sengupta and Behura, 1956; Sengupta and Behura, 1957). The egg, larval and pupal periods of the former species lasted for 8-10, 10-12 and 15-25 days, respectively, whereas that of the latter species lasted for 4-5, 15 and 19 days, respectively.

The other leaf feeding beetles recorded on turmeric include *Pseudocophora* sp., *Colasposoma splendidum* (F.), *Cryptocephalus rajah* Jac., *Epilachna sparsa* (Hbst.), *Ceratobasis nair* (Loc.), *Myllocerus viridanus* Fab., *L. lacordairei* Baly (Anon., 1977) and *Hedychorus rufofasciatus* M. (Nair, 1975).

3.2.4 *Rhizome Feeders*

3.2.4.1 *Rhizome maggots* : Various species of dipteran maggots are associated with ginger and turmeric. The maggots bore into and feed on the rhizomes and are generally seen in plants affected by rhizome rot disease. The maggots recorded include *Calobata* sp. (Fletcher, 1914), *Chalcidomyia atricornis* Mall., *Formosina flavipes* Mall. (Malloch, 1927), *Celyphus* sp. (Nair, 1975), *Mimegralla coeruleifrons* Macq. (Khaire *et al.*, 1972), *Eumerus albifrons* Wlk. (Sathiamma, 1979) and *E. pulcherrimus* Bru. (Anon., 1986). The maggots were also observed in decaying wild ginger, wild arrowroot, *Colocasia* sp. (Anon., 1986), *C. aromatica* and *C. zeodaria* (Anon., 1979).

Ghorpade *et al.* (1988) studied the nature of damage and life history of *M. coeruleifrons* in the laboratory on ginger and turmeric at Kolhapur (Maharashtra). The pest completed its life cycle in 32-35 days and 25-40 days on ginger and turmeric, respectively. The maximum percentage of damaged plants in the field was 37 and 35 on these crops respectively, which was observed after the receipt of heavy showers. The period August-October characterised by intermittant rains, cloudy weather, lower temperature and higher relative humidity favoured the abundance of flies. The life history of *M. coeruleifrons* was also studied in the laboratory at Calicut, Kerala on ginger. The maggots were also observed in decaying rhizomes of turmeric, wild ginger, wild arrowroot and *Colocasia* sp. (Koya, 1989).

Trichopria sp. (Diapriidae) and *Spalangia gemina* Boucek (Pteromalidae) were recorded as pupal parasites of *M. coeruleifrons* (Anon., 1977; Ghorpade *et al.*, 1988; Koya, 1989).

Jadhav *et al.* (1982) screened 20 turmeric cultivars against *M. coeruleifrons* and found that Sugandham and Duggirala were the most resistant in one year and Tekkurpeta, Sugandham, Duggirala, Waigaon and Kasturi in another year.

The association of dipteran maggots with diseased rhizomes was investigated by various workers. Premkumar *et al.* (1982) reported that 42 per cent of the diseased rhizomes examined had *Pythium* sp. alone and 58 per cent with *Pythium* sp. and maggots; none of the samples were infested with maggots alone. Iyer *et al.* (1981) reported that presence or absence of maggots did not make any difference in the initial incidence of the disease. Radke and Borle (1982), while studying the status of *M. coeruleifrons* on ginger, found that rotting of rhizomes due to disease began first and later the flies preferred such rhizomes for egg laying. Ghorpade *et al.* (1983) conducted surveys in Maharashtra and reported that *M. coeruleifrons* was endemic in Sangli and Satara districts. Losses due to the pest infestation resulted in 31 and 25 per cent reduction of yield in ginger and turmeric, respectively. The damage was less in light and well drained soils. Surveys conducted in ginger growing areas in Kerala indicated that *M. coeruleifrons* and *E. pulcherrimus* were the most common species occurring in diseased rhizomes; 26.4 per cent of the diseased rhizomes contained maggots. None of the healthy rhizomes contained maggots (Koya, 1988). Ghorpade *et al.* (1988) mentioned that, in the field, the feeding activity of the maggots was responsible for introduction of microorganisms such as *Fusarium, Pythium* and *Sclerotium* and nematodes of the genera *Tylenchus, Helicotylenchus, Meloidogyne* and *Dorylaimida.* However, studies conducted under controlled conditions in green house involving inoculation with *M. coeruleifrons* and *Pythium* sp. in various combinations clearly indicated that the maggots could infest only diseased ginger rhizomes and hence cannot be considered as a primary pest of the crop (Koya, 1990).

Various field trials have been conducted for the control of rhizome maggots. Dhoble *et al.* (1978) reported that in trials involving systemic granular insecticides, phorate was the most effective for control of *M. coeruleifrons* on turmeric. Koya and Banerjee (1981) reported that in trials against *M. coeruleifrons* on ginger, aldicarb, carbofuran and methyl parathion were effective in reducing the pest infestation. Ghorpade *et al.* (1982) found that among the 10 insecticides tested against *M. coeruleifrons* on turmeric, bromophos 5 G, quinalphos 5 G and aldicarb 10 G were effective.

3.2.4.2 *Root grubs* : Root grubs were recorded on turmeric in Andhra Pradesh and application of aldrex (5%) dust recommended for its control (Anon., 1975b). At Peruvannamuzhi (Calicut district) infestation of 2-3 month old ginger plants by *Holotrichia fissa* Brenske was observed. The grubs fed on the tender rhizomes and sometimes at the base of the pseudostems. Drenching the soil with aldrin (0.1%) was effective in controlling the pest infestation.

3.2.5 *Storage Pests*

Various insects have been recorded on ginger and turmeric in storage. Lefroy (1909) reported the occurrence of *Lasioderma serricorne* (Fab.) on stored turmeric. Rao and Rao (1954) reported that exposure of dry ginger to methyl bromide initially and application of lindane (0.05%) once in a month prevented the pest infestation.

Srivastava (1959) studied the biology of *Stegobium paniceum* L. on stored turmeric. Fumigation with a mixture of ethylene dibromide and carbon tetrachloride was effective in controlling the pest infestation. Srinath and Prasad (1975) reported that *L. serricorne* was the most common pest of stored turmeric. The other insects recorded by the authors include *S. paniceum* L., *Tribolium castaneum* (Hbst.), *Oryzaephilus surinamensis* (L.), *Araecerus fasiculatus* (Deg.) and *Tenebroides mauritanicus* (L.).

Abraham (1975) reported that *L. serricorne* and *A. fasciculatus* were the most important pests of stored ginger and turmeric in Kerala. The other pests recorded include *S. paniceum, T. mauritanicus* and *Ephestia* sp. Brief notes on the biology of these pests have also been furnished. Fumigation with methyl bromide and spraying the bags with malathion were effective in controlling the pest infestation.

Kavadia *et al.* (1978) reported that 68 per cent of turmeric samples collected from Udaipur (Rajasthan) were infested with *L. serricorne.* The pest infestation resulted in a weight loss of 39.78 per cent of the produce. Fumigation with phosphine gas from celphos tablets resulted in total mortality of the pest.

Jacob (1986) reported that *A. fasciculatus* attacked both fresh and dry ginger whereas *Pyralis manihotalis* Guen. and *Setomorpha rutella* Zell. infested dry ginger and turmeric; *S. paniceum* and *L. serricorne* also occurred in dry ginger and turmeric. Fumigation with aluminium phosphide tablets (3-4 tablets/tonne) in an air tight store for 2-3 days was suggested for controlling the pest infestation. Muthu and Majumdar (1974) have furnished the concentration, time of exposure and residual effects of various fumigants recommended for controlling insect infestations in various spices including ginger and turmeric.

4. CARDAMOM (*ELETTERIA CARDAMOMUM* MATON.)

4.1 Major Pests

4.1.1 *Cardamom Thrips (Sciothrips cardamomi Ramk.)*

The cardamom thrips is the most destructive pest of cardamom and was first described from Anamalai hills by Ayyar (1935). Studies on nature of damage and biology of thrips were reported by Cherian and Kylasam (1941), Nair (1975), Anon. (1985c), Kumaresan *et al.* (1988) and Krishnamurthy *et al.* (1989).

The adults and larvae lacerate and feed on leaves, shoots, inflorescences and capsules (Fig. 5). When panicles are infested, it results in shedding of flowers and

immature capsules. The feeding activity on tender capsules results in the formation of corky, scab-like encrustations on them. These later become malformed and shrivelled with slits on the outer skin; the seeds within them are poorly developed and lack the usual aroma. The extent of damage may be as high as 80 per cent in certain areas. The thrips breed within unopened leaf spindles, leaf sheaths, flower bracts and flower tubes.

The adults are greyish brown and measure 1.25-1.50 mm in length. Reproduction is by sexual and parthenogenetic means. The egg period lasts for 9-12 days. There are two larval, a prepupal and pupal stages. The life cycle from egg to adult is completed in 3-4 weeks. The population of thrips is generally high during summer months and declines with the onset of rains. The Mysore variety of cardamom is highly susceptible to thrips infestation. The pest infestation was also higher in closer spacings (Sridharan *et al.*, 1990).

A number of alternate hosts were recorded in the field. These include *Panicum longipes, Hedychium flavescens, H. coronarium, Amomum carnaecarpum, A. involucratum, A. subulatum, A. microstephanum, Afromomum melegueata, Remusatia vivipara, Colocasia antiquorum, Zingiber sp., Curcuma pseudomontana, Costus speciosus, Crinum sp., Globba ophioglossa* and *Alpinia galanga* (Anon., 1985a; Kumaresan *et al.*, 1988).

A number of field trials have been conducted for evaluating the efficacy of various insecticides in controlling the pest and only recent work are reviewed here.

Wilson *et al.* (1977) reported that among the 10 insecticides tested, quinalphos, monocrotophos, dimethoate, phenthoate and formothion (0.03% each) were more effective in controlling the thrips infestation when eight rounds of sprayings were given at monthly intervals from April. Wilson *et al.* (1978) tested the efficacy of three insecticides when sprayed at five different time intervals from April to January; quinalphos (0.03%) was the most effective and economical when sprayed at 40 days intervals. Pillai and Abraham (1978) reported that spraying quinalphos, phenthoate, dimethoate and phosphamidon (0.1% each) were more effective. Seven rounds of sprayings were recommended, the first in early June and the remaining six rounds at monthly intervals from late August onwards. Nair *et al.* (1979) conducted trials with 12 formulations as sprays and 5 as dusts and found that quinalphos (0.05%) was the most effective among sprays and quinalphos (1.5%) among dusts. Kumaresan (1982) tested the efficacy of five insecticides and found that all of them, viz., methidathion, carbosulfan (0.05% each), bendiocarb (0.16%), phoxim and isophenphos (0.075%) were effective.

Joseph (1983a) tested the efficacy of high volume sprays of permethrin (100 ppm) and cypermethrin (60 ppm) in comparison with monocrotophos (300 ppm) and quinalphos (500 ppm) and found that permethrin gave the best control when sprayed at monthly intervals from April to November (except June). Joseph (1983b) also tested the efficacy of dust and spray formulations of 11 insecticides and found that sprays of fenthion, quinalphos and phenthoate (0.03% each) and dusts of carbaryl, quinalphos,

phosalone, toxaphene and methyl parathion gave over 80 per cent control when applied at monthly intervals from April to December.

Kumaresan (1983) later evaluated six insecticides and found that permethrin or fenvalerate (0.01% each) applied eight times at monthly intervals from May gave the best control. Chandrasekharan (1984) reported that quinalphos (0.025%) and monocrotophos (0.03%) were the most effective among the various insecticides tested. Seven to eight rounds of insecticide applications are recommended. Spraying of quinalphos, dimethoate or methyl parathion (0.05%) or phosalone (0.07%) during March, April, May, August and September was recommended in Coorg area (Karnataka); in Kerala, seven rounds of spraying were recommended (Anon., 1985c).

Varadarasan and Kumaresan (1987) evaluated the efficacy of four insecticides at three concentrations against thrips and shoot and capsule borer at lower Pulney's in Tamil Nadu and recommended a schedule for the control of these pests with cypermethrin (0.01%), permethrin (0.01%) and monocrotophos (0.05%) which were more effective.

Extensive evaluation of numerous insecticides at Mudigere (Karnataka) indicated that Nuvacron, Zolone and Ekalux were more effective. Further studies revealed that application of only two sprays (first with Nuvacron/Ekalux and next with Zolone) during panicle initiation stage and 30 to 40 days later effectively checked thrips infestation (Krishnamurthy *et al.*, 1989).

4.1.2 *Shoot and Capsule Borer (Conogethes punctiferalis Guen.)*

The shoot and capsule borer (Fig. 6) is a serious pest in nurseries and main fields in Kerala, Karnataka and Tamil Nadu. The larvae bore into pseudostems and feed on the internal contents leading to formation of 'dead heart' symptoms. The larvae also bore into panicles resulting in drying up of the same and into capsules feeding on the seeds.

The adult is a small moth with a wing span of about 24 mm; the wings are orange-yellow with small black spots. The earlier instars of larvae bore into panicles, flower buds and capsules and the late instar larvae bore into pseudostems. Studies on the life cycle of the pest conducted at Idukki (Kerala) indicated that the total period from egg to adult took 41-57 days during summer (March-May) and 84-123 days during winter (November-February). The pest infestation was generally observed throughout the year but was higher during January, March, June, August and October (Varadarasan *et al.*, 1991).

Various natural enemies of shoot borer have been recorded. These include *Angitia (Dioctes) trochanterata* Morl. (Ichneumonidae), *Theromia inareolata, Bracon brevicornis* Wes. (Braconidae) and *Apanteles* sp. (Vipionidae) parasitic on larvae and *Brachymeria euploeae* West. (Chalcidae) parasitic on pupae (David *et al.*, 1964); *Microbracon hebetor* Say. (Braconidae) parasitic on larvae (Patel and Gangrade, 1971); *B. nosatoi* Habu, *B. lasus* West. (Joseph *et al.*, 1973); *Dolichurus* sp. (Sphegidae) and

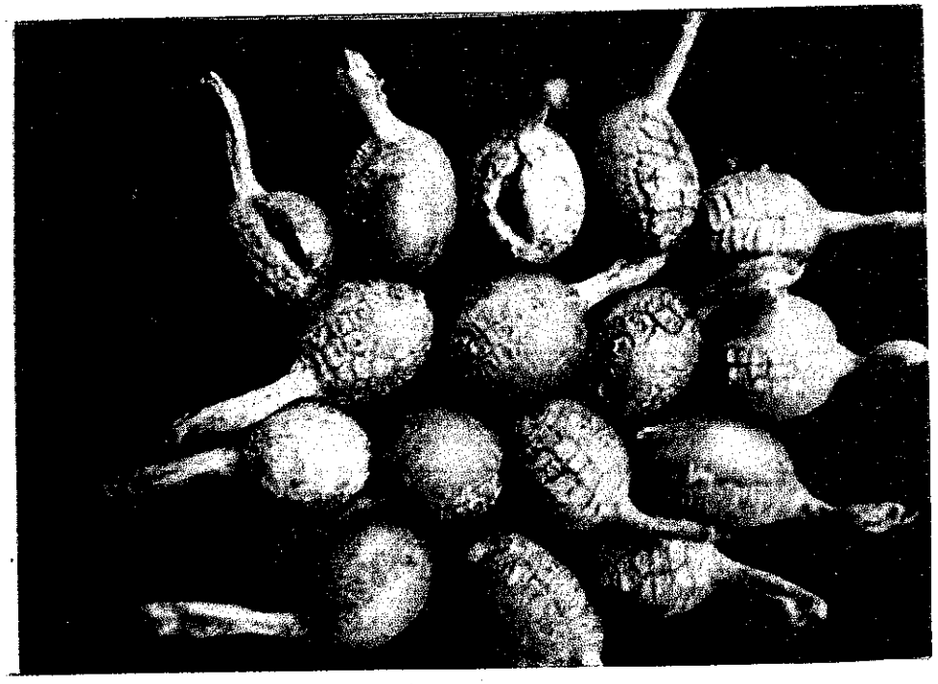


Fig. 5 : Cardamom capsules damaged by thrips.

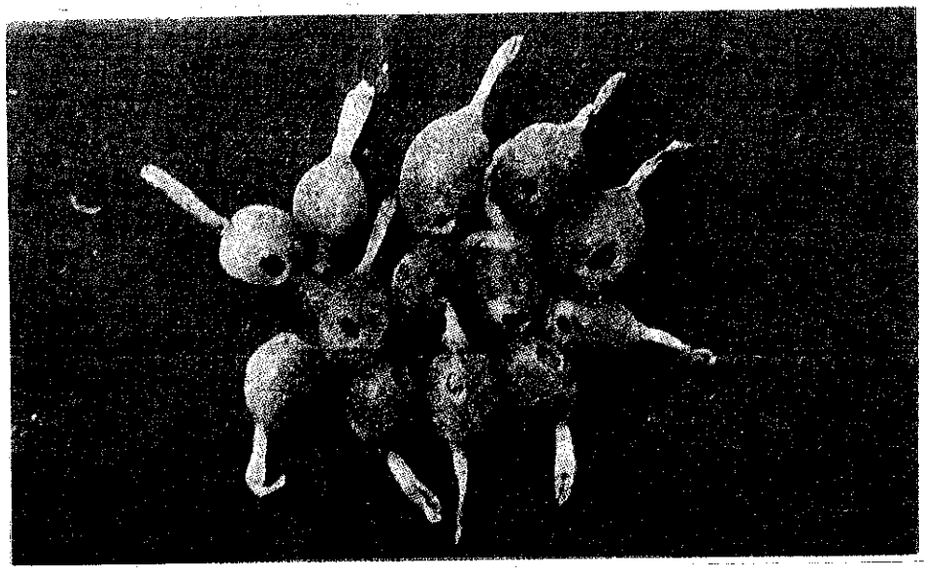


Fig. 6 : Cardamom capsules damaged by shoot and capsule borer.

Phanerotoma hendecasisella Cam. (Braconidae) (Anon., 1985a); *Myosoma* sp. (Braconidae), *Xanthopimpla australis* Kr. (Ichneumonide), mermithid nematode, dermpateran, asilid flies and spider (Jacob, 1981).

The shoot borer is highly polyphagous. Jacob (1980) has listed its alternate hosts which include guava, mango, peaches, pomegranate, jack, ginger, turmeric, avocado, mulberry, loquat, pear, sorghum, cocoa, castor, tamarind, amaranthus, soapnut, hollyhocks, *Caesalpinia bonducella* and *Anona cherimelia.* Nambiar *et al.* (1975) have reported zingiberaceous hosts like *Curcuma aromatica, C. amada, Alpinia* sp., *Amomum* sp. and *Aframomum melegueta.* The other zingiberaceous hosts recorded include *Amomum subulatum, A. microstephanum, Hedychium coronarium, H. flavescens* and *Alpinia galanga* (Anon., 1985a).

A few field trials were conducted for the control of shoot and capsule borer. Kumaresan *et al.* (1978) tested the efficacy of 10 insecticides and found that monocrotophos (0.1%) was the most effective. Regupathy (1979) reported that among the four granular insecticides tested, carbofuran (2 kg a.i./ha) was the most effective. Naganathan *et al.* (1983) tested the efficacy of 13 insecticides and found that spraying of garvox, sumicidin, acephate or tamaron (0.1% each) significantly reduced borer incidence. Collection and destruction of adult moths, removal of infested tillers and spraying of monocrotophos (0.075%) or fenthion (0.075%) was also recommended for the control of the pest (Anon., 1985c). Removing of infested suckers (if less than 10 per cent) during September-October and spraying quinalphos (0.03%), if the infestation was above 10 per cent, was also recommended by Krishnamurthy *et al.* (1989).

4.1.3 *Root Grub (Basilepta fulvicorne Jacoby)*

Root grubs are major pests of cardamom in nurseries and main fields being distributed in Kerala, Karnataka and Tamil Nadu (Varadarasan *et al.*, 1988). In Karnataka, the pest is generally serious in primary and secondary nurseries (Thyagaraj *et al.*, 1991). The grubs feed and damage roots and portions of rhizomes; sometimes the entire root system is eaten away. The infested plants turn yellow and are stunted; severely infested plants die.

The adults are shiny metallic blue, green or brown beetles measuring 4-6 × 2-4 mm. Males are smaller than females. The adults are polyphagous feeding on a number of plants that are present around cardamom plantations. The peak periods of adult emergence at Idukki (Kerala) was during April and September. The females lay eggs in soil around the base of clumps and fully grown grubs are pale white, stout and 'C' shaped, and measure about 1 cm in length. At Idukki, the egg, larval and pupal stages lasted for 13-19, 45-60 and 10-17 days, respectively (Varadarasan *et al.*, 1992). At Mudigere (Karnataka) the egg, larval and pupal stages lasted for 10-15, 78-80 and 20-25 days, respectively (Thyagaraj *et al.*, 1991).

An integrated management strategy was developed for the control of root grubs. This involves collection and killing of adult beetles during March-April and August-

September during peak periods of emergence and application of aldrin (0.1%), BHC (0.2%), chlorpyriphos (0.04%) or phorate 10 G (20-40 g/clump) during May and October (Anon., 1989b; Varadarasan *et al.*, 1990).

4.2 Minor Pests

4.2.1 *Capsule Borers*

The lycaenid borer *Jamides* sp. is sometimes serious in Karnataka and the caterpillars bore into and feed on flowers and capsules. The affected capsules become empty, decay and drop off. The pest is generally serious during the monsoon and hence control of the pest with insecticides is difficult. Spraying with quinalphos or methyl parathion (0.05% each) during early blooming period helps in reducing the pest damage (Kumaresan *et al.*, 1988). *J. alecto* was also reported from Mudigere (Karnataka) (Krishnamurthy *et al.*, 1989).

Adults and larvae of *Thamurgides cardamomi* bore into capsules and feed on the mucilage. The incidence of the pest is high during the monsoon, particularly in thickly shaded areas. Regulation of shade and spraying with quinalphos or methyl parathion (0.05% each) during the crop period was recommended for the control of the pest (Anon., 1985c).

Adults of *Onthophagus* sp. and *O. coorgensis* also bore into flowers and young capsules, while the larvae feed on roots. When young capsules are attacked, they decay and drop off. The symptoms of damage are similar to that of *T. cardamomi*. Regulation of shade and spraying with quinalphos or methyl parathion (0.05% each) was effective against the pest (Kumaresan *et al.*, 1988; Krishnamurthy *et al.*, 1989).

Tribolium castaneum (Hbst.) is a serious pest on stored cardamom. Storage of capsules in alkathene-lined jute bags sprayed with malathion (0.1%) or fumigation with methyl bromide was recommended to control the pest infestation (Abraham, 1975).

4.2.2 *Root and Rhizome Borers*

The larvae of *Hilarographa caminodes* Meyr. bore into roots making tunnels filled with frass. The roots die due to the pest infestation and the entire clump dries if the infestation is severe. The caterpillars of the moth remain inactive without feeding during summer months (Jones, 1944a). Destruction of infested plants and drenching with BHC (0.2%) was recommended for the control of the pest (Anon., 1985c).

The grubs of *Prodioctes haematicus* Chevr. tunnel into rhizomes and sometimes into pseudostems also. The pest infestation is generally serious in the secondary nursery. The grub phase is prolonged and lasts for about 3 months (Jones, 1941, 1944b). Destruction of infested rhizomes, drenching with BHC (0.2%) and use of healthy rhizomes collected from non-infested areas were recommended for the control of the pest (Anon., 1985c).

Maggots of *Hallomyia cardamomi* Nayar were recorded to bore into exposed roots causing extensive galling (Nair, 1975). Larvae of *Mimela xanthorrhina* Hope, *Holotrichia serrata* and *Anomala* sp. were also reported to damage roots and rhizomes of cardamom (Chakravarthy *et al.*, 1989; Anon., 1989b).

4.2.3 *Sap Feeders*

Infestation by *Dialeurodes cardamomi* David & Subr. is more serious in Kerala and Tamil Nadu. The adults and nymphs are seen in colonies on the lower leaf surface and they suck the sap. Severe infestation results in yellowing of leaves and the plants lose their vigour. The pest infestation is more severe during summer. *Encarsia* sp. was reported as a nymphal parasite (Kumaresan *et al.*, 1988). A fungus, *Aschersonia placenta* was found to infect over 95 per cent of the pupae during an outbreak of pest in Kerala (Muraleedharan, 1985). Spraying ethion (0.1%) or acephate (0.07%) and neem oil (5%) was effective in controlling the pest (Kumaresan *et al.*, 1988).

Colonies of *Pentalonia nigronervosa* f. *caladii* van der Goot are seen within leaf sheaths of older pseudostems. The adults and nymphs suck the plant sap. Though the damage caused by them is not very serious, they act as vectors of mosaic or 'katte' disease of cardamom. Siddapaji and Reddy (1972) confirmed that the form occurring on cardamom was *P. nigronervosa* f. *caladii*. Studies on virus-vector relationships were also undertaken (Uppal *et al.*, 1945; Varma, 1962; Rao and Naidu, 1973, 1974; Rajan, 1981; Naidu *et al.*, 1982). The biology of *P. nigronervosa* occurring on cardamom was studied by Rajan (1981). The adults are dark brown and around 1.4 mm in length. Reproduction is by viviparous and parthenogenetic means. The life cycle is completed in 10-15 days with four nymphal instars. The pest population was high during January-February in the field. The aphid was also found breeding on *Colocasia* sp., *Alocasia* sp. and *Caladium* sp. Two species of coccinellids, three species of syrphids and an unidentified hemerobiid were recorded to predate on the aphids in the field. Deshpande *et al.* (1972) reported the occurrence of an entomogenous fungus *Verticillium intertextum* on the aphids. Spraying of dimethoate or phosphamidon (0.05% each) was recommended for the control of aphids (Anon., 1985c).

The other sap feeders recorded on cardamom include *Planococcus citri, Saissetia nigra, S. coffeae* Walk. *Bothrogonia* sp., *Eosocarta nilgiriensis* Dist., *Aphrophora nuwarana* Dist., *Cosmoscarta thoracica* Dist., *Diaspis* sp., *Mytilaspis* sp., *Tettigoniella ferruginea, Riptortus pedestris* F., *Stephanitis typica* Dist. and *Ischnodemus vochus* Tol. (Siddappaji and Reddy, 1973; Nair, 1975; Nayar *et al.*, 1976; Kumaresan *et al.*, 1988; Krishnamurthy *et al.*, 1989).

4.2.4 *Foliage Feeders*

The grass hoppers *Orthacris* sp. and *Aularches miliaris* L., the leaf beetles *Lema*

sp., *L. admiralis*, *L. coromandeliana* and *L. subirdes* and thrips *Panchaetothrips indicus* Bagn. and *Leewania maculans* Pr. damage cardamom leaves (Nair, 1975; Kumaresan *et al.* 1988; Krishnamurthy *et al.*, 1989).

The leaf feeding caterpillars recorded on cardamom include *Acanthopsyche bipar* Walk., *Homona* sp., *Attacus atlas* L., *Plesionueura alysos* M., *Notocrypta feisthamelii* B., *Polythilpta maoralis* Led., *Eumelia rosalia* Cram., *Anisodes denticulatus* Hamps., *Thalassodes* sp. and *Arcilasia plagiata* M. (Nair, 1975; Kumaresan *et al.*, 1988; Varadarasan, 1986).

4.2.5 *Hairy Caterpillars*

Hairy caterpillars appear sporadically in large numbers and cause severe damage to cardamom by defoliating the plants. Reports on the incidence of hairy caterpillars in Kerala and Karnataka were provided by Puttarudriah (1955), Rajan (1958), Ranga Ayyar (1961) and Joseph *et al.* (1983). Eight species of hairy caterpillars are associated with cardamom. These include *Eupterote canarica* Moore, *E. cardamomi* Renga, *E. fabia* Cram., *E. testacea* Walk., *Lenodera vittata* Walk., *Euproctis lutifacia* Hamp. *Alphaea biguttata* Walk. and *Pericallia ricini* Fab. Among them, *E. cardamomi, E. canarica* and *L. vittata* are important. The caterpillars are gregarious in habit and they congregate on trunks of shade trees during day time. The females lay large number of eggs and the larval period is also extended. Details of biology of various species including their natural enemies and alternate host plants were given by Nair (1975) and Kumaresan *et al.* (1988).

Integrated control measures were suggested for controlling these pests. These include provision of tree less buffer zones, collection and destruction of larvae, spraying with BHC or carbaryl and biological control with parasitic tachinids and ichneumonids (Joseph *et al.*, 1983). Dusting with BHC (10%) or spraying with methyl parathion (0.1%) or quinalphos (0.05%) has also been recommended. Treating the shade trees where the caterpillars congregate in masses, mechanical killing of caterpillars and luring the adults in light traps and killing them is essential to obtain a satisfactory control (Anon., 1985c).

4.2.6 *Shoot Fly*

The larvae of *Formosina flavipes* Mall. feed on the growing shoot of young cardamom plants resulting in formation of dead hearts. The pest incidence is generally severe during March-April and young plants in new plantations with inadequate shade are seriously affected. The maggots are parasitised by *Opius mudigeransis* and braconid parasites. For controlling the pest, the affected shoots have to be destroyed. Spraying with dimethoate, quinalphos or methyl parathion (0.05% each) or application of carbofuran 3 G (20-25 kg/ha) is also effective. Sufficient shade should also be provided in the plantation (Anon., 1985c; Kumaresan *et al.*, 1988).

5. CINNAMON (*CINNAMOMUM VERUM* BERCHT. & PRESL.)

5.1 Major Pests

5.1.1 *Cinnamon Butterfly (Chilasa clytie L.)*

This is the most destructive pest of cinnamon and is widely distributed in all cinnamon growing areas in India. The pest is generally seen in the field during December-June. The larvae feed on tender and slightly mature leaves. In severe cases of infestation, the entire plant is defoliated and only the midribs of leaves with portions of veins remain. The adults are large; males have blackish brown wings with white spots on the outer margins; females have black wings with bluish white markings. Eggs are laid on tender leaves and shoots and they hatch in 3-4 days. The larval stage comprising of five instars is completed in 11-17 days. Fully grown larvae are pale yellow with dark stripes on the sides and are 25 mm in length. The pupal period lasts for 11-13 days. The eggs are parasitised by *Telenomus remus* Nixon (Scelionidae) (Singh *et al.*, 1978). The pest was also reported on other plants like *Alseodaphne semicarpifolia, Litsaea sebifera, Machilus gamblei* and *Phoebe lanceolata* (Beeson, 1941).

Spraying of quinalphos (0.05%) was recommended for controlling the pest infestation (Anon., 1979).

5.1.2 *Shoot and Leaf Webber (Sorolopha archimedias Meyr.)*

This is also a serious pest generally abundant in the field during August. The larvae web the tender shoots and leaves with silken threads, remain inside and feed on them. The adult is small with a wing span of 15 mm. The wings are greyish brown with black spots on the forewings.The egg, larval and pupal periods lasts for 3-4, 10 and 6-7 days, respectively (Singh *et al.*, 1978).

5.1.3 *Leaf Miner (Acrocercops sp.)*

The leaf miner infests tender leaves (Fig. 7) generally during the south-west monsoon period. The adult is small with grey fringed wings. The larvae feed on the tissues between the upper and lower epidermis of the leaf resulting in drying up of the infested portions. Fully grown larvae are pinkish red (Singh *et al.*, 1978). *Phyllocnistis citrella* Staint and *P. chrysophthalma* Meyr. were also reported to mine and damage tender leaves (Fletcher, 1920; Kumaresan *et al.*, 1988).

5.1.4 *Chafer Beetle (Popillia complanata Newman)*

The beetles feed on tender leaves and are generally common in the field during July-August. They are brown with a metallic green head and thorax and measure 15 × 6 mm. The eggs are laid in soil and the grubs feed on the roots. The egg, larval and pupal periods lasts for 5, 10 and 15 days, respectively (Singh *et al.*, 1978). The pest was also recorded on cashew, mango and rose (Sreeramulu *et al.*, 1975).

5.1.5 *Leaf Beetle (Singhala helleri Ohs.)*

The beetles congregate and feed on tender leaves and are generally seen in the field during August-October. They are brown and measure 8 × 5 mm. The eggs are laid in soil and the grubs feed on the roots. A reduviid bug *Sycanus collaris* (Fabr.) was observed to be predaceous on adults of *S. helleri* (Singh *et al.*, 1978).

5.2 Minor Pests

The other insects reported on cinnamon foliage include *Sauris* sp., *Euproctis fraterna* Moore, *Dasychira mendosa* Swinh, *Semiothisa* sp., *Selepa celtis* Moore, *Myllocerus subfasciatus* Guen., *Apoderus scitulus* Walk., *Ceroblastes rubens* Mask., *Oecophylla smaragdina* (F.) (Singh *et al.*, 1978); *Graphium saperodon* L., *Argina syringa* Cram., *Redoa submarginata* Walk., *Hypsidera talaca* Walk., *Gargara extrema* Dist. (Anon., 1979); *Diacrisia obliqua* W., *Cricula trifenestrata* H. (Anon., 1981); *Bemisia tabaci* Guen. (Koya *et al.*, 1983); *Graphium doson, Thalassodes* sp., *Orthaga vitalis* Walk. and *Bothrogonia* sp. (Kumaresan *et al.*, 1988).

Grubs of *Alcides morio* Heller were reported to feed on the inner contents of cinnamon seeds. Up to 60 per cent of seeds were damaged by the pest in some plantations (Premkumar, 1988). *Leucopholis pinguis* Burm. was also reported on cinnamon (Beeson, 1921).

Mani (1973) reported that unidentified psyllids and cecidomyiids produced galls on leaves and inflorescences, respectively.

6. CLOVE (*SYZYGIUM AROMATICUM* (L.) MERR. & PERRY)

The black scale *Parasaissetia (Saissetia) nigra* Nietn. was recorded on clove from Kallar and Burliar areas in Tamil Nadu especially during March-May (Abraham *et al.*, 1970). The masked scale *Mycetaspis personata* was reported to infest the under surface of older leaves in Trivandrum district. The infested leaves turned yellow and dropped. A spray of monocrotophos (0.05%) controlled the pest infestation (Nair *et al.*, 1978). *Lecanium psidii* was recorded on newly emerged leaves throughout the year in Kerala (Anon., 1981). *Pulvinaria psidii* Mask. (Coccidae) was reported to infest the underside of leaves in Trivandrum district. The infestation could be controlled by spraying monocrotophos (0.05%) (Visalakshi *et al.*, 1981). Field trials conducted later indicated that spraying with dimethoate (0.05 or 0.03%) was the most effective in controlling the pest infestation (Visalakshi and Mohandas, 1986). *Ceroplastes floridensis* Comstock was reported to infest clove seedlings (Fig. 8) in the nursery at Peruvannamuzhi (Kerala). The pest could be controlled by spraying monocrotophos (0.05%) (Vidyasagar *et al.*, 1989).

The other insects recorded on the crop include crickets, leaf feeding caterpillars and termites that damage nursery plants, spittle bugs, *Pauropsylla depressa* C., *Scirtothrips dorsalis* Hood, stem boring beetles, coffee stem borer *Zeuzera coffeae* Nietn. and teak

Fig. 7 : Cinnamon leaves infested with leaf miner.

Fig. 8 : Clove shoot infested with scale insects.

sapling borer *Sahyadrassus malabaricus* (Moore) (Simpson; Kannan, 1972; Nair *et al.*, 1978; Anon., 1981; Nair, 1982; Kumaresan *et al.*, 1988).

Araecerus fasciulatus De Geer was recorded to damage clove seeds in storage (Wadhi *et al.*, 1971).

7. NUTMEG (*MYRISTICA FRAGRANS* HOUTT.)

The black scale *Parasaissetia (Saissetia) nigra* Nietn. was recorded on nutmeg from Kallar and Burliar areas in Tamil Nadu especially during March-May (Abraham *et al.*, 1970). *Lecanium psidii* and mealy bugs were reported to infest tender leaves and shoots (Nair *et al.*, 1977).

Abraham and Remamony (1977) recorded the rice earhead bug *Leptocorisa acuta* (Thumb.) feeding on tender leaves in Ernakulam district. *Pauropsylla depressa* C. was also recorded on nutmeg (Kumaresan *et al.*, 1988).

8. ALLSPICE (*PIMENTA DIOICA* (L.) MERR.)

Infestation by *Helopeltis antonii* Sign. was observed on tender shoots and leaves at Peruvannamuzhi (Calicut district). The pest infestation resulted in drying of tender shoots and formation of necrotic spots on leaves (Devasahayam *et al.*, 1986).

The tender shoots were also damaged by an unidentified tree hopper in Kerala and could be controlled by spraying quinalphos (0.05%) (Anon.,1981).

Table 1 : List of insects recorded on spice crops in India

Insect	Common name	Nature of damage
Black Pepper		
Amrasca devastans (Dist.)	Cotton leaf hopper	Infest foliage
Aleurocanthus piperis Mask.	Pepper white fly	Infest tender shoots and leaves
Toxoptera aurantii (B. de F.)	Black citrus aphid	Infest tender shoots and leaves
Ferrisia virgata Ckll.	Striped mealy bug	Infest tender shoots and berries
Planococcus citri (Risso)	Citrus mealy bug	Infest tender shoots and berries
Marsipococcus marsupiale (Gr.)	Soft scale	Encrust stems, leaves and berries
Aspidiotus destructor Sign.	Coconut scale	Encrust stems, leaves and berries
Chionaspis raricosa Gr.	Hard scale	Encrust stems, leaves and berries
Pinnaspis aspidistrae Sign.	Armoured scale	Encrust stems, leaves and berries
P. marchali Ckll.	Hard scale	Encrust stems, leaves and berries
Hemichionaspis aspidistrae Sign.		Encrust stems, leaves and berries
Lepidosaphes piperis Gr.	Mussel scale	Encrust stems, leaves and berries
Disphinctus maesarum Kirk.		Infest tender shoots and leaves
Helopeltis antonii Sign.	Tea mosquito bug	Infest tender shoots and leaves
Cyclopelta siccifolia Westw.	Stink bug	Infest tender shoots
Liothrips karnyi Bagn.	Leaf gall thrips	Induce marginal galls on leaves
L. pallipes Karny	Leaf gall thrips	Induce marginal galls on leaves
L. chavicae Z.	Leaf gall thrips	Induce marginal galls on leaves
Diboma procera Pasc.		Grubs bore into old stems
Pterolophia annulata Chevr.		Grubs bore into old stems
Hermaeophaga sp.	Flea beetle	Adults feed on old leaves
Lanka sp.	Flea beetle	Adults feed on tender leaves
Longitarsus nigripennis Mots.	'Pollu' beetle	Grubs bore into berries; adults feed on buds, tender shoots, leaves and spikes
Neculla pollinaria B.	Flea beetle	Adults feed on tender leaves
Pagria costatipennis J.	Flea beetle	Adults feed on tender leaves

(Contd.)

Table 1 : *Contd.*

Insect	Common name		Nature of damage
Eugnathus curvus Faust	Pepper weevil		Adults feed on tender leaves
Myllocerus sp.	Ash weevil		Adults feed on foliage
Cecidomyia malabarensis Felt.	Pepper gall midge		Larvae induce galls on tender shoots, leaves and berries
Unidentified cecidomyid			Larvae induce pellet shaped galls on leaves
Unidentified cecidomyid			Larvae induce galls on tender stems
Latoia lepida Cram.	Nettle grub		Larvae defoliate
Thosea sinensis Wlk.	Slug caterpillar		Larvae defoliate
Cydia hemidoxa Meyr.	Top shoot borer		Larvae bore into tender shoots
Cricula trifenestrata Helf.	Wild hairy silkworm		Larvae defoliate
Spodoptera litura F.	Tobacco caterpillar		Larvae feed on leaves
Synegia sp.	Looper caterpillar		Larvae feed on tender leaves and spikes
Ginger and Turmeric			
Pentalonia nigronervosa Coq.	Banana aphid	Ginger	Infest leaves
Mealy bugs (Unidentified)		Ginger, Turmeric	Infest rhizomes
Aspidiella hartii Ckll.	Rhizome scale	Ginger, Turmeric	Encrust rhizomes
A. curcumae Gr.	Hard scale	Turmeric	Encrust rhizomes
Stephanitis typica Dist.	Banana lace bug	Turmeric	Infest leaves
Anaphothrips sudanensis (Trybom)	Leaf thrips	Turmeric	Infest leaves
Asprothrips indicus Bagn.		Turmeric	Infest leaves
Panchaetothrips indicus Bagn.	Turmeric thrips	Turmeric	Infest leaves
Thrips tabaci Lind.	Onion thrips	Ginger	Infest leaves
Holotrichia fissa Brenske	White grub	Ginger	Larvae feed on rhizomes
Root grubs (unidentified)		Turmeric	Larvae feed on rhizomes
Lasioderma serricorne (Fab.)	Cigarette beetle	Ginger, Turmeric	Infest stored rhizomes
Stegobium paniceum L.	Drug store beetle	Ginger	Infest stored rhizomes
Tribolium castaneum (Hbst.)	Red flour beetle	Turmeric	Infest stored rhizomes
Oryzaephilus surinamensis (L.)	Saw toothed grain beetle	Turmeric	Infest stored rhizomes
Epilachna sparsa (Hbst.)		Turmeric	Feed on leaves
Tenebroides mauritanicus (L.)	Cadella	Ginger, Turmeric	Infest stored rhizomes
Ceratobasis nair (Loc.)		Turmeric	Feed on leaves
Colasposoma splendidum (F.)		Turmeric	Feed on leaves
Cryptocephalus rajah Jac.		Turmeric	Feed on leaves

(Contd.)

Table 1 : *Contd.*

Insect	Common name		Nature of damage
Lema lacordairei Baly		Turmeric	Feed on leaves
L. praeusta Fab.		Turmeric	Feed on leaves
L. semiregularis Jac.		Turmeric	Feed on leaves
L. signatipennis Jac.		Turmeric	Feed on leaves
Pseudocophora sp.		Turmeric	Feed on leaves
Araecerus fasciculatus De Geer	Coffee bean weevil	Ginger, Turmeric	Infest stored rhizomes
Heydychorus rufofasciatus M.	Leaf weevil	Ginger	Adults feed on leaves
Myllocerus viridanus Fab.	Ash weevil	Turmeric	Adults feed on leaves
Calobata sp.	Rhizome fly	Ginger, Turmeric	Maggots bore into roots and rhizomes
Mimegralla coeruleifrons Macq.	Rhizome fly	Ginger, Turmeric	Maggots bore into rhizomes
Chalcidomyia atricornis Mall.	Shoot fly	Ginger	Maggots bore into shoots and rhizomes
Formosina flavipes Mall.	Shoot fly	Ginger	Maggots bore into shoots and rhizomes
Celyphus sp.	Rhizome fly	Ginger	Maggots bore into rhizomes
Eumerus albifrons Wlk.	Rhizome fly	Ginger	Maggots bore into rhizomes
E. pulcherrimus Bru.	Rhizome fly	Ginger, Turmeric	Maggots bore into rhizomes
Acrocercops irradians Meyr.	Leaf miner	Ginger	Larvae mine leaves
Setmorpha rutella Zell.		Ginger, Turmeric	Infest stored rhizomes
Conogethes punctiferalis Guen.	Shoot borer	Ginger, Turmeric	Larvae bore into shoots
Ephestia sp.	Grain moth	Ginger, Turmeric	Infest stored rhizomes
Pyralis manihotalis Guen.		Ginger, Turmeric	Infest stored rhizomes
Catopsila pomona F.		Turmeric	Larvae feed on leaves
Udaspes folus Cram.	Leaf roller, Skipper butterfly	Ginger, Turmeric	Larvae feed on leaves
Diacrisia obliqua Wlk.	Bihar hairy caterpillar	Turmeric	Larvae defoliate
Creatonotus gangis (L.)		Turmeric	Larvae defoliate
Bombotelia nugatrix Gr.		Turmeric	Larvae defoliate
Spodoptera litura (F.)	Army worm	Ginger	Larvae defoliate
Cardamom			
Aularches miliaris **L.**	Spotted grasshopper		Feed on leaves
Orthacris sp.	Wingless grasshopper		Feed on leaves
Aphrophora nuwarana Dist.	Spittle bug		Infest leaves

(Contd.)

Table 1 : *Contd.*

Insect	Common name	Nature of damage
Cosmoscarta thoracica Dist.	Banded spittle bug	Infest leaves
Eosocarta nilgiriensis Dist.	Brown spittle bug	Infest leaves
Bothrogonia sp.	Pink leaf hopper	Infest leaves
Tettigoniella ferruginea		Infest leaves
Dialeurodes cardamomi David & Subr.	Cardamom whitefly	Infest leaves
Pentalonia nigronervosa f. *caladii* van der Goot	Cardamom aphid	Suck sap from pseudostems and and leaves; transmit 'katte' disease
Planococcus citri (Risso)	Citrus mealy bug	Infest leaves
Parasaissetia nigra Nietn.	Black scale	Infest leaves
Saissetia nigra (Walk.)	Helmet scale	Infest leaves
S. coffeae Walk.	Helmet scale	Infest leaves
Diaspis sp.		Infest pseudostems and capsules
Mytilaspis sp.		Infest leaves
Ischnodemus vochus Tol.		Infest leaves
Stephanitis typica Dist.	Lacewing bug	Suck sap from leaves
Riptortus pedestris F.		Infest leaves
Leewania maculans Pr. & Sesh.		Damage leaves, inflorescences and capsules
Panchaetothrips indicus Bagn.	Turmeric thrips	Larvae feed on roots and rhizomes
Sciothrips cardamomi (Ramk.)	Cardamom thrips	Larvae feed on roots and rhizomes
Anomala sp.	White grub	Larvae feed on roots and rhizomes
Holotrichia serrata	White grub	Adults bore into flowers and capsules
Mimela xanthorrhina Hope		Adults bore into flowers and capsules
Onthophagus sp.		Infest stored capsules
O. coorgensis		Larvae feed on roots and rhizomes
Tribolium castaneum (Hbst.)	Red flour beetle	Adults and larvae feed on leaves
Basilepta fulvicorne Jacoby	Root grub	Adults and larvae feed on leaves
Lema sp.	Leaf beetle	Adults and larvae feed on leaves
L. admiralis		Adults and larvae feed on leaves
L. coromandeliana		Adults and larvae bore into capsules
L. subirdes		Larvae bore into rhizomes
Thamurgides cardamomi		Larvae bore into roots
Prodioctes haematicus Chevr.	Rhizome weevil	Larvae bore into shoots
Hallomyia cardamomi Nayar	Root gall maggot	Larvae feed on leaves
Formosina flavipes Mall.	Shoot fly	Larvae bore into roots
Acanthopsyche bipar Walk.	Bagworm	
Hilarographa caminodes Meyr.		

(Contd.)

Table 1 : *Contd.*

Insect	Common name	Nature of damage
Homona sp.	Leaf folder	Larvae fold and feed on leaves
Conogethes punctiferalis Guen.	Shoot and capsule borer	Larvae bore into pseudostems, inflorescences and capsules
Polythilepta maoralis Led.	Leaf webber	Larvae web and feed on leaves
Jamides sp.	Capsule borer	Larvae bore into flowers and capsules
J. alecto	Capsule borer	Larvae bore into flowers and capsules
Notocrypta feisthamelii B.	Skipper butterfly	Larvae fold and feed on leaves
Plesioneura alysos M.	Black skipper butterfly	Larvae fold and feed on leaves
Anisodes denticulatus Hamp.	Looper	Larvae feed on leaves
Eumelia rosalia Cram.	Looper	Larvae feed on leaves
Thalassodes sp.	Looper	Larvae feed on leaves
Lenodera vittata Walk.	Hairy caterpillar	Larvae defoliate
Attacus atlas L.	Atlas moth	Larvae defoliate
Alphaea biguttata Walk.	Tiger moth	Larvae defoliate
Pericallia ricini Fab.	Hairy caterpillar	Larvae defoliate
Arcilasisa plagiata	Cutworm	Larvae feed on leaves
Euproctis lutifacia Hamp.	Tiger moth	Larvae defoliate
Eupterote canarica Moore	Hairy caterpillar	Larvae defoliate
E. cardamomi Renga	Hairy caterpillar	Larvae defoliate
E. fabia Cram.	Hairy caterpillar	Larvae defoliate
E. testacea Walk.	Hairy caterpillar	Larvae defoliate
Cinnamon		
Gargara extrema Dist.		Infest leaves
Pauropsylla depressa C.	Jumping bug	Induce galls on leaves
Unidentified		Induce galls on leaves
Bothrogonia sp.	Pink leaf hopper	Infest leaves
Bemisia tabaci Genn.	Tobacco whitefly	Infest tender leaves
Ceroblastes rubens Mask.	Wax scale	Infest leaves
Leucopholis pinguis Burm.	White grub	
Popillia complanata N.	Chafer beetle	Adults feed on leaves
Singhala hellari Ohs.	Leaf beetle	Adults feed on leaves
Apoderus scitulus Walk.	Leaf twisting weevil	Adults damage leaves
Alcides morio Heller	Cinnamon fruit borer	Grubs bore into fruits
Myllocerus subfasciatus Guen.	Grey weevil	Adults feed on leaves
Unidentified		Induce galls on inflorescences
Acrocercops sp.	Leaf miner	Larvae mine leaves
Phyllocnistis chrysopthalma Meyr.	Leaf miner	Larvae mine leaves
P. citrella Staint	Citrus leaf miner	Larvae mine leaves
Zeuzera coffeae Nietn.	Coffee stem borer	Larvae bore into stems
Sorolopha archimedias Meyr.	Shoot and leaf webber	Larvae web tender leaves
Orthaga vitalis Walk.	Leaf webber	Larvae web leaves

(*Contd.*)

Table 1 : *Contd.*

Insect	Common name	Nature of damage
Chilasa clytie L.	Cinnamon butterfly	Larvae defoliate
Graphium doson C. & R.		Larvae feed on leaves
G. saperodon C. & R.	Blue bottle	Larvae feed on leaves
Hypsidera talaca Walk.		Larvae feed on leaves
Sauris sp.		Larvae feed on leaves
Semiothesia sp.		Larvae feed on leaves
Thalassodes sp.	Looper	Larvae feed on leaves
Cricula trifenestrata H.	Wild hairy silkworm	Larvae feed on leaves
Argyrina syringa Cram.		Larvae feed on leaves
Diacrisia obliqua Walk.	Tiger moth	Larvae feed on leaves
Selepa celtis Moore		Larvae feed on leaves
Dasychira mendosa Swinh.	Tusscok moth	Larvae feed on leaves
Euproctis fraterna Moore	Tussock moth	Larvae feed on leaves
Redoa submarginata Walk.		Larvae feed on leaves
Oecophylla smaragdina (F.)	Red tree ant	Cause nuisance
Clove		
Unidentified	Cricket	Damage nursery plants
Unidentified	Termite	Damage roots in nursery and field
Pauropsylla depressa C.	Jumping bug	Infest leaves
Unidentified	Spittle bug	Infest shoots
Ceroplastes floridensis Com.	Wax scale	Infest leaves
Lecanium psidii	Soft scale	Infest leaves
Parasaissetia nigra Nietn.	Black scale	Infest leaves
Pulvinaria psidii Mask.	Green shield scale	Infest leaves
Mycetaspis personata (Com.)	Masked scale	Infest leaves
Scirtothrips dorsalis Hood	Chilli thrips	Infest leaves
Unidentified		Bores into stems and branches
Araecerus fasciculatus De Geer	Coffee bean weevil	Infest stored seeds
Sahyadrassus malabaricus (Moore)	Teak sapling borer	Larvae bore into stem
Zeuzera coffeae Nietn.	Coffee stem borer	Larvae bore into stem
Nutmeg		
Pauropsylla depressa C.	Jumping bug	Infest leaves
Mealy bugs (unidentified)		Infest leaves
Lecanium psidii	Soft scale	Infest leaves
Parasaissetia nigra Nietn.	Black scale	Infest leaves
Leptocorisa acuta (Thumb.)	Rice earhead bug	Infest leaves
Allspice		
Unidentified	Tree hopper	Infest tender leaves
Helopeltis antonii Sign.	Tea mosquito bug	Infest tender leaves

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