DISTRIBUTION AND BIO-ECOLOGY OF PHYTOPHAGOUS MITES OF VEGETABLES, MEDICINAL PLANTS AND ORNAMENTALS IN THIRUVANANTHAPURAM DISTRICT

BY

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THESIS

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Dedicated to my beloved father

DECLARATION

I hereby declare that this thesis entitled **Distribution and bio ecology of phytophagous mites of vegetables medicinal plants and ornamentals in Thiruvananthapuram District** 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

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CERTIFICATE

Certified that this thesis entitled **Distribution and bio ecology of phytophagous mites of vegetables medicinal plants and ornamentals in Thiruvananthapuram District** is a record of research work done independently by Smt K Sudharma 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

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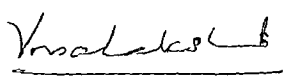
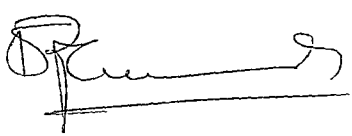
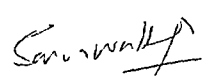
Dr (Mrs) A VISALAKSHI 

Dr S RAMACHANDRAN NAIR 

Dr (Mrs) P SARASWATHY 

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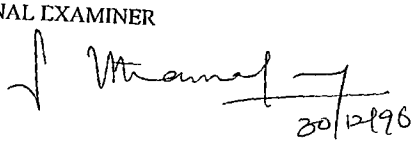

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INTRODUCTION

INTRODUCTION

Acarology the study of mites and ticks gained great importance during the latter half of the present century It has become a full fledged and independent area of specialisation as a result of the realisation that mites rival insects not only in abundance and distribution but also in their potential to cause serious damage as pests of crops By virtue of small size amazing speciation and high adaptability they have colonised plants animals and other diverse ecosystems as pests parasites predators and saprophytes Oribatids the soil mites are considered to be potential bio degraders of plant litter which accumulate on the surface of the earth and their activity involves in the humification process nutrient cycling and energy flow (Haq 1982 1984) These mites are also promising agents in the biological control of weeds (Ramani and Haq 1987) and certain nematodes including plant parasitic forms (Rockett 1980) The role of acarine predators in containing the outbreaks of crop pests has been widely accepted (Jeppson *et al* 1975 Dhooria 1982 Mc Murtry 1989 Croft and Mc Rae 1992)

The phytophagous forms however have gained the greatest attention in acarology They colonise almost all groups of vegetation agricultural horticultural and forest plants (Jeppson *et al* 1975) and are capable of exerting tremendous pressure on plants in a short period of time In the past, they were overlooked because of their small size and the damage caused by them was often confused with that caused by disease causing micro organisms

Ever since the introduction of synthetic organic pesticides for the control of crop pests the phytophagous mite population has been on the increase and the crop loss caused by their

infestation has become a serious handicap in the successful cultivation of many crops It has been widely accepted that the decimation of predatory fauna due to the indiscriminate use of broad spectrum synthetic pesticides was the major factor responsible for increase in mite infestation of cultivated crops Introduction of high yielding varieties which required improved nutrition has also aggravated the mite problem Hence it has become imperative to understand more about phytophagous mite species and to evolve appropriate measures to manage them Intensive research work on these lines has been carried out all over the world including India Research on the mite pests of coconut arecanut and tapioca has been done in Kerala also (Saradamma 1972 Saradamma and Nair 1976 Daniel and Premkumar 1976 Sathiamma 1981 Pillai and Palaniswamy 1982 1985) However investigations on the phytophagous mite fauna with special emphasis to vegetables medicinal plants and ornamentals in Kerala has been very limited

The cultivation of vegetables medicinal plants and ornamentals is gaining much importance in Kerala with a view to catering to the fast expanding domestic market and to earn valuable foreign exchange The Kerala Government has programmes to increase vegetable production in the state and the Kerala Horticultural Development Programme (KHDP) has been established for this purpose The district of Thiruvananthapuram has been selected as one of the centres for implementing the programme on vegetables

Kerala State is blessed with unique geographic position and favourable monsoon patterns for cultivation of a wide variety of subtropical and tropical ornamentals like orchids anthurium jasmines etc The international cut flower market is fast growing and Kerala is well suited to compete with the other developing countries in Asia like Thailand Malaysia and Srilanka in the multimillion dollar floribusiness Realising the importance of floriculture in Kerala and the

resultant potential of employment generation the Ministry of Agriculture Government of India has recently identified Thiruvananthapuram as a potential zone for floriculture development Since Thiruvananthapuram has an international airport perishables like flowers vegetables etc can be easily transported and delivered at any destination within a short period

Cultivation of medicinal plants is another area where Kerala has immense scope There is a revival of interest all over the world in natural products of drugs and cosmetics The requirement of these plants at present leaving aside a few are met from forest sources which is fast depleting Foundation for Revival of Local Health Traditions (FRLHT) an all India voluntary organisation has launched a massive programme sponsored by Government of India to strengthen the resource base of local health traditions The Tropical Botanical Garden and Research Institute (TBG&RI) Palode has been selected by the organisation as one of the fifteen germplasm centres in India (Pushpangadan 1995) Kerala Agricultural University TBG&RI (Palode) Rubber Board (Kottayam) Kerala Forest Research Institute (Peechi) Oushadhi Kottakkal Arya Vaidyasala etc are actively engaged in research and cultivat on of medicinal plants in Kerala In addition to the above there are many small medicinal plant gardens ma ntained by Ay rvedic drug houses traditional ayurvedic physicians and other cultivators in Kerala

To be commercially successful and competitive in the international market suitable agricultural practices and post harvest technologies have to be standardised so that the produce that reach the market are of international standards Co ntrol of pests in the pre and post harvest phases of the crops which is of prime importance in the cultivation of any crop has to be viewed

in this context also

Phytophagous m tes const tute a major group of pests of vegetables nedicinal plants and ornamentals which have not been explored in depth More over the mite problem will be more acute in some of the ornamentals and many of the medicinal plants which are collected from wild sources and cultivated on a large scale the reason being that spider mites occupy a pest status on cultivated plants and are of relatively little importance in undisturbed environments (Putman and Heine 1959 Post 1962)

As mentioned earlier research on the mite pests of vegetables medicinal plants and ornamentals in Kerala is very limited It is well known that for evolving effective management practices against these pests basic i nformation on the identity host plants and bio ecology are essential pre requisites As a step in this d rection a comprehensive research project entitled Distribution and bio ecology of phytophagous mites of vegetables medicinal plants and ornamentals in Th ruvananthapuram District has been carried out to

(1) conduct a detailed survey in two con ecutive years on phytophagous mites and their predators associated with veget ibles medicinal plants and ornamentals in Thiruvananthap ra n D str ct Kerala

(2) study the distri bu tion and abundance of the mites on different host plants of vegetables medicinal plants and ornamentals in different seasons

(3) investigate the seasonal variation in the population of the dominant mite species

(4) study the biology of dominant species of phytophagous mites on selected host pla nts and to

(5) assess the crop loss caused by the nfestation of the dominant mite species on selected host plants

REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

Mites belong to the sub class Acari of the Arthropodan class Arachnida and the majority of phytophagous mites are included in the families Tetranychidae Tenuipalpidae Tarsonemidae and Eriophyidae under the order Acariformes (Krantz 1978) The literature on host plants distribution bio ecology natural enemies and nature of damage of important phytophagous mites and on crop loss caused by them is briefly reviewed below

2 1 Host Plants and Distribution

2 1 1 Family Tetranychidae

2 1 1 1 Genus *Eutetranychus*

Eutetranychus orientalis (Klein) was reported as a destructive polyphagous pest in India (Sadana 1972 Dhooria 1981 Mathur *et al* 1995) Sadana (1972) found bhindi and cucurbits as important hosts of this mite in Punjab Ber trees in Haryana was also reported to be severely infested by this mite (Fotedar 1978)

E orientalis was reported as a limiting factor in the cultivation of fruit trees and ornamental plants in India (Dhooria 1981 Dhooria and Butani 1982 Bhumnavar and Singh 1986) The medicinal plant *Rauvolfia serpentina* (L) Benth was also reported as a host plant of the mite (Lal and Mukharji 1977 Rai *et al* 1995) In Kerala Pillai and Palaniswamy (1985) observed the damage of *E orientalis* in tapioca The infestation of *E orientalis* was

reported on *Zizıphus maurıtıa ıa* Lam ın Jammu and Kashmır (Rather 1989) and ın semı arıd regıons of Rajasthan (Sharma and Naqvı 1992) Deshpande *et al* (1992) reported the occurrence of thıs mıte ın cıtrus Ber cıtrus devadar and lemon were ıdentıfied as host plants of *E orıentalıs* ın Hıssar wh le papaya and peach were recorded as host plants ın Uttar Pradesh (ICAR 1993)

2 1 1 2 Genus *Oligonychus*

Among the mıte pests of roses *Oligonychus bıharensıs* (Hırst) was the most prevalent specıes ın Bangladesh (Majumder and Bhuıya 1995) *Oligonychus coffeae* was ıdentıfied as a pest of tea ın all the tea gıowıng counıies of the trop cs (Das 1959 Muraleedharan *et al* 1988; Gupta 1989)

Oligonychus ındıcus Hırst commonly known as whıte mıte was reported by Puttarudrıah and ChannaBasavanna (1953) on aıecanut seedlıngs near Bangalore ın Karnataka The mıte was ıdentıfied as an ımportant acarıne pest of sugarcane from dıfferent parts of Indıa (Harbans and Sıdhu 1961 ICAR 1993) Thıs mıte was reported to ınfest *Sorghum bıcolor* (L) Moench also (Jeppson *et al* 1975 Balasubramanıan *et al* 1988 Manjunatha *et al* 1992)

In coconut folıage the ıncıdence of *Oligonychus ıseılemae* (Hırst) was recorded by Satı ramma (1986) ın Kerala whıle thıt of *Oligo ıychus plegas* Baker and Prıtchard was recorded by Mohanasundaram a id Karuppuchamy (1989) ın Tamıl Nadu

Oligonychus mangiferus (Rahman and Sapra) was a serious pest not only from mango but also from a great variety of plants including ornamentals and fruit trees (Sadana and Chabra 1974 Rather 1989) The occurrence of *Oligonychus saccharinus* Baker and Pritchard on sugarcane was reported by Gupta (1976) and Vishnu Priya *et al* (1992)

2 1 1 3 Genus *Schizotetranychus*

Schizotetranychus asparagi (Oudemans) was found as a pest in the United States Germany and Holland in asparagus and ferns (Jeppson *et al* 1975)

Schizotetranychus cajani Gupta was reported to infest red gram in Tamil Nadu (Karuppuchamy *et al* 1990 Vijayraghavan *et al* 1992) and Punjab (Dhooria and Cheema 1995)

Dhooria (1995) recorded *Schizotetranychus lechrius* Rimando as a serious pest of Pinkcassia trees in Punjab

2 1 1 4 Genus *Panonychus*

Panonychus citri Mc Gregor the red spider mite was reported to be distributed in citrus orchards in India and abroad (Munger 1963 Ghanmi 1989 Xia 1989) *Panonychus ulmi* (Koch) was recorded as a major pest of apple and epidemic outbreaks of the mite in apple orchards in Himachal Pradesh were reported by Kumar and Bhalla (1995) Khajuria (1995) Kakar and Chander (1995)

2 1 1 5 Genus *Tetranychus*

Tetranychus form the most wide spread genus among phytophagous mites and hence economically the most important (Cone and Wildman 1989)

Tetranychus cinnabarinus (Boisduval) the carmine spider mite was reported as an important pest of many food plants in subtropical areas of the world (Jeppson *et al* 1975 Gunathilagaraj and Kumaraswam 1978 Misra and Somchoudhury 1989 Kaneria and Bharodia 1991) Gupta and Gupta (1985) reported the occurrence of this mite on beans bittergourd brinjal cucumber and lady s finger in eight districts of West Bengal while Vijayaraghavan *et al* (1992) reported its occurrence in bhindi brinjal and roses in Tamil Nadu

The occurrence of the tetranychid mite *Tetranychus floridanus* on arecanut cardamom coconut coffee nutmeg pepper and tea was reported from Kerala (Paul and Ramani 1991)

Tetranychus ludeni Zache was widespread throughout the tropics United States Mexico and Australia (Jeppson *et al* 1975) The occurrence of this mite in bhindi and brinjal was reported from Karnataka and Tamil Nadu (Puttaswamy and ChannaBasavanna 1979b Karuppuchamy and Mohanasundaram 1987) *Desmodium tortosum* also was identified as one of the host plants of *T ludeni* in Tamil Nadu Sathiamma (1988) recorded the mite as a major pest of coconut in Kerala

Tetranychus macfarlanei Baker and Pritchard was identified as a pest in cucumber egg plant gourds and okra in India and Mauritius (Jeppson *et al* 1975)

Tetranychus neocaledonicus Andre was reported to be present in the ecosystem of many crop plants causing serious damage to the crops (Siddappaji and Reddy 1972 Lal and Pillai 1978 Mohanasundaram and Karuppuchamy 1987 Pillai and Palamswamy 1985) It was distributed throughout the tropical and subtropical areas of the world including Hawaii Fiji Venezula and Mauritius (Jeppson *et al* 1975) In India the mite was reported as a major pest of vegetables (Krishnaiah and Tandon 1975 Mohan and Krishnaiah 1979 Pareek and Sharma 1982 Vijayaraghava *et al* 1992)

In Uttar Pradesh *T neocaledonicus* was reported as a pest of brinjal cabbage cowpea pumpkin and snakegourd(BHU 1987) The mite was observed to cause severe damage to rose plants in Kerala (Nair *et al* 1990) and Tamil Nadu (Vijayaraghavan *et al* 1992) In West Bengal occurrence of the mite in cucurbits and okra was reported (BCKVV 1987)

Sadana and Gupta (1983) observed the incidence of *Tetranychus puschelli* on *Calendula officinalis Chenopodium ambrosioides* and *Ocimum basilicum* in Assam

Magie and Poe (1972) noticed the two spotted spider mite *Tetranychus urticae* Koch as an important pest of gladiolus In Australia the two spotted spider mite was among the most serious pests of roses (Clark and Buckley 1984) This mite was also reported to cause serious damage to roses in greenhouse and outdoors (Van de Vrie 1985 Field and Hoy 1986 Jones 1990 Vijayaraghavan *et al* 1992) Heavy incidence of *T urticae* on Thompson seedless grapes was reported in Maharashra (Mali *et al* 1983)

Spider mites often occur on crops as species complex The spider mite complex on cotton was reported to include *T urticae T pacificus* and *T turkestani* (Brito *et al* 1986) Wilson *et al* (1991) recorded the occurrence of *Tetranychus pacificus* Mc Gregor and *Tetranychus turkestani* Ygrov and Nikolski on cotton

2 1 2 Family Tenuipalpidae

2 1 2 1 Genus *Brevipalpus*

Many species of plants have been reported by several authors as host plants of *Brevipalpus phoenicis* (Geijskes) in different parts of the world (Nagesh Chandra and Channa Basavanna 1976 Jeppson *et al* 1975 Ghai and Shenhmer 1984 Gupta 1985 Sadana and Kumari 1991) The mite was identified as one of the two species of tenuipalpid mites occurring on coconut in Karnataka (Nagesh Chandra and Channa Basavanna 1976) They also listed the host range of *B phoenicis* which included *Acalypha hispida* Burn *Alpinia* sp *Cassia spectabilis* DC *Cosmos* sp *Dhalia* sp *Gerbera* sp *Psidium guajava* L and *Theobroma cocao* L In Uttar Pradesh *B phoenicis* was reported as an important pest of bhindi brinjal and bean while *Brevipalpus creber* Chaudhri was reported on lemon without any apparent damage symptom (BIIU 1987)

The omnivores mite *Brevipalpus californicus* (Banks) was recorded from many orchids in Thailand (Chaianasri *et al* 1989) The oncidium mite *B oncidii* was reported as a serious pest of oncidium in England and California (Baker 1949)

Mohanasundaram (1982) identified two new species of *Brevipalpus* from Coimbatore They were *B cucurbitae* on *Cucurbita maxima* and *B euphorbiae* on croton

Sadana and Gupta (1983) during their studies observed the incidence of *B gauhatiensis* and *B tinsukianensis* in *Jasminum grandiflorum* L and *B phoenicis* in *Dahlia* sp and *Ocimum sanctum* L

Sadana and Balpreet (1995) listed new records of Brevipalpid mites in Northern India They reported the occurrence of *Brevipalpus tinsukianensis* sp nov on *Melia azadirachta Syzygium cumini* and *Vitis vinifera* and *B phoenicis* on *Melia azadirachta*

2 1 2 2 Genus *Tenuipalpus*

Tenuipalpus pacificus Baker was reported as a pest of orchids in California Florida Panama Australia Siam and England (Jeppson *et al* 1975) In Brazil *Tenuipalpus* sp was recorded as a serious pest of the orchids cattleya and hybrids (Bose and Yadav 1989) Among the many pests of orchids in Thailand mites and in particular *T pacificus* was considered to be the most common and most injurious ones (Charanasri *et al* 1989)

The pomegranate false spider mite *Tenuipalpus punicae* Pritchard and Baker was reported as an economically important pest of pomegranate in Iraq (Ibrahim and Haider 1989)

2 1 2 3 Genus *Raoiella*

Hirst (1924) first identified *Raoiella indica* Hirst on coconut leaves from India Since then this species has been reported from various countries and on different plants Reports of *R indica* as an important pest of coconut was subsequently published by many authors (Moutia 1958 Das 1980 Sathiamma 1981 Jalaluddin and Mohanasundaram 1990) The mite was reported to infest arecanuts also in Trichur District Kerala (Daniel and Premkumar 1976) and West Bengal (Senapathi and Biswas 1990)

2 1 2 4 Genus *Dolichotetranychus*

Saradamma and Nair (1976) reported the infestation of *Dolichotetranychus* sp on arecanut in Kerala Later in 1985 Sathiamma identified *Dolichotetranychus vandergooti* (Oudemans) as the perianth mite on coconut and in 1989 Mohanasundaram and Karuppuchamy reported the infestation of *Dolichotetranychus* sp on coconut buttons Surveys undertaken in West Bengal revealed the association of *Dolichotetranychus* sp with Pineapple (BCKVV 1987)

2 1 3 Family Tarsonemidae

2 1 3 1 Genus *Polyphagotarsonemus*

Polyphagotarsonemus latus Banks known by different names such as chilli murnai mite broad mite yellow tea mite and tropical mite was reported to be distributed throughout

the tropics and in green houses in the temperate regions on vegetables and ornamental plants (Jeppson *et al* 1975) In India this species was reported as a potential pest of vegetables and ornamental plants (ChannaBasavanna and Puttarudriah 1959 Sandhu *et al* 1974 Mote 1976 Dhooria and Bindra 1977 Kareem *et al* 1977 Patil and Dethi 1979 Awate *et al* 1981 SriRamachandra Murthy 1984 Karuppuchamy and Mohanasundaram 1986 Kandasamy *et al* 1987) Different citrus species in Punjab were also listed as host plants of *P latus* (Dhooria 1984) The mite was also reported to attack greenhouse gerberas (Bose and Yadav 1989)

2 1 4 Family Eriophyidae

The worm like eriophyid mites known by various names such as gall mite bud mite blister or rust mites are entirely phytophagous and feed on many plant species in the tropics (Keifer 1965 Jeppson *et al* 1975) Mondal and Chakraborti (1982) detected the association of the eriophyid mite *Aculus hibisci* with *Hibiscus rosifolicus* Ghosh *et al* (1986) found that the croton plant *Croton oblongifoliae* was the host of another eriophyid species *Diesella oblongifoliae*

In Tamil Nadu Sunder raj *et al* (1967) reported the occurrence of *Aceria jasmini* on *Jasminum auriculatum* *A jasmini* was also reported to infest brinjal and tomatoes in Allahabad and Varanasi (BHU 1987) The eriophyid mite *Paraphytoptus chrysanthemni* Keifer was also recorded from Chrysanthemum in Uttar Pradesh (BHU 1987)

The infestation of *Cisaberoptes kenyae* Keifer on mango was observed in Kerala and Tamil Nadu (Ramani and Haq 1989 ICAR 1993) The association of *Eriophyes mangiferae* Sayed with *Mangifera indica* L in Jammu and Kashmir was reported by Rather in 1989 *Acaphylla theae* (Watt) and *Calacarus carinatus* were reported to be next in importance to *Oligonychus coffea* (Neitner) as pests of tea in North as well as in South India (Gupta 1989)

Mohansundaram (1989) observed the incidence of *Calacarus jasmini* Chakraborti and Mondal on *Jasminum sambac* L and *Calacarus channabasavannae* on *Emblica officinalis* In 1991 he further recorded the incidence of *Rhombacus morrisi* Keifer on *Eucalyptus tetraticornis* and *Aculus ocimuma* sp nov an undersurface leaf vagrant on ocimum Studies on the gall and erineum forming mites attacking medicinal plants in northern Kerala revealed the presence of *Aceria acanthae on Kydia calycina* and *Aceria pongamiae* ChannaBasavannae on *Pongamia pinnata* (Sheela and Haq 1992) The infestation of *Aceria gossypi* Mohanasundaram on cotton *Aceria mangiferae* Sayed on Mango and *A sacchari* Channabasavanna on sugarcane were reported by Vijayaraghavan *et al* (1992)

2 1 5 Family Oribatidae

Oribatid mites commonly occurring in soil were reported to cause injury to plants also (Michael 1884 Aoki 1960) These mites were found to live in a wide variety of crop plants and weeds (Cordo and De Loach 1975 Haq and Ramani 1985 Ramani and Haq 1990) The oribatid mite *Orthogalumna terebrantis* Wallwork was reported to feed and survive on *Eichornia crassipes* (Ganga Visalakshy and Jayanth 1991)

2 2 Natural Enemies of Mites

2 2 1 Predatory mites

2 2 1 1 Family Anystidae

Species of the Anystidae family were reported to feed effectively on phytophagous mites The species were *Tencatia* sp nov and *Anystis indica* Gupta which feed on all stages of *T neocaledonicus* on betel vine and *T cinnabarinus* on peach (Gupta and Gupta 1992)

2 2 1 2 Family Ascidae

Sathiamma (1991) collected species of *Lasioseius* from colonies of *O iseilemae* and *T ludeni* infesting coconut in Kerala Excepting *Lasioseius terrestris* Menon and Ghai a stray feeder of *S andropogoni* which is a pest of paddy in North East India no other species has been reported to be of any potential value as an effective predator (Gupta and Gupta 1992)

2 2 1 3 Family Bdellidae

Only two species of the family were found to feed on phytophagous mites They were *Bdellodes affinis* Atyeo and *Bdella* sp which fed on *O indicus* and *O mangiferus* respectively (Gupta and Gupta 1992)

2 2 1 4 Family *Cheyletidae*

Cheyletus eruditus (Schrank) was identified as an efficient predator of *E orientalis* (Dhooria 1982) Other species of cheyletid mites found in the field predating on phytophagous mites were *Cheletogenes ornatus* (C& F)on mango bud mite *A mangiferae* and *Cheyletus fortis* on *O punicae* infesting pomegranate in Himachal Pradesh (Gupta and Gupta 1992) *Cunaxa* sp was identified as an efficient predator of spider mites in Tamil Nadu (Vijayaraghavan *et al* 1992)

2 2 1 5 Family Cunaxidae

Cunaxa setirostris (Aerman) was observed as cosmopolitan predator which fed on all stage of *E orientalis* infesting citrus in Punjab *O isolatae* infesting coconut in Kerala and *O mangiferus* infesting mango in Uttar Pradesh Meghalaya Assam and West Bengal (Dhooria 1982 Sathiamma 1991 Gupta and Gupta 1992) *Cunaxa womersleyi* Baker and Hoffmann and *Cunaxa cynodonae* Gupta and Ghosh p eyed *B delonii* on papaya and *Schizotetranychus* sp on grass respectively (Gupta and Gupta 1992)

2 2 1 6 Family Phytoseiidae

Phytoseiids have been recognized as one of the most valuable groups of predators of phytophagous mites (Chant 1959 Mc Murtry *et al* 1984) Studies of Mc Clanahan 1968 Laing 1968 and Krishnamoorthy and Mani 1989 on *Phytoseiulus persimiles* Athias Henriot indicated that this mite was extremely predac ous and also had a high reproductive rate as compared to other species of phytoseiid mites

Amblyseius finlandicus (Oudemans) occurred in the ecosystem of many phytophagous mites and had a very wide distribution (Gupta *et al* 1971 Sadana and Chabra 1974) It was reported as a promising predator preying on eggs and larvae of *E orientalis* (Gupta *et al* 1971)

Amblyseius channabasavanni Gupta and Daniel was reported as an efficient predator of *R indica* and *T fijiensis* (Gupta 1978 Daniel 1981)

Dhooria (1982) identified *Amblyseius alstonia* Gupta *Typhlodromus divergentis* Choudhari Akbar and Rasool as predators of *E orientalis* on citrus in Delhi The potential of *Typhlodromips tetranychivorus* as a predator and as a biocontrol agent of red palm mite *R indica* was reported by Jagdish and Nageshchandra (1982) Krishnamoorthy (1983) reported the occurrence of *Amblyseius rhododendronis* Gupta as a predator of *T ludeni* on okra Very low population of the predatory mite was reported to be present on plants in the absence of the prey mites

Gupta and Gupta (1985) reported the occurrence of *Amblyseius largoensis* (Muma) and *Amblyseius ovalis* (Evans) as predatory mites of *T cinnabarinus* and *T neocaledonicus* in West Bengal *A finlandicus* was reported to feed voraciously on the phytophagous mite *E orientalis* on citrus (Sarma and Sadana 1987) The natural enemy complex of coconut pest *R indica* was studied in West Bengal by Somchoudhury and Sarkar (1989) They reported that *Phytoseius* sp and *Amblyseius* sp were the dominant predatory mites Studies on the predatory behaviour of *A ovalis* and on the chilli mite *P latus* showed that the adult females consumed 11 72 larvae 9 33 nymphs or 5 07 adults per day while the larvae consumed 3 76 and 1 38

prey larvae and nymphs respectively and the protonymphs consumed 9 18 larvae 7 87 nymphs and 3 18 adults The phytoseiids were unsuccessful at a predator prey ratio of 1 150 (Hariyappa and Kulkarni 1988) Studies conducted by (Kaliuppuchamy *et al* 1994) revealed that the adult predators were the most efficient in devouring the chilli mites the average consumption per day by an adult being 5 76 4 64 3 20 and 2 12 numbers of eggs first instar nymph second instar nymphs and adults respectively They also found that the predatory potential was considerably less for the deutonymphs and protonymphs of the predator and the larva was the least effecient

Among the predatory mites in tea plants Phytoseiidae and Stigmaeidae were the most common (Gupta 1989) The predatory potential of *T ludeni* and its two phytoseiid predators *A longispionosus* and *Typhlodromous tetranychivorous* Gupta on *T ludeni* investigated by Mallik *et al* (1989) revealed that *A longispinosus* preferred the eggs and the younger immature stages of the prey where as *T tetranychivorous* preferred the adults and the older nymphal stages

Species of *Euseius* were the most common phytoseiid predator of *Oligonychus punicae* (Hirst) on both citrus and avocado in California (Mc Murtry 1989)

A alstoniae was identified as an important predator of cotton spider mite *T neocaledonicus* (Shah and Jose 1989) and *B phoenicis* (Kumari and Sadana 1991) The predatory mites viz *A alstoniae A finlandicus A multidentatus* and *Phytoseius roseus* were reported to be associated with brinjal crop in Punjab (Grewal 1992)

Metaseiulus occidentalis (Nesbitt) was reported to check the population build up of *P citri* effectively apple orchards in Oregon (Croft and Mc Rae 1992)

List of predatory mites in India their hosts and locality and their importance in biological control have been given by Gupta and Gupta (1992) The predatory mites *finlandicus A ovalis A longispinosus A largoensis A multidentatus A tetranychivorous* were reported to be highly effective in checking the population of *E orientalis O coffeae neocaledonicus O mangiferus T neocaledonicus* and *T ludeni* respectively

2 2 1 7 Family Stigmaeidae

The development and predatory efficiency of *Agistemus exsertus* Gonzalez was reported by Hafez *et al* (1983) *Agistemus* sp preying on *Acaphylla theae* (Watt and Mann) was recorded from North East India (Borthakur and Das 1987) *Agistemus* sp was also reported to feed effectively on *Aceria litchi* Keifer in litchi and *O iseilemae* in coconut (Singh *et al* 1989 Sathiamma 1991) Among the non phytoseiid predators stigmaeid mites were the most important and cosmopolitan in distribution and the species seen feeding on phytophagous mites in the field were *Agistemus fleschneri* Summers on *A mangiferae* on mango and *T cinnabarinus* on bhindi *Agistemus terminalis* (Quayle) on *A theae* *Agistemus heterophylla* Gupta on *Euteteranychus* sp (Gupta and Gupta 1992)

2 2 2 Insect predators

The coccinellid predators *Stethorus* spp feed almost exclusively on tetranychid mites and they were distributed throughout the world (Mc Murtry *et al* 1970 Singh and Ray 1977)

Stethorus pauperculus Weise was reported to prey on *E. orientalis* but under field situations its population was found to be very low (Dhooria 1982). Among the various insect predators of tetranychid mites in cassava *Stethorus gilvifrons* Muls was the most effective predator (Pillai and Palaniswamy 1985). *Stethorus picipes* Casey was identified by Mc Murtry (1989) as a specialised and voracious predator of spider mites in citrus and avocado (Mc Murtry 1989). The ovipositing females consumed upto 50 adult spider mites per day and several thousands during their life time. Sathiamma (1991) found that *Stethorus keralicus* Kapur occurred abundantly in the colonies of *R. indica* on coconut.

Oligota flaviceps, *Oligota oviformis* (Casey) and *Oligota pymal* Sol were identified as important staphylinid predator of phytophagous mites (Gupta 1985). The staphalinid *Oligota* sp. was also found as efficient predators of tetranychid mites infesting cassava (Pillai and Palaniswamy 1985). Gupta (1985) reported that the hemipteran bug *Anthocoris musculus* (Say) and *Orius insidiosus* (Say) were efficient predators of spider mites consuming 10-30 mites/hour.

Chrysopa carnea Stephens was known to feed upon *P. ulmi* in many parts of the world and the last instar larvae of the predator consumed 1000-1500 citrus red mites daily (Gupta 1985). The larvae of chrysopidae consumed *T. ludeni* and oribatid mites occuring on coconut (Sathiamma 1991).

The thrips *Scolothrips indicus* Priesner was reported to be an efficient predator of phytophagous mites in Bangalore (Reddy and Jagdish 1977). Dhooria (1982) reported the thrips as a predator of citrus mite *E. orientalis* while Pillai and Palaniswamy (1985) reported

it as an efficient predator of tapioca mites Predatory thrips were reported to feed occasionally on the larval mites of *O iseilemae* (Sathiamma 1991)

2 3 Nature and symptoms of damage

Jeppson *et al* (1975) described the nature of damage caused by mites as discolouration of leaves stunted growth and various other deformities in plants Besides the direct damages on plants many species of mites were reported as vectors of plant diseases also (Rajagopalan 1974 Slykhuis 1980)

2 3 1 Tetranychid mites

Feeding of *O mangiferus* in mango reduced the chlorophyll content of leaves with the development of characteristic yellow spots which later turned brownish and merged to form larger spots (Sadana and Chabra 1974)

Puttaswamy and ChannaBasavanna (1979b) found that feeding by *T ludeni* in french beans induced white stippling at the feeding points which later coalased and produced blotches and necrotic patches

According to Lal and Pillai (1981) the red mites *T cinnabarinus* and *T neocaledonicus* feed on the lower surface of leaves and produce yellowish specks which subsequently spread producing blotches and elongated streaks

The two spotted spider mite *T urticae* the major arthropod pest of strawberry in California suppressed photosynthetic activity in the plants due to their feeding on the foliage (Wyman *et al* 1979 Sances *et al* 1979 Butcher *et al* 1987) Sumangala and Haq (1991) observed severe chlorosis on *Eichornia crassipes* due to the feeding by the tetranychid mite *E orientalis* The chlorophyll loss as a result of the feeding was reported to be between 22 and 30 per cent Ansari and Pawar (1992) reported that the leaves become coppery thin and brittle as a result of feeding by *T ludeni*

T cinnabarinus was reported as a serious pest of brinjal which caused direct and indirect damage to the crop These sucking mites lived in colonies under silken webs which carried plenty of soil particles in windy weather and inhibited photosynthetic activity (Butani and Mittal 1992) Vijayaraghavan *et al* (1992) found that *S cajani* caused webbing and yellowing

Nandagopal and Gedia (1995) observed that leaves infested by *T cinnabarinus* showed stippling followed by light yellowing They also reported that damage was severe in crops that were under moisture stress and complete drying of foliage occurred in such plants

Histological and histochemical studies conducted in groundnut genotypes by Ravi *et al* (1995a) revealed that *T urticae* caused direct mechanical damage to the hypodermis and spongy parenchyma

Tetranychid mites were reported as vectors of diseases the species being *T urticae* transmitting the potato virus on potato (Schultz 1963) and *T ludeni* transmitting Dolichos enation mosaic virus on Dolichos lab lab (Rajagopalan 1974)

2 3 2 Tenuipalpid mite

Bronzing and silvering of leaves development of scars and deformities in leaves and fruits and overall stunting of growth were the major symptoms caused by the feeding activity of tenuipalpid mites on plants (Jeppson *et al* 1975 Sadana and Balpreet 1995)

The calyx mite *Dolichotet a tychus* sp infested the calyx region of tender arecanuts causing immature nut fall (Daniel and Premkumar 1976) and the species *Dolichotetranychus vandergooti* (Oudemans) infested the perianth portion of tender coconuts resulting in immature nut fall (Sathiamma 1985)

Ibrahim and Haider (1989) observed that the infestation of false spider mite *T punicae* caused considerable loss in yield of pomegranate in Iraq and the mite not only damaged the leaves but also caused corky appearance on the fruit wall

As a reaction to the feeding of the false spider mite *B phoenicis* protoplasm of the punctured cells coagulated the cells accumulated phenolic compounds and there was significant loss of chlorophyll (Kennedy and Waterkeyn 1995)

2 3 3 Tarsonemid mites

Infestation of *P latus* caused curling and necrosis of young leaves and flowers in cotton datura blackgram and cowpea However in brinjal these symptoms were not produced (Dhooria 1984)

Chilli mite *P latus* caused severe damage to chilli crops at flowering and fruiting stages and the feeding resulted in sudden curling and crinkling of leaves followed by the appearance of blister patches (Karuppuchamy *et al* 1994)

2 3 4 Eriophyid mites

Eriophyid mites were reported as potential parasites of plants and as vectors of many plant diseases (Rajagopalan 1974 Jeppson *et al* 1975) *A cajani* as a vector of the pigeon pea sterility mosaic disease was reported by Seth (1962) and later by Nene (1972) Reddy *et al* (1989) and Prabhuswamy and Srinivasiva (1992) Slykhuis (1980) in a review listed six eriophyid mites as vectors of nine virus diseases in plants

Eriophyid mites induced a variety of plant deformities (ChannaBasavanna 1966 Jeppson *et al* 1975) *A jamu* produced white felt like hairy outgrowth on the surface of the leaves tender shoots and buds leading to cessation of growth of plants and production of flowers (ChannaBasavanna 1966) The eriophyid mite *A sacchari* made gall like blisters on the inner surfae of the leaf sheath of sugarcane (Sithananthan *et al* 1975)

An account of the various types of damages due to the feeding of eriophyid mites in India was given by Ghosh *et al* (1989) Various symptoms of injury including formation of big buds by *Aceria mangiferae* and russetting by *Tegonotus mangiferae* (Keifer) in *Mangifera indica* curling and shrinkage in *Solanum melongena* by *Aceria lycopersici* (Wolff) discolouration in *Gardenia jasminoides* by *Diptilomiops bengalensis* Chakraborti and Mondal erineum in *Zizyphus jujuba* by *Eriophyes* sp and finger galls in *Pongamia pinnata* by *Aceria pongamiae* were reported by the authors

In Kerala two eriophyid mites viz *Eriophyes alangu* and *Paraphytoptus alangiae* were reported to produce pouch galls in *Alangium salvifolicum* (Sheela and Haq 1992)

2 4 Population dynamics

Population dynamics of Acari was studied by several workers Evans *et al* (1961) stated that the seasonal fluctuation was prominent in prostigmata while it was not so prominent in Mesostigmata and Astigmata as they were found in small numbers Sadana and Kanta (1971) mentioned that the mite damage was more apparent in summer Mohanasundaram and Karuppuchamy (1987) also reported that mites were abundantly seen during the summer months However Patel *et al* (1987) reported that mites occurred throughout the year on Betel vine

2 4 1 Tetranychid mites

Lal and Mukharji (1979) found the peak population density of *Eutetranychus orientalis* during March June on *Bauhinia variagata* and *Rauvolfia serpentina* Mali *et al* (1983) observed two peaks for the population of *Tetranychus urticae* in grapes one during September and the other during January

The population of spider mites of cassava (*Tetranychus* spp) was reported to be high from January to April with a range of 65 to 535 mites/leaf and there was a sudden decline in the number from April (Pillai and Pillaiswamy 1985) The authors further reported that an increase in maximum temperature above 31øC was found highly favourable for the rapid multiplication of the mites

Investigations on the population dynamics of oriental red mite *E orientalis* on Coorg Mandarin revealed that the mite was active from the fourth week of January to the third week of November with two peaks of population one during the first week of May and the other during the third week of September in Karnataka (Bhumnavar and Singh 1986)

Studies conducted on seasonal incidence of *T cinnabarinus* on brinjal by Misra and Somchoudhury (1989) indicated that the crop was free from the attack of *T cinnabarinus* from November to February

In field surveys in Meghalaya India the peak activity of *E orientalis* was observed in mandarins in early March and the population peaks were found to be related to temperature and rainfall (Gangwar 1988)

2 4 2 Tenuipalpid mites

Daniel and Premkumar (1976) reported that the tenuipalpid mite *R indica* caused serious damage to arecanut during summer months

The studies on the seasonal history of *B phoenicis* on guava (Sadana and Kumari 1987) revealed that the mites build up its population at low temperature (12 59øC) moderate humidity (71 74% RH) less rainfall (2 20 to 3 70 mm) and low wind velocity (3 08 km/hr 4 86 km/hr) They further reported that high temperature coupled with high or low humidity heavy rainfall and high wind velocity reduced the population level of this mite in guava The tenuipalpid mite *B phoenicis* was present on ten bushes throughout the year with peak

numbers occurring during May August (Gope and Das 1992) The seasonal fluctuations of *B phoenicis* (Geijskes) on Ka hzi nimb studied by Neena Goel and Sadana (1995) revealed that the population of *B phoc ucis* cached the peak when the temperature was high (32°C) the day length was maximum (13 hours) the wind velocity was moderate (5 68 KM/h) the sunshine was for 11 77 hrs and the rainfall was nil

2 4 3 Tarsonemid mites

Trivedi (1987) observed the nc dence of *Polyphagotarsonemus latus* on potato in Karnataka all round the year with major ncidence during August and Sontakke *et al* (1989) observed that relative humidity was pos tively correlated with the population of the mite

2 4 4 Predatory mites

The most important natural enemy of tetranychid mites on cotton was the predatory mite *Amblyseius gossypii* Elb dry (Elb dry *et al* 1968)

The population of predatory mites *Typhlodromus* sp and *Amblyseius* sp the most abundant during the month of August followed by the month of June and May while they were totally absent from December to February (Singh *et al* 1989)

Somchoudhry and S ik (1989) eported that the peak population of *Phytoseius* sp and *Oligota* sp the two predators of *Rao ella indica* coincided with those of the hosts

The population dynamics of mite predators of *Oligonychus iselemae* was studied by Sathiamma (1991) Phytosend predatoi s were reported to be abundant from January to May and totally absent in July and Novembei She also observed that cunaxid predators were less abundant compared to phytoseı d pıedıt s

2 5 Biology

2 5 1 Tetı anychid mites

Biology of tetranychid mites o ı different host plants was studied by many authors (Puttaswamy and ChannaBısıvanna 1979a 1981 Govindan *et al* 1981 Mallik and ChannaBasavanna 1983)

Puttaswamy and Ch ınnıBasav n ıı (1979b and 1980a) found that high temperature (30 35°C) and low relative humidity (55 75%) favoured the development of *T ludeni* and that the host plants had considerable influence on the developmental period of the mite According to Mallik and ChannaBasavı ına (1983) at 27 ± 0 5 C the development of egg larva protonymph and deuto ıympl of *T l ı k* was c ompleted in 10 6 32 5 34 5 and 49 hours respectively The mean egg l ı val p ı tonymphal and deutonymphal periods were found to be 5 3 2 7 3 6 and 4 9 days ıespectively for *T cinnabarinus* and that the fecundity of the mite ranged from 49 to 58 eggs with in average of 52 8 (Pillai and Palaniswamy 1985) When *T cinnabaı inus* was ıeared on J panese mint at Ludhiana Dhooria and Premsagar (1989) observed that the numbe of fe ı les we e greater than males and that the sex ratio was 1 1 9 and 1 1 5 on *Mentha a vensis* a id *Mentha piperita* respectively

2 5 2 Tenuipalpid mites

Studies conducted by S idhu and Kumari 1987) showed that a temperature of 25 C and 70% RH were suitable for the development of *B phoenicis* as the oviposition period fecundity and hatchability were found to be the highest and mortality the lowest under these conditions The life cycle of the tenuipalpid mite was found to be completed in 17 23 days during April August and 37 55 days during November February

2 6 Crop loss caused by mite infestation

Red spider mites in general and the genus *Tetranychus* in particular are important mite pests of agricultural crops and were reported to cause around 39 per cent of pre harvest loss in world food and fibre production (Wilcoxon 1979)

The eriophyid mite *A cajani* was known to cause yield losses as high as 95 per cent (Reddy and Nene 1981) Pillai and Pal uswamy (1982) estimated an yield reduction ranging from 17 to 33 per cent in cassava due to the feeding by *T cinnabarinus* and *T neocaledonicus*

The effect of different levels of mite population on the growth of french bean (*Phaseolus vulgaris*) was studied by Dhooria in 1983 and it was found that during April May even 5 female mites in a young plant bearing 5 7 leaves would cause significant damage to leaves resulting in low vitality of the plants

T cinnabarinus a major pest of betel vine caused 40 per cent reduction in yield (Sivakumar and Marimuthu 1987) The infestation of the same mite in brinjal resulted in a reduction of 28 08 20 53 and 14 37 per cent in mean yield mean weight and mean number of fruits per plant respectively in susceptible accessions (Palamswamy and Chelliah 1987)

Patel *et al* (1987) recorded over 90 per cent leaf infestation by *Schizotetranychus cajani* Gupta on red gram The depletion of chlorophyll was reported by the author to be between 15 71 and 23 75 per cent in various levels of leaf infestation

Crop losses due to the spider mite *O indicus* on sorghum was estimated by Manjunatha and Puttaswamy (1990) The studies revealed that the plant height grain yield and straw yield were reduced by 15 6 57 9 and 40 4 per cent respectively due to the infestation of the mite at 30 days of crop growth as compared with the uninfested plants Rao *et al* (1990) found that *T urticae* at Rajendranagar Andhra Pradesh caused 14 per cent damage to green gram

There are few reports on the beneficial effects of mite infestation also Effects of spider mite (*T urticae*) feeding on chrysanthemum bean and cucumber showed that low spider mite populations increased the yield of bean and strawberry (Tomezyk *et al* 1989)

2 7 Intra Plant Distribution of Mites

The within plant distribution of spider mites, *Tetranychus* spp on cotton studied by Wilson *et al* (1991) revealed that early in the season when plants had few leaves the mites

were located close to the terminal portion of the main stem During the phase of rapid vegetative growth the mites were located further from the terminal portion and as vegetative growth decreased late in the season the mites were again found closer to the shoot terminals

Sites and Cone (1985) found that *T urticae* were distributed mainly on the lower half of the plant from May to July and on the upper half of the plant by early August According to Perring *et al* (1987) adult females of *T urticae* were found to be more on primary branch of cantaloupe and hence this branch could be recommended for use in sampling programme

Vertical distribution of three species of eriophyid mites on tea was investigated by Muraleedharan *et al* (1988) The mean number of *A theae* was found to be significantly high on the leaves at the top upper strata of tea bushes as compared to middle and bottom The density of *C carinatus* was almost equal on all three levels of the plant

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3 1 Survey on phytophagous mites and their natural enemies

A detailed survey on the phytophagous mites and their natural enemies associated with vegetables medicinal plants and ornamentals was carried out in the district of Thiruvananthapuram Kerala during 1992 and 1993 The centres selected for the survey were the District Agricultural Farm Peringammala and the farms attached to the Ayurvedic Research Centre Poojappura the College of Agriculture Vellayani the Kerala University Centre Kariavattom and the Tropical Botanical Garden and Research Institute Palode The survey on the mites associated with medicinal plants was conducted in all the centres except the District Agricultural Farm Peringammala and that on the mites associated with ornamentals was conducted in the Agricultural College Farm Vellayani the District Agricultural Farm Peringammala and the Tropical Botanical Garden and Research Institute Palode taking into account the availability of sufficient number of host plants The Agricultural College Farm Vellayani and the District Agricultural Farm Peringammala where there was large scale cultivation of vegetables round the year were chosen for the survey on the mites associated with vegetables

In both the years the survey was carried out in the premonsoon monsoon and postmonsoon seasons During each survey plants for observation were selected randomly From each of the randomly selected plant samples of leaves twigs and flowers were collected from the top middle and bottom portions in separate polythene bags The samples were properly labelled and brought to the laboratory and population counts of phytophagous mites and predators recorded after detailed examination

In the laboratory the leaves twigs and flowers in each sample were first sorted for the presence or absence of mites and the percentage of infested leaves twigs and flowers were determined Three infested leaves from each sample were selected at random and counts of phytophagous mites and predators recorded In *Livinstona chinensis* which has large sized leaves mites present in an area of 1 cm^2/leaf were counted by placing a card board piece having a window of 1 cm^2 on the leaf surface and using a 10x lens

Permanent slides of the acarine fauna observed in the survey were prepared in Hoyer s medium The Hoyer s medium was prepared by mixing the following ingredients

Distilled water	50 ml
Gum arabic crystals	30 g
Chloral hydrate	200 g
Glycerine	20 g

After mounting the mites the slides were kept under a 60W bulb for clearance after which the edges of the coverslips were sealed with DPX mountant Two labels were used on each slide one label contained the details such as the host plant locality date of collection and collector s name and the other contained the details of the specimen The slides were serially numbered Insect predators of the mite were preserved in 70 per cent alcohol and later identified and catalogued

The nature and symptoms of damage caused by the mites in different host plants were also studied and recorded

3 2 Seasonal occurrence of mites

3 2 1 On vegetables

In the survey bhindi chilli pumpkin and vegetable cowpea were identified as important vegetable host plants of mites Hence these plants were selected for studies on seasonal occurrence of phytophagous and predatory mites Snakegourd which is an important vegetable crop of the area though not recorded as an important host plant of mites was also included in the study as a check

Replicated field trials in Randomised Blo k Design with six replications and five treatments were laid out in the Instructional Farm College of Agriculture Vellayani in the premonsoon monsoon and postmonsoon seasons of 1993 The varieties used for the trial were Kiron (bhindi) Jwala Mukhi (chilli) Ambili (pumpkin) Malika (vegetable cowpea) and TA 19 (snakegourd) Thirty plants each of bhindi chilli and vegetable cowpea and fifteen plants each of pumpkin and snakegourd formed one block Five p'ants in the centre of each replication were selected as observational plants and three leaves from each plant were randomly selected from the top/distal middle and basal portions of the plants and observation recorded Thus for each crop ninety leaves from six replications were examined and the population counts of phytophagous mites and predators recorded at fortnightly intervals

3 2 2 On medicinal and ornamental plants

In the survey two species of *Adhatoda* (*Adhatoda beddomei* and *Adhatoda vasica)* orchid (*Dendrobium* sp) rose (*Rosa spp*) and thunbergia (*Thunbergia alata)* were observed

to be seriously infested by different species of mites and hence these were selected for the study on seasonal occurrence The study was conducted in plants available in the farm of the College of Agriculture Vellayani during the period from January 1994 to December 1994 Observations were recorded at fortnightly intervals from ten randomly selected plants for each crop For each observation three leaves collected randomly from the top middle and bottom strata of each of the selected plant were examined Population counts of phytophagous mites and predators present on each leaf were recorded Maximum and minimum temperature relative humidity and rainfall were also recorded during the period of the study and correlations with population counts worked out

3 3 Biology, Mating behaviour and Oviposition pattern

In the survey conducted tetranychid mites viz *Tetranychus cinnabarinus* Boisduval *Tetranychus ludeni* Zacher and *Tetranychus neocaledonicus* Andre were identified as numerically more dominant than other mite pests The biology of these mites on vegetables have already been worked out (Mallik 1974 Puttaswamy and ChannaBasavanna 1980 b) Hence the study on biology of these mites has been confined to medicinal plants and ornamentals in the present investigations

Among the tetranychid mites *T cinnabarinus* was found to be the most dominant species on the medicinal plant *Adhatoda vasica* while *T ludeni* and *T neocaledonicus* were dominant on *Rosa spp* Hence the biology of *T cinnabarinus* on *Adhatoda vasica* and that of *T ludeni* and *T neocaledonicus* on *Rosa* sp were studied

Among the tenuipalpid mites *Tenuipalpus pacificus* and *Raoiella indica* were found to be dominant on orchids and thunbergia and the biology of these mites were studied on the orchid (*Dendrobium* sp) and thunbergia (*Thunbergia alata*) respectively The mite *Brevipalpus phoenicis* was found to be an important polyphagous species and hence the biology of the mite was studied on the ornamentals *Caladium* sp *Maranta* sp orchid (*Dendrobium* sp) and tube rose (*Polyanthes tuberosa*) and on the medicinal plant *Ocimum sanctum*

3 3 1 Maintenance of stock culture of mites

For studying the biology the mites *T cinnabarinus T ludeni T neocaledonicus B phoenicis T pacificus* and *R indica* were collected from their respective host plants in and around Agricultural College Farm Vellayani and further multiplied in the laboratory

Potted plants of *Adhatoda vasica Caladium* sp *Maranta* sp *Ocimum sanctum Rosa* sp *Thunbergia alata* and *Polyanthes tuberosa* Linn were used for further multiplication of the mites The mites collected from the fields were released on the selected host plants and were allowed to multiply thus serving as the stock cultures of the selected species for the studies on biology The potted plants were regularly examined and the predatory mites and insects removed as and when encountered

3 3 2 Biology

Biology of the mites were studied following the leaf disc techn que(Sathiamma 1991) Petri plates (9cm diameter) were used as cages for the mites Leaf bits (2 cm^2) of host plants placed on

moist cotton pad inside the lower petri plates formed the substrata for rearing the mites The cut end of each leaf bit was rimmed with a thin layer of cotton which prevented the escape of mites from the leaf bit The cotton pads were daily moistened with water to prevent drying up of leaf bits

Deutonymphs collected from the stock culture were released on the leaf bits of the respective host plants and the adults were allowed to emerge from teliochrysalis and mate with the opposite sex Males were removed after 24 hours from the petriplates and the mated females were released into leaf discs for egg laying The leaf bits were periodically replaced with fresh ones Ten replications were maintained for each species

Eggs laid on each day were recorded separately The emerging larvae were closely monitored to record the changes taking place in the developmental stages Initially observations were recorded at 15 minutes interval and later in the morning and evening The observations recorded were on pieoviposition oviposition and post oviposition periods duration of egg larva protonymph deutonymph intervening quiescent stages and adult and the number of eggs laid The morphological changes taking place during the course of development were also examined with the help of a stereo binocular microscope and recorded The morphometric observations of different life stages were recorded using an ocular micrometer standardised by a stage micrometer and the measurements were recorded in microns

The biology of the mites were studied twice first in November 1994 and second in March 1995

3 3 3 Matıng behavıour

Deutonymphs of both sexes of *T cınnabarınus T ludenı T neocaledomcus T pacıfıcus* and *R ındıca* were kept ın pairs as well as ın groups ın the leaf dıscs of the respectıve host plants ın separate petrı plate cages The deutonymphs and the newly emerged adults closely observed and the matıng behavıour of the adults descrıbed The matıng behavıoul of *B phoenıcıs* could not be studıed as no males were encountered ın the studıes

3 3 4 Ovıpositional pattern

The ovıpositional pattern of *B phoenıcıs* on five host plants was studıed as ıt was an ımportant polyphagous mıte The newly emerged females of *B phoenıcıs* were released ınto excısed leaf dıscs of five host plants vız *Caladıum* sp *Maranta* sp *O sanctum Dendrobıum* sp and *P tuberosa* for egg layıng and observatıons recorded on pre ovıpositıon ovıpositıon and post ovıpositıon perıods and the number of eggs laıd tıll the death of the females Fıve replıcatıons were maıntaıned for each host plant The data obtaıned were subjected to statıstıcal analysıs

3 4 Crop loss assessment

The vegetable crops bhındı and chıllı were observed to be serıously ınfested by mıtes *Tetranychus ludenı* and *Polyphagatarsonemus latus* were found ın the survey as the most ımportant mıte pests of bhındı and chıllı respectıvely Hence *T ludenı* on bhındı and *P latus* on chıllı were selected for studıes on crop loss assessment

3 4 1 Crop loss due to *Tetranychus ludeni* in bhindi

A pot culture experiment was carried out from December 1993 to February 1994 in the College of Agriculture Vellayani to study the crop loss caused by *T ludeni* in bhindi

3 4 1 1 Mass culturing of *Tetranychus ludeni*

A stock culture of *T ludeni* was maintained continuously to get sufficient population for releasing them on the test plants in the pot culture experiment For this purpose bhindi seeds were sown in pots in a phased manner commencing from three months prior to the experiment When the plants were three to four weeks old *T ludeni* collected from bhindi plants in the field were released on them and the mites were allowed to multiply thus serving as the stock culture The plants were closely monitored and the predators removed whenever encountered

3 4 1 2 Pot culture experiment to assess crop loss in bhindi

A pot culture experiment in completely randomised design with nine treatments and three replications was conducted The variety Kiron was used for the study Plants were raised in 12 x 15 sized flower pots at the rate of one plant per pot Manures and fertilizers were given to the plants as per the recommendations in the Package of Practices (KAU 1989) The different treatments were as detailed below

Treatment 1	30 mites/plant released at 15 DAS
Treatment 2	10 mites/plant released at 30 DAS
Treatment 3	30 mites/plant released at 30 DAS
Treatment 4	10 mites/plant released at 45 DAS
Treatment 5	20 mites/plant released at 45 DAS
Treatment 6	30 mites/plant released at 45 DAS
Treatment 7	40 mites/plant released at 45 DAS
Treatment 8	50 mites/plant released at 45 DAS
Treatment 9	Monocrotophos 0 05% sprayed at fortnightly intervals

In each treatment one plant was maintained for destructive sampling Sowing of bhindi seeds was staggered to effect the release of mites simultaneously

The plants were kept free of all pests by mechanically removing them as and when encountered upto the time of release of mites After the release of mites pests other than mites were periodically removed

3 4 1 2 1 Observations

The percentage of leaf infestation was assessed by counting the total number of leaves and the number of leaves infested by *T ludeni* The observation was recorded from each plant at weekly intervals The weight of fruits per plant in each treatment was recorded at harvest Population counts of *T ludeni* were recorded at weekly intervals Counts of *T ludeni* present in 1 cm^2 area on the ventral side in each of the three leaves selected from the top middle and

bottom portion of the plant were determined using a 10x lens The data was subjected to statistical analysis

The main symptoms produced by the feeding of *T ludeni* were speckling on the upper surface of the leaf lamina in the early stages of infestation followed by chlorotic patches (Sathiamma 1991) For assessing the development of these symptoms a 0 12 scale which was newly evolved for the present studies was followed

	Damage Grade Index
0 5% speckling alone	0
0 5% speckling + Chlorotic patches	1
6 20% speckling alone	2
6 20% specking + chlorotic patches	3
21 40% speckling alone	4
21 40% speckling + chlorotic patches	5
41 60% speckling alone	6
41 60% speckling + chlorotic patches	7
61 80% speckling alone	8
61 80% speckling + chlorotic patches	9
81 100% speckling alone	10
81 100% speckling + chlorotic patches	11
Drying of leaves	12

Grade points alloted were statistically analysed

3 4 1 2 2 Estimation of chlorophyll

Leaf samples of bhindi showing varying degrees of damage symptom (6 20% 21-40% 41 60% and > 60%) were collected from plants meant for destructive sampling in the pot culture experiment and were used for the estimation of chlorophyll Leaf samples taken from healthy plants served as control The samples were thoroughly cleaned after collection from the plants Chlorophyll was estimated by the spectrophotometric method according to the procedure outlined by Mahadevan a id Sridhar (1982)

3 4 2 Crop loss caused by *Polyphagotarsonemus latus* on chilli

Crop loss due to *P latus* on chilli was assessed by laying out pot culture experiments

3 4 2 1 Mass culturing of *Polyphagotarsonemus latus*

Stock culture of *P latus* was maintained in the laboratory in potted plants prior to the experiment Chilli seeds were sown and transplar ted in pots of 12 x 15 in a phased manner commencing from three months prior to the experiment Three to four weeks after transplanting *P latus* collected from chilli plants in the field were released on them and were allowed to multiply thus serving as the stock culture for the pot culture experiment

3 4 2 2 Pot culture experiment to assess crop loss in chilli

Two pot culture experiments were conducted in chilli to assess the damage caused by *P latus* the first from May to September 1993 and the second from October 1993 to

February 1994 The variety used was Jwalamukhi and the seedlings were raised in pots of size 12 x 15 One month old seedlings were transplanted to pots of size 12 x15 at the rate of one per pot The preparation of potting mixture and the application of manures and fertilisers were according to the recommendation of Package of Practices (KAU 1989) The treatments for the experiments were the following

Treatment 1 10 mites released per plant

Treatment 2 24 mites released per plant

Treatment 3 50 mites released per plant

Treatment 4 100 mites released per plant

Treatment 5 Monocrotophos 0 05 per cent sprayed at fortnightly intervals

The treatments were the same for both the experiments except that in the first experiment the mites were released three weeks after transplanting and in the second experiment the mites were released six weeks after transplanting The plants were kept free of all pests by mechanically removing them as and when encountered upto the time of release of mites After the release of mites pests other than mites were removed periodically Both experiments were laid out in Completely Randomized Design each with four replications

3 4 2 2 1 Observations

The percentage of leaf infestation was assessed by counting the total number of leaves and the number of leaves infested by *P latus* The observation was recorded from each plant at weekly intervals The weight of fruits per plant in each treatment was recorded at the time

of harvest Population counts of *P latus* present in three leaves per plant collected from top middle and bottom portions were recorded at weekly intervals

Development of symptoms in chilli due to *P latus* was observed and recorded at weekly intervals after the release of mites The damage was assessed on a 0 6 point scale newly evolved for the present studies as detailed below

	Damage grade index
No crinkling	0
Initiation of crinkling	1
Presence of slight upward and downward crinkling on the leaf	2
Crinkling of leaves + Tendency of leaves for downward curling	3
Downward curling of leaves	4
Downward curling of leaves + Slight tubular leaves	5
Downward curling of leaves + tubular leaves + clustering of leaves	6

The damage grade indices were analysed statistically

3 4 3 Intra plant distribution of mites

The intra plant distribution of *T ludeni* was assessed from the same pot culture experiment conducted to study the crop loss in bhindi (3 4 1) The population counts of *T ludeni* present in 1 cm^2 leaf area in each of the three leaves selected from the top middle and bottom portions of the plants were recorded at weekly intervals and anyalysed statistically

3 4 3 2 *Polyphagotarsonemus latus* on chilli

The intra plant distribution of *P latus* was also studied from the same pot culture experiments conducted to assess the crop loss in chilli (3 4 2) The population counts of *P latus* recorded in each of the three leaves selected in the top middle and bottom strata of the chilli plant at weekly intervals were statistically analysed

RESULTS

4 RESULTS

4 1 Survey on phytophagous mites and their natural enemies associated with vegetables, medicinal plants and ornamentals in Thiruvananthapuram District

4 1 1 Phytophagous mites

The summarised list of species of phytophagous mites associated with vegetables medicinal plants and ornamentals observed in the survey is presented in Table 1 The families identified in the survey were Tetranychidae Tenuipalpidae Tarsonemidae and Eriophyidae of the suborder Prostigmata and Galumnidae and Oribatidae of the suborder Cryptostigmata represented by the genera *Tetranychus Schizotetranychus Brevipalpus Raoiella Tenuipalpus Polyphagotarsonemus Tarsonemus Aceria Eriophyes* and *Orthogalumna* (Plate I)

At species level the mites were identified as *Tetranychus cinnabarinus* (Boisduval) *Tetranychus ludeni* Zacher *Tetranychus neocaledonicus* Andre and *Schizotetranychus hindustanicus* (Hirst) of the family Tetranychidae *Brevipalpus phoenicis* Geijskes *Raoiella indica* Hirst and *Tenuipalpus pacificus* Baker of the family Tenuipalpidae *Polyphagotarsonemus latus* (Banks) of the family Tarsonemidae and *Aceria pongamiae* of the family Eriophyidae The mites belonging to genus *Tarsonemus* of the family Tarsonemidae the genera *Aceria* and *Eriophyes* of the family Eriophyidae and the genus *Orthogalumna* of the family Galumnidae could be identified upto the genus level while the oribatids could be identified upto the family level

Table 1 Phytophagous mites associated with vegetables medicinal plants and ornamentals n Thiruvananthapuram District

Suborder	Family	Genus/Species
Cryptostigmata	Galumnidae	*Orthogalumna* sp
	Oribatidae	Unidentified
Prostigmata	Tetranychidae	*Tetranychus cinnabarinus* (Boisduval)
		Tetranychus ludeni Zacher
		Tetranychus neocaledonicus Andre
		Schizotetranychus hindustanicus (Hirst)
Prostigmata	Tenuipalpidae	*Brevipalpus phoenicis* (Geijskes)
		Raoiella indica Hirst
		Tenuipalpus pacificus Baker
Prostigmata	Tarsonemidae	*Polyphagotarsonemus latus* Banks
		Tarsonemus spp
Prostigmata	Eriophyidae	*Aceria* spp
		Aceria pongamiae Channabasavanna
		Eriophyes sp

Plate I **Phytophagous mites representing the important genera identified in the survey**

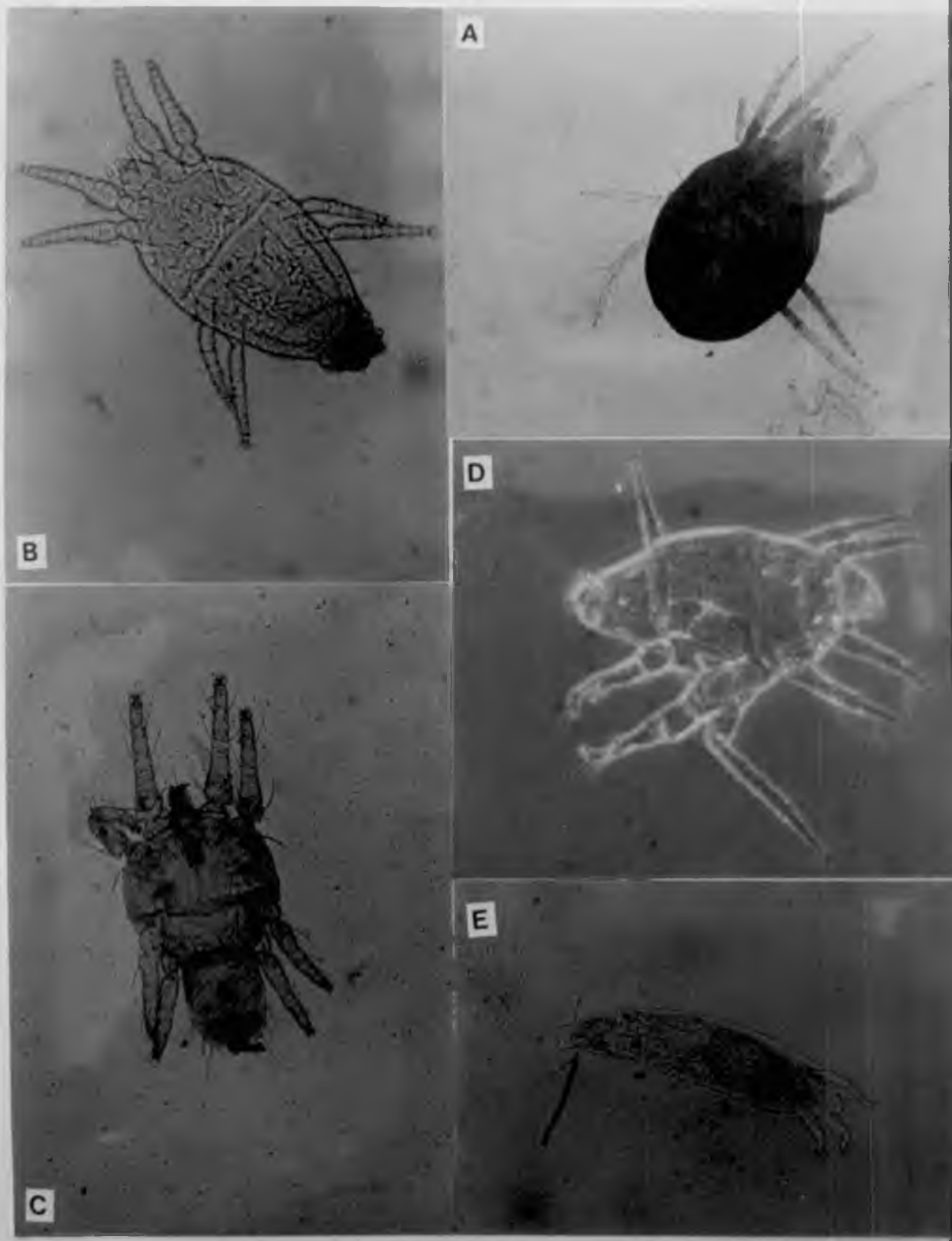
A *Tetranychus*

B *Brevipalpus*

C *Tenuipalpus*

D *Polyphagotarsonemus*

E *Aceria*


A
B
C
D
E

4 1 1 1 Phytophagous mites on vegetables

The details of phytophagous mites associated with different vegetables crops are given in Table 2

In the survey conducted it was found that the vegetable crops were infested with mites belonging to the families Tetranychidae Tenuipalpidae and Tarsonemidae In the family Tetranychidae the species *T c nnabarinus T ludeni* and *T neocaledonicus* were found to attack more than one host plant *T cinnabarinus* infested two species of Amaranthus viz *Amaranthus bicolor* and *A dubius T ludeni* was associated with *Abelmoschus esculentus* and *Vigna unguiculata* sub sp *sesquipedalis* while *T neocaledonicus* was associated with *Cucurbita pepo Moringa oleifera* and *Solanum melongena* The tarsonemid mite *P latus* was observed to have a wide host range and found to infest the vegetable crops *Momordica charantia Capsicum annum Cucurbita pepo Luffa acutangula V unguiculata* sub sp *sesquipedalis* (Plate II) *B phoenicis* was the only tenuipalpid mite found infesting vegetables and the infestation was recorded only in *S melongena*

4 1 1 2 Phytophagous mites on medicinal plants

The details of phytophagous mites associated with medicinal plants are presented in Table 3 The mites observed in the survey belonged to the families Tetranychidae Tenuipalpidae Tarsonemidae and Eriophyidae *Tetranychus* was found to be the most dominant genus infest ng sixteen of the one hundred and fourteen species of medicinal

Table 2 Phytophagous mites associated with vegetables n Thiruvananthapuram District

Host plant		Species of phytophagous mites
Bhindi	(*Abelmoschus esculentus* Linn (Moench)	*Tetranychus ludeni*
Amaranthus	(*Amaranthus bicolor* L)	*Tetranychus cinnabarinus*
Amaranthus	(*Amaranthus dubius* Mart ex Thell)	*Tetranychus cinnabarinus*
Chilli	(*Capsicum annum* L)	*Polyphagotarsonemus latus*
Pumpk n	(*Cucurbita pepo* L)	*Tetranychus neocaledonicus*
		Polyphagotarsonemus latus
Ridge gourd	(*Luffa acutangula* Roxb)	*Polyphagotarsonemus latus*
Bittergourd	(*Momordica charantia* L)	*Tetranychus* sp
		Polyphagotarsonemus latus
Moringa	(*Moringa oleifera* Lam)	*Tetranychus neocaledonicus*
Brinjal	(*Solanum melongena* L)	*Tetranychus neocaledonicus* *Brevipalpus phoenicis*
Vegetable cowpea	(*Vigna unguiculata* sub sp *sesquipedalis* (L) Verdcourt)	*Tetranychus ludeni* *Polyphagotarsonemus latus*

Table 3 Phytophagous mites associated with medicinal plants in Thiruvananthapuram District

Host plant		Species of phytophagous mites
Adalodakam	(*Adhatoda beddomei* Cl)	*Tetranychus cinnabarinus*
		Brevipalpus sp
		Tarsonemus sp
Adalodakam	(*Adhatoda vasica* Nees)	*Tetranychus cinnabarinus*
Chittaratha	(*Alpinia galanga* (L) SW)	*Tetranychus* sp
Vepu/Neem	(*Azadirachta indica* A Juss)	*Schizotetranychus hindustanicus*
Nagadanti	(*Baliospermum montanum* M Arg)	*Orthogalumna* sp
Kattu Vepu	(*Cipadessa* sp)	*Brevipalpus* sp
		Raoiella indica
Cheruthek	*Clerodendrumserratum* L	*Brevipalpus phoenicis*
Uzhinja	(*Cordiospermum halicacabum* Linn)	*Tetranychus* sp
Sanghupushpam	(*Clitoria ternatea* L)	*Tetranychus* sp
Pata	(*Cyclea* (*peltata*) *burmanni* Hook f & Thomas)	*Tetranychus* sp
Orila	(*Desmodium gangetum* (L) DC)	*Polyphagotarsonemus latus*
		Tetranychus ludeni
Avil	*Elaecarpus serratus* Linn	*Aceria* sp
Ithi	(*Ficus tuberculata*)	*Tetranychus* sp
Kumbil	(*Gmelina arborea* Linn)	*Polyphagotarsonemus latus*
Chakkarakolli	(*Gymnema sylvestre* (Retz) Schutt)	*Tetranychus* sp
		Brevipalpus phoenicis

Common names of medicinal plants are given in malayalam

contd

Table 3 contd

	Host plant	Species of phytophagous m tes
Kasthurivenda	(*Hibiscus abelmoschus* Linn)	*Tetranychus ludeni*
Puliyaral	(*Oxalis corniculata* Linn)	*Tetranychus ludeni*
Tulasi	(*Ocimum sanctum* Linn)	*Brevipalpus phoenicis*
Keezhanelli	(*Phyllanthus fraternus* Webster)	*Tetranychus* sp
Chetti koduveli	(*Plumbago rosea* Linn)	*Tetranychus* sp
Pongu	(*Pongamia pinnata* (L) P erre)	*Aceria pongamiae*
Malamkara	(*Randia spinosa* Poir)	*Aceria* sp
Manjatti	(*Rubia cordifolia* L sensu Hook f)	*Brevipalpus* sp
Sarpagandha	(*Rauvolfia serpentina* (L) Benth)	*Tetranychus ludeni*
Ponkarandi	(*Solacia reticulata* wt)	*Brevipalpus* sp
Chandanam	(*Santalum album* Linn)	*Polyphagotarsonemus latus*
Kurunthotti	(*Sida rhombifolia* Linn)	*Tetranychus neocaledonicus*
Chunda	(*Solanum indicum* Linn)	*Brevipalpus phoenicis*
Karimkurinji	(*Strobilanthes ciliates* Nees)	*Brevipalpus phoenicis*
Alpam	(*Thottea siliquosa* (Lamnk) Ding Hou)	*Tetranychus* sp
Karinochi	(*Vitex negundo* Linn)	*Polyphagotarsonemus latus*
Arogyapacha	(*Trichopus zeylamcus Gaertn*)	*Polyphagotarsonemus latus*
		Tarsonemus sp
Amukkuram	(*Withama somnifera* (L) Durnal)	*Brevipalpus phoenicis*

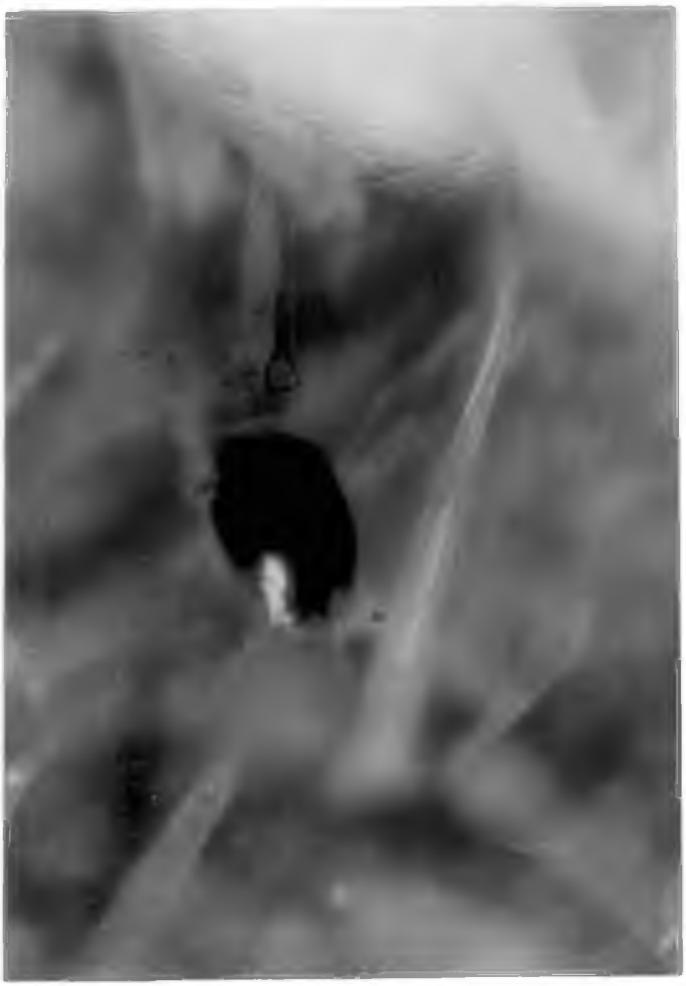
Common names of med cinal plants are gi en in malayalam

Plate II ***Polyphagotarsonemus latus*** **on pumpkin**

A As seen on the host plant

B Ventral view (after clearing)

Plate II



A

B

plants surveyed (Appendix I) while the genera *Brevipalpus* and *Polyphagotarsonemus* infested nine and five species respectively The Tetranychid mites *T cinnabarinus* *T ludeni* and *T neocaledonicus* the important mite pests of vegetables were found to infest the medicinal plants *Adhatoda* spp *Rauvolfia serpentina* and *Sida rhombifolia* respectively The tenuipalpid mite *B phoenicis* and the tarsonemid mite *P latus* were found to have wide host ranges infesting six and five species of medicinal plant respectively Species of *Aceria* belonging to the family Eriophyidae were recorded on *Elaeocarpus serratus* (Plate III) and *Randia pinosa*

4 1 1 3 Phytophagous mites on ornamental plants

The details of phytophagous mites associated with ornamental plants are presented in Table 4 The ornamental plants surveyed were observed to be infested by phytophagous mites belonging to the families Tetranychidae Tenuipalpidae Tarsonemidae Eriophyidae and Oribatidae Out of the thirty seven species of ornamental plants surveyed ten spec es of plants were seen infested with the genus *Tetranychus* while four species each were infested with the genera *Brevipalpus* and *Tenuipalpus* *Polyphagotarsonemus* infested two species of ornamental plants *Raoiella* *Tarsonemus* and *Eriophyes* were recorded in one species each of the ornamental plants

As observed in vegetables and medicinal plants *T ludeni* and *T neocaledonicus* were the important species of tetranychid mites infesting ornamental plants also The infestation of *T cinnabarinus* was recorded in croton sp only while *T ludeni* was observed on *Bauhinia acuminata* *Dahlia* sp and *Rosa* sp and *T neocaledonius* was observed in

Table 4 Phytophagous mites associated with ornamental plants in Thiruvananthapuram District

	Host plant	Phytophagous mites
Anthurium	(*Anthurium andreanum* (Lind) Schoot)	Oribatid mite
Bauhinia	(*Bauhinia acuminata* L)	*Tetranychus ludeni*
Caladium	(*Caladium* sp)	*Brevipalpus phoenicis*
Croton	(*Codiaeum variegatum* (L) Blume)	*Tetranychus cinnabarinus*
Crossandra	(*Crossandra* sp)	*Polyphagotarsonemus latus*
Dahlia	(*Dahlia* sp)	*Tetranychus ludeni*
Gardenia	(*Gardenia jasminoides* Ellis)	*Eriophyes* sp
Gladiolus	(*Glad olus* sp)	*Tetranychus* sp *Brevipalpus* sp
Hibiscus	(*Hibiscus rosa sinensis* L)	*Tetranychus neocaledonicus*
Jasmine	(*Jasminum grandiflorum* L)	*Tetranychus neocaledonicus*
	(*Jasminum sambac* (L) Ait)	*Tetranychus* sp
Maranta	(*Maranta* sp)	*Brevipalpus phoenicis*
Mussaenda	(Mussaenda erythrophylla *Schu nm and Thonn)*	*Tetranychus* sp
Orchid	(*Arachn s* sp)	*Tenuipalpus pacificus*
Orchid	(*Aranda* sp)	*Tenuipalpus pacificus*
Orchid	(*Dendrobium* sp)	*Tenuipalpus pacificus* *Brevipalpus phoenicis*
Orchid	(*Vanda* sp)	*Tenuipalpus pacificus*
Rose	(*Rosa* sp)	*Tetranychus ludeni* *Tetranychus neocaledonicus*
Marigold	(*Tagetes erecta* L)	*Polyphagotarsonemus latus* *Tarsonemus* sp
Thunbergia	(*Thunbergia alata* Boj ex Sims)	*Raoiella ind ca*

Plate III *Acerta* sp on *Elaeocarpus serratus*

Plate III

Hibiscus rosa - sinensis, *Jasminum grandiflorum*, *Jasminum sambac* and *Rosa* sp. The tenuipalpid mite, *T. pacificus* was observed in orchids of the genera *Arachnis*, *Aranda*, *Dendrobium* and Vanda while *R. indica* was observed only in *Thunbergia alata*. *B. phoenicis* was found in *Caladium* sp. and *Dendrobium* sp. The tarsonemid mite *P. latus* was found infesting *Crossandra* sp. and *Tagetes erecta*. Oribatids were the only mites recorded on *Anthurium andreanum*.

4.1.2 Predators

The details of predators of phytophagous mites associated with vegetables, medicinal plants and ornamentals observed in the survey are presented in Table 5 and plates IV to IX. Both acarine and insect predators were observed in the survey. Between the two, the acarines were found to be the dominant predatory group. The predatory mites observed during the survey belonged to the families Bdellidae, Cheyletidae, Cunaxidae, Phytoseiidae and Stigmaeidae which were represented by the genera *Cheyletus*, *Cunaxa*, *Amblyseius* *Phytoseiulus* and *Agistemus*. Besides these, mites belonging the family Ascidae were found in the colonies of *Tetranychus ludeni* on *Abelmoschus esculentus* and *Dahlia* sp.

Amblyseius, belonging to the family Phytoseiidae was found to be the most widespread genus of predatory mites (Table 5). This was found in association with the phytophagous mites *T. neocaledonicus* on *S. rhombifolia*, *C. ternatea*, *Hibiscus*, *C. pepo* and *J. grandiflorum*; *T. ludeni* on *A. esculentus*, *R. serpentina*, *Rosa* sp, *D. gangeticum* and *O. corniculata*; *B. phoenicis* on *G. sylvestre* and *O. sanctum*;

Table 5 Predators of phytophagous mites associated with vegetables, medicinalplants and ornamentals in Thiruvananthapuram District

Predator		Prey mite	Host plant
Order / Family	Species		
A. Predatory mite			
Ascidae	Unidentified	*T. ludeni*	*A. esculentus*
Bdellidae	Unidentified	*Tarsonemus* sp.	*A. beddomei*
Cheyletidae	*Cheyletus* sp.	*P. latus*	*T. zeylanicus*
Cunaxidae	*Cunaxa* sp.	*T. cinnabarinus*	*A. beddomei*
		T. ludeni	*H. abelmoschus*
		T. neocaledonicus	*S. melongena* *H. rosa sinensis*
Stigmaeidae	*Agistemus* sp.	*B. phoenicis*	*G. sylvestre*
Phytoseiidae	*Amblyseius (Amblyseius)* sp.	*T. neocaledonicus*	*S. rhombifolia*
		T. ludeni	*A. esculentus* *R. serpentina*
Phytoseiidae	*Amblyseius (Euseius)* sp.	*B. phoenicis* *B. phoenicis* *T. pacificus*	*G. sylvestre* *O. sanctum* *Dendrobium* sp.
Phytoseiidae	*Amblyseius longispinosus (Evans)*	*T. ludeni*	*A. esculentus*
Phytoseiidae	*Amblyseius (Neoseiulus)* sp.	*T. neocaledonicus*	*C. ternatea*
Phytoseiidae	*Amblyseius (Paraphytoseius) multidentatus Swirski and Schecter*	*T. necaledonicus* *S. hindustanicus*	*C. pepo* *A. indica*
Phytoseiidae	*Amblyseius (Typhlodromalus)* sp.	*R. indica*	*T. alata*

Contd.....

Table 5 contd.

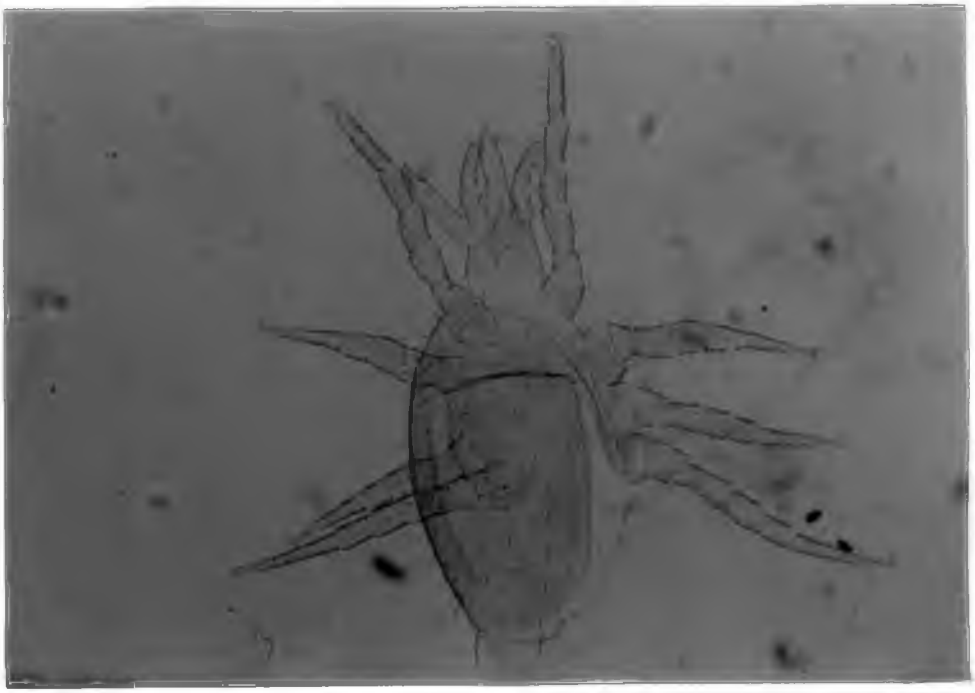
Predator Order / Family	Species	Prey mite	Host plant
Phytoseiidae	*Amblyseius* sp.	*T. cinnabarinus*	*A. dubius, A bicolor*
		P. latus	*C. annum*
		T. neocaledonicus	*H. rosa-sinensis*
		T. neocaledonicus	*J. grandiflorum*
		T. ludeni	*Rosa* sp. *D. gangeticum* *O. corniculata* *V. unguiculata* sub sp. sesquipedalis
		R. indica	*T. alata*
Phytoseiidae	*Phytoseiulus* sp.	*T. cinnabarinus*	*A. beddomei*
B. Predatory insects			
Coleoptera (Coccinellidae)	*Stethorus* sp	*T. neocaledonicus*	*C. pepo* *V. unguiculata* sub sp. *sesquipedalis*
		T. cinnabarinus	*A. dubius, A bicolor*
		T. ludeni	*Rosa sp.* *A. esculentus*
		P. latus	*C. annum*
Hemiptera	Unidentified	*P. latus*	*C. annum*
Thysanoptera	Unidentified	*T. neocaledonicus*	*A. bicolor*
			A. dubius

Plate IV Predatory mites

A. Predator belonging to the family Ascidae, associated with *Tetranychus ludeni* on bhindi

B. Predator belonging to the family Cunaxidae associated with *Tetranychus ludeni* on *Hibiscus abelmoschus*

Plate IV

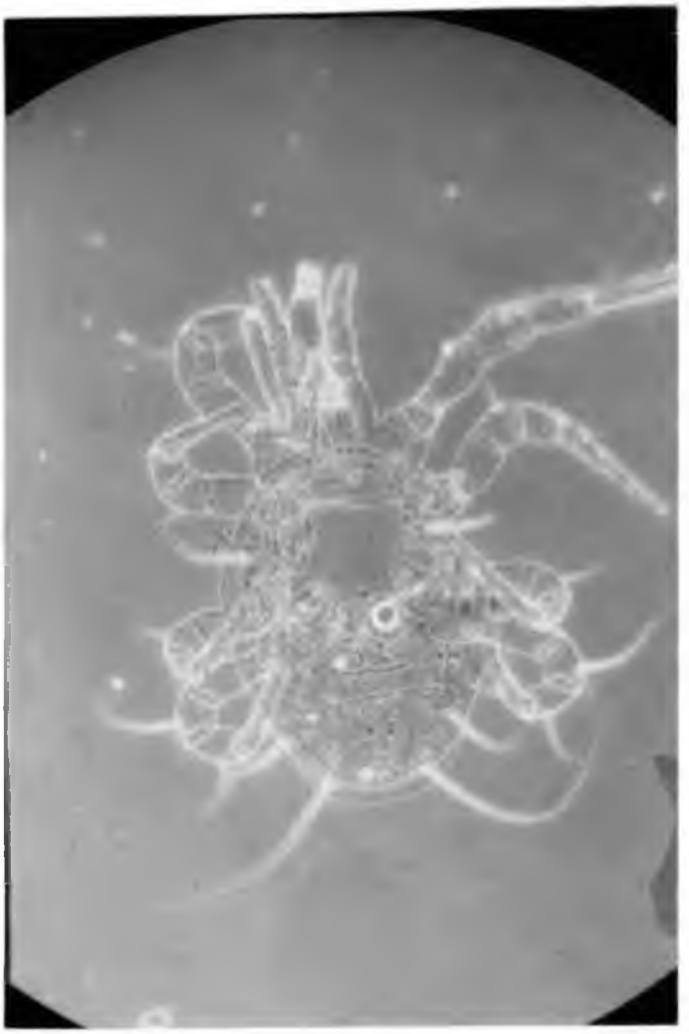


A

B

Plate V *Amblyseius* sp predatory on *Tetranychus cinnabarinus* on amaranthus

Plate V



I late VI *Amblyseius(Euseius)* sp predatory on *Polyphagotarsonemus latus* n chilli

Plate VI

Plate VII Predatory mites

A. *Amblyseius* (*Amblyseius*) sp. predatory on *Tetranychus ludeni* on *Rauvolfia serpentina*.

B. *Amblyseius* (*Euseius*) sp. predatory on *Tenuipalpus pacificus* on *Dendrobium* sp.

Plate VII

A

B

Plate VIII Predatory mites

A. *Amblyseius* (*Euseius*) sp. predatory on *Brevipalpus phoenicis* on *Gymnema sylvestre*

B. *Amblyseius* (*Euseius*) sp predatory on *Brevipalpus phoenicis* on *Ocimum sanctum*

Plate VIII

A

B

Plate IX Predators

A. Predatory mite belonging to the family stigmaeidae

B. *Stethorus* sp. belonging to the family Coccinellidae

Plate IX

A

B

T. pacificus on *Dendrobium*; *T. cinnabarinus* on *A bicolor*, *A. dubius*, *S. hindustanicus* on *A. indica* and *R. indica* on *T. alata.*

Cunaxa spp. of the family Cunaxidae were next in importance to *Amblyseius* and were found associated with tetranychid mites in *A. beddomei*, *H. abelmoschus* and *S. melongena.*

4.1.3 Percentage of mite infested leaves and population counts

The data on the mean percentage of mite infested leaves and the mean population counts of phytophagous mites associated with vegetables, medicinal plants and ornamentals in the survey conducted in Thiruvananthapuram District are presented in Tables 6-8.

4.1.3.1 Vegetables

The mean percentage of mite infested leaves and the mean population counts of phytophagous mites associated with vegetables in the premonsoon, monsoon and postmonsoon seasons of 1992 and 1993 in the Agricultural College Farm, Vellayani and in the District Agricultural College Farm, Peringammala are given in Table 6a and 6b respectively.

4.1.3.1.1 Agricultural College Farm, Vellayani

T. ludeni on *A. esculentus* and *V. unguiculata* sub sp *sesquipedalis; T. cinnabarinus* in *A. bicolor* and *A. dubious*, *P. latus* in *C. annum*, *C. pepo*, *L. acutangula* and

M. charantia; *T. neocaledonicus* in *C. pepo*, *M. oleifera* and *S. melongena* and *Brevipalpus* sp. in *S. melongena* were the phytophagous mites observed in vegetables in the Agricultural College, Vellayani (Table 6 a).

The mean percentage of leaves infested by *T. ludeni* in *A. esculentus* in the premonsoon season of 1992 was 63.63 while the mean population count of the mite was 10.33. During the premonsoon of 1993, the mite infested 93.1 per cent of the leaves and the mean mite count increased to 125.66. In the monsoon and postmonsoon seasons during 1992 the mean percentage of infested leaves were 0 and 12 per cent and the mean population counts were 0 and 12.12 respectively. In the corresponding seasons in 1993, the mean percentage of leaf infestation was 15.8 and 22 and population counts were 19.66 and 12 respectively.

There was no mite infestation in amaranthus during the year 1992 and in the postmonsoon season of 1993 while the percentage of leaf infestation by *T. cinnabarinus* in premonsoon season of 1993 was 53.3 and the mean population count was the 128.83. In the monsoon season of 1993, the values were 3.6 and 45.66 respectively.

In chilli 40.9 and 68.18 per cent of the leaves were infested by *P. latus* in the premonsoon seasons of 1992 and 1993 respectively while in the postmonsoon season of 1993 it went up to 74.2 per cent. However the population count in the premonsoon season of 1992 and 1993 were 14 and 12 mites per leaf respectively while in the postmonsoon season of 1993, the value was 17.66. There was no mite infestation in *M. charantia* in 1992 while in the premonsoon season of *P. latus* infested 24.5 per cent of leaves and the mean population count was 12.33 per cent. In *L. acutangula* also the mite showed the same trend.

Table 6a Mean percentage of mite infested leaves and mean population counts of phytophagous mites in vegetables at the Agricultural College Farm Vellayani

Host plant	Mite		Mean percentage of leaves infested			Mean population per leaf		
			Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean + SE	Postmonsoon season Mean + SE
Abelmoschus esculentus	*T ludeni*	+	63 63	0	12	10 33 + 5 68	0	12 12 + 4 22
(Bhindi)		+	93 10	15 8	22	125 66 + 54 50	19 66 + 2 08	12 0 + 7 93
Amaranthus bicolor	*T cinnabarinus*	+	0	0	0	0	0	0
(Amaranth		++	53 30	3 6	0	128 33 + 66 7	45 66 36 82	0
Capsicum annum	*P latus*	+	40 90	0	0	14 + 6 24	0	0
(Chilli)		+	68 18	13 3	74 2	12 + 5 29	5 + 1 73	17 66 + 3 78
Cucurbita pepo	*T neocaledonicus*	+	27 60	0	8 6	405 46 + 176 13	0	37 33 + 20 03
(Pumpkin)		++	45 00	0	25	9 33 + 2 51	0	8 6 + 5 29
	P latus	+	0	0	0	0	0	0
		++	0	0	20	0	0	8
Momordica charantia	*P latus*	+	0	0	0	0	0	0
(Bittergourd)		+	24 50	0	16 7	12 33 + 0 79	0 0	1 33 + 8 97

+ Survey in 1992 + Survey in 1993 SE Standard Error (Contd)

Table 6a contd

Host plant	Mite		Mean percentage of leaves nfested			Mean populatıon pe leaf		
			Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean + SE	Postmonsoon season Mean + SE
Moringa oleifera (Moringa)	*T neocaledonicus*	+	36 00	0	0	12 66 + 4 72	0	0
		++	6 79	0	8 23	9 33 + 5 50	0	2 66 + 1 52
Luffa acutangula Roxb Ridge gourd)	*P latus*	+	0	0	0	0	0	0
		++	37 50	0	0	9 33 + 7 76	0	0
Solanum melongena (Brınjal)	*T neocaledonicus*	+	6 5	0	40	8 + 4	0	2 + 1
		++	15 8	0	0	49 66 + 10 96	28 33 + 23 98	0
	Brevipalpus sp	+	6 5	0	0	5 66 + 1 33	0	0
		++	0	0	0	0	0	0
Vıgna unguiculata subsp *sesqupedalıs* (Vegetable cowpea)	*T ludenı*	+	19 5	74 2	75 7	70 66 + 63 44	38 33 + 18 55	0
		++	38 1	8 3	23 1	8 66 + 5 03	2 33 + 4 04	8 33 4 04

Survey ın 1992 ++ Survey ın 1993 SE Standard Error (Contd)

T neocaledonicus caused 27 6 per cent leaf infestation in *C pepo* with mean population of count was 405 46 mites per leaf in the premonsoon season of 1992 while in 1993 the infestation was 45 per cent and the mean population count was 9 33 In the postmonsoon season the infestation recorded during 1992 and 1993 were 8 61 and 25 per cent respectively In *M oleifera* the mite caused 36 per cent leaf infestation with a mean population count of 12 66 in the premonsoon season of 1992 and in 1993 the corresponding figures were 6 79 and 9 33 respectively

4 1 3 1 2 District Agricultural Farm Peringammala

The data on the mean percentage of mite infested leaves and the mean population counts of phytophagous mites in vegetables in the District Agricultural Farm Perimgammala are given in Table 6b

No mite infestation was observed in *A esculentus* during the premonsoon and monsoon seasons of 1992 However in the post monsoon season of the same year 27 27 per cent of the leaves were found infested by *T ludeni* with a mean population count of 48 mites per leaf In *V unguiculata* sub sp *sesquipelalis* also no mite infestation was observed in 1992 where as in the year 1993 there was 76 66 per cent of leaf infestation by *T ludeni* with a mean population of 10 mites per leaf

In Amaranthus *T cinnabarinus* was the mite observed Infestation of the mite was confined to the monsoon season of 1992 only the leaf infestation and the mean populat on count being 47 61 per cent and 29 14 mites per leaf respect vely

Table 6b Mean percentage of mite infested leaves and mean population counts of phytophagous mites in vegetables at District Agricultural Farm Peringammala

Host plant	Mite	Mean percentage of leaves infested			Mean population per leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean + SE	Postmonsoon season Mean + SE
Abelmoschus esculentus (Bhindi)	*T ludeni*	+ 0	0	27 27	0	0	48 + 58 07
		++ 10 66	0	0	20 + 5 29	0	0
Amaranthus bicolor (Amaranthus)	*T cinnabarinus*	+ 47 61	0	0	29 + 14 57	0	0
		++ 0	0	0	0	0	0
Capsicum annum (Chilli)	*P latus*	+ 24 85	14 28	0	17 33 + 6 11	14 + 6	0
		++ 30 47	0	15 38	7 33 + 3 51	0	2 66 + 1 15
Cucurbita pepo (Pumpkin)	*T neocaledonicus*	+ 0	0	0	0	0	0
		++ 14 28	9 37	36 36	16 33 + 6 35	11 + 7	505 + 163 70
Momordica charantia (Bittergourd)	*P latus*	+ 4	0	0	0 66 ± 1 15	0	0
		++ 25 71	0	0	10 66 + 4 16	0	0
Moringa oleifera (Moringa)	*T neocaledonicus*	+ 0	0	4	0	0	5 66 + 1 52
		+ 0	0	33 33	0	0	10 33 + 4 04
Solanum melongena (Brinjal)	*T neocaledonicus*	+ 20 75	0	0	11 66 ± 8 5	0	0
		++ 5 55	0	0	4 + 6 92	0	0
Vigna unguiculata subsp *sesqupedalis* (Vegetable cowpea)	*T ludeni*	+ 0	0	0	0	0	0
		++ 76 66	0	0	10 + 6 92	0	0

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error (Contd)

In *C pepo* the incidence of *T neocaledonicus* was high during post monsoon season of 1993 the percentage of infested leaves and mean population counts being 36 36 and 505 respectively The infestation during the premonsoon and monsoon seasons was comparatively lower The infested leaves were 14 28 per cent and 9 37 per cent with mean population counts of 16 33 and 11 mites per leaf respectively

In *C annum* and *M charantia* *P latus* was the phytophagous mite observed in the survey In *C annum* infestation of the mite was observed in the premonsoon and monsoon periods of 1992 where as in 1993 it was present only in the premonsoon and postmonsoon seasons In *M charantia* infestation of *P latus* was observed during the premonsoon season only The mean percentage of leaf infestation during 1992 and 1993 were 4 and 25 7 and the mean population counts were 0 66 and 10 66 respectively In *M oleifera* infestation of *T neocaledonicus* was observed only during the postmonsoon period only in both the years of survey and the mean percentage of leaves infested were 4 and 33 33 per cent while in *S melongena* the infestation was recorded during premonsoon only The mean percentage of infested leaves were 20 75 and 5 5 and the mean population counts were 11 66 and 4 during 1992 and 1993 respectively

4 1 3 2 Medicinal plants

The mean percentage of mite infested leaves and the mean population counts in medicinal plants at the Agricultural College Farm Vellayani District Agricultural Farm Peringammala Tropical Botanical Garden and Research Institute Palode and University Centre Kariavattom are presented in Tables 7a 7b 7c and 7d

4 1 3 2 1 Agricultural College Farm, Vellayani

The mean percentage of mite infested leaves and the mean population counts of phytophagous mites in medicinal plants at Agricultural College Farm Vellayani are given in Table 7a

T cinnabarinus was found to infest two species of *Adhatoda A beddomei* and *A vasica* but the infestation recorded in *A beddomei* was slightly higher The mean percentage of leaves damaged were 32 and 13 33 and the mean population counts were 52 and 10 66 mites per leaf in *A beddomei* and *A vasica* respectively during the premonsoon season of 1993

The polyphagous *T ludeni* was found to infest the medicinal plants *O corniculata Desmodium gangeticum* and *H abelmoschus T neocaledonicus* was observed in *C ternatea* while *Tetranychus* sp was observed on *P rosea* and *C halicacabum* and the infestation was more during the premonsoon season The tenuipalpid mite *B phoenicis* was observed to infest *O sanctum* the infestation of the mite was found to be more in the postmonsoon season

4 1 3 2 2 Ayurvedic Research Centre, Poojappura

The mean percentage of mite infested leaves and the population counts of phytophagous mites in medicinal plants at Ayurvedic Research Centre Poojappura are given in Table 7b

Table 7a Mean percentage of mite infested leaves and mean population counts of phytophagous mites in medicinal plants at Agricultural College Vellayani

Host plant	Mite	Mean percentage of leaves infested			Mean population per leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean SE	Postmonsoon season Mean + SE
Adhatoda beddomei (Chittadolodakam)	*T cinnabarinus*	+ 0	0	0	0	0	0
		++ 32	0	0	52 + 40 33	0	0
Adhatoda vasica (Adalodakam)	*T cinnabarinus*	+ 0	0	0	0	0	0
		++ 13 33	0	0	10 66 + 9 45	0	0
Ipcoria ternatea (Sanghupushpam)	*T neocaledonicus*	+ 19 0	0	0	8 66 + 2 08	0	0
		++ 28 1	0	25	110 + 51 39	0	14 66 1 15
Cordiospermum halicacabum halicacabum (Uzhinja)	*Tetranychus sp*	+ 28	0	35	9 2 + 2 58	0	11 + 1 73
		++ 53 3	0	0	30 33 + 20 79	0	0
Desmodium gangeticum (Orila)	*T ludeni*	+ 0	0	28 5	0	0	32 + 10 8
		++ 28	0	0	19 66 + 5 77	0	0
Hibiscus abelmoschus (Kasthurivenda)	*T ludeni*	+ 0	28 57	0	0	5 66 + 2 08	0
		++ 23 5	21 40	0	14 16 + 12 76	2 68 + 2 57	0
Ocimum sanctum (Tulasi)	*B phoenicis*	+ 0	4 44	25 45	0	2 66 + 2 51	11 33 + 3 05
		++ 15 85	0	46 66	4 + 3	0	6 + 2
Oxalis corniculata (Puliyaral)	*T ludeni*	+ 0	0	0	0	0	0
		++ 28	0	0	7 66 + 4 50	0	0
Plumbago rosea (Chettikoduveli)	*Tetranychus sp*	+ 0	0	0	0	0	0
		++ 35	20	5 85	14 + 16 13	2 66 + 4 61	0 31 + 0 57

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error

Table 7 Mean percentage of mite infested leaves and mean population counts of phytophagous mites in medicinal plants at Ayurvedic Research Centre Poojappura

Host plant	Mite	Mean percentage of leaves infested			Mean population per leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean + SE	Postmonsoon season Mean + SE
Adhatoda beddomei (Adalodakam)	*T cinnabarinus*	+ 11 11	0	18 75	8 5 + 6 92	0	46 66 + 18 92
		++ 6 45	0	42 85	33 66 + 10 69	0	3 + 1 73
Aristolochia indica (Garudakodi)	*B phoenicis*	+ 21 42	0	0	31 + 2 07	0	0
		++ 15 78	0	18 18	183 33	0	2 33 2 08
Cinnamomum zeylanicum (Cinnamon)	*Tetranychus* sp	+ 23 07	0	0	33 66 + 10 69	0	0
		++ 0	0	0	0	0	0
Clerodendrum serratum (Cheruthek)	*B phoenicis*	+ 5 33	21 05	0	4 66 + 3 78	9 33 + 4 16	0
		++ 14 81	0	5 26	2 66 + 1 15	0	3 33 + 1 15
Clitoria ternatea (Sanghupushpam)	*Tetranychus* sp	+ 42 30	0	25	15 66 + 8 02	0	0
		+ 12 30	0	19 49	14 0 + 9 16	0	11 33 + 9 07
Cyclea peltata (Pata)	*Tetranychus* sp	+ 63 63	0	0	8 22 + 11 36	0	
		+ 25	4 16	12 5	11 66 + 4 50	1 00 + 1 73	9 33 + 4 16
Desmodium gangeticum (Orila)	*T ludeni*	+ 16 66	33 33	0	23 33 + 10 11	1 33 + 1 52	0
		++ 25	0	16 66	12 66 + 9 07	0	13 + 12 16
Ficus tuberculata (Ithi)	*Tetranychus* sp	+ 14 28	0	0	142 33 + 12	0	0
		++ 27 27	0	0	23 66 + 25 42	0	0
Gymnema sylvestre (Chakkarakolli)	*B phoenicis*	+ 12	0	58 33	8 66 + 1 15	0	13 + 11 53
		++ 0	0	36 36	0	0	39 + 5 19

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error

Table 7b contd.

Host plant	Mite	Mean percentage of leaves infested			Mean population per leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean ± SE	Monsoon season Mean ± SE	Postmonsoon season Mean ± SE
Ocimum sanctum (Tulasi)	*B. phoenicis*	+ 0	0	25.45	0	0	11.33 ± 4.61
		++ 22.22	0	23.07	8.33 ± 2.51	0	9 ± 2
Oxalis corniculata (Puliyaral)	*T. ludeni*	+ 16.66	0	0	5 ± 6.08	0	0
		++ 10.86	0	0	7.66 ± 4.50	4.66 ± 2.08	2.66 ± 2.88
Pavetta indica (Pavetta)	*Tetranychus* sp.	+ 21.42	0	9.09	49.33 ± 40.01	0	120 ± 125.29
		++ 0	0	0	0	0	0
Phyllanthes fraternus (Keezhanelli)	*Tetranychus* sp.	+ 23.52	0	0	7 ± 3	0	0
		++ 32.50	0	0	13.33 ± 15.27	0	0
Plumbago rosea (Chetti koduveli)	*Tetranychus* sp.	+ 0	0	0	0	0	0
		++ 22.85	0	18.51	15 ± 9.64	0	5.66 ± 2.88
Rauvolfia serpentina (Sarpagandhi)	*T. ludeni*	+ 18.75	0	15.00	7.00 ± 5.56	0	3.66 ± 1.52
		++ 15.38	0	15.62	2.66 ± 1.15	0	6.33 ± 3.78
Rubia cordifolia (Manjatti)	*Brevipalpus* sp.	+ 0	0	0	0	0	0
		++ 14.28	0	0	1 ± 0	0	0
Sida rhombifolia (Kurunthotti)	*T. neocaledonicus*	+ 20	20	54.54	6 ± 2	12.33 ± 2.08	7 ± 5.29
		++ 14.04	14.28	15.78	16.66 ± 10.06	8.66 ± 5.03	4.33 ± 1.52
Solanum indicum (Chunda)	*B. phoenicis*	+ 0	0	0	0	0	0
		++ 19.04	23.52	38.38	6 ± 5.56	0	10.66 ± 5.77
Strobilanthes ciliatus (Karinkurinji)	*B. phoeincis*	+ 12	0	58.33	5 ± 1.73	0 ± 8.18	1.33 ± 0.57
		++ 0	0	36.36	6.0 ± 2	0 ± 0	2.0 ± 1.0
Trichopus zeylanicus (Arogya pacha)	*P. latus*	+ 0	0	0	0	0	0
		++ 0	0	36.36	0	0	21.16 ± 14.51

\+ Survey in 1992 ++ Survey in 1993 SE - Standard Error

T cinnabarinus was observed in *A beddomei* in the premonsoon and post monsoon season while *T ludeni* was observed in *D gangeticum O corniculata* and *R serpentina S rhombifolia* was infested by *T neocaledonicus*

Other *Tetranychus* species was observed in *C ternatea C peltata F tuberculata P indica P fraternus* and *P rosea* showing infestation uniformly more in the premonsoon season

The infestation of *B phoenicis* was recorded in *C serratum G sylvestre* and *S ciliates* The leaf infestation noticed varied from 5 26 to 21 05 per cent in *C serratum* 12 to 58 33 per cent in *G sylvestre* and 12 to 58 33 per cent in *S ciliates* respectively

4 1 3 2 3 Tropical Botanical Garden and Research Institute Palode

The data related to the mean percentage of mite infested leaves and the mean population counts of phytophagous mites in medicinal plants at the Tropical Botanical Garden and Research Institute Palode are presented in Table 7c

Tetranychid and tenuipalpid mites were found to infest the medicinal plants at this centre *T neocaledonicus* was observed during premonsoon season of 1993 in *C ternatea* and the mean percentage of infested leaves was 7 69 per cent with a mean population count of 28 33 mites per leaf *T ludeni* was found to infest *D gangetium* and the mean percentage of leaf infestation varied from 29 41 to 50 per cent while the mean population count varied from 2 to 24 33 mites per leaf The infestation of *B phoenicis* was observed in *S ciliates* during the premonsoon seasons in both the years of survey The mean

Table 7c Mean percentage of mite infested leaves and mean population counts of phytophagous mites in medicinal plants at TBGRI Palode

			Percentage of infested leaves			Mean Population per leaf		
			Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon Mean + SE	Monsoon Mean + SE	Postmonsoon Mean + SE
Clitoria ternatea (Clitoria)	*T neocaledonicus*	+	0	0	0	0	0	0
		++	7 69	0	0	28 33 + 23 28	0	0
Desmodium gangeticum (Orila)	*T ludeni*	+	0	0	29 41	0	0	24 33 +11 06
		++	30	0	50 0	17 66 + 7 5	0	2 + 1 73
Ficus tuberculata (Ithi)	Tetranychus sp	+	0	0	60	0	0	11 + 5 19
		++	0	0	44 44	0	0	29 66 + 16 86
Strobilanthes ciliates (Karimkurinji)	*B phoenicis*	+	14 28	0	0	6 5 + 2 12	0	0
		++	6 66	0	0	3 0 2 64	0	0

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error

infestations recorded were 65 and 3 mites per leaf during the first and second year of survey respectively

4 1 3 2 4 University Centre Karıavattom

The data related to the mean percentage of mite infested leaves and mean population counts of phytophagous mites in the medicinal plants in the farm attached to the University Centre Karıavattom are presented in Table 7d

T cinnabarinus T ludeni and *P latus* were observed to infest the medicinal plants in this centre also *T cinnabarinus* was recorded from *A beddomei* during all the three seasons surveyed The mean percentage of infestation varied from 9 52 to 45 45 per cent and the mean population varied from 8 33 to 14 mites per leaf

4 1 3 3 Ornamentals

The data on the mean percentage of mite infested leaves and the mean population counts of phytophagous mites on ornamentals recorded in the survey conducted during the pre monsoon monsoon and postmonsoon periods of 1992 and 1993 at the Agricultural College Farm Vellayani District Agricultual Farm Peringammala and Tropical Botanical Garden Palode are given in tables 8a 8b and 8c

4 1 3 3 1 Agricultural College Farm, Vellayam

The data on the mean percentage of mite infested leaves and the mean population

Table 7d Mean percentage of mite infested leaves and mean population counts of phytophagous mites in medicinal plants at University Centre Karlavattom

			Percentage of infested leaves			Population per leaf		
			Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon Season Mean + SE	Postmonsoon Season Mean + SE
Adhatoda beddomei (Adalodakam)	*T cinnabarinus*	+	45 45	9 52	45 45	8 33 + 9 57	8 33 +9 07	10 33 +5 03
		+	18 18	0	11 76	11 33 + 4 79	0	14 +7 21
Alpinia galanga (Chittaratha)	*Tetranychus* sp	+	40	0	13 33	3 66 + 4 04	0	1 66 + 1 52
		++	6 66	0	0	2 66 + 4 61	0	0
Cinnamomum zeylanicum (Cinnamon)	*Tetranychus* sp	+	3 12	0	0	0 66 + 1 15	0	0
		++	0	0	0	0	0	0
Oxalis corniculata (Puliyaral)	*T ludeni*	+	0	0	0	0	0	0
		++	21 42	0	0	5 66 + 2 30	0	0
Gmelina arborea (Kumbil)	*P latus*	+	0	0	9 37	0	0	2 + 1
		+	10 7	0	0	19 66 + 1 52	0	0
Premna serratifolia (Premna)	*Tetranychus* sp	+	0	0	0	0	0	0
		++	41 66	0	0	15 66 + 6 50	0	0

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error

counts of phytophagous mites recorded at the Agricultural College Farm Vellayani are given in Table 8a

Oribatids were the only mites recorded on *A andreanum* in the survey The infestation of the mites were recorded only during the post monsoon of 1992 while in 1993 the incidence was recorded during premonsoon monsoon and postmonsoon seasons The mean percentage of infested candles varied from 3 12 to 18 18 and the mean population counts varied from 0 66 to 4 33 mites/candle The phytophagous mite recorded on *Caladium* sp and *P tuberosa* was *B phoenicis* In both the ornamentals there was no infestation during 1992 while in 1993 it was confined to the postmonsoon season only In *Dendorbium* sp the mite was recorded in the postmonsoon of 1993 In *Croton* sp the mite observed was *T cinnabarinus* and the infestation was found in the premonsoon and post monsoon seasons of 1993 only the percentage of infested leaf being 12 3 and 21 4 and the mean population counts being 2 66 and 8 66 mites per leaf respectively

The mite species recorded from *H rosa sinensis Dahlia* sp *L chinensis* and *Rosa* sp was *T ludeni* In *Rosa* sp the pest was recorded in all the three seasons in both the years where as in *L chinensis* it was recorded only in the premonsoon season of 1992 and 1993 respectively In *Dahlia* sp it was recorded in the premonsoon season of both the years In addition to *T ludeni T neocaledonicus* was also recorded in *Rosa* sp in the premonsoon seasons of 1992 and 1993 and the post monsoon season of 1993 The percentage of leaves infested by *T ludeni* was 41 30 in the premonsoon season of 1992 where as that by *T neocaledonicus* was 40 8 in the postmonsoon of 1993 *T neocaledonicus* was recorded from *J grandiflorum* also

Other species of *Tetranychus* were also recorded from *Coleus* sp *Coriopsis* sp and *M erythrophylla* In *Coleus* sp and *Coriopsis* sp the infestation was sparse In *J sambac* 18 90 per cent leaves were infested and in *M erythrophylla* 37 8 per cent leaves were infested in the premonsoon season of 1993

The tenuipalpid mite *T pacificus* was found to infest *Dendrobium* sp Leaf infestation of *T pacificus* observed at Vellayani varied from 32 and 18 26 per cent during premonsoon season and 11 53 and 3 63 during post monsoon season and the mean population recorded were 480 and 655 mites per leaf during premonsoon season and 8 to 9 33 during post monsoon season of 1992 and 1993 respectively

The tenuipalpid mite *R indica* recorded on *T alata* was observed during premonsoon monsoon and postmonsoon periods in both the years surveyed The infestation varied from 2 2 per cent in the monsoon season to 25 5 per cent in the premonsoon season with a mean population count of 2 66 mites per leaf during monsoon season and 66 33 mites per leaf during premonsoon season of 1992

4 1 3 3 2 District Agricultural Farm Peringammala

The mean percentage of mite infested leaves and the population counts of phytophagous mites in ornamentals at the Dis rict Agricultural Farm Peringammala are given in Table 8b

Oribatid mites were found to infest the candles of *A andreanum* at the District Agric ltural Farm Permgammala also During the premonsoon season the infestation

Table 8a Mean percentage of mite infested leaves and mean population counts of phytophagous mites in ornamentals at the Agricultural College Vellayani

Host plant	Mite	Mean percentage of leaves infested			Mean population per leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean + SE	Postmonsoon season Mean + SE
Anthurium andreanum (Anthurium)	Oribatid	+ 0	0	18 18	0	0	4 33 + 4 04
		++ 3 12	8	14 3	0 66 + 1 1	2 66 + 2 51	1 33 + 2 3
Caladium sp (Caladium)	*B phoenicis*	+ 0	0	0	0	0	0
		++ 0	0	11 11	0	0	14 00 + 12 28
Coleus sp (Coleus)	*Tetranychus* sp	+ 8	0	0	21 33 + 0	0	0
		++ 0	0	0	0	0	0
Coriopsis sp (Coriopsis)	*Tetranychus* sp	+ 0	0	0	0	0	0
		++ 1 2	0	0	8 33 + 3 51	0	0
Codiaeum variegatum (Croton)	*T cinnabarinus*	+ 0	0	0	0	0	0
		++ 12 3	0	21 4	2 66 +12 58	0	8 66 + 4 72

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error Contd

Table 8a contd.

Host plant	Mite	Mean percentage of leaves infested			Mean population per leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean ± SE	Monsoon season Mean ± SE	Postmonsoon season Mean ± SE
Dhalia sp. (Dhalia)	*T. ludeni*	+ 37.50	0	0	80.66 ± 3.72	0	0
		++ 25	0	0	5.33 ± 2.3	0	0
Dendrobium sp. (Orchid)	*T. pacificus*	+ 32	0	11.53	480 ± 135.31	0	9.33 ± 7.52
		++ 18.26	0	3.63	655 ± 262.22	0	8 ± 5.29
	B. phoenicis	+ 0	0	0	0	0	0
		++ 0	0	11.42	0	0	0.7 ± 2.36
Hibiscus rosa-sinesis (Hibiscus)	*T. ludeni*	+ 23.9	0	0	10 ± 8.71	0	0
		++ 0	0	0	0	0	0
Jasminum grandiflorum (Jasmine)	*T. neocaledonicus*	+ 12.9	0	19.4	11.33 ± 4.04	0	22.66 ± 17.66
		++ 28.60	8	0	8.00 ± 6.55	5.66 ± 5.68	0
Jasminum sambac (Jasmine)	*Tetranychus* sp.	+ 0	0	1	0	0	22.86 ± 0
		++ 18.90	8.3	0	13.3 ± 6	2.66 ± 3.78	0
Livinstona chinesis (Chinese fan palm)	*T. ludeni*	+ 0	0	0	0	0	0
		++ 12.50	0	0	16.87	0	0
Mussaenda erythrophylla (Mussaenda)	*Tetranychus* sp.	+ 37.5	0	0	8.06 ± 2.08	0 ± 0	4 ± 2
		++ 0	4.68	19.5	0	10.33 ± 3.21	4.66 ± 2.08
Maranta sp. (Maranta)	*B. phoenicis*	+ 0	0	0	0	0	0
		++ 36.3	0	0	12.66 ± 6.11	0	0
Polyanthes tuberosa (Tube rose)	*B. phoenicis*	+ 0	0	0	0	0	0
		++ 0	0	2	0	0	14.6 ± 7.6
Rosa sp. (Rose)	*T. ludeni*	+ 41.30	3.1	9.6	39 ± 22.61	9.33 ± 8.08	30 ± 13
		++ 13.4	15.38	2.1	16 ± 17.43	39 ± 11.26	7.6 ± 8.04
	T. neocaledonicus	+ 25	0	0	17.33 ± 7.02	0	0
		++ 9.25	0	40.8	34 ± 11.53	0	59.32
Thunbergia alata (Thunbergia)	*R. indica*	+ 25.5	2.2	11.6	66.33 ± 35.10	2.66 ± 0.57	25.00 ±
		++ 21.8	3.2	20	27.66 ± 15.5	5.33 ± 6.11	8.66 ± 5.50

+ Survey in 1992 ++ Survey in 1993 SE - Standard Error # Per cm²

Table 8b Mean percentage of mite infested leaves and mean population counts of phytophagous mites in ornamentals at District Agricultural Farm Peringammala

Host plant	Mite	Mean percentage of leaves infested			Mean population pe leaf		
		Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon season Mean + SE	Monsoon season Mean SE	Postmonsoon season Mean + SE
•*Anthurium andreanum* (Anthurium)	Oribatid	+ 7 69	0	0	1 33 + 1 15	0	0
		++33 33	15 38	0	0 66 + 1 15	2 33 + 1 30	0
Hibiscus rosa sinesis (Hibiscus)	*T neocaledonicus*	+ 0	0	0	0	0	0
		++ 0	6 12	0	0	21 66 + 8 14	0
Jasminum grandiflorum (Jasmine)	*T neocaledonicus*	+ 4 44	0	40	7 33 ± 6 28	0	5 66 + 5 68
		++ 0	0	0	0	0	0
Jasminum sambac (Jasmine)	*Tetranychus* sp	+ 4 44	0	0	7 33 + 7 02	0	0
		++ 6 06	1 66	0	86 33 + 40 95	0	0
Rosa sp (Rose)	*T ludeni*	+ 40	0	0	24 66 + 16 16	0	0
		++ 0	0	0	0	0	0
Maranta sp (Maranta)	*B phoenicis*	+ 14 28	0	0	6 33 + 2 08	0	0
		++ 0	0	0	0	0	0
Mussaenda erythrophylla (Mossaenda)	*Tetranychus* sp	+ 0	0	6 2	0	0	0
		++ 0	15 62	0 70	0	5 66 ± 4 64	0

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error

• The infestation of the oribatid mites were in the candles

observed were 7 69 and 33 33 per cent in 1992 and 1993 respectively But the number of mites present in the candle were few The mean number of mites varied between 0 66 to 2 33 mites per candle The incidence of *T neocaledonicus* was observed in *H rosa sinensis* and *J grandiflorum* In *H rosa sinensis* the mites were noticed only in the monsoon season of 1993 with a mean population of 21 66 while in *J grandiflorum* the occurrence was noted during premonsoon and postmonsoon season of 1992 Heavy incidence of *T ludeni* on *Rosa* sp was observed during premonsoon season of the first year of survey The leaf infestation was 40 per cent with a mean population of 24 mites per leaf As in the Agricultural College Farm Vellayani *B phoenicis* was observed in *Maranta* sp in the District Agricultural Farm Peringammala also

4 1 3 3 3 Tropical Botanical Garden and Research Institute, Palode

The mean percentage of mite infested leaves and the population counts of phytophagous mites in ornamentals at th Tropical Botanical Gardens and Research Institute Palode are given in Table 8c

Mites were observed from few plants only at the Tropical Botanical Garden and Research Institue Palode The incidence of oribatid mite in *A andreanum* was recorded only during premonsoon season The extent of leaf infestation was 5 71 per cent and the mean population of mites were 0 60 mites per leaf Similarly the occurrence of *T neocaledonicus* in *J grandiflorum* was observed only during premonsoon seasons of 1992 and 1993 and the extent of leaf infestation recorded were 8 78 and 20 45 per cent respectively But the occurrence of *T ludeni* in *Rosa* sp was observed during both the premonsoon and monsoon seasons The infestation varied from 8 to 18 75 per cent

Table 8c Mean percentage of mite infested leaves and mean population counts of phytophagous mites in ornamentals at TBGRI Palode

			Percentage of infested leaves			Population per leaf		
			Premonsoon season	Monsoon season	Postmonsoon season	Premonsoon Mean + SE	Monsoon Mean + SE	Postmonsoon Mean + SE
Anthurium andreanum (Anthurium)	Oribatid	+	0	0	0	0	0	0
		++	5 71	0	0	0 66 + 1 15	0	0
Jasminum grandiflorum (Jasmine)	T neocaledonicus	+	8 78	0	0	6 66 + 3 78	0	0
		++	20 45	0	0	6 00 + 4 35	0	0
Orchid (Hybrid)	T pacificus	+	3 57	0	4	4 + 3 60	0	7 33 + 7 02
		++	26 66	0	12 72	22 33 + 9 09	0	15 45 + 4 58
Rosa sp (Rose)	T ludeni	+	8 0	8 33	0	21 66 + 21 60	16 + 9 16	0
		++	18 75	0	0	11 33 + 8 32	0	0

\+ Survey in 1992 ++ Survey in 1993 SE Standard Error

No infestation of the mite was recorded during the post monsoon season *T pacificus* an important pest of orchid was observed at this centre also The infestation was prevelant during the premonsoon and post monsoon periods The leaf damage noted during premonsoon seasons of 1992 and 1993 were 3 57 and 26 66 per cent respectively While the values were 4 and 12 72 per cent during the post monsoon seasons of the respective years The population counts per leaf were 4 and 22 33 mites per leaf in the premonsoon seasons and 7 33 and 15 45 during the postmonsoon seasons of 1992 and 1993 respectively

4 1 4 Predator Prey Ratio

The mean population counts of predators their prey mites and the predator prey ratio observed in vegetables during the premonsoon monsoon and post monsoon periods are presented in Table 9a

The predator prey ratio in the premonsoon season of 1992 in the Agr cultural College Farm Vellayani in *A esculentus A dubius C annum S melongena* and *V unguiculata* sub sp *sesquipedalis* were 1 7 7 0 1 1 4 1 70 6 respectively In the monsoon and post monsoon season of the year the population of prey mites and their predators was comparably lower in most vegetables observed except in cucurbits and vegetable cowpea where the predator prey ratio was 1 11 2 in the post monsoon season and 1 14 6 in the monsoon season respectively In 1993 also almost the same trend was observed the premonsoon season showing higher population counts of prey mites and predators

Table 9a Mean population counts of Phytophagous mites and their predators and the predator prey ratio in vegetables

A Agricultural College Vellayani

Host plant	Prey mite	Premonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Monsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Postmonsoon season Phytophagous mite Number/3 leaves	Predator	Predato prey ratio
Abelmoschus esculentus	*T ludeni*	+ 31	4 (P)	1 7 7	0	0	0	37	0	0
		++ 37	0	0	59	28 (P)	1 2 1	36	0	0
Amaranthus bicolor	*T cinnabarinus*	0	0	0	0	0	0	0	0	0
		++ 385	9 (S)	1 42 7	137	0	0	0	0	0
			17 (T)	1 22 6	0	0	0	0	0	0
			2 (P)	1 192 5	0	0	0	0	0	0
Capsicum annum	*P latus*	+ 42	6 (P)	1 7	0	0	0	0	0	0
			7 (H)	1 6	0	0	0	0	0	0
			2 (S)	1 21	0	0	0	0	0	0
		++ 36	0	0	15	0	0	53	8 (P)	1 6 6
									2 (H)	1 26 5
Cucurbita pepo	*T neocaledonicus*	+ 1217	8 (S)	1 152 1	0	0	0	112	10 (S)	1 11 2
									5 (P)	1 22 4
		++ 28	0	0	1	0	0	24	0	0
Solanum melongena	*T neocaledonicus*	+ 20	14 (P)	1 1 4	0	0	0	6	0	0
		+ 48	3 (P)	1 16	85	0	0	0	0	0
			40 (C)	1 1 2	0	0	0	0	0	0
Vigna unguiculata sub sp *sesquipdalis*	*T ludeni*	+ 212	3 (P)	1 70 6	115	8 (S)	1 14 3	0	0	0
						11 (P)	1 10 4			
		++ 26	0	0	7	0	0	25	0	0

B D strict Agr cultural Farm Peringammala

Abelmoschus esculentus	*T ludeni*	+ 0	0	0	0	0	0	144	11 (P)	1 13 1
		++ 60	5 (P)	1 12	0	0	0	0	4 (S)	1 36
			3 (S)	1 20	0	0	0			
Solanum melongena	*T neocaledonicus*	+ 35	2	1 17 5 (C)	0	0	0	0	0	0
		++ 12	0	0	0	0	0	0	0	0
Vigna unguiculata sub sp *sesquipedal s*	*T ludeni*	+ 0	0	0	0	0	0	0	0	0
		++ 30	5	1 6 P)	0	0	0	0	0	0

+ Survey in 1992 ++ Survey in 1993 C *Cunaxa* sp S *Stethorus* sp H Hemiptera P Phytoseiids T Thrips

The predator prey ratio in the premonsoon season of 1992 at the District Agricultural Farm Permgammala in *S melongena* was 1 17 5 while there was no incidence of the prey mite or predator in the premonsoon season in *A esculentus* and *V unguiculata* sub sp *sesquipedalis* In the premonsoon season of 1993 the predator prey ratio in *A esculentus* was 1 12 and 1 20 and in *V unguiculata* 1 6 There was no incidence of the prey mites and predators in the monsoon and postmonsoon seasons of 1992 and 1993 in all the vegetables observed except *A esculentus* in which the predator prey ratio was 1 13 1 and 1 36

The mean population counts of predators their prey mites and the predator prey ratio in medicinal plants during premonsoon monsoon and post monsoon periods are presented in Table 9b

The occurrence of predators in the premonsoon period of 1992 in the Agricultural College Farm Vellayani was low The predator prey ratio was 1 13 in *C ternatea* while predators were widely present in the premonsoon season of 1993 and the predator prey ratio was 1 14 18 1 27 5 1 14 75 and 1 7 6 in *A beddomei C ternatea D gangeticum* and *O corniculata* respectively During the monsoon season cunaxid predators alone were encountered in both the years of survey and the predator prey ratio was 1 0 6 and 1 1 12 in *Haemaphysalis* during 1992 and 1993 respectively

In the premonsoon season of 1992 at Ayurvedic Research Centre Poojappura the predator prey ratio was 1 4 6 1 23 33 1 12 4 and 1 1 3 in *C serratum D gangeticum Pavetta* sp and *R serpentina* respectively while in 1993 it was 1 1 6 and

Table 9b Mean population counts of phytophagous mites and their predators and the predator prey ratio in medicinal plant

A Agricultural College Vellayani

Host plant	Prey mite	Premonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Monsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Postmonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio
Adhatoda beddomei	*T cinnabarinus*	+ 0	0	0	0	0	0	0	0	0
		++ 156	11 (P)	1 14 18	0	0	0	0	0	0
Clitoria ternatea	*T cinnabarinus*	+ 26	2 (P)	1 13	0	0	0	0	0	0
		++ 330	12 (P)	1 27 5	0	0	0	44	0	0
Desmodium gangeticum	*T cinnabarinus*	+ 0	0	0	0	0	0	96	0	0
		++ 59	4 (P)	1 14 75	0	0	0	0	0	0
Hibiscus abelmoschus	*T ludeni*	+ 0	0	0	17	27 (C)	1 0 6	0	0	0
		++ 43	0	0	9	8 (C)	1 1 2	0	0	0
Oxalis corniculata	*T ludeni*	+ 0	0 (P)		0	0	0	0	0	0
		++ 23	3 (P)	1 7 5	0	0	0	0	0	0

B Ayurvedic Research Centre Poojappura

Clerodendrum serratum	*B phoenicis*	+ 14	3 (P)	1 4 6	28	0	0	0	0	0
		++ 8	5 (P)	1 1 6	0	0	0	10	0	0
Desmodium gangeticum	*T ludeni*	+ 70	3 (P)	1 23 33	4	0	0	0	0	0
		++ 38	0	0	0	0	0	40	3 (P)	1 13 3

\+ Survey in 1992 ++ Survey in 1993 P Phytoseiids

Contd

Table 9b contd.

Host plant	Prey mite	Premonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Monsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Postmonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio
Gymnema sylvestre	*B. phoenicis*	+ 25	5 (P)	1:5	0	0	0	40	0	0
		++ 0	0	0	0	0	0	118	0	0
Ocimum sanctum	*B. phoenicis*	+ 0	0	0	0	0	0	34	0	0
		++ 25	6 (P)	1:4.1	0	0	0	27	2	1:13.5 (P)
Pavetta	*Tetranychus* sp.	+ 148	12 (P)	1:12.4	0	0	0	360	0	0
		++ 0	0	0	0	0	0	0	0	0
Sida rhombifolia	*T. neocaledonicus*	+ 18	0	0	39	0	0	21	0	0
		++ 50	0	0	26	4 (P)	1:6.5	13	0	0
Rauvolfia serpentina	*T. ludeni*	+ 21	7 (P)	1:3	0	0	0	11	0	0
		++ 8	0	0	0	0	0	19	0	0
C. Tropical Botanical Garden and Research Institute, Palode										
Desmodium gangeticum	*T. ludeni*	+ 0	0	0	0	0	0	73	5 (P)	1:14.6
		++ 53	0	0	0	0	0	6	0	0
Ficus tuberculata	*Tetranychus* sp.	+ 0	0	0	0	0	0	33	4 (P)	8.25
		++ 0	0	0	0	0	0	89	8 (P)	1:11.1
D. University Centre, Kariavattom										
Adhatoda beddomei	*T. cinnabarinus*	+ 25	3	1:12.5	0	0	0	31	0	0
		++ 34	3	1:11.33	0	0	0	42	2	1:21
Strobilanthes ciliates	*B. phoenicis*	+ 0	0	0	13	3	1:4.33	22	2	1:11
		++ 37	3	1:12.33	0	0	0	23	4	1:5.75

\+ Survey in 1992 ++ Survey in 1993 P - Phytoseiids

1 4 1 in *C serratum* and *O sanctum* respectively The predators were low in number during the monsoon and postmonsoon of 1992 and 1993 and the predator prey ratio was 1 13 33 in *D gangeticum* and 1 13 5 in *O sanctum* during 1992 and 1993 respectively

At the Tropical Botanical Garden and Research Institute Palode no predators were encountered during the premonsoon and monsoon seasons in both the years of survey while in the postmonsoon season the predator prey ratio was 1 14 6 and 0 during 1992 and 1 8 25 and 1 11 1 during 1993 in *D gangeticum* and *F tuberculata* respectively

Phytosend mites were observed in *A beddomei* and *S ciliates* at the University Centre Kariavattom during 1992 and 1993 In the premonsoon seasons of 1992 the predator prey ratio was 1 12 5 and 0 in *A beddomei* and *S ciliates* while in 1993 the values were 1 11 33 and 1 12 33 Predators were present at a predator prey ratio of 1 4 33 in *S ciliates* during the monsoon season of 1993 During post monsoon season of 1992 and 1993 phytosend predators were encountered

The mean population counts of predators their prey mites and the predator prey ratio observed in ornamentals observed during premonsoon monsoon and postmonsoon periods are presented in Table 9c

Only phytoseiid predators were encountered in the premonsoon season of 1992 in the Agricultural College Farm Vellayani and the predator prey ratio was 1 7 5 and 1 6 8 in *H rosa sinensis* and *J grandiflorum* respectively In 1993 the predator prey ratio was 1 8 1 491 2 and 1 5 3 (Phytoseiids) in *J sambac Dendrobium* and *Rosa* respectively In addition to phytoseiid predators *Cunaxa* sp and *Stethorus* sp were present

Table 9c Mean population counts of phytophagous mites and their predators and the predator prey ratio in ornamenta

A Agricultural College Vellayani

Host plant	Prey mite	Premonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Monsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio	Postmonsoon season Phytophagous mite Number/3 leaves	Predator	Predator prey ratio
Dendrobium sp	B *phoenicis*	+ 1440	0	0	0	0	0	28	0	0
		++ 1965	4 (P)	1 491 2	0	0	0	24	0	0
Hibiscus rosa sinensis	*T neocaledonicus*	+ 30	4 (P)	1 7 5	0	0	0	0	0	0
			8 (C)	1 3 7	0	0	0	0	0	0
		++ 0	0	0	0	0	0	0	0	0
Jasminum grandiflorum	*T neocaledonicus*	+ 34	5 (P)	1 6 8	0	0	0	68	0	0
		++ 24	0	^	17	0	0	0	0	
Jasminum sambac	*Tetranychus sp*	+ 0	0	0	0	0	0	69	0	0
		++ 40	5 (P)	1 8	8	0	0	0	0	0
Rosa sp	*T ludeni*	+ 117	0	0	28	0	0	90	0	0
		++ 48	9 (P)	1 5 3	102	4 (P)	1 25 5	23	0	0
			4 (S)	1 12						
Thunbergia alata	R *indica*	+ 199	0	0	8	0	0	75	3 (P)	1 25
		++ 83	0	0	16 00	0	0	26	0	0
B District Agricultural Farm Peringammala										
Rosa sp	*T ludeni*	+ 74	1	1 74 (P)	0	0	0	0	0	0
			3	1 24 6 (S)						
		++ 0	0	0	0	0	0	0	0	0

\+ Survey in 1992 ++ Survey n 1993
C *Cunaxa sp* S *Stethorus sp* P Phytoseiids

in *H rosa sinensis* and *Rosa* sp at a predator prey ratio of 1 3 7 and 1 12 respectively During the monsoon seasons predators and prey mites were encountered in 1993 only and in *Rosa* sp alone at a ratio of 1 25 5 In the post monsoon season of 1992 predator prey ratio was 1 25 in *T alata* while there were no predators during 1993

4 1 5 Nature and symptoms of damage

4 1 5 1 Tetranychid mites

4 1 5 1 *Tetranychus cinnabarinus* on *Adhatoda*

Distinct symptoms were produced by *T cinnabrinus* on *Adhatoda* In the initial stages of attack white speckles appeared on the leaf lamina which concentrated near midrib and veins Subsequently the symptoms spread all over the leaf (Plate X) Due to continuous removal of plant sap by larva, protonymph deutonymph and adults colonising on the under surface the leaves were devitalised When the infestation was severe they formed webs and appreared on both surfaces of leaves and the leaves withered dried and fell off prematurely

4 1 5 1 2 *Tetranychus neocaledonicus* on *Rosa* sp

Feeding by *T neocaledonicus on rose* resulted in the production of white spots in infested leaves These spots gradually coalasced and the leaves lost green color and presented a sickly appearance

4 1 5 1 3 *Tetranychus ludeni on Rosa* sp

Infestation by *T ludeni* resulted in the formation of white speckles at the feeding sites As feeding progressed these speckles joined together to from large blotches In severe cases the leaves developed necrotic patches and dried up

More or less similar types of damages were produced by tetranychid mites in other host plants also and the symptoms produced are shown in Plate X

4 1 5 2 Tenuipalpid mites

4 1 5 2 1 *Tenuipalpus pacificus on Dendrobium* sp

Nymphs and adults of *T pacificus* congregated in large numbers on the undersurface of leaves and sucked sap As a result sunken spots appeared on the leaves along with chlorotic spottings which later merged to form yellow patches Subsequently brown patches appeared on the leaves which later dried up and fell off prematurely (Plate XI) When infestation became severe mites appeared on the upper surfaces of the leaves also Occasionally flowers were also found infested and the flowers presented brown spots and patches

4 1 5 2 2 *Raoiella indica* on *Thunbergia alata*

General chlorosis was the symptom noticed due to feeding of *R indica* on *T alata* In the beginning yellow speckles appeared on the leaves and later these speckles coalased and formed yellow patches The infested leaves had diseased look

Plate X **Damage symptoms caused by tetranychid mites on**

A *Adhatoda beddomei*

B *Cardiospermum halicacabum*

C *Jasminum grandiflorum*

Plate X

A

C

B

Plate XI **Damage symptoms caused by *Brevipalpus phoenicis* on**

A S *h lantl s c la*

B *D l ob* sp

Plate XI

A

B

4.1.5.2.3 *Brevipalpus phoenicis*

As in the case of *R. indica*, general chlorosis was the symptom observed due to the feeding of *B. phoenicis* on *G. sylvestre* and *S. ciliates* (Plate XI). But in *O. sanctum* white speckles which spread over the entire leaf were observed. This was followed by drying up of leaves. In *Gladium* sp., *Maranta* sp., and *Dendrobium* sp., yellowing was observed in the initial stages of attack. As feeding advanced necrotic patches also appeared in the leaves. In *Dendrobium* sp., the mites produced sunken spots in which the mites were found to rest and feed. Subsequently yellowing and necrotic patches also appeared.

4.1.5.3 Tarsonemid mites

4.1.5.3.1 *Polyphagotarsonemus latus*

Chilli plants infested by *P. latus*, in the initial stages showed slight crinkling of leaves. Later, edges of the leaves rolled downwards and the leaves became narrow and brittle. The lower surface became bronzed. Blister formation was also noticed in the infested leaves. Narrow, crinkled, and rolled leaves were produced in bittergourd and ridge gourd as a result of infestation of *P. latus* while in *T. erecta* and *V. negundo* the leaves infested by the mite showed slight crinkling only.

4.1.5.4 Eriophyid mites

Different types of symptoms were observed due to feeding of eriophyid mites on medicinal and ornamental host plants (Pate XII). The injury resulted in the development of different plant deformities which included formation of erineum and galls.

4.1.5.4.1 Erineum

Erineum on *Gardenia jasminoides*

Growth of hairs on the underside of leaves in *G. jasminoides* was noticed due to feeding of *Eriophyes* sp. The erineum in the early stages were shiny white and sparsely distributed. During later stages the white colour of the erineum changed to brown.

Erineum on *Elaeocarpus serratus*

Dense velvet patchy growth of hairs, which almost completely covered the entire surface of leaves were noticed. This erineum was crimson coloured and produced by *Aceria* sp.

4.1.5.4.2 Galls

Bead galls on *Randia spinosa*

Green Bead galls were produced on leaves of *R. spinosa* by *Aceria* sp. These galls were globose and sessile. Numerous galls were produced in a single leaf (Plate XII) Inside the galls white erineal growth was observed.

Finger galls on *Pongamia pinnata*

Finger galls were produced in *P.pinnata* by *Aceria pongamiae* Channabasavanna. These galls had on the inner side thick set hairs among which the mites were found. Galls were elongate, solitary and greenish.

4.1.5.4.3 Oribatid mites on *Anthurium andreanum*

Black patches were produced on the candles of *A.andreanum* due to the feeding of oribatid mites (Plate XIII).

Plate XII Damage symptoms caused by eriophyid mites

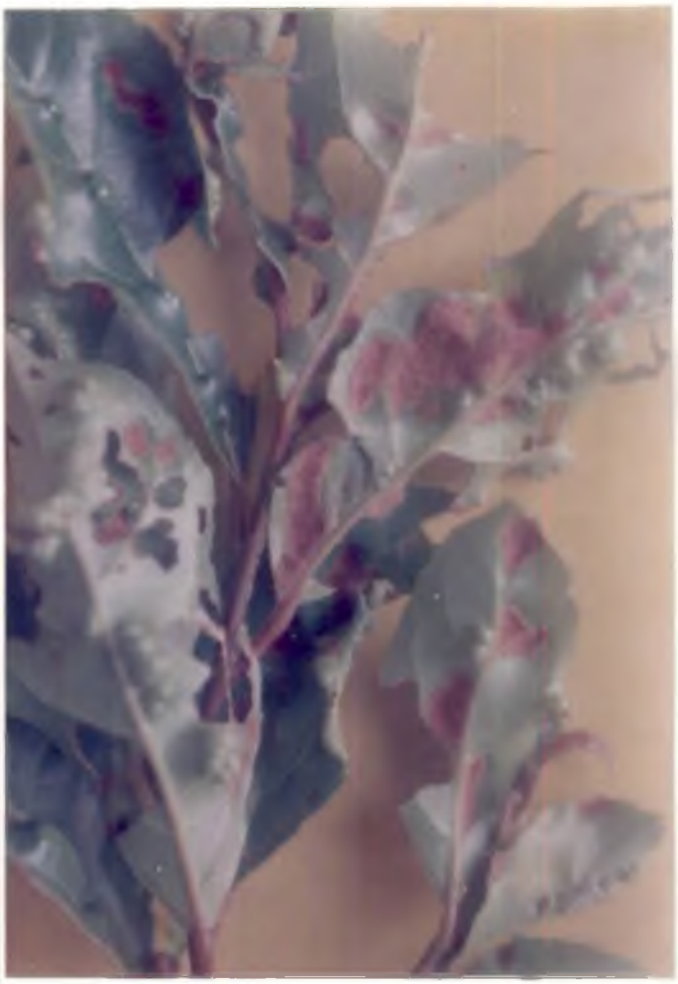
A. *Aceria pongamiae* on *Pongamia pinnata*

B. *Aceria* sp. on *Elaeocarpus serratus*

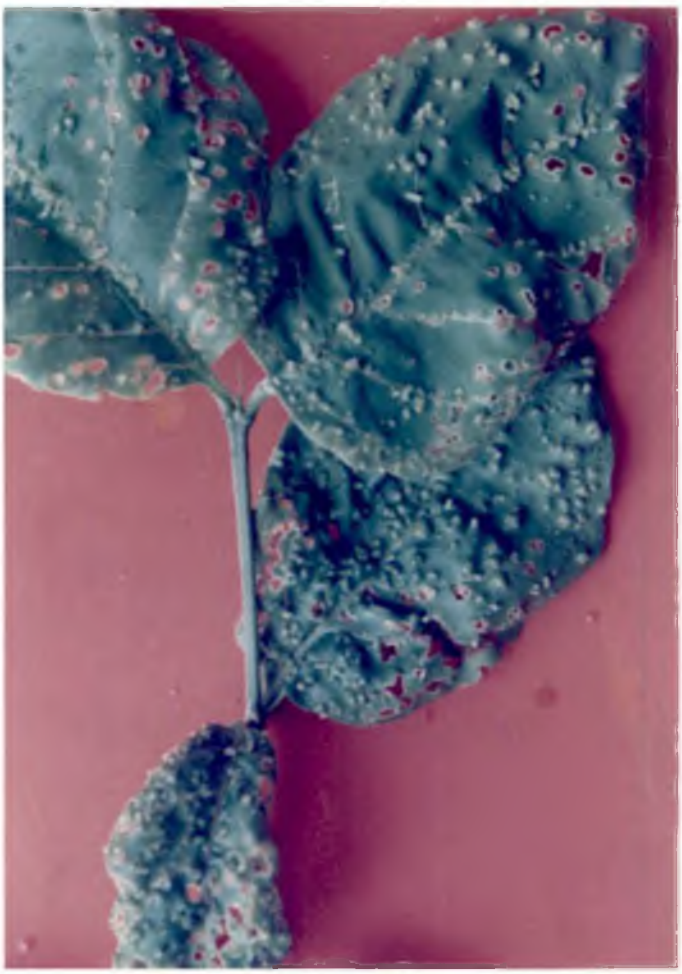
C. *Aceria* sp. on *Randia spinosa*

Plate XII

A



B



C

Plate XIII Oribatid mite and the damage symptom caused by it on the candle f
Anthurium andreanum

A Oribatid mite

B Damages po

Plate XIII

A

B

4 2 Seasonal occurrence of mites

The seasonal occurrence of mites on vegetables medicinal plants and ornamentals are presented in Tables 10 to 14

4 2 1 On vegetables

The mean population counts of phytophagous mites observed at fortnightly intervals after planting in the premonsoon monsoon and postmonsoon seasons are presented in Table 10 In all the crops mite infestation was absent until one month after planting and no mites were encountered in snakegourd during the entire period in all the three seasons while in pumpkin the infestation occured during the postmonsoon season alone

During the premonsoon season there was significantly higher population of *T ludeni* in bhindi than in vegetable cowpea during the third and fourth fortnights after planting However the populations were on par during the fifth and sixth fortnights During the monsoon and postmonsoon seasons there was significant differences in the population of *T ludeni* between the two crops except during the fifth fortnight after planting in the postmonsoon season

There was no incidence of *P latus* on pumpkin in the premonsoon and monsoon crops In the postmonsoon crops there was no significant difference in the population of *P latus* observed on chilli and pumpkin except during the fourth fortnight after planting

Table 10 Mean number of phytophagous mites per leaf observed at fortnightly intervals on vegetables

Crop	Mite	Premonsoon (Planted during January 1992) Fortnights after planting				Monsoon (Planted during May 1993) Fortnights after planting			Postmonsoon (Planted during October 1993) Fortnights after planting			
		3	4	5	6	4	5	6	3	4	5	6
Bhindi	*T ludeni*	0 79 (1 34)	2 56 (1 88)	4 98 (2 45)	4 41 (2 33)	0 2 (1 1)	1 19 (1 48)	1 99 (1 73)	0 (1)	0 (1)	0 44 (1 20)	11 05 (3 47)
Chilli	*P latus*	0 (1 0)	1 (1 42)	2 31 (1 82)	3 13 (2 03)	0 (1)	0 31 (1 14)	1 96 (1 72)	0 35 (1 16)	0 (1)	0 31 (1 14)	2 25 (1 80)
Vegetable cowpea	*T ludeni*	0 (1 0)	1 25 (1 50)	6 73 (2 78)	4 70 (2 39)	0 (0)	1 76 (1 66)	1 17 (1 47)	0 56 (1 24)	0 (1)	3 39 (2 09)	3 31 (2 08)
Snakegourd	No mites	0 (1 0)	0 (1 0)	0 (1 0)	0 1 0)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Pumpkin	*P latus*	0 (1 0)	0 (1 0)	0 (1 0)	0 (1 0)	0 (1)	0 (1)	0 (1)	0 63 (1 28)	2 23 (1 78)	1 23 (1 49)	0 29 (1 14)
CD		0 23	0 62	0 87	0 97	0 05	0 44	0 57	0 33	0 12	0 41	2 00

Figures in parentheses are $\sqrt{x+1}$ values

In *A esculentus* infestation of *T ludeni* commenced in the third fortnight after planting in the pre monsoon crop the fourth fortnight in the monsoon crop and in the fifth fortnight in the postmonsoon crop where as in *V unguiculata* sub sp *sesquipedalis* the commencement of the infestation of the mite in the corresponding seasons were in fourth fifth and third fortnights after planting respectively In *A esculentus* the mean number mites per leaf in the monsoon season increased from 0 79 in the third fortnight to 4 98 in the fifth fortnight and then the population declined to 4 41 in the sixth fortnight In the postmonsoon season there was a sudden increase of the mite population from 0 44 in the fifth fortnight to 11 05 in the sixth fortnight

In *V unguiculata* sub sp *sesquipedalis* the population of *T ludeni* increased from 1 25 in the fourth fortnight to 6 73 in the fifth fortnight and then decreased to 4 70 in the sixth fortnight In the monsoon season the population in the fifth and sixth fortnights were 1 76 and 1 1 respectively and in the post monsoon season the mean population counts in the third fourth fifth and sixth fortnights after planting were 0 56 0 ⅗ 39 and 3 31 respectively

The commencement of infestation of *P latus* in chillies was in the fourth fifth and third fortnights after planting in the premonsoon monsoon and postmonsoon seasons respectively In pumpkin the infestation of *P latus* was observed only in the postmonsoon crop The population build up of *P latus* was from 1 in the fourth fortnight to 3 13 in the sixth fortnight in the premonsoon crop where as in the monsoon crop the increase was from 0 31 in the fifth fortnight to 1 96 in the sixth fortnight In the postmonsoon period the population increased to 2 25 in the sixth fortnight

In *C pepo* the mean population of *P latus* was 0 63 in the third fortnight 2 23 in the fourth fortnight 1 23 in the fifth fortnight and 0 21 in the sixth fortnight in the postmonsoon season and there was no infestation in the two earlier seasons

4 2 1 2 Correlation of mite populations with weather parameters

The correlations between weather parameters and population counts of phytophagous mites are presented in Table 11 No significant correlation was observed between population counts of *T ludeni* and weather parameters in bhindi and vegetable cowpea However *P latus* had significant positive correlation with maximum and minium temperatures and negative correlation with humidity and rainfall in chillies Conversely in pumpkin *P latus* had sigr ificant negative correlation with maximum temperature and positive correlation with rainfall and humidity

4 2 1 3 Seasonal occurrence of predators of phytophagous mites on vegetables

The data on the mean number of predators per leaf observed in the field trial on vegetables are presented in Table 12

The predatory mites of *T ludeni* were found scattered on the leaves Fredato y mites predatory insects and *T ludeni* were occasionally found together in the leaves Among predatory mites the phytosends were found widely distributed They appeared on the plants along with *T ludeni* and they persisted in the environment where as the population of the coccinellid grub *Stethorus* sp were found to be sporadic in occurrence The field population of the phytoseiids var ed from 0 1 to 0 43 0 to 0 16 and 0 to 0 36

Table 11 Correlation between weather parameters and population counts of phytophagous mites on vegetables

Crop	Mite	Maximum temperature	Minimum temperature	Humidity	Rainfall
Bhindi	*T ludeni*	0 1005	0 0346	0 0334	0 1549
Chilli	*P latus*	0 4535	0 2853	0 3442	0 3692
Pumpkin	*P latus*	0 2377	0 0549	0 4173	0 7015
Vegetable cowpea	*T ludeni*	0 0896	0 0863	0 1527	0 1982

* Significant at 5% level ** Significant at 1% level

Table 12 Mean number of predators per leaf in the field trial on vegetables

Crops	Premonsoon Fortnights after planting			Monsoon Fortnight after planting			Postmonsoon fortnights after planting			
	4	5	6	4	5	6	3	4	5	6
Bhindi	0 10(P)	0 1(P) 0 1(S)	0 43(P) 0 23(S)	0 10(P)	0 16(P) 0 10(S)	0	0 16(P)	0	0	0 36(P) 0 13(S)
Chilli	0 23(P)	0 1(P)	0	0 06(P)	0 2(P)	0	0	0 1(P)	0 4(P)	0
Pumpkin	0	0	0	0	0	0	0 1(P)	0 13(P)	0 13(P)	0
Snakegourd	0	0	0	0	0	0	0	0	0	0
Veg table Cowpea	0	0 2(P) 0 16(T) 0 26(S)	0 23(P) 0 7(T)	0	0	0	0	0	0 16(P)	0

P Phytosends S *Stethorus* sp T Thrips Data not analysed statistically

mites per leaf during the premonsoon monsoon and postmonsoon periods The corresponding values for *Stethorus* sp were 0 1 to 0 23 0 to 0 1 and 0 to 0 13

Phytoseiid mites were encountered in association with *T ludeni* in vegetable cowpea also Predatory thrips and coccinellid predators (*Stethorus* sp) were also found feeding on *T ludeni* on vegetable cowpea The predatory mites were present during the premonsoon and postmonsoon periods while the thrips and *Stethorus* sp were observed in the premonsoon crop only The population counts varied from 0 to 0 23 mites per leaf and that of thrips from 0 16 to 0 7

Phytoseiids were also associated with the tarsonemid mite *P latus* in chilli and pumpkin In chilli, the population varied from 0 to 0 23 0 to 0 2 and 0 to 0 4 mites per leaf during the premonsoon monsoon and postmonsoon periods and in pumpkin it varied from 0 to 0 13 during the post monsoon periods

4 2 2 On medicinal plants

The mean population count per leaf of *T cinnabrinus* on *A beddomei* and *A vasica* observed at fortnightly intervals from January to December 1994 are presented in Table 13 Maximum population of the mite was recorded during the first fortnight of January in *A beddomei* (8 53) and during the first fortnight of March (3 04) in *A vasica* Mites were totally absent from the second fortnight of June to the fourth fortnight of August in *A beddomei* and from the first fortnight of June to the first fortnight of August in *A vasica* The residual population left after the rains was again found to increase from August second week and there was a gradual increase in population till December first fortnight after which a slight reduction in population was recorded

Table 13 Mean population counts of phytophagous mites on medicinal plants and ornamentals

Fortnight intervals	Mean number of mites/leaf *T cinnabarinus* on *A beddomei*	*T cinnabarinus* on *A vasica*	*T luden* on *Rosa* sp	*R indica* on *T alata*	*T pacificus* on *Dendrobium* sp
January I	8 53	0 92	1 28	4 26	73 25
	(3 09)	(1 39)	(1 51)	(2 29)	(8 62)
January II	6 92	0 86	2 91	8 22	115 49
	(2 81)	(1 36)	(1 98)	(3 04)	(10 79)
February I	3 18	0 76	6 84	18 29	765 18
	(2 04)	(1 33)	(2 80)	(4 39)	(27 68)
February II	2 63	0	14 08	25 92	808 19
	(1 91)	(1)	(3 08)	(5 19)	(28 45)
March I	1 56	3 04	54 43	71 67	680 34
	(1 60)	(2 01)	(7 45)	(8 52)	(26 10)
March II	1 04	1 83	67 61	73 81	410 35
	(1 43)	(1 68)	(8 28)	(8 65)	(20 28)
April I	0 41	1 14	40 08	5 48	31 64
	(1 19)	(1 46)	(6 41)	(2 55)	(5 71)
April II	0	0 31	45 03	3 23	13 22
	(1)	(1 14)	(6 78)	(2 06)	(3 71)
May I	0 64	0 66	11 73	0 34	20 36
	(1 28)	(1 29)	(3 51)	(1 16)	(4 62)
May II	0 69	0 36	0 95	4 44	29 78
	(1 3)	(1 16)	(1 40)	(2 33)	(5 55)
June I	0 38	0	0	1 60	1 80
	(1 17)	(1)	(1)	(1 61)	(1 67)
June II	0	0	0	0 52	0 30
	(1)	(1)	(1)	(1 23)	(1 14)
July I	0 31	0	0	0	0
	(1 14)	(1)	(1)	(1)	(1)
July II	0	0	0	0	0
	(1)	(1)	(1)	(1)	(1)
August 1	0	0 8	0	1 54	0
	(1)	(1 04)	(1)	(1 59)	(1)
August II	0 19	0	2 09	1 11	1 60
	(1 09)	(1)	(1 76)	(1 45)	(1 61)
September I	0 35	0 21	6 40	6 71	2 20
	(1 16)	(1 1)	(2 72)	(2 78)	(1 79)
September II	0 37	0 31	2 09	2 75	0
	(1 17)	(1 14)	(1 76)	(1 94)	(1)
October I	0 13	0 12	2 75	0 48	0
	(1 06)	(1 06)	(1 94)	(1 22)	(1)
October II	0 33	0 11	9 39	0 72	0 93
	(1 15)	(1 05)	(3 2)	(1 31)	(1 38)
November I	0 81	0 26	2 33	1 65	2 72
	(1 34)	(1 12)	(1 83)	(1 63)	(1 9
November II	1 68	1 29	5 04	0 91	2 82
	(1 63)	(1 51)	(2 46	(1 38)	(1 95)
December I	1 18	0 19	1 20	1 61	3 23
	(1 48)	(1 09)	(1 48)	(1 62)	(2 05)
December II	0 59	1 01	3 31	2 15	7 32
	(1 26)	(1 42)	(2 07)	(1 78)	(2 88)
CD	0 91	0 61	1 00	0 73	1 55

I First fortnight II Second fortnigh Figures with in parenthes are $\sqrt{x+1}$ values

The correlation coefficients worked out with weather parameters and population counts of mites are presented in Table 14 The population build up of mites had a positive correlation with minimum temperature In *A vasica* the population of *T cinnabarinus* showed no significant correlation with humidity and rainfall where as in *A beddomei* it had negative correlation with rainfall

4 2 3 On ornamental plants

The incidence of *Tetranychus ludeni* on rose observed at fortnightly intervals from January to December 1994 are presented in Table 13 The mean population count per leaf during the first fortnight of January was 1 78 The population gradually increased and reached the peak of 67 61 per leaf during the second fortnight of March Then the population started to decrease and became nil in the first fortnight of June and remained as such till the first fortnight of August From the second fortnight of April the population began to increase but oscillated between the highest values of 9 39 in the second fortnight of October and lowest value of 1 2 in the first fortnight of December

The mean population counts per leaf of *T pacificus* on *Dendrobium* sp observed at fortnightly intervals from January to December 1994 are presented in Table 13 The mean population per leaf was 73 25 when the observation started in January 1994 and it increased to reach the peak of 808 19 during the second fortnight of February Then the population declined to 680 34 in the first fortnight of March and 410 35 in the second fortnight of March Thereafter there was substantial reduction in the level and became nil in the month of July From August to December the population remained at low levels

Table 14 Correlations between weather parameters and population counts of phytophagous mites on medicinal and ornamental plants

Host plant		Maximum temperature (øC)	Minimum temperature (øC)	Humidity (%)	Rain fall (cm)
Adhatoda beddomei	*T cinnabarinus*	0 0936	0 1598	0 0857	0 1607
Adhatoda vasica	*T cinnabarinus*	0 0704	0 1627	0 0289	0 0756
Dendrobium sp	*T pacificus*	0 2195	0 2912	0 5634	0 3686
Rosa sp	*T ludeni*	0 3684	0 0271	0 2990	0 2408
Thunbergia alata	*R indica*	0 1677	0 2345	0 3334	0 3161

* S gmficant at 5% level ** Signficant at 1% level

Correlation studies between weather parameters and population counts revealed that there was positive correlation with maximum temperature and negative correlation with minimum temperature rainfall and humidity (Table 14)

The mean population count per leaf of *Raoiella indica* on *T alata* observed at fortnightly intervals from January to December 1994 are presented in Table 13 The data showed that *R indica* was present in *T alata* through out the year except in the month of July The population recorded prior to the south west monsoon was significantly higher than the population recorded after the rains Maximum infestation was recorded during March the mean population per leaf being 1 67 and 73 81 during the first and second fortnight respectively After the rains the population level remained comparatively low the peak population being 6 71 per leaf during first fortnight of September

Correlation studies revealed positive correlation with maximum temperature and negative correlation with minimum temperature rainfall and humidity (Table 14)

4 3 Biology

4 3 1 *Tetranychus cinnabarinus* on *Adhatoda vasica*

The life cycle was completed in five stages viz egg larva protonymph deutonymph and adult stages Three non feeding quiescent stages viz protochrysalis deutochrysalis and teliochrysalis intervened the active stages Details on the developmental period of the male and female during November 94 and March 95 are presented in Table 15

Table 15 Biology and Biometrics of *Tetranychus cinnabarinus* reared on *Adhatoda vasica*

Stage	Length (u)	Width (u)	Developmental period (Duration in days)			
			November		March	
	Mean + SD	Mean + SD	Male Mean + SE	Female Mean + SE	Male Mean + SE	Female Mean + SE
Egg	123 + 6 78	118 5 + 11 06	5 2 + 0 39	6 + 0 78	4 33 + 0 4	4 75 + 1 58
Larva	187 5 + 31 81	145 5 + 15 89	1 77 + 0 16	2 2 + 0 29	1 61 + 0 23	1 8 + 0 23
Nymphochrysalis			1 47 + 0 13	1 5 + 0 24	1 3 + 0 26	1 26 + 0 24
Protonymph	263 33 + 10 89	156 + 17 60	1 08 + 0 22	1 2 + 0 21	1 23 + 0 25	1 09 + 0 19
Deutochrysalis			1 25 + 0 46	0 94 + 0 12	1 05 + 0 23	1 00 + 0 18
Deutonymph	310 ± 19 84	1 98 + 9 48	2 1 + 0 25	1 57 + 0 29	1 7 + 0 46	1 86 ± 0 31
Teliochrysalis			1 21 + 0 21	1 12 + 0 13	1 16 + 0 40	1 07 + 0 23
Developmental period			14 54 + 2 15	14 5 + 1 26	12 4 + 1 93	12 85 + 0 8
Adult Longevity			7 4 + 0 67	14 2 + 1 93	6 3 + 0 67	12 4 + 1 51
Male	396 + 14 45	201 + 14 45				
Female	507 + 23 23	276 + 30 98				
Preoviposition				1 3 + 0 48		0 95 + 0 10
Oviposition				12 8 + 7 87		11 5 + 1 50
Post oviposition				2 + 1 1		1 8 + 0 78
Total number of eggs/female				58 1 + 8 35		54 3 + 5 92
Eggs/female/days				4 74 + 0 63		4 70 + 0 72

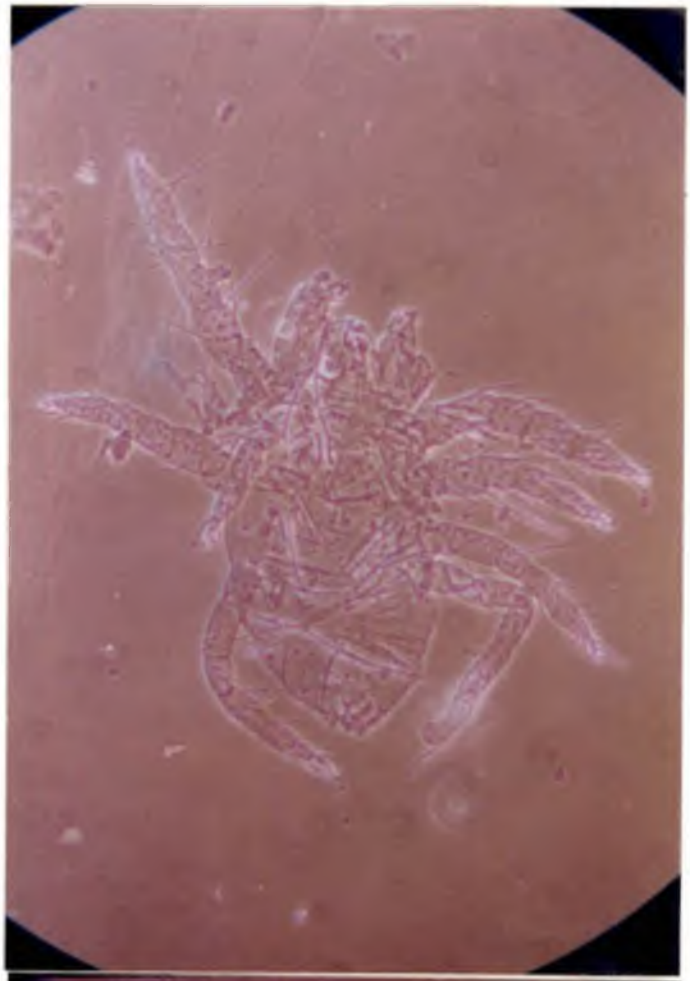
* significantly higher based on t test SE Standard Error

Plate XIV **Carmine spider mite, *Tetranychus cinnabarinus***

A Male nymph

B Female nymph

Plate XIV



A

B

Developmental stages

Egg

Eggs were laid more near the mid rib on the ventral side of leaves, but were also laid near side ribs and on leaf lamina. Freshly laid eggs were translucent white, which later changed to pearly white. Eggs measured on an average 123 $\pm$ 6.78μ in diameter.

Eclosion

Eclosion was completed in three minutes. The egg shell after emergence of larva was found to be glassy white. The newly emerged larvae moved about actively and started feeding within 1-2 minutes.

Larva

The newly hatched larva was white and was almost the size of the egg from which it emerged. It moved about actively and started feeding immediately after hatching. As development proceeded it acquired uniform greenish black tinge internally. Towards the later larval period two greenish black blotches appeared internally. The larvae measured 187.5 $\pm$ 31.81 μ in length and 145.5 $\pm$ 15.89 in width.

Nymphochrysalis (Protochrysalis)

The full grown larva anchored itself on the leaf surface with its legs bent and then

entered into quiescence. During this time the body colour darkened. The period of nymphochrysalis varied from 1.26 ± 0.24 days in March to 1.5 ± 0.24 days in November.

Protonymph

The protonymph possessed four pairs of legs. The gnathasomal region, chelicera and legs were white in colour and the idiosoma was whitish with greenish black internal markings. Females and males could be clearly distinguished at this stage (Plate XIV), with the presence of prominent internal black patch and slightly tapering idiosoma. The protonymph measured 263.33 ± 10.89 μ in length and 156 ± 17.60 μ in width. There was significant difference in the duration of protonymph between March and November for both male and female.

Deutochrysalis

This is the second quiescent stage in the life cycle. During this stage the colour became darker the duration of this quiescent period varied from 0.94 ± 0.12 to 1.25 ± 0.46 days.

Deutonymph

The deutonymph that emerged from deutochrysalis was white with greenish black internal marking. Deutonymph measured 310 + 19.84 μ in length and 1.98 ± 9.48 μ in width. The duration of males and females were 2.1 and 1.57 days during November and 1.7 and 1.86 days during March respectively.

Teliochryaslis

This is the third quiescent stage in the life cycle. The mature deutonymph entered into this stage before emerging as adults. The teliochrysalis stage lasted 107±0.23 days in March and 1.21±0.21 days in November.

Adults

The male *T. cinnabarnius* was found to be meroon coloured with whitish chelicera and legs and distinctly tapering idiosoma. The first and fourth pairs of legs were longer as compared to the second and third pairs of legs. The female was reddish meroon. The male was smaller in size and measured 396 ±14.45μu length and 201 ±14.45μ in width where as the female was 507 ± 23.23 μ in length and 276 ± 30.98 μ in width. The males completed its life cycle in a shorter period compared to females. The longevity of the male was 6.3 ± 0.67 and 7.4 ± 0.67 days and that of the female was 12.4 ± 1.51 and 14.2 ± 1.93 during March and November respectively. Adult longevity also differed significantly during March and November.

Ecydsis

The quiescent stages viz. nymphochrysalis, deutochaysalis and teliochrysalis were terminated by moultings. At the time of moulting the body appeared swollen. The mite applied pressure anteriorly so that the exuvium got split transversely in between the second and third pair of legs and the mite crawled out through the split. The posterior part of the body was released at first from the exuviun followed by the gnathsomal region.

Mating

During the stage of teliochrysalis, the females were seen continuously guarded by males. On emergence of the adult female four to five males were seen competing one another to accomplish mating with the female. The successful one crawled beneath the female from behind and pushed the female upwards and arched its conical idiosomal region and inserted the aedeagus into the genital aperture of the female. During mating the female was held in position by the male with the anterior legs.

Oviposition

The data related to the preoviposition, oviposition and post oviposition periods of *T. cinnabarinus* are furnished in Table 15. The pre oviposition periods were 0.95 ± 0.10 and 1.3 ± 0.48, oviposition periods 11.5 ± 1.50 and 12.8 ± 7.87, and post oviposition periods 1.8 ± 0.78 and 2 ± 1.1 days during March and November respectively. The total number of eggs laid per female were 54.3 ± 5.92 during March and 58.1 ±8.35 during November. The mean number of eggs per female per day were 4.70 ± 0.72 during March and 4.74 ± 0.63 during November. Maximum number of eggs (7 ± 3.77), were laid on the sixth day during March and on the eighth day (7 ± 2.78) during November. Later the egg production declined and reached the minimum on the eighteenth day (4 ± 1.26).

4.3.2 *Tetranychus ludeni* on *Rosa* sp.

The life cycle of *T. ludeni* was similar to that of *T. cinnabarinus*. The details on biology and biometrics of the mite are given in the Table 16.

Table 16 Biology and Biometrics of *Tetranychus ludeni* Zacher reared on Rose

Stage	Length (u)	Width (u)	Developmental period (Duration in days)			
			November		March	
	Mean ± SD	Mean ± SD	Male Mean ± SE	Female Mean ± SE	Male Mean ± SE	Female Mean ± SE
Egg	136.53 ± 4.74(dia.)	-	5.5 ± 0.70*	5.8 ± 0.48	5.0 ± 0.71*	4.7 ± 0.4
Larva	204 ± 8.21	144 ± 8.21	0.76 ± 0.16	0.8 ± 0.20*	0.95 ± 0.1	0.92 ± 0.10*
Nymphochrysalis	-	-	0.77 ± 0.10	0.72 ± 0.12	0.75 ± 0.1	0.71 ± 0.11
Protonymph	261.42 ± 8.01	186.42 ± 8.01	1.52 ± 0.28*	2.2 ± 0.30	1.87 ± 0.25*	2.18 ± 0.25
Deutochrysalis	-	-	0.91 ± 0.27	0.91 ± 0.27	1.00 ± 0.25	0.88 ± 0.1
Deutonymph	317.5 ± 6.12	215 ± 7.74	1.21 ± 0.21	1.46 ± 0.14	1.37 ± 0.25	1.40 ± 0.05
Teliochrysalis	-	-	1.47 ± 0.21*	1.43 ± 023*	0.S5 ± 0.1*	1.22 ± 0.18*
Developmental period	-	-	12.26 ± 0.88	13.38 ± 0.61*	11.9 ± 0.66	12.28 ± 0.53*
Adult Longevity	-	-	6.86 ± 0.60	11.7 ± 2.0*	7 ± 1.65	9.8 ± 1.30*
Male	324.37 ± 37.05	291 ± 8.21	-	-	-	-
Female	395 ± 17.32	280 ± 3.66	-	1.43 ± 0.23	-	0.92 ± 0.11
Preoviposition	-	-	-	8.6 ± 1	-	8 ± 1
Oviposition	-	-	-	1.9 ± 1.1	-	1.4 ± 0.55
Total number of eggs/female	-	-	-	38.5 ± 8.71	-	39.2 ± 5.44
Eggs/female/day	-	-	-	4.48 ± 0.95	-	5.25 + 0.98

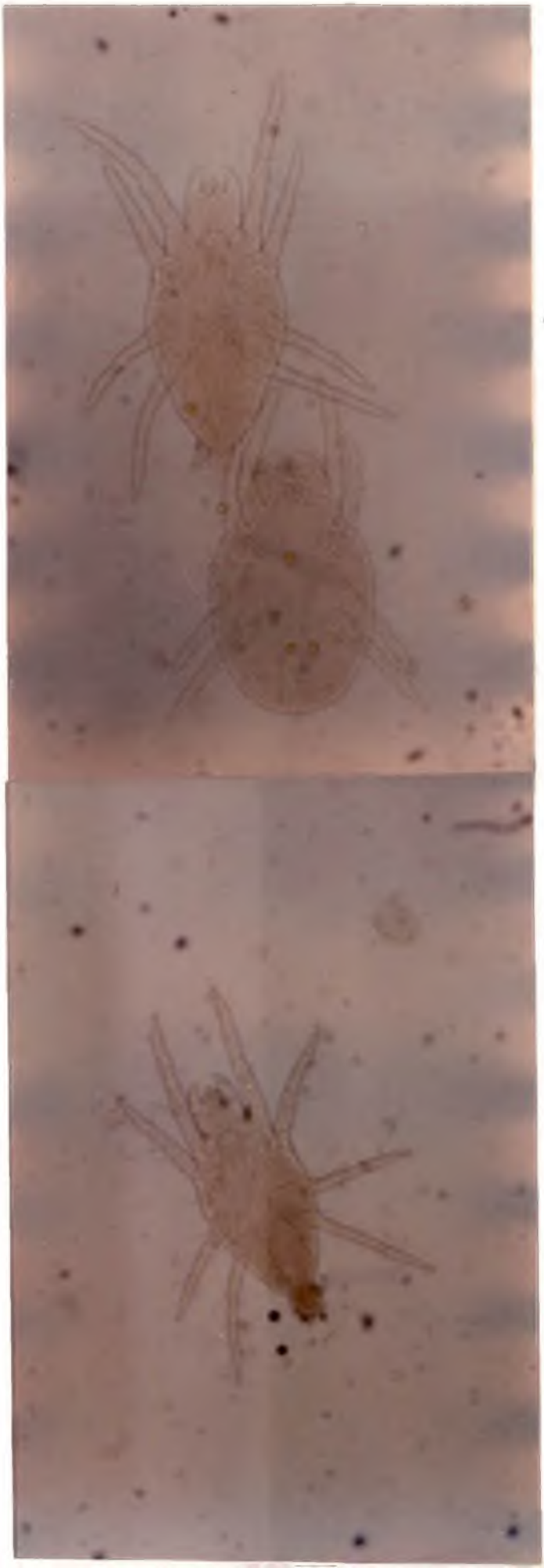
* significantly higher based on `t' test SE - Standard Error

Plate XV Tetranychid mites

A. Male and female nymphs of *Tetranychus ludeni*

B. Male nymph of *Tetranychus neocaledonicus*

Plate xv



A

B

Egg

Freshly laid eggs were translucent with light golden tinge As the development proceeded the eggs acquired deep meroomsh tinge at one end and golden brownish t nge at the other end At the time of hatching a white coating appeared around the egg The eggs measured on an average 136 5 ± 4 74 μ in diameter The mean egg period was found to be 4 70 ± 0 44 and 5 8 + 0 48 days for the female during March and November respectively

Larva

The newly hatched larva with three pairs of legs was golden coloured and measured 204 ± 8 21 μ in length and 144 + 8 21μ in width The larval period was found to be less than a day for both the male and the female

Nymphochrysalis

The quiescent stage that followed the active larval stage was also of very short duration The duration of nymphochrysalis varied from 0 72 ± 0 12 days to 0 77 ± 0 10 days

Protonymph

The protonymph had dark meroomsh idiosoma and golden brownish gnathosoma and measured 261 42 ± 8 01 u in length and 186 42 ± 8 01 u in width (Plate XV) The active period of the

protonymph lasted 2 18 ± 0 25 days during March 2 2 + 0 30 days in November for the female and 1 87 + 0 25 in March and 1 52 ± 0 28 in November for the male Before entering the second quiescent stage the nymph became sluggish in movements and the body became dark in colour

Deutochrysalis

This is the second quiescent stage of the mite During this stage the chelicerae and palps were seen bent downwards The anterior legs were seen directed forward and the posterior legs backwards The duration of deuotchrysal s ranged between 0 88 + 0 1 and 1 0 5 days

Deutonymph

The deutonymph resembled protonymph except for the size The deutonymph measured 317 5 ± 6 12 u in length and 215 ± 7 74 u in width The mean deutonymphal period varied from 1 21 ± 0 21 to 1 46 ± 0 14 days

Teliochrysalis

This is the third quiescent stage of the mite and the duration was 1 47 + 0 21 for male and 1 43 ± 0 23 for female during November The values were 0 95 ± 0 1 and 1 22 ± 0 18 for male and female respectively when reared in March

Adult

The full grown adult male was blackish meroon in colour and measured 324 77 ± 37 55 u in length and 291 ± 8 21 u in width The female was reddish brown in colour and measured 395 ± 17 32 u in legnth and 280 ± 3 66 u in width The total developmental period of the male was found to be 12 26 ± 0 88 and 11 9 ± 0 66 days in November and March respectively and that of the female was 13 88 ± 0 61 and 12 28 ± 0 53 days respectively during the same periods The females had significantly longer duration in November than March

Oviposition

The total number of eggs laid by a female was found to be 39 2 + 5 44 in March and 38 5 ± 8 77 in November The mean number of eggs laid per female per day was 5 25 + 0 98 in March and 4 48 ± 0 95 in November However there was no significant d fference between the two periods in the number of eggs laid

4 3 3 *Tetranychus neocaledonicus* on *Rosa* sp

As in other tetranychid mites life cycle of *T neocaledonicus* was completed in five stages with three intervening quiescent stages The data on biometrics and biology are presented in Table 17

Table 17 Biology and Biometrics of *Tetranychus neocaledonicus* reared on *Rosa* sp

Stage	Length (u)	W dth (u)	Developmental per od (Dura ion in days) March	
	Mean ± SE	Mean ± SE	Male Mean ± SE	Female Mean ± SE
Egg	136 5 ± 4 74 (Diameter)		6 33 ± 0 57	6 45 ± 0 64
Larva	205 ± 8 66	145 ± 8 66	0 86 ± 0 11	0 95 ± 0 03
Nymphochrysalis			0 93 ± 0 23	0 87 ± 0 14
Protonymph	249 ± 31 10	199 5 ± 56 59	1 23 ± 0 25	1 24 ± 0 25
Deutochrysalis			1 66 ± 0 28	1 83 ± 0 41
De tonvmph	323 57 ± 25 77	214 28 ± 11 33	1 5 ± 0 5	1 69 ± 0 21
Teliochrysal s			1 86 ± 0 41	1 04 ± 0 31
Developmental per od			14 06 ± 1 87	14 80 ± 0 58
Adult Longevity			6 66 ± 0 57	11 9 ± 1 19
Male	498 ± 6 70	222 ± 6 70		
Female	543 ± 6 70	309 ± 53 66		
Preoviposition				0 94 ± 0 09
Ovipos tion				11 9 ± 1 19
Post ovipos tion				1 09 ± 0 30
To al no of eggs/female				59 8 ± 6 84
Eggs/female day				5 9 ± 0 5

SE Standard Error

Egg

Freshly laid eggs were translucent and measured 136 5 ± 4 74 u in diameter The egg acquired a golden tinge as development proceeded and as it approached hatching a white coating appeared on the egg The egg period lasted 6 45 ± 0 64 and 6 33 ± 0 57 days for the female and male respectively

Larva

The larva was golden brown in colour Larval period was less than a day for the male as well as for the female the value being (0 86 + 0 11 and 0 95 ± 0 03 days respectively After the active period the larva entered into the quiescent stage (nymphochrysalis)

Nymphochrysalis

The nymphochrysalis was also of short duration the values being 0 93 + 0 23 and 0 87 ± 0 14 days for the male and female respectively

Protonymph

The protonymph was golden brownish with light meroomsh spots and measured 249 ± 31 10 μ in length and 199 5 ± 56 59 μ in width The protonymphal periods for the male and female were 1 23 ± 0 25 and 1 24 ± 0 25 days respectively

Deutochrysalis

This quiescent period intervened the protonymphal and deutonymphal stages and was slightly longer for the female (1 83 + 0 41) as compared to the male (1 66 + 0 28)

Deutonymph

The deutonymph was larger with two distinct dark spots and the measurements were 323 57 + 25 77 μ long and 214 28+ 11 33 μ wide

Tehochrysalis

The stage of tehiochrysahs lasted 1 64 $\pm$ 0 31 and 1 86 $\pm$ 0 41 days for the female and male respectively

Adult

The adult was golden brown with dark brown golden spots Male measured 498 + 6 70 μ length and 222 + 6 70 μ wide the female measured 543 + 6 70 μ long and 309 + 53 66 μ wide Not much difference was noted in the developmental periods of the male and the female The total development periods were 14 06 $\pm$ 1 87 for the male and 14 80 + 0 58 for the female

Oviposition

Mean number of eggs laid per female was 59 8 + 6 84 The average number of eggs per female per day was 5 9 ± 0 5 and the oviposition period was found to be 11 9 ± 1 19 days

4 3 4 *Raoiella indica* on *Thunbergia alata*

Raoiella indica during its development passed through egg larval protonymphal and deutonymphal stages to attain adulthood The t(t il developmental periods of the different stages of the female and the male during November 1994 and March 1995 are presented in Table 18

Egg

Freshly laid eggs were bright orange red in colour oval in shape and stalked As development proceeded the colour turned to blackish orange

The eggs measured 95 + 10 6 u in length and 73 33 + 11 72 u in diameter The incubtion period for males and females lasted 8 12 ± 0 63 and 7 15 + 1 1 days respectively during March and 7 75 + 3 and 7 45 + 1 0 days respectively during November

Nymphochrysalis

Duration of the nymphochrysalis stages for males and females were 0 95 + 0 1 and

Table 18 Biology and Biometrics of *Raoiella indica* reared on *Thunbergia alata*

Stage	Length (u)	Width (u)	Developmental period (Duration in days) November		March	
			Male	Female	Male	Female
	Mean + SE	Mean + SE	Mean + SE	Mean + SE	Mean + SE	Mean + SE
Egg	95 0 + 10 60	73 33 + 11 72	7 75 + 0 95	7 45 + 1 01	8 12 + 0 63	7 15 + 1 11
Larva	126 66 + 18 22	100 + 10 6	1 63 + 0 25	1 73 + 0 29	1 35 + 0 24	1 01 + 0 29
Nymphochrysalis			1 25 + 0 29	1 44 + 0 25	0 95 + 0 1	1 05 + 0 18
Protonymph	164 91 + 14 57	112 5 + 7 90	2 63 ± 0 23	2 69 ± 0 26	2 25 + 0 29	2 6 + 0 31
Deutochrysalis			1 25 + 0 29	1 1 + 0 21	1 12 ± 0 25	0 96 + 0 08
Deutonymph	236 2 + 11 83	145 ± 7 74	3 35 + 0 23	3 31 + 0 32	3 38 + 0 25	3 2 + 0 28
Teliochrysalis			1 35 + 0 24	1 02 + 0 04	0 9 + 0 12	0 89 + 0 12
Developmental period			19 2 + 0 65	18 83 + 1 0	17 95 + 0 93	17 25 + 0 95
Adult Longevity			7 25 + 1 25	14 4 + 3 81	10 + 3 16	11 8 + 0 21
Male	221 25 + 4 3	146 25 + 7 5				
Female	252 + 9 48	160 5 + 7 24				
Preoviposition				2 28 + 0 91		3 2 + 1 47
Oviposition				6 78 + 1 71		6 85 + 3 61
Post oviposition				2 78 + 1 71		3 04 + 1 57
Total number of eggs/female				8 78 + 2 80		7 93 + 2 21
Eggs/female/day				1 6 + 0 26		1 79 + 0 32

Significantly higher based on t test * at 5% level ** at 1% level
SE Standard Error

1 44 ± 0 25 days During nymphochrysalis stage the mite appeared similar to the egg and the legs were bent and kept close to the body

Larva

Colour of the larva was bright orange red with slight blackish tinge with legs and chelicerae whitish The size was almost that of an egg only The larva measured 126 66 ± 18 22 u in length and 100 ± 10 6 u in width The larval period was observed to range between 1 01 ± 0 29 and 1 73 ± 0 29 days

Protonymph

Colour of the protonymph was bright orange red with distinct lateral black markings Chelicera and legs were white The active protonymphal period ranged between 225 + 0 29 and 2 69 ± 0 26 days

Deutochrysalis

The duration of deutochrysalis stage ranged from 0 96 ± 0 08 to 1 25 + 0 29 days

Deutonymph

The deutonymph resembled the protonymph but differed in size It measured 236 2 + 11 83 u in length and 145 ± 7 74 um in width

Teliochrysalis

This quiescent stage also lasted less than a day (0 89 + 0 12 days in March and 1 35 + 0 24 days in November)

Adult

Body of the female was deep meroomsh in colour with prominant black lateral markings The hysterosoma was blunt in female and narrow and pointed in male The female measured 252 + 9 48 u in length and 160 5 ± 7 24 u in width and the male measured 221 25 ± 4 3 u in length and 146 25 ± 7 5 u in width The total developmental period was 17 25 + 0 95 days during March and 18 83 + 1 0 days during November for the female and 17 95 ± 0 93 days and 19 2 + 0 65 days respectively for male There was significant difference in adult longevity between the mites reared in November and March

Oviposition

The preoviposition period was 3 2 + 1 47 and 2 28 ± 0 91 days The ov position period was found to last roughly for a week (6 85 ± 3 61 and 6 78 + 1 71) during March and November The average number of eggs laid by a single female was 7 93 + 2 21 and 8 78 ± 2 80 during March and November respectively The average number of eggs laid by a female per day was 1 79 + 0 32 in March and 1 6 + 0 26 in November

4 3 5 *Tenuipalpus pacificus* on orchids (*Dendrobium* sp)

Like the tetranychid mites the tenuipalpid mite *Tenuipalpus pacificus* also passed through four stages viz egg larva protonymph and deutonymph before reaching the adult stage The data on the biology and biometrics are given in Table 19

Egg

The eggs were elliptical orange red with light black coloration Towards eclosion the egg developed a wh te outer covering The egg measured 97 5 ± 8 01 u in length and 63 75 ± 6 94 u in width Incubation period lasted 8 83 + 0 28 and 8 ± 0 33 days respectively for male and female

Larva

The larva was found to be orange red in colour and measured 143 33 ± 12 5 u in length and 98 33 + 7 90 in width The active larval period lasted 3 66 + 0 58 and 3 33±0 33 days respectively for the male and female Fully matured larva entered into a quiescent stage

Nymphochrysalis

During quiescence the mites were seen with in small depressions formed in the leaf tissues They were flat and scale like The duration of nymphochysalis was 1 33 ± 0 27 and 1 5 ± 0 23 days respectively for the male and female

Table 19 Biology and Biometrics of *Te uipalpus pacificus* reared on *Dendrobium* sp

Stage	Length (u)	Width (u)	Developmental period (Duration in days) November	
	Mean ± SE	Mean ± SE	Male Mean ± SE	Female Mean ± SE
Egg	97 5 ± 8 01	63 75 ± 6 94	8 33 ± 0 28	8 ± 0 33
Larva	143 33 ± 12 5	98 33 ± 7 90	3 66 ± 0 58	3 33 ± 0 33
Nymphochrysalis			1 33 ± 0 29	1 5 ± 0 23
Protonymph	171 5 ± 8 51	112 5 ± 7 90	4 ± 0 5	4 3 ± 0 25
Deutochrysalis			1 16 ± 0 28	1 5 ± 0 23
Deutonymph	295 ± 7 5	145 ± 15	3 83 ± 0 28	4 95 ± 0 55
Teliocrysalis			1 66 ± 0 28	1 25 ± 0 26
Developmental period			24 5 ± 1 32	24 93 ± 0 88
Adult Longevity			21 33 ± 3 51	27 50 ± 3 13
Male	311 42 ± 9 07	168 75 ± 20 83		
Female	252 5 ± 8 01	187 5 ± 8 0		
Preoviposition				6 5 ± 0 97
Oviposition				17 3 ± 3 09
Post ov position				3 7 ± 1 33

SE Standard Error

Plate XVI ***Brevipalpus phoenicis***

A Dorsal view

B Ventral view

C Nymph

A

B

C

Protonymph

The protonymph was orange red with dark internal spots and lines chelicera and palps golden brown The protonynymph measured 171 5 ±8 51 and 112 5 + 7 90 u respectively in length and width

Deutochrysalis

The quiescent stage of deutochrysalis lasted 1 16 ± 0 28 and 1 5 ± 0 23 days for male and female respectively

Deutonymph

The deutonymph was similar to protonymph but varied in size It measured 295 + 7 5 u in length and 145 + 15 u width The total developmental period for male and female were 24 5 ± 1 32 and 24 93 ± 0 88 days respectively

Adult

The adults are flat and orange red in body colour with golden brown palps and chelicera Male was smaller with narrow hyst rosoma The female measured 252 5 ± 8 01 and 187 5 ± 8 u in length and width respectively while the male measured 311 42 + 9 07 and 168 75 ± 20 83 u in length and width

Mating

As in tetranychid mites quiescent deutonymphs of *T pacificus* were also attended by males The male also assisted the female deutonymph in moulting which was completed within ten minutes On emergence of the female adult the males competed with each other and the one succeeded mated with the female

4 3 6 Biology of *Brevipalpus phoenicis* on *Caladium* , *Dendrobium*, *Maranta Ocimum sanctum* and *Polyanthes tuberosa*

Details on the biology of *B phoenicis* (Plate XVI) reared on different host plants are presented in Table 20

Egg

The eggs are elliptical and reddish brown The egg period varied from 6 3 days in *P tuberosa* to 7 2 days in *Dendrobium* and *Caladium*

Larva

The mites are flat slow moving and reddish brown in colour The active period was the shortest when reared on *Dendrobium* (4 2 days) and the longest in *P tuberosa* (4 8 days) The mean larval period in *Maranta* was 4 6 days and that in *Caladium* and *O sanctum* was 4 5 days

Table 20 Biology of *Brevipalpus phoenicis* reared on five host plants

Host	Mean development period (m days)								
	Egg	Larva	Nympho chrysalis	Proto nymph	Deuto chrysalis	Deuto nymph	Telio chrysalis	Total Development	Adult longevity
Caladium sp	7 1	4 5	2 3	4 6	3 7	7 2	5 1	34 5	28 2
Dendrobium sp	7 1	4 2	2 2	4 9	3 8	8 1	5 2	35 5	30 2
Maranta sp	6 6	4 6	1 8	5 3	3 3	7 9	4 8	34 3	28 8
O sanctum sp	6 9	4 5	2 3	5 1	3 6	7 0	4 7	34 1	29 6
P tuberosa	6 3	4 8	1 3	4 4	3 0	7 5	4 7	32 0	31 6

Nymphochrysalis

The quiescent stage of nymphochrysalis varied from 1 3 to 2 3 days There was significant difference in the per od of nymphochrysalis n different host plants The period was significantly shorter in *P tuberosa* (1 3 days) while in *O sanctum* and *Caladium* the quiescent stage lasted upto 2 3 days

Protonymph

The active period of protonymph varied from 4 4 days in *P tuberosa* to 5 3 days in *Mai anta* sp

Deutochrysalis

The period was the shortest in *P tuberosa* (3 days) This was followed by *Maranta* (3 3 days) and *O sanctum* (3 6 days) Maximum period of deutochrysalis was observed in *Dendrobium* (3 8 days)

Deutonymph

The deutonymphal period varied from 7 2 days in *Caladium* to 8 1 days in *Dendrobium*

Teliochrysalis

Teliochrysalis was the longest in *Dendrobium* (5 2 days) and the shortest in *P tuberosa* and *O sanctum* (4 7 days)

Total developmental period

There was significant difference in the total developmental period in the different host plants The life cycle of the mite was completed in a shorter period in *P tuberosa* (32 days) while in *Dendrobium* the total period was 35 5 days The total development periods were 34 1 34 3 and 34 5 days in *O sanctum Maranta* and *Caladium* respectively

4 3 7 Oviposition pattern of *Brevipalpus phoenicis* on *Caladium Dendrobium Ocimum sanctum* and *Polyanthes tuberosa*

The data on pre oviposition oviposition post oviposition periods total number of eggs laid and number of eggs laid per female per day in the different host plants are presented in Table 21

There was significant difference in the preoviposition periods in the different host plants The period was maximum in *O sanctum* (10 8 days) and was on par with that recorded in *Caladium* (10 4 days) and *Dendrobium* (10 6 days) Pre oviposition period was the lowest in *Maranta* (9 6 days) which was significantly shorter than in *P tuberosa* (10 2 days) No significant difference was observed with respect to oviposition and post oviposition periods

Table 21 Oviposition pattern of *Brevipalpus phoenicis* on five host plants

Host	Duration in days			Total number of eggs/ female	No of eggs/female/ day
	Preovipo sition	Ovipo sition	Postovi position		
Caladium sp	10 4	10 0	7 8	6 2	1 14
Dendrobium sp	10 6	9 8	9 8	8 8	1 20
Maranta sp	9 6	9 8	9 4	9 8	1 28
O sanctum sp	10 8	9 8	9 0	8 8	1 16
P tuberosa	10 2	12 4	10 2	12 4	1 38
C D	0 525			2 134	

The total number of eggs laid by a female was significantly higher in *P tuberosa* (12 4) The total number of eggs laid in *Dendrobium Maranta* and *O sanctum* was on par (8 8 9 8 and 8 8) but was significantly higher than that laid in *Caladium* (6 2)

4 4 Crop loss caused by *Tetranychus ludeni* on bhindi and *Polyphagotarsonemus latus* on chilli

4 4 1 *Tetranychus ludeni* on bhindi

The crop loss caused by *Tetranychus ludeni* on bhindi assessed in terms of leaf infestation chlorophyll content damage grade index population build up and weight of fruits are presented in tables 21 25

4 4 1 1 Effect of different population levels of *Tetranychus ludeni* on the number of leaves infested in bhindi

The data on the number of leaves infested at different intervals after the release of the mites are presented in Table 22

In the first week after release the treatment 10 mites per plant released 45 DAS (days after sowing) had significantly lower number of infested leaves than that in the treatments 30 mites per plant released 15 DAS 30 mites per plant released 30 DAS 30 40 and 45 mites per plant released 45 DAS During the second week after release significantly lower number of leaves were infested in the treatments 10 mites per plant released 45 DAS than in the treatments 30 mites per plant released 15 DAS 40 and 50 mites per plant released 45 DAS

Table 22 Mean number of leaves infested by *Tetranychus ludeni* in bhindi when released at different growth stages of the plant and at different population levels

Treatments	Weeks after release of T ludeni			
	1	2	3	4
30 mites/plant 15 DAS	5 30 (2 51)	5 10 (2 47)	3 16 (2 04)	1 34 (1 53)
10 mites/plant 30 DAS	3 00 (2 00)	4 61 (2 37)	5 71 (2 59)	4 76 (2 40)
30 mites/plant 30 DAS	4 95 (2 44)	4 52 (2 35)	5 92 (2 63)	5 55 (2 56)
10 mites/plant 45 DAS	2 31 (1 82)	2 65 (1 91)	5 00 (2 45)	5 50 (2 55)
20 mites/plant 45 DAS	3 12 (2 03)	4 24 (2 29)	4 43 (2 23)	5 00 (2 45)
30 mites/plant 45 DAS	4 43 (2 33)	3 80 (2 19)	5 20 (2 49)	6 18 (2 68)
40 mites/plant 45 DAS	5 20 (2 49)	4 66 (2 38)	6 24 (2 69)	4 95 (2 44)
50 mites/plant 45 DAS	5 25 (2 50)	4 48 (2 34)	6 29 (2 70)	5 60 (2 57)
Control (Monocrotophos sprayed at 0 05%)	0 (0 87)	0 (0 88)	0 (0 79)	1 34 (1 53)
CD	0 30	0 402	0 497	0 396

Figures within parentheses are adjusted means DAS Days after sowing

4 4 1 2 Damage grade indices in bhindi plants infested with different population levels of *Tetranychus ludeni*

The data on damage grade indices and yield per plant in bhindi infested with different population levels of *T ludeni* are presented in Table 23 There was significant differences in damage grade indices with respect to the various treatments The damage grade index was maximum when mites were released at the rate of 30 mites per plant 15 DAS (10 09) and was significantly higher than all other treatments The damage grade indices were on par when mites were releas d @ 50 mites per plant 45 DAS and 30 mites per plant 30 DAS and the values being 7 76 and 7 29 respectively At population levels of 10 mites per plant 30 and 45 DAS the damage grade indices were significantly lower (2 25 and 2 16) than all other treatments but higher than in control

The damage caused by *T ludeni* in bhindi leaves var ed significantly with respect to the period after the release of mites as indicated by the damage grade indices at one two and three weeks after the release of mites The mean damage index increased from 2 07 during the first week to 2 95 during the third week after the release of mites

During the first week after release damage grade index was maximum in plants released with 30 mites per plant 15 DAS (8 33) and it progressively increased to 10 and 12 during the second and third week after release respectively An increasing trend in damage grade indices was also noticed in other treatments also during the second and third week after release Significant negative correlation were observed between damage grade indices and yield

Table 23 Damage grade indices of leaves and yield per plant in bhindi infested with different levels of *Tetranychus ludeni*

Treatment	Weeks after release of mites 1	2	3	Mean (Treatments)	Mean weight of fruits/ plant (g)
30 mites/plant 15 DAS	8 33 (3 05)	10 00 (3 32)	12 00 (3 61)	10 09 (3 33)	0
10 mites/plant 30 DAS	2 00 (1 73)	3 78 (2 19)	7 00 (2 83)	4 06 (2 25)	150 67
30 mites/plant 30 DAS	4 32 (2 31)	8 33 (3 05)	9 66 (3 27)	7 29 (2 88)	137 33
10 mites/plant 45 DAS	2 0 (1 73)	2 00 (1 73)	8 00 (3 00)	3 67 (2 16)	165 67
20 mites/plant 45 DAS	2 32 (1 82)	7 33 (2 89)	8 00 (3 00)	5 60 (2 57)	146 67
30 mites/plant 45 DAS	4 00 (2 00)	7 66 (2 94)	8 00 (3 00)	6 02 (2 65)	139 00
40 mites/plant 45 DAS	2 65 (1 91)	8 33 (3 05)	9 33 (3 21)	6 45 (2 73)	114 33
50 mites/plant 45 DAS	5 81 (2 61)	8 33 (3 05)	9 33 (3 21)	7 76 (2 96)	127 33
Control (Monocrotophos sprayed at 0 05%)	0 (1 00)	0 (1 00)	0 (1 00)	0 (1 00)	159 33
Mean	(2 07)	(2 63)	(2 95)	CD for treatments	0 185
(Weeks)	4 28	6 92	8 70	CD for weeks	0 086
				CD for weeks Vs treatments	0 259
				CD for yield	44 06

Figures in parentheses are $\sqrt{x+1}$ values
DAS Days after sowing

4 4 1 3 Weight of fruits

The data on the mean weight of fruits per plant are presented in table 23 No yield could be obtained from plants treated with 30 mites per plants 15 days after sowing as the plants were dried as a result of infestation of *T ludeni* Plants with 10 mites per plant released 45 days after sowing recorded the maximum yield (165 67g) This was on par with all other treatments except the treatment 40 mites per plant released at 45 DAS which showed the lowest yield of 114 33 g per plant

4 4 1 4 Effect of different population levels of *Tetranychus ludeni* on the chlorophyll content in leaves

Analysis of chlorophyll content in bhindi leaves revealed that there was reduction in the content of chlorophyll due to the feeding of the mites Table 24 Chlorophyll content in uninfested leaves was to the tune of 2 20 mg per gram and was significantly higher than in leaves with different degrees of damage symptom There was no significant difference in the content of chlorophyll in leaves with 6 to 20 per cent speckling + patches and 21 to 40 per cent speckling + patches But the chlorophyll content in leaves with 6 20 per cent speckling + patches was significantly higher than in leaves with 41 to 60 per cent speckling + patches and also leaves with more than 60 per cent speckling + patches

4 4 1 4 Population build up

Data on the population build up of *T ludeni* on bhindi at different intervals after the release of mites are presented in Table 25

The highest population of *T ludeni* was observed in plants with 30 mites per plant

Table 24 Chlorophyll content in bhindi leaves infested by *Tetranychus ludeni* at different levels of damage symptoms

Number of mites released	Damage symptom	Chlorophyll content (mg/g)
20 mites/plant 45 DAS	6 20% speckling + chlorotic patches	0 88
30 mites/plant 45 DAS	21 40% speckling + chlorotic patches	0 85
40 mites/plant 45 DAS	41 60% speckling + chlorotic patches	0 52
50 mites/plant 45 DAS	>60% speckling + chlorotic patches	0 19
Control (uninfested plant)		2 20
CD		0 35

DAS Days after sowing

released 30 DAS (5 96 mites per sq cm) which was on par with the population levels observed in plants with 30 40 and 50 mites per plant released 45 days after sowing the mean values being 4 29 4 29 and 4.66 respectively The population counts in all other treatments were on par

The population counts recorded in leaves in the different strata of bhindi plants viz top middle and bottom showed no significant difference But there was significant difference in the population build up of the mites at different intervals after release The population recorded during the second and third weeks (4 90 and 4 95) were significantly higher than that recorded during the first week after release (3 28) But the population of was found to decline significantly during the fourth week after release and the mean population recorded was 2 76 mites per sq cm There was significant difference in the population of the mites at different intervals after release During the first week after release significantly higher population of the mites were observed in plants treated with 30 mites per plant released 15 and 30 DAS and 10 mites per plant released 30 DAS were on par and were significantly higher than in plants treated with different population of the mites released 45 DAS

During the second week after release also maximum population was recorded in plants with 30 mites per plant released 15 DAS However the population in plants with 20 30 40 and 50 mites per plant released 45 DAS were on par The mean population recorded were 4 76 6 02 4 90 4 71 and 6 12 respectively But during the third week after release singificantly lower population was observed in plants released with 30 mites per plant 15 DAS (0 53) and was on par with control Population recorded in plants released with 50 mites per plant was significantly higher (12 54) and was superior to all other treatments The population in plants released with 40 mites per plant 45 DAS and 30 mites

Table 25 Intra plant distribution and population build up of *Tetranychus ludeni* when released at different population levels

Treatments	Strata			Weeks after release				Treatment Mean
	Top	Middle	Bottom	1	2	3	4	
				(Mites per cm^2)				
30 mites/plant 15 DAS	3 20 (2 05)	2 35 (1 83)	2 65 (1 91)	6 89 (2 81)	6 12 (2 67)	0 53 (1 24)	0 0 (1)	2 72 (1 93)
10 mites/plant 30 DAS	5 55 (2 56)	4 15 (2 27)	2 96 (1 99)	6 45 (2 73)	3 45 (2 11)	4 42 (2 33)	2 65 (1 91)	2 96 (1 99)
30 mites/plant 30 DAS	4 86 (2 42)	3 97 (2 23)	9 69 (3 27)	5 25 2 50)	4 80 (2 41)	7 94 (2 99)	6 02 (2 65)	5 96 (2 64)
10 mites/plant 45 DAS	2 46 (1 86)	3 67 (2 16)	2 84 (1 96)	1 13 1 46)	4 42 (2 33)	4 38 (2 32)	2 46 (1 86)	3 12 (2 03)
20 mites/plant 45 DAS	3 29 (2 07)	3 45 (2 11)	2 57 (1 89)	1 37 (1 54)	4 76 (2 40)	4 33 (2 31)	2 50 (1 87)	3 88 (2 21)
30 mites/plant 45 DAS	3 58 (2 14)	3 58 (2 14)	4 52 (2 35)	2 68 (1 92)	6 02 (2 65)	4 24 (2 29)	2 96 (1 99)	4 29 (2 30)
40 mites/plants 45 DAS	3 84 (2 20)	5 20 (2 49)	3 84 (2 20)	2 09 (1 76)	4 90 (2 43)	8 12 (3 02)	2 96 (1 99)	4 29 (2 30)
50 mites/plant 45 DAS	5 50 (2 55)	4 15 (2 27)	4 33 (2 31)	2 53 (1 88)	4 71 (2 39)	12 54 (3 68)	3 84 (2 20)	4 66 (2 38)
Control (Monocrotophos sprayed at 0 05%)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Mean	3 97 (2 23)	3 79 (2 19)	4 01 (2 24)	3 28 (2 07)	4 90 (2 43)	4 95 (2 44)	2 76 (1 94)	
Weeks after release								
1	3 49 (2 12)	4 06 (2 25)	5 20 (2 49)					
2	3 28 (2 07)	3 08 (2 02)	4 90 (2 43)					
3	5 40 (2 53)	2 16 (1 78)	3 32 (2 08)					
4	5 70 (2 59)	4 38 (2 32)	2 84 (1 96)					

CD Treatments	0 355
CD Weeks	0 290
CD Treatments Vs weeks	0 819

Figures within parantheses are $\sqrt{x+1}$ values
DAS Days after sowing

per plant 30 DAS were on par but significantly inferior to 50 mites per plant released 45 DAS Population recorded in plants released with 10 mites per plant 30 DAS and 10 and 20 mites per plant released 45 DAS were on par The mean population counts of *T ludeni* observed were 2 33 2 32 and 2 31 mites per leaf respectively Except in plants released with 30 mites per plant 30 DAS and 50 mites per plant 45 DAS the population level recorded in all other treatments were on par During the fourth week after release significantly higher population was recorded in the treatments 30 mites per plant released 30 DAS

4 4 1 6 Intraplant distribution

The data on the intraplant distribution of *T ludeni* on bhindi are presented in Table 25

Statistical analysis of the population counts of *T ludeni* present in the different strata of bhindi plants at different intervals after release indicated that there was no significant difference in the population of the mite in top middle and bottom strata of the plant The mean population counts recorded were 3 97 3 79 and 4 01 per sq cm leaf area in the top middle and bottom portion of the plant respectively

4 4 2 Crop loss in chilli due to *Polyphagotarsoneums latus*

4 4 2 1 Crop loss in chilli due to *P latus* when released on the plant at different population levels three weeks after transplanting

The data relating to crop loss in chilli assessed in terms of leaf infestation population build up and weight of fruits harvested are presented in Tables 26 and 27

Table 26 Mean number of leaves infested by *Polyphagotarsonemus latus* when released on chilli plants three weeks after planting and mean yield per plant

Treatments	Weeks after release of *P latus*					Mean weight of of fruits/plant (g)
	1	2	3	4	5	
	(Mean number of mites per leaf)					
10 mites/plant	0 (1)	0 58 (1 26)	4 43 (2 33)	15 08 (4 01)	19 25 (4 50)	147 50
24 mites/plant	0 (1)	1 82 (1 68)	14 21 (3 90)	30 80 (5 64)	40 34 (6 43)	107 50
50 mites/plant	0 39 (1 18)	1 56 (1 60)	13 82 (3 85)	44 42 (6 74)	47 30 (6 95)	55 00
100 mites/plant	0 (1 00)	2 61 (1 90)	10 69 (3 42)	48 00 (7 00)	36 08 (6 09)	58 75
Control (Monocrotophos sprayed at 0 05%)	0 (1 00)	0 0 (0 88)	0 54 (1 24)	0 0 (0 64)	2 28 (1 81)	168 75
CD	0 27	0 78	0 91	1 66	1 84	26 63

Figures within parentheses are adjusted means

Plate XVII Damage symptoms in chilli plants caused by different population levels of *Polyphagotarsonemus latus*

A 24 mites per plant released thr e weeks after transplanting

B 100 mites per plant released three weeks after planting

C Control plants sprayed with monocrotophos 0 05%

Plate XVII

A

B

C

4 4 2 1 1 Mean number of infested leaves

The data as given in Table 26 indicated that there was no significant difference in the number of leaves infested in the treatments one week after release of the mites The mean number of leaves infested showed no significant variation between the plants released with 10 24 50 and 100 mites per plant during the second and third weeks after release During the fourth and fifth weeks the plants released with 10 mites per plant had significantly lower number of infested leaves than the plants released with 24 50 and 100 mites per plant Monocrotophos treated control plants had significantly lower number of infested leaves than all the treatments in the third fourth and fifth weeks after release (Plate XVII)

4 4 2 1 2 Yield loss

The data on the mean weight of fruits per plant are presented in Table 26

The maximum mean yield of 168 75 g of fruits were obtained from the monocrotophos treated control plants This was significantly higher than from other treatments The plants released with 10 mites and 24 mites per plant gave a mean yield of 147 5 g and 107 5 g respectively which showed significant variation between them The plants released with 50 and 100 mites per plant yielded 55 and 58 75 g fruits respectively which was on par and significantly lower than other treatments

4 4 2 1 3 Population build up

Data on the mean number of *P latus* per leaf at 1 2 3 4 and 5 weeks after release three weeks after transplanting at the rates of 10 24 50 and 100 mites per plants are

given in Table 27 The maximum population of 5 40 per leaf was observed when 100 mites were released This value was found to be significantly higher than the values in other treatments The mean population per leaf when 24 and 50 mites were released did not differ between them but was significantly higher than the population in plants released with 10 mites per plant

There was significant difference in the population of mites at different intervals also The mean population of 0 42 mites per leaf observed during the second week increased significantly and reached the level c f 1 66 mites per leaf during the third week The population continued to increase during the fourth and fifth weeks after release the mean values being 3 58 and 4 66 mites per leaf respectively

When the mites were released at 10 and 24 mites per plant the population increased significantly from the second week and reached peak population level during the fourth week after which there was reduction in the population The mean number of mites per leaf were 3 04 and 6 56 during the fourth week and 0 96 and 2 20 during the fifth week wnen released at 10 and 24 mites per plant respectively In the treatments of 50 and 100 mites released per plant the populations were found to increase significantly until the fifth week after release

4 4 2 1 4 Intra plant distribution

No significant difference in the popul tion of *P latus* was noticed in the leaves at the top middle and bottom strata of the plant (Table 27)

Table 27 Intra plant distribution and population build up of *Polyphagotarsonemus latus* when released at different levels three weeks after transplanting

Treatment	Mean number of mites/ leaf in each stratum			Mean number of mites/leaf/ plant Weeks after release					Treatment mean
	Top	Middle	Bottom	1	2	3	4	5	
10 mites/plant	1 82 (1 68)	1 28 (1 51)	0 99 (1 41)	0 42 (1 19)	0 59 (1 26)	2 24 (1 80)	3 04 (2 01)	0 96 (1 40)	1 34 (1 53)
24 mites/plant	2 50 (1 87)	2 92 (1 96)	2 46 (1 86)	0 93 (1 39)	1 10 (1 45)	3 45 (2 11)	6 56 (2 75)	2 20 (1 79)	2 61 (1 90)
50 mites/plnat	2 28 (1 81)	3 37 (2 07)	3 37 (2 09)	5 66 (2 58)	0 30 (1 14)	0 74 (1 32)	3 0 (2 0)	7 59 (2 93)	2 96 (1 99)
100 mites/plant	7 18 (2 86)	4 57 (2 36)	4 62 (2 37)	3 71 (2 17)	0 30 (1 10)	2 50 (1 87)	7 01 (2 83)	20 90 (4 68)	5 40 (2 53)
Control (Monocrotophos sprayed at 0 05%)	0 44 (1 20)	0 12 (1 06)	0 17 (1 08)	0 80 (1 34)	0 00 (1 00)	0 06 (1 03)	0 21 (1 10)	0 21 (1 10)	0 25 (1 12)
Mean	2 53 (1 88)	2 20 (1 79)	2 10 (1 76)	1 99 (1 73)	0 42 (1 19)	1 66 (1 63)	3 58 (2 14)	4 66 (2 38)	

Weeks after release

1	1 47 (1 57)	0 44 (1 20)	2 03 (1 74)
2	4 48 (2 34)	5 55 (2 56)	(2 20) (1 79)
3	0 54 (1 24)	1 40 (1 55)	3 08 (2 02)
4	4 52 (2 35)	2 24 (1 83)	0 25 (1 12)
5	1 53 (1 59)	3 16 (2 04)	3 97 (2 23)

CD Treatment	0 25
CD Weeks	0 233
CD Treatment Vs Week	0 52

Figures within parantheses are $\sqrt{x+1}$ values

4 4 2 2 Crop loss in chilli due to *Polyphagotarsonemus latus* when released on the plant six weeks after transplanting

Crop loss caused by *P latus* in chilli assessed in terms of leaf infestation population build up damage grade index and weight of fruits harvested are presented in Table 28 to 30

4 4 2 2 1 Mean number of leaves infested

The data on the mean number of leaves infested when different populations levels of *P latus* were released six weeks after transplanting are presented in Table 28

The control plants had the least number of infested leaves and the values were s gnificantly lower than the other treatments Leaf infestation showed no significant variation among the plants released with 24 50 and 100 mites during the second and third week after release and were higher than in plants released with 10 mites per plant In the fourth and fifth week the plants released with 10 24 and 50 mites were on par but lower than plants released with 100 mites In the sixth week all the treatments were significantly different except plants released with 50 and 100 mites per plant which were on par

4 4 2 2 2 Damage grade index in chilli plants infested with different population levels of *Polyphagotarsonemus latus*

Data on Damage grade index (DC I) determined for different population levels of *P latus* are presented in Table 29 There were significant differences in damage grade indices with respect to the various treatments Maximum damage occurred to plants

Table 28 Mean number of leaves infested by *Polyphagotarsonemus latus* in chilli when released on the plant six weeks after transplanting

Treatments	Mean number of mites per leaf (weeks after release of mites)				
	2	3	4	5	6
10 mites/plant	2 84 (1 96)	3 37 (2 09)	7 29 (2 88)	9 49 (3 24)	10 09 (3 33)
24 mites/plant	6 13 (2 67)	6 56 (2 75)	7 64 (2 94)	9 56 (3 25)	28 26 (5 41)
50 mites/plant	6 95 (2 85)	10 22 (35)	12 76 (3 71)	15 48 (4 06)	43 89 (6 70)
100 mites/plant	6 62 (2 76)	10 70 (3 40)	15 (4 00)	16 81 (4 22)	42 16 (6 57)
Control (Monocrotophos sprayed at 0 05%)	0 23 (1 11)	0 14 (1 07)	1 46 (1 57)	2 20 (1 79	0 44 (1 22)
CD	0 456	0 545	0 867	0 905	1 116

Figures within parentheses are adjusted means

infested with 100 mites per plant as indicated by the damae grade index (3 88) followed by plants released with 50 mites (3 79) 24 mites (2 88) and 10 mites (2 31) All the treatments were significantly different

4 4 2 2 3 Effect of different populations levels of *Polyphagotarsonemus latus* on the yield of chilli

The data on yield in terms of weight of fruits are presented in Table 29 The results showed that the yield was significantly reduced in plants infested with 50 and 100 mites per plant The weight of fruits recorded from these plants were on par (61 5 and 60 5 g per plant) The weight of fruits recorded from plants infested with 24 mites per plant was significantly lessor (112 5 g per plant) than that from uninfested plants (152 5 g per plant) Weight of fruits obtained from plants treated with 10 mites per plant (121 25g per plant) was on par with the yield from control plants

4 4 2 2 4 Population build up

The data related on the mean population count of *P latus* released on chilli plants at different levels six weeks after planting are presented in Table 30 Mite population was significantly different in the various treatments All treatments recorded a population significantly higher than in control Plants infested with 50 and 100 mites per plant were not significantly different in population build up and the population counts were significantly higher (3 93 and 3 97) than in plants infested with 10 and 24 mites per plant (1 40 and 2 17) Population build up in plants treated with 24 mites per plants was also significantly higher than in plants infested w th 10 mites

Table 29 Damage grade indices in leaves and mean weight of fruits per chilli plant at different population levels of *Polyphagotarsonemus latus* released six weeks after planting

Treatments	Mean number of mites/leaf Weeks after release 1	2	3	4	Mean (Treatments)	Mean weight of fruits/ plant g
10 mites/plant	1 00 (1 41)	1 00 (1 41)	3 00 (2 00)	5 00 (2 45)	2 31 (1 82)	121 25
24 mites/plant	1 23 (1 49)	1 73 (1 65)	4 00 (2 24)	5 24 (2 50	2 88 (1 97)	112 50
50 mites/plant	2 24 (1 80)	2 74 (1 93)	4 74 (2 40)	6 00 (2 65	3 79 (2 19)	61 50
100 mites/plant	2 00 (1 73)	3 00 (2 00)	5 00 (2 45)	6 00 (2 65)	3 88 (2 21)	60 50
Control (Monocrotophos sprayed at0 05%)	0 00 (1 00)	0 00 (1 00)	0 00 (1 00)	0 00 (1 00)	0 (1 00)	152 50
Mean (Weeks)	1 22 (1 49)	1 56 (1 60)	3 08 (2 02)	5 00 (2 45)	CD for treatments	0 070
					CD for weeks	0 041
					CD for treat ments Vs Weeks	0 090
					CD for yield	35 77

Figures within parentheses are $\sqrt{x+1}$ values

Table 30 Intra plant distribution and population build up of *Polyphagotarsonemus latus* when released at different intervals six weeks after transplanting

Tre t ment	Mean number of mites/leaf in each stratum			Mean number/leaf/plant Weeks after release					Treat ment mean
	Top	Middle	Bottom	1	2	3	4	5	
10 mites/plant	2 80	1 43	0 28	0 57	0 51	0 23	3 80	0 90	1 40
	(1 95)	(1 56)	(1 13)	(1 23)	(1 23)	(1 71)	(2 19)	(1 38)	(1 55)
24 mites/plant	3 24	2 42	1 02	0 66	1 66	3 88	5 40	6 46	2 17
	(2 06)	(1 85)	(1 42)	(1 29)	(1 63)	(2 21)	(2 53)	(1 21)	(1 78)
50 mites/plant	6 51	3 88	1 99	1 16	1 82	5 55	12 61	1 19	3 93
	(2 74)	(2 21)	(1 73)	(1 47)	(1 68)	(2 56)	(3 69)	(1 73)	(2 22
100 mites/plant	6 24	3 80	2 28	1 25	1 82	4 48	18 36	0 51	3 97
	(2 69)	(2 19)	(1 81)	(1 50)	(1 68)	(2 34)	(4 40)	(1 23)	(2 23)
Control (Monocrotophos sprayed at 0 05%)	0 25	0 08	0 12	0 06	0 06	0 21	0 46	0 17	
	(1 12)	(1 04)	(1 06)	(1 31)	(1 44)	(1 97)	(2 78)	(1 35)	
Mean	(2 11)	(1 77)	(1 43)	(1 31)	(1 44)	(1 97)	(2 78)	(1 35)	
	3 45	1 10	1 05	0 72	1 07	2 88	6 73	0 82	

Week after release

1	1 19	2 03	5 00
	(1 48)	(1 74)	(2 45)
2	10 70	1 16	0 80
	(3 42)	(1 47)	(1 34)
3	0 66	0 37	6 73
	(1 29)	(2 09)	(2 78)
4	0 80	0 21	0 69
	(1 34)	(1 10)	(1 30)
5	0 88	3 58	0 54
	(1 37)	(2 14)	(1 24)

CD for treatments	0 181
CD for Strata	0 133
CD for weeks	0 176
CD Treatment Vs Strata	0 298
CD Treatment Vs Week	0 394
CD strata Vs week	0 305

Figures within parantheses are $\sqrt{x+1}$ values

The population of the mites recorded did not show any significant difference during the first and second week after release There was an increase in the population build up of mites up to fourth week after release and thereafter there was a decline in the population

There was significantly higher population of the mites during the third and fourth week after release in all the treatments Maximum population of the mites were recored during fourth week after release of mites and the population recorded were 3 80 5 40 12 61 and 18 36 in plants treated with 10 24 50 and 100 mites per plant respectively

4 4 2 2 5 Intraplant distribution

Results presented in Table 30 indicated that there was significant difference in the number of mites per leaf in the top middle and bottom strata of the plant The top strata recorded higher population (3 45) than in the middle (1 10) and the population in the middle strata was significantly higher (1 10) than in the lower strata (1 05) In all the treatments maximum population was recorded in the top strata This was followed by the middle strata and minimum population was recorded in the bottom strata The mean number of mites recorded per leaf being 2 80 3 4 6 51 6 24 in the top strata 1 43 2 42 3 88 3 80 in the middle strata and 0 28 1 02 1 99 2 28 in the bottom strata of plants treated with 10 24 50 and 100 mites per plant respectively

DISCUSSION

5. DISCUSSION

The survey on phytophagous mites and their predators associated with vegetable medicinal and ornamental plants in the five centres selected in Thiruvananthapuram District Kerala during the premonsoon monsoon and postmonsoon seasons of 1992 and 1993 revealed the existence of phytophagous and predatory mites belonging to six families each The families under the former group were Tetranychidae Tenuipalpidae Tarsonemidae Eriophyidae Galumnidae and Oribatidae while those in the latter group were Ascidae Bdellidae Cheyletidae Cunaxidae Stigmaeidae and Phytosenda^e (Tables 1 and 5) A few of the insect predators belonging to the orders Coleoptera Hemiptera and Thysanoptera were also observed The tetranychids tenuipalpids and tarsonemids were the most widespread in the phytophagous group and most of the important species under these families were commonly found in all the three groups of plants (Tables 2 3 and 4)

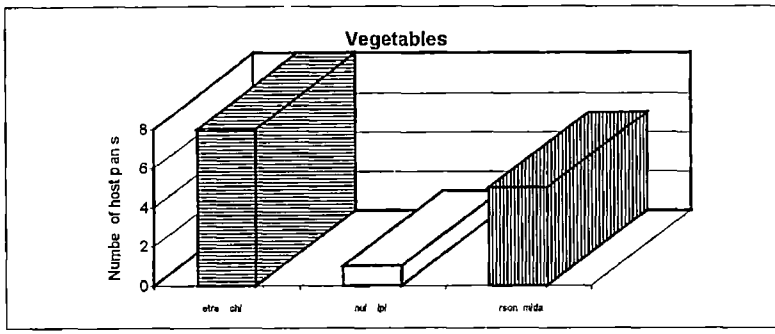
The survey further helped to identify eighteen new host plants of the phytophagous mite species which are new reports They are *Tetranychus cinnabarinus* on *Adhatoda beddomei* and *Adhatoda vasica* *Tetranychus ludeni* on *Hibiscus abelmoschus* *Livinstona chinensis* *Rauvolfia serpentina* and *Oxalis corniculata* *Schizotetranychus hindustanicus* on *Azadirachta indica* *Brevipalpus phoenicis* on *A beddomei* *Clerodendrum serratum* *Gymnema sylvestre* *Strobilanthes ciliates* and *Withania somnifera* *Raoiella indica* on *Thunbergia alata* *Polyphagotarsonemus latus* on *Gmelina arborea* *Luffa acutangula* *Trichopus zeylanicus* and *Vitex negundo* and oribatid mites on *Anthurium andreanum*

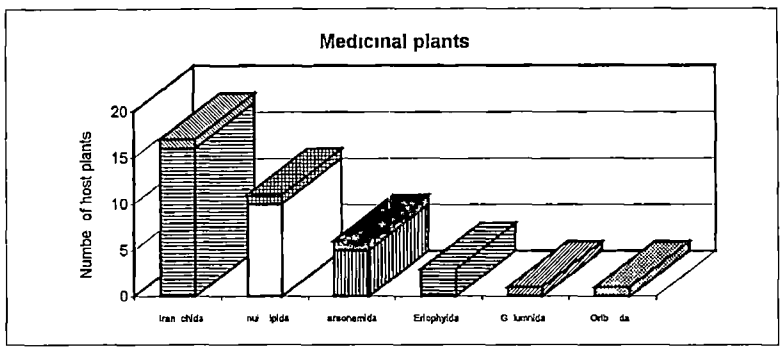
T cinnabarinus *T ludeni* and *T neocaledonicus* of the family Tetranychidae and *P latus* of the family Tarsonemidae were found to be the important mite pests of vegetables in the District (Table 2) The same species were reported as important mite pests of vegetable crops in the other parts of the country also (Kareem *et al* 1977 Awate *et al* 1981 Mali *et al* 1983 Mohanasundaram 1986 Beevi and Natarajan 1991) The tenuipalpid mite *Brevipalpus phoenicis* was observed only in brinjal

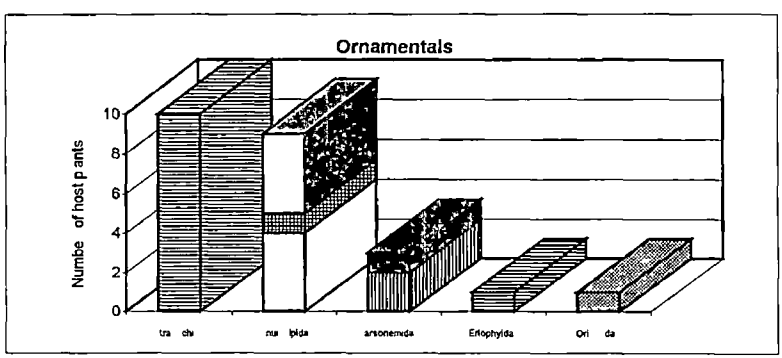
T cinnabarinus *T ludeni* *T neocaledonicus* and other species of *Tetranychus* were the most widespread phytophagous mites observed in the survey on medicinal plants (Table 3) The tenuipalpid *B phoenicis* the tarsonemid *P latus* and a few other species under the genera *Brevipalpus* and *Tarsonemus* were next in importance The tenuipalpids were found in more number of host plants among the medicinal plants (Fig 1) The eriophyids *Aceria pongamiae* and other *Aceria* species were also observed in the medicinal plants Research reports on phytophagous mites associated with medicinal plants are few in India The reports on the occurrence of *Eutetranychus orientalis* on *Rauvolfia serpentina* (Lal and Mukharji 1977b) *Aceria acanthe* on *Kydia calycina* and *A pongamiae* on *Pongamia pinnata* (Sheela and Haq 1982) and *Aculus ocimumae* an under surface leaf vagrant on *Ocimum* sp (Mohanasundaram 1991) were some of those already reported which were not observed in the present survey

As in the vegetable and medicinal plants the dominant species infesting ornamentals in the District were *T cinnabarinus* *T ludeni* *T neocaledonicus* and other species under the genus *Tetranychus* of the family Tetranychidae and *P latus* of the family Tarsonemidae The tenuipalpids were also found to be equally important as the other two families as pests of

Fig 1 Infestation by different groups of phytophagous mites in vegetables ornamentals and medicinal plants







Tetranychus
Schizotetranychus
Brevipalpus
Rao ella
Tenu palpus
Polyphagotarsonemus
Tarsonemus
Aceria
Galumnidae
Or batidae

ornamentals and had a wider host range than tarsonemids *B phoenicis Raoiella indica* and *Tenuipalpus pacificus* were the important tenuipalpid species observed on ornamentals in the district (Table 4 and Fig 1)

One important observation in the survey was the widespread presence of *T pacificus* on orchids This false spider mite was observed to occur on orchids in India for the first time This mite infested different orchid genera viz *Arachnis Aranda Dendrobium* and *Vanda* while *B phoenicis* was recorded only on *Dendrobium* The conditions prevailing in the state presumably is not only favourable for the growth of orchids but for their mite pests also Though Charanasri *et al* (1989) had reported five species of mites infesting orchids only the above mentioned two were collected from orchids in Thiruvananthapuram district

Jeppson *et al* (1975) reported the same species as an important pest of orchids in the USA *Oligonychus biharensis* and *O mangiferus* reported as important tetranychid pests of many ornamentals (Sadana and Chabra 1974 Majumder and Bhuiya 1995) were not observed in the survey

Another important observation in the survey was the occurrence of oribatid mites in the candles of anthurium Though oribatids are primarily soil inhabitants phytophagous forms have been reported (Ramani and Haq 1987) Though the population counts of these mites were observed to be very low with extensive cultivation of the crop the chances of these mites becoming their serious pests cannot be ruled out

Natural enemies of phytophagous mites have received increasing attention because of their potential to reduce their prey populations considerably Hence identification of predator complex of phytophagous mites associated with vegetables medicinal plants and ornamentals was included as an important component of the survey (Table 5) Species belonging to the family Phytoseiidae were found to be the most ubiquitous in the survey and in this family the species of the genus *Amblyseius* were the most widespread Many authors have reported the abundance of the family Phytosendae in general and the genus *Amblyseius* in particular as predatory on phytophagous mites (Elbadry *et al* 1968 Singh *et al* 1989 Sathiamma 1991)

Among insect predators of phytophagous mites *Stethorus* sp belonging to the coleopteran family Coccinellidae was found to be the most important This predatory insect was found feeding on *T neocaledonicus T cinnabarinus T ludeni* and *P latus* Two unidentified species one each under Hemiptera and Thysanoptera were also found in the colonies of *P latus* and *T neocaledonicus*

One important aspect of the survey was to study the nature and symptoms of damage caused by plant feeding mites on different host plants Accordingly it was done with special emphasis on ornamental and medicinal plants The nature and symptoms of damage were studied and described in detail in item 4 1 5 under Results

The nature and symptoms of damage of *T cinnabarinus* on *Adhathoda* (Plate X) and *T neocaledonicus* and *T ludeni* on *Rosa* were described under subtitles 4 1 5 1 1 4 1 5 1 2 and 4 1 5 1 3 in the chapter Results The infestation of *T cinnabarinus* in *Adathoda* has been recorded for the first time and hence it is a new report On all the hosts the mitial

symptoms were white speckli ıgs wh ch gı adually co ılesced and spıead to all parts of leaves In case of severe ınfestatıon the leaves wıthered dried and fell off prematurely

The different types of dıma̲ges encountered by the feedıng of tetranychid mites were speckling yellowing of leaves due to loss of chlorophyll bronzing and necrosis The loss of leaf chlorophyll and foi mation of neciotic senescent tissue are the most common events associated with mite dam ıge ın plants (Tanı̲goshi and Davis 1978 Bellotte and Byrne 1979 Carlson *et al* 1979 Mothes and Seitz 1982) The loss of chlorophyll is the result of oxidation ınduced by ıncıeased pe oxidising conditions Loss of chlorophyll due to mite damage has been shown to occur simultaneously with the degradation of chloroplast resulting from oxidation of chloroplast lipids (Tamgoshi and Davis 1978 Mothes and Seitz 1982 Luthy *et al* 1984) Sathiamma (1991) found that the spider mites caused significant feeding ınjury o leaves of coconut The damage was reported to be caused by the entry of stylets of the mites thı ou̲h the sto natı for the consumption of the cell contents Tissues were damaged dui ing the process and visible symptoms of ınjury appeared on the leaves

The nature and symptoms of dam ıge by the tenuipalpid mites *T pacıficus* on *Dendı obium R ındica* o ı *T alata* ı nd *B phoenıcis* on dıffeı ent host plants are desci ibed under sub titles 4 1 5 2 1 4 1 5 2 2 and 4 1 5 2 3 respectively The ınfestation of *T pacıficus* on *Dendrobium* was recorded for the fiıst time ın India The major symptom caused by this mite and the other tenuipalpid *B phoenıcis* on *Dendrobium* is the presence of sunken spots on the under surface of leaves where the mites weıe found to rest and feed

Larvae protonymphs deutonymphs and adults of tenuipalpids cause injury to the plants by piercing the chelicerae into the plant tissues and sucking the sap Continued desapping results in the expression of the symptoms (Nageshchandra and ChannaBasavanna 1976)

Tenuipalpid mites were found to cause general chlorosis of leaves and in advanced stages development of necrotic lesions were also observed According to Kennedy and Waterkeyn (1995) as a reaction to the attack of the tenuipalpid mite *Brevipalpus phoenicis* the protoplasm of the punctured cells become coagulated and the phenolic compounds accumulated in the cells Significant reduction in chloroplast was also reported

The nature and symptoms of damage of the tarsonemid mite *P latus* on chilli bittergourd ridgegourd and *Tagetes erecta* are described under the subtitle number 4 1 5 3 1

P latus has been reported on chilli causing Murda disease (Kulkarni *et al* 1922) Feeding of the mite in chilli produced slight crinkling in leaves in the early stages of attack Later the leaves curled downwards and became narrow Ravi *et al* Puttaswamy (1995) observed that the tarsonemid mite *P latus* feeding on the undersurface of chilli leaves caused downward curling of the leaves They further reported that there was reduction in the thickness and size of leaves and the number of starch grams due to the feeding of the mites

The symptoms produced by eriophyid mites on some medicinal plants and ornamentals are described under the subtitle number 4 1 5 4 1 and 4 1 5 4 2

Durmg the survey conducted eriophyid mites were observed to produce bead galls pouch galls and erineum in the infested plants Jeppson (1975) stated that galls were special sites where the mites develop and which provides food and shelter He further reported that the leaf galls made by these mites remained localized But erineum producing factors remain usually spread laterally on leaf surface Sheela and Haq (1992) found that the feeding activity of the eriophyid mite *Aceria xeriomphisi* produced small round galls on *Randia spinosa* in northern Kerala Similar galls were found in *R spinosa* in the present survey also

In addition to identification of mites and their host plants it is equally important to understand the distribution and abundance of different species of mites on different host plants in different seasons Accordingly the mean percentage of mite infested leaves and the mean population counts were also assessed in the survey (Tables 6 7 and 8)

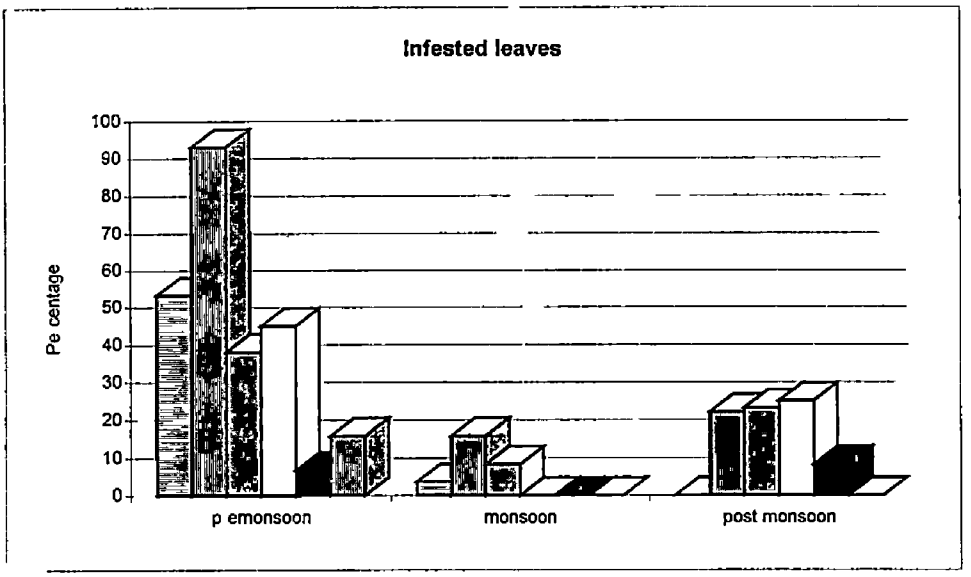
On vegetables (Table 6a and 6b) *T ludeni* was observed on bhindi and vegetable cowpea and *T neocaledonicus* on pumpkin moringa and brinjal The population count indicated that both the species are capable to cause serious damage to these crops *T cinnabarinus* was found on amaranthus in good numbers The tarsonemid *P latus* even though observed on chilli bittergourd ridgegourd and pumpkin was the most serious on chilli followed by bittergourd and ridgegourd in damage potential and in pumpkin the mite was scarce One remarkable observation was that in chilli the mite appeared ivory white while in pumpkin it was black in colour (Plate II) Jeppson (1975) had stated that the adult female of *P latus* was rich amber or dark green the colour depending on the host and food supply

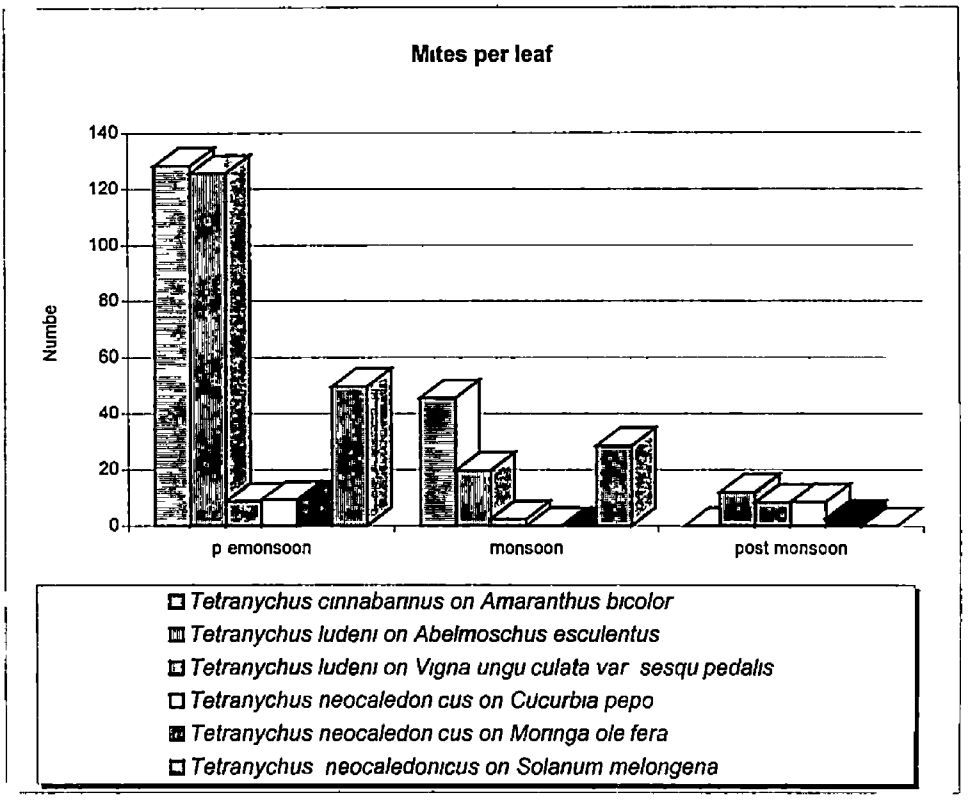
The tetranychids *T cinnabarinus* and *T ludeni* are considered to be the principal mite pests of vegetables in South India (Puttaswamy and ChannaBasavanna 1981) and the latter is the most commonly encountered tetranychid occuring in India (Mallik and ChannaBasavanna 1983) According to Goldsmidh (1962) *T neocaledonicus* was a severe pest of vegetables all over the world *P latus* the broad mite is a potential pest of many vegetables fruits ornamentals and weed plants throughout India (ChannaBasavanna and Puttarudriah 1959 Dhooria and Bindra 1977) The mite is one of the most destructive pests of chilli and is considered to be the root cause for Murda disease in chilli due to leaf curling (Sanap and Nawale 1986) The findings in the survey on vegetables generally support the above reports

The data on the survey on vegetables in the Agricultural College Farm Vellayam (Table 6a) revealed that the mean percentage of mite infested leaves were in general more in the premonsoon seasons in both the years 1992 and 1993 The mean percentage of mite infested leaves give information only on the distribution of the mites on leaves It gives no idea on the intensity of infestation for which the mean population counts per leaf has to be considered The mean population count (Table 6a and Fig 2) also showed that the population was more in the premonsoon season than in the monsoon and the postmonsoon seasons This was true for both the years 1992 and 1993 The percentage of mite infested leaves and the mean population counts between the monsoon and the postmonsoon seasons did not show much variation

In the District Agricultural Farm Perirgammala which was the other centre for the survey on vegetables the reduction in the percentage of mite infested leaves and the mean

Fig 2 Infestation by tetranychid mites in vegetables at the Agricultural College farm , Vellayani in 1993





population counts was more pronounced in the monsoon season as compared to the other two seasons No such clear cut distinction was evident when the data on the monsoon season and postmonsoon season were compared

The survey on medicinal plants was conducted in four centres viz Agricultural College Farm Vellayani TBG&RI Palode Ayurvedic Research Centre Poojappura and University Centre Karyavattom The important species identified on medicinal plants were *T cinnabarinus T neocaledonicus T ludeni B phoenicis P latus* and other species under the genus *Tetranychus*

T cinnabarinus was found to infest two species of *Adhatoda Adhatoda beddomei* and *A vasica* and was distributed in all the centres surveyed except TBG&RI Palode *T ludeni* was found to infest *Rauvolfia serpentina* Earlier the occurrence of the tetranychid mite *Eutetranychus orientalis* was reported on *R serpentina* (Lal and Mukharji 1982) Besides infesting *R serpentina T ludeni* also infested *Hibiscus abelmoschus* and *Oxalis corniculata T neocaledonicus* was found to infest only one species of medicinal plant viz *Sida rhombifolia*

Mites of the genus *Brevipalpus* was widespread among medicinal plants The polyphagous species *B phoenicis* was found to infest *Alpinia galanga Gymnema sylvestre Ocimum sanctum Solanum indicum Strobilanthes ciliates* and *Withania somnifera* and was found in all the seasons surveyed the infestation being the highest during the postmoonson season

Two tarsonemid mites viz *Phyphagotarsonemus latus* and *Tarsonemus* sp were identified from medicinal plants *P la* the polyphagous mite was found to coexist with *Tarsonemus* sp in *A beddomei* *P latus* was also found to infest *Desmodium gangeticum* *Gmelina arborea* *Santalum album* *Vitex negundo* and *Trichopus zeylanicus* besides *A beddomei*

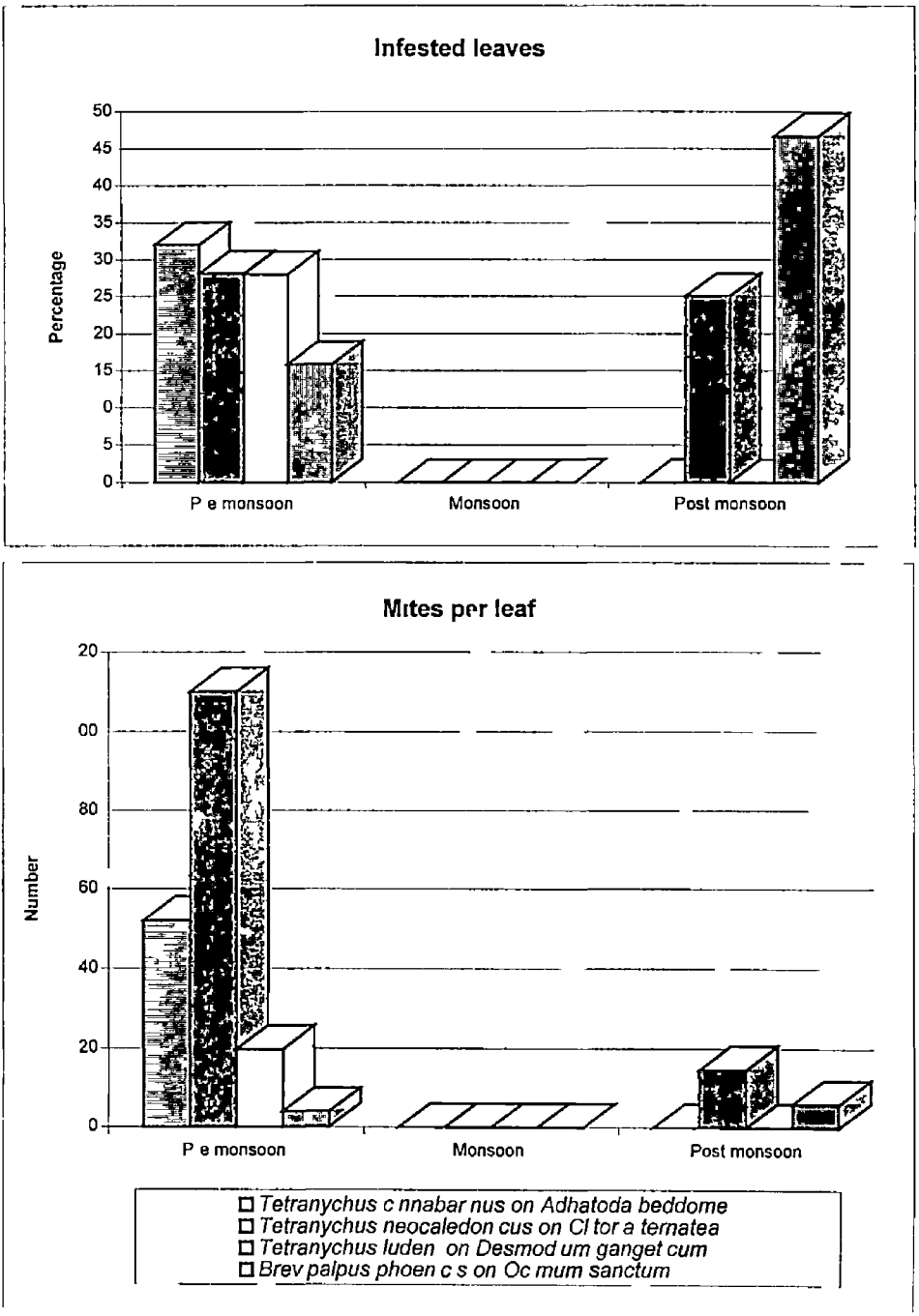
Two species of eriophyid mites were found to be associated with medicinal plants *Aceria* sp was found to cause beaded galls in the leaves of *Randia spinosa* (Plate XII) and was located at Vellayani while another species under the genus *Aceria* was found associated with *Elaeocarpus serratus*

The mean percent of mite infested leaves and the mean population counts in medicinal plants showed the same trend as in vegetables in all the centres ie the monsoon season showing the lowest values (Fig 5) In the TBG&RI Palode no mite could be observed during this season

The survey on phytophagous mites associated with ornamental plants were conducted in the Agricultural College Vellayani the District Agricultural Farm Peringammala and the TBG&RI Palode (Table 8 8b and 8c) *T ludeni* among the tetranychids and *B phoenicis* among the tenuipalpids were the most widespread species found in the ornamental plants in the district

Roses were found to be infested by *T ludeni* and *T neocaledonicus* Puttaswamy and ChannaBasavanna (cited) stated that presence of both the species in a plant was rare In the

Fig 3 Infestation of phytophagous mites in medicinal plants at the Agricultural College farm Vellayani in 1993



detailed studies undertaken in the laboratory the same authors found that irrespective of the period of infestation the population multiplication was significantly higher in *T ludeni* as compared to *T neocaledonicus* and *T ludeni* spread to all the leaves in a plant when present alone or together with the other one In the present survey also *T ludeni* was found in higher population density as compared to *T neocaledonicus* In Kerala the incidence of *T neocaledonicus* in rose was reported by Nair *et al* (1990) *T ludeni* was also found to infest heavily the chinese fan palm *Livinstona chinensis* The eriophyid mite *Aceria jasmini* Channabasavanna which was reported to cause felt like growth on leaves of jasmine in Tamil Nadu (Vijayaraghavan *et al* 1992) was not encountered in the survey The species observed on jasmine was *T neocaledonicus*

When the seasons were compared the mean percentage of mite infested leaves and mean population counts in ornamentals were the least in the monsoon season as compared to the premonsoon and postmonsoon seasons In the Agricultural College Farm Vellayani in most of the plants the mite population was absent or negligible during the monsoon season When the premonsoon and postmonsoon seasons were compared the values of mite infested leaves and population counts did not show much variation However in the District Agricultural Farm Peringammla and TBG&RI Palode infested leaves and population counts were very low not only in the monsoon season but in the postmonsoon season also

Seasonal fluctuation in the population of mites were studied by many workers who have found that the mite damage was more during the summer months (Sadana and Kanta 1971 Bhumnavar and Singh 1986 Mohanasundaram and Karuppuchamy 1987 Sivakumar and Marimuthu 1987)

During the monsoon season which lasted from the first week of June to the first week November in Kerala the heavy downpour washed the mites away from their host plants and the elimination of mites would be nearly total in most of the cases During the post monsoon season the population slowly started to multiply and reached the maximum during the premonsoon months

Population dynamics of Acarines studied by many workers Evans *et al* (1961) stated that the seasonal fluctuation was prominant in Prostigmata while it was not so prominent in Mesostigmata and Astigmata as they were found in small numbers The phytophagous mites being prostigmatids multiply and exhibit high population levels in the post and premonsoon seasons ie from November to May in Kerala The variation in the population counts of phytophagous mites between the premonsoon season on the one hand and the monsoon and postmonsoon seasons on the other can be explained as discussed earlier by the practical elimination of phytophagous mites by the splashing rain water during the monsoon season The tetranychids tenuipalpids and tarsonemids which constituted the major chunk of phytophagous mite fauna were external feeders on leaf surfaces and were likely to be washed away by the rain water

The role of predators on the population regulation of phytophagous mites is well established (Singh and Ray 1977 Hussappa and Kulkarni 1988 Gupta and Gupta 1992 Karuppuchamy *et al* 1994) Two major hypotheses have been put forward concerning outbreaks of phytophagous mites One is that the cultural methods result in more nutrition to the host plants which promotes increased fecundity (Chaboussou 1960 Storms 1971) The second hypothesis is that modern insecticides reduce natural enemies drastically causing

mite outbreaks and giving pest status to previously innocuous species (Huffaker *et al* 1970 Mc Murtry *et al* 1970) The later hypothesis seems to be more acceptable to many scientists (Van de Vrie 1970 Mc Murtry 1982 Krishnamoorthy and Mani 1989) emphasising the importance of natural enemeies in the suppression of mite out breaks Hence any study on the distribution and abundance of phytophagous mites has to be accompanied by a related study on their predators as well Mites and to a lesser extent insects were found to be the important predators of phytophagous mites (Table 5)

Phytoseiids were found to be the most widespread predatory fauna in the vegetables ornamentals and medicinal plants surveyed Two species of predatory mites under the genus *Amblyseius* were observed The species were *A multidentatus* from the colonies of *T neocaledonicus* on pumpkin and *Schizotetranychus hindustanicus* on neem These two species were found to feed on eggs and the nymphs of the prey mites The predator appeared red coloured after the meal due to the intake of body contents of the prey mites Mites of the family Phytosendae were reported as the most effective predators of plant feeding mites (Huffaker *et al* 1970 Mc Murtry *et al* 1934 Pickett and Gilstrap 1986) The potential of *Typhlodromips tetranychivorus* in the population build up of the red palm mite *Raoiella indica* was reported by Jagadish and Nageshchandra (1982) From the coconut palm foliage Sathiamma (1991) recorded *i paraaerialis* from the coconut palm foliage which checked the population of *T ludeni* The predatory fauna which Grewal (1992) identified m brinjal were *A finalandicus* and *A multidentatus* Mallik (1981) identified *A tetranychivorus* and *A longispinosus* as efficient predators of *T ludeni* on bhindi Gupta and Gupta (1992) has listed 18 species of phytoseiid predators from India

Next to Phytoseiidae mites belonging to the family Cunaxidae (Plate IV) were found to be the major predatory acarine fauna in the survey These quick moving reddish mites were found in the colonies of *T ludeni* and *T neocaledonicus* *Cunaxa setirostris* (Hermann) was reported to be an important predator of cosmopolitan nature and were found to feed on all stages of *Oligonychus mangiferus* (Gupta 1989)

In the present investigations *Agistemus* sp belonging to the family Stigmaeidae (Plate IX) was found associated with *B phoenicis* on *Gymnema sylvestre* Tseng (1982) reported twenty five species of *Agistemus* from Taiwan *Agistemus* spp were reported as potential predators of phytophagous mites on different crops in India also *Agistemus* sp was associated with *Eutetranychus orientalis* (Sadana and Kanta 1971) and *O mangiferus* (Sadana and Chabra 1974)

Predatory mites belonging to the family Bdelloidae were found in association with *P latus* on *T zeylanicus* Gupta (1989) stated that only two species of Bdelloidae were found to feed on phytophagous mites and both the species were scarce in the field He further stated that mites of the family Ascidae were found abundantly in the colonies of *S andropogon* and could be of some value in biological control In the present studies mites of the family Ascidae were observed in association with *T ludeni* on bhindi

Besides the acarine predators identified coccinellid grubs of the genus *Stethorus* was found to be of importance in suppressing tetranychid and tarsonemid populations in the field The colour of this predator was also found to change following a meal These predators were usually encountered when the prey population was relatively high unlike the acarine predators which were distributed in all the seasons even at low prey population densities

Pillai and Palaniswamy (1985) identified *S indicus* from the colonies of tetranychid mites in cassava Predatory thrips were also encountered in the field in the colonies of *T neocaledonicus*

The mean population counts of phytophagous mites and their predators and the predator prey ratio in vegetables for the premonsoon monsoon and postmonsoon seasons of 1992 and 1993 in the Agricultural College Farm Vellayani and the District Agricultural Farm Perimgammala are given in Table 9a In both the centres and in both the years the population of phytophagous mites and their predators were absent or negligible in the monsoon and postmonsoon seasons in most of the crops surveyed However in the premonsoon season most of the crops harboured both phytophagous mites and their predators Similar trend was observed in medicinal plants in the two centres (Table 9b) and in ornamental plants in the Agricultural College Vellayani (Table 9c) The premonsoon and postmonsoon counts of phytophagous mites and their predators in medicinal plants in the Ayurvedic Research Centre Poojappura TBG&RI Palode and the University Centre Kariavattom were similar eventhough the predator counts were lower in the postmonsoon season as compared to that in the premonsoon season With regard to distribution and abundance the phytoseiids were found to be the most dominant group predatory on phytophagous mites of vegetables ornamentals and medicinal plants of the district The coccinellids predator *Stethorus* sp and the predatory mite cunaxid were also found to be of importance to a lesser extent

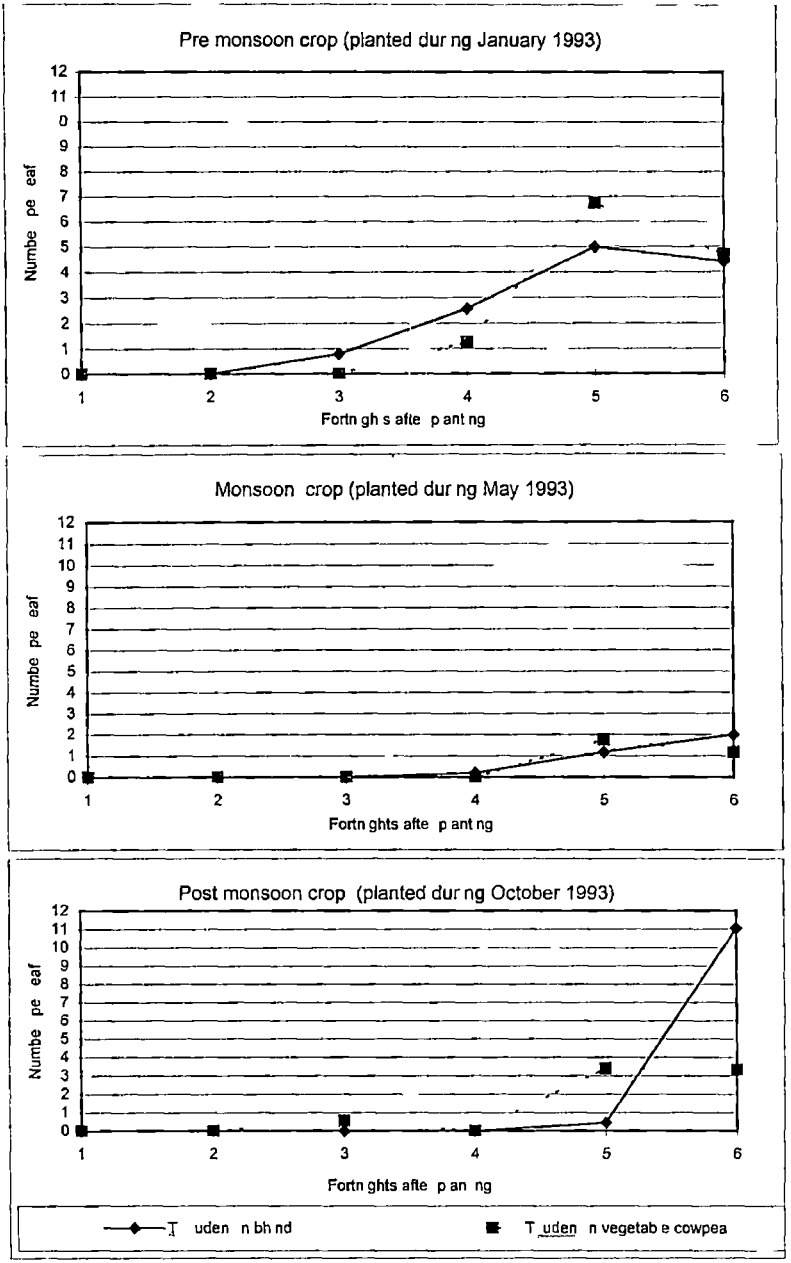
The field survey carried out in 1992 and 1993 in the selected centres yielded data on the distribution and abundance of phytophagous mites associated with vegetables medicinal plants and ornamentals plants in the district in different seasons It was found essential to

corroborate the data with those generated in statistically designed field experiment Accordingly a replicated field trial on vegetables was laid out in the farm attached to the College of Agriculture Vellayani in 1993 The trials on medicinal plants and ornamentals were conducted using the existing plants in the farm

The replicated field experiment with five treatments (bhindi chilli pumpkin snakegourd and vegetable cowpea) was laid out in the premonsoon monsoon and postmonsoon seasons and the population counts were recorded at fortnightly intervals (Table 10) The infestation of *T ludeni* on bhindi commenced by the third fortnight after planting in the premonsoon crop which is the earliest occurrence of the mite while in the crops planted during May and September the incidence commenced only on the fourth and fifth fortnights after planting (Fig 4) In vegetable cowpea *T ludeni* appeared only at a later stage ie during the fourth fortnight after planting The infestation of *P latus* on chilli started during the second fortnight of February There was appreciable increase in the population of the mites during the second fortnight after which the population declined (Fig 5) In general infestation commenced by the middle growth stage of the plants (three to four fortnights after planting) after which there was a gradual increase of population for nearly two fortnights The initial and peak populations were lower in the monsoon season as compared to the other two seasons

One significant observation is that snakegourd was free of mite pests in the replicated field trials as well as in the survey conducted in the district during during 1992 and 1993 The absence of mites noticed in snakegourd in the survey and in the field experiments needs confirmation and the reasons for the lack of mites require further

Fig 4 Population build up of of *Tetranychus ludeni* on bhindi and vegetable cowpea in the field trial conducted at the Agricultural College Vellayani

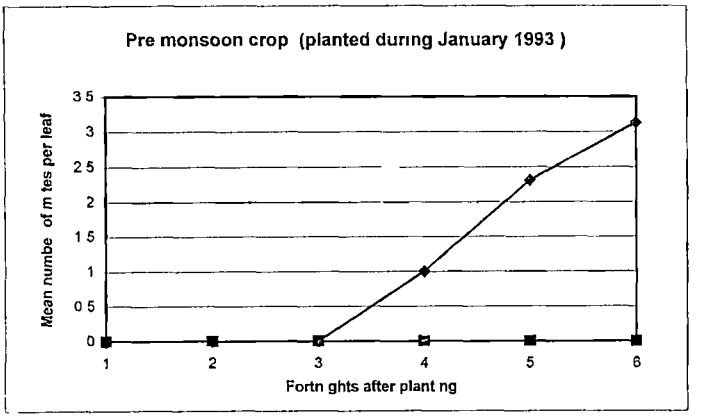


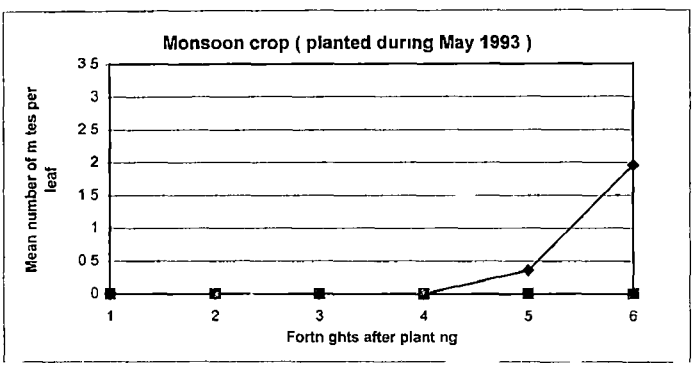
detailed investigations With regard to pumpkin the crops planted during December and May were free of mite attack but the incidence of a black tarsonemid mite (Plate II) identified as *P latus* was recorded in the crop planted during the second fortnight of September The population of the tarsonemid appeared during the third week after planting which gradually increased and reached peak population level during the next fortnight (Fig 5) In the survey conducted during 1992 and 1993 pumpkin was found to be highly susceptible to attack of the tetranychid mite *T neocaledonicus* where as in the replicated field trial pumpkin was found to be free of tetranychid mites

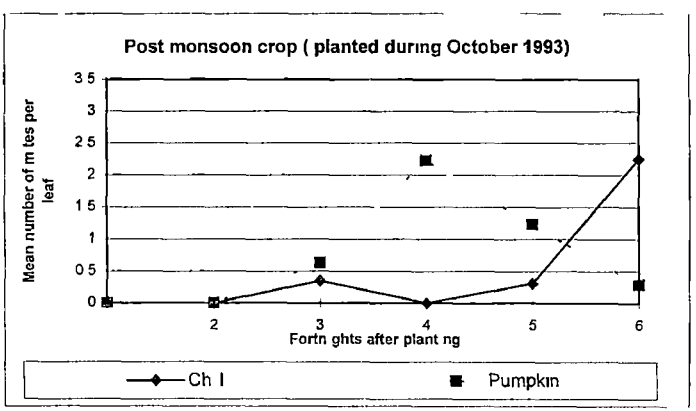
Puttaswamy and ChannaBasavanna (1980a) found that mite populations were present in vegetable crops throughout the year The population built up from April and reached peak levels during May July and became low from August to February According to Sathiamma (1991) *T ludeni* was present on coconut foliage in Kerala during all months of the year except June Maximum population was reported to occur during January and February

The population of phytophagous mites were regulated to a certain extent by weather factors However in the present studies the correlation studies did not reveal any consistant results in this regard The population counts of the tetranychid mite *T ludeni* on bhindi and vegetable cowpea showed no significant correlation with weather parameters where as that of *P latus* on chilli had significant positive correlation with maximum and minimum temperatures and negative correlation with humidity rainfall In contrast to this population counts of *P latus* in pumpkin showed correlation with weather parameters quite opposite to those in chillies In pumpkin the correlation was negative with maximum and minimum temperature and positive with rainfall and humidity (Table 11)

Fig 5 Population build up of *Polyphagotarsonemus latus* in chilli and pumpkin in the field trial conducted at Agricultural College Vellayani







Pillai and Palanisw my (1985)] ned that rainfall w is the most important limiting factor for population out break of] der mites According to Pillai and Jolly (1986) a temperature of 28 33 C and low humidity of 45 50 per cent were favourable for spider mites on mulberry Sathiamma (1991) obse ed that fluctuation in spider mite population was closely associated with weather parame te s and that maximum population of *T ludeni* occurred when the temperature and relative h midity anged from 33 34 C and 87 89 per cent respectively Studies conducted by De (1992) revealed significant positive correlation between minimum temperature and popul ation growth of tetranychid mites in bhindi

It may look strange that the popul ation of *P latus* on pumpkin showed correlation with we ather factors just the opposite to th it] chilli There w is infestation of *P latus* on pumpkin only during the post monsoon season nd the mite was totally absent during the other two seasons and this may be the reason for this type of correlation of *P latus* on pumpkin Moreover population development of mites is dependent on many factors of which weather is only one Presence of natural enemies l iochemical and biophysical characters and nutritional status of the host plants ue othe r p ortant factors It may also be remembered that generalisations cannot be made indiscri n ately for any group because there are remarkable exceptions which must be recognised

Population fluctu it on of *T inabarinus* on *Adhatoda beddomei* and *A vasica* *T ludeni* on Rosa sp *R orella i idica* *I alata* and *T pacificus* on *Dendrobium* sp were studied by recording pop l tion cou nts f rtnightly intervals from January to December 1994 in the existing plants in th e farm (Table 13)

Maximum population of *T cinnabarinus* was observed in January in *A beddomei* and in March in *A vasica* The population decreased to the lowest levels in June July and August Thereafter it started to increase (Fig 6)

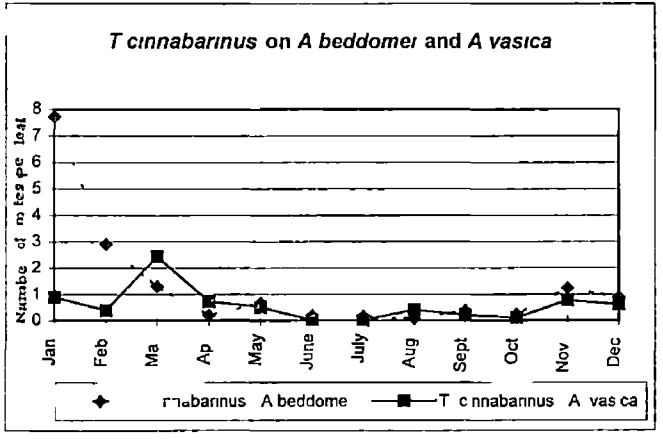
T ludeni on rose *I indica* on *T alata* peaked their population in March and then they started to decrease and reached the lowest levels in the period between June and August After August the population started to increase until they reached the peak in March (Fig 6)

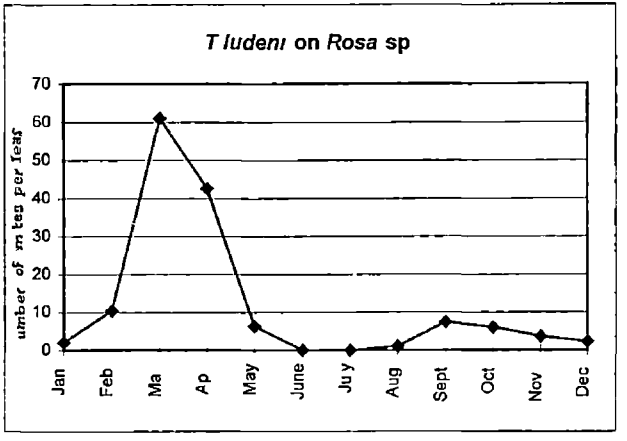
The population of *P pacificus* on *Dendrobium* sp started with 93 in January and reached a peak level of 808 in February Thereafter it decreased gradually and became nil in the months of September and October (Fig 6)

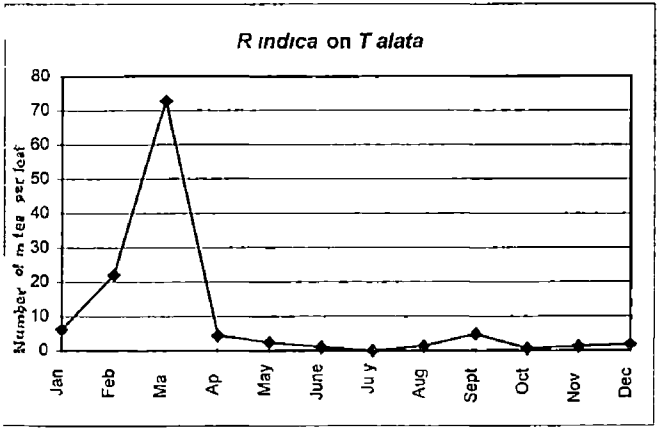
With regard to *P latus* on *A beddomei* and *A vasica* *T ludeni* on *Rosa* *R indica* on *T alata* and *P pacificus* on *Dendrobium* high populations were observed during the period from February to April During the period of July and August the populations were at the minimum levels These observations corroborate with the earlier observations that the monsoon period is the least favourable period for population growth of these mites and the premonsoon periods the most favourable

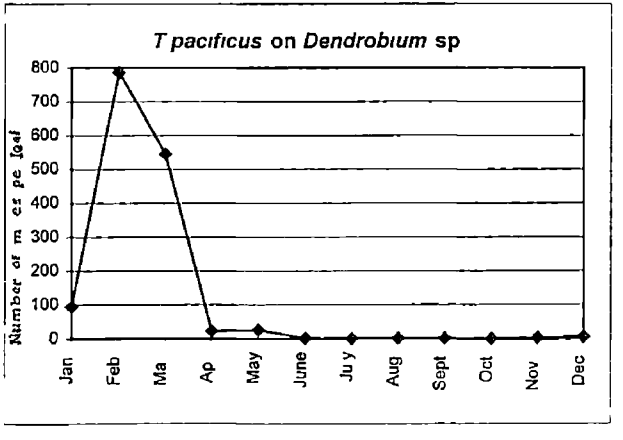
Population of *T cinnabarinus* on *A beddomei* showed significant positive correlation with minimum temperature and negative correlation with rainfall indicating high population in the premonsoon period when the minimum temperatures is high and population low in the monsoon period when the rainfall is high With regard to *T ludeni* on *Rosa* significant positive correlation with maximum temperature was observed *T pacificus* on *Dendrobium*

Fig 6 Population fluctuation of phytophagous mites in ornamentals and medicinal plants at Agricultural College farm Vellayani in 1994









and *R indica* on *T alata* showed positi c correlation with maximum temperature and negative correlation with mi nimun te npei tu c l n dity and rainfall

In general popul t on development of phytophagous mites in vegetables medicinal plants and ornamentals w s found to be positively correlated with maximum temperature and negatively correlated witl humidity except in the case of *P latus* in pumpkin which was discussed earlier It has lc ng been rep ed tl at mite outbreaks took place when temperature was high and humidity low (Ewing 1914) The problem of water conservation under these conditions in such small animals as mites has been dealt with differently by different scientists It was postulated that the favourable effect of lower relative humidity on reproductive rate was the result of increased feeding on plant l qu ds brought about by higher water loss through cuticular evapoi ation (Boudieaux 1958) However this explanation was contradicted by Mc Enroe (1961a) by demonstrating th it elatively little water loss occurred through cuticular evaporation and that wate loss could be controlled by regulating the spiracular openings

The problem of v ite conse v t on in mites is met through a combination of adaptations The cuticle iel tively v tei proof (Gibbs a d Morrison 1935 Mc Enroe 1961a) and the diet is liquid Furthe v tei conservation is affected through the production of guanine which is the n tio genous excietoiy mateii il as in other arachnids Guanine is water insoluble and hence wateiloss on excict i is reduced considerably (Mc Enroe 1961b) It seems that higher maximu i tempeiatu e id lower relative humidity and lack of rains in the premonsoon season ae ide lly suited f population out bieaks of phytophagous mites in Kerala

Depending on the host plants the developmental period and adult longevity of mites were found to vary considerably (Dhooria and Prem Sagar 1989) For evolving effective and timely management measures it is essential to have a proper understanding of the biology of the pest species on different host plants Hence it was found worthwhile to study the biology and biometrics of important phytophagous mites on selected medicinal and ornamental plants The biology of the mites on vegetables have already been worked out by several authors under different environmental conditions and on different host plants (Puttaswamy and Channa Basavanna 1979b 1980b Gupta *et al* 1982 Mallik and Channa Basavanna 1983) Accordingly the biology and biometrics of *T cinnabarinus* on *A vasica* *T ludeni* and *T neocaledonicus* on *Rosa* sp *R indica* on *T alata* and *T pacificus* on *Dendrobium* were studied in detail during November and March

The results of the study are given under the sub title number 4 3 and in tables 15 to 21 As the other tetranychid mites *T cinnabarinus* completed its life cycle on *A vasice* in five stages ie egg larva protonymph deutonymph adult and with the usual intervening quiescent stages (Table 15) The female of *T cinnabarinus* has completed its development in 14 5 days during November and 12 85 days in March while the male completed its development slightly earlier during March (12 4 days) and in November it took a few hours more compared to female (14 54 days) Biology of *T cinnabarinus* was worked out by Pillai and Palaniswamy (1985) Nanda Gopal and Gedia (1995) Dhooria and Premsagar (1989) studied the biology of the mite on four species of Japanese mint *Mentha arvensis* *M peperita* *M spicata* and *M citrata* and found the developmental period varying in the four species The adult longevity on the four species were found to be 8 73 9 00 8 67 and 12 00 days respectively In the present studies the adult longevity of the mite on *A vasica* was found to be 7 4 and 14 2 dyas for the male and the female respectively in November

The developmental period of *T ludeni* on rose for both male and female were slightly longer during November (12 26 and 13 38 days) compared to March (11 9 and 12 28 days) This may be due to the higher mean temperature in March than in November The incubation period as well as the duration of the various stages of mites is a linear function of temperature within limits (English and Turmpseed 1941) During both the periods the males were found to emerge earlier Puttaswamy and ChannaBasavanna (1979a) also observed that males of *T ludeni* on french bean completed their development earlier than females and the total developmental period was shorter at 35øC than at lower temperature He stated that developmental period from egg to adult was affected by temperature and the relative humidity played only a minor part The present studies revealed that *T ludeni* laid on an average 38 5 eggs per female during November and 39 2 eggs per female during March and the mean oviposition periods being 8 6 and 8 during November and March respectively Howevever when reared on coconut the mite laid only a mean number 13 eggs/female (Sathiamma 1991) This shows that coconut is a poorer host than rose The description given for *T ludeni* by Mallik (1981) was that the protonymphs and deutonymphs had light green colour which darkened with age In the present studies it was observed that the protonymphs and deutonymphs had dark meroomsh idiosomaland golden brownish grathosomal region This description seems to be more in confirmity with that furnished by Jeppson *et al* (1975)

The total developmental period of *T neocaledonicus* on rose was found to be longer than *T ludeni* on the same host This shorter developmental period helped *T ludeni* to complete its life cycle faster than *T cinnabarinus* and that may be one of the reasons for the numerical dominance of the former over the latter when both the species were seen together in rose plants

While studying the biology of the tetranychid mites one interesting observation was that the males continuously attended the quiescent female deutonymphs. This type of tetranychid behaviour like hovering over pheric females, guarding females against other males and mating attempts with teliochrysalis were presumed to be controlled by pheromones (Cone *et al.*, 1971).

The false spider mite *R. indica.* as the tetranychids, passed through four stages viz., egg, larva, protonymph and deutonymph before reaching adulthood. The days taken to attain maturity when reared on *T. alata* was found to be 19.2 and 17.95 for the male and 18.83 and 17.20 for the female in November and March respectively. The biology of *R. mcfarlanaei,* a related species occurring on *Syzygium jambolanum* studied by Sobha and Haq (1995) revealed that the mite completed its development in about 16 days at a temperature of 27 ± 1° C. The oviposition period of *R. indicia* on the host plant was around seven days and the average number of eggs per female only around nine. These figures indicate that the pest would under normal condition may not cause serious damage to the host plant.

T. pacificus passed through four stages ie. egg, larva, protonymph and deutonymph before reaching adulthood. The mite when reared on orchid, *Dendrobium*, had a total developmental period of 24.83 days before reaching adulthood and the female adults lived for 27.50 days. As the mite on orchids was a new report in India and as the orchids are gaining great importance detailed investigations have to be carried out on this mite pest.

B. phoenicis was observed to be a polyphagous pest attacking a variety of medicinal and ornamental plants surveyed. This polyphagous nature was found to be of

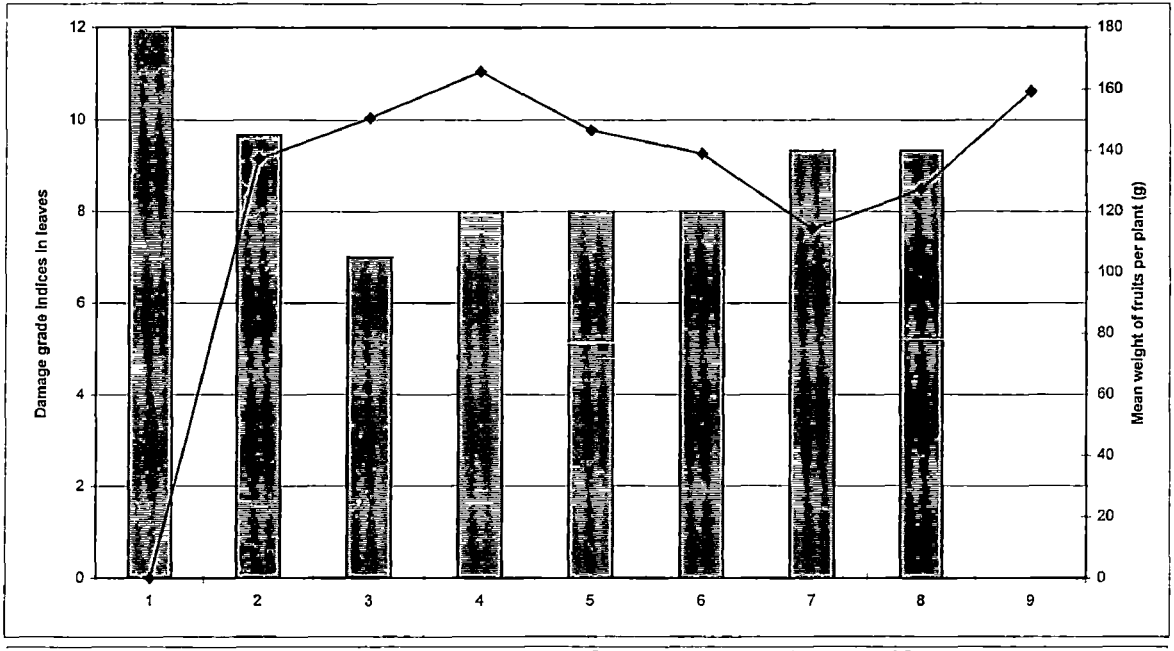
advantage to the mite as it could develop simultaneously on a number of crops within an ecosystem and develop continuously by exploiting the different food sources available When reared on different host plants viz *Caladium* sp *Maranta* sp *Tube rose P tuberosa* *Dendrobium* Orchid and *Ocimum* sp the developmental period showed no significant variation (Table 20) However *P tube rosa* was found to be preferred for oviposition and significant differences in the number of eggs laid were observed (Table 21) Oviposition is not a fortuitous act It involves a series of behavioural changes influenced by the host plants The biochemical and biophysical characters of *P tuberosa* may be more suitable for the mite species for oviposition

As bhindi and chilli were two of the important vegetables grown in the state and both were susceptible to serious mite attack it was considered worth while to take up crop loss studies in these vegetables The results presented in Tables 22 25 revealed that the stage of the crop attacked by the mites was an important criterion which determined the crop loss When the mites (*T ludeni*) were released at the rate of thirty mites per plant a fortnight after planting the bhindi plants could not withstand the infestation and succumbed to death It was also evident from the Table 23 that if the mite attack was at a later stage ie 45 days after sowing no significant reduction in yeild was noticed when released at the rate of 10 20 and 30 mites per plant While studying the effect of different levels of *T neocaledonicus* on growth of french bean *Phaseolus vulgaris* Dhooria (1983) found that during April May even 5 mites per young plant bearing 5 7 leaves could cause significant damage to the leaves resulting in low vitality of plants On the basis of symptom development in bhindi due to different population levels of *T cinnabarinus* the same author in 1985 stated that okra plant having 4 5 leaves per plant could tolerate 100 mites per plant without any adverse effect on growth during May June

The damage grade indices on a 0 12 scale recorded from the leaves of bhindi plants of the above mentioned experiment also showed almost similar trends Plants released with 30 mites per plant 15 days after sowing showed an index value of 10 09 and succumbed to the infestation Plants released with different levels of mite populations at 30 days after sowing or afterwards could tolerate the infestation and gave yields not significantly lower than from the control plants in spite of the fact that their damage grade indices differed significantly This shows that even lower mite loads on the plants are critical only in the early stages of the growth of bhindi plants

Chlorophyll contents were estimated from the leaves of bhindi plants released with different levels of mite population 45 days after sowing The data (Table 24) revealed that the highest chlorophyll content (2 20 mg/g) was in the uninfested leaves and lowest in leaves with more than 60 per cent speckling + chlorotic patches (0 19 mg/g) caused by 50 mites released per plant at 45 days after sowing Even 20 per cent speckling + chlorotic patches caused by releasing 20 mites/plant 45 days showed significant reduction in the chlorophyll content As the percentage of speckling goes up the chlorophyll content goes down Chlorophyll content can be considered as one of the parameters in determining the photosynthetic efficiency of the plant (Maithra and Sen 1988) and hence it can also be considered as an indicator for the crop loss caused by phytophagous mites Loss of chlorophyll affect the usual physiology and growth of the plant The covering on the leaf surface formed by the exuviae and egg cases of the mites and the soil particles lodged in the webbings aggravate the situation and affect the photosynthesis by the residual chlorophyll left in the leaves (Sumangala and Haq 1991) However in the present experiment the difference in chlorophyll content did not affect the yield as infestation and the consequent reduction m chlorophyll content took place 45 days

Fig 7 Mean damage grade indices in leaves recorded three weeks after release of different levels of *Tetranychus ludeni* on bhindi plants and mean weight of fruits



1 30 m tes /plant 15 DAS
2 30 m tes / plant 30 DAS
3 10 m tes / p ant 30 DAS
4 10 m tes / plant 45 DAS
5 20 m tes / plant 45 DAS
6 30 m tes / plant 45 DAS
7 40 m tes / plant 45 DAS
8 50 m tes / plant 45 DAS
9 Monocrotophos sprayed at 0 05 %
DAS Days after sow ng
Damage grade nd ces
Mean we ght of fru ts per plant

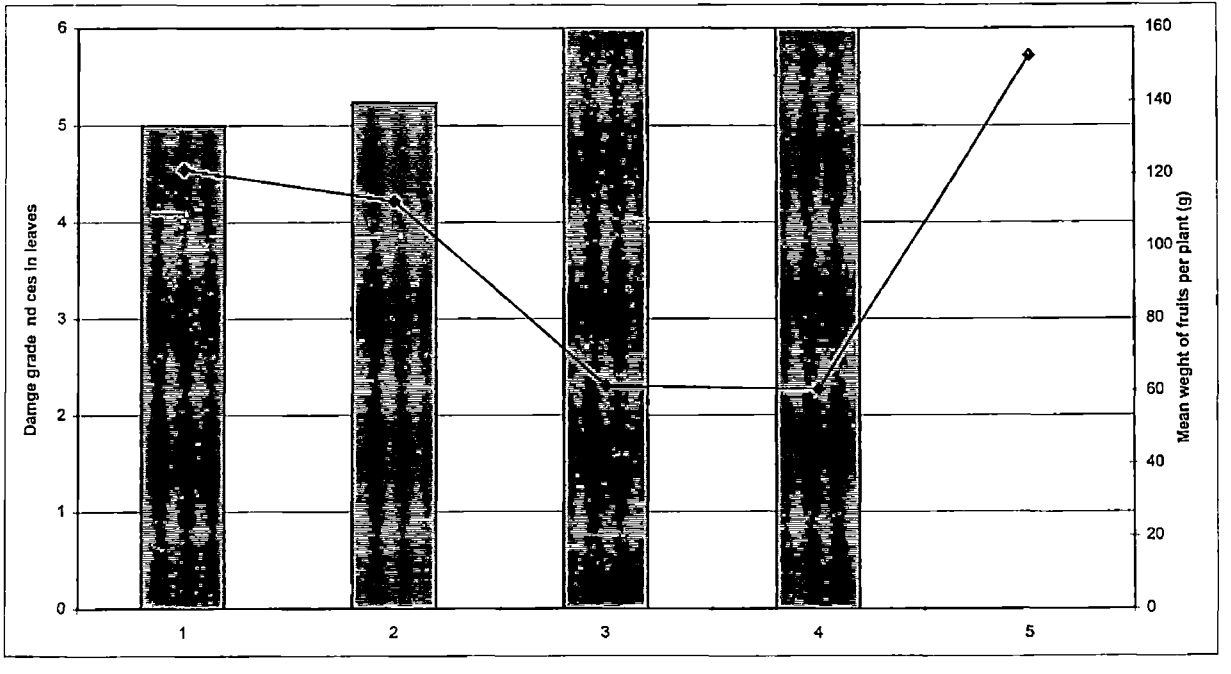
after sowing by which time the plants might have passed the critical period of photosynthesis contributing to yield

Two experiments were conducted in chilli to assess the effect of different population levels of *P latus* on the crop The mites were released three weeks after planting in the first experiment and six weeks after planting in the second In both the experiments it was found that *P latus* at the rate of 50 and 100 mites per plant caused significant reduction in yield as compared to uninfested plants The yield from plants treated with 10 mites per plant did not show any significant reduction in yield The damage grade indices on a 0 6 scale recorded from the plants also have shown almost similar trends(Table 29) It was obvious that there is crop to crop variation in the level of tolerance to mite pests While plants like bhindi could tolerate population levels of *T ludeni* as high as 30 mites per plant chilli plants could not tolerate population levels of 24 (*P latus*) mites per plant Kareem *et al* (1977) reported that chilli crop failed to yield if *P latus* infested at the flowering and fruiting stage of the crop

The studies on the intraplant distribution of *T ludeni* on bhindi indicated that there was no significant difference in the number of mites observed in the top middle and bottom strata of bhindi plants at different intervals when released on the plant at different population levels and different growth stages of the plant Studies conducted by Devi (1992) also indicated that *T cinnabarinus* did not show any preference to the top middle and bottom portions of bhindi plant

The intra plant distribution of *P latus* studied did not give consistent results When *P latus* were released on chilli plants three weeks after transplanting at different population

Fig 8 Mean damage grade indices in leaves recorded four weeks after release of different levels of *Polyphagotarsonemus latus* on chilli plants six weeks after transplanting and mean weight of fruits / plant



1 10 m tes / plant 2 24 m tes / plant 3 50 m tes / plant 4 100 m tes / plant 5 Monocrotophos sprayed at 0 05%

Damage grade nd ces

Mean we ght of fru ts/ plant

levels the mites were found distributed throughout the plant at different intervals after the release and there was no significant difference in the population levels observed in the different strata of the plant When *P latus* were released on the plants six weeks after transplanting significant difference in the population of the mites were found in the different strata of the chilli plant the top strata recording maximum population followed by the middle region It showed that in young chilli plants the mites were distributed throughout and no particular preference was shown to the various regions But in the older plants preference to the growing regions was indicated as seen from high population levels in the top strata compared to basal strata of the plant

SUMMARY

SUMMARY

A detailed survey on phytophagous mites and their predators associated with vegetables medicinal plants and ornamentals was conducted for the first time in Thiruvananthapuram District Kerala during the premonsoon monsoon and postmonsoon season of 1992 and 1993 The centres selected for the survey were the College of Agriculture Vellayani Ayurvedic Research Centre Poojappura University Centre Kariavattom Tropical Botanical Garden and Research Institute Palode and the District Agricultural Farm Peringammala

The survey revealed the presence of phytophagous and predatory mites belonging to six families each The families under the former group were Tetranychidae Tarsonemidae Tenuipalpidae Eriophyidae Galumnidae and Oribatidae and under the latter group were Phytoseiidae Ascidae Bdellidae Cheyelitidae Cunaxidae and Stigmaeidae (Table 5) Phytophagous mites belonging to the families Tetranychidae Tenuipalpidae and Tarsonemidae were the most wide spread and the dominant species of these families were commonly found in all the three groups of plants

The survey further helped to identify eighteen new host plants of the phytophagous mite species which are new reports *Tetranychus cinnabarinus* on *Adhatoda beddomei* and *Adhatoda vasica* *Tetranychus ludeni* on *Hibiscus abelmoschus* *Livinstona chinensis* *Rauvolfia serpentina* and *Oxalis corniculata* *Schizotetranychus hindustanicus* on *Azadirachta indica* *Brevipalpus phoenicis* on *A beddomei* *Clerodendrum serratum* *Gymnema sylvestre* *Strobilanthes ciliates* and *Withania somnifera* *Raoiella indica* on *Thunbergia alata* *Polyphagotarsonemus latus* on *Gmelina arborea* *Luffa acutangula*

Trichopus zeylanicus and *Vitex negundo* and oribatid mites on *Anthurium andreanum* are the new reports

The phytophagous species *T cinnabarinus T ludeni* and *T neocaledonicus* of the family Tetranychidae and *P latus* of the family Tarsonemidae were found to be the important mite pests of vegetables in the district (Table 2) On medicinal plants *T cinnabarinus T ludeni T neocaledonicus* and a few other species under the genus Tetranychidae were observed to be the most wide spread species and the tenuipalpid *B phoenicis* and the *tarsonemid P latus* were next in importance On ornamentals the important species were *T ludeni T cinnabarinus* and *T neocaledonicus* of the family Tetranychidae *B phoenicis T pacificus* and *R indica* of the family Tenuipalpidae and *P latus* of the family Tarsonemidae The *Tenuipalpus* mid a wider host range than the tarsonemids

An important observation in the survey was the widespread presence of *T pacificus* on orchids The false spider mite was observed to occur on orchids in India for the first time Another observation was the occurrence of oribatids on the candles of anthurium eventhough the mites were sparsely distributed

Among the acarine predators of phytophagous mites the species belonging to the family Phytoseiidae were found to be the most widespread and in the family Phytoseiidae species of the genus *Amblyseius* were the most ubiquitous Next to Phytoseiidae mites belonging to the family Cunaxidae were found be the major acarine predators Mites belonging to the families Stigmaeidae and Bdellidae were also found to be predatory to a lesser extent Among the insect predators *Stethorus* sp belonging to the Coleopteran family Coccinellidae was the most important (Table 5)

As part of the survey the mean percentage of mite infested leaves and the mean population counts were also assessed to understand the distribution and abundance of different species of mites on different host plants in different seasons On vegetables *T ludeni* on bhindi and vegetable cowpea *T cinnabarinus* on amaranthus and *T neocaledonicus* on pumpkin moringa and brinjal were found in higher numbers capable of causing serious damage to the crops The tarsonemid *P latus* eventhough found on chill bittergourd ridgegourd and pumpkin was the most serious on chilli (Table 6a and 6b)

B phoenicis T cinnabarinus T neocaledoni us T ludeni P latus and a few other species in the genera *Tetranychus Brevipalpus* and *Tarsonemus* were the dominant species on medicinal plants (Table 7) On ornamentals *T ludeni* among the tetranychids and *B phoenicis* among the tenuipalpids were found to be the most widespread species in the district On roses *T ludeni* and *T neocaledonicus* were found on the same plants and the former dominated numerically over the latter (Table 8)

The mean percentage of mite infested leaves and the mean population counts of phytophagous mites were the least in the monsoon season as compared to the premonsoon and post monsoon seasons in vegetables medicinal plants and ornamentals The premonsoon season was generally found to favour the population build up of phytophagous mites The tetranychids tenuipalpids and tarsonemids which constituted the major chunk of the phytophagous mite fauna are external feeders and are likely to be washed away by rain during the monsoon season After the rains the population slowly started to build up in the postmonsoon season and reached peak levels in the premonsoon season

The mean population counts of predators in different seasons showed trends similar to those of the phytophagous mites the monsoon season having the least or no predatory populations In the postmonsoon season also their numbers were negligible The phytoseiids were numerically the most dominant predators on vegetables ornamentals and medicinal plants The coccinellid predator *Stethorus* and the acarine predator cunnaxids were also found to be important to a lesser extent

Studying the nature and symptoms of damage on the crops caused by the dominant phytophagous mite species was an important aspect of the survey Accordingly the nature and symptoms of damage of *T cinnabarinus* on *Adhatoda T ludeni* and *T neocaledonicus* on *Rosa T pacificus* on *Dendrobium R indicia* on *T alata B phoenicis* on different host plants and *P latus* on chillies bittergourd ridgegourd and *T erecta* were studied and described in detail

To corroborate the data generated from the field survey conducted in the district on the distribution and abundance of phytophagous mites in different seasons replicated field trials were conducted in 1993 In vegetables bhindi chilli pumpkin snakegourd and vegetable cowpea were planted and were used as the five treatments of the trial which was conducted in the premonsoon monsoon and postmonsoon seasons The results showed that in general the infestation of mites commenced in the middle growth stages of the plants (three to four weeks after planting) after which there was an increase in the population levels for nearly two fortnights The initial and peak population levels were lower in the monsoon season as compared to the other two seasons An important observation was the complete absence of mite infestation in snakegourd in the replicated field trials as well as in the field survey

The field trials on medicinal plants and ornamentals were conducted by making use of the existing plants in the Agricultural College Farm Vellayni by taking observations from January to December in 1994 at fortnightly intervals The plant species used in the trial were *A vasica A beddomei Rosa* sp *T alata* and *Dendrobium* The population levels of *T cinnabarinus* on *A beddomei* and *A vasica T ludeni* and *R indica* on *T alata* and *T pacificus* on Dendrobium were found to be higher from February to April while those were lower from July to August Correlation studies revealed that population build up of the mites was positively correlated with maximum temperature and negatively with relative humidity

The biology and biometrics of *T cinnabarinus* on *A vasica T ludeni* and *T neocaledonicus* on *Rosa R indica* and *T pacificus* on *Dendrobium* were studied for the first time and described in detail (Tables 15 19) The developmental period of *T ludeni* was found to be shorter than *T neocaledonicus* on rose indicating a speedier population build up of the former When the biology and ov positional preference of *B phoenicis* on five host plants viz *Caladium Marantha P tuberosa Dendrobium* and *Ocimum* were compared no significant difference in the developmental periods were observed However *P tuberosa* was found to be more preferred for oviposition as the total number of eggs laid on the host was significantly higher than on others

Bhindi and chilli were two of the most important vegetables grown in the state As these two crops were susceptible to serious mite damage it was considered worth while to conduct crop loss studies by releasing different population levels of *T ludeni* and *P latus* on bhindi and chilli respectively The results indicated that the stage of the crop at which mite infestation commenced was an important factor which determined the yield loss When *T ludeni* was released at 30 mites per plant 15 days after sowing the plants did not survive There was no

significant difference in the yield when the mites at the rate of 10 20 and 30 per plant were released 45 days after sowing eventhough significant reduction in the chlorophyll content were noticed as compared to the mite free plants The crop loss studies on chillies showed that 24 mites per plant could cause significant yield loss in the crop This indicated that there is crop to crop variation in the level of tolerance to mite infestation The studies on intra plant distribution of *T ludeni* on bhindi indicated that there was no significant difference in the number of mites observed in the top middle and bottom strata of the plants When *P latus* were released on chilli plants three weeks after transplanting similar results were observed However when *P latus* was released at six weeks after transplanting the mites congregated more on the top stratum as compared to the lower strata showing a preference to the young growing tissues for feeding and oviposition

REFERENCES

REFERENCES

Ansari M A and Pawar A D 1992 Biology of spider mite *Tetranychus ludeni* (Zacher) (Acari Tetranychidae) recorded on water hyacinth *Plant Prot Bull* **44**(3) 28 31

*Aoki J A 1960 Soil mites (Oribatids) climbing tree *Proc* III *Internat Cong Acarol* Prague p 59 65

Awate B G Gandhale D N Naik L M and Patil A S 1981 Chemical control of mite *Polyphagotarsonemus latus* Banks on chilli *Capsicum annum* L *Indian J Plant Prot* **9** 193

*Baker E W 1949 The genus *Brevipalpus* (Acarina Pseudoleptidae) *The American Midland Naturalist* **42** 350 402

Balasubramanian G Chelliah S Jayaraj S Gopalan M 1988 Chemical control of the mites *Oligonychus indicus* on sorghum *Indian J Plant Prot* **16**(1) 51 52

BCKVV 1987 Report 1983 1987 All India multilocational research programme on Agricultural Acarology (Destructive mite pests and predatory mites) (ICAR) Department of Agricultural Entomology Bidhan Chandra Krishi Viswa Vidyalaya West Bengal p 44

Beevi N D and Natarajan K 1991 Control of *Tetranychus ludeni* on bhindi *South Indian Hort* **39**(4) 204 206

Bellotti A C and Byrne 1979 Host plant resistance to mite pests of cassava In *Recent advances in acarology* Vol 1 (Rodriguez ed) A ademic Press New York p 13 21

BHU 1987 Report 1984 87 All India Multilocational Research Programme on Agricultural Acarology (Destructive mite pests and predatory mites) Department of Entomology Institute of Agricultural Science Banaras Hindu University Varanasi p 6

Bhumnavar B S and Singh S P 1986 Studies on the population dynamics of oriental red mite of citrus *Eutetranychus orientalis* (Klein) *Entomon* **11**(4) 223 226

Borthakur and Das 1987 Studies on acarine predators of phytophagous mites on tea in North East India *Two Bud* **34** 1 2

Bose T K and Yadav L P 1989 *Commercial flowers* Naya Prakash Bidhan Sarani Calcutta, p 875

Boudreaux H B 1958 The effect of relative humidity on egg laying hatching and survival in various spider mites *J Insect Physiol* **2** 65 72

Brito R M Stern V M and Sances F V 1986 Physiological response of cotton plants to feeding of *Tetranychus* spider mite species (Acari Tetranychidae) *J Econ Entomol* **79** 1217 1220

Butani P G and Mittal V P 1992 Chemical control of red spider mite *Tetranychus cinnabarinus* Boisduval infesting brinjal In *Man Mites and Environment* (Haq M A and Ramani N (eds) Anjengo Publications Calicut Kerala p 1 4

*Butcher M R Penman D R and Scott R R 1987 Field predation of two spotted spider mite in a New Zealand strawberry crop *Entomophaga* **33** 173 185

Carlson E C Beard B H Tarailo R and Witt R L 1979 Testing soybeans for resistance to spider mites *Calif Agric* **33** 9 11

*Chaboussou F 1960 Nouveaux aspects de la phytiatrie et de la phytopharmacie Le phenomene de la trophobiose *Proc FAO Symp Integr Pest Control* **1** 33 61

ChannaBasavanna G P 1966 *A contribution to the knowledge of Indian eriophyid mites* (Eriophyoidea Trombidiformes Acarina) Univ Agri Sci Bangalore p 153

ChannaBasavanna G P and Puttarudriah M 1959 *Hemitarsonemus latus* Banks a potential pest of cotton in Mysore *Sci Cult* **25** 322 323

*Chant D A 1959 Phytoseiid mite (Acarina Phytoseiidae) Part I Bionomics of seven species in South Eastern England Part II A taxonomic review of the Phytoseiidae with descriptions of 38 new species *Can Ent* **91** 1 166

Charanasri V Saringkaparbul C and Kongu Chuensin M 1989 Mites injurious to orchids in Thailand In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 201 206

Clark J and Buckley R 1984 Control of two spotted mite in the National Rose garden *Australian Hort* **82**(1) 42 47

Cone W W and Wildman T E 1989 Cold hardiness of diapausing two spotted spider mite (Acari Tetranychidae) on hops in the Yakima Valley U S A In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 5 10

Cone W W Mc donough L M Maitlen J C and Burdajewicz 1971 Pheromone studies of the two spotted spider mite I Evidence of a sex pheromone II Behavioural response of males to quiescent deutonymphs *J Econ Entomol* 64 p 355 358 379 382

Cordo H A and De Loach C J 1976 Biology of water hyacinth mite in Argentina *Weed Science* 24 245 249

Croft B A Mc Rae I V 1992 Biological control of apple mites by mixed population of *Metaseiulus occidentalis* (Nesbitt) and *Typhlodromus pyri* Schelter (Acari Phytoseiidae) *Environ Entomol* 21(1) 202 209

Daniel M 1981 Bionomics of the predacious mite *Amblyseius ChannaBasavanni* (Acari Phytoseiidae) predacious on palm mite In *Contributions to Acarology in India* (ChannaBasavanna G P ed) Acarological Society of India Bangalore p 167 173

Daniel M and Premkumar T 1976 Pests of arecanut *J Plant Crops* 4(2) 68 77

Das G M 1959 Bionomics of the tea red spider *Oligonychus coffea* (Neitner) *Bull Entomol Zool* 4(4) 23 24

Deshpande R R Shaw S S Srivastav R C and Mandoli K C 1992 Relative toxicity of pesticides against red spider mite *Eutetranychus orientalis* (Klein) on citrus *Pesticides* 22(3) 45 46

Devi A 1992 *Spatial distribution and control of tetranychid mites on bhindi* Ph D thesis Indian Agricultural Research Institute New Delhi p 131

Dhooria M S 1981 Studies on the ovipositional preference host range and seasonal incidence of *Eutetranychus orientalis* (Acari Tetranychidae in Delhi *Indian J Acar* 6 77 83

Dhooria M S 1982 Natural enemy complex of citrus mite *Eutetranychus orientalis* in Delhi India *Acarology Newsletter* 11 p 6

Dhooria M S 1983 Effect of different levels of mite population on the growth of french bean *Phaseolus vulgaris Acarology Newsletter* 2 5

Dhooria M S 1984 Preliminary observations on the biology and hostrange of tarsonemid mite *Polyphagotarsonemus latus* (Acari Tarsonemidae) *Acarology Newsletter* 31 4

Dhooria M S 1995 Studies on the biology of spider mite *Schizotetranychus lechrius* a serious pest of Pinkcassia trees in Punjab *Abstr* V *National Symposium on Acarology* Sept 20 22 1995 Bangalore p 41

Dhooria M S and Bindra O S 1977 *Polyphagotarsonemus latus* Banks a mite pest of chilli and potato in Punjab *Acarology Newsletter* **4** 7 9

Dhooria M S and Butani D K 1982 Seasonal incidence of citrus mite *Eutetranychus orientalis* and its predators *Indian J Acar* 7 59 62

Dhooria M S and Cheema G S 1995 Studies on the biology of spidermite *Schizotetranychus cajani* (Acari Tetranychidae) on red gram *Cajanus cajan* Abstr V *National Symposium on Acarology* Sept 20 22 1995 Bangalore p 42

Dhooria M S and Prem Sagar 1989 Preliminary studies on the biology of carmine spider mite *Tetranychus cinnabarinus* on four species of Japanese Mint at Ludhiana India In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 39 42

*Elbadry E A Afifi A M Issa G I and Elbanhawy E M 1968 Effectiveness of the predacious mite *Amblyseius gossypii* as a predator of three tetranychid mites (Acarina Phytoseiidae) *J Appl Entomol* **62** 188 192

English L L and Turnipseed G F 1941 The influence of temperature and season on the citrus red mite (*Paratetranychus citri*) *J Agr Research* **62** 65 78

*Evans G O Sheals J G and Macfarlane D 1961 *The terrestrial Acari of the British Isles An introduction to their morphology biology and classification* British Museum London p 203 259

*Ewing H E 1914 The common red spider or spider mite *Oregon Agr Exp Sta Bull* No 121

*Field R P and Hoy M A 1986 Ev luation of genetically improved strains of *Metaseiulus occidentalis* Nesbitt (Acari Phytoseiidae) for integrated control of spider mites on roses in green house *Hilgardia* **54** 1 31

Fotedar R 1978 Records of a few phytophagous mites from Hissar Haryana *Aca ology Newsletter* 1 4

Ganga Visalakshy P N and Jayanth K P 1991 Studies on the life history and development of *Orthogalumna terebrantis* Wallwork an exotic oribatid of *Eichornia crassipes Entomon* **16**(1) 53 57

Gangwar S K 1988 Population levels of *Euteranychus orientalis* Klein and its predators on *Citrus reticulata* Blanco at higher altitudes *Indian J Ecol* **15**(2) 156 158

Ghai S and Shenhmer M 1984 A review of the world fauna of Tenuipalpidae *Oriental Ins* **18** 99 172

*Ghanmi M E L 1989 Red citrus mite *Panonychus citri* McGregor identified in Morocco *FAO Plant Prot Bull* **37**(2) 97

Ghosh B S Mandal S and Chakrabarti S 1986 Studies on the eriophyid mites (Acarina Eriophyidae) Description of three new species from West Bengal *Entomon* **11**(4) 193 196

Ghosh N K Das B and Chakrabarti S 1989 Injury by gall mites (Acari Eriophyoidea) to plants in North East India In *Progress in Acarology* (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing house New Delhi Bombay Calcutta p 135

Gibbs K E and Morrison F O 1935 The cuticle of the two spotted mite *Tetranychus telarius* (Linnaeus) *Can J Zool* **31** 633 37

*Goldsmid J M 1962 The mites (Acarina) of the Federation of Rhodesia and Nayasaland *Salesburg Rhodesia and Nayasaland* Bull 2166

Gope B and Das S C 1992 Biology and effect of pruning and skiffing on the distribution of the scarlet mite *Brevipalpus phoenicis* Geijskes on tea in North India *Two Bud* **39** 1 23

Govindan R Puttaswamy and Devaiah M C 1981 Comparative biology of red spider mites *Tetranychus ludeni* Zacher and *Tetranychus neocaledonicus* Andre (Acari Tetranychidae)on mulberry *Mysore J Agric Sci* **15** 530 534

Grewal I S 1992 Seasonal fluctuation in the populations of various mite species associated with brinjal crop in Punjab *Annals of Entomology* **10** 37 40

Gunathilagaraj K and Kumaraswami T 1978 Resistance in certain egg plant varieties (*Solanum melongena* L) to Red spider mite *Tetranychus cinnabarinus Food Farming and Agriculture* **10**(6) 219 220

Gupta S K 1976 Contribution to our knowledge of tetranychid mites (Acarina) with description of three new species from India *Oriental Ins* **10** 327 351

Gupta S K 1978 Some phytoseiids from South India with description of five new species *Oriental Ins* **13** 327 388

Gupta S K 1985 *Hand book Plant mites of India* Zoological Survey of India Calcutta p 520

Gupta S K 1989 Mites occurring on tea plants in India with a key for their identification In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 177 182

Gupta S K Dhooria, M S and Sidhu A S 1971 A note on predators of citrus mite in Punjab *Sci Cult* **37**(10) 484

Gupta S K and Gupta A 1992 Predatory plant mites of India and their importance in biological control In *Man Mites and Environment* (Haq M A and Ramani N eds) Anjengo publications Calicut Kerala p 146 153

Gupta S K Dhooria M S and Sidhu 1982 Effect of temperature on the rate of development fecundity and longevity of vegetable mite *Punjab Hort J* **22**(3&4) 200 202

Gupta V N and Gupta S K 1985 Mites associated with vegetable crops in West Bengal *Indian J Acar* **10**(2) 61 64

Hafez S M Rasmy A H and Elsawy S A 1983 Effect of prey species and stages on predatory efficiency and development of the Stigmaeid mite *Agistemus exsertus*-*Acarologia* **24** 281 283

Harbans S K and S idhu A S 1961 Sugarcane mite and its control *Ind J Sugarcane Res* 5 92 95

Hariyappa A S and Kulkarni K A 1988 Biology and feeding efficiency of the predatory mite *Amblyseius longispinosus* Evans on chilli mite *Polyphagotarsonemus latus* Banks *J Biol Control* **2** 131 132

Haq M A 1982 Feeding habits of ten species of oribatid mites (Acari Oribatei) from Malabar South India *Indian J Acarol* 6 39 50

Haq M A 1984 Role of microbes in the nutrition of a lohmannid mite In *Acarology VI* Vol 2 Ellis lHorwood Limited England P 838 846

Haq M A and Ramani N 1985 Possible role of oribatid mites in weed control *Proc Natl Sem Entomoph Ins* Calicut p 214 220

*Hirst S 1924 On some new species of red spider mites *Ann Mag Nat Hist* **14** 522 527

Huffaker C B Van de Vrie M and Mc Murtry J A 1970 Ecology of tetranychid mites and their natural enemies A review II Tetran/chid populations and their possible control by predators An evaluation *Hilgardia* **40** 391 458

Ibrahim A G and Haider E H 1989 Studies on some factors affecting the pomegranate false spider mite *Tenuipalpus punicae* (Acarina Tenuipalpidae) in Iraq In *Progress in Acarology* (ChannaBasavanna, G P and Viraktamath C D eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 67 72

ICAR 1993 *Annual Report 1991 92 All India Research Project on Agricultural Acai ology* p 92 102

Jagdish P S and Nagesh Chandra B K 1982 Biology of *Typhlodromips tetranychivorus* (Acari Phytoseiidae) on red palm mite *Raoiella indica* (Acari Tenuipalpidae) *Acarology Newsletter* **11** 9

Jalaluddin S M and Mohanasundaram M 1990 Control of the coconut red mite *Raoiella indica* Hirst (Tenuipalpidae Acari) in the nursery *Indian Coco J* **21**(6) 7 8

Jeppson L R Keifer H H and Baker E W 1975 *Mites injurious to economic plants* University of California Press California p 614

Jones V P 1990 Sampling and dispersion of two spotted spider mite (Acari Tetranychidae) and Western Orchard Predatory mite (Acari Phytosendae) on tart cherry *J Econ Entomol* **83** 1376 1380

Jose V T and Shah A H 1989 Bionomics of the spider mite *Tetranychus macfarlanei* injurious to cotton in Gujarat India In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 24 28

Kakar K L and Chander R 1995 Pest management strategies against European red mite *Panonychus ulmi* on Apple in Himachal Pradesh *Absti V National Symposium on Acarology Sept* 20 22 1995 Bang§alore p 74

Kandasamy C Mohanasundaram M and Karuppuchamy P 1987 Evaluation of insecticides for the control of yellow mite *Polyphagotarsonemus latus* Banks on chillies *Madras Agric J* **74** (8) 351 355

Kaneria V S and Bharodia R K 1991 Efficacy relative toxicity and residual persistent toxicity of different pesticides to the adults of *Tetranychus cinnabarinus* Boisduval infesting brinjal crop *Gujarat Agric Univ Res J* **17**(1) 54 59

Kareem A Thangavel P and Balasubramanian M 1977 A new mite *Hemitarsonemus latus* Banks (Tarsonemidae Acarina) as a serious pest on chilli *Capsicum annum* L *Pesticides* **11**(6) 42 43

Karuppuchamy P and Mohanasundaram M 1986 Control of chilli Murnai mite *TNAU Newsletter* **15**(10) 2

Karuppuchamy P and Mohanasundaram M 1987 New species and records of tetranychid mites (Tetranychidae Acarina) from India *Entomon* **12**(2) 89 94

Karuppuchamy P Balasubramanian G Sundarababu P C and Gopalan M 1994 A potential predator of chilli mite *Polyphagotarsonemus latus* (Banks) (Tarsonemidae Acari) *Madras Agric J* **81**(10) 552 553

Karuppuchamy P Mohanasundaram M Ganesh kumar M and Ramakrishnan M 1990 Biology varietal screening and control of spider mite *Schizotetranychus cajani* Gupta (Acari Tetranychidae) infesting red gram *Legume Res* **13**(4) 183 187

KAU 1989 *Package of Practices Recommendations* Directorate of Extension Kerala Agricultural University Trissur p 2 3

Keifer H H 1965 Eriophyid studies B 14 *Bur Ent Calif Dept Agr* p 20

Kennedy J S and Waterkeyn L 1995 Phytoh stology of injuries caused by mites and thr ps *Abstr V Nat onal Symposium on Acar ology* Sept 20 22 19)5 Bangalore p 37

Khajuria D R 1995 Development of spray schedule again t phytophagous mites of apple in lower areas of Kullu valley *Abstr V National Symposium on Acarology* Sept 20 22 1995 Bangalore p 75

Krantz G W 1978 *A manuel of Acarology* Second edition Oregon State University Book Stores Inc Corvall s p 509

Krishnamoorthy A 1983 A new record of phytoseiid mite from Karnataka *Acarology Newsletter* **13** (2) 1

Krishnamoorthy A and Mani M 1989 Effect of releases of *Phytoseiulus persimilis* in the control of Two spotted spidermite on french beans *J Biol Control* **3**(1) 33 36

Krishnaiah K and Tandon P L 1975 Chemical control of *Tetranychus neocaledonicus* Andre infesting okra and brinjal *Curr Res* **4** 87 89

Kulkarni G S 1992 The Murda disease of chilli (capsicum) *Trop Agr Peredenya* **58** 237

Kumar R and Bhalla O P 1995 An epidemic outbreak of *Panonychus ulmi* (Koch) (Acari Tetranychidae) in apple orchards of Himachal Pradesh India *Curr Sci* **64** (10) 709

Kumari M and Sadana G L 1991 Influen e of temperature and relative humidity in the development of *A alstoniae* (Acari Phytosei dae) *Expe Appl Acarol* **11** (2&3) 199 203

Laing J E 1968 Life history and life table of *Phytoseiulus persimilis* Athias Henriot *Acarologia* **10** 578 588

Lal L and Mukharji S P 1977 A contribution to knowledge of phytophagous mites infesting medicinal plants *Sci Cult* **43**(7) 313 316

Lal L and Mukharji S P 1979 Seasonal history of three phytophagous mites at Varanasi Uttar Pradesh *Indian J Acar* **4** (2) 61 67

Lal L and Mukharji S P 1982 Relative toxicity of some insecticides against *Eutetranychus orientalis* in relation to two host plants *Acarology Newsletter* **11** 3 4

Lal S S and Pillai K S 1978 A new record of tetranychid spider mite *Tetranychus neocaledonicus* on cassava *J Root Crops* 4(1) 43 44

Lal S S and Pillai K S 1981 Pests attacking cassava *Manihot esculenta* Crantz in Southern India *Tropical Pest Management* **27**(4) 480 491

Luthy B Martinoia E Matile P and Thomas H 1984 Thylakoid associated chlorophyll oxidase distinction of lipoxygenase *Z Pflanzenphysiol* **113** 423 434

Magie R O and Poe S L (1972) *The world of Gladiolus* NAGC USA p 155 81

Mahadevan A and Sridhar R 1982 *Methods in physiological plant pathology* 2nd Ed Sivakami publications Madras p 316

Maitra N and Sen S P 1988 Photosynthetic activity of leaves and non leaf green organs of plants belonging to different families *Ind J Physiol* **31**(2) 127 133

Majumdar M Z R and Bhuiya A D 1995 Radiation disinfection of *Oligonychus biharensis* infesting rose Meeting quarantine requirements *Abstr V National Symposium on Acarology* Sept 20 22 1995 Bangalore p 77

Mallik B 1974 *Biology of Amblyseius longispinosus (Evans) (Acarina Phytoseiidae) and Tetranychus ludeni Zacher (Acarina Tetranychidae) and interaction between them* M Sc (Ag) Thesis University of Agricultural Sciences Bangalore p 72

Mallik B 1981 *Interaction studies of Tetranychus ludeni Zacher (Acari Tetranychidae with two predacious phytoseiids and development of a model* Ph D thesis Univ Agril Sciences Bangalore

Mallik B and ChannaBasavanna G P 1983 Life history and life tables of *Tetranychus ludeni* and its predator *Amblyseius longispinosus* (Acari phytoseiidae) *Indian J Acar* **8** 1 12

Mallik B Krishnaswamy H S and ChannaBasavanna G P 1989 Mathematical models for the interaction between *Tetranychus ludeni* and its phytoseiid predators In *Progress in Acarology* Vol 2 (ChannaBasavanna, G P and Vinaktamath C A eds) Oxford and IBH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 345 355

Manjunatha M and Puttaswamy 1990 Estimation of crop losses due to the spider mite *Oligonychus indicus* Hirst in sorghum *Indian J Plant Prot* **18**(2) 245 249

Manjunatha M Puttaswamy Basarkar P W and Lingappa S 1992 Incidence of *Oligonychus indicus* Hirst (Acari Tetranychidae) on Sorghum genotypes and role of biochemical constituents in host plant resistance In *Man Mites and Environment* (Haq M A and Ramani N (eds) Anjengo Publications Calicut Kerala p 5 14

Mathur S Putatunda B N and Mathur R B 1995 Mites associated with some fruit trees in Hisar Haryana *Abstr V National Symposium on Acarology* Sept 20 22 1995 Bangalore p 13

Mc Clanaham R J 1968 Influence of temperature on the reproductive potential of two mite predators of the two spotted mite *Can Ent* **100** 549 556

Mc Enroe W D 1961a The control of water loss by two spotted spider mite (*Tetranychus telarius* (L) *An* ı Entomol Soc Am **54** 883 87

Mc Enroe W D 1961b Guanine excretion by the two spotted spider mite *Tetranychus telarius* (L) *Ann Entomol Soc Am* **54** 925 96

Mc Murtry J A 1982 The use of phytoseiid for biological control Progress and future prospects In *Proc Conf Recent Advances in Knowledge of the Phytoseiidae* (Hoy M A ed) San Diego p 23 29

Mc Murtry J A 1989 Utilizing natural enemies to control pest mites on citrus and avocado in California U S A In *Progress in Acarology Vol 2* (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH Publishing Co Pvt Ltd New Delhi Bombay Calicut p 325 337

Mc Murtry J A Badii M H and Johnson H G 1984 The broad mite *Polyphago_tarsonemus latus* as a potential prey for phytoseiid mites in California *Entomophaga* **29**(1) 83 86

Mc Murtry J A Huffaker C B and Van de Vrie M 1970 Ecology of Tetranychid mites and their natural enemies a review I tetranychid enemies their biological characters and impact of spray practices *Hilgardia* **40** 331 390

*Michael A D 1884 Oribatidae In *Tierreich* Berlin **3** 1 93

Mis ra K K and Somchoudhury A K 1989 Seasonal incidence of *Tetranyhus cinnabarinus* Boisd (Acari Tetranychidae) on some selected accessions of brinjal and their susceptability in West Bengal conditions *Orissa J Agric Res* **2**(1) 50 54

Mohan M J and Krishnaiah K 1979 Chemical control of *Tetranychus neocaledonicus* infesting okra *Abstr I All India Symposium on Acarology* April 23 25 1979 Bangalore p 57

Mohanasundaram M 1982 Two new species oi *Brevipalpus* (Tenuipalpidae Acarina) from Tamil Nadu *Entomon* **1**(4) 427 429

Mohanasundarm M 1983 A new species of *Terminalichus* Anwarullah and Khan from South India (Tenuipalpidae Acari) *Entomon* **8**(3) 221 223

Mohanasundaram M 1989 Four new species of Eriophyoidea (Acari from Tamil Nadu *Entomon* 14(3&4) 261 267

Mohanasundaram M 1991 Further studies on the Eriophyid fauna (Eriophyoidea Acari) of Tamil Nadu *Entomon* 16(3) 187 192

Mohanasundaram M and Karuppuchamy P 1987 Final Report *All India Multilocational Research Programme on Agricultural Acarology (ICAR)* Tamil Nadu Agricultural University Coimbatore p 77

Mohanasundaram M and Karuppuchamy P 1989 A review of the mites attacking coconut and new records of mites on coconut in Tamil Nadu *Indian Cocon J* **20**(5) 9 13

Mondal S Chakrabarti S 1982 Studies on the erophid mites (Acarina Eriophyoidea) of India Description of three new species from West Bengal *Entomon* 7(3) 361 366

Mote U N 1976 Seasonal fluctuation in population and chemical control of chilli mite *Polyphagotarsonemus latus* Banks *Veg Sci* 3(1) 54 60

Mothes U T and Seitz K A 1982 Fine structural alterations of bean plant leaves by feeding injury of *Tetranychus urticae* Koch (Acari Tetranychidae) *Acarologia* **23** 149 157

Moutia L A 1958 Contribution to the study of some phytophagous Acarina and their predators in Mauritius *Bull Entomol Res* **49** 59 75

Munger F 1963 Factors affecting of growth and multiplication of the citrus red mite *Panonychus citri Ann Entomol Soc Am* **56** 867 874

Muraleedharan N Radhakrishnan B and Devadas V 1988 Vertical distribution of three species of Eriophyid mites on tea in South India *Exp Appl Acarol* 4 359 364

Muraleedharan M Selvasundaram R and Radhakrishnan B 1988 Natural enemies of certain tea pests occuring in southern India *Insect Science and its Application* 9(5) 647 654

Nageshchandra, B K and ChannaBasavanna, G P 1976 Host plants of *Brevipalpus phoenicis* Geijskes (Acarina Tenuipalpidae) in India *Acarology Newsletter* **2** 3

Nair V V Beevi S N Visalakshi A 1990 On the control of *T neocaledonicus* on rose *South Indian Hort* **38** 3

Nandagopal V and Gedia, M V 1995 Biology of the red spider mite *Tetranychus cinnabarinus* (Boisd) a pest of groundnut *Entomon* **20**(1) 41 45

Neena Goyal and Sadana G L 1995 Seasonal fluctuations in population of *Brevipalpus phoenicis* (Acarina Tenuipalpidae) on Kaghzi Nimbu *Citrus aurantifolia Abstr V National Symposium on Acarology* Sept 20 22 1995 Bangalore p 27

Nene Y L 1972 A survey of viral disease of pulse crops in Uttar Pradesh *Experimental station Bulletin No 4* G B Pant University of Agricultural and Technology Pantnagar p 191

Palanisamy S and Chelhah S 1987 Assessment of yield loss in egg plant *Solanum melongena* L caused by carmine spider mite *Tetranychus cinnabarinus* Boisduval *Abstr I National Seminar on Acarology* Oct 29 31 1987 BCKVV Kalyani p 27

Pareek B L and Sharma A 1982 Efficacy of some newer pesticides in the control of vegetable mite *Tetranychus neocaledonicus* infesting okra *Acarology News letter* June 4 5

Patel B R Jagdale G B Ajri D S 1987 Seasonal incidence of insect pests and mites infesting betelvine *Curr res reptr* 3(1) 114 115

Patil N G and Dethi M D 1979 Chemical control of Chilli thrips and mites *Pestology* 3(1) 30 31

Paul V I and Ramani N 1991 Acarine fauna associated with plantation crops of Kerala *Proc Kerala Science Congress* Feb March 1991 Kozhikode p 130 131

Perring T M Farrar C A and Royalty R N 198 Intra plant distribution and sampling of spider mites (Acari Tetranychus)on Cantaloupe *J Econ Entomol* **80**(1) 96 101

Pickett C H and Gilstrap F E 1986 Predation of *Oligonychus pratensis* (Acari Tetranychidae) by *Phytoseiulus persimilis* and *Amblyseius californicus* (Acari Phytoseiidae) under controlled laboratory conditions *Entomophaga* **31** 205 21

Pillai S V and Jolly M S 1986 Studies on the population build up and control measures of the red spider mite *Tetranychus equatorius* (MC Gr) *Indian J Seri* **25**(1) 15 20

Pillai K S and Palaniswamy M S 1982 Assessment of loss in yield due to spider mite damage on cassava *Proc International Workshop on control of mealy bugs and green spider mites* National Root Crops Research Institute Umudika Nigeria p 23 32

Pillai K S and Palniswamy M S 1985 *Spider mit s of cassava Technical Bulletin* I Central Tuber Crops Research Institute Sreekariyam Trivandrum p 2

Post 1962 Effect of cultural measures on the population density of the fruit tree red spider mite *Metatetranychus ulmi* Koch (Acari Tetranychidae) *Diss Rijksuniv* Leiden p 110

Prabhuswamy H P and Srinivasa N 1992 Studies on the pigeonpea sterility mosaic disease mite vector *Aceria cajani* ChannaBasavanna (Acari Eriophyidae) In *Man Mites and Environment* (Haq M A and Ramani N eds) Anjengo Publications Calicut Kerala p 33 37

Pushpangadan P 1995 Prospects of Horticulture in Kerala with special reference to ornamental medicinal and aromatic plants In *Science and Technology for Development* State Committee on Science Technology and Environment p 240 253

Putman W L and Herne D C 1958 Natural control of phytophagous mites in Ontario peach orchards *Proc Int Congr Entomol* 10th Montreal p 667 673

Puttarudriah M and ChannaBasavanna G P 1953 Some new insect and mite pests of Areca palm in Mysore *Mon Bull Indian Areacanut Comm* 4 71 74

Puttaswamy and ChannaBasavanna G P 1979a Effect of temperature and relative humidity on the development and oviposition of *Tetranychus li deni Indian J Acar* 4(1) 31 40

Puttaswamy and ChannaBasavanna G P 1979b Life history of *Tetranychus ludeni* (Acari Tetranychidae) under field conditions *Indian J Acar* 4(2) 41 48

Puttaswamy and ChannaBasavanna G P 1979c Competition between *Tetranychus neocaledonicus* and *Tetranychus ludeni* (Acari Tetranychidae) *Indian J Acar* 4(2) 49 54

Puttaswamy and ChannaBasavanna G P 1980a Influence of weather factors and predators on the population of the spider mite *T ludeni* (Acarina Tetranychidae) *Indian J Acar* **5** 69 79

Puttaswamy and ChannaBasavanna G P 1980b Influence of host plants on the development fecundity and longevity of *Tetranychus ludeni* Zacher (Acari Tetranychidae) *Indian J Acar* **5** 80 84

Puttaswamy and ChannaBasavanna G P 1981 Influence of host plants on the reproductive biology of *Tetranychus neocaledonicus* (Acari Tetranychdidae) *Indian J Acar* **6** 72 76

Rai S N Singh R K and Singh D J 1995 Biology of *Eutetranychus orientalis* on *Bauhinia variegata* and *Rauvolfia serpentina Abstr V National Symposium on Acarology* September 20 22 1995 Bangalore p 41

Rajagopalan K 1974 First record of spider mites *Tetranychus ludeni* Zacher transmitting *Dolichos Enation Mosaic Virus Curr Sci* **43**(15) 488 489

Ramani N and Haq M A 1987 Biology of Scheloribates decarinatus Aoki 1984 (Acari Oribatei) inhabiting *Chromolanea odorata J Soil Biol Ecol* 7 (1) 27 35

Ramani and Haq M A 1988 Incidence and relative abundance of the mango mite *Cisaberoptes Kenyae* (Acari Eriophyidae) In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A) Oxford and IBH publishing Co Pvt Ltd Delhi Bombay Calcutta p 115 119

Ramani N and Haq M A 1990 Oribatid mites from coconut palm I A new species of *Uracrobates* (Acari Oribatei) from Kerala India *Acarologia* **31**(3) 297 302

Rao S S Rao S N Azam K M 1990 Occurrence of *Tetranychus urticae* Koch on green gram (*Vigna radiata*) *Indian J Ent* **52**(1) 158 159

Rather A Q 1989 Studies on mites (Acari) associated with Stone fruits in subtropical temperate and cold arid zones of Jammu and Kashmir In *Progress in Acrology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd Delhi Bombay Calcutta p 184 185

Ravi K C Puttaswamy Joshi S S and Mallik 1995 Effect of feeding by mites on histology and histochemistry of Cassia chilli and jasmine leaves *Abstr V National Symposium on Acarology* Sept 20 22 1995 Bangalore p 38

Ravi K C Puttaswamy Joshi S S and Mallik 1995 a Reaction of some groundnut genotypes to *T urticae Abstr V National Symposium on Acarology* Sept 20 22 Bangalore p 38

Reddy D N R N and Jagdish A 1977 *Scolothrips indicus* (Thysanoptera Thripidae) predating on mites in Bangalore Karnataka *Acarology Newsletter* **5** 7

Reddy M V and Nene Y L 1981 Estimation of yield losses in pigeon pea due to sterility mosaic In *Proc International workshop on pigeon pea* Vol 2 ICRISAT Centre Patencheru Andhra Pradesh p 305 312

Reddy M V Beniwal S P S Sheila V K Sithananthan and Nene Y L 1989 Role of eriophyid mite *Aceria cajani* (Acari Eriophyidae) in transmission and spread of sterility mosaic of pigeonpea In *Progress in Acarology* Vol 2 (ChannaBasavann G P and Viraktamath C A eds) Oxford and IBH publishing Co Pvt Ltd Delhi Bombay Calcutta p 121 127

Rockett C L 1980 Nematode predation by oribatid mites (Acari Oribatida) *Internat J Acarol* **6** (3) 219 224

Sadana G L and Chabra, S C 1974 New records of the host and predators of the phytophagous mite *Oligonychus mangiferus* (Rahman and Sapra) *Sci Cult* **40** 362 363

Sadana G L 1972 Studies on the host range of the citrus mite *Eutetranychus orientalis* (Klein) *Sci Cult* **38**(12) p 528 530

Sadana, G L and Balpreet 1995 New species new records of brevipalpid mites and their hosts from Northern India *Entomon* **20**(1) 75 79

Sadana G L and Gupta B K 1983 Phytophagous mite fauna of Assam together with new records and new species *Entomon* **8**(1) 1 6

Sadana G L and Kanta V 1971 Predators of citrus mite *Eutetranychus orientalis* (Klein) in India *Sci Cult* **37** 530

Sadana, G L and Kumari M 1987 Seasonal history of *Brevipalpus phoenicis* Geijskes (Acari Tenuipalpidae) on *Psidium guajava* c v seedless guava *Abstr I National Seminar on Acarology* West Bengal p 19

Sadana G L and Kumari M 1991 Effect of temperature and relative humidity on the development of *Brevipalpus phoenicis* Geijskes (Acari Tenuipalpidae) *J Insect Sci* **4**(2) 157 159

Sanap M M and lNawale R N 1986 Relative efficacy of modern synthetic pesticides for the control of mites *(Hemitarsonemus latus)* on chilli *(Capsicum annum L) Pesticides* **20** (1) 31

Sandhu G S Dhooria M S Ajith Singh C 1974 Chemical control of tarsonemid mite *Hemitarsonemus latus* Banks (Acarina Tarsonemidae) infesting brinjal in Punjab *Sci Cult* **40**(6) 258 260

Sances F V Wyman J A and Ting I P 1979 Morphological response of strawberry leaves to infestation of two spotted spider mite *J Econ Entomol* **72** 710 713

Saradamma K 1972 Evaluation of the toxicity of some pesticides to the red mite on coconut *Raoiella indica* Hirst (Phytoptipalpidae) Agrl Res J Kerala 10 61 62

Saradamma K and Nair M R G K 1976 Phytophagous mites recorded in Kerala *Acarology Newsletter* **2** 6

Sarma, N K and Sadana G L 1987 Effect of predator prey density on the prey consumption and daily rate of egg production of the predatory mite *Amblyseius finlandicus* (Oudemans) (Acarina Phytoseiidae) *Entomon* **12**(3) 191 195

Sathiamma, B 1981 Mite fauna associated with coconut palm in Kerala In *Contributions to acarology in India* (ChannaBasavanna G P ed) Acarological society of India Bangalore p 11 14

Sathiamma B 1985 Record of *Dolichotetranychus vandergooti* Oudemans (Acarina Tenuipalpidae) a perianth mite on coconut *J Plant Crops* **14** 71 73

Sathiamma B 1986 *Oligonychus iselemae* (Hirst) and observations on a red spider mite *Tetranychus sp* on coconut foliage *J Plant Crops* **14** 71 73

Sathiamma B 1988 Record of red spider mite *Tetranychus ludeni* Zacher (Acarina Tetranychidae) on coconut palm *Entomon* **13**(1) 191 192

Sathiamma B 1991 Investigations on *Oligorychus iselemae* (Hirst) (Acarina) and other tetranychid mites on coconut foliage Ph D thesis University of Kerala p 206

Senapati S K and Biswas 1990 Efficacy of some pesticides against *Raoilla indica* Hirst (Tenuipalpidae) on arecanut seedlings in Terai region of West Bengal *Environ Ecol* 8(2) 763 765

Schulz J T 1963 *Tetranychus telarius* L new vector of virus Y *Pl Disease Reptr* 47 584 596

Seth M L 1962 Transmission of pigeon pea sterility by an eriophyid mite *Indian phytopath* 15 225 227

Shah A H and Jose V T 1989 The bionomics of *Amblyseius alstoniae* Gupta the predatory mite of cotton spider mite *Gujarat Agric Univ Res J* 14 2 53 57

Sharma A and Naqvi A R 1992 Seasonal incidence and varietal susceptibility of *Eutetranychus orientalis* (Klein) infesting ber In *Man Mites and Envn onemnt* (Haq M A and Ramani N eds) Anjengo Publications Calicut Kerala p 142 145

Sheela K and Haq M A 1992 Gall forming eriophyid mites of some economically important plants of Northern Kerala In *Man Mites and Environment* (Haq M A and Ramani N eds) Anjengo publications Calicut Kerala p 96 100

Siddappaji C and Reddy D N R 1972 Some new insect and mite pests of cardamom and their control *Abstr III Int Symp Trop Hort Crops* p 74

Singh J and Ray R 1977 *Stethorus* sp (*Coleoptera* Coccinelhdae) a predator of *Tetranychus neocaledonicus* Andre on okra at Varanasi *Acarology Newsletter* 4 5 6

Singh P Somchoudhury A K and Mukherjee A B 1989 The influence of natural enemy complex in the population of *Aceria litchi* (Acari Eriophyidae) In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktmath C A eds) Oxford and IBH publishing Co Pvt Ltd Delhi Bombay Calcutta p 361 367

Singh R K Mukherjee I N and Singh R N 1989 Records of mites associated with water hyacinth (*Eichornia crassipes* in Uttar Paradesh India In *Progress in Acarology* Vol 2 (ChannaBasavanna G P and Viraktamath C A eds) Oxford and IBH publishing Co Ltd New Delhi Bombay Calcutta p 215 221

Sites R W and Cone W W 1985 Vertical dispersion of two spotted spider mites on hops throughout the growing season *J Entomol Soc Brit* Columbia **82** p 22 25

Sitl ananthan S Muthuswamy S Dura R 1975 Direct effects of infestation by the Eriophyid mite *Aceria sacchari* on composition of sugarcane leaf sheath *Sci Cult* **41**(7) 327 328

Sivakumar M and Marimuthu T 1987 Control of red spider mite *Tetranychus cinnabarinus* Boisd on betel vine *Entomon* **12**(4) 315 319

Slykhuis J T 1980 Mites In *Vectors of plant Pathogens* (Harris K F and Maramorosch K eds) Academic Press New York.p 325 326

Sobha T R and Haq M A 1995 Biology of *Raoiella mcfarlanei* (Acari Tenuipalpidae) *Abstr V National* Symposium on Acarology Sept 20 22 1995 Bangalore p 43

Somachoudhury A K and Sarkar P K 1989 Observations on natural enemies found in association with coconut mite *Raoiella indica* Hirst *Bull Ent* **28**(2) 104 107

Sontakke B K Singh D N and Misra B 1989 Seasonal abundance of potato pests in relation to environmental factors *Environ Ecol* **7**(2) 391 394

Sriramachandramurthy 1984 Chilli cultivation in Andhra Pradesh *Indian cocoa Arecanut and Spices Journal* Chilli special issue **1**(4) 103 105

Sumangala K and Haq M A 1991 Tetranychid mites as natural enemies of water hyacinth in Kerala *Proc Kerala Science Congress* February March Kozhikode p 25 26

Sumangala, K and Haq M A 1995 Chlorophyll depletion in *Eichornia crassipes* due to feeding and colonisation by *Eutetranchus orientalis Abstr V National Symposium on Acarology* Anjengo Sept 1995 Bangalore p 5

Sundararaj J S Seeri anthaini B and Varadan K M 1967 A mullai (*Jasminum auriculatum*) selection highly resistant to gall mite *Madras Agri J* **54** 599 601

Tanigoshi L K and Davis 1978 An ultrastructural study of Tetranychus mcdanieh feeding injury to the lleaves of red delicious apple *Indian J Acarol*.**4** 47 51

Tomczyk Kropczynska D Vande Vrie M and Kielkiewicz M 1989 Stimulative effects of spider mite *Tetranychus urticae* feeding on three host plants In *Progress in Acarology* Vol 2 Oxford and BH publishing Co Pvt Ltd New Delhi Bombay Calcutta p 15 21

Trivedi T P 1987 Incidence of mite *Polyphagotarsonemus latus* on potato crop in Karnataka *Abstr I National Seminar on Acarology* Oct 29 31 1987 West Bengal p 12

Tseng Y H 1982 Mites of the family Stigmaeidae of Taiwan with key to genera of the world (Acarina Prostigmata) *NTU Phytopathologist and Entomologist* 9 1 52

Van de Vrie M 1985 Greenhouse ornamentals In *Spider mites Their biology natural enemies and control* (Helle W Sabelis M eds) Vol 1B Elsevier Amsterdam p 273 283

*Van De Vrie M 1970 The influence of predaceous mite *Typhlodromus (A) potentillae* (Garman) on the development of *Panonychus ulmi* (Koch on apple grown under various nitrogen conditions *Entomophaga* 15 291 304

Van De Vrie M McMurtry J A and Huffaker C B 1972 Ecology of tetranychid mites and their natural enemies A review III Biology ecology and pest status and host plant relations of tetranychids *Hilgardia* 41 343 432

Vijayaraghavan S Subba Rao P V Tamil Selvi M Sundaralabu P C and Mohanasundaram M 1992 *Mites of economic importance* Department of Agricultural Entomology Centre for plant protection studies Tamil Nadu Agricultural University Coimbatore p 23

Vishnupriya R Mohan R and Mohanasundaram M 1992 Incidence of sugarcane mite *Oligonychus sacchari* Baker and Pritchard on certain sugarcane clones In *Man Mites and Environment* (Haq M A and Ramani N (eds) Anjengo Publications Calicut Kerala 27 31

Wilson L T Trichilo P J and Gonzalez D 1991 Spider mite (Acari Tetranychidae) Infestations rate and initiation Effect on cotton yield *J Econ Entomol* 84(2) 593 600

Wrensch D L 1979 Components of reproductive success in spider mites In *Recent Advances in Acarology* Vol 1 (Rodriguez J G ed) Proc of the V International Congress of Acarology August 6 12 1978 Michigan Academic Press New York p 155 164

Wyman J A Ortman E R and Van Steenwyk R A 1979 Integrated pest management on vegetable crops in Southern California *California Agriculture* 32 27 28

*XIA Y L 1989 Comparative studies on ecology of two species of predacious phytoseiid mites and their prey citrus red mite In *Studies on the Integrated Management of citrus pests* Guangzhov China Academic Book and Periodical Press 27 38

* Originals not seen

APPENDICES

Appendix I

Species of plants surveyed for the presence of mites in Thiruvananthapuram District, Kerala

Vegetables

Abelmoschus esculentus (L) Moench

Amaranthus bicolor L

Amaranthus dubious Mart ex Thell

Amaranthus tricolor L

Capsicum annum L

Ccucurbita pepo L

Luffa acutangula Roxb

Lycopersicon esculentum Mill

Momordica charantia L

Moringa oleifera Lam

Solanum melongena L

Trichosanthes anguina L

Vigna unguiculata sub sp sesquipedalis (L) Verdcourt

Medicinal Plants

Abrus precatorius L

Acalypha hispida Burm F

Adenocalymma nitidum Mart ex DC

Adhatoda beddomei Clarke

Adhatoda vasica Nees

Aegle marmelos (L) Corr

Aerva lanata (L) Juss

Alangium salvifolium (L f) Wang

Aloe barbadensis Mill

Alpinia calcarata Roxb

Alpinia galanga (L) Sw

Alstonia acuminata Miq

Ammi visnaga Lam

Anamirta cocculus (L) Wight & Arn

Andisia umbellata Baker

Andrographis paniculata (Burm f) Wall ex Nees

Antidesma acuminatum Wall

Ardisia littoralis Baker

Aristolochia indica Linn

Artemesia vulgaris Clarke

Asparagus racemosus Willd

Asterocantha longifolia Nees

Azadirachta indica A Juss

Bacopa monnieri Linn

Baliospermum montanum (Willd) Muell

Boerhavia diffusa L

Butea frondosa (Lam) Kurz

Calotropis gigantea Linn

Calycopteris floribunda (Roxb) Lamk

Caryopteris incana Miq

Celastrus paniculata Willd

Centella asiatica (L)

Cinnamomum zeylanicum Blume

Cipadessa sp

Cissus quadrangularis Linn

Citrus aurantifolia (Christm)

Commiphora mukul (Hook ex Stox) Engle

Coscenium fenestratum Garton

Clerodendrum serratum L

Clitoria ternatea L

Cordiospermum halicacabum Linn

Costus speciosus (Koen ex Retz)

Croton tiglium Linn

Cyclea (peltata) *burmanni* Hook f Thomas

Datura stramonium L

Desmodium gangeticum (L) DC

Ecbolium linneanum Kurz

Heretia acuminata R Br

Elaeocarpus serratus Linn

Elephantopus scober L

Eclipta alba (Husk)

Emelia sonchifolia D C

Ficus gibbosa Blume

Ficus tuberculata glomerata Rox

Fluggea leucopyrus (Koen) Willd

Gmelina arborea L

Gossypium herbaceum L

Gymnema sylvestre (Retz) Schult

Helicteres isora L

Hemidesmus indicus (L) Schult

Hibiscus abelmoschus L

Holoptelia integrifolia (Rox)

Hydrocarpus wightiana Blume

Hygrophila auriculata (Schum) Heine

Indigofera tinctoria L

Justicia gendarussa L f

Kaempferia galanga L

Lannea coromandelica (Houtt) Merr

Lea sambucina (Willd)

Leucas aspera (Willd) Spreng

Lythrum fruticosum L

Maesa indica Wall

Millingtonia hortensis L f

Myxopyrum serratum A W Hill

Ocimum sanctum (L)

Orthosiphon spiralis (Lour) Merrill

Oxalis corniculata L

Pavetta indica L

Persea micrantha Mill

Phyllanthus fraternus Webster

Piper longum L

Plumbago capensis Lamk

Plumbago rosea Linn

Plumbago zeylanica L

Polyscias fruticosa Harms

Pongamia pinnata (L) Pierre

Premna serratifolia Roxb

Pseudarthira viscida (L) Wight & An

Psophocarpus tetragonolobus (L) DC

Punica granatum L

Randia spinosa Poir

Rauvolfia serpentina (L) Benth ex Kurz

Rubia cordifolia L

Santalum album L

Saraca indica auct non L

Sida cordifolia L

Smilax glabra Roxb

Solacea reticulata f

Solanum xanthocarpum Vendal

Spilanthes oleracea Murr

Strobilanthes cilates Nees

Strychnos colubriana L

Symplocos laurina (Retz) Wall

Talinum portulacifolium (Forsk) Ascher and Schweinf

Terminalia chebula Retz

Thevitia neriifolia Juss

Thottea siliquosa (Lamk)

Tilophora indica (Mer)

Trichopus zeylanicus Gaertn

Vitex trifolia L

Vitex negundo Linn

Withania somnifera (L) Durnal

Woodfordia fruticosa Salisb

Ziziphus jujuba (L) Lam

Ornamental Plants

Alocasia sp

Anthurium andreanum (Lind) Schott

Arachnis sp

Aranda sp

Bauhinia acuminata L

Begonia spp

Bougainvillea buttiana Holttum and Standley

Caladium spp

Canna spp

Cassia spp

Chrysanthemum spp

Codiaeum variegatum (L) Blume

Coix lacryma Jobi L *Coleus* spp

Cosmos sp

Crossandra sp

Dendrobium sp

Dieffenbachia sp

Dracena sp

Gardenia jasminoides Ellis

Gerbera sp

Gladiolus sp

Gomphrena globosa L

Hibiscus rosa sinensis L

Hydrangea paniculata var grandiflora Sieb

Ixora sp

Jasminum grandiflorum L

Jasminum sambac (L) Ait

Kopsia fruticosa A DC

Livinstona chinensis R Br ex Mart

Maranta sp

Mussaenda erythrophylla Schum and Thonn

Pentas sp

Polyanthes tuberosa Linn

Pongamia pinnata Linn

Sansevieria hyacinthoides (L) Druce

Thunbergia alata Boj ex Sims

Vanda sp

Appendix II

Weather parameters during 1993

Month	Maximum temperature (øC)	Minimum temperature (øC)	Humidity (%)	Rainfall (mm)
January I	30 39	19 91	75 87	0
January II	30 36	21 16	78 56	0
February I	31 09	19 96	73 13	0
February II	31 39	22 89	8 31	0 10
March I	32 50	22 21	75 36	0
March II	32 29	24 12	75 97	2 26
April I	32 12	24 42	81 37	1 38
April II	32 93	24 93	83 00	1 26
May I	35 29	25 87	84 82	1 18
May II	30 17	24 20	82 19	10 62
June I	29 58	23 68	85 73	17 95
June II	30 29	24 57	86 03	8 13
July I	28 95	22 89	88 13	10 97
July II	28 53	23 05	86 94	3 72
August I	29 61	23 76	83 63	0 07
August II	29 07	23 62	82 34	1 37
September I	30 49	23 50	81 27	0
September II	30 49	23 77	80 67	5 25
October I	29 34	23 31	84 40	12 07
October II	30 32	23 38	83 22	8 19
November I	29 34	23 18	88 80	25 24
December I	30 31	23 32	84 60	6 87
December II	30 05	22 77	83 84	1 51

I First fortnight II Second fortnight

Weather parameters during 1994

Month	Maximum temperature (øC)	Minimum temperature (øC)	Humidity (%)	Rainfall (mm)
January I	30 78	22 85	85 10	0
January II	31 08	22 10	81 13	0 31
February I	30 93	23 09	81 13	2 35
February II	31 00	23 25	77 35	0
March I	31 68	21 00	74 63	0
March II	30 31	24 19	85 28	1 13
April I	31 30	23 15	86 33	6 16
April II	32 29	25 04	77 43	5 09
May I	31 70	26 25	81 57	0
May II	31 33	24 62	85 43	16 51
June I	29 55	23 42	89 00	12 77
June II	30 47	24 35	81 43	2 35
July I	29 77	23 72	84 56	3 92
July II	29 45	23 22	82 97	11 29
August I	27 97	23 41	87 80	11 39
August II	29 75	23 78	81 03	1 55
September I	29 74	25 94	86 97	4 43
September II	30 63	23 85	84 70	0 16
October I	29 39	22 61	87 00	12 24
October II	31 90	23 49	81 90	11 40
November I	30 00	23 26	81 56	6 93
December I	30 71	21 69	83 93	0 60
December II	31 69	22 69	78 97	0

I First fortnight II Second fortnight

ABSTRACT

A detailed survey on phytophagous mites and their predators associated with vegetables medicinal plants and ornamentals was conducted for the first time in Thiruvananthapuram District Kerala during the premonsoon monsoon and postmonsoon seasons of 1992 and 1993 The centres selected for the survey were the College of Agriculture Vellayani Ayurvedic Research Centre Poojappura University Centre Kariavattom Tropical Botanical Garden and Research Institute Palode and the D strict Agricultural Farm Per ngammala

The survey revealed the presence of phytophagous and predatory mites belonging to six families each The families under the former group were Tetranychidae Tarsonemidae Tenuipalpidae Eriophyidae Galummdae and Oribatidae and under the latter group were Phytoseiidae Ascidae Bdellidae Cheyelitidae Cunaxidae and Stigmaeidae Phytophagous mites belong ng to the families Tetranychidae Tenuipalpidae and Tarsonemidae were the most w despread and the dominant species of these families were commonly found on all the three groups of plants

The survey further helped to ident fy eighteen new host plants of phytophagous mites which are new reports The phytophagous mites *T cinnabarinus T ludeni T neocaledonicus B phoenicis T pacificus R indica P latus* and a few species under the genera *Tetranychus Brevipalpus* and *Tarsonemous* were the important species infesting vegetables medicinal plants and ornamentals in the District

Among the acarine predators of phytophago is mites the species belonging to the family Phytoseiidae were the most dominant species of the genus *Amblyseius* in

particular were the most widespread The mites belonging to the family Cunaxidae and the Coccinellidae *Stethorus* sp were also found to be important predators of phytophagous mites

The mean percentage of mite infested leaves and the mean population counts were also assessed to study the distribution and abundance of different groups of mites on different host plants in different seasons The species *T ludeni T cinnabarinus T neocaledonicus* and *P latus* on vegetables *T ludeni* and *B phoenicis* on ornamentals and *B phoenicis T cinnabarinus T ludeni T neocaledonicus* and *P latus* on medicinal plants were found to be numerically dominant species capable of causing serious damage to the crops

The mean percentage of mite infested leaves and the mean population counts of phytophagous mites were the least in the monsoon season as compared to the premonsoon and postmonsoon seasons in vegetables medicinal plants and ornamentals The mean population counts of predators in different seasons also showed trends similar to those of phytophagous mites the monsoon season having the least or no predatory populations In the postmonsoon season also their numbers were negligible The phytoseiids were numerically the most dominant predators on vegetables ornamentals and medicinal plants The coccinellid predator *Stethorus* and acarine predator cunaxids were also found to be important to a lesser extent

The results of replicated field trials conducted in the College of Agriculture Vellayani on selected vegetables medicinal plants and ornamentals also revealed that in general the mite population was the least in the monsoon season as compared to the premonsoon and postmonsoon seasons In general the population development was found to be positively correlated with maximum temperature and relative humidity

The nature and symptoms of damage of *T cinnabarinus* on *Adhatoda T ludeni* and *T neocaledonicus* on *Rosa T pacificus* on *Dendrobium R indica* on *T alata B phoenicis* on the medicinal plants *G sylvestre S ciliates O sanctum* and on *Caladium Maranta* and *Dendrobium* and *P latus* on chilli bittergourd ridgegorud and *T erecta* were studied and described in detail

The biology and biometrics of *T cinnabarinus T ludeni T neocaledonicus T pacificus* and *B phoenicis* were studied on selected host plants and described in detail

Crop loss studies conducted on bhindi and chilli by releasing different population levels of *T ludeni* and *P latus* revealed that the stage of the crop at which infestation commenced was an important factor which determind the crop loss It was also found that there was crop to crop variation on the levels of tolerance to different mite loads No significant difference was noticed in the distribution of *T ludeni* on the top middle and bottom strata of bhindi plants while in chillies the mite *P latus* preferred the top stratum indicating a preference for young growing tissues for feeding and oviposition