Journal of Plantation Crops 16 (1): 1-11 June, 1988

Review Article

INSECT PESTS OF BLACK PEPPER *PIPER NIGRUM* L. IN INDIA*

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ABSTRACT

The information available on distribution, nature and extent of damage, life history, seasonal abundance, natural enemies and control measures of various insect pests infesting black pepper *Piper nigrum* L. in India has been reviewed.

INTRODUCTION

Black pepper, the dried mature berries of *Piper nigrum* L. (Piperaceae), a perennial climbing vine is of considerable economic importance earning more than 242 crore rupees annually in foreign exchange. India is a leading producer of black pepper in the world and the crop is grown in about 1,06,700 ha (mainly in Kerala) with a production of about 40, 000 t (Anonymous, 1987). However, the productivity of the crop is very low, the national average being about 375 kg per ha. Among the various factors responsible for the low productivity, infestation by insect pests has been identified as a major one. Thirty four species of insects have been reported to infest the crop in India. In view of their considerable importance, the information available on these pests has been consolidated in this review. Earlier attempts to review the information available on insect pests of black pepper are that of Pillai (1978) and Butani (1983) who had included 17 and 15 insect pests on the crop, respectively.

The various insects recorded on black pepper in India and their nature of damage are listed in Table I. Among the 34 species of insects recorded on the crop, four of them *viz.*, 'pollu' beetle, top shoot borer, leaf gall thrips and scale insects are of importance.

MAJOR PESTS

Longitarsus nigripennis Mots.

(Chrysomelidae : Coleoptera)

The 'pollu' beetle is the most destructive pest of black pepper in India. 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

* *Contribution No. 91 of National Research Centre for Spices, Calicut 673 012, Kerala*

Table I. *List of insects record*

Insect	Common name	Nature of damage
ORDER: HEMIPTERA		
FAMILY: CICADELLIDAE		
Amrasca devastans (Dist.)	Cotton leaf hopper	Infest foliage
FAMILY: ALEYRODIDAE		
Aleurocanthus piperis Mask.	Pepper white fly	Infest tender shoots and leaves
FAMILY: APHIDIDAE		
Toxoptera aurantii (B. de F.)	Black citrus aphid	Infest tender shoots and leaves
FAMILY: PSEUDOCOCCIDAE		
Ferrisia virgata Ckll.	Striped mealy bug	Infest tender shoots and berries
Planococcus citri (Risso)	Citrus mealy bug	Infest tender shoots and berries
FAMILY: COCCIDAE		
Marsipococcus marsupiale (Gr.)	Soft scale	Encrust stems, leaves and berries
FAMILY: DIASPIDIDAE		
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
FAMILY: MIRIDAE		
Disphinctus maesarum Kirk.		Infest tender shoots and leaves
Helopeltis antonii Sign.	Tea mosquito bug	Infest tender shoots and leaves
FAMILY: PENTATOMIDAE		
Cyclopelta siccifolia Westw.	Stink bug	Infest tender shoots and leaves
ORDER: THYSANOPTERA		
FAMILY: PHLAEOTHRIPIDAE		
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
ORDER: COLEOPTERA		
FAMILY: CERAMBYCIDAE		
Diboma procera Pasc.		Grubs bore into old stems
Pterolophia annulata Chevr.		Grubs bore into old stems

n black pepper in India

Insect	Common name	Nature of damage
FAMILY: CHRYSOMELIDAE		
Hermaeophaga sp.	Flea beetle	Adults damage old leaves
Lanka sp.	Flea beetle	Adults damage tender leaves
Longitarsus nigripennis Mots.	'Pollu' beetle	Grubs bore into berries; adults damage leaves and spikes
Neculla pollinaria B.	Flea beetle	Adults damage tender leaves
Pagria costatipennis J.	Flea beetle	Adults damage tender leaves
FAMILY: CURCULIONIDAE		
Eugnathus curvus Faust	Pepper weevil	Adults damage tender leaves
Myllocerus sp.	Ash weevil	Adults damage foliage
ORDER: DIPTERA		
FAMILY: CECIDOMYIDAE		
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 rinden galls on stems
ORDER: LEPIDOPTERA		
FAMILY: LIMACODIDAE		
Latoia lepida Cram.	Nettle grub	Larvae defoliate
Thosea sinensis Wlk.	Slug caterpillar	Larvae defoliate
FAMILY: TORTRICIDAE		
Cydia hemidoxa Meyr.	Top shoot borer	Larvae bore into tender shoots
FAMILY: SATURNIDAE		
Cricula trifenestrata Helf.	Wild hairy silk worm	Larvae defoliate
FAMILY: NOCTUIDAE		
Spodoptera litura F.	Tobacco caterpillar	Larvae damage leaves
FAMILY: GEOMETRIDAE		
Synegia sp.	Looper caterpillar	Larvae damage tender leaves and spikes

Kerala (Anonymous, 1954). Abraham (1959) reported that the loss from 'pollu' ranged from 6–21 per cent. Rehiman and Nambiar (1967) reported that 30–40 per cent of the yield was lost due to the 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 have been conducted by Ayyar (1920), Ayyar, Muliyil and Susainathan (1921), Rao and Ramaswamiah (1927) and Premkumar (1980). The adult beetles have been described by Maulik (1926). Recently, Vidyasagar, Devasahayam and Koya (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 the tender berries which hatch into creamy-white grubs in 5–8 days. The grubs bore into the berries and feed on the internal contents making them hollow. The infested berry turns yellow and finally black and easily crumbles 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 pericd lasts for 6–7 days. There are four or five generations in an year. The adults feed on tender shoots, leaves and spikes by scraping the tissues. During the period 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' beetles conducted at Calicut and Kottayam districts in Kerala indicated that the pest population was high during July to January at Calicut. At Kottayam, the pest population was high during May to 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 predacious 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 indicated 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

nd Kalluvally Type–II, the least. Similar esults have also been reported by remkumar (1980).

Evaluation of insecticides for he control of 'pollu' beetle has drawn he attention of various workers. Nambiar and Kurien (1962) and Rehiman nd 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, monocrotophos, 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. Multilocational 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 (1987 a) 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) have reported that three rounds of spraying of endosulfan 0.05% during May, July and September was the most effective treatment. Balakrishnan, Premkumar and Devasahayam (1984) have worked out the economic viability of spraying endosulfan, quinalphos and methyl parathion in the control of the pest taking into consideration the cost of spraying, the levels of pest infestation and the yield potential of the vines.

Cydia hemidoxa Meyr.

(Tortricidae : Lepidoptera)

The top shoot borer 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 the top shoot borer has been studied by Visalakshi and Joseph (1965). The adults have been described by Meyrick (1931). Adults are small with a wing 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 the drying up of the same. Repeated infestations of new shoots affect the growth of the vine. Fully grown larvae are greyish-green and measure 12–14mm 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). We have observed a mermithid nematode (unidentified) parasitising the larvae of the pest at Peruvannamuzhi (Calicut district). No alternate host of the pest has been recorded.

Very few field trials have been conducted for the control of top shoot borer. Banerjee, Premkumar and Koya (1981) conducted field trials with nine insecticides and found that endosulfan 0.05% was the most effective in controlling the pest infestation. 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.

Liothrips karnyi Bagn.

(Phlaeothripidae : Thysanoptera)

Leaf gall thrips infest leaves of black pepper and induce the formation of tubular marginal leaf galls within which they live. The pest infestation is generally serious at higher altitudes and also in the nurseries in the plains. Visalakshi and Joseph (1967) considered the leaf gall thrips as a persistent pest occurring throughout Kerala. Banerjee et al. (1981) reported that the leaf gall thrips were the most important pest of black pepper in South Wynad area in Kerala.

The adults of leaf gall thrips have been described by Ananthakrishnan (1960). Visalakshi and Joseph (1967) have studied the nature of damage and life history of the pest. Raman and Ananthakrishnan (1983) have 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, 4–7, 2, 2–3 and 2–3 days, respectively.

Montandoniola moraguesi Puton (Anthocoridae) and *Androthrips flavipes* Schmutz (Phlaeothripidae) have been recorded as predators of leaf gall thrips (Ananthakrishnan, 1978). Visalakshi and Joseph (1967) have reported that an unidentified species of anthocorid and a mite predate on the juvenile stages of the pest.

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 day intervals. Recent studies on the residual toxicity of nine insecticides against the pest indicated that residual toxicity was

aximum in monocrotophos 0.05% levasahayam, 1987).

ale insects (Hemiptera)

Scale insects sometimes cause severe image to black pepper vines in certain eas especially at higher altitudes. The festation is seen in the form of encrustions on the stems, leaves and berries id generally becomes more severe iring the summer months. Scale sects suck the plant sap resulting in llowing and withering of the infested oots and in severe cases the vines dry). The pest infestation is sometimes ry severe in the nursery especially in der cuttings. Among the various ecies recorded on the crop, *Lepidosaphes Aytilaspis) piperis* Gr. and *Marsipococcus ecanium) marsupiale* (Gr.) are important; these were first recorded by froy (1909) and Fletcher (1914), spectively. The former is elongated id dark brown and the latter oval and ile brown. No field trials have been nducted for the control of scale insects.

MINOR PESTS

ip feeders

Gautam (1980) reported the occurrice of *Toxoptera aurantii* (B. de F.) on ack pepper at Sultan's Battery (Wynad istrict) and Koothali (Calicut district) eas. The aphid colonies were found n the ventral surface of the leaves which hibited yellowing symptoms.

Colonies of mealy bugs are somemes seen on tender shoots and berries. he species recorded on black pepper clude *Ferrisia (Pseudococcus) virgata* Ckll. Rao, 1926) and *Planococcus citri* (Risso) Nayar, Ananthakrishnan and David, 976).

Apart from the scale insects mentioned earlier, *Hemichionaspis aspidistrae* Sign. (Ayyar, 1919), *Pinnaspis aspidistrae* Sign. (Rao, 1926), *Aspidiotus destructor* Sign. (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, Koya and Premkumar (1986) reported the occurrence of *Helopelits 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 devastans* (Dist.), *Disphinctus maesarum* Kirk. (Hill, 1983), *Cyclopelta siccifolia* Westw. (Nayar et al., 1976) and *Aleurocanthus piperis* Mask. (Nair, 1975).

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. About 53 per cent of the leaves were found to be damaged in a sample of 50 vines, during May 1979.

Premkumar and Devasahayam (unpublished) have 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).

Leaf feeding beetles and weevils

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

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

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, Pillai and Nambiar (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.

Gall thrips

Apart from *L.karnyi*,two other species of *Liothrips* have also been 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.

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. has been observed to parasitise the maggots. Mani (1973) reported the occurrence of two unidentified species of cecidomyids causing hypophyllous globose solitary pellet-shaped galls on the leaf and minute irregular rinden galls on the stem.

REFERENCES

ABRAHAM, P. 1959. *Pepper Cultivation in India.* Farm Bulletin No. 55. Farm Information Unit, Directorate of Extension, Ministry of Food and Agriculture, Government of India, New Delhi. pp. 75–77.

ANANTHAKRISHNAN, T. N. 1960. Thysanoptera from the Nilgiri and Kodaikanal hills (South India). *J. Bombay Nat. Hist. Soc.* 57 : 557–578.

ANANTHAKRISHNAN, T. N. 1978. *Thrip Galls and Gall Thrips.* Technical Monograph No. 1. Zoological Survey of India. 69 pp.

ANONYMOUS. 1954. *Annual Report (1949–1953).* Scheme for scientific aid to pepper industry in South India. Directorate of Agriculture, Madras.

ANONYMOUS. 1987. *Pepper Statistical Year Book 1986.* International Pepper Community, Jakarta, Indonesia. 224 pp.

AYYAR, T. V. R. 1919. Some South Indian coccids of economic importance. *J. Bombay Nat. Hist. Soc.* 26 : 621–628.

AYYAR, T. V. R. 1920. Notes on the life history o the 'pollu' flea beetle (*Longitarsus nigripennis* Mots.) of pepper. *Rept. Proc. 3rd Ent. Meeting, Pusa.* 3 : 925–928.

AYYAR, T. V. R. 1940. *Hand Book of Economic Entomology for South India.* Government Press, Madras. 528 pp.

AYYAR, T. V. R., MULIYIL, J. A. and SUSAINATHAN, P. 1921. A preliminary investigation of the 'pollu' disease of pepper in North Malabar in 1918. *Madras Agricultural Year Book.* pp. 18–31.

BALAKRISHNAN, R., PREMKUMAR, T. and DEVASAHAYAM, S. 1984. The economic viability of three insecticides in the control of 'pollu' beetle (*Longitarsus nigripennis* Mots.) in black pepper. *J. Plant. Crops.* 12 : 164–168.

BANERJEE, S. K., KOYA, K. M. A., PREMKUMAR, T. and GAUTAM, S. S. S. 1981. Incidence of marginal gall forming thrips on pepper in South Wynad *J. Plant. Crops.* 9 : 127–128.

BANERJEE, S. K., PREMKUMAR, T. and ABDULLA KOYA, K. M. 1981. Preliminary evaluation of some insecticides against 'pollu' beetle and top shoot borer of black pepper. In *Abstracts, National Seminar on Strategies of Pest Management.* 21–23 December 1981, New Delhi. p. 32.

BUTANI, D. K. 1983. Spices and pest problems. 3–Pepper. *Pesticides.* 17 (8) : 39–42.

DEVASAHAYAM, S. 1987. Residual toxicity of certain insecticides to gall thrips *(Liothrips karnyi* Bagnall) on black pepper. *Abstract of Papers, National Symposium on Integrated Pest Control – Progress and Perspectives.* 15–17 October 1987, Trivandrum. p. 44.

DEVASAHAYAM, S., ABDULLA KOYA, K. M. and PREMKUMAR, T. 1986. Infestation of tea mosquito bug *Helopeltis antonii* Signoret (Heteroptera : Miridae) on black pepper and allspice in Kerala. *Entomon.* 11 : 239–241.

DUBEY, O. P., PILLAI, G. B. and NAMBIAR, P. K. V. 1976. Record of *Pterolophia annulata* Chevr. and *Diboma procera* Pasc. (Lamiinae : Cerambycidae : Coleoptera) as new pests of pepper (*Piper nigrum* L.) from India. *Curr. Sci.* 45 : 670–671.

FLETCHER, T. B. 1914. *Some South Indian Insects and other Animals of Importance considered especially from an Economic Point of View.* Government Press, Madras. 565 pp.

GAUTAM, S. S. S. 1980. *Spodoptera litura* Fabr. and *Toxoptera aurantii* (B. de F.) – two new pests of black pepper. *Indian J. Ent.* 42: 330.

HILL, D. S. 1983. *Agricultural Insect Pests of the Tropics and their Control.* Cambridge University Press, Cambridge. 746 pp.

LEFROY, H. M. 1909. *Indian Insect Life–A Manual of the Insects of the Plains (Tropical India).* Agricultural Research Institute, Pusa. 786 pp.

MANI, M. S. 1973. *Plant Galls of India.* Macmillan India. 354 pp.

MAULIK, S. 1926. *The Fauna of British India including Ceylon and Burma. Coleoptera : Chrysomelidae (Chrysomelinae and Halticinae).* Taylor and Francis, London. pp. 338–340.

MEYRICK, E. 1931. *Exotic Microlepidoptera. IV, pt. 6.* pp.161–192. Marlborough, Wilts.

NAIR, M. R. G. K. 1975. *Insects and Mites of Crops in India.* Indian Council of Agricultural Research, New Delhi. 404 pp.

NAIR, M. R. G. K. and CHRISTUDAS, S. P. 1976. On the control *Liothrips karnyi* Bagnall pepper leaf gall thrips. *Agric. Res. J. Kerala.* **14**: 173–174.

NAMBIAR, P. K. V. and KURIEN, K.C. 1962. Pepper and its 'pollu' beetles. *Indian Fmg.* **12** (4) : 17.

NANDAKUMAR, C., RAGHUNATH, P., VISALAKSHI, A. and MOHANDAS, N. 1987. Management of pollu beetle on pepper by adjusting the spray schedules. *Abstract of Papers, National Symposium on Integrated Pest Control – Progress and Perspectives,* 15–17 October 1987, Trivandrum. p. 50.

NAYAR, K. K., ANANTHAKRISHNAN, T. N. and DAVID, B. V. 1976. *General and Applied Entomology.* Tata McGraw-Hill Publishing Company Limited, New Delhi. 589 pp.

PILLAI, G. B. 1978. Pests of pepper. pp.15–17. In *Proceedings, National Seminar on Pepper.* eds. NAIR, M. K. and HARIDASAN, M. Central Plantation Crops Research Institute, Kasaragod.

PILLAI, G. B. and ABRAHAM, V. A. 1974. Chemical control of black pepper 'pollu' beetle, *Longitarsus nigripennis* Mots. (Coleoptera : Chrysomelidae). *J. Plant. Crops.* **2** : 34–36.

PILLAI, G. B. and ABRAHAM, V. A. 1979. Intensity of 'pollu' beetle, *Longitarsus nigripennis* Mots. (Coleoptera : Chrysomelidae) infestation in different cultivars of black pepper *Piper nigrum* L. pp. 289–293. In *Proc. PLACROSYM–II.* ed. Venkataram, C. S. PLACROSYM Standing Committee.

PREMKUMAR, T. 1980. Ecology and control of pepper pollu beetle *Longitarsus nigripennis* Motschulsky (Chrysomelidae : Coleoptera). *Ph. D. Thesis.* Submitted to Kerala Agricultural University, Vellayani. 160 pp.

PREMKUMAR, T., BANERJEE, S. K., DEVASAHAYAM, S. and ABDULLA KOYA, K. M. 1986. Effect of different insecticides on the control of 'pollu' beetle *Longitarsus nigripennis* Mots., a major pest of black pepper *Piper nigrum* L.. *Entomon.* **11** : 219–221.

PREMKUMAR, T. and NAIR, M. R. G. K. 1985. Seasonal fluctuation of population and habits of adults of *Longitarsus nigripennis* Mots. on black pepper. *J. Plant. Crops.* **13** : 138–141.

PREMKUMAR, T. and NAIR, M. R. G. K. 1986. Insecticidal control of adults of *Longitarsus nigripennis* Mots. infesting black pepper. *Indian Cocoa, Arecanut & Spices J.* **10** : 1–3.

PREMKUMAR, T. and NAIR, M. R. G. K. 1987 a. Reduction of damage *Longitarsus nigripennis* to berries of black pepper by insecticides. *Madras Agric. J.* **74** : 326–327.

PREMKUMAR, T. and NAIR, M. R. G. K. 1987 b. New record of two flea beetles infesting black pepper *Piper nigrum* L. leaves. *Curr. Sci.* **56** : 271.

RAMAN, A. and ANANTHAKRISHNAN, T. N. 1983. Studies on some thrips (Thysanoptera : Insecta) induced galls – Developmental morphology. *Proc. Indian Nat. Sci. Acad.* B **49** : 313–358.

RAO, Y. R. 1925. A new pest of pepper. *Madras Agric. Dept. Year Book, 1924.* pp. 21–23.

RAO, Y. R. 1926. The 'pollu' disease of pepper. *J. Madras Agric. Stud. Un.* **14** (1) : 5.

RAO, Y. R. 1928. Administrative report of the government entomologist, Coimbatore for 1927–28. 30 pp.

RAO, Y. R. and RAMASWAMIAH, A. G. 1927. Notes on the life history of *Longitarsus nigripennis* – the 'pollu' flea beetle of

pepper. *Year Book Dept. Agric. Madras, 1926*. pp. 51–64.

HIMAN, P. V. A. and NAMBIAR, P. K. V. 1967. Insecticidal trial on the control of pollu beetle *(Longitarsus nigripennis* M.) on pepper. *Madras Agric. J.* **54**: 39–40.

DYASAGAR, P. S. P. V., DEVASAHAYAM, S. and ABDULLA KOYA, K. M. 1988. Sexing live adults of the 'pollu' beetle *Longitarsus nigripennis* Mots. (Chrysomelidae : Coleoptera). *Curr. Sci.* **57**: 869.

SALAKSHI, A. and JO.EPH, K. V. 1965. The biology of the pepper top shoot borer *Laspeyresia hemidoxa* Meyr. (Eucosmidae : Lepidoptera). *Agric. Res. J. Kerala.* **3** (1) : 48–50.

VISALAKSHI, A. and JOSEPH, K. V. 1967. Biology of *Gynaikothrips karnyi* Bagnall the marginal gall forming thrips of pepper. *Agric. Res. J. Kerala.* **5** (1–2) : 79–81.

VIVEKANANDAN, P., REGUPATHY, A., HABEEBULLAH, B., BALASUBRAMANIAN, M. and IRULAPPAN, I. 1981. Dissipation of insecticides in black pepper applied to control leaf gall thrips *Liothrips karnyi* Bagnall. *Indian Spices.* **18** (2–4) : 25, 27–29.