NATURE AND EXTENT OF DAMAGE CAUSED BY INSECT PESTS ON STORED PEPPER CARDAMOM, GINGER AND TURMERIC

BY

JIJY JOSEPH

THESIS
submitted in partial fulfilment of
the requirement for the Degree
MASTER OF SCIENCE IN AGRICULTURE
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1992

DECLARATION

I hereby declare that this thesis, entitled **'NATURE AND EXTENT OF DAMAGE CAUSED BY INSECT PESTS ON STORED PEPPER, CARDAMOM, GINGER AND TURMERIC'** , is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Jijy Joseph

(JIJY JOSEPH)

Vellayani

22 - 9 - 1992

CERTIFICATE

Certified that this thesis, entitled **'NATURE AND EXTENT OF DAMAGE CAUSED BY INSECT PESTS ON STORED PEPPER, CARDAMOM, GINGER AND TURMERIC'** is a record of research work done independently by Smt. Jijy Joseph, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

T. Nalinakumari

Associate Professor of Agrl. Entomology
Chairperson,
Advisory Committee

Vellayani
22-9-1992

APPROVED BY :

CHAIRPERSON :

DR.(Mrs.) T. NALINAKUMARI

MEMBERS :

1. DR. K.V. MAMMEN

2. DR. (Mrs.) A. VISALAKSHY

3. DR. S. BALAKRISHNAN

External Examiner P.C Sundara Babu 24/4/92

Dedicated to

The Eternal Power guiding me

ACKNOWLEDGEMENTS

A millennium of thanks flows towards DR.(Mrs.) T.Nalinakumari, Associate Professor of Agricultural Entomology who offered a zealous hand of perfect guidance and sincere help coupled with creative suggestions throughout, which turned this humble endeavour a blooming reality.

My thanks are also due to DR. K.V.Mammen, Professor and Head, Department of Agricultural Entomology and DR.S.Balakrishnan, Professor of Plant Pathology for their sincere and timely help with positive criticisms during the study.

For me it is a pleasure to keep in mind the affectionate help and constant encouragement rendered by DR. (Mrs.) A.Visalakshi, Professor of Agricultural Entomology as the advisory committee member in these two years.

Even within the busy schedule DR. (Mrs.) P.Saraswathy, Professor of Agricultural Statistics kept apart her valuable time for me in the design of the experiments and statistical analysis. I am very much indebted to her for that. My sincere thanks are also due to Sri. Ajith Kumar, programmer for his generous help in the statistical analysis of the data.

I am thankful to the staff members, senior and junior students of Department of Agricultural Entomology for their

encouragement during these two years. I pleasantly recall the affectionate help of Smt. Hebsy Bai during the course of the study- yes, it's a joy to remember.

I herewith take the opportunity to express my gratitude to DR.N.Saifudeen, Associate Professor, Department of Agricultural Chemistry and Soil Science, who helped me in taking the photographs needed.

My sincere thanks are also due to DR.Sivadasan and Smt.Padmaja and others of Quality control, Evaluation and Upgradation Lab, Spices Board, Kochi.

I am also much indebted to the Dean, College of Agriculture for providing the facilities to conduct the work.

Words actually know no bounds to blaze my mounting feelings towards my friends, Saiju, Jomol, Asha, Deepa and Sindhu (Vava) for they filled me with inspiration alongwith sharing all my pleasures and pains throughout these two years.

Above all, I feel that the debt to my Dadda, Amma, sisters, Mini and Jancy and brother Jerry can never be repaid. The feelings towards them cast beyond expression.

(JIJY JOSEPH)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

The aroma and flavour of spices attracted traders in ancient days from the far corners of the world to the **'land of spices'**, India. Blessed with varied agro-climatic conditions, almost every state grows one spice or the other. Two million hectares of our land are under spices with an annual output of 1.8 million tonnes. The bulk of this produce is consumed within the country and only one lakh tonnes are exported earning foreign exchange to the tune of Rs.275 to 300 crores (Velappan, 1991).

The world demand of spices by 2000 A.D. has been estimated to be four million tonnes per annum (Edison and Johny, 1991). In the last two decades, a sharp decline has been experienced in India's share in the world market. Among the major constraints leading to this decline, pest damage under storage and poor quality of exported produce play a key role. According to American Spice Trade Assocition cleanliness specifications, tolerance limit for the presence of insects by count is three per pound in stored ginger and four per pound in stored turmeric, cardamom and pepper (Purseglove, 1981). Moreover, the importing countries have quarantine regulations to prevent the infestation of known and unknown insect pests. Often, the spices exported from India are contaminated with dead and live insects, their excreta, rodent excreta, moulds and other extraneous matter.

There is an urgent need for a 'market driven approach' to

improve export of Indian spices and regain the eminent position, the nation held in the forties in the world market. The post-harvest operations like packaging and storaging have to be toned up for quality assurance.

In view of this quality consciousness, efforts have been made else where in our country to assess the magnitude and intensity of pest problems in stored pepper, cardamom, ginger and turmeric. No such detailed studies have been done in Kerala. The present studies were hence taken up with a view to assess

(1) the occurrence and distribution of insect pests infesting stored ginger, turmeric, pepper and cardamom in five districts of Kerala

(2) the nature and extent of damage caused by the major pests infesting stored ginger, turmeric, pepper and cardamom and

(3) the development of major insect pests in stored ginger,turmeric, pepper and cardamom.

REVIEW OF LITERATURE

1. REVIEW OF LITERATURE

A number of insect pests infesting stored ginger, turmeric, pepper and cardamom have been reported by various workers.

1.1 The cigarette beetle, Lasioderma serricorne Fab.

Order: Coleoptera Family:Anobiidae

1.1.1 Distribution of the pest

1.1.1.1 Ginger

L. serricorne was noted as a pest of ginger from Sierra Leone (Hargreaves, 1926), London (Richards and Herford, 1930), Ceylon (Jepson, 1935), Japan (Shibuya and Yamada, 1935), India (Rao and Rao, 1954; Srivastava and Saxena, 1975; Abraham, 1975; Govindarajan, 1982; Jacob, 1986; Sivadasan, 1991 and Jacob, 1992) and from Bangladesh (Rezaur et al., 1982).

1.1.1.2 Turmeric

The incidence of L. serricorne as a pest of turmeric was reported from India (Anonymous, 1970; Gahukar, 1972;

Srivastava and Saxena, 1975; Srinath and Prasad, 1975; Abraham, 1975; Kavadia et al., 1978; Agrawal et al.,1981; Jacob, 1986; Desai et al., 1987; Patil et al., 1988; Sudhakar and Rao, 1989 and Jacob, 1992) and from Bangladesh (Rezaur et al., 1982).

1.1.1.3 Pepper

L. serricorne was observed as a pest of pepper from South East Asia (White, 1957) and India (Muthu and Majumder, 1974).

1.1.1.4 Other hosts

L. serricorne was noted as a destructive pest of tobacco in USA (Runner, 1919), Bulgaria (Popov, 1960), Turkey (Kismali and Goktay, 1988) and in Taiwan (Chin and Lin, 1990).

It was also observed as a pest of cocoa beans in Nigeria (Cotterel, 1952), Ghana (Forsyth, 1957), Brazil (Ghosh and Silva, 1972) and in Belgium (Janssens and Clercq, 1990).

L. serricorne was reported to infest spices and condiments like nutmeg in London (Richards and Herford, 1930), cumin in Cyperus (Morris, 1938), coriander in Fiji (Lever 1941), Bangladesh (Razaur et al., 1982) and Pakistan (Khan and Naqvi, 1984), garlic bulbs in Egypt (Nasr, 1974), chillies (Rezaur et al., 1982) and in stored drug likeCentella asiatica (Malek et al., 1988) in Bangladesh.

In India, the incidence of L. serricorne was reported from Delhi in striga seeds (Rao and Prasad, 1956), Calcutta in castor beans (Hussain and Khan, 1966), Jammu in Acorus calamus and Colchicum luteum (Srivastava and Saxena, 1975), Uttar Pradesh in soybean and soybean meal (Bhattacharya et al., 1977), Gujarat in seeds of Plantago ovata (Patel and Makadia, 1981), Tamil Nadu and Maharashtra in coriander (Bhutani, 1984) and from Andhra Pradesh in cashew kernels (Singh, 1988) and in Carum copticum (Padmavathamma and Rao, 1989).

L. serricorne was observed in tapioca chips (Joseph and Oommen, 1963., Pillai and Rajamma, 1987; Ramlabeevi, 1988 and Jacob, 1992), cashew kernels (Oommen et al., 1985) and copra (Nalinakumari, 1989) in Kerala.

1.1.2 Biology

The fecundity of L. serricorne had been reported as 60 eggs per female on tobacco (Kurup and Parkhe, 1961), 12.8 on cotton seed, 82.9 on cotton seed meal and 32 on ginger (Ali et al., 1972), 18 on tobacco powder and 28 on an artifical diet containing wheat flour, maize flour and yeast (Farag and Ismail, 1985) and 23.8 on tobacco and 86.1 on maize meal with yeast (Burcea, 1986).

The incubation period of the eggs of L. serricorne as reported by different authors showed considerable variations. This ranged from 8 to 12 days on tobacco (Popov, 1960), 4 to 7 days on bari, a pulse based processed food (Joshi and Srivastava, 1964), 6 to 7 days on stored spices (Mehta and Varma, 1968), 9 to 14 days on spices (Abraham, 1975), 4 to 5 days on black mushroom (Srinath and Prasad, 1980), 10 to 19 days on wheat flour with yeast (Samuel et al., 1984), 6 to 8 days on cashew kernels (Oommen et al., 1985), 7.1 to 7.9 days on tobacco (Kismali and Goktay, 1988) and 6 to 7 days on medicinal plant, Carum copticum (Padmavathamma and Rao, 1989).

The larval duration of L. serricorne had been recorded as 32 to 46 days on tobacco (Popov, 1960), 20 to 38 days on bari (Joshi and Srivastava, 1964), 17 to 29 days on stored spices (Mehta and Varma, 1968 and Abraham, 1975), 24 to 30 days on black mushroom (Srinath and Prasad, 1980), 10 to 18 days on a mixture of wheat flour and yeast (Samuel et al., 1984), 26 to 44 days on cashew kernels (Oommen et al., 1985), 50 to 52 days on tobacco (Kismali and Goktay, 1988) and 32 to 34 days on Carum copticum (Padmavathamma and Rao, 1989).

The pupal period of L. serricorne ranged from 5 to 12 days on both tobacco (Popov, 1960) and bari (Joshi and Srivastava, 1964), 4 to 8 days on spices (Abraham, 1975), 5 to 7 days on black mushroom (Srinath and Prasad, 1980), 4 to 12 days on wheat flour with yeast (Samuel et al., 1984), 7 days on cashew kernels (Oommen et al., 1985), 6.1 days on tobacco (Kismali and Goktay, 1988) and 9 to 10 days on Carum copticum (Padmavathamma and Rao, 1989).

The longevity of adult insect was observed as an average of 8.1 days on black mushroom (Srinath and Prasad, 1980), 16 to 19 days on a mixture of wheat flour and yeast (Samuel et al., 1984) and 12 to 18 days on Centella asiatica (Malek et al., 1988).

The life cycle of L. serricorne was completed in 41 to 58 days on tobacco under normal storage conditons and in 218 days in cold storage at 66 to 69°F (Kurup and Parkhe, 1961), 50.1 days on cumin and 77 days on ginger at 30°C and 70 to 75 per cent relative humidity (Ali et al., 1972), 54.5 days at 80°F and 42.5 days at 100°F on stored tobacco (Mannan and Alam, 1981), 57 days on bread crumbs at 30°C and 70 percent relative humidity (Niiho, 1984), 159.4 days on Capsicum annuum at 24°C (Burcea, 1986) and in 7 to 8 weeks on dried Centella asiatica at 31 to 32°C and 75 per cent relative humidity (Malek et al., 1988.)

1.1.3 Nature of damage

Joseph and Oommen (1963) observed that the grubs and adults of L. serricorne bored into parboiled tapioca chips and reduced it to mere powder. The beetle attacked bari, a pulse based processed food and the capsules were hollowed out due to the feeding of the larvae and converted into powdery mass (Joshi and Srivastava, 1964). The grubs of the beetle bored into the rhizomes of ginger and turmeric, tunnelled in all directions and riddled them badly as reported by Abraham

(1975). Srinath and Prasad (1975) observed that the infested turmeric rhizomes were light in weight with characteristic adult emergence holes and filled with powdery material and frass. The beetle damaged all parts of stored black mushroom and converted them into powdery mass as reported by Srinath and Prasad (1980). Agrawal et al. (1981) observed reduction in both the quantity and quality of turmeric due to the infestation by L. serricorne. The adults and grubs of the beetle attacked cashew kernel pieces (Oommen et al., 1985) and bored into pieces of copra through the testa and fed by making galleries (Nalinakumari, 1989).

1.1.4 Extent of damage

Stamatinis (1935) recorded five per cent loss of tobacco in a year in Greece due to the infestation by L. serricorne. Golding (1941) estimated that 5.8 per cent of the cocoa beans were attacked by the pest in Nigeria. According to Joshi and Srivastava (1964) 60 to 100 per cent of bari showed infestation by the beetle and the infested stock emitted foul smell under humid conditions. In an all India survey conducted by Srinath and Prasad (1975), 43.6 per cent of the turmeric samples analysed showed infestation by L. serricorne. A market survey in Rajasthan revealed that 67.74 per cent of the turmeric samples were infested by the beetle

and caused 39.78 per cent weight loss (Kavadia et al., 1978). The total weight loss in turmeric due to the infestation by the pest was 8.85 per cent in a period of seven months as reported by Agrawal et al. (1981). Sudhakar and Rao (1989) recorded 80.0 per cent damage in turmeric when stored in bamboo baskets in open varandah and 28.5 to 40.0 per cent when stored in jute gunny bags.

1.2 The coffee bean weevil, Araecerus fasciculatus De Geer.

Order: Coleoptera Family: Anthribidae

1.2.1 Distribution of the pest

1.2.1.1Ginger

A. fasciculatus was reported as a pest of ginger from India (Reghunath and Nair, 1970; Abraham, 1975; Govindarajan, 1982; Jacob, 1986; Sivadasan, 1991 and Jacob, 1992).

1.2.1.2Turmeric

Srinath and Prasad (1975) and Abraham (1975) identified A. fasciculatus as a pest of turmeric in India.

1.2.1.3 Other hosts

The beetle was observed to attack cassava chips in West Indies (Ballou, 1919), Tanzania (Mphuru, 1974), Nigeria (Nwana, 1978) and in Indonesia (Mangoendihardjo, 1983).

It was reported to infest cocoa beans in London (Munro and Thompson, 1929), Ghana (Forsyth, 1957), Brazil (Ghosh and Silva, 1972), and in Belgium (Janssens and Clercq, 1990).

A. fasciculatus was recorded as a pest of coffee beans in Japan (Miwa, 1937), Venezuella (Iragorry, 1940), Columbia (Concha, 1956), Brazil (Guerra and Santos, 1977) and in Haiti (Soux, 1985).

The insect was observed to attack other materials such as nutmeg in London (Munro and Thompson, 1929), cereals in Nigeria (Cotterel, 1934), soybean in Ceylon (Hutson, 1939), maize, sweet potato and Ligusticum acutilobum in Taiwan (Lin, 1976), garlic bulbs in Japan (Nagano, 1979) and Yams in Nigeria (Nwana and Azodeh, 1984 and Iheagwam, 1986).

The incidence of A.fasciculatus was reported in cassava chips (Joseph and Oommen, 1963; Reghunath and Nair, 1970; Thampan, 1979; Pillai and Rajamma, 1987;

Ramlabeevi, 1988 and Jacob, 1992), maize and blackgram (Reghunath and Nair, 1970), tubers of Dioscorea alata and Amorphophallus companulatus (Lal and Pillai, 1977), cashew kernels (Oommen et al., 1985), copra (Nalinakumari, 1989) and coffee, cured arecanuts, cocoa beans, nutmeg seeds, maize and groundnut (Jacob, 1992) from Kerala.

1.2.2 Biology

The fecundity of A.fasciculatus had been reported as 52 eggs per female on a compound containing ground green coffee and chocolate (Concha, 1956), 10.8 on blackgram, 17.7 on ginger and 36.0 on maize (Reghunath, 1969) and 33.4 on maize (Lin, 1976).

Concha (1956) observed that the egg, larval and pupal stages of A. fasciculatus lasted for 5 to 7, 46 to 66 and 5 to 8 days respectively on a product containing ground green coffee and chocolate. According to Reghunath (1969) the egg cum larval duration of A. fasciculatus ranged from 24 to 33 days on tapioca chips and 37 to 66 days on ginger and the pupal duration was 5 to 6 days both on tapioca chips and ginger at 27^{o}C and 88 per cent relative humidity.

The total developmental period from egg to adult of the insect was 30 to 45 days on stored coffee beans (Figueiredo jr., 1957), 3 to 4 weeks on spices (Abraham, 1975), 26 days at 80°F and in 56 days at 72°F on artificial diets (Vitelli et al., 1976) and 30 to 45 days on cashew kernels (Oommen et al., 1985).

The longevity of females of A. fasciculatus was 15.8 days on ginger and 56.8 days on tapioca chips (Reghunath, 1969) and 83 to 114 days on different host materials (Goncalves et al., 1976).

1.2.3 Nature of damage

Munro and Thompson (1929) observed that the cocoa beans damaged by A. fasciculatus showed large exit holes and the internal contents converted to yellow powder. The adults and grubs of the beetle bored into the tapioca chips, larvae made small tunnels and pupated there in (Joseph and Oommen, 1963). According to Abraham (1975) the grubs and adults fed on the internal tissues of ginger reducing it to a powdery mass leaving the outer covering intact. The grubs of the beetle bored inside the stored tubers of Amorphophallus companulatus and Dioscorea alata, formed zigzag galleries and fed on the internal contents and the tubers showed characteristic adult emergence holes (Lal and Pillai, 1977).

The adults and grubs bored into stored cashew kernel pieces (Oommen et al., 1985), multiplied rapidly on ginger rhizomes and made it into a powdery mass (Jacob, 1986) and bored into the copra pieces through the inner side and fed from within (Nalinakumari, 1989).

1.2.4 Extent of damage

Figueiredo jr. (1957) reported 30 per cent loss of coffee beans by A. fasciculatus in Brazil. According to Joseph and Oommen (1963) cent per cent damage occurred in tapioca chips due to the infestation by the the beetle in a period of three months. The beetle caused a maximum of 61 per cent damage in coffee imported into Poland from Columbia (Malinowska, 1964). Puzzid and Pereira (1967) recorded 31.5 to 48.4 per cent damage of coffee beans during the hottest months in Santos, Brazil.

Bitran (1973) observed that 35.7 to 67.8 per cent of the coffee beans had been damaged in Brazil and the losses in weight ranged from 7.2 to 13.7 per cent. Lin (1976) reported loss of 22.6, 26.6 and 31.4 per cent on maize, Ligusticum acutilobum and sweet potato respectively due to the infestation by the pest. According to Lal and Pillai (1977) the stored tubers of Dioscorea alata and

15

Amorphophallus companulatus attacked by the beetle were reduced to mere black powder, rendered unsuitable for consumption as well as seed purpose. Tapioca chips attacked by the adults and grubs of the beetle were reduced to powder in a short period of storage (Thampan, 1979). Ramlabeevi (1988) reported that the intensity of infestation by A. fasciculatus on tapioca chips progressively increased upto the third month after storage and by that time the entire chips were powdered.

1.3 The drug store beetle, Stegobium paniceum (Linn.)

Order: Coleoptera Family: Anobiidae

1.3.1 Distribution of the pest

1.3.1.1Ginger

S. paniceum was reported as a pest of ginger from India (Muthu and Majumder, 1974; Govindarajan, 1982; Jacob, 1986 and Jacob, 1992) and Bangladesh (Rezaur et al., 1982).

1.3.1.2 Turmeric

It was observed as a pest of turmeric in India (Srivastava, 1959; Muthu and Majumder, 1974; Srinath and Prasad, 1975; Abraham, 1975; Jacob 1986 and Jacob, 1992) and Bangladesh (Rezaur et al., 1982).

1.3.1.3 Pepper

White (1957) observed S. paniceum in cargo of pepper from South East Asia. S. paniceum was recorded as a pest of pepper from India by Pruthi (1969), Gahukar (1972) and Muthu and Majumder (1974).

1.3.1.4 Cardamom

Muthu and Majumder (1974) and Jacob (1992) reported S. paniceum as pest of stored cardamom from India.

1.3.1.5 Other hosts

S. paniceum was observed to infest cumin and coriander in Fiji (Lever, 1943), drugs and spices in America (White, 1982) and chilli and coriander in Bangladesh (Rezaur et al., 1982).

17

It was also reported to infest dried fruits in Australia (Zeck, 1943), beans and chickpea in Chile (Faure, 1953), cereals in London (Parkin, 1958), woollen garments in Western countries (Laibach, 1967), confectioneries in English countries (Turner, 1975) and timber in Australia (Paton and Creffield, 1987).

The incidence of S. paniceum was reported in redgram, coriander seed flour and jeera from North India (Girish and Punj, 1969) and in coriander, cumin, fennel, raw rice, greengram and asafoetida from South India (Thangavelu, 1981). The pest was also observed to attack dry roots of Atropa accuminata, seeds of Fagopyrum tataricum, dry rhizomes of Rheum emodi and corms of Colchicum luteum in Jammu (Srivastava and Saxena, 1975) and papads in Ludhiana (Chander et al., 1990).

In Kerala the beetle was found attacking tapioca chips (Joseph and Oommen, 1963; Thampan, 1979 and Ramlabeevi, 1988) and coriander, chillies, biscuits, confectioneries and chocolates (Jacob, 1992).

1.3.2 Biology

The fecundity of S. paniceum has been reported as 40 to 60 eggs per female on turmeric (Srivastava, 1959), 37 eggs

18

per female on raw rice, 71 on greengram, 110 on black pepper, 130 on cumin, 133 on fennel and 150 eggs per female on coriander (Thangavelu, 1981).

Srivastava (1959) reported that S. paniceum completed its life cycle in six weeks on turmeric. The incubation, larval and pupal periods averaged 9.2, 50.1 and 7.4 days respectively on coriander at 30°C and 70 per cent relative humidity (Brar and Chahal, 1980). According to Thangavelu (1981) the developmental periods of S.paniceum ranged from 28±1.5 days on coriander, 32 ± 2.0 on cumin, 35 ±3 3.0 on fennel, 35 ± 3.5 on black pepper, 38 ± 2.0 on raw rice and 35 ± 3.5 days on green gram at 25 to 28°C and 70 to 80 per cent relative humidity.

1.3.3 Nature of damage

Calf starter pellets were found attacked by S. paniceum which produced burrows and all stages of the beetle were present within the pellets (Stone, 1949). The larvae of the beetle tunnelled through turmeric rhizomes and pupated in those tunnels (Srivastava, 1959), bored into the tapioca chips and fed from within (Joseph and Oommen, 1963), attacked the pepper seeds and produced holes on them (Gahukar, 1972) and bored into ginger and turmeric rhizomes (Abraham, 1975).

1.3.4 Extent of damage

A survey in South India revealed that 10 per cent of the pepper samples were infested by S. paniceum (Gahukar, 1972). An all India survey showed that 1.2 per cent of the turmeric samples analysed contained S. paniceum as the major pest (Srinath and Prasad, 1975). Thangavelu (1981) recorded weight loss of 21 per cent in coriander, 15 in cumin and fennel, 7 in black pepper, 2.5 in raw rice and 8 per cent in green gram due to the attack by S. paniceum. Chander et al. (1990) observed that the samples of papads infested by the beetle were made unfit for human consumption.

1.4 Other pests

Some other species of insects were also reported to cause damage to stored spices.

Rezaur et al. (1982) recorded the lesser grain borer Rhyzopertha dominica (Fab.) as serious pest of stored ginger in Bangladesh. The foreign grain beetle Ahasverus advena Walt. was reported in ginger from Australia (Lincoln Plant Protection Centre, 1985).

Various pests reported to infest stored ginger in Kerala include, the cadelle Tenebriodes mauritanicus Linn. and fig moth Ephestia sp.(Abraham, 1975), the tapioca moth Pyralis manihotalis Guen. and the tobacco moth Setomorpha rutella Zell. (Jacob,1986), the red flour beetle Tribolium castaneum and psocids (Sivadasan, 1991) and T. castaneum (Jacob, 1992).

The incidence of the short winged bettle Carpophilus dimidiatus F. was reported by Dobson (1960) in turmeric from Asia. Pests such as T.castaneum and Sitophilus oryzae Linn. were observed in exported turmeric from India at British ports (Anonymous, 1970). A market survey in Bangladesh revealed the infestation of R. dominica in turmeric.

The secondary infestation by T. castaneum, Oryzaephilus surinamensis Linn. and T. mauritanicus was reported in turmeric in India by Srinath and Prasad (1975). T. mauritanicus and Ephestia sp. were found to infest stored turmeric in Kerala (Abraham, 1975). Jacob (1986) recorded the incidence of P. manihotalis and S. rutella in stored turmeric. Reports of infestation of T. castaneum were also made by Desai et al. (1987) and Jacob (1992).

White (1957) recorded Callosobruchus maculatus (F.), C. chinensis (L.), A. advena, T. castaneum, T. confusum (Duv.), Sitotroga cerealella (Oliv.), Ephestia sp., S. rutella, psocids and mites in large scale shipment of black pepper from South East Asia.

In India, stored pepper was found to be infested by S. rutella and the sago moth Erechthias zebrina Butler. (Oommen and Joseph, 1961), P. manihotalis (Joseph and Oommen, 1963) and Laemophloeus minutus (Oliv.), T. castaneum, S. oryzae, O. surinamensis, psocids and mites (Muthu and Majumder, 1974).

Blumberg (1939) observed the infestation by Tribolium sp. on decorticated cardamom. The incidence of T. castaneum in cardamom was recorded by Abraham (1975) and Desai et al. (1987).

MATERIALS AND METHODS

2. MATERIALS AND METHODS

2.1 Survey of storage pests associated with ginger, turmeric, pepper and cardamom

The occurrence and distribution of insect pests in stored ginger, turmeric, pepper and cardamom in the godowns in Kozhikode, Ernakulam, Idukki, Alappuzha and Kollam districts of Kerala were studied through a preliminary survey conducted in July 1991. Five godowns were selected from each district where ginger, turmeric and pepper were stored, and only the godowns in Idukki district had cardamom stock for six months. The godowns selected in the five districts were as given in table 1.

The survey was conducted during the months of August, October and December, 1991. Ten samples each of ginger, turmeric, pepper and cardamom were collected from each godown during the first week of alternate months. The bags containing the produces were selected at random from the bottom, middle and top layers of the stack. These bags were opened and 100 g sample was taken from each bag. From the stocks held in heaps, samples were drawn from different depths and 100 g lots were collected. Each sample was taken in polythene bag and brought to the laboratory for further examination.

2.1.1 Observations

The adult insects present in each sample of the produces brought to the laboratory were counted. The number of adults and immature stages of all the insects present inside were also counted after splitting up the produces. The total number of the immature stages and adults of each species of insect was treated as its population during the period of observation. The populations of the different species of insects found infesting the produces at different godowns were statistically analysed.

2.2 Assessment of the extent of damage to stored ginger, turmeric and pepper by insect pests

The insect infestation was noticed in ginger, turmeric and pepper during the survey. None of the samples of cardamom collected showed infestation of insect pests and hence the study was restricted to the other three produces.

2.2.1 Preparation of ginger, turmeric and pepper

Freshly harvested ginger and turmeric were procured from the market and washed in water to remove mud and other extraneous matter. Ginger rhizomes were partially peeled and were spread uniformly on clean floor and sun dried for five

days with intermittent turning over. The moisture content of the rhizomes was brought to a range of 10.5 to 11.0 per cent which was ascertained by the toluene distillation method using a Dean and Stork apparatus (AOAC, 1975). Turmeric rhizomes were boiled in water taken in metal containers till the fingers became soft and were sundried for six days with occasional turning over. The moisuture content of turmeric was brought to a range of 10.8 to 11.0 per cent which was determined as in the case of ginger. Pepper used in this experiment was prepared by sundrying mature pepper berries for four days. The moisture content of pepper was brought to a level of 9.5 to 9.8 per cent which was ascertained as in the case of ginger.

2.2.2 Rearing of L. Serricorne

L. serricorne was collected from the godowns in specimen tubes using a camel hair brush. Five hundred numbers of the insect were introduced to one Kg each of turmeric and ginger samples kept in circular troughs (20x15cm). Ten such troughs were set up and were kept undisturbed for two months for multiplication of the insects. Insects required for the experiment were obtained by removing all the adults present in the culture and collecting those emerging on the succeeding day, treating them as one- day- old insects.

25

2.2.3 Rearing of A. fasciculatus

A. fasciculatus was collected and reared on ginger and one- day- old adults needed for the experiment were collected as described in 2.2.2

2.2.4 Rearing of S. paniceum

Adults of S.paniceum were collected from pepper. Insects required for the experiment were obtained from the rearings in coriander, since the multiplication rate of the insect was comparatively slower in pepper. One- day- old adults required for the experiment were obtained as detailed in 2.2.2

2.2.5 Exposure of ginger, turmeric and pepper to insects

The treatments included were the exposure of ginger to L. serricorne and A. fasciculatus, turmeric to L. serricorne and pepper to S. paniceum. Control samples without insect were also set up. Each treatment was replicated six times.One hundred g of cleaned ginger, turmeric and pepper was taken separately in plastic bottles for each replication. Fifty numbers of each species of insect collected as described in 2.2.2, 2.2.3 and 2.2.4 were released in each

replication except in control. The bottles were then closed with muslin cloth and kept in position with rubber band. Six such lots were set up for each treatment so that each lot could be utilised for observations at monthly intervals from the commencement of the experiment.

2.2.6 Observations

The contents in each bottle were transferred to a piece of paper. Each piece of the produces was split open and the powdered portions and the dead and live insects and their immature stages were removed thoroughly using a camel hair brush. The undamaged portions of the produces were then weighed and with reference to the weight at the time of storage, the weight of the produces damaged by the pests were calculated. The number of dead and live adults and the developmental stages of these insects observed at the end of each month after treatment were also recorded.

The volatile oil from each replicate of ginger and turmeric was estimated by the water distillation method (Clevenger, 1928). The volume of volatile oil was measured and from the data the percentages of the volatile oil in the samples were calculated on a volume to weight basis.

The non volatile acetone extract from each replicate was estimated using Soxhlet apparatus with acetone as the solvent (ASTA, 1968). The non volatile acetone extract was weighed on a moisture free basis and from the data the percentage of non volatile acetone extract in the samples were calculated.

2.3 Development of insect pests in ginger, turmeric and pepper

The treatments included the exposure of ginger to L. serricorne, A. fasciculatus, turmeric to L. serricorne, S. paniceum and pepper to S. paniceum. Ten gram of each host material was weighed out and kept in petridishes of nine cm diameter. One-day-old adults of each insect collected from the culture were introduced into each dish and closed with the lid. Ten such sets were set up as replication for each insect. The beetles were then transferred to another set of petridishes set up at the same condition after 24 hours and this process was continued till the adult beetles died. The petridishes with the produce were examined daily and the emerging larvae were collected carefully using camel hair brush within 24 hours after emergence. They were released into the specimen tubes of 10x2.5 cm size with the produce. Ten replications were maintained for each insect on each produce.

28

The data on the incubation period, larval period, pupal period and adult longevity were recorded daily.

The experiment was set up during September to October 1991. Data on weather factors viz., maximum and minimum temperature and relative humidity during the experimental period were collected and recorded (Appendix I).

2.4 Statistical analysis

Data relating to each aspect were analysed statistically. The 'F' test was done by analysis of variance (Panse and Sukhatme, 1978). Correlation coefficients relating different aspects were worked out. Significant results were compared on the basis of critical differences.

RESULTS

3. RESULTS

3.1 Important pests observed in ginger

The insects recorded in the survey were Lasioderma serricorne (Fab). Araecerus fasciculatus (De Geer), Tribolium castaneum (Hbst.), Laemophloeus minutus (Olivier), Oryzaephilus surinamensis (Linn.) Rhyzopertha dominica (Fab.), Pyralis manihotalis Guen., Erechthias zebrina Butl. and Setomorpha rutella Zell. (PLATE I).

3.1.1 Cigarette beetle, L. serricorne (Coleoptera : Anobiidae)

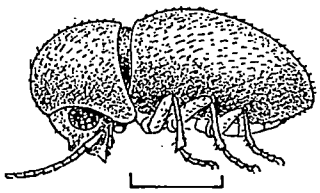
The adult is a dark brown beetle measuring 2.5 to 3 mm length. When disturbed, the thorax and head of the insect bend downwards giving a humped appearance to the beetle. The elytra is hairy and the antennae are 11 segmented and uniformly thick. The adult female laid eggs on the skin and powdered portions of the rhizomes. Damage caused to the rhizomes was due to the extensive feeding by the adults and grubs of the beetles. They bored into the rhizomes and made tunnels in all directions. Pupation also occurred inside the

PLATE I

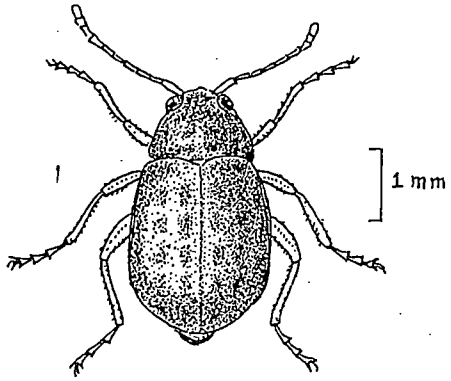
Major insect pests infesting stored ginger in the five districts of Kerala

1. L. serricorne
2. A. fasciculatus
3. T. castaneum
4. L. minutus
5. O. surinamensis
6. R. dominica
7. P. manihotalis
8. E. zebrina
9. S. rutella

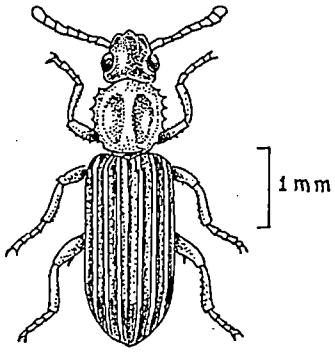
PLATE I



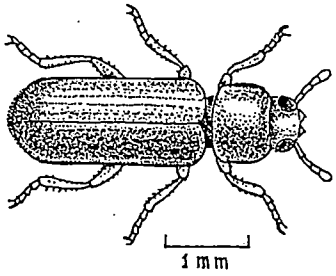
1



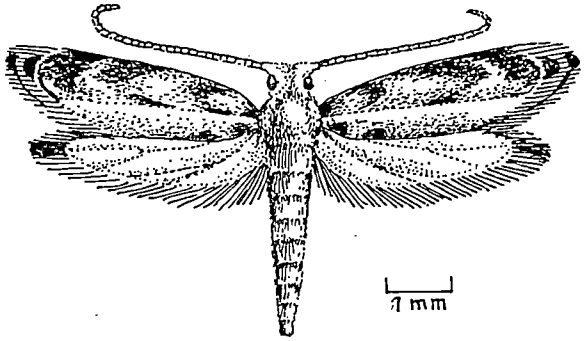
2



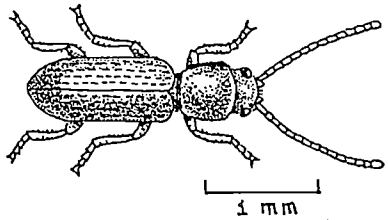
5



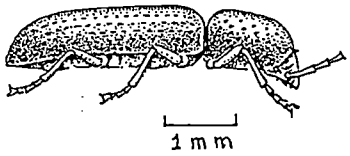
3



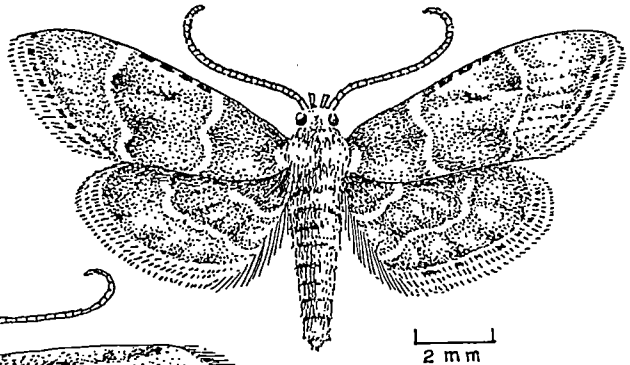
8



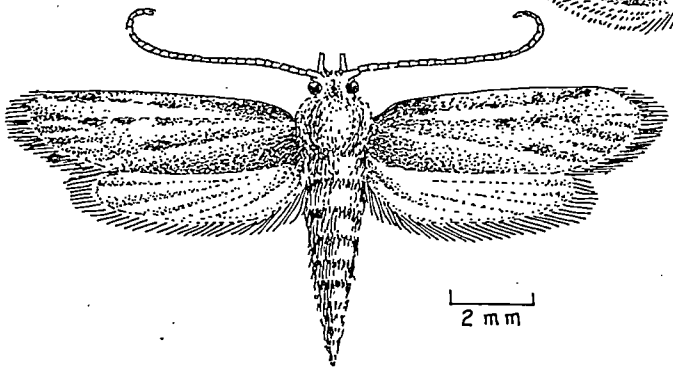
4



6



7



9

tunnels within the pupal cell. Circular adult emergence holes of 1 to 1.5 mm diameter were seen on the surface of the rhizomes. (Fig. 1). Severely attacked rhizomes were light in weight and friable since the internal contents were reduced into powder.

3.1.2 Coffee bean weevil, *A. fasciculatus* (Coleoptera: Anthribidae)

This is a grey coloured beetle with small dark patches on the elytra and prothorax. The body is covered with small hairs. The female beetle made small depressions on the surface of the rhizomes and laid eggs there. The grubs and adults of the pest bored into the rhizomes. Due to the extensive feeding by the grubs the internal tissues were reduced to powdery material leaving hollowed out rhizomes with the outer covering undisturbed. Attacked rhizomes when broken showed irregular tunnels also. Irregular adult emergence holes of 2.5 to 3mm width were noticed on the surface of the rhizomes (Fig. 2).

3.1.3 Red flour beetle, *T. castaneum* (Coleoptera : Tenebrioniidae)

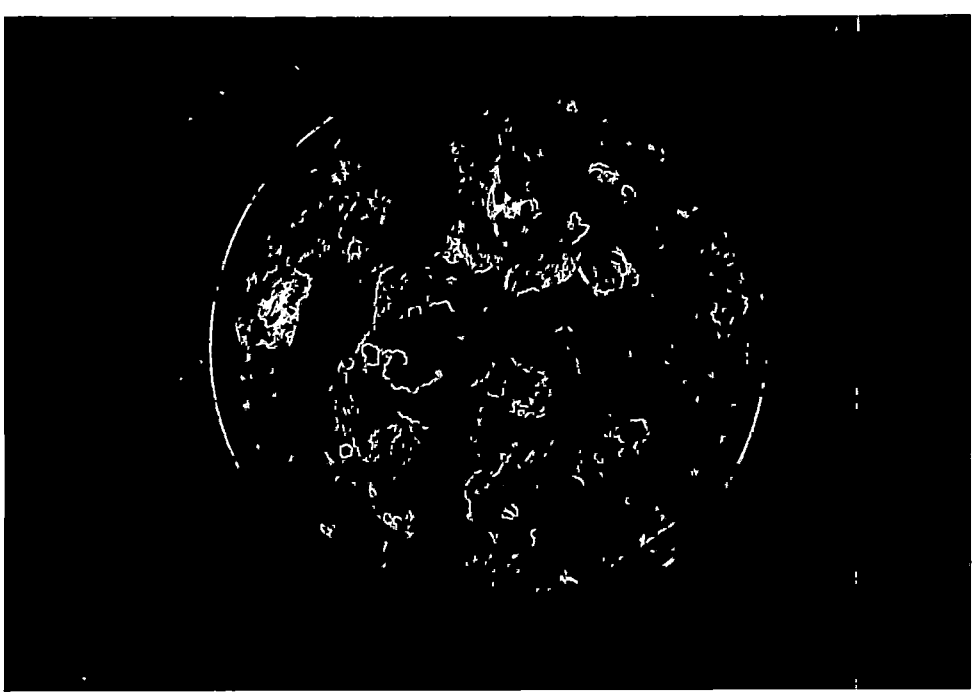
This is a reddish brown, flat, elongate beetle.

Fig.1 Nature of damage caused by *L. serricorne* in stored ginger

Fig.2 Nature of damage caused by *A. fasciculatus* in stored ginger

Fig. 1

Fig. 2



Adults of this beetle were found in small numbers in the samples collected. They were observed feeding on the broken rhizomes and powdered portions. The immature stages of the insect could not be observed in the samples.

3.1.4 Flat grain beetle, *L. minutus* (Coleoptera : Cucujidae)

The adult is a small, reddish brown, flat beetle. Antennae are filiform and longer than half the length of the body. Adults of this beetle only could be observed in the samples. They were seen feeding on the skin and powdered portions of the rhizomes.

3.1.5 Saw toothed grain beetle, *O. surinamensis* (Coleoptera : Silvaniidae)

This is a slender, dark brown, flattened beetle with a row of sharp teeth like projections on either side of the prothorax. The adults of this beetle could only be observed in the samples collected. They were seen feeding on the powdered portions of the rhizomes.

3.1.6 Lesser grain borer, *R. dominica* (Coleoptera : Bostrychidae)

The adult is a dark brown beetle measuring about 3.5 to 4 mm in length. Antenna is 10 segmented with an abrupt three segmented club. The head of the beetle being bent under the thorax and the posterior abdominal end blunt. Adults of the beetle bored into the rhizomes and fed from within. Rhizomes when split up showed irregular tunnels and bore holes of the beetle were seen on the surface of the rhizomes. Immature stages of the insect could not be observed in the samples.

3.1.7 Tapioca moth, *P. manihotalis* (Lepidoptera : Pyralidae)

It is a greyish brown moth with dark wavy lines and spots on the wings. Dull white coloured caterpillars of this moth were recorded in small numbers in poor quality ginger samples. The caterpillars webbed together the rhizomes and made tubular galleries with silk, frass and excreta and fed from within and bored into the rhizomes eventually. Infested samples presented a dirty appearance with profuse quantity of excreta (Fig. 3).

Fig.3 Nature of damage caused by *P. manihotalis* in stored ginger

Fig. 3

33

3.1.8 Sago moth, *E. zebrina* (Lepidoptera : Lyonetiidae)

The adult moth is greyish with black grey spots and bands on the wings. The hind wings are pale greyish and edged with long fringes of hairs. Small numbers of caterpillars of the moth were seen in discarded samples of ginger. The caterpillars webbed together the rhizomes, constructed tubular galleries with silk and excreta and fed by remaining inside the galleries(Fig. 4). In the later stages they were seen boring into the rhizomes and eventually the rhizomes were hollowed out and filled with excreta.

3.1.9 Tobacco moth, *S. rutella* (Lepidoptera : Tineidae)

The moth have drab grey forewings with several irregular dark spots. The hind wings are edged with long fringes of hairs. Dirty white coloured caterpillars of this moth were seen in the samples in small numbers. The caterpillars made galleries of loosely woven silk on the produce and remained inside and fed on the outer portions of the rhizomes. In the later stages they bored into the rhizomes and fed on the internal parts. The webs of caterpillars were overlaid with profuse amount of excreta and the samples presented a dirty appearance (Fig. 5).

Fig.4 Nature of damage caused by

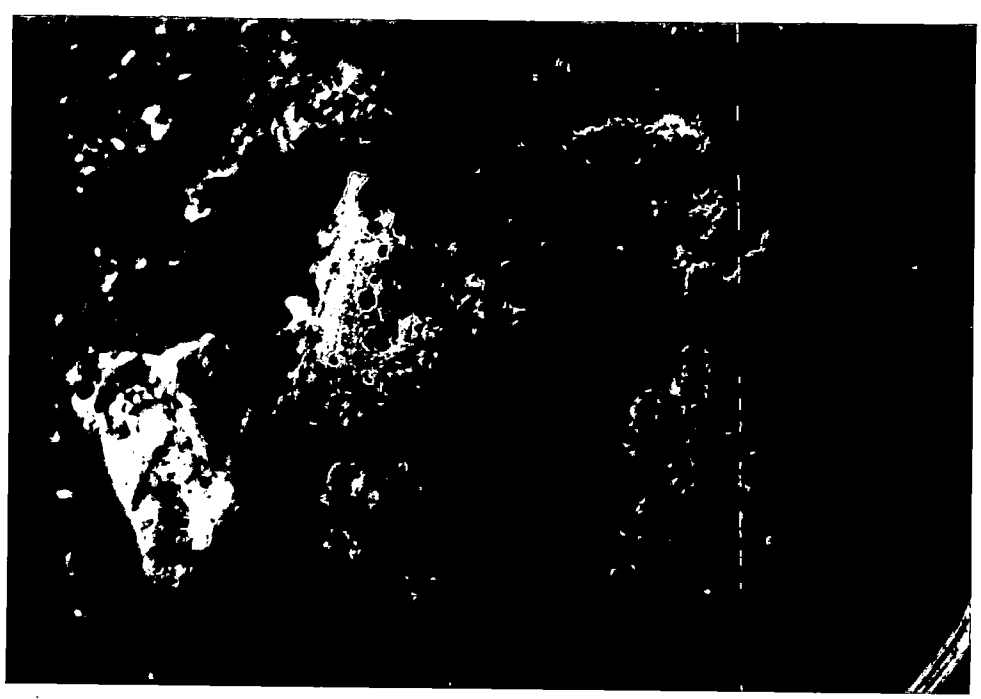
E. zebrina in stored ginger.

Fig.5 Nature of damage caused by

S. rutella instored ginger

Fig. 4

Fig. 5



3.2 Important pests observed in turmeric

The insects recorded in the survey were Lasioderma serricorne, Laemophloeus minutus, Tribolium castaneum, Oryzaephilus surinamensis, Stegobium paniceum, Rhyzopertha dominica and Pyralis manihotalis (PLATE II).

3.2.1 L. serricorne

The adult female laid eggs on the skin of the rhizomes and the powdery materials present in the samples. The grubs and adults bored into the rhizomes and the pupation also occurred in the larval tunnel (Fig. 6a). Adult emergence holes of 1 to 1.5 mm diameter were seen on the surface of the rhizomes (Fig. 6b). Rhizomes which were severely bored by the grubs and adults showed tunnels in all directions. Ultimately the rhizomes were converted to mere powder leaving the outer skin in a brittle condition.

3.2.2 L. minutus

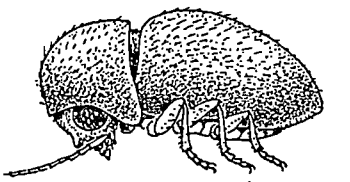
Adults of this beetle were observed feeding on the powdered portions of the turmeric rhizomes. They were present only in small numbers and the immature stages could not be observed in the samples.

PLATE II

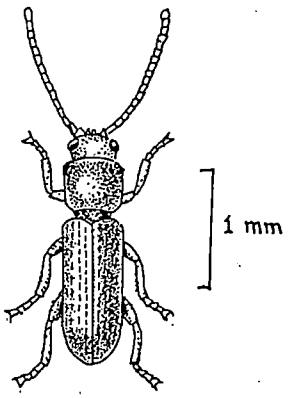
Major insect pests infesting stored turmeric in the five districts of Kerala

1. L. serricorne
2. L. minutus
3. T. castaneum
4. O. surinamensis
5. S. paniceum
6. R. dominica
7. P. manihotalis

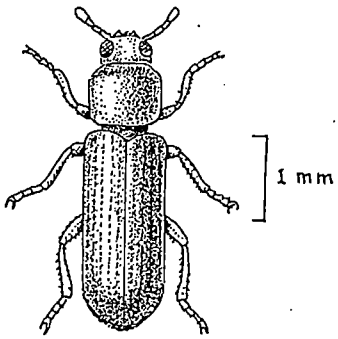
PLATE II



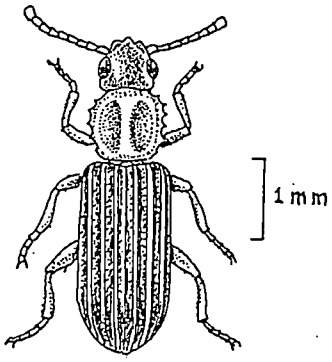
1



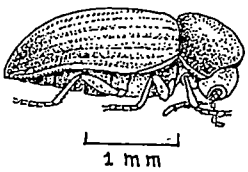
2



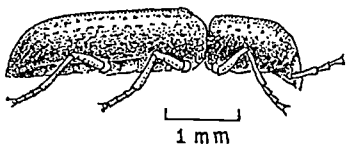
3



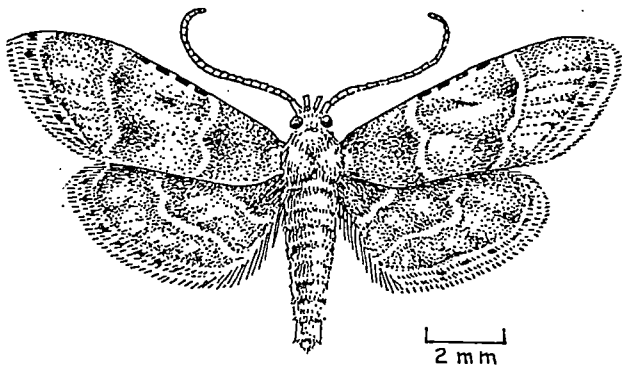
4



5



6



7

Fig.6 Nature of damage caused by *L.serricorne* in stored turmeric

a. With immature stages

b. With adult emergence holes.

Fig. 6a

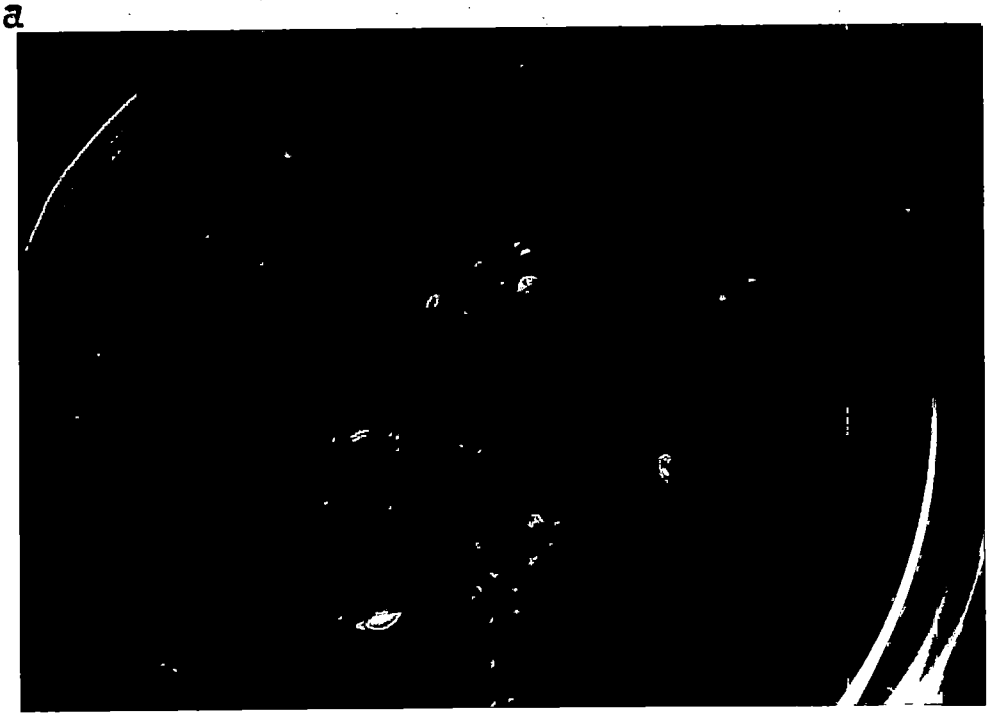
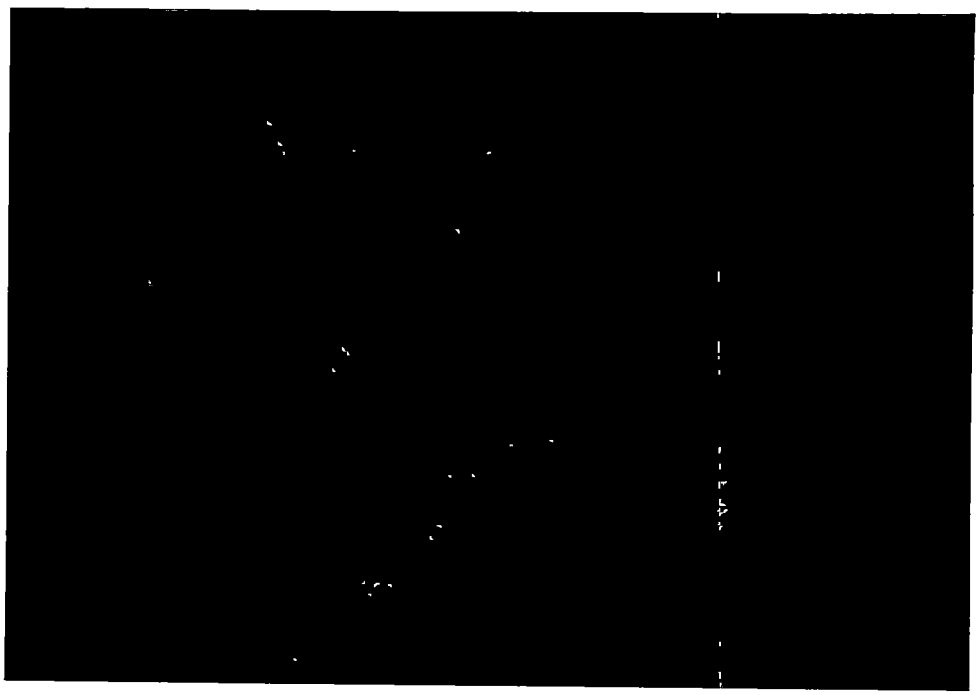


Fig. 6b



35

3.2.3 T. castaneum.

Small numbers of the adults of this beetle could be observed in the samples. They were seen feeding on the broken rhizomes and powdered portions.

3.2.4 O. surinamensis

Adults of this beetle only could be observed in the samples. They were found feeding on the skin of the rhizomes and the powdered inner portions.

3.2.5 Drug store beetle, S. paniceum (Coleoptera : Anobiidae)

The adult is a brownish small beetle of 2 to 2.5 mm length. The insect has striated elytra and clubbed antennae. Adults and immature stages of the insect were recorded in small numbers in the samples collected. The adults and grubs bored into the rhizomes. Pupation also occurred within the larval tunnel. Circular adult emergence holes of 1 to 1.25 mm diameter were observed on the surface of the rhizomes. Powdered portions of the rhizomes were also noticed (Fig. 7).

3.2.6 *R. dominica*

Adult beetles were seen boring into the rhizomes. Attacked rhizomes showed tunnels inside. Bore holes of the adult beetle were seen externally. Immature stages of the insect could not be observed in the samples.

3.2.7 *P. manihotalis*

Caterpillars of this moth were seen in neglected stocks of turmeric. In the initial stages the caterpillars webbed together the rhizomes and remained inside the webs made of silk, frass and excreta and fed on the adjoining sides of the rhizomes. Gradually they bored into the interior and fed on the internal contents and made the interior hollow. The infested samples presented a dirty appearance due to the presence of profuse excreta (Fig. 8).

3.3 Important pests observed in pepper

The insects observed during the survey were *Stegobium paniceum*, *Laemophloeus minutus* and *Erechthias zebrina*.

Fig. 7 Nature of damage caused by *S.paniceum* in stored turmeric

Fig. 8 Nature of damage caused by *P. manihotalis* in stored turmeric

Fig. 7

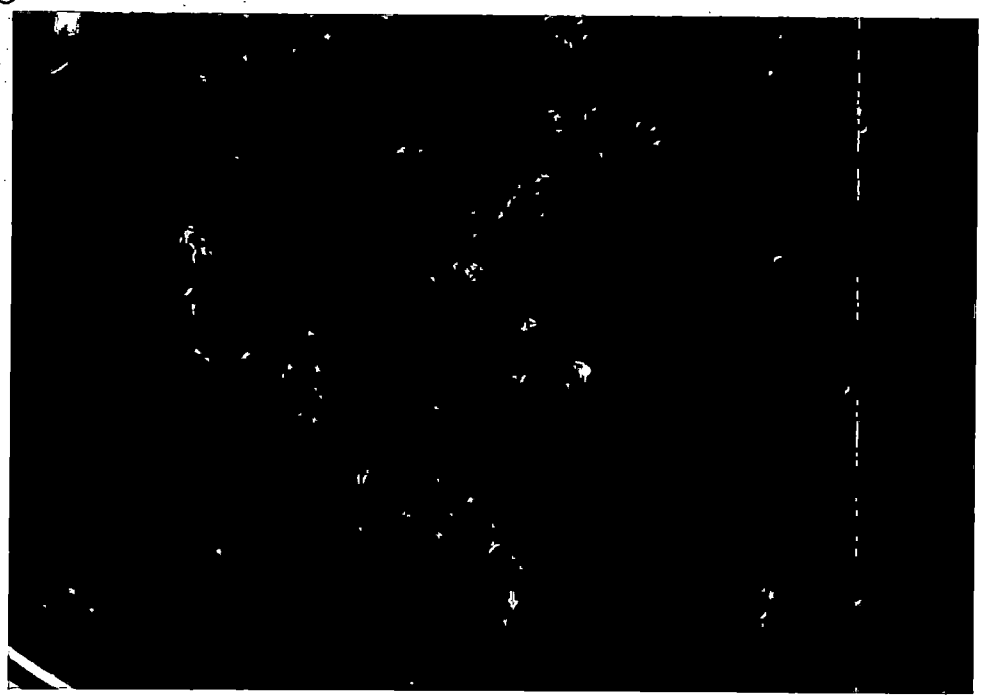
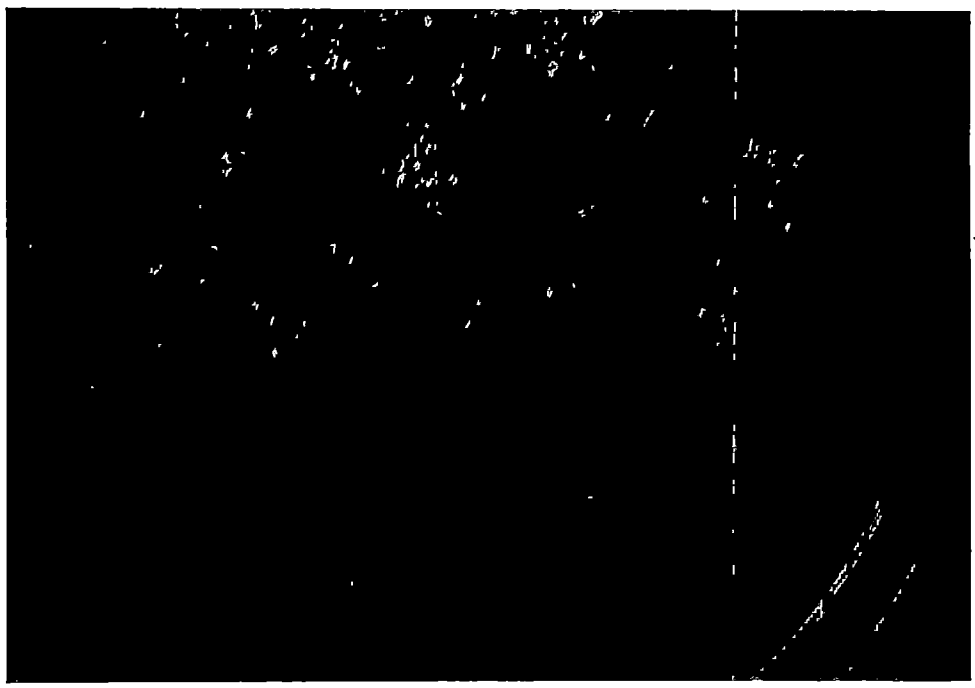


Fig. 8



37

3.3.1 S. paniceum

The adults of the insect were seen in small numbers. The adult female laid eggs on the surface of the berries. The grubs bored into the rhizomes and pupated there in. Adult emergence holes were also seen on the surface of the berries (Fig. 9). The adult beetles were found feeding on the rind of the berries and the internal contents by remaining inside the larval tunnels.

3.3.2 L. minutus

Adults of this beetle only were observed in the samples. They were found feeding on the spike stalks left over and the powdery materials present in the samples. They did not attack the sound pepper berries.

3.3.3 E. zebrina

Larvae of this moth were observed in neglected pepper samples. Pepper berries were seen webbed together with silk, frass and excreta. The caterpillars fed on the outer skin of the berries by remaining concealed in the webbings (Fig. 10). The attacked samples presented a very dirty appearance due to the profuse amount of excreta.

Fig. 9 Nature of damages caused by *S. paniceum* in stored pepper

Fig.10 Nature of damages caused by *E. zebrina* in stored pepper

Fig. 9

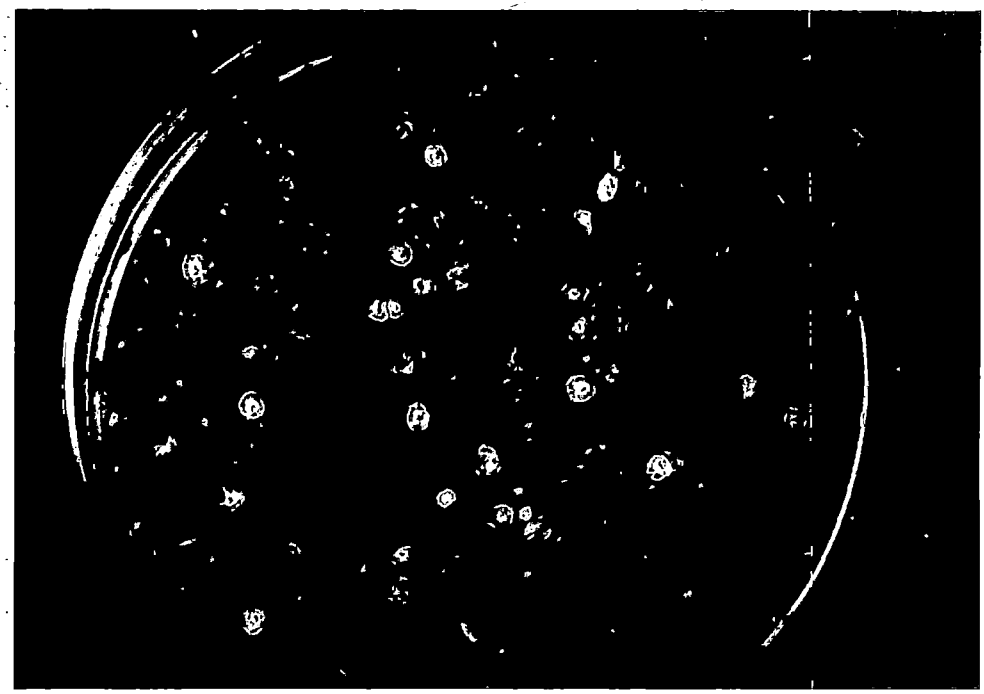


Fig. 10

38

3.4 Pest observed in cardamom

No serious pests were recorded on cardamom during the survey. Adults of Laemophloeus minutus were seen in the samples but they were not seen feeding on the cardamon capsules.

3.5 Distribution of insect pests of stored spices in five districts of Kerala

The data relating to the distribution of insect pests of ginger, turmeric, pepper and cardamom and the results of statistical analysis of the same are presented in Tables 1 to 3.

3.5.1 Insect pests observed in stored ginger

3.5.1.1 L. serricorne

Among the insect pests observed in stored ginger during the survey the most abundant one was L. serricorne. In Kozhikode district the highest mean population of 8.4 was recorded in the godown, Manackal Trading Company. This was followed by the mean population in Josco Spices and Mubarack Traders (4.6) and showed significant difference compared to

Manackal Trading Company. Significantly lower mean populations of 1.5 and 1.4 were noticed in the other two godowns which were on par. In Ernakulam district the highest mean incidence of 7.5 was observed in the godown, Kottacheril Brothers and Company and this did not show significant difference with the mean population recorded in the godowns, Mehta Spices and Company (4.8), Allide Traders (5.2) and Vijaya Spices (6.0). The lowest mean population of 2.8 was noticed in the godown, Pankaj Brothers and Company and was significantly low compared to the mean incidence observed in Allide traders, Vijaya Spices, and Kottacheril Brothers and Company but on par with the incidence in Mehta Spices and Company. Significant differences were lacking in the mean population of the pest observed in the different godowns of Idukki, Alappuzha and Kollam districts. The mean incidence in the different godowns ranged from 1.3 to 3.5 in Idukki, 0.5 to 1.7 in Alappuzha and 0.2 to 1.7 in Kollam district (Table 1).

As evidenced from the data, the incidence of the pest in the three periods of the survey showed good amount of variation. The highest mean population was recorded in the month of August in majority of the districts. Significant

differences in the mean incidence were noticed between the three periods of the survey in the districts of Kozhikode and Ernakulam. The highest mean population was noticed in August (6.7) followed by that in October (4.0) and the least incidence recorded in the month of December (2.1) in Kozhikode. In Ernakulam district the highest mean population of 11.0 was recorded in August followed by that in October (4.6) and the lowest incidence noticed in December (1.6). The mean population observed during August and October were on par (3.0 and 2.8) in Idukki district but significantly lower mean population of 1.8 could only be noticed in December. In Alappuzha district significantly higher mean population of 1.5 was observed in the month of October, lower mean population in August and December (1.0 and 0.7) which were on par. The mean incidence seen in the months of August, October and December in the godowns of Kollam district was very low and ranged from 0.4 to 0.8 only.

3.5.1.2 A. fasciculatus

As noticed in the data the mean incidence of A. fasciculatus also showed great fluctuations (Table 1). In Kozhikode district the highest mean population of 5.4 was noticed in the godown, Josco Spices and was on par with the mean population in Mubarack Traders (5.0), and Bhima Produces (4.8). Significantly lower mean incidence of 1.1 and 1.7

were observed in the other two godowns which were on par. The highest mean population of 6.3 was recorded in the godown, Allide Traders in Ernakulam district. Significantly lower incidence was observed in the other four godowns which ranged from 0.9 to 2.7. In Idukki district the highest mean population of 3.2 was noticed in the godown, S.R.T. Trade Links which was on par with the mean incidence noticed in Cheruvallil Traders (1.8) and Chennattumattom Traders (2.4). Significantly lower mean population of 0.9 and 0.2 was observed in the other two godowns. The incidence of the pest was low in the different godowns of Alappuzha district. Among these, the highest mean population of 1.9 was recorded in the godown, Aravindakshan Pillai & Sons and this was on par with the mean incidence in K.A.K. Traders (1.7), which was on par with the incidence in Peroor Stores (1.0). Lower incidence of 0.3 and 0.7 were observed in the other two godowns. Significant differences were lacking in the mean populations recorded in the different godowns of Kollam district. The mean incidence ranged from 1.3 to 2.8.

Significant variations in the distribution of the pest could be observed during the three periods of survey. Higher incidence of the pest was noticed during the month of August in majority of the districts. The trend observed in the population distribution of the pest during the three periods

43

of the survey was similar in the districts of Kozhikode, Ernakulam and Kollam. In these districts, significant differences were recorded in the mean incidences in August, October and December. The mean populations were 5.6, 3.0 and 2.0 in Kozhikode, 3.6, 2.3 and 1.0 in Ernakulam and 2.5, 1.9 and 1.2 in Kollam in August, October and December respectively. The mean incidence observed in August and October were on par in Idukki (1.9 and 2.3 respectively) and Alappuzha districts (1.3 and 1.5 respectively). But the mean populations recorded in the month of December were significantly low (0.6 and 1.2 respectively) in these districts.

3.5.1.3 T. castaneum

The mean population ranged from 0.5 to 0.9 in the godowns in Kozhikode, 0.4 to 0.9 in Ernakulam, 0.5 to 0.8 in Idukki, 0.4 to 0.7 in Alappuzha and 0.5 to 0.7 in Kollam district. Significant differences could not be seen in the distribution of T.castaneum in the godowns of different districts.

Variations in the mean incidence of the pest were recorded in the different periods of observation. In all the districts the mean population noticed in August and October were on par but significantly low population was recorded in December. The mean populations recorded were 0.8, 0.7 and 0.5 in Kozhikode and Idukki, 0.7, 0.7 and 0.5 in Ernakulam, 0.6, 0.6 and 0.4 in Alappuzha and 0.7, 0.6 and 0.5 in Kollam district in August, October and December respectively.

3.5.1.4 L. minutus

Low mean populations of L. minutus were observed in the godowns of the various districts and the mean incidence ranged from 0.4 to 0.7 in the godowns of Kozhikode district, 0.5 to 0.7 in both Ernakulam and Idukki districts, 0.5 to 0.9 in Alappuzha and 0.4 to 0.6 in Kollam district.

The mean population in the three months of observation showed variations. The mean incidence noticed in August and October were on par in Kozhikode (0.6 in both the months), and in Ernakulam (0.6 to 0.8). Significantly lower population of 0.3 was observed in both districts in the month of December. The mean population observed in Alappuzha in the three periods were on par which ranged from 0.6 to 0.8 only. In Idukki and Kollam districts, significant difference

45

in mean population was not observed in the months of October and December (ranged from 0.4 to 0.5 and 0.4 in both the months , respectively) but the incidence in August was significantly higher (0.7 and 0.6 respectively).

3.5.1.5 Other pests

Low populations of R.dominica, P.manihotalis, E.zebrina and S.rutella were recorded in few samples collected and hence could not be included in the table.

3.5.2 Insect pests observed in stored turmeric

3.5.2.1 L. serricorne

Among the insect pests observed in the survey in stored turmeric, the most abundant one was L. serricorne. (Table 2). The mean incidence of the pest in the different godowns of Kozhikode district ranged from 6.3 to 10.5. Significant differences were recorded in the mean population of the pest between the different godowns in Ernakulam district. Here the highest mean population of 9.0 was observed in the godown, Kottacheril Brothers and Company.

Significantly lower mean populations were observed in all the other godowns which were on par also. The mean incidence in these godowns ranged from 2.9 to 5.4. Significant differences were lacking in the mean population of the pest among the godowns in Idukki, Alappuzha and Kollam districts and the mean incidence ranged from 3.1 to 4.8 in the godowns in Idukki, 1.0 to 2.3 in Alappuzha and 1.2 to 2.1 in Kollam district.

The mean population levels of the pest in the different periods of the survey showed fluctuations. Significant reduction in mean incidence was recorded from the month of August to October and December in the districts of Kozhikode, Ernakulam and Idukki. The highest mean population of 14.5 was observed in the month of August in Kozhikode district followed by that in October (8.8) and the least incidence in December (2.4). Significantly higher population of 6.8 was recorded in August in Ernakulam district, followed by a mean population of 5.8 in October and a significantly low incidence of 2.4 in December. The mean populations noticed in Idukki district in the months of August, October and December were 5.3, 3.7 and 2.7 respectively. The mean populations recorded in the three surveys conducted were on par in Kollam district which ranged from 1.4 to 1.8. In

Alappuzha district the mean incidences observed in August and October were 2.1 and 1.9 respectively and did not show significant differences. But significantly low mean population of 1.6 was recorded in December compared to that in August.

3.5.2.2 *L. minutus*

The mean population ranged from 0.3 to 0.7 in the godowns in Kozhikode district, 0.4 to 0.8 in Ernakulam, 0.2 to 0.9 in Idukki, 0.3 to 0.7 in both Alappuzha and Kollam districts. Significant differences were not observed in the mean incidence of *L. minutus* among the different godowns in the various districts.

The mean population of *L. minutus* observed in different months showed variations. The mean incidence recorded in August and October were on par in Kozhikode district (0.7 and 0.6) but significantly low mean population of 0.4 was noticed in December. In Ernakulam district significant differences were noticed in the mean populations in the three periods and were 0.9, 0.4 and 0.3 in August, October and December respectively. In Idukki district the mean populations in August and December were on par (0.5 and 0.4) but significantly higher mean incidence in October

(0.6). In Alappuzha significantly higher mean population of 0.7 was observed in August but the incidence in October and December were on par (0.5 and 0.4). Significant differences in the mean population in the three periods were lacking in Kollam district which ranged from 0.4 to 0.5.

3.5.2.3 T. castaneum

The mean incidence of T. castaneum among the different godowns in the five districts was insignificant. The mean population ranged from 0.4 to 0.7 in the godowns both in Kozhikode and Idukki, 0.4 to 0.6 in Ernakulam, 0.3 to 0.6 in Alappuzha and 0.3 to 0.7 in Kollam district.

The populations recorded during different periods were not significant. The mean populations were 0.6, 0.5 and 0.4 in Kozhikode, 0.6, 0.5 and 0.5 in Ernakulam, 0.5, 0.7 and 0.5 in Idukki, 0.4, 0.4 and 0.4 in Alappuzha and 0.6, 0.7 and 0.4 in Kollam district in August, October and December respectively.

3.5.2.4 O. surinamensis

The mean population of the insect noticed in the different godowns in the different districts were low.Neither the mean incidence of the pest among the godowns nor the

variation in three periods in different districts were found significant. The mean population ranged from 0.6 to 0.7 in the godowns in Kozhikode, 0.5 to 0.6 in both Ernakulam and Idukki and 0.5 to 0.7 in both Alappuzha and Kollam districts. The mean incidence in the three periods ranged from 0.5 to 0.7 in Kozhikode, Alappuzha and Kollam districts, 0.5 to 0.6 in Ernakulam and 0.4 to 0.6 in Idukki district.

3.5.2.5 Other pests

Low incidence of S.paniceum,R.dominica and P.manihotalis were recorded in few of the samples and hence could not be included in the table.

3.5.3 Insect pests observed in pepper

3.5.3.1 S. paniceum

Very low incidene of this pest was noticed only in the godowns in Idukki district (Table 3). Significant differences were lacking in the mean population of the pest observed in the different godowns and during different periods. The population ranged from 0.6 to 1.0 in different godowns and 0.6 to 1.2 in different periods.

Table 3. Distribution of the insects infesting stored pepper and cardamom in Idukki district of Kerala as observed in a survey conducted at bimonthly intervals (August 1991 - December 1991)

		Insect pests observed in pepper								Insect pests observed in cardomom			
		Mean numbers of insects in 100g samples								Mean numbers of insects in 100g samples			
		S. paniceum				*L. minutus*				*L. minutus*			
District	Name of godown	Aug	Oct	Dec	Mean	Aug	Oct	Dec	Mean	Aug	Oct	Dec	Mean
Idukki	S.R.T. Trade Links	1.8(1.7)	0.6(1.3)	0.8(1.3)	1.0(1.4)	1.4(1.6)	0.7(1.3)	0.7(1.3)	0.9(1.4)	1.5(1.6)	0.8(1.4)	0.7(1.3)	1.0(1.4)
	Cheruvallil traders	0.9(1.4)	1.1(1.4)	0.7(1.3)	0.9(1.4)	1.7(1.7)	2.2(1.8)	0.8(1.4)	1.6(1.6)	0.8(1.3)	0.5(1.2)	0.3(1.2)	0.5(1.2)
	Chennattumattom Traders	1.4(1.6)	0.6(1.3)	0.5(1.2)	0.8(1.2)	1.7(1.6)	1.7(1.6)	0.8(1.3)	1.3(1.5)	1.5(1.6)	1.1(1.4)	0.6(1.3)	1.0(1.7)
	Vazhayil Traders	1.1(1.4)	0.7(1.3)	0.5(1.2)	0.7(1.3)	0.8(1.3)	0.6(1.3)	0.6(1.3)	0.7(1.3)	1.2(1.5)	1.4(1.6)	0.6(1.3)	1.1(1.4)
	Kattappana Traders	0.8(1.3)	0.7(1.3)	0.5(1.2)	0.6(1.3)	0.7(1.3)	2.1(1.8)	1.5(1.6)	1.4(1.6)	1.6(1.6)	0.8(1.3)	0.2(1.1)	0.8(1.3)
	Mean	1.2(1.5)	0.7(1.3)	0.6(1.3)		1.3(1.5)	1.4(1.6)	1.9(1.4)		1.3(1.5)	1.9(1.4)	0.5(1.2)	

Figures in paranthesis are transformed values, $\sqrt{x+1}$

3.5.3.2 L. minutus

The mean population observed in the different godowns of Idukki district ranged from 0.7 to 1.6 only. The mean population in August, October and December were 1.3, 1.4 and 1.9 respectively. Significant differences were not seen in the mean incidence of the pest in the different godowns and in the three periods of survey.

3.5.3.3 Other pest

Low population of caterpillars of E.zebrina was observed in few samples of pepper collected and hence it was not included in the table.

3.5.4 Insect pest observed in cardamom

3.5.4.1. L. minutus

The mean incidence of the insect in the different godowns of Idukki district ranged from 0.5 t0 1.1. The mean population noticed in the three periods ranged from 0.5 to 1.3 (Table 3).

3.6 Extent of damage caused by the attack of insect pests to stored ginger, turmeric and pepper

The data relating to the experiment and the results of statistical analysis of the same are given in Table 4.

An increase in the percentage weight loss was observed in ginger exposed to L. serricorne over a period of six months which ranged from 1.07 to 13.01 per cent. The insect caused only 1.07 per cent loss during the first month and a sharp increase in intensity of damage was observed at the end of the second month (8.84 per cent). The mean weight loss in the second, third and fourth months showed marginal difference only (8.84, 8.99 and 11.68 per cent, respectively). Significantly high percentage loss was observed between third and fifth month (8.99 to 12.72) and third and sixth month (8.99 to 13.01) (Fig.11b). A gradual insignificant increase in percentage weight loss was observed from fourth month onwards.

The intensity of damage observed in ginger exposed to the attack of A. fasciculatus showed a mean weight loss of 1.25 per cent in the first month and then a sharp increase in weight loss noticed during the second month (6.01 per cent).

Table 4. Extent of weight loss in stored ginger, turmeric and pepper exposed to the attack of different insect pests observed at monthly intervals after exposure

Treatment	Mean per cent loss in weight in treatments over that of control					
	1	2	3	4	5	6
Ginger						
L. serricorne	1.07	8.84	8.99	11.68	12.72	13.01
A. fasciculatus	1.25	6.01	6.98	8.63	10.86	11.58
Turmeric						
L. serricorne	3.92	15.01	15.63	16.94	17.84	17.97
Pepper						
S. paniceum	0.15	0.42	0.61	0.79	0.90	1.12

	Ginger-L.serricorne	Ginger-A.fasciculatus	Turmeric-L.serricorne	PepperS.paniceum
CD (0.05)	3.3	1.43	3.27	0.07

Number of insects released in each replication of 100g produce - 50.

The mean weight loss in the second and third month and fifth and sixth months showed marginal difference (6.01 to 6.98 and 10.86 to 11.58 percent, respectively). Significant difference in mean weight loss was recorded between third and fourth month and fourth and fifth months (6.98 to 8.63 and 8.63 to 10.86 per cent, respectively). The mean weight loss observed at the end of sixth month was 11.58 per cent (Fig. 12b).

When turmeric was exposed to L. serricorne 3.92 per cent loss was noticed at the end of first month and during the second month the intensity of damage reached up to 15.01 per cent. Thereafter a gradual increase in mean weight loss was observed in the succeeding months (15.01 to 17.97 per cent) and they were on par (Fig. 13b).

The intensity of damage caused by S. paniceum in pepper was very low which ranged from 0.15 to 1.12 per cent only. Significant increase in the weight loss was recorded in each observation from first month to sixth month.

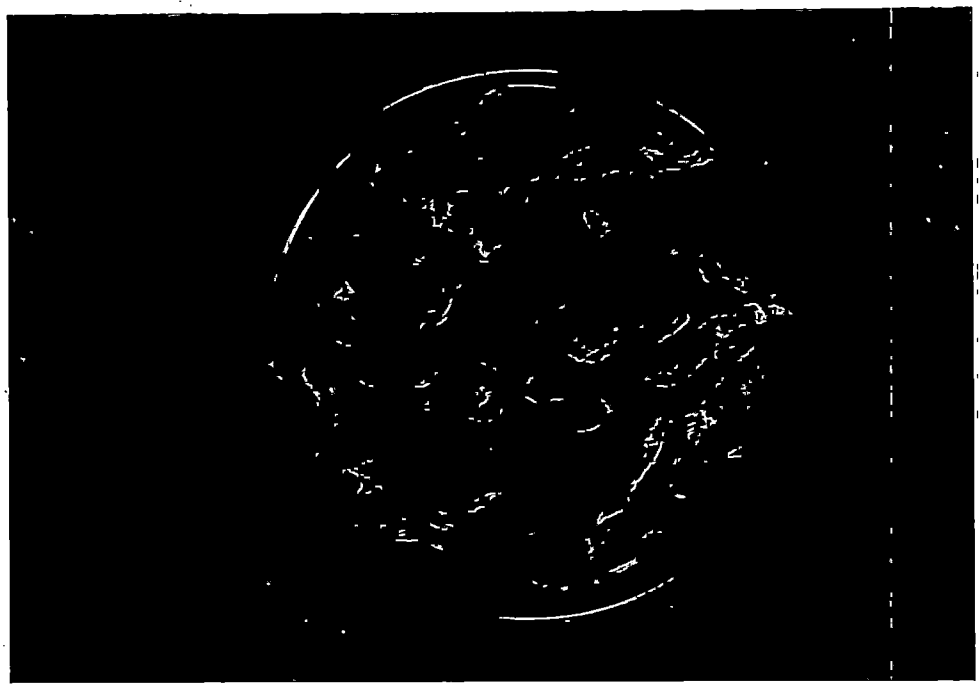
3.7 The population build up of insect pests in stored ginger, turmeric and pepper

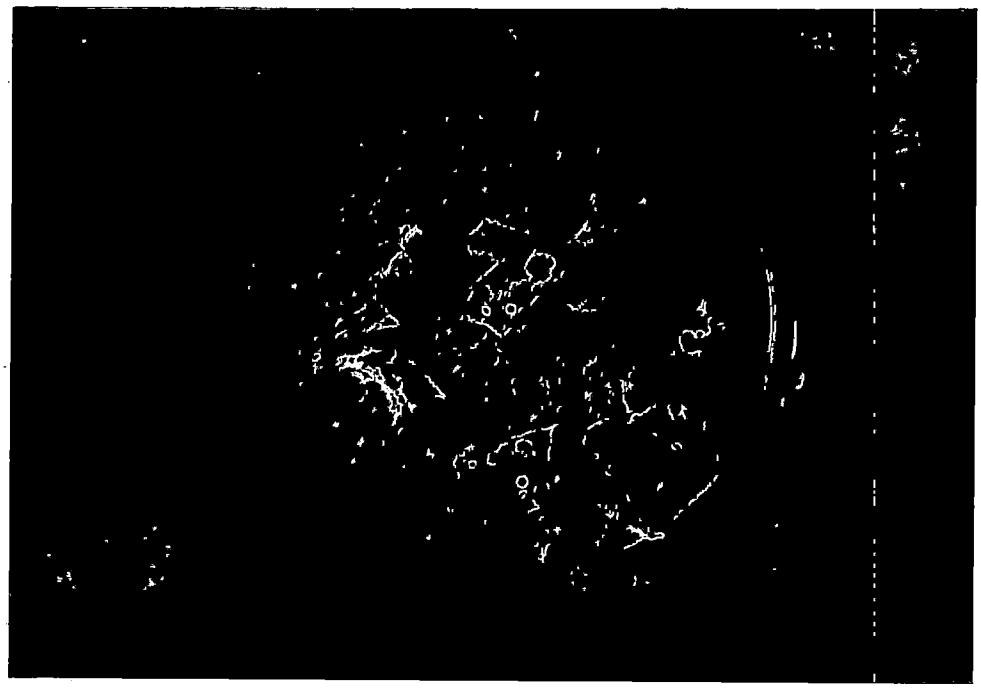
The data relating to the experiment and the results of statistical analysis of the same are given in Table 5.

Fig.12 Extent of damage caused by *A. fasciculatus* to stored ginger

a. control

b. six months after release





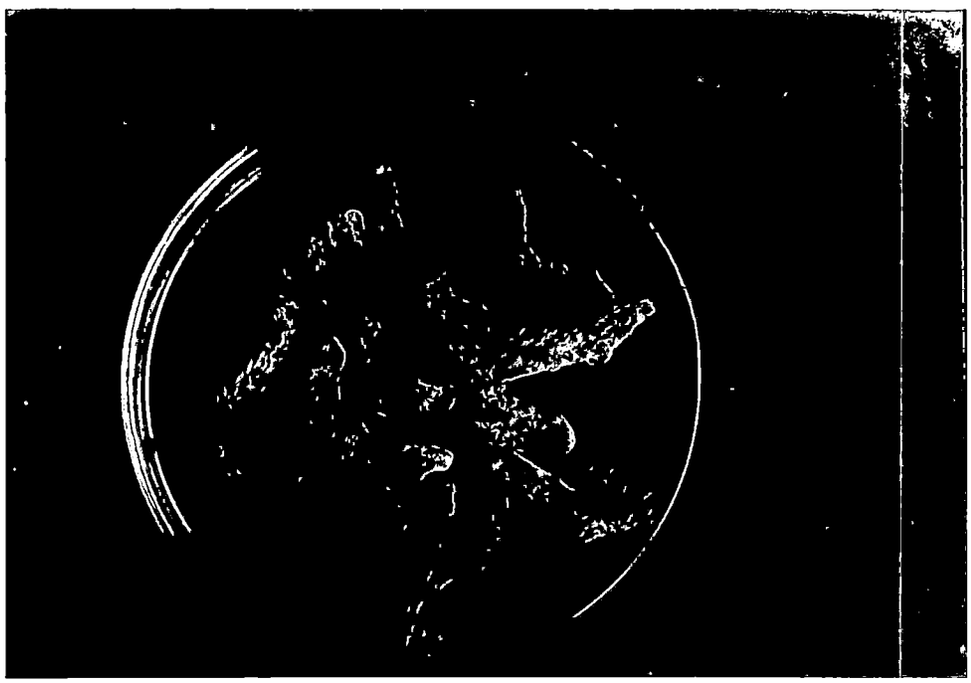


Table 5. The population build up of insect pests in stored ginger, turmeric and pepper observed at monthly intervals after infestation

Treatments	Mean number of developmental stages observed (6 months). 1	2	3	4	5	6	CD (0.05)
Ginger							
L. serricorne							
Larva	6.08 (2.66)	14.60 (3.95)	12.18 (3.63)	10.76 (3.43)	4.95 (2.44)	5.25 (2.50)	(0.67)
Pupa	0.96 (1.40)	7.01 (2.83)	2.57 (1.89)	2.84 (1.96)	1.86 (1.69)	2.65 (1.91)	(0.52)
Adult	50.84 (7.20)	103.04 (10.20)	142.52 (11.98)	127.37 (11.33)	143.72 (12.03)	143.00 (12.00)	(1.68)
A. fasciculatus							
Larva	4.81 (2.41)	13.98 (3.87)	8.24 (3.04)	6.67 (2.77)	10.83 (3.44)	6.90 (2.81)	(0.58)
Pupa	1.07 (1.44)	2.76 (1.94)	1.62 (1.62)	2.92 (1.98)	2.76 (1.94)	1.26 (1.50)	(0.41)
Adult	49.69 (7.12)	59.22 (7.76)	64.93 (8.12)	68.22 (8.32)	88.68 (9.47)	101.41 (10.12)	(0.41)
Turmeric							
L. serricorne							
Larva	16.47 (4.18)	35.98 (6.08)	13.41 (3.80)	11.47 (3.53)	5.94 (2.63)	4.59 (2.36)	(0.74)
Pupa	4.89 (2.43)	11.74 (3.57)	1.11 (1.45)	5.16 (2.48)	0.89 (1.37)	0.95 (1.40)	(0.46)
Adult	52.79 (7.33)	179.09 (13.42)	200.92 (14.21)	188.06 (13.75)	214.80 (14.69)	184.78 (13.63)	(0.95)
Pepper							
S. paniceum							
Larva	3.34 (2.08)	6.64 (2.76)	5.55 (2.56)	3.28 (2.07)	3.56 (2.14)	5.60 (2.57)	(0.39)
Pupa	0.00 (1.00)	1.21 (1.49)	1.21 (1.49)	1.06 (1.44)	0.54 (1.54)	0.87 (1.37)	-
Adult	50.00 (7.14)	54.00 (7.42)	57.65 (7.66)	62.00 (7.94)	62.97 (8.00)	65.65 (8.16)	(0.14)

Figures in parantheses are transformed values, $\sqrt{x+1}$.

3.7.1 Ginger

3.7.1.1 L.serricorne

Ginger exposed to the attack of L. serricorne showed a mean larval population of 6.08 at the end of first month. Compared to this, significantly higher mean populations were recorded in second, third and fourth months (14.60, 12.18 and 10.76, respectively) and these were on par. Significant reduction in mean larval population was noticed between fourth to sixth month (10.76, 4.95 and 5.25, respectively). A slight insignificant increase in mean population was recorded in sixth month compared to that in fifth (5.25 and 4.95 respectively).

Significantly higher population of the pupae of L. serricorne was observed in the second month compared to that of the first month (0.96 and 7.01) and after that significantly lower mean population of pupae was observed from third month onwards when compared with that of the second month and during this period the pupal population ranged from 1.86 to 2.84 and were on par.

Significant increase in population of the adults of L. serricorne was observed up to the third month of exposure (50.84 to 142.52) and a decrease in the mean adult population was noticed in the fourth month (127.37). A slight increase in the adult population was recorded in the fifth and sixth months (143.72 and 143.0).

3.7.1.2 A. fasciculatus

The mean number of larvae of A. fasciculatus exposed to ginger by the end of the first month was 4.81. Compared to this, significantly higher larval populations were noticed in the second, third and fifth months (13.98, 8.24 and 10.83, respectively). Significant reduction in mean larval population was observed in third, fourth and sixth months when compared to the second month (8.24, 6.67 and 6.90, respectively) and were on par. But no significant difference could be seen in the mean larval population of second and fifth month (13.98 and 10.83).

The mean pupal population recorded at the end of first month was 1.07. Significantly higher mean pupal populations were observed in second, fourth and fifth months (2.76, 2.92 and 2.76, respectively) and which were on par. The mean pupal populations in the first, third and sixth month were on par which ranged from 1.07 to 1.62.

Fig.13 Extent of damage caused by *L. serricorne* to stored turmeric

a. control

b. six months after release

A. fasciculatus when exposed to ginger showed a mean adult population of 49.69 at the end of first month. Compared to this significantly higher adult populations were recorded from second month onwards which ranged from 49.69 to 101.41. The mean population between second and third month and third and fourth month were on par (59.22 and 64.93 and 64.93 and 68.22 respectively). The mean adult populations noticed in fourth, fifth and sixth months showed significant difference (68.22, 88.68 and 101.41 respectively).

3.7.2 Turmeric

3.7.2.1 L. serricorne

A mean larval population of 16.47 was noticed in the first month when turmeric was exposed to L. serricorne. Significantly higher mean larval population was recorded in the second month (35.98). Significantly lower mean populations of larva were observed in the succeeding months compared to that of the second month which ranged from 4.59 to 35.98. The mean larval population seen in the third and fourth months (3.80 and 3.53) did not show significant difference compared to the first month and that recorded in the fifth and sixth month were on par (5.94 and 4.59, respectively).

Significantly higher mean population of pupae was observed in the second month compared to that of the first month (11.74 and 4.89). The mean populations noticed in third, fourth, fifth and sixth months were significantly low compared to the second month. The mean pupal populations in the third, fifth and sixth months were on par (1.11, 0.85 and 0.95 respectively).

The mean adult population of L. serricorne in turmeric was 52.79 in the first month. Significantly higher mean populations were observed in rest of the period compared to that of the first month. The mean populations in the second, third, fourth and sixth months were on par (179.09, 200.92, 188.06 and 184.78 respectively). The highest mean population of 214.80 was recorded in fifth month and this did not show significant difference compared to that of the third month.

3.7.3 Pepper

3.7.3.1. S. paniceum

Pepper exposed to S. paniceum showed a mean larval population of 3.34 in the first month. Significantly higher mean population of 6.64 was observed in the second month and

it was on par with the mean population noticed in third and sixth month (5.55 and 5.60 respectively). The mean larval population recorded in first, fourth and fifth months also did not show any significant difference.

The mean pupal population of S. paniceum ranged from 0 to 1.21 and it did not show any significant difference over six months time.

Significant differences in the mean adult population could be observed between the observations recorded in all the months except in fourth and fifth, which were on par (62.0 and 62.97). The mean population ranged from 50.00 to 65.65 from first to sixth month.

3.8 Voltaile oil content of stored ginger and turmeric exposed to insect pests

The data relating to the experiment and the results of statistical analysis of the same are presented in Table 6.

The mean volatile oil content of ginger exposed to L. serricorne showed a reduction from 2.86 to 0.93 per cent, over a period of six months, from the time of storage,

TABLE 6. Volatile oil content of stored ginger and turmeric exposed to the attack of insect pests observed at monthly intervals from the time of exposure onwards

Treatments	Mean percentage volatile oil content (V/W)						
	At the time of exposure	1	2	3	4	5	6
Ginger							
L. serricorne	2.86	2.00	1.60	1.60	1.60	1.07	0.93
Control	2.86	2.00	2.00	2.00	2.00	1.60	1.60
A. fasciculatus	2.86	2.00	1.60	1.60	1.60	1.13	0.87
Control	2.86	2.00	2.00	2.00	2.00	1.60	1.60
Turmeric							
L. serricorne	4.47	4.27	3.60	3.07	3.07	3.00	2.73
Control	4.47	4.40	4.00	4.00	4.00	4.00	4.00

CD(0.05) Ginger - *L. serricorne* - 0.09 Ginger - *A. fasciculatus* - 0.07

Turmeric- *L. serricorne* - 0.16.

whereas a decrease from 2.86 to 1.60 per cent only was noticed in the control. Significant loss in the volatile oil content was observed in the infested samples compared to that of the control from second month onwards.

Ginger infested by A. fasciculatus also showed a decrease in mean percentage volatile oil content. At the end of the sixth month the mean volatile oil content of infested samples recorded a reduction from 2.86 to 0.87 per cent. But the corresponding decrease in the control samples was from 2.86 to 1.60 per cent only. Significant differences in the volatile oil content of infested and control samples were observed from the second month onwards.

When turmeric was exposed to L. serricorne the mean volatile oil content showed a decrease from 4.47 to 2.73 per cent over a period of six months. The corresponding decrease in the control samples observed was from 4.47 to 4.00 per cent only. Significant decrease in mean percentage volatile oil content was noticed in infested samples from the second month onwards compared to that in control.

3.9 Non volatile acetone extract of stored ginger and turmeric exposed to insects

The data relating to the experiment and the results of the statistical analysis of the same are shown in Table 7.

Table 7. Non volatile acetone extract of stored ginger and turmeric exposed to the attack of different insect pests observed at monthly intervals from the time of exposure onwards

Treatments	Mean percentage non volatile acetone extract (w/w)						
	At the time of exposure	1	2	3	4	5	6
Ginger							
L. serricorne	5.82	5.55	5.14	4.92	4.72	4.57	4.37
Control	5.82	5.83	5.42	5.30	5.22	5.21	5.20
A. fasciculatus	5.82	5.65	5.21	4.86	4.70	4.62	4.35
Control	5.82	5.83	5.42	5.30	5.22	5.21	5.20
Turmeric							
L. serricorne	12.59	12.28	12.13	12.03	11.75	11.56	11.16
Control	12.59	12.49	12.45	12.40	12.23	12.20	12.21

CD (0.05) Ginger -L. serricorne - 0.29 Ginger - A. fasciculatus - 0.26

Turmeric -L.serricorne-0.52.

The mean percentage non voltaile acetone extract of ginger exposed to L. serricorne noticed a reduction from 5.82 to 4.37 per cent at the end of the sixth month where as in control a decrease from 5.82 to 5.20 per cent was observed. Significant reduction in mean percentage non volatile acetone extract was recorded from third month to six month, compared to that in control (4.92 and 5.30, 4.72 and 5.22, 4.57 and 5.21, and 4.37 and 5.2, respectively).

When ginger was exposed to A. fasciculatus the mean non volatile acetone extract showed a reduction 5.82 to 4.35 per cent over a period of six months. The corresponding decrease in the non volatile acetone extract of control samples was from 5.82 to 5.20 per cent. When compared to control the mean percentage non volatile acetone extract infested samples suffered significant loss from the third month onwards.

The mean non volatile acetone extract of turmeric exposed toL. serricorne showed a reduction from 12.59 to 11.16 per cent by the end of the sixth month where as a decrease from 12.59 to 12.21 per cent was noticed in control. Significant loss in mean percentage non volatile acetone extract was observed in infested samples compared to that of control in fifth and sixth month.

The correlation between the population build up of the different insect pests and the percentage weight loss and the qualitative parameters, namely, percentage volatile oil content and non volatile acetone extract were worked out and the results are presented in Table 8. There was significant positive correlation between the percentage weight loss and the total population build up of L. serricorne in ginger and turmeric and A. fasciculatus in ginger. Positive correlation was obtained between the percentage weight loss and the total population build up of S. paniceum in pepper but it was not significant. Significant negative correlation was seen between the total population build up and volatile oil content in ginger exposed to L. serricorne and A. fasciculatus and turmeric exposed to L. serricorne. There was significant negative correlation between the population build up and the percentage non volatile acetone extract in ginger exposed to L. serricorne and A. fasciculatus. Negative correlation was obtained between the population build up and the percentage non volatile acetone extract inturmeric exposed to L. serricorne but it did not attain the significant levels.

3.10 Development of insect pests in ginger, turmeric and pepper

The data relating to the experiment and the results of the statistical analysis of same are shown in Table 9.

Table 8.

Correlation between the population of insect pests attacking ginger, turmeric and pepper and the percentage weight loss, the percentage volatile oil content and non volatile acetone extract

Insects	Observations taken over a period of six months. Weightloss	Volatile oil	Non volatile acetone extract
Ginger			
L. serricorne	0.8053**	- 0.5226**	- 0.4924**
A fasciculatus	0.9034**	- 0.8514**	- 0.7578**
Turmeric			
L serricorne	0.8069**	- 0.8070**	- 0.2000
Pepper			
S paniceum	0.2901		

** significant at 1 per cent level

Table 9. Development of insect pests in ginger, turmeric and pepper

Treatments	Mean time observed for the development of different life stages (Days)			
	Egg period	Larval period	Pupal period	Adult longevity
L. serricorne				
Ginger	6.10	26.50	4.60	10.80
Turmeric	4.90	24.60	4.10	11.40
S. paniceum				
Turmeric	8.20	30.10	6.30	7.40
Pepper	9.70	31.30	7.80	5.70
A. fasciculatus				
Ginger	6.90	38.20	5.80	14.00

CD (0.05) *L. serricorne* Egg period-1.19 Larval period—Pupal period — Adult longevity

CD(0.05) *S.paniceum* Egg period-0.98 Larval period—Pupal period -1.36 Adult longevity- 1.26.

Among the mean durations of different developmental stages of L. serricorne on ginger and turmeric, significant difference was noticed in the incubation period only and were 6.10 days in ginger and 4.90 days in turmeric. The mean larval durations recorded were 26.50 days in ginger and 24.60 days in turmeric.

The mean pupal periods were 4.60 and 4.10 in ginger and turmeric respectively. The adult beetle had a mean longevity of 10.80 days in ginger and 11.40 days in turmeric.

The mean incubation period of S. paniceum showed significant difference in turmeric and pepper. Significantly higher duration of 9.70 days was observed in pepper and 8.20 days in turmeric. The mean larval durations observed in turmeric and pepper were not significant which were 30.10 days in turmeric and 31.30 days in pepper. Significant differences in the pupal duration of S. paniceum could be seen in turmeric (6.30 days) and pepper (7.80 days). Significantly high longeity of adults was observed in turmeric (7.40 days) compared to that in pepper (5.70 days.)

The incubation, larval and pupal duration of A. fasciculatus in ginger were 6.90, 38.20 and 5.80 days, respectively. The mean longevity of adult beetles in ginger was observed as 14.00 days.

DISCUSSION

4. DISCUSSION

A detailed survey was undertaken to assess the pest problems of stored ginger, turmeric, pepper and cardamom in five districts of Kerala for a period of six months. The distribution, nature of damage, extent of damage and biology of important insect pests associated with these commodities were investigated in detail. The results of the studies are discussed below:

The periodic survey revealed that stored ginger was infested by two major pests, L.serricorne and A.fasciculatus and two minor pests, T.castaneum and L.minutus. Low populations of O.surinamensis, R.dominica, P.manihotalis, E.zebrina and S.rutella were seen in some of the godowns. Earlier workers also have reported infestation of stored ginger by insects. Abraham (1975) mentioned infestation by L.serricorne, A.fasciculatus, T. mauritanicus and Ephestia sp. in giger from Kerala. In Bangladesh, L.serricorne, S.paniceum and R.dominica were reported as serious pests of stored ginger (Rezaur et al.,1982). But S.paniceum was not observed in ginger in the present survey and R.dominica and E.zebrina were noticed only in a few samples. E.zebrina identified in the present survey was not reported earlier as a pest of ginger.

As evidenced from the survey in the godowns of five districts over a period of six months, the incidence of one of the major pests of ginger, L.serricorne showed significant variation in the different godowns of Kozhikode and Ernakulam districts. The highest mean population was noticed in August followed by that in October in the above disricts and the least incidence was observed in the month of December in all the districts.

Observations on the nature of damage of L.serricorne showed that the adults and grubs were boring into the rhizomes of ginger. Severely attacked rhizomes showed irregular larval tunnels internally and circular adult emergence holes on the surface and the internal contents were converted into powder. Abraham (1975) also reported similar damage where the grubs of L.serricorne bored into the rhizomes of ginger, tunnelling in all directions and riddling them badly.

Laboratory studies on the extent of damage (Table 4) revealed that dry ginger exposed to the attack of L.serricorne suffered significant damage. The extent of damage caused by a population of 50 insects of L.serricorne per 100 g weight of ginger reached 1.07 per cent by the end of first month, 8.84 per cent by second month and 11.68 and 13.01 per cent by the end of fourth and sixth months respectively. An eight fold increase in mean percentage weight loss was recorded in ginger exposed to

L.serricorne at the end of the second month compared to the first month. This might be due to the presence of high population of immature stages. The apparent stagnation in weight loss observed between the second and third, fourth and fifth and fifth and sixth months might be due to the reduction in the mean population of the immature stages. Though the adult population in the third month showed significant increase, corresponding increase in weight loss was not observed. This indicates that the grubs of the insect might be the active feeder.

Along with the assessment of quantitative loss due to the infestation by L.serricorne, the qualitative loss also was estimated in terms of percentage volatile oil content and non volatile acetone extract. It was observed that the pest infestation affects the quality of the produce. As per the British and U.S. government standards (Purseglove et al., 1981) and ISO specifications (Govindarajan, 1982) ginger should contain a minimum of 1.5 per cent volatile oil (V/W). When compared to this minimum prescribed requirement, ginger infested by L.serricorne suffered significant loss in quality after a period of five months. According to the United Kingdom standards (Purseglove etal., 1981), the percentage non volatile acetone extract of ginger should not be less than 4.5 per cent. Compared to this minimum requirement, ginger exposed to L.serricorne suffered significant loss after the sixth month of exposure.

There was significant positive correlation between the percentage weight loss and the total population build up of L.serricorne in ginger. Significant negative correlations were observed between the total population build up and the percentage volatile oil content and non volatile acetone extract.

The biological observations of L.serricorne on ginger showed that the mean incubation period, larval and pupal durations and adult longevity were 6.1, 26.5, 4.6 and 10.8 days respectively. Investigations on the development of L.serricorne on stored spices were made by earlier workers also. The incubation and larval periods of the insect were 6.7 days and 17 to 29 days in stored spices as reported by Mehta and Varma (1968) and the incubation cum larval cum pupal duration was 77 days in ginger (Ali etal., 1972).

The mean incidence of another major pest of ginger, A.fasciculatus showed significant variations between the godowns in Kozhikode, Ernakulam, Idukki and Alappuzha districts and significant variations was not recorded in the godowns of Kollam district. Significant difference in the distribution of the pest could be seen during August, October and December in Kozhikode, Ernakulam and Kollam districts. In these districts, significantly high populations were observed in August followed by October and low mean populations in December. In the other two districts also, the least incidence was noticed in the month of December.

Investigations on the nature of damage of A.fasciculatus showed that the adults and grubs were boring into the rhizomes of ginger. The attacked rhizomes showed irregular tunnels made by the larvae and adult emergence holes. Severely infested rhizomes became hollow, leaving the outer covering intact.

Studies on the extent of damage (Table 4) revealed that a damage of 6.01 per cent was caused by the end of two months after storage and 8.63 by the end of four months and 11.58 per cent by the end of six months. About five fold increase in mean percentage loss was noticed in the second month compared to that in the first month. This might be due to the feeding by the high population of immature stages during this period. Only marginal increase in weight loss was recorded between the second and third and fifth and sixth months and this might be due to the significant reduction in the mean larval population.

The qualitative analysis of ginger infested by A.fasciculatus showed that the quality was adversely affected in terms of percentage volatile oil content and non volatile acetone extract (Table 6 & 7). Significant loss in percentage volatile oil content was observed in ginger exposed to A.fasciculatus. When compared to the minimum prescribed requirement of volatile oil content (Govindarajan, 1982), ginger exposed to A. fasciculatus suffered significant loss from five months onwards.

The percentage non volatile acetone extract of ginger infested by A.fasciculatus also suffered significant loss after the sixth month of release when compared to the United Kingdom standards (Purseglove et al., 1981).

Significant positive correlation was observed between the total population build up and percentage weight loss caused by A.fasciculatus in ginger.There was significant negative correlation between the total population build up and percentage volatile oil content and non volatile acetone extract.

The biological observations of A.fasciculatus revealed that the mean incubation, larval and pupal periods were 6.9, 38.2 and 5.8 days respectively and the adults had a longevity of 14.0 days (Table 9). In a similar study by Reghunath (1969) the egg cum larval and pupal duration of A.fasciculatus ranged from 37 to 66 days and 5 to 6 days respectively on ginger and the adult females had a longevity of 15.8 days.

Along with the major pests, the distribution and nature of damage of two minor pests, namely, T.castaneum and L.minutus were also studied. Significant differences were lacking in the distribution of T.castaneum and L.minutus in the godowns surveyed in different districts. The mean populations of T.castaneum recorded in the months of August and October were on par in all the five districts and the least incidence noticed in the month of December. The mean population of L.minutus observed in the two

months (August and October) did not show significant variation in Kozhikode, Ernakulam and Alappuzha districts where as in the other two places significantly higher incidence was noticed in August. The mean population of L.minutus noticed in December was significantly low compared to that in August and October in Kozhikode and Ernakulam districts.

Observations on the nature of damage showed that the adults of T.castaneum were feeding on the broken pieces and powdered portions of ginger rhizomes. Adults of L.minutus and O.surinamensis were noted as feeding on the skin and powdered portions of ginger rhizomes.

Investigations were made on the nature of damage caused by R.dominica and some lepidopteran pests. The incidence of R.dominica in ginger was not previously reported in the State. Adults of this beetle were seen boring into the rhizomes and the split up rhizomes showed irregular tunnels made by the beetle. Combined infestation by the lepidopteran pests namely, P.manihotalis, E.zebrina and S.rutella was observed in samples of stored ginger. Caterpillars of these moths webbed together the rhizomes and remained inside the larval galleries made of silk, frass and excreta and fed from within. Though very few samples were infested by these pests, the attacked samples were made totally unfit for consumption and presented a very dirty

appearance (Fig.3,4 & 5). Mostly poor quality and neglected stocks of ginger showed serious damage by these caterpillars. Jacob (1986) also noticed rare occurrence of P.manihotalis and S.rutella in stored ginger.

The periodic survey conducted in the five districts of Kerala over a period of six months revealed that the predominant pest of stored turmeric was L.serricorne. L.minutus, T.castaneum, O.surinamensis, S.paniceum, R.dominica and P.manihotalis were also seen infesting stored turmeric at low levels. The serious pests identified in turmeric by earlier workers were S.paniceum (Muthu and Majumder, 1975) and S.paniceum and L.serricorne (Srinath and Prasad, 1975). T.castaneum, O.surinamensis, A.fasciculatus and T.mauritanicus also were recorded in turmeric as secondary pests by Srinath and Prasad (1975).

The survey revealed that the most serious pest attacking stored turmeric was L.serricorne (Table 2). Eventhough high mean populations of the pest were recorded in the various godowns of Kozhikode district compared to other districts surveyed, significant variations between godowns were lacking. The mean population levels recorded in the different godowns of Ernakulam district showed significant variation but the mean incidence recorded in the other three districts were not significant. The population levels of L.serricorne recorded significant reduction

during the months of October and December compared to that in August in the districts of Kozhikode, Ernakulam and Idukki. The mean incidence of the pest in the three periods of observation did not show much variation in Kollam district. In Alappuzha district, high mean population was observed in August compared to that in December.

Observations on the nature of damage revealed that the grubs and adults of L.serricorne bored into turmeric rhizomes (Fig. 6a) and the severely attacked rhizomes showed irregular tunnels internally and adult emergence holes externally. The internal contents were converted into powder, leaving the outer skin in a brittle condition. The similar investigations made in stored turmeric by Srinath and Prasad (1975), observed that the L.serricorne infested rhizomes were light in weight and presented adult emergence holes on the rind.

Laboratory investigations on the extent of damage caused by L.serricorne in turmeric showed a significant increase in mean weight loss (Table 4) and mean larval and pupal populations at the end of the second month (Table 5). The extent of damage reached 3.92 per cent at the end of the first month. The mean percentage loss was 15.01 per cent by the end of two months, 16.94 per cent after four months and 17.97 per cent by the end of the sixth month. About four fold increase in weight loss could be observed by the end of the second month compared to that of

the first. This increase in percentage loss was attributed to the presence of the highest mean population of the immature stages. Only a marginal increase in weight loss was recorded in the succeeding months and this might be due to the significant reduction in the population of immature stages during that period. In a similar study conducted by Agrawal et al. (1981), a weight loss of 8.85 per cent was noticed in turmeric infested by L.serricorne over a period of seven months.

Turmeric infested by L.serricorne suffered qualitative loss in terms of percentage volatile oil content and non volatile acetone extract. As per the British government standards (Purseglove et al., 1981), the minimum percentage volatile oil content of turmeric should be 3.5 per cent (V/W) and in infested turmeric samples the percentage volatile oil content got reduced from third month onwards when compared to the minimum requirement stipulated. The percentage non volatile acetone extract of turmeric samples infested by L.serricorne suffered significant loss five months after the exposure of the insects to the produce compared to that of the control.

There was significant positive correlation between the total population build up and percentage weight loss caused by L.serricorne in turmeric. Significant negative correlation was

observed between the total population build up and the percentage volatile oil content but the correlation between the population build up and the percentage non volatile acetone extract did not attain significant levels.

Investigations on the development of L.serricorne in turmeric showed that the mean incubation, larval and pupal periods and adult longevity were 4.9, 24.6, 4.1 and 11.4 days respectively.

Observations were made on the distribution of three minor pests, namely, L.minutus, T.castaneum and O.surinamensis. Significant differences were not seen in the mean incidence of these pests in the godowns of all the five districts surveyed. The mean populations of L.minutus were on par in August and October and significantly low in December in Kozhikode district where as in Idukki district significantly high mean populations were noticed in October compared to that in August and December. Significantly high mean incidence could be observed in August in Ernakulam and Alappuzha districts and was on par in October and December in Alappuzha district. The difference between the mean populations noticed in the three periods of survey in Kollam district was insignificant. The mean populations of the other two minor pests, T.castaneum and O.surinamensis were on par in the different periods of survey in the five districts.

Studies on the nature of damage of these minor pests showed that L.minutus and O.surinamensis were not causing serious damage to turmeric. The adults of these beetles fed on the skin and powdered portions of rhizomes. Adults of T.castaneum were noticed feeding on the broken pieces and powdered portions of rhizomes.

Observations were made on the nature of damage of S.paniceum, R.dominica and the lepidopteran pest, P.manihotalis in turmeric which were noticed only in few samples. Adults and grubs of S.paniceum and adults of R.dominica were seen boring into the rhizomes and feeding on the internal contents. Rhizomes showed tunnels internally and bore holes externally. The incidence of R.dominica in turmeric was not previously reported from the State. But R.dominica was noticed as a serious pest of turmeric in Bangladesh by Rezaur et al. (1982). Caterpillars of P.manihotalis were seen in few neglected samples of turmeric. Hundred per cent damage of the attacked rhizomes was observed (Fig.8) though the attack was confined to few of the samples. Jacob (1986) also recorded rare occurrence of P.manihotalis and S.rutella in turmeric.

Even though periodic survey was conducted in the godowns of five districts for the pests of pepper, the infestation could only be noticed in some of the samples from the godowns in Idukki district.

The pests observed in pepper samples collected were, S.paniceum, L.minutus and E.zebrina. Incidence of E.zebrina was noticed at low levels in few of the samples. Earlier workers also noticed the incidence of insect pests in stored pepper. Muthu and Majumder (1974) mentioned the incidence of S.paniceum, L.serricorne, L.minutus, T.castaneum, S.oryzae, O.surinamensis, psocids and mites in pepper samples. But as reported by Abraham (1975), stored pepper was relatively free from pest damage under Kerala conditions.

Low mean populations of S.paniceum and L.minutus were observed in pepper (Table 3) in the different godowns in Idukki district. The mean incidence of these pests did not show significant variations in the different godowns and different periods.

The grubs of S.paniceum were seen boring into pepper berries and pupated there in and the attacked berries showed adult emergence holes also. Adult insects were seen inside the larval tunnels and fed on the internal contents of berries and the outer rind. Adults of L.minutus observed in pepper samples were seen feeding on the spike stalks and the powdery materials. They were not seen feeding on whole pepper berries. Low incidence of E.zebrina was noticed in few samples of pepper. The

caterpillars of this moth webbed together the berries and the webs were made of silk and profuse amount of excreta. The caterpillars remained concealed in the webs and fed on the outer skin of the berries and were not seen boring into the berries.

Studies on the quantitative loss caused by 50 adults of S.paniceum in 100 g of pepper was only 1.12 per cent at the end of the sixth month. In a study conducted by Thangavelu (1981) seven per cent weight loss was observed in pepper exposed to five pairs of adults of S.paniceum in a period of three months. Positive correlation was observed between the total population build up and the percentage weight loss caused by S.paniceum in pepper but did not attain significant levels.

Biological investigations of S.paniceum were carried out in turmeric and pepper. Significant variations in incubation and pupal periods and the adult longevity were observed when reared on these hosts. On turmeric, the incubation, larval and pupal periods and the adult longevity of S.paniceum were 8.2, 30.1, 6.3 and 7.4 days respectively. The corresponding durations in pepper were 9.7, 31.3, 7.8 and 5.7 days respectively. Thangavelu (1981) also studied on the development of S.paniceum on different produces. According to him the total developmental period of the insect ranged from 28±1.5 days on coriander, 32±2.0 days on cumin and 35±3.0 days on fennel.

As discussed under results, cardamom samples were relatively free of insect infestation. Samples were taken only from the godowns in Idukki district since the stock was not available in other districts throughout the period of observation. Although low incidence by adults of L.minutus was observed, it was not seen feeding on the capsules of cardamom. A survey conducted in South India by Gahukar (1972) also revealed that cardamom samples were free of insect infestation. But Muthu and Majumder (1974) mentioned S.paniceum, Abraham (1975) and Desaiet al.(1987) identified T.castaneum as attacking stored cardamom.

The detailed survey done in the State revealed that the infestation by insects is not a serious problem in small scale storimg and trading centres where these spices are not usually stored for more than one month. In medium and large godowns, high insect infestation was noticed where these spices were stored throughout the year and frequent fumigations were not followed. In these godowns, higher incidence of the pests was observed during the months of August and October and this finding is in accordance with the report of Pruthi (1969).

SUMMARY

SUMMARY

5.1. Survey on the incidence of insect pests of ginger, turmeric, pepper and cardamom

Samples of ginger, turmeric, pepper and cardamom were collected from godowns in Kozhikode, Ernakulam, Idukki, Alappuzha and Kollam districts of Kerala at bimonthly intervals for a period of six months to study the occurrence and distribution of insect pests in these produces under storage conditions. The various life stages of the insects present were counted and recorded. The results led to the following conclusions:

(1) Stored ginger was infested by two major pests L. serricorne and A. fasciculatus; stored turmeric by L. serricorne and pepper by S. paniceum. Cardamom was relatively free of insect infestation.

(2) Both larvae and adults of L. serricorne bored into the rhizomes of ginger and turmeric, by making irregular tunnels within and circular adult emergence holes on the surface of the rhizomes and converted the internal contents into powder.

(3) Adults and grubs of A. fasciculatus bored into the rhizomes of ginger, tunnelled in a zigzag manner and under severe infestation reduced the internal contents into powder leaving the outer skin intact.

(4) T. castaneum and L. minutus and O. surinamensis occurred in stored ginger and turmeric as minor pests.

(5) Adults of R. dominica bored and fed on the internal contents of ginger and turmeric in a few samples.

(6) Adults and grubs of S. paniceum bored into turmeric rhizomes, made irregular tunnels and fed on the internal contents.

(7) Caterpillars of P. manihotalis, E. zebrina and S. rutella were seen infesting neglected stocks of stored ginger and P. manihotalis in turmeric. Attacked samples were totally damaged.

(8) Grubs of S. paniceum bored into pepper berries, fed on the internal contents and pupated there in. Adult emergence holes were noticed on the surface of the berries. Adults of L. minutus fed on the spike stalks

and powdery portions found in the samples. Caterpillars of E. zebrina webbed pepper berries together and remained within the webs made of silk and excreta and fed on the skin of the berries.

5.2. Extent of damage caused by L. serricorne and A. fasciculatus in ginger, L. serricorne in turmeric and S. paniceum in pepper

A laboratory experiment was carried out to assess the quantitative and qualitative losses caused by these insects by exposing 50 numbers of the insects to 100 g of the produces. The extent of damage caused and the population build up of these insects were recorded at monthly intervals for six months. The results revealed that:

(1) L. serricorne caused 8.84 per cent loss by the end of two months, 11.68 per cent after four months and 13.01 per cent at the end of six months in ginger ; 15.01 per cent by the end of two months, 16.94 per cent after four months and 17.97 per cent at the end of six months in turmeric.

11.58 per cent after six months in ginger

(3) the extent of damage caused by S. paniceum in pepper was only 1.12 per cent at the end of six months.

(4) L. serricorne and A. fasciculatus infested ginger suffered significant loss in volatile oil content after five months compared to the fixed quality standards.

(5) turmeric infested by L. serricorne showed significantly low content of volatile oil after three months of storage compared to the fixed quality standards.

(6) Ginger exposed to L. serricorne and A. fasciculatus suffered significant loss in non volatile acetone extract only in the sixth month of storage compared to the fixed quality standards.

(7) Turmeric exposed to L. serricorne showed significant loss in non volatile acetone extract after five months of storage compared to that of control.

(8) In ginger exposed to L. serricorne, A. fasciculatus and turmeric exposed to L. serricorne the highest mean population of immature stages and sharp increase in intensity of damage were observed at the end of second month of exposure.

(9) Significant positive correlation existed between the population build up and the percentage weight loss in ginger exposed to L. serricorne and A. fasciculatus and turmeric exposed to L. serricorne, but in pepper exposed to S. paniceum the correlation did not attain the significant levels.

(10) Significant negative correlation existed between population build up and the volatile oil content of ginger exposed to L. serricorne and A. fasciculatus and turmeric exposed to L. serricorne.

(11) Significant negative correlation was reocorded between the population build up and non volatile acetone extract in ginger exposed to L. serricorne and A. fasciculatus, but in turmeric exposed to L. serricorne the correlation did not reach the significant level.

5.3. Development of insect pests in ginger, turmeric and pepper

Laboratory studies on the development of L. serricorne in ginger and turmeric, S. paniceum in turmeric and pepper and A. fasciculatus in ginger revealed the following :

(1) Significantly high incubation period of L. serricorne was recorded in stored ginger compared to that in turmeric (6.1 and 4.9 respectively). Insignificant differences were noticed between the mean larval and pupal duration and adult longevity of L. serricorne in ginger and turmeric.

(2) Significantly high egg and pupal periods of S. paniceum were noticed in pepper compared to that in turmeric ; where as the adult longevity was significantly low in pepper compared to that in turmeric.

(3) Compared to L. serricorne, A. fasciculatus took longer period to complete its development in ginger.

REFERENCE

REFERENCES

Abraham, C.C. (1975). Insect pests of stred spices and their control. Arecanut and Spices Bull. 7 (1): 4-6.

Agrawal, J.P., Pandey, G.P. and Doharey, R.B., (1981) : Storage losses in turmeric (Curcuma longa L.) by Lasioderma serricorne Fab. Bull. Grain Tech. 19 (3): 223-225.

* Ali, A.D. Donia, A.R. and El-Sawaf, S.K. (1972). The influence of natural food on the development and reproductive rate of Lasioderma serricorne Fab. (Coleoptera: Anobiidae). Zeitschrift fur Angewandte Entomologie 72 (2): 212-220.

* Anonymous, (1970). F.I.C.L. Entomol. Dept. circ. 197 (1&8)

A.O.A.C. (1975). Official Methods of Analysis. Association of Official Agricultural Chemists Washington, 12th Edition.

ASTA (1968). Official Analytical Methods American Spice Trade Association, INC, New Jersey, 2nd Edition.

* Ballou, H.A. (1919). Miscellaneous Insects. Agric. News, Barbados 18 : 74.

Bhattacharya, A.K., Vyas, H.J. and Rathore, Y.S. (1977). Damage of soybean by Lasioderma serricorne (Fab.). Bull. Grain Tech. 15 (2): 151-152.

Bhutani, D.K. (1984). Spices and pest problems: 3. coriander. Pestcides 18 (9): 15-17.

* Bitran, E.A. (1973). An evaluation under experimental conditions of the damage caused by the coffee bean weevil Araecerus fasciculatus (Degeer, 1775) (Coleoptera, Anthribidae) in stored cured coffee. Arquivos do Instituto Biologic 40 (4): 343-355.

* Blumberg, B.L. (1939). Insect infestation of drugs. J. Am. Pharm. Assoc. 28 : 483.

Brar, J.S. and Chahal, B.S. (1980). Biology of drug store beetle, Stegobium paniceum (Linn.) Coleptera: Anobiidae. J. Res., Punjab Agricultural University 17 (2): 240-241.

* Burcea, D. (1986). Development of cigarette beetle (Lasioderma serricorne Fab.) on various food products. Bulletinal Informativ al Academiei de Stiinte Agricole si silvice. 15: 163-173.

Chander, H., Kulkarni, S.G. and Berry, S.K. (1990). Infestation and breeding capability of insect pests in some Indian savoury preparation. Ann. Biol. 6 (1): 69-74.

* Chin, W.T. and Lin, H.C. (1990). Studies on the occurrence of cigarette beetle, Lasioderma serricorne (Fab.) with serrico trap in Fen-Yuan tobacco factory. Bull. Tobacco Res. Institute 32: 53-58.

Clevenger, J.F. (1928). Apparatus for the determination of volatile oil. J. Am. Pharm. Assoc. 17: 346.

* Concha, C.A. (1956). The bionomics and control of Araecerus fasciculatus at Burranquilla, Columbia Rev. Fac. Agron. 18 (49): 30-31.

* Cotterel, G.S. (1934). Infestation of stored cacao by weevil Araecerus. fasciculatus and moth Ephestia cautella. Bull. Dep. Agric. Gold coast 28 : 14.

* Cotterel, G.S. (1952). The insects associated with export produce in Southern Nigeria. Bull. Ent. Res. 43 : 145-152.

Desai, S.R.P., Sharma, A. and Amonkar, S.V. (1987). Disinfestation of whole and ground spices by gamma irradiation. J. Fd. Sci. and Tech. 24 (6): 321-322.

* Dobson, O.M. (1960). Entomol. Monthly Mag. 95: 158-159.

Edison, S. and Johny, A.K. (1991). Increasing yield of spices by growing new varieties: A status report. Indian Cocoa, Arecanut and Spices J. 14 (4): 138-144.

* Farag, F.A. and Ismail, A.Y. (1985). Study on the biological activities of the adult cigarette beetle, Lasioderma serricorne Fab. Iraqui J. Agric. Sci. 3 (4): 107 - 112.

Faure, O.G. (1953). Pests of edible legumes in Chile. FAO Pl. Prot. Bull. 1 (11): 166-168.

* Figueiredo jr., E.R. (1957). The control of Araecerus fasiculatus. Biologico 23 (1): 197-200.

* Forsyth, J. (1957). Insect infestation in stored cocoa in Ghana. Ghana Fmr. 1 (4): 133-135.

Gahukar, R.T. (1972). Pest infestation survey of agricultural commodities in South India. Bull. Grain Tech. 10 (3): 173-180.

* Ghosh, B.N. and Silva, P. (1972). Some observations on the storage of cacao in Brazil. Cacau Atualidades 9 (1): 11-21.

Girish , G.K. and Punj, G.K. (1969). Dietary efficiency of natural foods for the growth and development of stored grain insect pest. Bull. Grain Tech. 7 (1): 9-18.

Golding, F.D. (1941). Two new methods of trapping the cacao moth (Ephestia cautella). Bull . Ent.Res. 32: 123-132.

Goncalves, L.I. Bitran, H. V. and Bitran, E.A. (1976). Contribution to the biology of the coffee borer Araecerus fasciculatus (Degeer, 1775) (Coleoptera: Anthribidae). Arquivos do Instituto Biologico, Sao Paulo 43 (3 & 4) : 81-88.

Govindarajan, V.S. (1982). Ginger - Chemistry, technology and quality evaluation. part 2. CRC Crit. Rev. Fd. Sci. nutr. 17 (3): 189-258.

* Guerra, M.D. and Santos, S.M.D. (1977). Occurrence of insects in dried fruits in Rio Grande do sul. Anais da Sociedade Entomotogica do Brasil 6 (2): 306-311.

* Hargreaves, E. (1926). Reports of the Entomological section. Rep. Lds For. Dep. Sierra Leone, pp. 16-18.

Hussain, M. and Khan, M.Q. (1966). Record of Lasioderma serricorne Fab. (Anobiidae: Coleoptera) on stored castor beans. Sci. and Cult. 32: 212.

* Hutson, J.C. (1939). Report on the work of the Entomological Division. Adm. Rep. Dir. Agric. Ceylon pp. D19-D20.

* Iheagwam, E.U. (1986). Preliminary observations on the entomofauna of the water yam, Dioscorea alata L. during storage. Deutsche Entomologische Zeitschrift 33 (1&2): 71-73.

* Iragorry, B.L. (1940). A note on Araecerus fasciculatus attacking coffee beans. Bot. Lab. Clin. Luis Ruzelti 1 (1): 2-4.

Jacob, S. (1992). Storage pests of spices and their management. Spice India 5 (2): 14-15.

Jacob, S.A. (1986). Important pests of ginger and turmeric and their control. Indian Cocoa, Arecanut and Spices J. 9: 61-62.

* Janssens, J.and Clercq, R.D. (1990). Arthropods in imported cocoa stocks. Revue de l' Agriculture 43 (4): 581-585.

* Jepson, F.P. (1935). Report on the work of the Entomological Division, 1934. Adm. Rep. Dir. Agric. Ceylon pp. D 132- D147.

Joseph , K.V. and Oommen, C.N. (1963). Insect pests of stored tapioca (Manihot utilissima Pohl.) in Kerala: Notes on the biology of a new pest. Pyralis manihotalis Guen. (Pyralidae) Agric. Res. J. Kerala 2 (1): 53-62.

Joshi, H.C. and Srivastava, B.K. (1964). Insects intercepted in the processed food, Bari in storage. Bull. Grain Tech. 2 (4): 115-123.

Kavadia, V.S. Pareek, B.L. and Sharma, K.P. (1978). Control of Lasioderma serricorne Fab. infestation of dry turmeric by phosphine fumigation. Entomon 3 (1): 57-58.

Khan, S.A. and Naqvi, S. N.H. (1984). Laboratory tests on the efficacy and penetration of phosphine at varied temperatures, humidities and exposure periods against Lasioderma serricorne Fab. in coriander seeds (Coleoptera: Anobiidae). Proc. Entomol. Soc. Karachi 14 & 15 : 59-66.

* Kismali, S. and Goktay, M. (1988). Investigations on some characteristics of Lasioderma serricorne (Fab.) (Coleoptera: Anobiidae). Turkiye Entomologi Dergisi 12 (1): 55-59.

Kurup, A. and Parkhe, D.P. (1961). Some observation on the biology of the cigaratte beetle (Lasioderma serricorne Fab.) Ind. J. Ent. 23 : 274 - 278.

* Laibach, E. 1967. Anz. Schadlingsk. 38 (3): 33-36.

Lal, S.S. and Pillai, K.S. (1977). New record of Araecerus fasciculatus Degeer. On Dioscorea alata and Amorphophallus companulatus under storage at Trivandrum. Bull. Grain Tech. 15 (3): 225.

* Lever , R.J.A.W. (1941). Entomological notes. Agric. J. Fiji 12: 19-22.

* Lever , R.J.A.W. (1943). Entomological notes. Agric. J. Fiji 14 (1): 14-18.

* Lin, T. (1976). Studies on life cycle and control of coffee bean weevil, Araecerus fasciculatus (Degeer) (Coleoptera: Anthribidae). J. Agric. Res. China 25 (1) : 44-52.

* Lincoln Plant Protection Centre (1985) Weta 8 (2): 34-35.

Malek, M.A. Khanom, L.A.M. and Parveen, B. (1988). New record of an alternate host plant of cigarettee beetle, Lasioderma serricorne Fab. (Coleoptera, Anobiidae.) Bangladesh J. Zool. 16 (1): 59-60.

* Malinoswka, B.D. (1964). The cofee bean beetle Araecerus fasciculatus in a consignment of coffee. Polskie. Pismo. Ent. (B): 109-111.

* Mangoendihardjo, S. (1983). Studies on major pests of dried cassava and their control. Proc. Biotrop Symp. on pests of stored products p. 24-26.

Mannan, M.A., Alam, M.Z. (1981). Effect of temperatures on the developmental stages of cheroot beetle Lasioderma serricorne (Fab.). Bangladesh J. Agric. Res. 6 (1) : 39-44.

* Mehta, P.R. and Varma, B.K. (1968). Plant Protection. Directorate of Extension, Ministry of Food. pp. 587.

* Miwa, Y. (1937). Insect pest of coffee and coffee trees. Bull. Govt. Res. Inst. Formosa 126 : 33.

* Morris, H.M. (1938). Annual report of the Entomologist for 1937. Rep. Dep. Agric. Cyprus 42 - 47.

* Mphuru, A.N. (1974). Trop. Stored Prod. Inf. 26: 7-15.

* Munro , J.W. and Thompson, W.S. (1929). Report on insect infestation of stored cacao. EMS, 24: 40.

Muthu, M. and Majumder, S.K. (1974). Insect control of spices. Proc. Symp. Dev. prospects Spice Ind. pp. 35.

* Nagano, M. (1979). Coffee bean weevil injurious to garlic. Proc. Assoc. pl. Prot. Kyushu. 25 : 92-94.

Nalinakumari, T. (1989). Studies on the extent of damage caused by pests of stored copra and control of the important pests. Ph.D. thesis, Kerala Agricultural University, Vellanikkara, Thrissur. pp. 171.

* Nasr, A.S.E., Assem, M.A. and Sherif, A.R.A. (1974). Rates of infestation of the main insects attacking stored garlic bulbs. Bull. de la Soc. Ent. Egypte 58: 31-34.

* Niiho, C. (1984). Ecological study of the tobacco beetle, Lasioderma serricorne (Fab.). II. Growth of tobacco beetles fed on bread crumbs. Japanese J. Appl. Ent. and Zool. 28 (4). 209-216.

* Nwana, I.E. (1978). Entomological problems in root crops production in Nigeria. Proc. National Seminar on root and tuber crops, 1st Umdike, Nigeria : 71-80.

* Nwana, I.E. and Azodeh, I.C. (1984). The effect of variety and processing method on damage to dried yams by Araecerus fasciculatus Degeer (Coleoptera, Anthribidae). Trop. Stored Prod. Inf. 49: 3-7.

Oommen, C.N. and Joseph, K.V. (1961). Two caterpillars destructive to stored products in Kerala. Agric. Res. J. Kerala 1 (1) : 30-34.

Oommen, C.N. Nair, M.R.G.K., Das, M.N. and Visalakshi, A(1985) Insect pests of factory processed Cashewnuts. and their control. Directorate of Extn., KAU, Thrissur pp.45.

Padmavathamma, K and Rao, P.K. (1989). A new host record of cigarette beetle, Lasioderma serricorne Fab. Ind. J. Ent. 51 (2): 223-224.

Panse, V.G. and Sukhatme, P.V. (1978). Statistical methods for Agriculatural workers. ICAR, New Delhi pp. 347.

Parkin, E.A. (1958). A provisional assessment of malathion for stored product insect control. J. Sci. Fd. Agric. 9 (6): 370-375.

Patel, D.J. and Makadia, B.M. (1981). Isabgul (Plantago ovata) seeds , a new host of cigarette beetle (Lasioderma serricorne, Fab). Gujarat Agric. Uty. Res. J. 7 (1): 43-44.

Patil, A.P., Thakur, S.G. and Mohalkar, P.R. (1988). Incidence of pests of turmeric and ginger in Western Maharashtra. Indian Cocoa, Arecanut and Spices J. 12 (1): 8-9.

* Paton, R. and Creffield, J.W. (1987). The tolerance of some timber insect pests to atmospheres of CO_2 and CO_2 in air. International pest control 29 (1): 10-12.

Pillai, K.S. and Rajamma, P. (1987). Storage pests of tuber crops Annual. progress report for 1986 : 89-90.

* Popov, V.I. (1960). The tobacco beetle - Lasioderma serricorne Fab. in Bulgaria and its control. Nauch. Trud. Agron. Fak. Selsk. Inst. Dimitrov. 8 : 327-356.

Pruthi, H.S. (1969). Textbook on Agricultural Entomology. ICAR, New Delhi pp. 977.

Purseglove, J.W. Brown, E.G., Green, C.L. and Robbins, S.R.J. (1981). Spices Vol. 2. Longman group Ltd. pp.813.

Puzzid, D. and Pereira, H.F. (1967). Preliminary studies on the bionomics of the coffee beetle Araecerus. fasciculatus. Biologico 33 (5): 97.101.

Ramlabeevi, S. (1988). Studies on the nature and extent of damage caused by insect pests to stored tapioca chips. M.Sc thesis, Kerala Agricultural University, Thrissur pp. 80.

Rao, D. and Prasad, S.N. (1956). A new record of Lasioderma serricorne Fab. (cigarette beetle) breeding on stored seed of Striga spp. Ind. J. Ent. 18: 459-460.

Rao, T.V. and Rao, N.K.R. (1954). A note on the control of Lasioderma serricorne Fab. - a pest of stored dry ginger. Ind. J. Ent. 16 (4); 416-418.

Reghunath, P. (1969). Studies on the host-biology relations of Araecerus fasciculatus Degeer (Anthribidae : Coleoptera). M.Sc. thesis, University of Kerala, Trivandrum pp. 47.

Reghunath, P. and Nair, M.R.G.K. (1970). Host-biology relations of Araecerus fasciculatus Degeer. Agric. Res. J. Kerala 8 (1): 17-21.

Rezaur, R., Ahmed, M., Hossain, M. and Nahar, G. (1982). A preliminary report on the problems of dried spice pests and their control. Bangladesh J. Zool. 10 (2): 141-144.

* Richards, O.W. and Herford, G.V.B. (1930). Insects found associated with cacao, spices and dried fruits in London warehouses. Ann. Appl. Biol. 17: 367-395.

* Runner, G.A. (1919). The Tobacco Beetle : an important pest in tobacco products. Bull. U.S. Dep. Agric. 737:77.

Samuel, R., Prabhu, V.K.K. and Narayanan, C.S. (1984). Influence of spice essential oil on the life history Lasioderma serricorne (F.). Entomon 9 (3): 209-215.

*Shibuya, S. and Yamada, S. (1935). Life history of Lasioderma serricorne Fab., injuring dried gingers. Oyo. Dobuts Zasshi 7 : 104-106.

Singh, V. (1988). Serious pests of stored cashew kernels. J. Plant. Crops 16 (2) : 133-137.

Sivadasan, C.R. (1991). Quality of dried ginger produced at grower's level. Quality improvement of ginger. Spices Board, Kochi, p. 16-18.

* Soux, A.P. (1985). Some current diseases and pests of coffee. Feuille d' Extension 59:5.

Srinath, D. and Prasad, C. (1975). Lasioderma serricorne F. as a major pest of stored turmeric. Bull. Grain Tech. 13 (3): 170-171.

Srinath, D. and Prasad, C. (1980). Development of Lasioderma serricorne (F). (Coleoptera: Anobiidae) on stored black mushroom, (Morchella esculenta) (Linn.) Pers. Bull. Grain Tech. 18 (3): 233-235.

Srivastava, B.K. (1959). Stegobium paniceum as a pest of stored turmeric in Rajasthan, India and its control by fumigation. FAO Pl. Prot. Bull. 7 (8): 113-114.

Srivastava, J.B. and Saxena, B.P. (1975). Lasioderma serricorne Fab. and Stegobium paniceum Linn. (Anobiidae: Coleoptera) as pests of stored drugs. Sci. and Cult. 41 (10): 478-479.

*Stamatinis, N.C. (1935). The enemies of tobacco in warehouses, Ephestia elutella Hb. and Lasioderma serricorne Fab. The biology and measures for their control. Commun. Tob. Inst. Greece 4: 65.

Stone, P.C. (1949). Drug store beetle infesting calf starter pellets. J. Econ. Ent. 42 (2) : 371.

Sudhakar, R.T. and Rao, N.P.V. (1989). Survey on storage losses of turmeric in Guntur district of Andhra Pradesh. Bull. Grain Tech. 27 (3): 225-227.

Thampan, P.K. (1979). Stored product pests of cassava. Kerala Agricultural University. pp. 170.

Thangavelu, K. (1981). First report of Stegobium paniceum (Linn.) on some stored food products and notes on its biology. Bull. Grain Tech. 19 (2): 150-152.

* Turner, B.V.H. (1975). Food Manufacture 50 (12): 23-27.

Velappan, E.(1991). Integrated programme for the development of spices - Annual plan. Indian Cocoa,Arecanut and Spices J. 14 (4) : 137.

Vitelli, M.A., Nigg, H.N. and Brooks, R.F.(1976). Laboratory rearing of the coffee bean weevil. Florida Entomologist 59 (3): 301-303.

*White, R.E. (1982). A catalogue of the coleoptera of America north of Mexico, Family: Anobiidae. Agric. Handbook, Agric. Res. Service, U.S. Dept. of Agriculture. pp. 529-570.

White, R.T. (1957). Studies on the storage and shipment of whole pepper grown in the oreint. J. Econ. Ent. 50: 423.

*Zeck, E.H. (1943). Pests of dried fruits. Agric. Gaz. New South Wales 54: 67-71.

* Original not seen

APPENDICES

APPENDIX - I. Weather data observed at the mateorological observatory at College of Agriculture, Vellayani during the experimental period (September '1991 - February '1992)

Month	Mean temperature in °C		Relative humidity(%)
	Maximum	Minimum	
1991			
September	30.7	24.1	76.9
October	30.8	23.7	80.5
November	30.2	23.2	81.6
December	30.4	21.9	74.3
1992			
January	30.3	20.4	73.0
February	28.4	20.5	70.4

APPENDIX -II. Summary of analysis of variance for the distribution of the insect pests infesting stored ginger in five districts of Kerala

Source	Df	Mean sum of squares			
		L.serricorne	*A.fasciculatus*	*T.castaneum*	*L.minutus*
Total	749				
Districts	4	38.09**	8.26**	0.03	0.21
Months	2	29.32**	15.44**	0.66**	0.73**
Between godowns within districts					
Kozhikode	4	12.29**	7.73**	0.09	0.06
Ernakulam	4	3.80**	9.11**	0.18	0.07
Idukki	4	1.62	4.92**	0.04	0.06
Alappuzha	4	0.97	1.78*	0.06	0.04
Kollam	4	1.59	0.78	0.04	0.06
District x Month	8	7.61**	1.42*	0.01	0.15
Error	715	0.81	0.64	0.12	0.12

APPENDIX - III. Summary of analysis of variance relating to the distribution of the insect pests infesting stored turmeric in five districts of Kerala

Source	Df	Mean sum of squares			
		L.serricorne	*L.minutus*	*T.castaneum*	*O.surinamensis*
Total	749				
Districts	4	47.08**	0.02	0.07	0.03
Months	2	38.48**	0.86**	0.20	0.27
Between godowns within districts					
Kozhikode	4	2.27	0.17	0.11	0.01
Ernakulam	4	6.32**	0.13	0.02	0.02
Idukki	4	0.76	0.30	0.06	0.02
Alappuzha	4	0.91	0.10	0.09	0.02
Kollam	4	0.38	0.11	0.08	0.06
District x Month	8	8.90**	0.12	0.06	0.01
Error	715	1.01	0.12	0.10	0.11

APPENDIX -IV. Summary of analysis of variance for the distribution of the insect pests infesting stored pepper and cardamom in five districts of Kerala

Source	Df	Mean sum of squares		
		Pepper		Cardamom
		S.paniceum	*L.minutus*	*L.minutus*
Total	149			
Months	2	0.72	0.40	0.79
Between godowns within district	4	0.09	0.52	0.28
Month x Godown	8	0.09	0.28	0.12
Error	135	0.28	0.26	0.30

APPENDIX - V. Original data based on which the variations from corresponding control were worked out and presented in Table 4

Values relating to column					
1	2	3	4	5	6
Ginger					
L.serricorne					
0.46	7.25	8.50	17.10	10.90	15.25
1.36	14.50	9.00	6.98	18.10	12.86
1.20	8.20	11.30	6.50	15.80	12.46
1.12	7.05	7.55	16.25	7.95	13.89
0.76	7.58	8.50	11.75	15.30	12.99
1.38	8.59	9.25	11.72	8.50	10.85
Ginger					
A.fasciculatus					
1.18	6.80	6.95	8.05	9.00	14.95
1.27	6.85	7.00	10.35	12.80	10.95
1.11	5.58	6.85	8.28	10.01	9.96
1.13	5.85	6.50	8.08	9.85	9.95
1.16	5.23	6.85	8.20	11.90	13.95
1.78	5.85	7.95	9.05	11.78	9.95
Turmeric					
L.serricorne					
4.50	16.55	19.85	10.85	10.15	20.80
4.32	14.85	12.95	14.85	17.40	18.90
3.68	15.25	14.50	20.50	20.60	18.86
3.42	14.25	13.85	20.85	23.12	15.85
3.85	14.29	16.80	18.89	20.10	16.95
3.93	15.05	15.98	15.89	15.85	16.69
Pepper					
S.paniceum					
0.14	0.40	0.60	0.72	0.92	1.16
0.16	0.50	0.50	0.76	0.90	1.08
0.14	0.34	0.72	0.78	0.80	1.16
0.16	0.50	0.56	0.88	0.90	1.06
0.16	0.36	0.70	0.80	0.90	1.20
0.12	0.40	0.56	0.78	0.92	1.04

APPENDIX - VI Summary of analysis of variance for the extent of weight loss in stored ginger, turmeric and pepper exposed to the attack of different insect pests observed at different intervals after exposure

		Mean sum of squares			
		Ginger		Turmeric	Pepper
Source	Df	L.serricorne	A.fasciculatus	L.serricorne	S.paniceum
Total	35				
Treatments	5	118.95**	84.94**	171.06**	0.72**
Error	30	8.25	1.47	7.68	0.004

APPENDIX - VII. Summary of analysis of variance for volatile oil content of stored ginger and turmeric exposed to the attack of insect pests observed at different intervals from the time of exposure onwards

		Mean sum of squares		
		Ginger		Turmeric
Source	Df	*L.serricorne*	*A.fasciculatus*	*L.serricorne*
Total	83			
Treatments	1	2.47**	2.47**	7.32**
Months	6	3.31**	3.33**	2.14**
Interaction	6	0.19**	0.21**	0.69**
Error	70	0.006	0.003	0.02

APPENDIX - VIII. Summary of analysis of variance for non volatile acetone extract of stored ginger and turmeric exposed to the attack of insect pests observed at different intervals from the time of exposure onwards

		Mean sum of squares		
		Ginger		Turmeric
Source	Df	L.serricorne	A.fasciculatus	L.serricorne
Total	83			
Treatments	1	3.58**	3.27**	4.03**
Months	6	1.92**	2.05**	1.18**
Interaction	6	0.21**	0.24**	0.34
Error	70	0.06	0.05	0.20

APPENDIX - IX Summary of analysis of variance for the population build up of insect pests in stored ginger, turmeric and pepper observed at different periods after infestation

		Mean sum of squares											
		Ginger						Turmeric			Pepper		
urce	Df	L.serricorne			A.fasciculatus			L.serricorne			S.paniceum		
		larva	pupa	adult	larva	pupa	adult	larva	pupa	adult	larva	pupa	adult
Total	35												
Between Months	5	** 2.54	** 1.38	** 21.56	** 1.65	* 0.36	** 7.43	** 10.60	** 4.62	** 44.86	** 0.55	0.24	** 0.90
Error	30	0.32	0.19	2.04	0.24	0.12	0.12	0.40	0.15	0.66	0.11	0.11	0.02

APPENDIX - X. Summary of analysis of variance relating to the development of insect pests in stored ginger, turmeric and pepper

Source	Df	Mean sum of squares: Ginger & Turmeric *L. serricorne*	Mean sum of squares: Turmeric & Pepper *S. paniceum*
Egg period			
Total	19		
Treatments	1	7.20*	11.25**
Error	18	1.61	1.09
Larval period			
Total	19		
Treatments	1	18.05	7.20
Error	18	4.83	7.94
Pupal period			
Total	19		
Treatments	1	1.25	11.25*
Error	18	0.63	2.09
Adult longevity			
Total	19		
Treatments	1	1.80	14.45
Error	18	9.44	1.81

* significant at 5 per cent level

** significant at 1 per cent level

NATURE AND EXTENT OF DAMAGE CAUSED BY INSECT PESTS ON STORED PEPPER CARDAMOM, GINGER AND TURMERIC

BY

JIJY JOSEPH

ABSTRACT OF A THESIS
submitted in partial fulfilment of
the requirement for the Degree
MASTER OF SCIENCE IN AGRICULTURE
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1992

ABSTRACT

The occurrence and distribution of insect pests in stored ginger, turmeric, pepper and cardamom in five districts of Kerala were assessed in a survey conducted at bimonthly intervals for a period of six months. In stored ginger, the major pests recorded were L. serricorne and A. fasciculatus and in turmeric, L. serricorne. Low infestation of S. paniceum occurred in pepper. Cardamom was relatively free of insect infestation. Both adult and larval stages of these pests damaged these produces. Besides these, damages by T. castaneum, L. minutus, O. surinamensis and R. dominica in ginger and turmeric were observed in a few samples. Stray samples of turmeric also showed infestation by adults and grubs of S. paniceum. Caterpillars of P. manihotalis, E. zebrina and S. rutella were seen infesting neglected stocks of ginger and P. manihotalis and E. zebrina in neglected stocks of turmeric and pepper respectively.

Quantitative loss studies revealed a loss of 13.01 per cent and 17.97 per cent respectively in ginger and turmeric by L.serricorne in six months, where as A. fasciculatus caused 11.58 per cent loss in ginger. Pepper exposed to S. paniceum caused only 1.2 per cent loss over a period of six months.

While the volatile oil content of ginger infested by L. serricorne and A. fasciculatus reduced significantly after five months, the non volatile acetone extract reduced significantly in the sixth month compared to the fixed quality standards. In turmeric L. serricorne infestation resulted in a significant decrease in volatile oil content after three months of storage and non volatile acetone extract after five months.

Significant positive correlation existed between the population build up and weight loss in ginger infested by L. serricorne and A. fasciculatus and turmeric by L. serricorne. In pepper exposed to S. paniceum the correlation was not significant.

Significant negative correlation existed between the population build up of L. serricorne and A. fasciculatus and volatile oil content and non volatile acetone extract of ginger and L. serricorne and volatile oil content of turmeric. The correlation between the population build up of L. serricorne and non volatile acetone extract in turmeric was not significant.

Significantly high incubation period of L. serricorne

was recorded in ginger compared to turmeric and only insignificant differences were noticed in larval and pupal duration and adult longevity. S. paniceum showed significantly high incubation and pupal period in pepper compared to that in turmeric where as the adult longevity was significantly higher in turmeric. Compared to L. serricorne, A. fasciculatus took longer period to complete its development in ginger.