BIO-ECOLOGY OF COCONUT ERIOPHYID MITE, *Aceria guerreronis* Keifer AND YIELD LOSS DUE TO ITS INFESTATION ON POPULAR COCONUT CULTIVARS

BY

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THESIS

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DEDICATED

TO

MY PAPPA AND AMMA

DECLARATION

I hereby declare that this thesis entitled **"Bio-ecology of coconut eriophyid mite, *Aceria guerreronis* Keifer and yield loss due to its infestation on popular coconut cultivars"** 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 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 **"Bio-ecology of coconut eriophyid mite *Aceria guerreronis* Keifer and yield loss due to its infestation on popular coconut cultivar"** is a record of research work done independently by Ms. Ambily Paul (99-11-17) 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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INTRODUCTION

1. INTRODUCTION

Kerala is the land of coconut. Coconut plays a pivotal role in the agrarian economy of Kerala state. Presently, the crop occupies an area of 1.08 million ha with an annual production of 5759 million nuts. It is estimated that about 10 million people depend directly or indirectly on coconut cultivation and industry for their livelihood. Thus any menace on coconut will affect the life of Keralites.

Coconut palm is prone to infestation by a large number of insects and non-insect pests. A total of 547 species of insects and mites are reported to attack coconut (Kurian *et al.*, 1979). The recently introduced coconut eriophyid mite, *Aceria guerreronis* Keifer has been a burning issue in social, political and economic scenario of Kerala, as it is a threat to copra and coir industry. The mite infestation of coconut in Kerala has assumed the proportion of a national disaster.

The mite inhabits the floral bracts and the tender portion of the nuts covered by the perianth. Due to sucking of sap from the meristematic tissues, scars are developed on the surface of the nut.

The coconut eriophyid mite, *A. guerreronis* was first reported in 1965 from the Guerrero state of Mexico (Keifer, 1965). In India, it was first reported in the later part of 1997 from Ernakulam district of Kerala (Sathiamma *et al.*, 1998). In the same period it was observed to cause husk drying of coconut in certain parts of Ernakulam, but reported later by Saradamma and co-workers in 2000 a.

The losses of copra due to infestation of *A. guerreronis* is estimated to be 10-30 % from most of the mite infested countries (Moore, 1986). Annual loss due to mite infestation alone is estimated between Rs.100 – 150 crores (Nair *et al.*, 2000). Apart from copra loss, both quality and quantity of coir is also affected by mite infestation. In Kerala, coir and coir products provide direct employment to greater than half a million people (Thampan *et al.*, 2000). This is like a natural calamity which has caused unexpected and extensive damage to the economy of the small farmers of Kerala who depend upon coconut for their livelihood. In the recent history of the state this is one problem which has attracted the attention of every segment of the society. The market of coconut related products such as copra, coconut oil, food processing and soap manufacturing is likely to be hit hard due to fall in production (Saradamma *et al.*, 2000 b).

Realising the severity of infestation of *A. guerreronis*, several projects have been implemented to tackle the problem. However, many fundamental aspects like investigation on basic biology, mite-host interactions and variability in susceptibility to coconut mite among the popular coconut cultivars were poorly studied. Information on bio-ecological factors, mite-host interactions and population build up of the pests could play an important role in decision making for IPM. Crop loss assessment in different cultivars will help in establishing economic injury levels and action thresholds for pest management. Yield loss in relation to plant characteristics may be useful for the breeders to develop tolerant varieties as a long term strategy in managing the pest.

Hence the present work was under taken with the following objectives.

1. To generate basic information on biology, ecology and mite host interactions
2. To study the population dynamics of *A.guerreronis* in susceptible and tolerant types of palms.
3. To study the variability in susceptibility of palms to mite infestation.
4. To conduct a detailed study of yield loss in five coconut cultivars
5. To develop an idea of economic loss due to mite infestation.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Aceria guerreronis Keifer is the only species of eriophyid mite considered to be a serious pest of coconut. It was first described in 1960 from specimens collected from Guerrero state, Mexico (Cartujano, 1963 and Keifer, 1965) Venezuela (Doreste, 1968) Benin (Mariau, 1969), Puerto Rico in 1977, Florida in 1984 (Howard *et al.*, 1990), Sri Lanka, 1997 (Fernando *et al.*, 2000), and many coconut growing regions of America, West Africa from Cote d'Ivoire to Nigeria (Hall and Espinosa, 1981). However, there is an evidence that at least in some localities the coconut mite was present long before it was identified and reported (Howard *et al.*, 1990). Its first report in India was from Ernakulam district of Kerala during the later part of 1997 and it was the first report of a nut infesting eriophyid mite from Asian countries (Sathiamma *et al.*, 1998). In the same period, the eriophyid mite was identified as the cause of a new "husk drying disease of coconut" occurred in certain parts of Ernakulam district and reported later by Saradamma *et al.* (2000 a) and in the same period it was reported from Tamil Nadu (Ramaraju *et al.*, 2000 a) and Andaman (Prasad and Ranganath, 2001) also. With in two years, it has spread to most of the districts in the states of Kerala, Tamil Nadu and Karnataka.

Reports and occurrence of *A. guerreronis* on different countries

	Country	Year noted
1.	Mexico	1960 (Cartujano, 1963 and Keifer, 1965)
2.	Venezuela	1969 (Doreste, 1968)
3.	Sao Tome	1963 (Mariau, 1969)
4.	Benin	1967 (Mariau, 1969)
5.	Cameroon	1967 (Mariau, 1977)
6.	Nigeria	1967 (Mariau, 1977)
7.	Togo	1967 (Mariau, 1977)
8.	Ghana	1977 (Mariau, 1977)
9.	Ivory coast	1975 ((Mariau, 1977)
10.	Cote d'Ivorie	1975 (Mariau, 1986)
11.	Cuba	1972 (Moore, 1986)
12.	St. Lucia	1987 (Moore and Alexander, 1987)
13.	Puerto Rico	1977 (Howard *et al.*, 1990)
14.	Florida	1984 (Howard *et al.*, 1990)
15.	India	1997 (Sathiamma *et al.*, 1998).
16.	Sri Lanka	1997 (Fernando *et al.*, 2000)

Geographical distribution of the coconut eriophyid mite might have expanded greatly in recent decades (Griffith, 1984). Appearance of coconut mite in India and Sri Lanka could be the beginning of a significant threat to the major coconut producing regions of the world in Asia and Oceania (Moore, 2000).

Though the major coconut growing countries *viz.* Malaysia, Indonesia, Philippines and some Pacific islands are comparatively free from its infestation at present, there is a pqtential danger of the pest spreading to these countries in future.

Absence of these mites in presumed area of origin of coconut probably indicated that it has moved from an unknown host to coconut (Moore and Howard, 1996., Rao *et al.*, 2000).

Eriophyid mite was also reported from a cocosoid palm species *Lytocaryum weddellianum* (Flechtmann, 1989). However Mohanasundaram *et al.* (1999) contradicted that this mite is specific to coconut alone and so far it has not been reported from any other host.

Nine species of eriophyid mites have been reported to affect coconut leaves and nuts. *Acathrix trymutus* Keifer, *Scolocenus spiniferus* Keifer, *Dialox stellatus* Keifer and *Notostrix attenuata* Keifer (Briones and Sill, 1963) and leaf infesting mite *Amrineus cocofolius* Flechtmann, *A. coconuciferae* Keifer are eriophyid mites infesting coconut other than *A.guerreronis.* Kang (1981) reported that except *A. guerreronis*, others do not cause significant impact on coconut production.

2.1 Biology

Many of the fundamental aspects on the bio-ecology of the mite are poorly understood. Moore and Howard (1996) opined that further investigations on basic biology is essential by rearing and maintaining laboratory colonies of coconut mite.

Adult of this mite have a worm like body (Keifer, 1965) having two pairs of legs in the anterior portion. Mohanasundaram (2000) studied the biology of *A. guerreronis* at Tamil Nadu and found that the abdominal portion is studded with micro tubercles in a series of rings. The anal opening is terminal, while the genital opening is anterior below leg base. A general characteristic feature is the possession of two long setae arising from the posterior end of the body (Ramarethinam and Loganathan, 2000). Mohanasundaram (2000) studied the reproductive behaviour of *A. guerreronis* and reported that there is no copulation among the sexes, the sperm transfer to the female occurs accidentally through the spermatophores during the movement of female.

Abou - Award (1979) studied the biology of *Eriophyes datura* and reported that it laid 8.35 ± 0.84 eggs during its lifetime and protonymph lasted 3.16 ± 0.25 days. Mariau (1977) and Ramarethinam (2000) reported that the female mites of *A.guerreronis* lay about 20 – 100 eggs during its lifetime. The eggs are glossy, transparent having a diameter of about 35 – 40 micron. The egg hatch in about two days and first instar nymph lasted for about two days and second instar lasted for three days. The adult mites lived for a maximum period of 25 days. First instar nymph was 90 μ m long, second instar nymph was 150 μ m long and the adult was 36-52 μ m width and 205 – 255 μ m in length (Keifer, 1965; Gopal and Gupta, 2001).

2.2 Mite-host interaction and symptamatology

Recently introduced coconut eriophyid mite, *A. guerreronis* Keifer has assumed the proportion of a disaster affecting coconut industry in Kerala and neighbouring states (Nair *et al.*, 2000).

The nature of damage inflicted by the mite on the buttons was studied by Mariau (1977). The first symptom appears in the form of a whitish triangular patch extending down from the perianth. At this stage, when the perianth is lifted up, a white area is perceived where thousands of mites at all stages of their development accumulate. The whitish triangular patch turns brown and the epidermis of the button becomes crackled and the mesocarp splits to form deep fissures. Quite often the attack occurs on much older nuts alone and in such cases the fruit will be only slightly deformed and of practically normal size.

Feeding of adults and nymphs in the meristematic region under the perianth causes physical damage so that as the newly formed tissue expands, surface become necrotic and suberised (Moore and Howard, 1996). Nair *et al.* (2000) reported that in extreme cases of infestation, the attack continues up to complete growth of the nut (nine month after pollination) which affect normal growth. Un even growth occurred as a result of necrotic lesion and suberisation result in distortion and stunting of the coconut leading to reduction in copra yield. Drying and shedding of buttons also occur. Mohanasundaram (2000) classified the damage caused by the mite in four categories depending on the variety of coconut. In the first instance, the young buttons slowly dried out without shedding and the whole bunch stood full of dried buttons. In the second type of damage, buttons of 40 days old to fruits of tender coconut size were shed periodically, leaving a very few nuts in the bunches or none. In the third type of damage fruits of 6 inches and above developed a 'T' shaped crack below the calyx, slowly spreaded down, turned brown, then the husk developing warty patches and reduction in nut size.

2.3 Population dynamics

Precise information on the abundance of mite population and resultant economic losses in terms of reduction in weight of coconut and coconut products is very essential for attempting establishment of economic injury levels or action threshold.

In terms of relative numbers of mites per nut, infestation was very low in the first month after fertilization, but rapid build up was observed in third to sixth bunch nuts (Moore and Alexander, 1987). The number of mites per square centimeter area of the meristematic zone during peak period of infestation reached more than 1200 under Kerala condition (Haq, 1999). However Ramaraju *et al*. (2000 b) reported that as many as 2 – 140 mites along with large number of eggs were found in an area of four square millimeter.

2.3.1 Assessment of population of Eriophyid mites

Population of mites in a colony is estimated by calculating the mean number of mites per square millimeter and multiplying by the total square millimeter occupied by the colony (Howard *et al*., 1990). Eriophyid mites are so minute and numerous that their populations are very difficult to count (David and Varadarajan, 2001).

Various methods have been proposed by different authors to count the mite numbers in a unit area. Youthers and Miller (1934) who first made a 'counting template' (0.5" square) to sample the citrus rust mite, *Phyllocoptruta oleivora*. A combination of alcohol and ultrasonic vibration was used by Gibson (1975) to estimate the density of *Aculodes dubius* on rye grass. Zacharda *et al.* (1988) used an alcohol based technique without ultrasonic vibration to monitor *Aculus schlechtendale* in apple orchards.

Allen (1976) estimated densities of *P. oleivora* on citrus fruit using a 10x hand lens mounted over a piece of clear plastic etched with a 1cm^2 grid. The grid was divided into 25 equal subdivisions each having an area of 4 mm^2. Moore and Alexander (1987) assessed the populations of *A. guerreronis* by using a log scale in each tepal (0 = no mites, 1 = 1 to 10 mites, 2 = 11-100 mites), especially when infestations were very heavy. Gipsert *et al.* (1989) counted the tomato nisset mite, *Accelops lycopersici* by placing the tomato leaflets between the glass microscope slides with the slide on lower leaf surface etched with three 1 cm^2 squares corresponding to medial, central and terminal leaflets. Glycerine drop trap method was standardised for accurate measurement of *A. guerreronis* population by David and Varadarajan in 2001.

Ranjith *et al.*, 2000 suggested a washing method to assess the population of the coconut eriophyid mite, *A. guerreronis*. However a simpler method for rapid and more accurate counting of eggs, nymphs and adult population of *A. guerreronis* on the meristematic surface of young coconuts by immobilising and embedding them between a cellotape and microslide, was standardised by Girija and co-workers (2001). Advantage of this method was that it could measure colony wise population of mites from a sample.

2.3.2 Influence of age of young nuts on population

Mites are not found under the bracts of unfertilized female flowers but may be present under the external bracts just after fertilization (Mariau and Julia, 1970). Hall *et al.* (1980) claimed that nuts remain susceptible to mite attack almost throughout the whole development, but in more mature fruits (10-13 months) coconut mites are found rarely and in small numbers. In terms of relative mite numbers/nut, infestations were very low in the first month after fertilization, peak numbers from all trees occurred on bunches 3 – 6 and then dropped and tended to be low from ninth bunch. (Moore and Alexander, 1987) and were virtually absent from coconuts of about 20 cm in length (Howard and Abreau, 1991). In 2000, Mathew *et al.*, reported that peak mite population was observed in fifth bunch (90 to 100 days after opening of spadix) followed by fourth and sixth bunches. However Ranjith *et al.* (2001) reported that highest population was observed in fourth bunch. Study on critical age of nuts for colonization and build up of *A. guerreronis* is very important for locating the most susceptible bunches to be targeted for spraying.

2.3.3 Flowering and phenology of palm

The mite problem was compounded by the pattern of coconut production where a new inflorescence is produced approximately once a month and so the coconut bears bunches of varying ages from flower to mature dry nut. The period of time during which nuts contain mites is important as they act as reservoirs for mites capable of migrating and infesting clean nuts (Moore and Alexander, 1987).

Each coconut inflorescence is produced at approximately 120° around (clockwise or anticlockwise) from the just previous inflorescence and hence is almost directly above the coconut bunch derived form a much previous inflorescence. Thus the spikelets of a fresh inflorescence are always in contact with the spikelet of another infested bunch and mites migrated upwards. This suggests that coconut trees would have to be cleared of mites over large areas to prevent rapid colonization (Moore and Alexander, 1987).

2.3.4 Influence of ecological parameters on population

The relationship of the mite with the seasonal growth cycle of the plant is important to study. Coconut mites may have been present at low levels and have undergone an explosive population increase in recent years because of unknown ecological factors (Doreste, 1968; Zuluaga and Sanchez, 1971). Howard *et al.* (1990) reported that mites can be found both in tropical and subtropical climates and can serve short period of frost and temperature just above zero.

Many reports are available to indicate that infestation by coconut mite is more severe in relatively dry climates or during the dry seasons of wetter climates (Zuluaga and Sanchez, 1971; Griffith, 1984). The reason behind is that during drier period, growth of coconut is slower, thus young developing tissue is subjected to mite damage for longer periods (Mariau, 1977, 1986; Romney, 1980). In Indian condition ecological studies were conducted by Nair *et al.* (1999) and Nair and Koshy (2000). They reported that population was peak in summer months (April – May). However, this was contradictory to the earlier reports that there is no clear relationship between coconut mite population and wet or dry weather (Doreste, 1968; Mariau, 1969, 1977; Howard *et al.*, 1990 and Ramaraju *et al.*, 2000). Small size of *A. guerreronis* coupled with the large size of palm create special problems in ecological research (Pierring, 2000). But Nair and co-workers (1999) studied the seasonal incidence of the mite in Kerala and revealed that occasional rains accelerated the population growth. High relative humidity and temperature were found to be the favourable factors for the multiplication of mite. Similar study was done by Mathew *et al.* (2000) and reported that relative humidity prevailed during the period in which the respective bunches were in the critical stage of mite entry (45 – 55 days after opening of spadix) had a direct positive influence on population dynamics. Mean relative humidity over the developmental period of mite colonies in the nuts also did not show any relation with mite population. Cumulative rainfall during the developmental period of peak population of mite colonies in the nuts (65 – 115 days after emergence) showed a negative influence on the dynamics of mite population. They further observed that age of the bunch was the most critical factor in the study of population dynamics and the fifth bunch harboured peak population.

2.4 Morphological characters of buttons and influence of varieties

Variability in nut characters such as size, shape, colour, presence or absence of ridges, thickness of husk etc. are considered as factors determining susceptibility or tolerance to injury by mite (Mathew, T.B. Personal communication). Mariau (1977) and Moore and Alexander (1990) found that nuts of a very rounded form were less susceptible to attack than more elongated one and explained that in round nuts it was mechanically impossible for the mite to get under perianth which adhered closely to the nut surface. Later Moore (2000) explained that round and elongated nuts came from the same tree and even same bunches and hence the effect is probably not a genetic feature, but more likely a matter of resource allocation.

Varietal differences in susceptibility to coconut mite have been demonstrated in Cote d'Ivoire (Mariau, 1977; Julia and Mariau 1979; Julia *et al.*, 1979), Costa Rica (Schliesske, 1988) and Cuba (Suarez, 1991).

Colour also played an important role in susceptibility or tolerance of palms to coconut mite. Moore and Alexander (1990) reported that the young nut from the trees with dark green inflorescence showed less damage than the other trees. Contradictory to this, Muthiah and Bhaskaran in 2000 reported that green coloured nuts are more susceptible to mite attack than orange or yellow. However Cheziyan and Ramar (2000) observed yellow types as more susceptible ones in Tamil Nadu.

Lakshadweep Ordinary, Cochin China, Andaman Ordinary and Ganga Bondam recorded less than 13 per cent damage by the mite (Muthiah and Bhaskaran, 2000). The arrangement of the bracts on young nuts influences the pattern of attack by *A. guerreronis.* Mite damage was worse where the bracts were less tightly adpressed to the nut and where bracts overlapped each other. The bract that overlapped at one end showed intermediate levels. An overlapping bract could not adpress so tightly to nut surface and this allowed access of the mite to initiate infestation (Moore, 1986).

The tightness of adpression may be a characteristic of a cultivar. Haq, 1999 opined that variety of coconut having tight fitting tepal should be selected for planned farming system in future. Crop breeding can produce great benefits, but is a long term and probably partial solution to coconut mite (Moore, 2000).

2.4.1 Growth rate of nuts

The nuts elongate from the meristem which is basal and protected by the calyx and grown three quarters after six months. The daily elongation of a nut averages about 1.5 mm. When six months old, a nut attains approximately 75 per cent of its final weight and volume. The nut becomes full sized after 5–6 months, but not mature until after 11-13 months (Vanderplank, 1958). Bunches 1–6 were the most susceptible to colonization of coconut mite and 75 per cent of growth of the nuts took place in 1–6 month age, hence any menace attacking at this stage adversely affected the yield of coconut (Moore and Alexander, 1987).

2.4.2 Expansion of air space

Moore (1986) reported that physical space between tepals is most important in coconut mite infestation. Tightness of the perianth to the coconut appears to be a key factor in its susceptibility or resistance to coconut mite attack. The ink penetration test conducted by Howard and Abreau (1991) to determine how the perianth protects the meristematic zone. They suggested that the technique could be developed as a simple screening method to identify coconut cultivars potentially resistant to coconut mite.

2.5 Assessment of yield loss

Crop loss estimation in different coconut cultivars is an important aspect to be investigated to put an economic cost to the coconut mite both where it presently occurs and potential costs for areas yet to be colonized (Moore, 2000). Economic losses occurring in the Indian subcontinent are going to be of great concern there by making a serious impact on the countries and crop loss assessment in different areas with different varieties are essential.

The first attempt to assess crop loss in coconut was done by Ramachandran *et al.* (1963). The estimated losses of copra reported from other countries vary very much from 30 per cent in Mexico (Hernandez, 1977), 10 per cent in Benin 16 per cent in Ivory coast and 11-28 per cent in St. Lucia (Moore and Alexander, 1987). Moore *et al.* (1989), Moore and Howard (1996) and Rao *et al.* (2000) pointed out that even the most damaged nuts yield some copra but dehusking of these nuts is very difficult and it fetches additional labour requirement and often not done resulting in complete loss. Moore and his co-workers (1989) assessed yield loss by dividing harvested nuts into five damage categories adopting the method of Julia and Mariau (1979). Most yield loss resulted from severe damage such as category 4 and 5. Preliminary studies conducted in Kerala indicated that there is a production fall of 30 – 40 per cent in several affected districts of Kerala state and annual loss due to mite infestation alone is roughly estimated as Rs. 100 – 150 crores (Nair *et al.*, 2000). Moore (2000) reported that economic losses due to the mite may reach many hundreds of millions of dollars.

The palms may become more tolerant of mite populations, showing reduced losses despite visible evidence of attack or mite population may begin to fall, reducing the inoculum available to continue the spread of the pest (Moore, 2000). The quality and quantity of fibre was also deteriorated due to mite infestation. The annual loss of husk was reported to be 41.74 per cent (Muralidharan *et al.*, 2001).

2.5.1 Nut fall

Nut fall is one of the major components in assessing crop loss and often left unaccounted. However disputable reports on nut fall due to infestation of eriophyid mites are available. Thus in 1968 itself, Doreste furnished the severity of premature nut fall. But Mariau in 1986 disputed this extensive pre-mature nut fall stating that mite infestation only affects the copra content of nuts and not nut fall. Geethalakshmi and Rabindra (2000) reported that no significant difference was observed in the level of shedding.

2.6 Bio-chemical changes

Geethalakshmi and Rabindra (2000) studied the bio-chemical properties of nuts as influenced by mite infestation. Amount of reducing sugars in coconut water was found to be more in healthy nuts than in infested ones. However, total sugar content of coconut water was higher in the infested nuts than healthy one in the later stage of infestation. Similarly peroxidase content was also higher in infested nuts. Increased peroxidase levels indicated that the infested nuts may quickly prone to be rancid. Manickam and Muthuswamy (2000) reported that infested tissue showed more phenolics than in healthy ones. There is no characteristic toxin production either by secondary fungal infection or by mite infestation.

2.7 Dispersal

The dispersal of the mite has been explained by various workers. Moore and Alexander (1987), Moore and Howard (1996) and Ramaraju *et al.* (2000 a) reported that coconut mite spreads mainly through wind or by phoresy, either on animals directly attracted to the inflorescences (pollinating insects like bees, rodents which feed on the fruits) or on those attracted by such animals (eg. Predatory lizards, birds, predaceous insects) (Moore and Howard, 1996) or by human activities like transport of materials, particularly tender nuts may facilitate establishment of the mite population in the new areas. Sathiamma *et al.* (1998) stressed the essentiality of prompt quarantine measures to prevent the dispersal of mite by regulating the transport of nuts, leaves etc from the infested locations to the other foci from where they have not so far been reported.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Experiment 1. Biology of *A.guerreronis* under laboratory conditions

Biology of *A. guerreronis* was studied under laboratory condition during May – June, 2001. Tender and succulent tepals were taken from fourth bunch nuts. Square discs of about one cm diameter free from insects and mites were used for this purpose (Plate 1). The discs were placed to keep the upper surfaces in contact with tender coconut water in small containers. The tender coconut water was changed daily to keep the discs fresh which helped to rear the mite for longer period.

Female mites were placed singly on the inner surface of the perianth discs by using a camel hairbrush. The females were allowed 12 hours to lay eggs, and then the mites were removed from the discs. The eggs were observed under a stereo binocular microscope daily in morning and evening hours for observing the developmental changes.

The length and width of egg, protonymph, deutonymph and adult were measured by using ocular micrometer in a calibrated microscope. All stages of mites were drawn by using camera lucida and measured.

Plate 1 – Laboratory rearings of *A.guerreronis* in perianth discs

3.1.1 Studies on population buildup in fourth, fifth and sixth bunches under field conditions

Another experiment was conducted in May 2001 to study the development of egg, nymph and adult population in young nuts of critical age under field conditions. Nuts with uniform external symptom of triangular marks were labelled by pasting sticker labels. Such nuts having apparently identical population were harvested at weekly intervals for a period of four weeks and the population growth of the mite was recorded.

3.2 Experiment 2. Mite host interaction and symptomatology

Mite host interaction studies were conducted in both young and mature nuts. The growth of lesion and colour changes that were taking place in the meristematic zone under the perianth due to the feeding injury by the mites were recorded, by observing nuts sampled from bunches with varying levels of external symptoms. Different intensities of triangular markings on the nut surface and the corresponding patches on the meristematic zone just above the markings were closely observed to study the symptomatology.

3.3 Experiment 3. Histopathological studies

Hand sections were taken from lesions of different intensities of light brown to dark brown colour on nut surface, stained and mounted on glass slide. Changes due to feeding injury by mite colonies taking place in epidermal cells and the subsequent histological changes in the exocarp were recorded by taking photographs.

3.4 Experiment 4: Preliminary evaluation of coconut palms (WCT and Komadan) for identification of tolerant and susceptible types

The experiment was conducted in C and D block of Instructional farm, Vellayani. Fifteen palms each in WCT and Komadan were randomly selected for the preliminary evaluation to identify susceptible and tolerant palms. Observations were made from two successive harvests done during March and May – 2000. Harvested nuts were divided into five damage categories (Plate 2a) and classified according to visible surface damage (Julia and Mariau, 1979).

Category 1 – Nuts with no mite damage (0 %)

Category 2 – Nuts with superficial mite damage (1-10 %)

Category 3 – Nuts with significant mite damage but not much smaller (11-25 %)

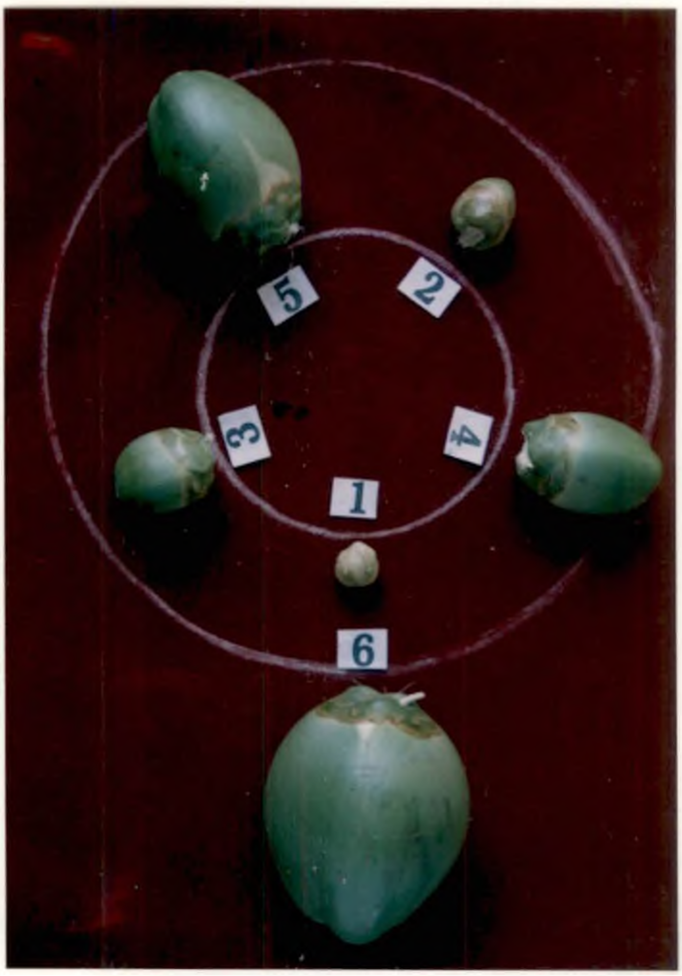
Category 4 – Nuts with significant mite damage, smaller and with some distortion (26-50 %)

Category 5 – Nuts very heavily attacked, very much reduced in size and often greatly distorted (51-100 %)

Plate 2a – Five damage categories of coconuts as per the classification suggested by Julia and Mariau (1979).

Plate 2b – Arrangement of young coconut bunches (1 to 6) in a coconut crown represented by placing the nuts in their natural positions.


1
2
3
4
5


5
2
3
4
1
6

Based on the per cent nuts in each damage category, palms were classified as susceptible and tolerant. Palms that had greater than 25 per cent of nuts falling under category 3, 4, and 5 were treated as susceptible and those with less than 25 per cent of nuts coming in the above categories were selected as tolerant. Four susceptible and four tolerant palms were selected from each variety. These selected palms were used for further studies.

3.5 Experiment 5. Study of population dynamics of *A. guerreronis* in susceptible and tolerant types of WCT and Komadan

Population dynamics of CEM, *A. guerreronis* in coconut buttons was studied in the palms which were selected from Experiment 4.

In order to study the population dynamics it was necessary to know the age and pattern of bunch production.

3.5.1 Arrangement of young bunches in the crown

Arrangement of the youngest six bunches in a coconut crown is represented in Plate 2b, by placing the nuts sampled from each bunch in their natural position. The first (youngest) to sixth bunches were labelled in the sequence of flowering (in reverse order) in such a way that the last opened one was considered as the first bunch, the just previous inflorescence at 120^0 around the crown as the second bunch and so on. Third and fourth bunches were on either side of the first bunch. Fifth bunch was opposite (120^0) to the first bunch on the other side of the crown and sixth one was always vertically below the first bunch. Labels (3" x 3") made of 'sun pac' board were tied to the bunch stalk with plastic tape.

3.5.2 Sampling and assessment of population

One nut each representing the three bunches at the critical age (fourth, fifth and sixth) was sampled every month. During the next month, sampling was done from the then fourth, fifth and sixth bunches which were the third, fourth and fifth respectively during the previous month. Thus the age of the sampled nuts was maintained uniformly every month. Immediately after sampling, the nuts were brought to the laboratory for population assessment..

Population of mites under each tepal was counted immediately after removing the tepals very carefully using a forceps. Tepal number was marked below each colony using a marker. For counting population of eggs, nymphs and adults, the cellotape embedding technique (Girija *et al.*, 2001) was adopted which was a simple, rapid and more accurate method facilitating measurement of colony wise population. Transparent cello tape of one inch width was used to wipe out the colonies. A piece of cello tape was pressed gently over the mite colony under each tepal to immobilise and embed the whole population including nymphs and eggs to the cello tape as seen in Plate 3a. Cello tape with

Plate 3a – Cellotape embedding technique - Pressing of a piece of transparent cellotape on to a mite colony.

Plate 3b – Pasting of the cellotape with embedded mite colony on a microscopic slide.

embedded mite colonies under different tepals was pasted separately on microscopic slides and labelled (Plate 3b). Boundary of each colony was marked on the cello tape using a marker pen and the area was measured by placing a transparent graph paper on the slide. Population of egg, nymph and adult was counted in a calibrated student (compound) microscope at 100x magnification. Counts were taken in ten randomly selected microscopic fields in each colony and the mean population per field was worked out. This was then projected to the actual area occupied by the embedded mite colony on the slide using the following formula,

$$\text{Population of mites in a colony} = \text{Mean population of mites in microscopic field} \times \frac{\text{Area of mite colony (sq.cm)}}{\text{Microscopic area (sq.cm)}}$$

Total population/nut was worked out by adding the population in all the colonies on a nut. The palms selected under Experiment 1 representing susceptible and tolerant types of WCT and Komadan were observed every month for a period of one year from February 2000. The data on population dynamics was subjected to statistical analysis to study the monthly variation and the influence of variety, susceptibility and age of bunch on population dynamics.

3.5.3 Monthly variation of population as influenced by weather parameters

The data on various weather parameters *viz.*, maximum and minimum temperature, rainfall and relative humidity during the period of observation were collected from the Department of Agro-metereology, College of Agriculture, Vellayani.

The entry of coconut eriophyid mite on young nuts was believed to be from 25-35 days after opening of the spadix onwards. Hence population of mites in a particular bunch during a month was correlated with relative humidity, temperature and rainfall prevailed during the period in which the respective bunches were in the critical stage of mite entry (45-55 days after fertilization). Correlation was also worked out with average relative humidity, temperature and rainfall prevailed during the critical growth period (third to fifth bunch) of respective bunches, in addition to the usual correlation studies with weather parameters of the corresponding months.

3.6 Experiment 6: Investigation on the morphological characters of the nut and their influence on extent of damage by coconut eriophyid mite

Morphological characters of young and harvested nuts coming under each damage category were taken.

3.6.1 Length of nut

Length of nut from calyx end to other end through curved surface of nuts coming under each category was measured using a twine and scale.

3.6.2 Circumference of nut

Circumference of nut at the widest part of nuts coming under each category was measured using a twine and scale

3.6.3 Thickness of husk

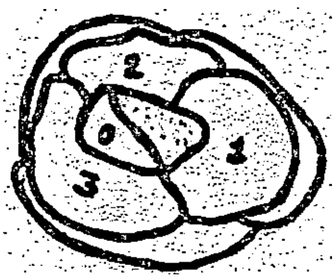
Thickness of the husk was recorded by piercing the husk with a poker till it reached the shell and mean length of the needle from the shell to the outer surface of the husk pierced at the three flat surfaces of the nut gave the thickness of husk in cm.

3.6.4 Arrangement of tepals (bracts)

The severity of coconut mite damage was studied in relation to arrangement of tepals of young nut. Population of mites under tepals was assessed by removing each tepal and the mite population was counted using cello tape embedding technique. Colour of the lesion was noted and the area measured.

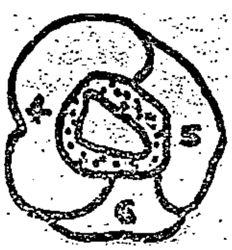
There were two types of arrangement of tepals namely arrangement I and II. In type I, tepal number 4 overlapped tepal 5 and 6 at both ends, tepal number 6 was overlapped by tepals 4 and 5 at both ends and the tepal number 5 overlapped only at one end. In bract arrangement II, each bract overlapped at one end and it was overlapping at the other end (Fig 1).

Tepal where the mite damage extended farthest down the nut surface and the colour of feeding area was darkest brown, was considered the region where initial colonization had occurred. Percentage of buttons having mite attack started from the overlapping edge or middle of the tepal was also worked out. Mite population under each

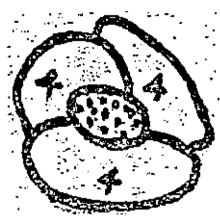


External tepals (1 to 3)

Arrangement 1



Arrangement II



Internal tepals

Fig. 1. Arrangement of tepals on coconuts

Bract arrangement 1.
Tepal 4 –overlaps 5 and 6 at both ends
Tepal 5 – overlaps 6 at one end
Tepal 6 – overlapped by 4 and 5 at both ends

Bract arrangement II
Tepal 4 – each bract overlaps at one end

tepal in fifth bunch sampled under Experiment 3.5 was also assessed to study the spatial distribution within the tepals.

3.6.5 Colour of nut

Colour of the nuts harvested from each palm under Experiment 4 was observed and the percentage of damaged nuts in each colour category was worked out.

3.6.6 Shape of nut

Data on length and circumference of the young nuts sampled under Experiment 5 was used to work out length to circumference ratio as an index of its shape. Based on the range of length to circumference ratios, nuts were classified into round or elongated.

3.6.7 Growth rate of nuts and its influence on expansion of scar leading to damage categories

Elongation of nut at monthly intervals was measured by adopting the techniques of O' Connor, 1951. Growth rate was studied by making a mark on the nut along the bottom edge of the calyx at monthly intervals using a sharp needle. Growth rate of nuts was measured by taking the length and circumference of area between the two consecutive marks. To study the expansion of feeding scar on coconut due to injury by mites in relation to nut growth, young nuts with different degree of injury (number of triangular marks) in second and third bunches were labelled. Dwarf palms were selected for this experiment to facilitate close observation. Monthly observations on the length and circumference of the nuts were recorded. Outline of the feeding scars on the husk was traced on tracing paper to measure the area. These observations were recorded at monthly intervals till they became eleven months old. Based on these measurements, drawings of the nuts with feeding scars were made at monthly intervals on a graph paper, to scale. Drawings were classified based on the damage categorisation (Julia and Mariau, 1979) and a pictograph was made to represent the development of feeding scars leading to the different damage categories.

3.7 Experiment 7. Assessment of yield loss in coconut cultivars due to infestation of *A. guerreronis*

The experiment was conducted in the instructional farm, College of Agriculture, Vellayani during the period from February 2000 to July 2001.

The following five varieties of coconuts were selected for study.

1. WCT
2. Komadan
3. Laccadive ordinary
4. Dwarf Orange
5. T x YD

Five coconut palms were randomly selected from each variety from the same locality and an experiment was laid out in CRD to study the response of different cultivars of coconut to injury by eriophyid mite. Bunches were labelled initially as done under item 3.2.1 and subsequently opened ones were labelled in succession.

Harvested dry nuts were divided into five damage categories and classified according to visible surface damage (Julia and Mariau, 1979) as described under 3.1. This classification was made at the foot of the trees and the total number of nuts and percentage of damaged nuts in each category was assessed.

After the categorisation of nuts, samples were taken from each category for assessment of yield loss. Nuts were labelled by making incision on husk and carried to the lab for taking further observations.

3.7.1 Assessment of extent of damage due to mite infestation based on pooled data from ten harvests

The extent of damage due to mite infestation in five coconut cultivars *viz.*, WCT, Komadan, Laccadive Ordinary, Dwarf orange and T x YD was studied by taking five palms in each variety. The percentage of nuts in five damage categories in ten harvests were pooled and mean was calculated and presented.

3.7.2 Fresh weight of unhusked coconut

Weight of unhusked nuts were taken by using a pan balance in 'g'.

3.7.3 Weight of dehusked nut

The nuts were dehusked, cleaned and weighed and the weight expressed in 'g'.

3.7.4 Weight of husk

Weight of husk was determined by subtracting the weight of dehusked nut from the weight of fresh nut and it was expressed in 'g'.

3.7.5 Weight of opened (split) nut

The dehusked nuts were split into two halves, coconut water was drained and the weight was expressed in 'g'.

3.7.6 Thickness of meat

Thickness of meat was measured using Vernier Calipers at three different places on the nut and mean thickness expressed in 'cm'.

3.7.7 Weight of copra

Both healthy and infested kernels excised out of the shell were dried under sun for 4-5 consecutive days and moisture content was brought down from 50-55 % to 5-6 % and the weight was recorded in 'g'.

Actual and potential yield were estimated by using the above data.

Actual Yield = Wt. of copra harvested

Potential Yield = Mean wt. of category 1 nuts x total no. of nuts

$$\text{Yield loss} = \text{Potential yield} - \text{Actual yield}$$

$$\text{Percentage Yield loss} = \frac{\text{Yield loss} \times 100}{\text{Potential Yield}}$$

3.7.8 Correlation studies between population of *A. guerreronis* and yield loss parameters

Correlation and regression analysis were carried out.

3.7.9 Comparison of variation in yield loss in susceptible and tolerant types of WCT and Komadan

Percent reduction in weight of meat, husk and copra was studied in four palms each in susceptible and tolerant types of WCT and Komadan by taking the mean of per cent reduction in ten harvest and presented.

3.7.10 Economic loss

Annual yield loss in terms of fresh nut as well as copra was worked out for each palm as a cumulative total of yield loss (Potential yield – actual yield) + loss due to nut fall, recorded in seven consecutive harvests. This was converted to economic loss (Rs./palm/year) taking into account the price of nut and copra prevailed during the harvest period.

3.8 Experiment 8. Assessment of increased labour required for dehusking infested nuts compared to uninfested nuts, using mechanical dehusker

Additional labour required for dehusking of infested nuts was studied in a separate experiment in terms of dehusking time. Nuts from each damage category was deshusked using mechanical dehusker. Time required to dehusk 100 nuts was recorded.

3.9 Experiment 9. Assessment of the effect of mite damage on quality of fibre and coir

An experiment was conducted to assess the effect of mite injury on the quality of fibre and coir. Husk obtained from 50 nuts harvested at eleventh month representing the damage categories 1 to 5 were subjected to natural retting practices. The soaking was done in a pit dug near Vellayani lake and covered with coconut leaves and mud for a period of six months.

Husk were taken out of water, washed and the outer skin (exocarp) was peeled off. They were placed on wooden blocks and beaten with a wooden mallet to separate the fibre, cleaned and dried after labelling them. Fibre obtained from each damage category nuts was combed and cleaned again. Length of the fibre in each category was measured.

Coir yarn was spun by hand spinning. The strands were taken in pairs and twisted together in the opposite direction to form a 2-ply yarn and then reeled using the wheel spinning method. Coir yarn spun from different damage categories were studied.

Statistical analysis

Data relating to each character were analysed by applying the analysis of variance techniques as applied to CRD described by Cochran and Cox (1965) and the significance was tested by F test (Snedecor and Cochran, 1967). In cases were the effects were found to be significant CD values were calculated by using standard technique.

RESULTS

4. RESULTS

4.1 Experiment 1. Biology and Population build up

The life history of coconut eriophyid mite, *A. guerreronis* includes four stages *viz.*, egg, protonymph, deutonymph and adult.

The eggs were laid singly on the meristematic tissue of young buttons and on the inner surface of the perianth. Eggs are ovoid, glossy, translucent and white coloured having a length of 39.9 µm and a width of 30 µm (Table 1). The incubation period was 2.8 days (Table 2). The newly hatched protonymph had 74.5 µm length and 32 µm width and having two pairs of legs as in adult stage. Two setae were present in abdominal end. Duration of protonymph was 3.4 days.

The deutonymph was more elongated than protonymph having a length of 129.7 µm and 33µm width. It was white in colour and had two pairs of legs as in the case of protonymph. Setae were present in the deutonymph also. It took 3.7 days to become an adult.

A. guerreronis moulted twice and the moulted skin was white in colour. Total life cycle of *A. guerreronis* from egg to adult took 9.8 days in April 2001. The adult mites were pale white in colour and elongated or worm like in appearance. Body was covered by microtubercles in a series of rings and two anal openings were terminal and genital opening was anterior. The life history of *A. guerreronis* is presented in Plate 4.

Plate 4 – Life history of *A.guerreronis*

A - Egg

B - Hatching of egg

C - Protonymph

D - Moulting

E - Deutonymph

F - Adult

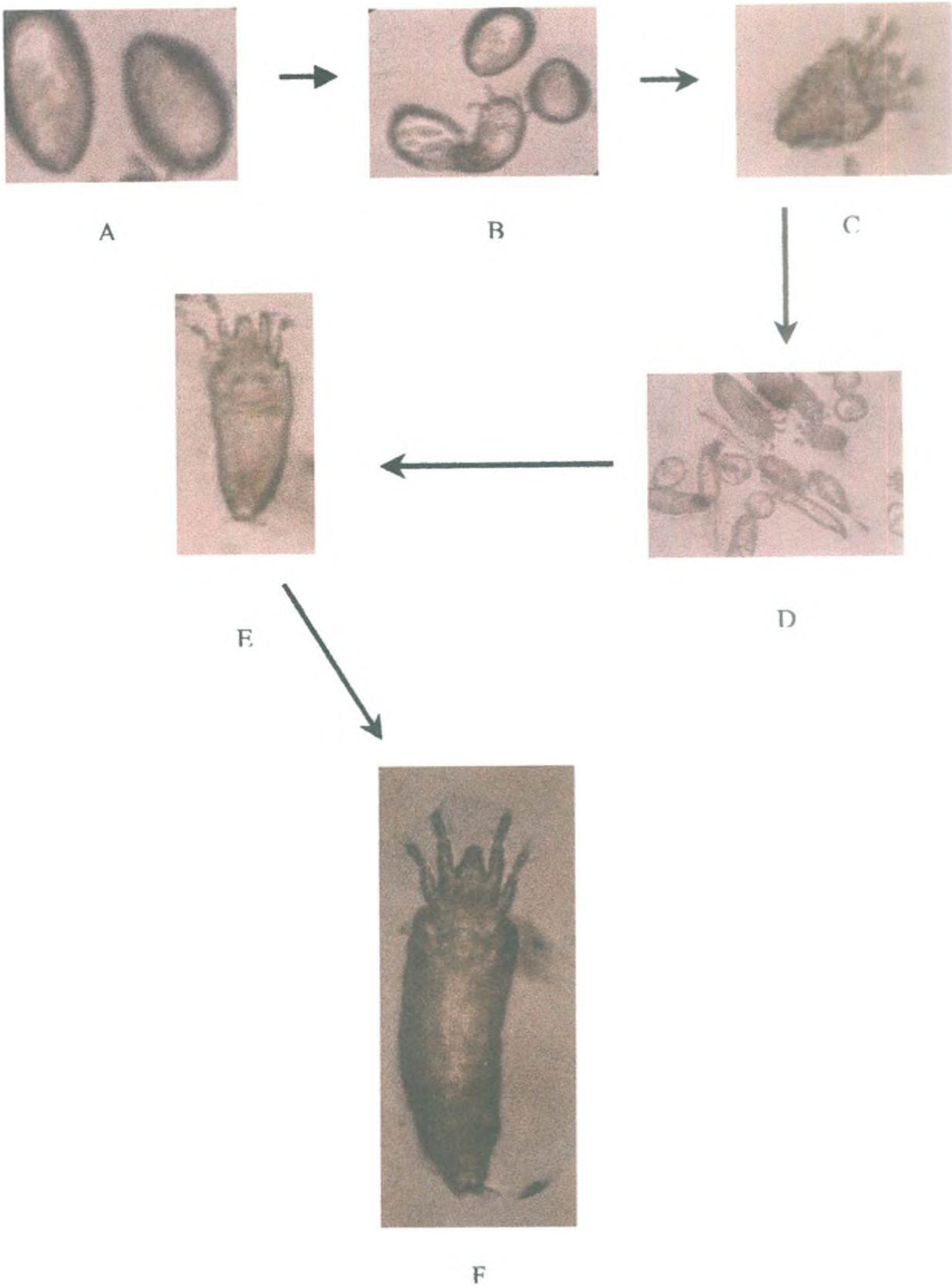


Plate 4. Life history of *A.guerreronis*

Table 1. Measurements (in μm) of different stages of *A. guerreronis*

Details	Length	Width
Egg	39.9	30
Protonymph	74.5	32
Deutonymph	129.7	33
Adult	230.5	47

Table 2. Life cycle of *A. guerreronis*

Life stages	Period (in days)
Egg incubation	2.8
Protonymph	3.4
Deutonymph	3.7
Total life cycle	9.8
Eggs / female	14.3

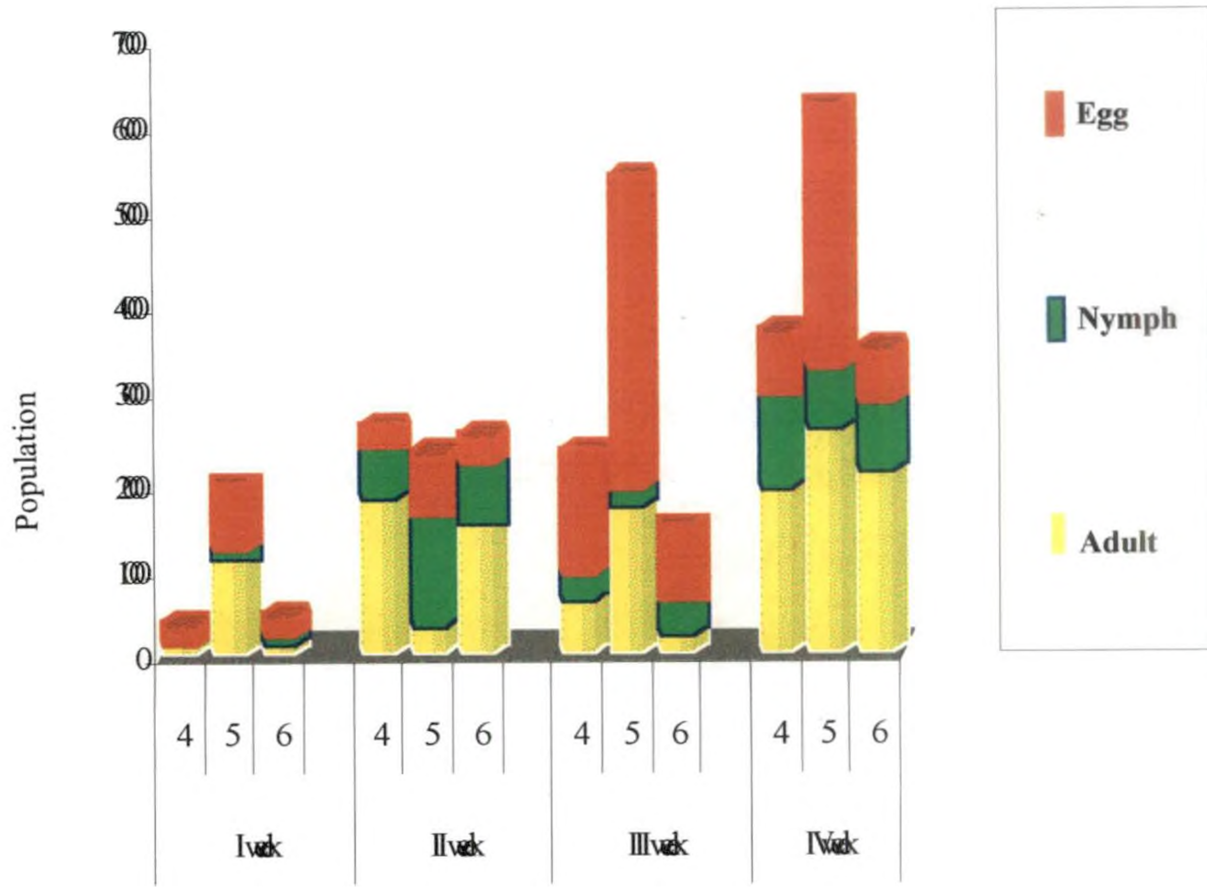


Fig. 2. Population build up of *A.guerrreronis* in fourth, fifth and sixth bunches in four consecutive weeks

In another experiment, the population build up of *A. guerreronis* was studied under field conditions in March, 2001. Nuts from fourth, fifth and sixth bunches were sampled from labelled bunches. Total population of adult, nymph and eggs of *A. guerreronis* were taken by using the cellotape embedding technique. The data on population build up of *A. guerreronis* in fourth, fifth and sixth bunches during the first, second, third and fourth weeks of May 2001 are presented in Fig 2.

A steady increase in population of *A. guerreronis* in the three bunches during the four consecutive weeks could be observed. Adult population increased in the first two weeks, then began to decline in fourth week. Adult population was built up to eight fold in fourth week of May. More or less a similar trend was observed in the case of nymphal population also. But it was increased to significantly higher population levels up to 22 fold during the last week of observations. But egg population increased steadily from first week to third week and then decreased.

4.2 Experiment 2. Mite-host interactions and symptomatology

A series of laboratory and field investigations were conducted to study the mite host interactions. The colonies of the coconut mites congregated on the white tender portion covered by inner tepals of the perianth (Plate 5A) and sucked sap from the tender meristematic tissues. As shown in Plate 5B, a triangular white patch extend from the lower edge of the perianth. The triangular chlorotic patches appeared to be the extension of feeding area of meristematic tissue with pale creamy yellow colour. When the perianth is raised, feeding area appeared as a white patch with creamy white colony consisting of thousands of mites. Colony was visible through naked eye as a

Plate 5 – Feeding injury by mites leading to different symptoms of damage

A - Feeding area of a mite colony exposed by raising the perianth

B - Triangular creamy yellow patch extending from the edge of perianth

C & D - Feeding area with increasing shades of brown colour

E - Necrotic patch grown out of perianth

F - Necrotic patch with fissures and streaks

G - Y shape cut on husk in young nuts

H - Y shape cut on husk in mature nut

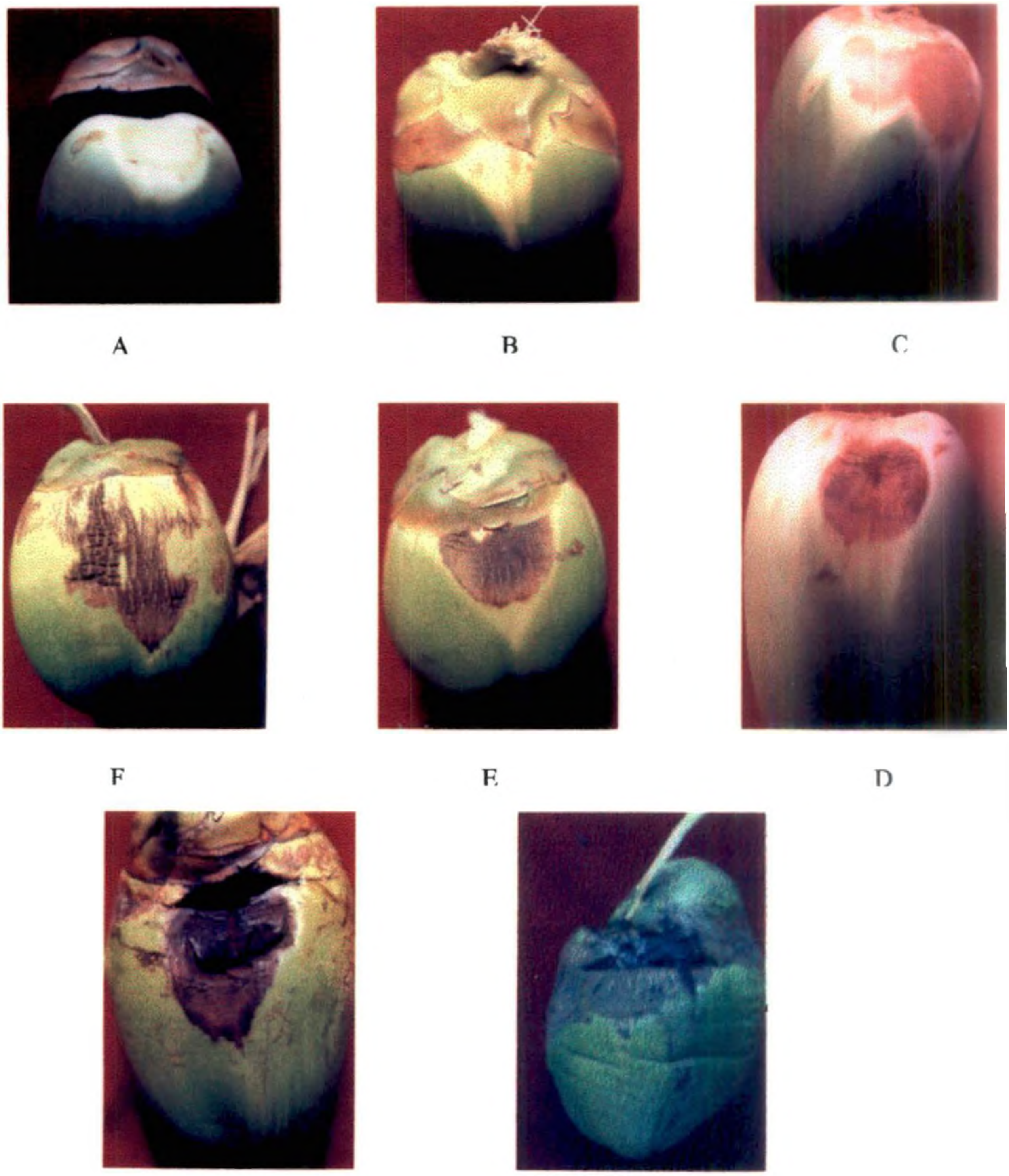


Plate 5. Feeding injury by mites leading to different symptoms of damage

powdery mass when the surface was viewed under direct sunlight keeping at a slightly tilted position. Colour of the feeding site changed to increasing shades of brownish patches (Plate 5C and 5D). As the patch became light brown in colour indicating cell death, the mites moved to the adjacent site (Plate 5C) and started a new colony. This resulted in the formation of few lesion which often coalesced to form contiguous patches. The more the number of mites per nut, the more was the number of feeding lesions under the perianth. As the nut grew, these lesions became necrotic patches and developed small fissures and streaks along the necrotic area (Plate 5E). Then these brown necrotic patches enlarged and covered almost the entire length of the affected nut. The damaged epidermis became crackled and deep fissures were formed later on the exocarp (Plate 5F). Due to the gradual drying of the tissues of coconut, the enlargement of the nut is affected leading to drastic reduction in size of the coconut and copra.

In rare cases, a characteristic T or Y shaped cut near perianth region could be seen on both young and mature nuts (Plate 5G and 5H).

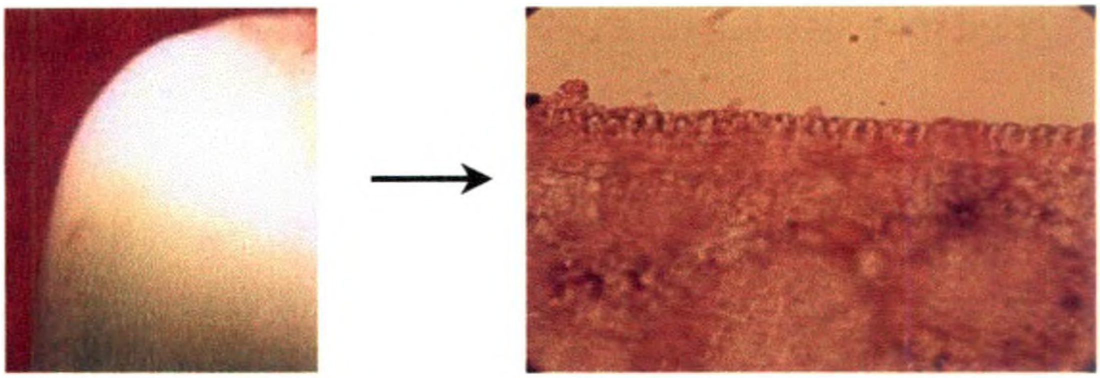
4.3 Experiment 3. Histopathology

Photomicrographs showing histology of meristematic zone of healthy and infested nuts are presented in Plate 6A and Plate 6B respectively. As it is clear in the photographs, epidermal layer is the feeding area of mite colony. This also indicated that once the epidermal layer became necrotic, showing slight browning of the

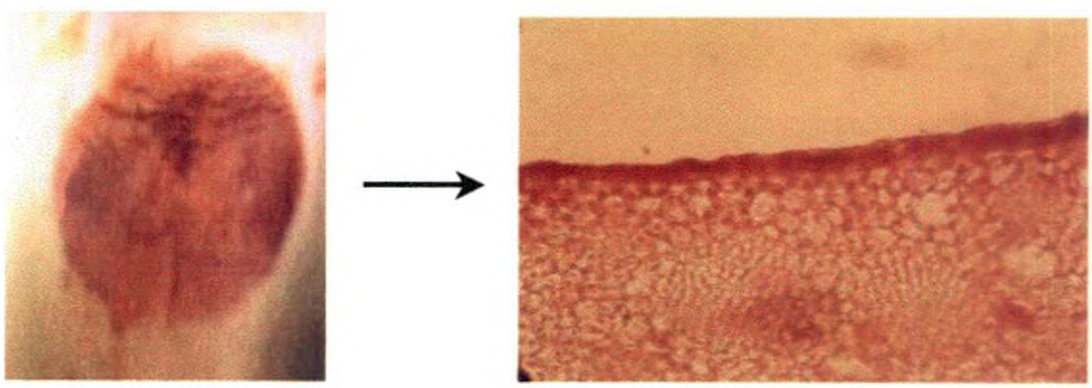
Plate 6 – Histology of meristematic zone of young nuts with different degree of feeding injury

A - Section of a meristematic zone of a healthy tissue.

B - Section of a meristematic zone of an infested tissue.



A



B

Plate 6. Histology of meristematic zone of young nuts with different degree of feeding injury.

feeding site, the colony vacated the area and established a new colony at the adjacent zone.

4.4 Experiment 4. Preliminary evaluation of coconut palms (WCT and Komadan) for identification of tolerant and susceptible types.

Fifteen palms each of WCT and Komadan were selected for preliminary evaluation in order to identify at least four palms under tolerant and susceptible categories. Observations were made from mature nuts in two harvests from these palms (March 2000 and May 2000). The data on the damage intensity of the nuts harvested during March and May 2000 in varieties WCT and Komadan presented in Table 3a and 3b, showed that the mite infestations caused significant damage in terms of percentage of nuts coming under the categories causing significant damage, 3, 4 and 5.

The increased number of nuts in the damage categories (3, 4 and 5) demonstrated a high rate of susceptibility to infestation of coconut eriophyid mite. With in the two varieties, those palms that had greater than 25 per cent of the nuts falling in category 3, 4 and 5 were selected as susceptible and those with less than 25 per cent of nuts falling in the above categories were selected as tolerant.

Based on the above criteria (Table 3a and 3b), the palms numbered C 329, C 396, C 472 and C 1054 in the variety WCT and D 19, D 43, D 1, D 422 in Komadan were selected as susceptible and the palms C 260, C 362, C 277 and C 278 in WCT and D 3, D 2, D 51 and D 113 in Komadan were treated as tolerant.

Table 3a. Preliminary evaluation of coconut palms for identification of tolerant and susceptible palms (WCT)

Sl. No.	Palms	Months of harvest	Percentage of nuts in damage categories					% of nuts in 1 & 2	% of nuts in 3,4 & 5
			1	2	3	4	5		
	WCT								
1	C 245	March	32	58	0	10	0	90	10
		May	47	41	6	6	0	88	12
2	C 255	March	20	60	20	0	0	80	20
		May	50	30	20	0	0	80	20
3	C 260	March	80	20	0	0	0	100	0
		May	25	65	0	0	0	90	10
4	C 265	March	50	25	0	25	0	75	25
		May	70	0	10	20	0	70	30
5	C 276	March	14	43	14	14	14	58	42
		May	25	25	25	25	0	50	50
6	C 277	March	33	34	0	33	0	67	33
		May	14	43	14	14	14	58	42
7	C 278	March	80	10	10	0	0	90	10
		May	50	40	10	0	0	90	10
8	C 279	March	90	10	0	0	0	100	0
		May	24	76	0	0	0	100	0
9	C 316	March	4	50	25	5	10	60	40
		May	96	0	4	0	0	96	4
10	C 327	March	96	0	4	0	0	96	4
		May	75	25	0	0	0	100	0
11	C 329	March	40	20	20	20	0	60	40
		May	56	24	0	10	10	80	20
12	C 362	March	72	28	0	0	0	100	0
		May	92	8	0	0	0	100	0
13	C 396	March	4	58	26	4	8	62	38
		May	14	42	14	14	14	56	44
14	D 472	March	33	34	0	33	0	67	33
		May	17	0	75	8	0	17	83
15	C1054	March	75	0	0	17	8	75	25
		May	63	0	12	25	0	63	37

Table 3b. Preliminary evaluation of coconut palms for identification of tolerant and susceptible palms (Komadan)

Sl. No.	Palms	Months of harvest	Percentage of nuts in damage categories					% of nuts in 1 & 2	% of nuts in 3,4 & 5
			1	2	3	4	5		
	Komadan								
1	D-1	March	80	20	0	0	0	100	0
		May	50	50	0	0	0	100	0
2	D-3	March	65	35	0	0	0	100	0
		May	80	20	0	0	0	100	0
3	D-2	March	10	85	0	5	0	95	5
		May	4	42	17	25	13	46	54
4	D-17	March	25	50	25	0	0	75	25
		May	50	50	0	0	0	100	0
5	D-18	March	40	40	20	0	0	80	20
		May	25	50	25	0	0	75	25
6	D-19	March	22	50	0	14	14	72	28
		May	5	37	37	16	5	42	58
7	D-43	March	67	0	15	18	0	67	33
		May	36	57	0	7	0	93	7
8	D-51	March	50	50	0	0	0	100	0
		May	60	30	10	0	0	90	10
9	D-57	March	50	25	15	0	0	75	25
		May	14	29	43	14	0	43	57
10	D-40	March	75	20	0	5	0	95	5
		May	50	25	25	0	0	75	25
11	D 113	March	70	30	0	0	0	100	0
		May	75	25	0	0	0	100	0
12	D 126	March	20	40	25	15	0	60	40
		May	40	20	0	20	20	60	40
13	D 422	March	20	60	0	20	0	80	20
		May	40	20	0	20	20	60	40
14	D 49	March	50	20	30	0	0	70	30
		May	40	40	20	0	0	80	20
15	D 94	March	80	10	10	0	0	90	10
		May	50	40	0	10	0	90	10

4.5 Experiment 5. Study of population dynamics of *A. guerreronis* in susceptible and tolerant types of WCT and Komadan

The palms selected under Experiment 4 representing susceptible and tolerant types of WCT and Komadan were observed for a period of one year from February 2000. Total population of mite was estimated in nuts sampled from fourth, fifth and sixth bunches in every month, in order to study the monthly variation and influence of variety, susceptibility and age of bunch on population dynamics.

4.5.1 Monthly variation in different bunches of susceptible and tolerant types of WCT and Komadan

Monthly variation in the population of *A. guerreronis* in nuts sampled from fourth, fifth and sixth bunch of tolerant and susceptible types of WCT is presented in Table 4a. In fourth bunch of susceptible types the population ranged from 1338 to 4615 mites per nut. The highest population was noticed during March (4615), which was significantly different from the other months, and it was followed by February (3475), June (3381), August (3271) and October (2728). Lowest population was observed in September with a mean population of 1338. In tolerant types of WCT, the population was significantly lower and it ranged from 120 to 1888 mites per nut only. Considering the monthly variation in population, a more or less similar trend was observed in the same bunch in tolerant type though numerically the population level was much less. The highest population was noticed during March (1888) followed by

February (1359), January (969) and June (948). However the lowest population was observed in September with a mean population of only 120 mites per nut.

Contradictory to the population in fourth bunch, the highest population of *A. guerreronis* was noticed in the fifth bunch during October (7233) followed by January (6029), March (5723), February (5679), April (5014), August (4791) and May (3687). Significantly lower population was noticed in November (1673) which came on par with those in December (1768) and July (2385). However in the fifth bunch of tolerant palms, the highest population was noticed in March (2349) which was followed by October (2079) and February (1811). Lowest population was observed in December (968).

In the sixth bunch of susceptible types, the population level was significantly lower than in other bunches. Highest population was observed in April (1315) followed by May (1208). Lowest population was observed in November (306). However in tolerant type, highest population was observed one month before *ie.*, in March (599) and lowest in September (218).

The data on monthly variations in the population of *A. guerreronis* in fourth, fifth and sixth bunch of susceptible and tolerant types of Komadan are presented in Table 4b.

Significantly higher population was noticed during August in fourth bunch of susceptible (4896) and tolerant (2553) types followed by January (4825, 2301). Lower population was noticed in July (441) in susceptible types. However in tolerant types, lower population was noticed in May (272).

Table 4a. Monthly variation in population of *A. guerreronis* in susceptible and tolerant types of WCT

Months of observation	Mean population from four palms each in nuts sampled from three bunches					
	Fourth bunch		Fifth bunch		Sixth bunch	
	Susceptible	Tolerant	Susceptible	Tolerant	Susceptible	Tolerant
Feb	3475	1359	5679	1811	1103	413
Mar	4615	1888	5723	2349	634	599
Apr	1933	381	5014	1620	1315	315
May	2697	897	3687	1603	1208	574
Jun	3381	948	2774	1548	675	299
Jul	1485	762	2385	1514	629	288
Aug	3271	751	4791	1401	1025	423
Sep	1338	120	3380	1521	480	218
Oct	2728	167	7233	2079	620	472
Nov	1619	237	1673	1343	306	283
Dec	1354	191	1768	968	598	265
Jan	2229	969	6029	1714	931	293.5

CD (0.05) = 804.9

Table 4b. Monthly variation in population of *A. guerreronis* in susceptible and tolerant types of Komadan

Months of observation	Mean population from four palms each in nuts sampled from three bunches					
	Fourth bunch		Fifth bunch		Sixth bunch	
	Susceptible	Tolerant	Susceptible	Tolerant	Susceptible	Tolerant
Feb	3019	1661	2830	1429	1050	711
Mar	2202	1502	1146	1614	479	454
Apr	1205	1257	2761	2260	1888	1672
May	665	272	2293	1711	2739	1658
Jun	1512	1869	3853	2994	1024	943
Jul	441	618	2556	1977	1260	1393
Aug	4896	2553	2099	2716	2698	2175
Sep	1440	1041	4327	2867	1465	1302
Oct	3036	1729	2005	1601	1933	1755
Nov	1028	823	1821	1482	805	389
Dec	2311	1943	972	1694	1225	1149
Jan	4825	2301	3174	2685	1400	414

CD (0.05) = 759.96

But in fifth bunch, significantly higher population was observed in September (4327) followed by June (3853), January (3174), February (2830), July (2556) and August (2099) in susceptible type. In tolerant types, the highest population was observed in June (2994) followed by September (2867), August (2716), January (2685), April (2260), July (1971) and May (1711). However lowest population was in December (972) in susceptible types and it was in February (1429) in tolerant type. These observations were contradictory to the population levels observed in fourth bunch.

In sixth bunch of susceptible type, higher population was observed in May (2739) followed by August (2698) but in tolerant type, higher population was in August (2175) followed by October (1755) and April (1672).

Fig. 3, shows three clear peaks in March, August and October in fourth and fifth bunch in susceptible type of WCT. But in tolerant type, only two peaks were observed in March and October.

Three peak population in June, August and October were observed in fourth bunch of susceptible as well as in tolerant types of Komadan. Where as in fifth bunch, peak population was observed in April, June and September in both susceptible and tolerant types of Komadan. (Fig. 4)

The pooled data on population in susceptible and tolerant types of WCT and Komadan by taking the mean of population in fourth, fifth and sixth bunches of each palm are presented in Table 5.

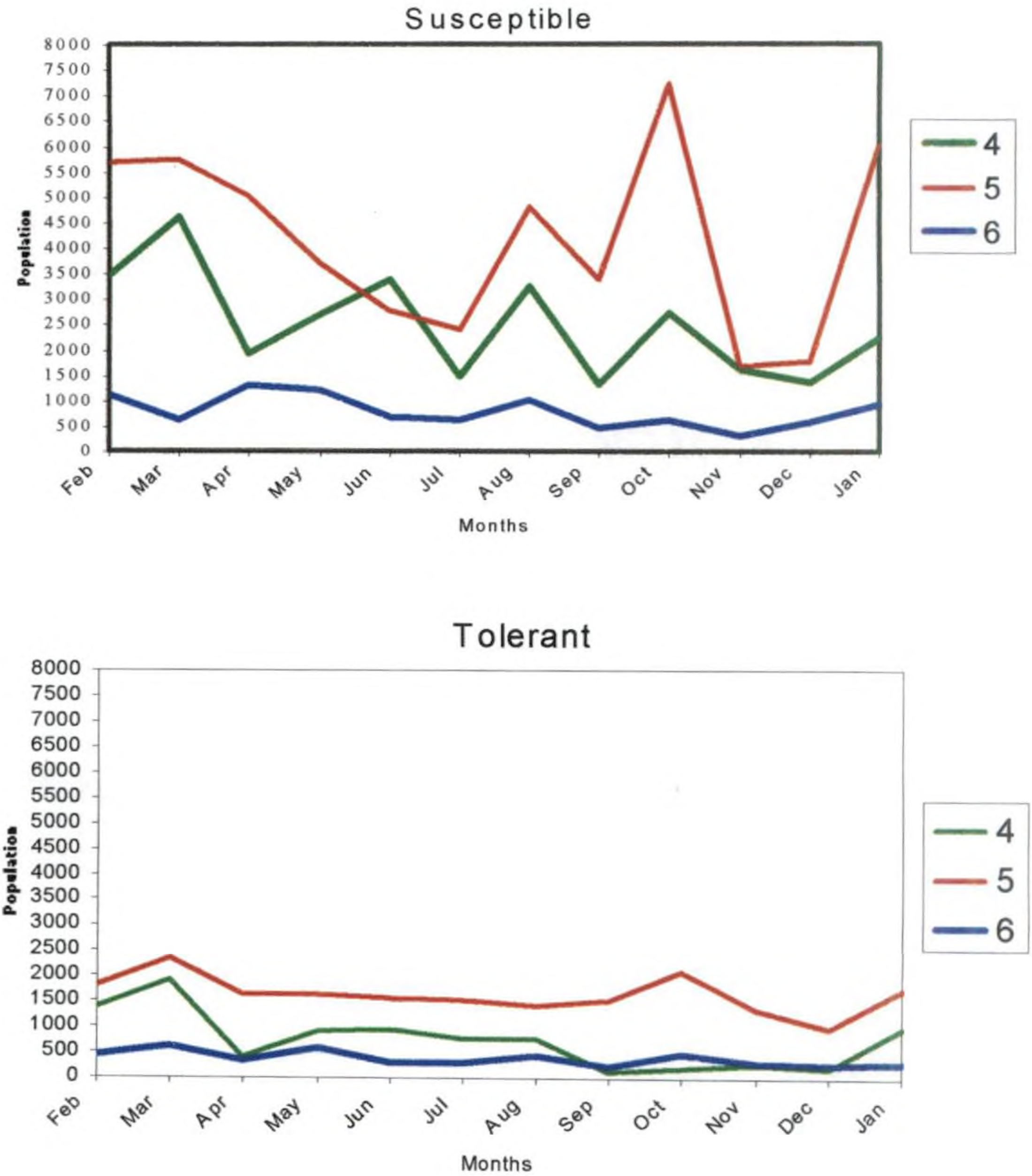


Fig. 3. Population of *A.guerreronis* in nuts sampled from fourth, fifth and sixth bunches in different months (2000-2001) in susceptible and tolerant types of WCT

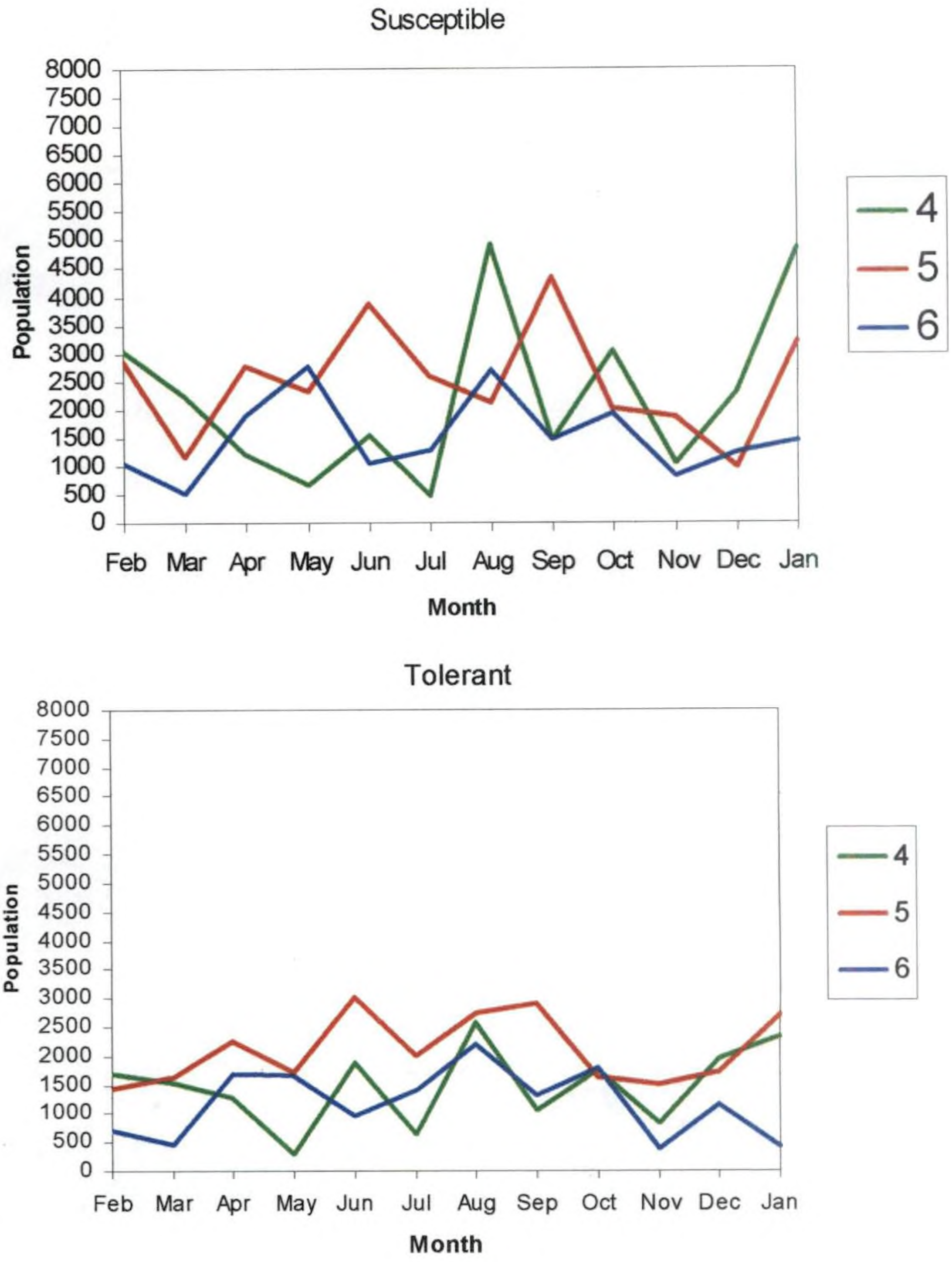


Fig. 4. Population of *A.guerreronis* in nuts sampled from fourth, fifth and sixth bunches in different months (2000-2001) in susceptible and tolerant types of Komadan

Table 5. Population of *A. guerreronis* in susceptible and tolerant types of WCT and Komadan

Month	WCT		Komadan	
	Susceptible	Tolerant	Susceptible	Tolerant
February	3419	1194	2300	1267
March	3658	1612	1275	1190
April	2754	772	2300	1729
May	2531	1025	1899	1213
June	2277	932	2129	1935
July	1499	854	1419	1329
August	3029	859	3231	2480
September	1733	620	2411	1736
October	3527	906	2325	1695
November	1199	621	1218	898
December	1240	474	1503	1595
January	3063	992	3133	1800
	CD (0.05) = 464.74		CD (0.05) = 437.03	

In the susceptible type of WCT, significantly higher population of *A. guerreronis* was noticed in March (3658) followed by October (3527) and February (3419). Population was lower in November (1199) which came on par with those in December (1240), July (1499) and September (1733). Similar to susceptible types, in tolerant palms also, highest population was noticed in March (1612) followed by February (1194), May (1025) and January (992). Significantly lower population was noticed in December (474) which came on par with September (620), November (621), April (772), July (854), August (859), October (906) and June (932).

In susceptible types of Komadan, highest population was observed in August (3231), and it followed a different trend when compared with the observations in WCT. It was followed by populations in January, September, October, April, February, June and May having populations 3133, 2411, 2375, 2300, 2300, 2129 and 1899 respectively. Lowest population was noticed in November (1218) which came on par with March (1275), July (1419) and December (1503). Similar to susceptible types, highest population was observed in August (2480) in tolerant types followed by June (1935), January (1800), September (1736), April (1729), October (1695) and December (1595). The lowest population was observed in November (898) which came on par with March (1190), May (1213), February (1267) and July (1329).

Results of pooled data on population dynamics in WCT and Komadan by taking the mean of populations with respect to tolerant and susceptible types within a variety are presented in Fig. 5.

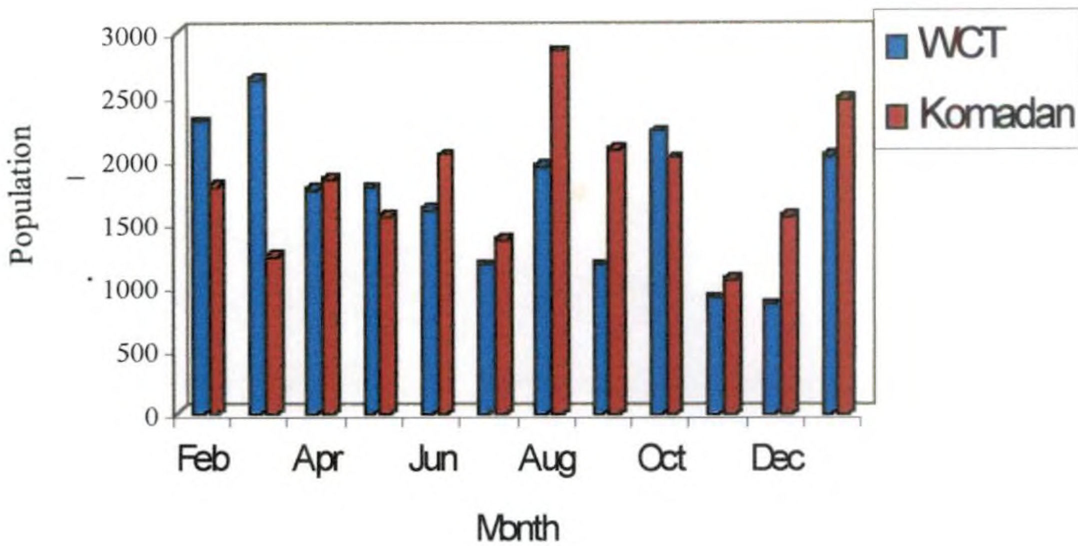


Fig. 5. Monthly variation of the population of *A.guerreronis* in WCT and Komadan by taking the pooled mean of observations in nuts sampled from three bunches

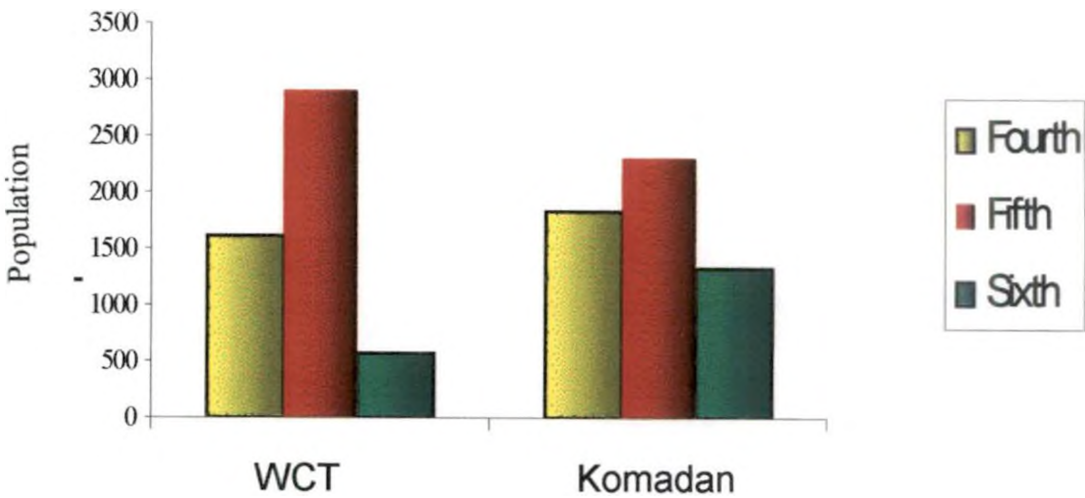


Fig. 6. Mean population of *A.guerreronis* in nuts sampled from fourth, fifth and sixth Bunches of WCT and Komadan by taking the pooled mean of observations in susceptible and tolerant types

In the variety WCT, highest population irrespective of susceptibility of the palms was observed during March (2635) followed by February (2307), October (2216), January (2028), August (1944), May (1778), April (1763) and June (1604). However, significantly lower population was observed during December (857) which came on par with November (910), September (1176) and July (1177).

In the variety Komadan, highest population was observed in August (2856) which was followed by January (2466), September (2073), June (2032), October (2010), April (1840), February (1783), May (1556), December (1546) and July (1374). Lowest population was noticed during November (1058) which came on par with March (1232).

4.5.2 Influence of bunches in population build up of *A. guerreronis*

The pooled mean population of *A. guerreronis* over the different months in fourth, fifth and sixth bunch of susceptible and tolerant types of WCT and Komadan are presented in Table 6.

Table 6. Population of *A. guerreronis* in nuts sampled from fourth, fifth and sixth bunches of WCT and Komadan in tolerant and susceptible types

Bunches	WCT		Komadan	
	Susceptible	Tolerant	Susceptible	Tolerant
Fourth (60-70 DAF)	2510	723	2215	1464
Fifth (80-90 DAF)	4178	1622	2486	2086
Sixth (110-120 DAF)	794	370	1497	1168
	CD (0.05) = 332.36		CD (0.05) = 218.51	

DAF: Days after flowering (opening of the spadix)

The table showed highly significant differences among the population of *A. guerreronis* in nuts sampled from fourth, fifth and sixth bunches in the susceptible and tolerant types of WCT and Komadan. Significantly higher population was observed in the fifth bunch in both susceptible and tolerant types of WCT (4178, 1622) and Komadan (2486, 2086) followed by the fourth bunch. Significantly lower population was noticed in sixth bunch in susceptible and tolerant types of WCT and Komadan having populations 794, 370 and 1497, 1168 respectively.

The data showing pooled values of population in susceptible and tolerant types of WCT and Komadan presented in Fig. 6 also showed significantly higher population in the fifth bunch of WCT and Komadan followed by fourth and sixth bunches.

4.5.3 Correlation studies between population and weather parameters

The data on population of *A. guerreronis* in susceptible and tolerant types of WCT and Komadan was correlated with weather parameters *viz.* relative humidity, temperature and rainfall and the results are presented in Table 7.

Weather parameters like relative humidity and temperature prevailed at the time of mite entry (25-35 DAF), average relative humidity, temperature and rainfall during critical growth period of the three young bunches were correlated with the population.

Perusal of the data indicated that population in susceptible type of Komadan had a positive correlation with relative humidity at the time of mite entry (0.3761)

Table 7. Correlation between population of *A. guerreronis* in tolerant and susceptible types of WCT and Komadan and weather parameters

	Population in tolerant type of WCT X_1	Population in susceptible type of WCT X_2	Population in tolerant type of Komadan X_3	Population in susceptible type of Komadan X_4	R.H. at the time of mite entry Y_1	Temp. at the time of mite entry Y_2	Total R.F. at the time of mite entry Y_3	Average R.H. during growth period Y_4	Average temp. during growth period Y_5	Average R.F. during growth period Y_6
Population in tolerant type of WCT X_1	1.0000									
Population in susceptible type of WCT X_2	0.8634	1.0000								
Population in tolerant type of Komadan X_3	0.4516	0.4617	1.0000							
Population in susceptible type of Komadan X_4	0.3300	0.3663	0.8068	1.0000						
R.H. at the time of mite entry Y_1	0.2544	0.2536	0.2322	0.3761	1.0000					
Temp. at the time of mite entry Y_2	0.0355	-0.0409	0.0537	-0.2229	-0.4314	1.0000				
Total R.F. at the time of mite entry Y_3	-0.0557	-0.0665	0.0988	-0.1548	-0.0062	-0.5650	1.0000			
Average R.H. during growth period Y_4	0.0955	0.1566	-1.1548	0.1133	0.4266	-0.6458	0.3118	1.0000		
Average temp. during growth period Y_5	-0.1953	0.0725	-0.1141	-0.2077	0.2362	0.5271	-0.4863	-0.4390	1.0000	
Average R.F. during growth period Y_6	-0.2987	-0.1949	0. 1610	0.1036	-0.3791	-0.3081	0.4560	0.0316	-0.8108	1.0000

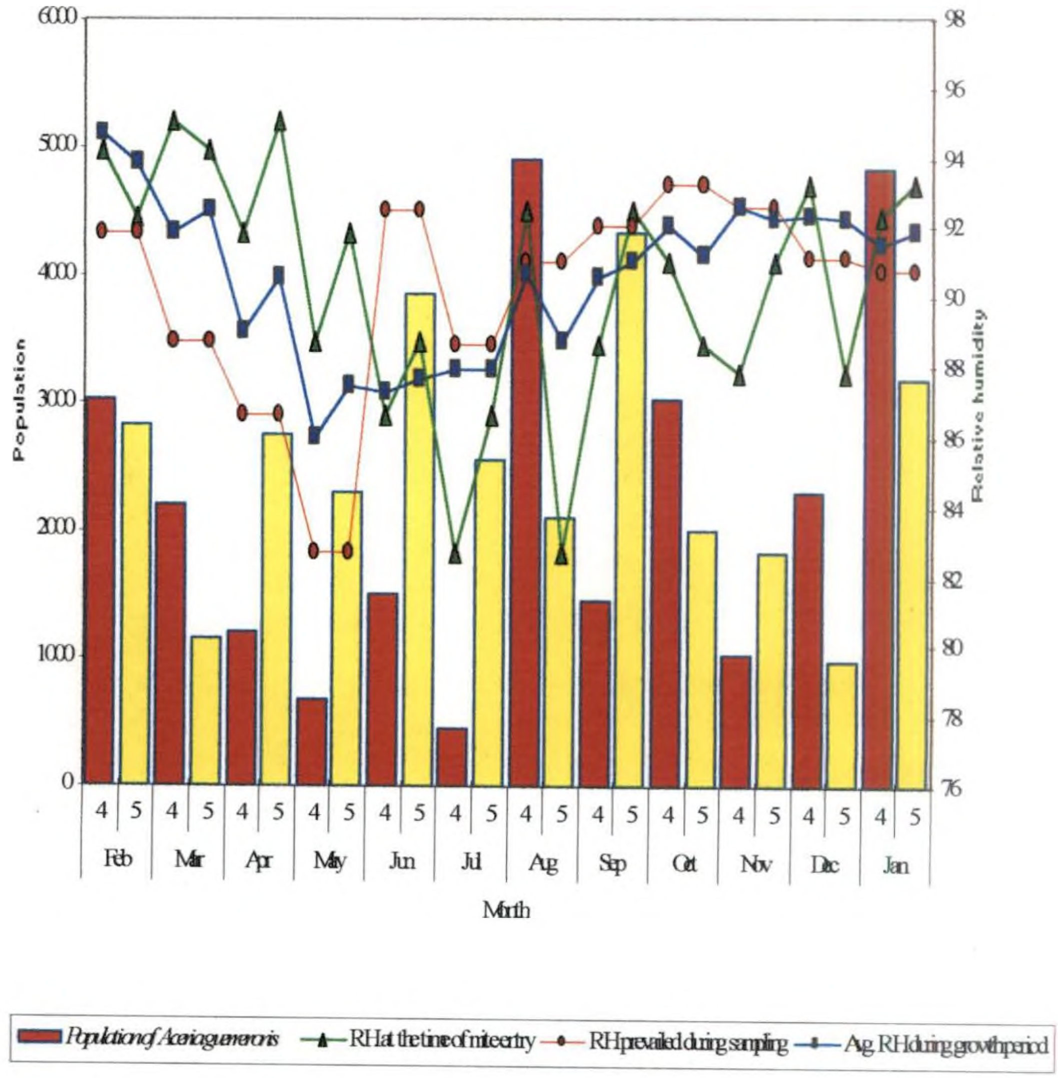
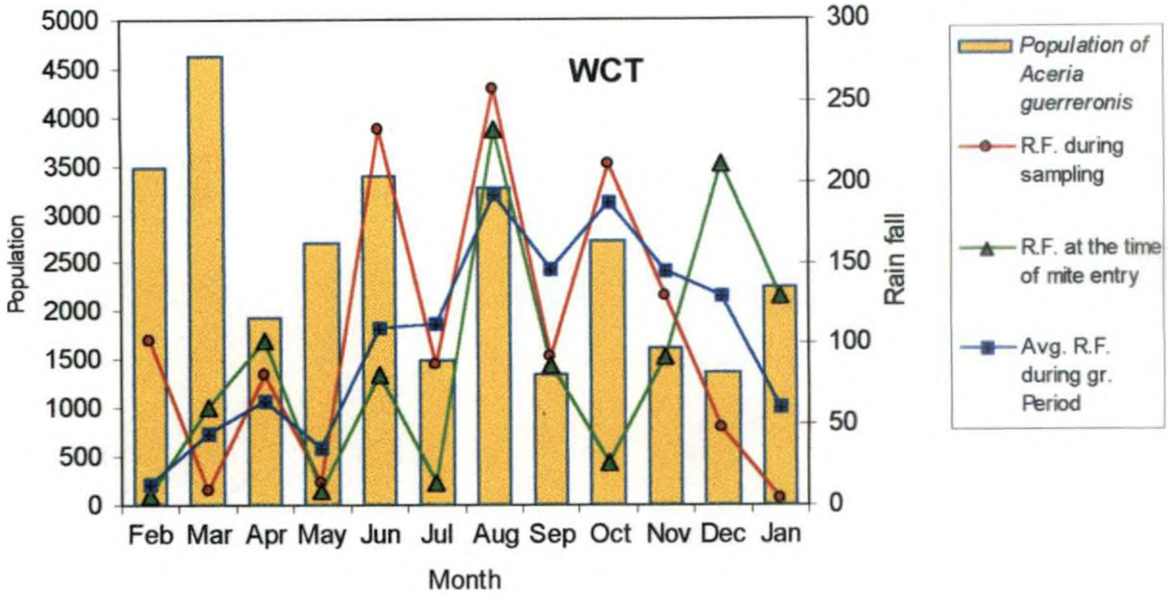


Fig. 7. Population of *A.guerreronis* in 4th and 5th bunches of susceptible type of Komadan as influenced by relative humidity



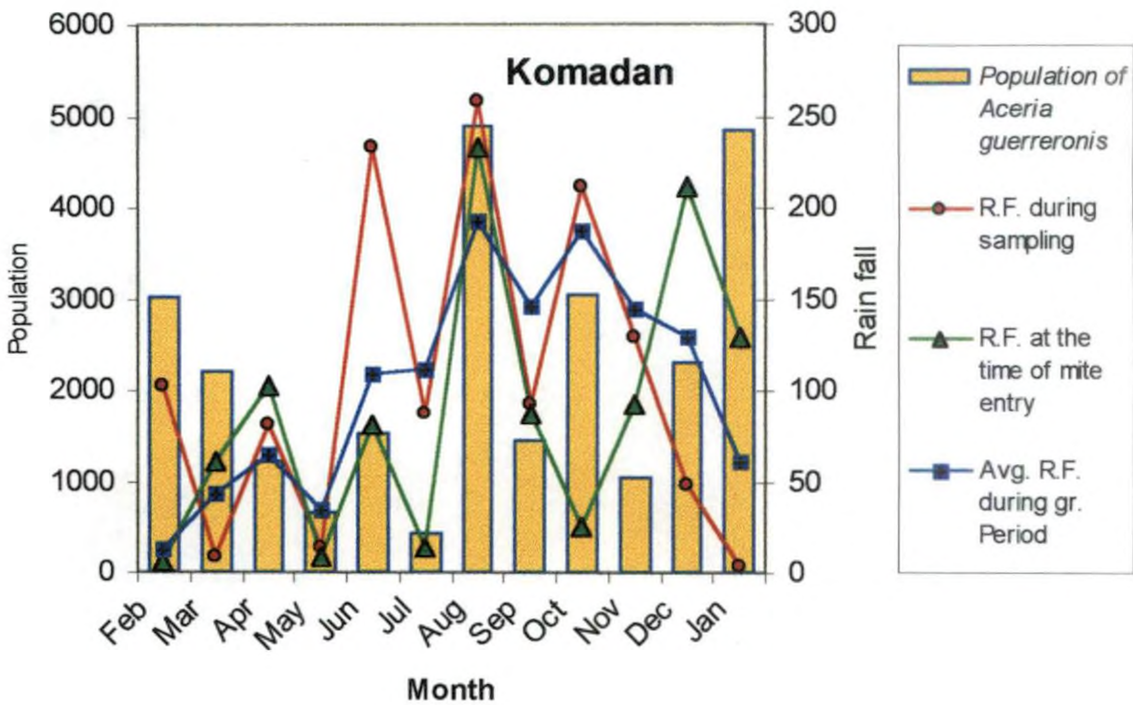
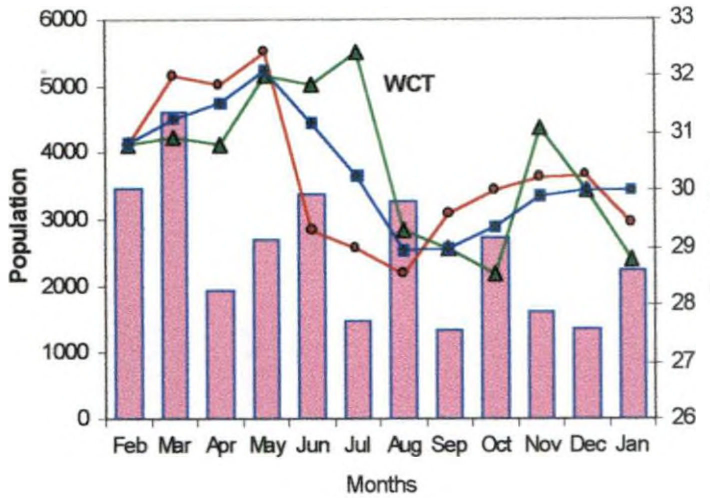


Fig. 8a. Population of *A.guerreronis* in susceptible types of WCT and Komadan as influenced by rainfall



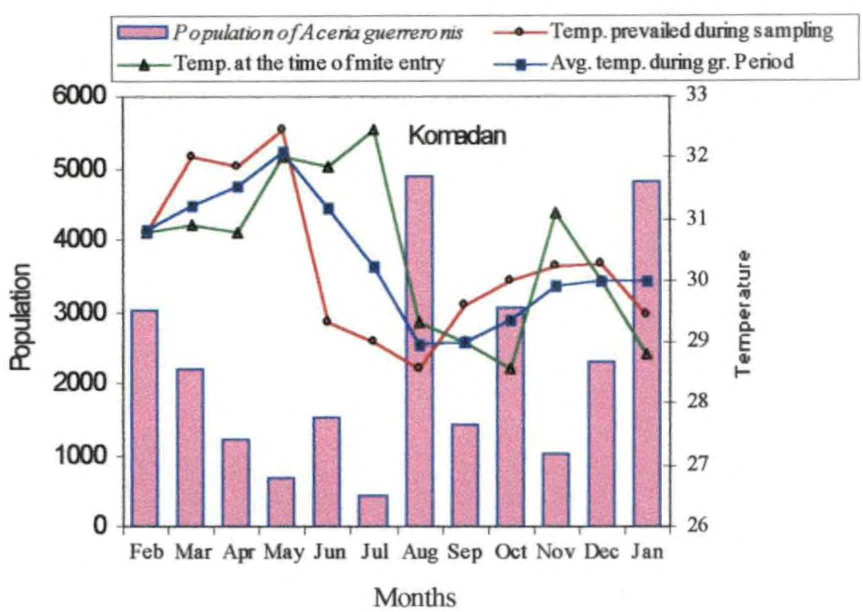


Fig. 8b. Population of *A.guerreronis* in susceptible types of WCT and Komadan as influenced by temperature

(Fig. 7). A slight negative association was noticed between population and average rainfall during growth period in WCT and Komadan (Fig. 8a). None of the other did not have any significant influence on the population build up of *A. guerreronis* (Fig. 8b)

4.6 Experiment 6: Investigation on the morphological characters of the nut and their influence on extent of damage by coconut eriophyid mite

4.6.1 Length of coconut

Data on the per cent reduction in length of coconut due to infestation of *A .guerreronis* observed in ten harvests in five popular cultivar *viz.*, WCT, Komadan, LO, DO and T x YD are given in Table 8.

Harvest done during March 2000 indicated that, highest percentage reduction in length was observed in WCT (26.14), which came on par with Komadan (24.02), and LO (19.77). However, lower per cent reduction in length was observed in T x YD (7.36) followed by DO (11.40). Similar trend was observed in May 2001 harvest among varieties WCT, Komadan, LO, DO and T x YD with per cent reduction in length of nuts 20.25, 14.01, 11.89, 8.76 and 13.06 respectively.

4.6.2 Circumference of coconut

The data showing per cent reduction in circumference of coconut in ten harvests in five coconut varieties *viz.*, WCT, Komadan, LO, DO and T x YD are presented in Table 9.

Table 8 : Mean per cent reduction in length of harvested nut category 3, 4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall (WCT)	26.14 (5.21)	10.40 (3.38)	17.97 (4.36)	7.91 (2.99)	14.30 (3.91)	14.52 (3.94)	12.20 (3.63)	17.97 (4.36)	20.25 (4.61)	29.56 (5.53)
2. Komadan	24.02 (5.00)	17.13 (4.26)	15.51 (4.06)	14.73 (3.97)	9.44 (3.23)	17.22 (4.27)	10.91 (3.45)	16.01 (4.12)	14.01 (3.88)	25.62 (5.16)
3. Laccadive ordinary (LO)	19.77 (4.56)	17.10 (4.25)	13.92 (3.86)	14.06 (3.88)	10.92 (3.45)	12.35 (3.65)	11.18 (3.49)	15.29 (4.04)	11.89 (3.59)	23.38 (4.94)
4. Dwarf orange (DO)	11.40 (3.52)	19.00 (4.47)	12.80 (3.72)	9.74 (3.28)	12.32 (3.65)	10.59 (3.40)	11.15 (3.49)	10.14 (3.34)	8.76 (3.12)	28.19 (5.40)
5. Tall x Yellow Dwarf (T x YD)	7.36 (2.89)	19.55 (4.53)	11.33 (3.51)	12.07 (3.62)	17.26 (4.27)	12.76 (3.71)	19.88 (4.57)	17.01 (4.24)	13.06 (3.75)	30.75 (5.64)
F	(8.76*)	(1.40)	(0.861)	(2.13)	(1.34)	(0.83)	(2.58)	(2.34)	(4.37*)	(1.56)
CD (0.05)	1.01	NS	NS	NS	NS	NS	NS	NS	0.77	NS

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

Table 9 : Mean per cent reduction in circumference of harvested nuts in category 3, 4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000	May-2000	Jul-2000	Aug-2000	Oct-2000	Dec-2000	Jan-2001	Mar-2001	May-2001	Jul-2001
	1	2	3	4	5	6	7	8	9	10
1. West Coast Tall (WCT)	24.00 (5.00)	20.14 (4.60)	24.43 (5.04)	15.48 (4.06)	18.30 (4.39)	17.79 (4.33)	16.48 (4.18)	22.59 (4.86)	19.86 (4.57)	24.95 (5.09)
2. Komadan	26.49 (5.24)	20.66 (4.65)	25.96 (5.19)	16.89 (4.23)	16.03 (4.13)	24.29 (5.03)	16.32 (4.16)	19.07 (4.48)	18.98 (4.47)	28.80 (5.46)
3. Laccadive ordinary (LO)	13.17 (3.76)	22.73 (4.87)	19.74 (4.55)	23.73 (4.97)	15.21 (4.03)	21.93 (4.79)	18.34 (4.40)	18.40 (4.41)	15.99 (4.12)	26.99 (5.29)
4. Dwarf orange (DO)	8.58 (3.10)	18.78 (4.45)	11.30 (3.51)	10.93 (3.45)	12.77 (3.71)	12.41 (3.66)	19.79 (4.56)	17.14 (4.26)	11.21 (3.49)	19.32 (4.51)
5. Tall x Yellow Dwarf (T x YD)	8.53 (3.09)	22.62 (4.86)	23.76 (4.98)	14.85 (3.98)	14.88 (3.98)	11.10 (3.48)	17.96 (4.36)	18.70 (4.47)	20.44 (4.63)	25.61 (5.16)
F	(31.03*)	(0.76)	(3.95*)	(3.44*)	(0.26)	(10.92)	(0.27)	(1.02)	(3.73)	(19.80)
CD (0.05)	0.56	NS	1.03	0.89	NS	NS	NS	NS	NS	NS

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

Reduction in circumference of coconut was significantly different among varieties in six harvests done during March 2000, July 2000, August 2000, December 2000, May 2001 and July 2001.

In the harvest done during March 2000, the highest per cent reduction in circumference was observed in Komadan (26.49) followed by WCT (24.00). No significant variation in per cent reduction in circumference of coconut was observed in Komadan (25.96), WCT (24.43), T x YD (23.76) and LO (19.74) in the harvest done during July 2000. However, lowest reduction in circumference was observed in the variety DO (11.30), which was significantly lower than those in all other varieties. A more or less similar trend was observed in December 2000 and July 2001 harvests also.

Highest per cent reduction in circumference was observed in the variety LO (23.73) in August 2000 harvest which came on par with that in Komadan (16.89) and the lowest reduction in circumference was observed in DO (10.93).

Harvest done during May 2001 indicated that highest per cent reduction in circumference was in T x YD (20.44) followed by WCT (19.86), Komadan (18.98), LO (15.99) and DO (11.21).

4.6.3 Thickness of husk

The data on per cent reduction in thickness of husk in severely damaged nuts (Category 4 and 5) among five varieties WCT, Komadan, LO, DO and T x YD are presented in Table 10.

Table 10 : Mean percent reduction in thickness of husk in category 3, 4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall	15.59	23.88	21.72	17.92	14.68	26.59	16.37	15.16	19.29	25.22
(WCT)	(4.07)	(4.99)	(4.77)	(4.35)	(3.96)	(5.25)	(4.17)	(4.02)	(4.50)	(5.12)
2. Komadan	20.83	25.40	16.13	21.74	19.67	24.73	19.46	20.62	16.36	21.42
	(4.67)	(5.14)	(4.14)	(4.77)	(4.55)	(5.07)	(4.52)	(4.65)	(4.17)	(4.74)
3. Laccadive ordinary	20.48	23.08	18.33	21.31	14.24	31.80	21.18	18.19	9.84	11.37
(LO)	(4.61)	(4.91)	(4.40)	(4.72)	(3.90)	(5.73)	(4.71)	(4.38)	(3.29)	(3.52)
4. Dwarf orange	18.44	25.76	19.46	17.63	17.92	25.69	19.75	14.58	13.96	18.61
(DO)	(4.41)	(5.17)	(5.52)	(4.32)	(4.35)	(5.17)	(4.56)	(3.95)	(3.87)	(4.43)
5. Tall x Yellow Dwarf	20.25	19.52	21.18	21.72	22.91	19.07	28.59	7.20	14.84	18.13
(T x YD)	(4.61)	(4.53)	(4.71)	(4.77)	(4.89)	(4.48)	(5.44)	(2.86)	(3.98)	(4.37)
F	(1.39)	(2.23)	(0.67)	(0.73)	(1.38)	(4.02*)	(3.66*)	(5.90*)	(1.18)	(3.69*)
CD (0.05)	NS	NS	NS	NS	NS	0.67	0.73	0.84	NS	0.93

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

Significant variation with respect to reduction in thickness was observed among the varieties in four harvests done during December 2000, January 2001, March 2001 and July 2001.

No significant variation in per cent reduction in thickness of husk was observed in LO (31.80), WCT (26.59) and DO (25.69) in December 2000 harvest. However, reduction in thickness of husk was lowest in T x YD (19.07) which came on par with Komadan (24.73).

Higher per cent reduction in thickness of husk was observed in T x YD (28.59) followed by LO (21.18), DO (19.75), Komadan (19.46) and WCT (16.37) in the harvest done during January 2001.

Next harvest done during March 2001 indicated that no significant variation existed in the reduction of thickness of husk in Komadan (20.62), LO (18.19), WCT (15.16) and DO (14.58). However, reduction in thickness of husk was least in T x YD (7.20) which was significantly different from others. A more or less similar trend was observed in July 2001 harvests among varieties WCT (25.22), Komadan (21.42), DO (18.61), T x YD (18.13) and LO (11.37).

4.6.4 Arrangement of tepals (bracts)

Coconut showed two types of tepals i.e., external and internal tepals. External tepal was on top of three inner tepals which were adpressed to the surface of the nut. On removing the perianth, it was clearly visible that tepal number four always overlapped the other tepals at both ends and tepal five overlapped at one end and the tepal six was overlapped at both ends.

Table 11. Location of initial colonisation of the mites indicated by symptoms extending from the tepals

Month of observation	Percentage of buttons having mite attack started from the edge of tepal	Percentage of buttons having mite attack initiated from middle of tepal
Feb	58	42
March	70	30
April	63	37
May	69	31
June	70	30
July	63	37
Aug	69	31
Sept	65	35
Oct	57	43
Nov	60	40
Dec	57	43
Jan	57	43

Based on the location of initial colonisation of the mites indicated by the triangular patch extending from the tepals, the buttons sampled every month for study of population dynamics were grouped into two, *viz.*, the colonisation started from the edge or from the middle of the tepals. The data presented in Table 11 indicated that in about two third of samples examined, mite infestation started from the edge where two tepals overlapped. Data revealed that mite infestation initiated from the edge of tepals in 57-70 % of sampled buttons while , in 30-42 % of buttons, infestation started from the middle of the tepal.

Table 12. Spatial distribution of *A. guerreronis* under each tepal in fifth bunch

Mean population of *A. guerreronis* under each tepal						
Month	**4th tepal**	**5th tepal**	**6th tepal**	**Between 4th & 5th tepal**	**Between 5th & 6th tepal**	**Between 4th & 6th tepal**
February	2427	0	0	3650	753	0
March	5620	750	1173	0	0	0
April	2510	2130	0	0	0	1997
May	750	180	0	2670	0	0
June	1045	0	0	0	0	2755
July	0	950	1050	800	0	0
August	160	0	0	0	0	4807
TOTAL	12512	4010	2223	7120	753	9559

Spatial distribution in mean population of *A. guerreronis* under different tepals in the fifth bunch is presented in Table 12. Colony under the fourth tepal had highest population with a mean total of 12512 mites observed in 15 nuts sampled in every month and it was followed by the population at the edge between fourth and sixth tepals with a mean total of 9559 mites. Population at the edge between fourth and fifth tepal was the next in rank with a mean total of 7120 mites and it was followed by the colony under tepal five was next higher with a mean total of 4010 mites.

4.6.5 Colour of nut

The data on susceptibility of the palms to coconut mite *A. guerreronis* as influenced by the variation in the colour of nuts is presented in Table 13.

Table 13. Influence of nut colour on the extent of damage by *A. guerreronis*

Sl.No	Colour of nut	Percentage of nuts in damage categories 4 and 5 in 10 harvests
1	Moderate brown	28.2
2	Moderate olive green	20.7
3	Greyish olive green	23
4	Dark brown	28.1

Moderate brown nuts had 28.2 per cent nuts coming under damaged categories, while greyish olive green nuts had 23 per cent damage. Nuts having moderate olive green colour had 20.7 per cent nuts in damaged categories and in dark brown nuts 28.1 per cent damage was observed. Data clearly indicated that there was no significant variation in susceptibility of nuts having different colour towards mite infestation.

4.6.6 Shape of nut

Data on the length to circumference ratios of young nuts as an index of their shape (elongated or round) and percentage of undamaged nuts are presented in Table 14.

There was a wide range of length to circumference ratios from the elongated (1:1.40) to the round nuts (1:2.29). The data presented in table 14, showed that 30 per cent of undamaged nuts came under the length to circumference ratios, 1: 1.40 to 1.59. However young nuts having length to circumference ratio 1: 1.60 to 1.69 suffered less damage than nuts with more circumference. Plate 7, represents the elongated and round nuts sampled from bunches one to nine of susceptible and tolerant palms.

Table 14. Length to circumference ratio of young nuts and percentage of undamaged nuts

Length : Circumference ratio	Total no. of young nuts	No.of undamaged nuts	Undamaged nuts (%)
Elongated nut			
1:1.40 – 1.59	120	36	30
1:1.60 – 1.69	72	18	25
Total	**192**	**106**	**55**
Round nuts			
1:1.90 – 2.09	144	110	76
1:2.10 – 2.29	48	38	80
Total	**192**	**148**	**77**

Rounded nuts with length to circumference ratio 1: 1.90 to 1: 2.09 suffered significantly low level of mite infestation with 76 per cent of undamaged nuts. The percentage of undamaged nuts was still higher (80 %) in the case of more round nuts with length to circumference ratio of 1:2.1 to 1:2.29. The length to circumference

Plate 7 – Nuts sampled from first to ninth bunches (in succession) of susceptible (elongated) and tolerant (round) palms representing periodic growth and development of nuts

ratios of nuts and the per cent of undamaged young nuts showed that the more round nuts the less will be the infestation by mites when compared with the elongated ones. Plate 8a and 8b, represents variability in susceptibility of nuts as influenced by shape of nuts. Of the 192 nuts each observed under the two categories representing round and elongated shapes, significantly higher percentage (71 %) of nuts having round shape were free from mite damage. While only 28 percent of the elongated nuts were free from damage.

4.6.7 Growth rate of nuts and its influence on expansion of scar leading to different damage categories

Growth rate of nuts and its influence on expansion of scar leading to different damage categories is presented in Table 15.

From the Table, it is evident that up to 82 per cent increase in length and breadth was noticed in the case of nuts coming under category 1 and 2, when they attained the age of ten months (after opening). However in categories 3, 4 and 5, growth rate of nuts was significantly lower in terms of percent increase in length and breadth which ranged from 69-79 % in length and 64-80 % in breadth. The growth rate of nuts was lowest in category 5 followed by category 4 and 3.

The development and expansion of feeding scars on the nuts was measured periodically and a pictograph (Fig. 9) was drawn to represent the growth of nuts and expansion of scars. Growth rate of nuts was more or less similar up to 5^{th} bunch in all damage categories. As is shown in the pictograph, significant reduction in length was evident from the eighth bunch onwards in nuts coming under category 4 and 5.

Plate 8a – Variability in susceptibility of nuts as influenced by shape of nut – round and elongated representing fourth, fifth and sixth bunches.

Plate 8b – Section of nuts to show the variability in shape representing fourth, fifth and sixth bunches.

Table 15. Percentage increase of length and breadth of nuts from different bunches representing five damage categories

	2nd month		3rd month		4th month		5th month		6th month		7th month		8th month		9th month		10th month		11th month		12th month	
Category	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B
Category 1	17	33	33	47	44	56	58	67	69	73	72	76	77	81	80	81	81	82	82	82	82	82
Category 2	17	33	33	47	44	56	57	60	69	68	72	76	77	80	80	81	81	82	82	82	82	82
Category 3	17	33	33	47	44	56	57	61	69	68	71	75	75	78	77	79	79	81	79	81	79	80
Category 4	17	33	33	47	44	56	57	58	67	61	69	62	69	64	71	64	72	68	72	68	72	68
Category 5	17	33	33	47	44	56	57	58	67	60	69	60	69	62	69	64	69	64	69	64	69	64

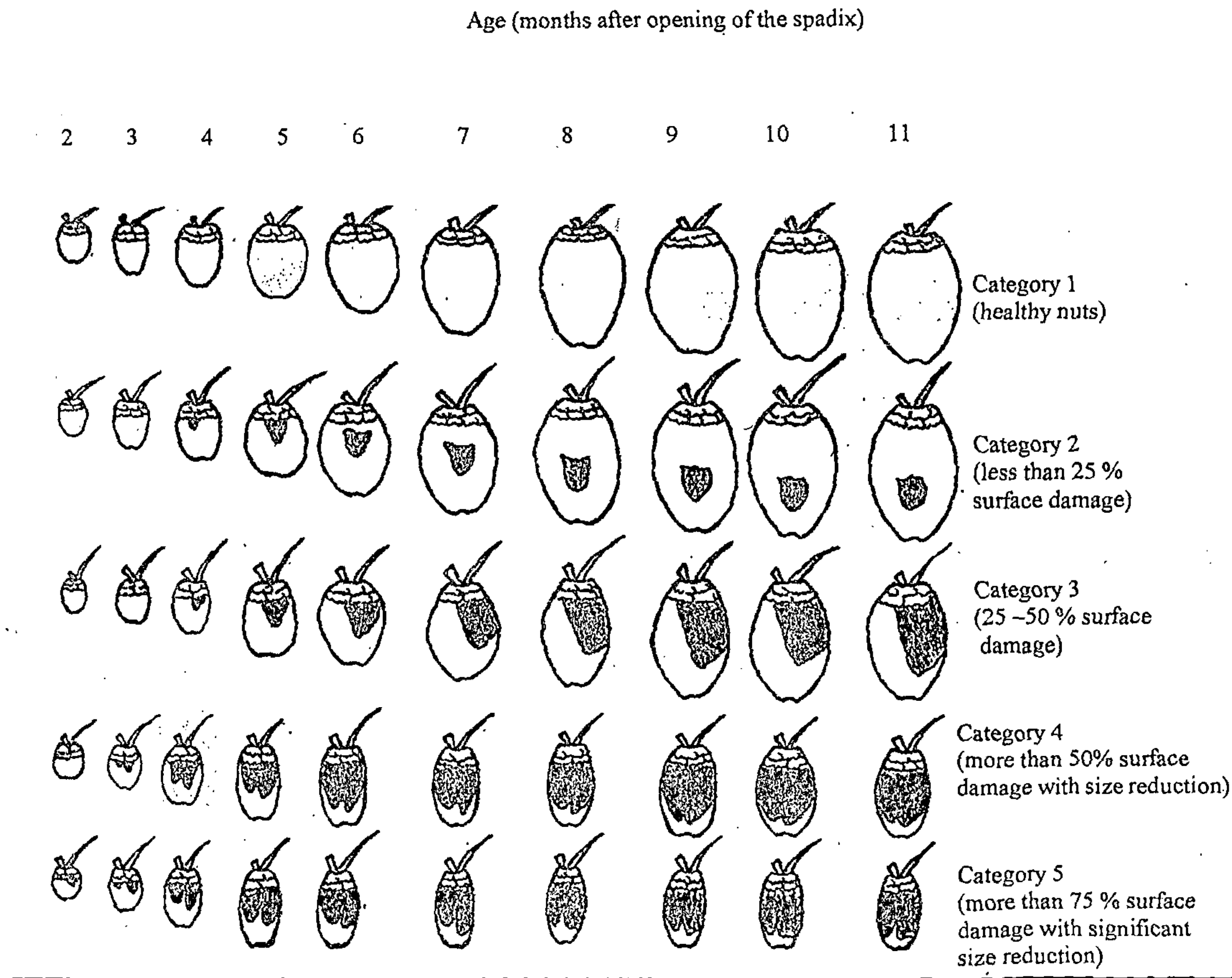
However, significant reduction in breadth was noticed even from fifth bunch onwards (Table 15 and Fig 9).

From Fig.9, it is clear that the growth rate was almost similar in nuts coming under category 1, 2 and 3 though surface damage by mite injury to a certain extent was visible in 2 & 3. Significant reduction in nut size was noticed in nuts coming under category 4 and 5 and the reduction was evident only after attaining the age of eight month onwards.

. As it is clearly shown in the pictograph, the severity of infestation was decided by the age of the nut at which the colonization of mites and feeding injury started. It was also seen that the infestation started as early as in one to one and half months stage (second bunch after opening) has led to the development of nuts into the damaged category 5 with greater than 75 per cent surface damage and significant size reduction. Had the infestation started later, *ie.* from third or fourth bunch stage, it was found to fall in the damage category 4 at harvest, with greater than 75 per cent surface damage. However, initial appearance of damage symptoms in later stages *ie.* fourth bunch or older bunches led to the development of damage category 2 or 3.

Nuts coming under categories 4 and 5 had 3 - 4 colonies in the fourth bunch stage itself, as indicated by the number of triangular marks (Fig. 9). Development of these colonies and their feeding injury resulted in the reduction of growth and these nuts fell in category 4 and 5. However, nuts coming under category 2 and 3 had only one or two colonies in the fourth or fifth bunch stage.

Fig. 9. Expansion of feeding scar on coconut due to injury by mites in relation to growth of nuts, leading to different damage categories



4.7 *Experiment 7:* *Assessment of yield loss in coconut cultivars due to infestation A. guerreronis.*

4.7.1 Assessment of extent of damage due to mite infestation based on data from ten harvests

The extent and level of mite attack in five coconut cultivars in ten harvests is presented in Table 16. Highest percentage of nuts in damage categories 3, 4 and 5 was observed in Komadan (43.08) followed by WCT (31.08), Lacadive Ordinary (26.64) and T x YD (22.12). Lowest percentage of nuts in damage categories was noticed in Dwarf Orange (15.84). Highest per cent of damage free nuts (Category 1 and 2) was in Dwarf Orange (84.16), which was followed by T x YD (77.88) and Lacadive Ordinary (73.36). Percentage of damage free nuts was lowest in Komadan with a mean per cent of 56.92.

Table 16. The percentage of nuts harvested in each damage category in different coconut cultivars (total nuts harvested in ten successive harvests: March 2000-July 2001)

Cultivars	Damage category					Total 1&2	Total 3,4&5
	1	2	3	4	5		
1. WCT	38	30.92	19	10.08	2.01	68.92	31.08
2. Komadan	30.02	26.6	18.76	14.98	9.34	56.92	43.08
3. Laccadive Ordinary	28.68	44.68	14.64	9.78	2.22	73.36	26.64
4. Dwarf Orange	51.12	33.04	9.76	6.08	0	84.16	15.84
5. T x YD	44.7	33.18	14.94	5.98	1.2	77.88	22.12

Table 17 : Mean per cent reduction in fresh weight of coconut in category 3, 4 and 5 over category 1 in five popular coconut varieties

Cultivars	Mar-2000 1	May-2000 2	July-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	March-2001 8	May-2001 9	July-2001 10
1. West Coast Tall (WCT)	23.42 (4.94)	30.50 (5.61)	43.35 (6.66)	35.95 (6.08)	30.75 (5.63)	31.09 (5.66)	22.25 (94.82)	25.94 (5.19)	24.77 (5.04)	38.36 (6.27)
2. Komadan	32.33 (5.77)	38.58 (6.29)	42.92 (6.63)	27.52 (5.34)	26.80 (5.27)	35.43 (6.04)	20.59 (4.65)	25.41 (5.14)	25.53 (5.15)	38.98 (6.32)
3. Laccadive ordinary (LO)	27.01 (5.29)	30.87 (5.65)	31.10 (5.67)	31.78 (5.73)	35.00 (6.00)	27.56 (5.34)	19.31 (4.51)	28.70 (5.45)	28.09 (5.39)	39.79 (6.39)
4. Dwarf orange (DO)	20.40 (4.63)	26.40 (5.23)	22.93 (4.89)	29.16 (5.49)	19.79 (4.56)	13.02 (3.74)	26.90 (5.28)	19.93 (4.58)	22.27 (4.82)	38.73 (6.30)
5. Tall x Yellow Dwarf (T x YD)	27.19 (5.31)	31.38 (5.69)	32.24 (5.77)	23.23 (4.92)	15.54 (4.07)	18.22 (4.38)	24.90 (5.09)	28.95 (5.47)	28.18 (5.40)	35.58 (6.05)
F	(0.77)	(1.04)	(3.40*)	(2.75)	(3.74*)	(6.61*)	(0.31)	(0.95)	(1.95)	(1.86)
CD (0.05)	NS	NS	(1.20)	NS	(1.22)	(1.10)	NS	NS	NS	NS

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

4.7.2 Fresh weight of unhusked coconut

The data on the percentage reduction in weight of fresh nut observed in ten harvest done from March 2000 to July 2001 in five popular cultivars *viz.*, WCT, Komadan, LO, DO and T x YD are presented in Table 17.

Perusal of the data indicated that significant reduction in fresh weight of nuts was observed among the varieties in the three harvest done during July 2000, October 2000 and December 2000. In the harvest done during July 2000, the highest percentage reduction in weight of fresh nut was in the variety WCT (43.35), which came at par with Komadan (42.92), T x YD (32.24) and LO (31.10). The reduction in fresh weight was lowest in DO (22.93).

A more or less similar trend was observed during the successive harvest made during October 2000. The percentage reduction in fresh weight of the nuts in the varieties LO (35.00), WCT (30.75) and Komadan (26.80) was at par. Lowest percentage reduction was observed in T x YD (15.54).

In the next harvest done in December 2000, no significant variation in the reduction of fresh weight was observed in the varieties Komadan, WCT and LO with the per cent reduction being 35.43, 31.09 and 27.56 respectively. Lowest reduction in fresh weight was observed in DO (13.02).

4.7.3 Weight of dehusked nut

The data on the percentage reduction in weight of dehusked nut in damaged category 3, 4 and 5 in five coconut varieties are presented in Table 18.

Table 18 : Mean per cent reduction in weight of dehusked nut in category 3,4 and 5 over category 1 in five popular coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall (WCT)	32.45 (5.78)	30.60 (5.62)	39.19 (6.34)	20.68 (4.66)	28.43 (5.43)	35.61 (6.05)	25.91 (5.19)	25.30 (5.13)	23.68 (4.97)	38.21 (6.26)
2. Komadan	33.74 (5.89)	45.98 (6.85)	25.10 (5.11)	29.23 (5.50)	29.65 (5.54)	41.00 (6.48)	22.81 (4.88)	19.13 (4.49)	19.16 (4.49)	38.98 (6.32)
3. Laccadive ordinary (LO)	35.75 (6.06)	35.08 (6.01)	27.90 (5.38)	27.52 (5.34)	28.67 (5.45)	38.74 (6.30)	35.22 (6.02)	29.26 (5.50)	27.73 (4.88)	14.46 (5.94)
4. Dwarf orange (DO)	28.43 (5.43)	31.73 (5.72)	26.02 (5.20)	28.39 (5.42)	21.56 (4.75)	25.56 (5.15)	27.12 (5.30)	27.73 (5.36)	25.49 (5.15)	38.98 (6.32)
5. Tall x Yellow Dwarf (T x YD)	21.01 (4.69)	25.97 (5.19)	22.16 (4.81)	22.56 (4.85)	22.56 (4.72)	24.25 (5.02)	20.62 (4.65)	14.46 (3.93)	14.40 (3.92)	41.71 (6.54)
F	(2.83)	(2.66)	(2.65)	(0.74)	(1.23)	(3.27*)	(1.40)	(3.05*)	(3.34*)	(1.04)
CD (0.05)	NS	NS	NS	NS	NS	(1.11)	NS	(1.13)	(0.80)	NS

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

Table 19 : Mean per cent reduction in fresh weight of husk in category 3,4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall (WCT)	21.31 (4.72)	27.77 (5.36)	39.05 (6.33)	28.31 (5.41)	28.50 (5.43)	27.26 (5.32)	24.32 (5.03)	25.05 (5.10)	26.29 (5.22)	37.57 (6.21)
2. Komadan	22.23 (4.52)	35.13 (6.01)	40.13 (6.41)	26.01 (5.20)	18.48 (6.41)	27.56 (5.34)	30.24 (5.59)	25.03 (5.10)	25.03 (5.10)	37.44 (6.20)
3. Laccadive ordinary (LO)	25.38 (5.14)	29.27 (5.50)	25.00 (5.10)	21.50 (4.74)	33.43 (5.87)	29.29 (5.50)	13.46 (3.50)	22.15 (4.81)	22.15 (4.81)	39.71 (6.38)
4. Dwarf orange (DO)	18.40 (4.43)	26.64 (5.26)	20.05 (4.59)	31.16 (5.67)	18.65 (4.43)	28.78 (5.46)	24.12 (5.01)	11.77 (3.57)	15.69 (4.09)	32.78 (5.81)
5. Tall x Yellow Dwarf (T x YD)	29.81 (5.55)	31.38 (5.69)	24.43 (5.04)	24.43 (5.04)	24.18 (5.02)	28.20 (5.40)	34.39 (5.95)	28.13 (3.40)	27.94 (5.38)	32.93 (5.83)
F	(2.77)	(0.39)	(1.75)	(1.19)	(4.53*)	(0.08)	(5.28*)	(2.26)	(1.93)	(3.10)
CD (0.05)	NS	NS	NS	NS	0.89	NS	1.06	NS	NS	NS

Figures in parenthesis are values after √X+1 transformation

The results of statistical analysis of the data showed that, significant reduction in weight of dehusked nut among the varieties was observed in December 2000, March 2001 and May 2001 harvests.

Harvest done during December 2000 showed that, the highest percentage reduction in weight of dehusked nut was in Komadan (41.00) which came on par with LO (38.74) and WCT (35.61). The percent reduction was lower in DO (24.25).

No significant variation in the reduction in weight of dehusked nut was observed in varieties LO (29.26), WCT (25.30) Komadan (19.13) and T x D (14.46), in the harvest done during March 2001. However, percentage reduction in weight of dehusked nut was lower in DO (14.46). A more or less similar trend was observed in May 2001 harvest also.

4.7.4 Weight of husk

The data on percentage reduction in weight of husk in five popular coconut varieties are presented in Table 19.

Perusal of the data indicated that significant differences among reduction in weight of husk in five varieties was observed in the harvests done during October and January. LO (33.43) showed highest percentage reduction in weight of husk, which was significantly different from other varieties like WCT (28.50), T x YD (24.18), DO (18.63) and Komadan (18.48). In the harvest done during January 2001 no significant variation in per cent reduction in weight of husk could be observed among T x YD (34.39), Komadan (30.24), WCT (24.32) and DO (24.12). However, the lowest per cent reduction was observed in LO (13.46) which was significantly different from all other varieties and this observation was contradictory to the observation made during October harvest.

4.7.5 Weight of opened (split) nut

The data on per cent reduction in the weight of opened nut (without water) in five coconut varieties and the results of statistical analysis of the same are presented in Table 20.

Per cent reduction in the weight of opened nuts sampled from among five coconut varieties was significantly different in harvests done during October 2000 and May 2001. No significant difference was observed in the nuts harvested in other months.

In the harvest done during October, LO (38.19) showed the highest percentage reduction in weight of opened nut which came on par with the reduction in weight of WCT (31.51). No significant variation in the reduction of weight of opened nut was observed in varieties *viz.*, Komadan (20.66), T x YD (17.93) and DO (13.92). Similar trend was observed in harvest done during May 2001 among the varieties LO (21.74), T x YD (21.14), Komadan (20.40), WCT (19.97) and DO (9.74).

Plate 9a and 9b represents the dehusked and opened nuts coming under damage categories 1, 2, 3 and 4 in the variety WCT.

4.7.6 Thickness of kernel

The data on the per cent reduction in thickness of kernel in severely damaged nuts (Category 3, 4 and 5) infested by *A. guerreronis* in five coconut varieties are presented in Table 21.

Plate 9 – Nuts representing damage category 1 to 4.

9a – Dehusked nut

9b – Opened (split) nuts


1
2
3
4

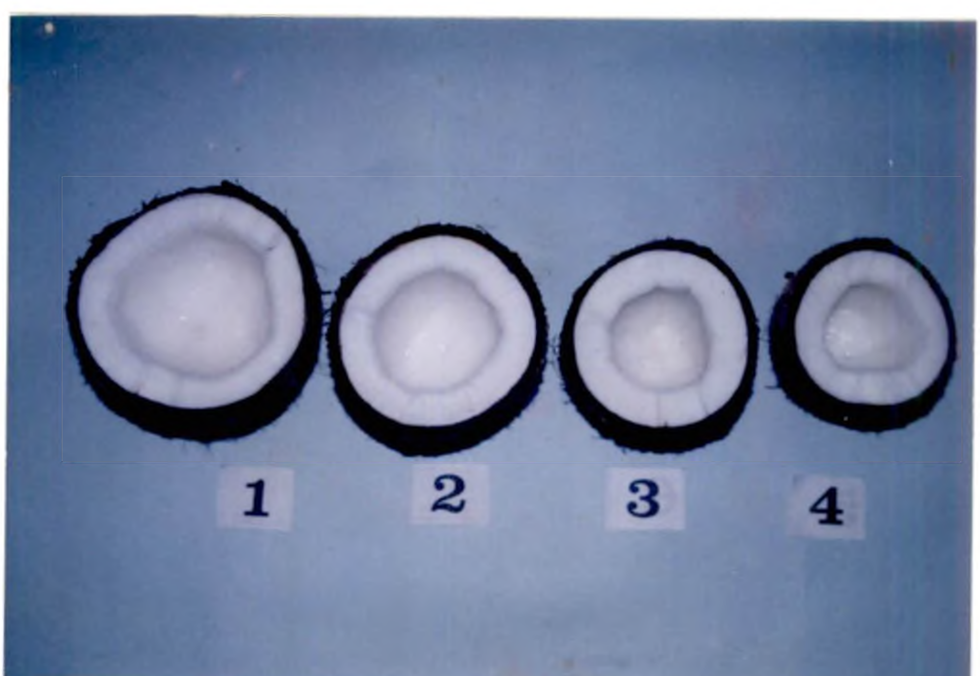

1
2
3
4

Table 20 : Mean per cent reduction in fresh weight of opened (split) nuts in category 3,4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall (WCT)	28.06 (5.39)	31.48 (5.70)	43.02 (6.64)	26.55 (5.25)	31.51 (5.61)	32.55 (5.79)	16.66 (4.20)	20.12 (4.60)	19.97 (4.58)	33.92 (5.91)
2. Komadan	33.29 (5.86)	40.34 (6.43)	38.12 (6.26)	28.81 (5.46)	20.66 (4.65)	22.84 (4.88)	25.08 (5.11)	23.13 (4.91)	20.40 (4.63)	29.35 (5.51)
3. Laccadive ordinary (LO)	33.91 (5.96)	33.08 (5.84)	34.97 (6.00)	31.89 (5.74)	38.19 (6.26)	36.45 (6.12)	22.81 (4.88)	23.48 (4.95)	21.74 (4.77)	35.36 (6.03)
4. Dwarf orange (DO)	26.10 (5.21)	31.12 (5.67)	20.78 (4.67)	20.77 (4.67)	13.92 (3.86)	26.88 (5.28)	11.27 (3.50)	16.50 (4.18)	9.74 (3.28)	33.90 (5.91)
5. Tall x Yellow Dwarf (T x YD)	29.75 (5.55)	28.78 (5.46)	34.96 (6.00)	29.58 (5.53)	17.93 (4.35)	33.43 (5.70)	21.54 (4.75)	21.54 (4.75)	21.17 (4.71)	32.96 (5.83)
F	(1.06)	(1.36)	(1.90)	(0.91)	(9.16*)	(1.87)	(2.40)	(1.41)	(9.58*)	(2.12)
CD (0.05)	NS	NS	NS	NS	0.96	NS	NS	NS	0.61	NS

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

Table 21. Mean per cent reduction in thickness of kernel of coconut in category 3, 4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall	5.19	7.99	2.94	5.69	9.61	11.83	10.65	8.35	9.38	13.30
(WCT)	(2.49)	(3.00)	(1.99)	(2.59)	(3.26)	(3.58)	(3.41)	(3.06)	(3.22)	(3.78)
2. Komadan	10.36	10.82	2.25	1.97	7.49	13.16	4.99	4.60	5.15	12.73
	(3.37)	(3.44)	(1.80)	(1.72)	(2.91)	(3.76)	(2.45)	(2.37)	(3.48)	(3.71)
3. Laccadive ordinary	11.36	4.16	2.63	4.56	1.66	9.78	3.27	9.38	5.68	17.90
(LO)	(3.52)	(2.27)	(1.91)	(2.36)	(1.63)	(3.28)	(2.07)	(3.22)	(2.59)	(4.35)
4. Dwarf orange	7.80	12.48	13.18	2.19	2.38	10.49	4.09	4.98	4.96	13.77
(DO)	(2.97)	(3.67)	(3.77)	(1.79)	(1.84)	(3.39)	(2.26)	(2.45)	(2.44)	(3.84)
5. Tall x Yellow Dwarf	7.55	9.80	5.05	2.19	12.32	9.16	8.20	8.78	4.63	20.98
(T x YD)	(2.92)	(3.29)	(2.46)	(1.79)	(3.65)	(3.19)	(3.03)	(3.13)	(2.37)	(4.69)
F	(2.28)	(4.43*)	(8.26*)	(3.06*)	(7.96*)	(3.25*)	(3.77*)	(1.26)	(3.46*)	(7.81*)
CD (0.05)	NS	0.77	0.85	0.68	0.94	0.39	0.87	NS	0.56	0.46

Figures in parenthesis are values after √X+1 transformation

The results of statistical analysis of the data showed that no significant reduction in thickness of kernel among varieties was observed in harvests done during March 2000 and July 2001. However, significant difference in per cent reduction in thickness of kernel was observed in all the other months of harvests.

Harvest done during May 2000 indicated that per cent reduction in thickness of kernel was highest in DO (12.48) followed by Komadan (10.82), T x YD (9.80), WCT (7.99) and LO (4.16). More or less similar trend was observed in harvest done during July 2000 with highest per cent reduction in thickness of kernel in DO (13.18) and lowest in Komadan (2.25).

No significant variation in per cent reduction in thickness of kernel among varieties LO (4.56), DO (2.19), T x D (2.19) and Komadan (1.97) was noticed in August 2000 harvest. However highest per cent reduction in thickness of kernel was observed in WCT (5.69), which came on par with LO (4.56). Harvest done during October 2000, indicated that highest per cent reduction in thickness of kernel was in the variety T x YD (12.32) and lowest in LO (1.66).

In December 2000 harvest, highest per cent reduction in thickness of kernel was in the variety Komadan (13.16) followed by WCT (11.83), DO (10.49), LO (9.78) and T x YD (9.16). More or less similar trend was observed in May 2001 harvest also. No significant variation was observed between varieties WCT (10.65) and T x D (8.20) in January 2001. Lowest per cent reduction in thickness of kernel was in LO (3.27) followed by DO (4.09) and Komadan (4.99). Harvest done during July 2001 indicated that highest per cent reduction was in T x YD (20.98) and the lowest in Komadan (12.73).

4.7.7 Weight of copra

The data showing per cent reduction in weight of copra in damaged nuts (Category 3, 4 and 5) over corresponding controls and statistical analysis of the same are presented in Table 22.

Significant reduction in weight of copra was observed among varieties *viz.*, WCT, Komadan, LO, DO and T x YD in six harvests done during March 2000, July 2000, August 2000, October 2000, March 2001 and May 2001.

In the harvest done during March 2000, no significant variation in percentage reduction in weight of copra was noticed among the varieties WCT (33.95), LO (32.49), T x YD (32.51) and Komadan (29.14). Per cent reduction observed in DO was lowest (16.32) which was significantly lower than those in the other four varieties. In July harvest also, a similar trend was observed without significant differences among the four varieties T x YD (34.05), LO (32.04), WCT (31.87) and Komadan (29.92). DO showed the least per cent reduction (11.05) in copra weight.

Harvest done during August 2000 indicated that highest per cent reduction in weight of copra was in LO (42.50) which was significantly different from other varieties. *viz.*, WCT (23.67), Komadan (28.82), DO (11.07) and T x YD (22.91). Similar trend was observed in October 2000 harvest among varieties WCT, Komadan, LO, DO and T x YD with per cent reduction in weight of copra 15.30, 27.24, 33.30, 12.00 and 15.96 respectively. Highest per cent reduction in weight of copra was recorded in Komadan (29.77) in March 2001 harvest which came on par with LO (26.97) and WCT (19.72). However lowest reduction in weight of copra was observed

Table 22 : Mean per cent reduction of copra in category 3, 4 and 5 over category 1 in five coconut varieties

Cultivars	Mar-2000 1	May-2000 2	Jul-2000 3	Aug-2000 4	Oct-2000 5	Dec-2000 6	Jan-2001 7	Mar-2001 8	May-2001 9	Jul-2001 10
1. West Coast Tall (WCT)	33.95 (5.91)	30.19 (5.59)	31.87 (5.73)	23.67 (4.97)	15.30 (4.04)	37.72 (6.22)	26.49 (5.24)	19.72 (4.55)	20.37 (4.62)	35.51 (6.04)
2. Komadan	29.14 (5.49)	30.27 (5.59)	29.92 (5.56)	28.82 (5.46)	27.24 (5.31)	24.76 (5.08)	30.71 (5.63)	29.77 (5.55)	28.99 (5.48)	38.98 (6.32)
3. Laccadive ordinary (LO)	32.49 (5.79)	27.92 (5.38)	32.04 (5.75)	42.50 (6.60)	33.30 (5.86)	29.54 (5.53)	34.64 (5.97)	26.97 (5.29)	28.56 (5.44)	38.77 (6.33)
4. Dwarf orange (DO)	16.32 (4.16)	22.42 (4.84)	11.05 (3.47)	11.07 (4.01)	12.00 (3.60)	28.93 (5.47)	19.68 (4.55)	11.35 (3.51)	12.83 (3.72)	38.23 (6.26)
5. Tall x Yellow Dwarf (T x YD)	32.51 (5.79)	26.07 (5.20)	34.05 (5.92)	22.91 (4.89)	15.96 (4.12)	21.26 (4.72)	25.02 (5.10)	17.68 (4.32)	17.57 (4.31)	36.58 (6.13)
F	(4.54*)	(0.50)	(7.36*)	(11.74*)	(6.90*)	(2.58)	(1.31)	(5.58*)	(6.88*)	(0.36)
CD (0.05)	1.02	NS	1.31	0.83	1.09	NS	NS	1.03	0.86	NS

Figures in parenthesis are values after $\sqrt{X+1}$ transformation

in DO (11.35) followed by T x YD (17.68). Similar trend was noticed in May 2001 harvest also with per cent reduction in weight of copra in varieties *viz.*, WCT, Komadan, LO, DO and T x YD are 20.37, 28.99, 28.56, 12.83, 17.57 respectively.

4.7.8 Correlation between populations of *A. guerreronis* and loss in yield parameters

The data relating to the characters studied in the experiment were subjected to correlation and regression analysis and the results are presented in Table 23.

Population of *A. guerreronis* showed high positive correlation with per cent reduction in weight of opened nut (0.5733), husk (0.6588), copra (0.7267) and area of lesion (0.6149).

Table 23. Correlation between population of *A. guerreronis* and yield loss

	Population X	Percentage reduction in weight of meat Y_1	Percentage reduction in weight of husk Y_2	Percentage reduction in weight of copra Y_3	Length / circumference Y_4	Area of lesion Y_5
X	1.000					
Y_1	0.5733**	1.0000				
Y_2	0.6588**	0.5690**	1.0000			
Y_3	0.7267**	0.6796**	0.7853**	1.0000		
Y_4	0.2578*	0.1235	0.2484	0.2354	1.0000	
Y_5	0.6149**	0.3728*	0.5374**	0.4992**	0.2656	1.0000

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

Significant positive correlation was observed between per cent reduction in weight of husk and meat (0.5690). Per cent reduction in copra yield had high positive correlation with meat (0.6796) and husk (0.7853). Area of lesion exhibited significant positive correlation with per cent reduction in weight of husk (0.5374) and copra (0.4992).

Regression equations to predict the yield loss from population of *A. guerreronis* were,

$Y_1 = 13.075 + 0.002846\ X$ (opened nut)

$Y_2 = 11.114 + 0.003036\ X$ (coconut husk)

$Y_3 = 9.367 + 0.004072\ X$ (copra)

$Y_4 = 0.862 + 0.001550\ X$ (area of lesion)

4.7.9 Comparison of variation in yield loss in susceptible and tolerant types of WCT and Komadan

Mean percentage reduction in yield parameters in susceptible and tolerant types of WCT and Komadan are presented in Table 24.

The table clearly showed that per cent reduction in opened nut, husk and copra was much higher in susceptible than in tolerant types. In susceptible type of WCT, per cent reduction in weight of opened nuts ranged from 21 – 28.6 % while in tolerant types, a reduction in weight of opened nut was lower (14.8 – 21 %). In susceptible type of Komadan, the per cent reduction in opened nuts ranged from 22.2 to 27.4 %, while in tolerant types it was only 11-19 %.

Table 24. Per cent reduction in weight of opened nut, husk and copra in susceptible and tolerant types of WCT and Komadan

Variety	Per cent reduction in weight of opened nut		Per cent reduction in weight of husk		Per cent reduction in weight of copra	
	Susceptible	Tolerant	Susceptible	Tolerant	Susceptible	Tolerant
a. WCT						
1.	21.8	14.8	22.8	18.8	23.4	17.6
2.	25.0	15.8	23.4	11.6	27	9.6
3.	28.6	21	20.2	17	25.6	18.8
4.	21	18.6	24.4	15	22.8	13.2
Mean	24.1	17.55	22.7	15.6	24.7	14.8
b. Komadan						
1.	22.2	19	22.6	11	28.4	13.6
2.	26.2	18.6	25	15.4	36.2	16.6
3.	27.4	19.2	30	16.2	29.8	18.2
4.	23.8	17.6	24.8	19	23.8	17.8
Mean	24.9	18.6	25.6	15.4	29.55	16.55

More or less the same trend was observed in per cent reduction in husk and copra in susceptible and tolerant types of WCT and Komadan.

4.7.10 Economic loss

Annual yield loss in terms of fresh nut as well as copra was worked out for each palm as a cumulative total of yield loss (Potential yield – actual yield) + loss due to nut fall recorded in seven consecutive harvests. This was converted to economic loss (Rs./palm/year) taking into account the price of nut and copra prevailed during the harvest period.

Annual economic loss due to infestation of *A. guerreronis* in Rs./palm is presented in Table 25. When coconuts were considered to be marketed as fresh nut, the annual economic loss due to infestation by CEM was worked out to be Rs. 38.40 to 67.2./ palm in susceptible types of WCT. However in tolerant types it was ranged from Rs. 17.9 to 40 / palm. In the variety Komadan, annual economic loss was 33.61 to 73.80 Rs./palm in susceptible types and 17.4 to 36.8 Rs. /palm in tolerant types.

The annual economic loss would have been 78.99 to 105.16 Rs /palm in susceptible types and 17.4 to 36.8 Rs. / palm in tolerant types in the variety WCT, when the coconuts were assumed to be marketed as copra. While in the variety Komadan, the predicted annual economic loss ranged from 50.28 to 100.95 Rs /palm. However in tolerant types it was ranged from 23 to 79.9 Rs. / palm.

Table 25. Annual economic loss due to infestation of *A. guerreronis*

Cultivar	Annual economic loss in Rs/palm in terms of			
	Fresh nut		Copra	
WCT	Susceptible	Tolerant	Susceptible	Tolerant
1.	67.20	30.50	105.16	73.00
2.	48.90	22.00	78.99	55.00
3.	59.00	28.20	104.00	78.30
4.	38.40	17.90	80.74	60.40
5.	51.00	40.00	98.20	70.50
Mean	52.90	27.72	93.42	67.44
Komadan				
1.	47.30	24.00	62.63	32.80
2.	73.80	36.80	100.95	79.90
3.	59.50	28.50	89.38	56.70
4.	33.61	17.40	50.28	23.00
5.	49.30	21.00	68.20	28.52
Mean	52.70	25.54	74.29	44.18

4.8 . Experiment 8 : Assessment of increased labour for dehusking infested nuts compared to uninfested nuts using mechanical dehusker

A separate experiment was conducted to study the additional labour required for dehusking of infested nuts in terms of time taken for dehusking 100 nuts.

The data on the per cent increase of time required for dehusking 100 infested nuts representing in different damage categories are presented in Table 26.

Table 26. Time required for dehusking of 100 infested nuts in different damage categories over control using mechanical dehusker

Damage category	Time taken to dehusk 100 nuts		
	Actual (minutes)	Increase over uninfested nuts (minutes)	Percent increase over uninfested
5	75.00	41.74	63
4	58.30	25.05	50
3	50.00	16.75	40
2	33.24	0	0
1	33.25	0	0

Damaged nuts coming under category 5 took maximum time for dehusking (75 minutes) followed by nuts of 4th and 3rd categories (58.3 and 50 minutes respectively). Additional time taken for dehusking the damaged nuts coming under category 5, 4 and 3 over uninfested nuts were 41.75, 25.05, 16.75 minutes respectively. However the time required for dehusking nuts coming under category 2 was same as that for uninfested nuts indicating no additional labour requirement.

4.9 Experiment 9. Assessment of the effect of mite damage on quality of fibre and coir

An experiment was conducted to assess the effect of mite injury on the quality of fibre and coir. Husk obtained from fifty nuts representing the damaged category 1-5 were subjected to usual retting practices and the fibre representing each damaged category was analysed for qualitative parameters. Mite damage caused significant reduction in quality of fibre in terms of fibre length and tensile strength. Fibre from husks coming under category 4 and 5 suffered 47 and 53 per cent reduction in fibre length respectively when compared with category 1 (Plate 10a and 10b). There was no significant difference in reduction in fibre length of category 2 nuts over category 1. However category 3 nuts had 26 % reduction in fibre length (Table 27).

Table 27. Reduction in length of fibre due to infestation of *A. guerreronis*

Sl.No.	Damage category	Per cent reduction in length of fibre
1.	5	53
2.	4	47
3.	3	26
4.	2	0
5.	1	0

Since the fibre obtained from nuts coming under damage categories 4 and 5 were very short and fragile, it was very difficult to spin the coir (Plate 11a and 11b).

Plate 10a – Comparison of fibre from nuts coming under healthy (1) and damage category (5)

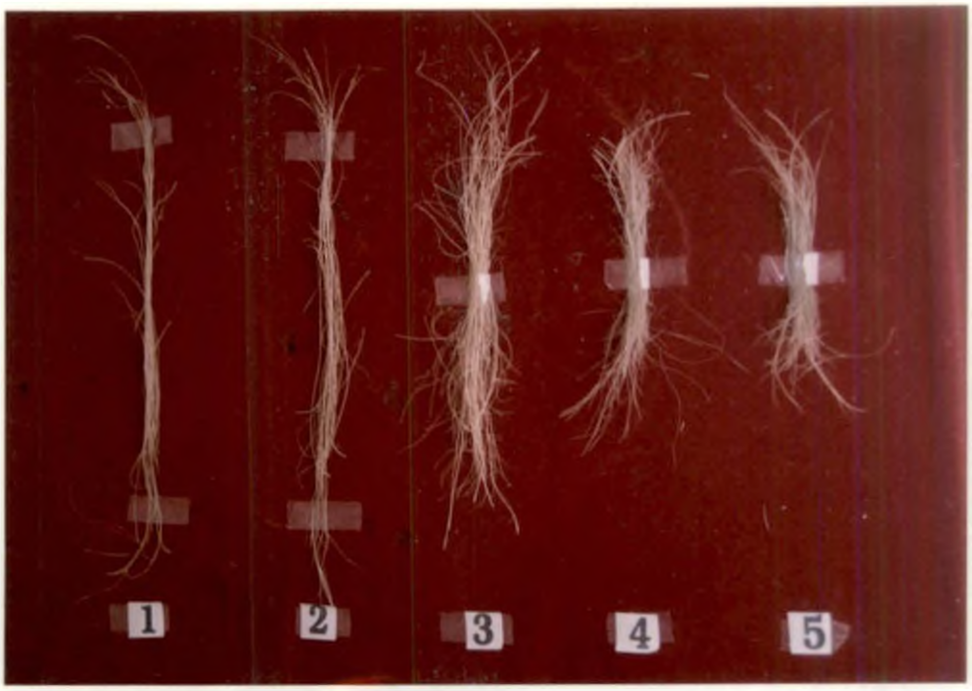
10b – Comparison of coir yarn spun from fibre of healthy (1) and damage category (5) husks.


1
5


1
5

Plate 11a – Fibre obtained from retted husks of nuts under damage categories 1 to 5

Plate 11 b – Coir yarns spun from fibre of husks in damage categories 1 to 5.


1
2
3
4
5


1
2
3
4
5

DISCUSSION

5. DISCUSSION

Aceria guerreronis is a recently introduced pest of coconut in Kerala and its sudden outbreak is a burning issue of date, as it threatens the life of coconut farming community. As it is a new pest of coconut in India, the literature regarding basic and fundamental aspects are so meagre. The need for basic research on *A. guerreronis* was emphasized by Moore and Howard in his review paper (1996).

Briones and Sill (1963) observed nine species of eriophyid mites attacking coconut. But Kang (1981) reported that *A. guerreronis* is the only species of eriophyid mite causing serious damage.

In 1965 itself, Keifer tried to study the biology of *A.guerreronis*. Later in 1977, Mariau made an attempt to study the development cycle of *A.guerreronis*. But none of them gave the exact methodology for rearing mites in lab condition. Moore and Howard (1996) pointed out the essentiality for a method to rear and maintain laboratory colonies of mite. In Indian conditions, biology was studied by Haq (1999) ; Mohanasundaram (2000) and Ramarethinam and Loganathan (2000).

Biology was studied under laboratory condition during March 2001. The eggs were seen on the inner surface of perianth or on the meristematic tissue. The present study revealed that the incubation period was 2.8 days, However, Ramarethinam and Loganathan (2000) reported that it took 2.6 days for incubation. The duration of total life cycle, protonymph and deutonymph was observed to be 9.8, 3.4 and 3.7 days respectively. Study of biological aspects of mite revealed that a total period of 10-12 days was required for completing one generation (egg to egg).

Data obtained from population build up under field conditions (Fig.2) revealed that about 3-4 generations are completed during the one month period in the most critical age of the bunch *ie.* fifth bunch. Additional information generated from the present study indicated that the interval between two consecutive sprays should be fixed with reference to the pattern of bunch production and not on the basis of the life cycle of mite. An interval as short as 10-15 days between two sprays was recommended in the initial phase by some agencies which is obviously not possible under practical conditions.

Study of population dynamics and yield loss due to infestation of *A.guerreronis* is important to establish economic injury level or action threshold. The present study revealed that the age of the nut was the most critical factor in the study of population dynamics. It has been observed that mean mite population was highest in nuts sampled from fifth bunch followed by fourth and sixth bunch. This is in agreement with the observations made by Mathew *et al.* (2000). However, Ranjith *et al.* (2001) observed that highest population was in buttons from fourth bunch. This may be explained in terms of the difference in the pattern of bunch production in palms where a new inflorescence is usually produced at an interval of 20-25 days. But in some seasons, the interval for the emergence of a new spadix may vary. Depending upon the frequency of bunch production, different palms bear different ages of bunches. According to the interval between production of spadices, growth rate of nuts also varies, which in turn influence susceptibility of palms to mite infestation. In palms having more bunches per year, the number of bunches susceptible to mite attack would be more and mite colony could be seen up to sixth to seventh bunch stage. In the present study highest population could be noticed in the fifth bunch and thereafter it declined drastically. But in palms having less bunches per year, mite colonies would be seen only up to fifth bunch stage and fourth bunch might harbour higher population than in fifth bunch, in such palms. Moore and Alexander (1987) reported that population was very low in the first month after fertilization, but rapid build up of population was observed in three to six bunch nuts. However Hall *et al.* (1980) argued that nuts remain susceptible to mite attack almost throughout the whole period of development. But present study showed that mite population was present as visible colonies from third bunch onwards, reached the peak population in fifth bunch and suddenly declined in the sixth bunch stage onwards.

Both earlier and present researchers have followed different methods for the assessment of population of mites like counting template method (Youthers and Miller, 1934), log scale method (Moore and Alexander, 1987) and Glycerine drop trap method (David and Varadarajan, 2001). Cello tape embedding technique proposed by Girija and co-workers (2001) was used in the present study as it facilitated colony-wise measurement of mite population from a sample after making the colony immobile on the cello tape.

The present study revealed that the highest population was observed during March and the lowest in December in the variety WCT. However, in the variety

Komadan, the highest population was in August and the lowest in November. Zuluaga and Sanchez in 1971 reported that mite infestation is more severe in relatively dry climates or during the dry seasons of wetter climates. The reason was explained by Mariau, (1977), (1986) and Romney (1980) that during drier period, growth of nut was slower, thus young developing tissues were subjected to mite damage for longer period. Nair and his co-workers in 1999 and Nair and Koshy (2000) reported that population was highest in summer months (April-May). The present findings were also in agreement with these findings. However, Doreste, (1968), Mariau, (1969), (1977) and Howard *et al.* (1990) claimed that there is no clear relationship between coconut mite population and wet and dry climates.

In the present study, population of *A. guerreronis* was correlated with weather parameters. It has been observed that population in susceptible types of Komadan had positive correlation with relative humidity prevailed at the time of mite entry (45-55 days after fertilization / 65-80 days after emergence) of bunch. This is in confirmation with observations made by Mathew *et al.* (2000). The data presented in Fig 7, 8 and Table 7 showed that the usual method of correlating between population and weather parameters in the corresponding period did not yield any association . But when the same data was correlated with the weather prevailed in previous months corresponding to the probable time of mite entry, positive correlation was observed with relative humidity at the time of mite entry. This showed that the correlation studies should also take into consideration the biology and developmental period and perhaps it may be the reason for not getting clear relationship as reported by the previous workers.

Nair and his co-workers (1999) studied the seasonal incidence of the mite in Kerala and found that occasional rains accelerated the population build up. They reported that high relative humidity and temperature were found to be the favourable factors for the multiplication of mites.

Morphological character of nut was studied in a separate experiment. The arrangement of the bracts on young nuts influenced the pattern of attack by *A. guerreronis*. Present study revealed that in 57-70 per cent of young nuts, mite infestation initiated from the edge of tepals than from the middle of tepals which confirmed the results of Moore (1986). He explained in detail about the extent of mite damage as influenced by bract arrangement. An overlapping bract could not adpress so tightly to nuts surface and this might allow access of the mite to initiate infestation. The tightness of adpression of perianth to nuts surface is a characteristic of a cultivar. Haq (1999) proposed that tight fitting tepal variety of coconut should be selected for planned farming system in future. But coconut is highly cross pollinated, there is no guarantee of the progeny being similar to parents. However, Moore (2000) explained the benefits of crop breeding but is a long term and probably partial solution to coconut mite problem.

The present study revealed that the colour of nut was not a factor determining susceptibility / tolerance of palm to coconut mite. Moore and Alexander (1990) reported that the young nuts from the trees with dark green inflorescence showed less damage than other trees. Contradictory to this, Muthiah and Bhaskaran (2000) from Tamil Nadu reported that green coloured nuts are more susceptible to mite attack than orange or yellow. However Chezhiyan and Ramar (2000) observed that yellow types are more susceptible to mite infestation. But the present studies showed that the colour of nuts does not play a major role towards susceptibility or tolerance of the palm.

Unlike the influence of nut colour, the shape of the nut had significant influence on population of mites. Round nuts having more circumference as compared to length with a length to circumference ratio of 1 : 2.1 to 1 : 2.3 suffered less damage and a significantly higher per cent of undamaged nuts (greater than 75 %) could be obtained from such palms. The present study is in confirmation with the observation made by Mariau (1977) and Moore and Alexander (1990). The reason behind this was that in round nuts it was mechanically impossible for the mite to get under perianth, which adhered very closely to the nut surface. However, Moore (2000) explained that round and elongated nuts came from the same tree and even same bunch and hence the effect is probably not a genetic feature but it is a matter of resource allocation. Hence crop breeding has a limited scope in evolving varieties with round nuts. But this feature may also be taken as a criteria to identify the susceptible palms with more elongated nuts in a homestead and to focus control operations on them.

Growth rate of nuts was studied by using the method of O'conner (1951). The study revealed that growth of nuts extended upto ninth bunch stage and afterwards only maturity took place. Moore and Alexander (1987) reported that 75 per cent of growth took place in one to six month. Hence any menace on coconut in this stage might adversely affect yield of nuts. Effect of mite injury on growth rate leading to different damage categories is illustrated in Fig. 10. No difference in growth rate was observed in nuts coming under damage category 1 and 2. Significant reduction in growth rate was observed in nuts coming under damage categories 4 and 5. It was also evident that the mite injury affected elongation of nuts from eighth bunch onwards, but significant reduction in circumference was noticed even from the fifth bunch stage. Bunches 3 to 6 were the most susceptible stages for colonization of mites.

An important finding of the study illustrated in the pictograph (Fig. 9) is that the nuts with 3 to 4 feeding lesions indicating mite colonies in the fourth bunch stage developed into the economically damaged categories 4 and 5. Apart from initiation of colonies, the number of colonies in the young nuts was also a factor determining severity of infestation. This was studied indirectly by counting the number of triangular patches appearing on the young nuts. Each triangular mark invariably had an active colony just above the mark, protected by the perianth. Some times feeding by adjacent colonies resulted in coalescence of triangular markings resulting in large patches. These observations would help one to predict the approximate crop loss and extent of damage due to infestation of mite, in the fourth or fifth bunch stage itself. It would be helpful to decide whether the spraying would be economic or not. As it is clearly illustrated in the pictograph, the appearance of external symptoms as early as in the third bunch will lead to the damage category 4 & 5 with 51-100 per cent surface damage and maximum

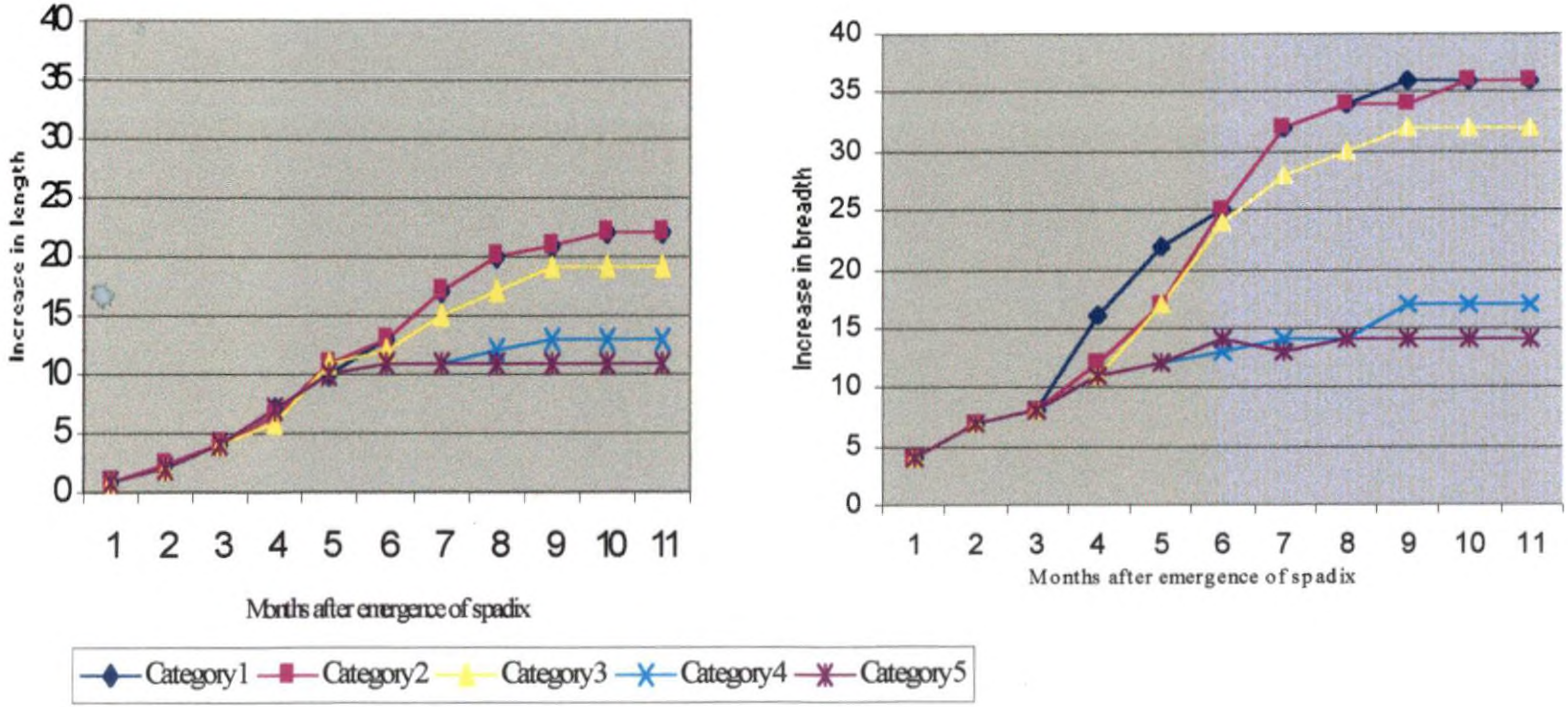


Fig. 10. Effect of mite injury on growth of nuts leading to different damaged categories

reduction in size. Such nuts are often discarded by buyers and hence the efficiency of spray application on second, third and fourth bunches should be focussed to gain maximum benefit. This result emphasize the need to train the climbers to locate the critical age of bunches to be targeted for control operations.

Assessment of the yield loss due to infestation of *A.guerreronis* in five coconut cultivars like WCT, Komadan, Laccadive Ordinary, Dwarf Orange and T x YD were conducted under the present investigation. Moore (2000) raised the need for crop loss estimation in different coconut cultivars so that one can put an economic cost to the coconut mite. The percentage loss due to infestation of *A. guerreronis* in fresh weight of unhusked coconut (Table 17), husked coconut (Table 18), husk (Table 19), opened nut (Table 20) and copra (Table 22) were studied in this experiment. The present study revealed that there was no significant variation in the per cent reduction in yield among the varieties indicating that mite attacked all the varieties in more or less in similar intensity and there is no varietal preference. However, lowest per cent reduction with respect to yield parameters was noticed in Dwarf orange. Per cent copra loss ranged from 11-42 % (Table 22). This is in agreement with the observations of Moore and Alexander (1987).

Correlation was worked out between population and yield loss. It has been noticed that population of *A. guerreronis* showed high positive correlation with per cent reduction in weight of opened nut, husk, copra and area of lesion. Similarly area of lesion had high positive correlation with per cent reduction in weight of husk (0.5374) and weight of copra (0.4992). The result revealed that increase in area of lesion which is proportional to the size of mite colony has resulted in reduction in weight of husk as well as copra.

Population of *A.guerreronis* in fifth bunch was higher in the months March 2000 and October 2000. Nuts from the respective bunches were harvested in December 2000 and July 2001. High per cent reduction in weight of husked nut and copra was observed in nuts harvested in these months. Thus a perfect coincidence between population and yield loss could be demonstrated in the present study.

Study on intensity of mite attack among different varieties showed that highest percentage of nuts coming under damage category 3, 4 and 5 was observed in the variety Komadan followed by WCT, Laccadive Ordinary and T x YD and the lowest was in Dwarf Orange. However Muthiah and Bhaskaran (1999) reported that Laccadive Ordinary, Cochin China, Andaman Ordinary and Ganga Bondam recorded less than 13 per cent damage by the mite.

The present study indicated that there were significant differences among the yield loss data obtained from susceptible and tolerant types of WCT and Komadan. Per cent yield reduction in terms of opened nut, husk and copra was 30-40 per cent more in susceptible types than in tolerant types in WCT and Komadan. The data (Table 24) also indicated that the palm to palm variation with respect to the susceptibility or tolerance with in a variety is the major factor deciding upon the extent of yield loss. Loss of copra in susceptible palms (WCT and Komadan) ranged from 22-36 per cent while in tolerant palms it ranged from 9-18 per cent only. Economic loss in terms of copra yield in susceptible palms ranged from Rs. 50-105 / palm / year. While in tolerant palms, it ranged from 23 to 79 Rs. / palm / year only. Hence an assessment of economic loss in homesteads should be made before making decision to adopt control recommendations. Instead of massive sprays with chemicals or botanicals, marking and spraying the trees suffering a loss equivalent or greater than the cost of control alone in a homestead should be considered. Such exercises can also be done on a ward / village / panchayat level before launching massive spraying operations.

Another important finding of yield loss studies was that the nuts falling in the damage category 4 and 5 with greater than 50 per cent surface damage showed significant reduction in the weight of coconut meat and copra (18-42 %). But in nuts having significant external mite damage on the nuts with a maximum of 25 per cent or less reduction in the size of the nuts, the copra loss was only less than 15 per cent. This indicated that the injury by mite population up to a threshold level may cause only surface damage on coconut husk without any significant yield loss. Attempts were made to determine such a threshold from field data on population and yield loss, but could not derive a threshold under field level due to non-significant correlation between the two. This aspect should be taken up as a future line of study as it is a very important lacuna in information in the context of economics of pest management. .

Moore *et al.* (1989), Moore and Howard (1996) and Rao *et al.* (2000) reported that dehusking of infested nuts is very difficult and it fetches additional labour requirement and often not done resulting in complete loss. But no information was available on quantitative terms, to demonstrate this. Hence additional labour requirement for dehusking of infested nuts was studied in a simple experiment. It was observed that an additional time of 25.05-41.75 minutes (50-63 per cent increase) was required for dehusking 100 infested nuts coming under damaged category 4 and 5 compared to healthy nuts. Increased labour requirement for dehusking infested nuts would cause an additional loss, as it would increase economic loss further.

Muralidharan *et al.* (2001) reported that quality of fibre deteriorated due to mite infestation. In Kerala coir workers are estimated to be half a million and these people solely depend on coir industry for their livelihood. The reduction in quality of fibre would adversely affect the coir industry. Practically no information was available on the effect of mite damage on quantity or quality of fibre as well as coir yarn spun from the fibre. Hence another experiment was conducted to study this by retting husk obtained from nuts in different damage categories.

Results presented in Table 27 and Plates 10 and 11 showed significant reduction in quantity and quality of husk in the nuts due to injury by mites. Up to 40.13 per cent reduction in the husk yield was observed due to mite injury and up to 53 per cent reduction in fibre length was observed in the above categories caused significant reduction in tensile strength of the coir yarn spun from the fibre. It was very difficult to spin coir from the damaged fibre (Plate 11a and 11b).

An overall analysis of the data and results of statistical analysis indicated that susceptibility of individual palms and growth stage of the nuts were the critical factors contributing to economic loss due to mite injury. Results also demonstrate that the youngest three or four bunches should be given maximum protection and the early initiation leading to more number of subdivided colonies during these bunches of critical stage decide the extent of economic damage at harvest.

SUMMARY

SUMMARY

The study entitled "Bio-ecology of coconut eriophyid mite, *Aceria guerreronis* and the yield loss due to its infestation on popular coconut cultivars" has been carried out at the Instructional farm, College of Agriculture, Vellayani, Thiruvananthapuram during 1999-2001. The main objectives of the study were to generate basic information on development of biology, ecology and mite-host interactions of *A. guerreronis* on popular cultivars of coconut in Kerala and to assess the damage on coconut as influenced by nut characters and weather parameters.

Preliminary evaluation of coconut palms was conducted for identification of tolerant and susceptible types. Population dynamics of *A. guerreronis* and influence of ecological parameters on population build up in both susceptible and tolerant types of WCT and Komadan was studied. Variability in susceptibility of palms as influenced by morphological characters of nut, biology and mite-host interactions were included in the present study.

The salient findings of this investigation are summarized below.

1. Biology of coconut eriophyid mite *A. guerreronis* was studied under lab condition on isolated tepals. The study revealed that the total life was completed in 9.8 days with two nymphal instars *viz.*, Protonymph (3-4 days) and deutonymph (3-7 days) during May

2000. Study of population build up in field level revealed that about 3-4 generations are completed during one month period resulting in up to 22 fold increase in population.

2. Population of *A.guerreronis* in susceptible types was about three times higher than in tolerant types in both the varieties.

3. Highest population of *A. guerreronis* was observed in buttons / nuts sampled from fifth bunch followed by fourth and sixth in both susceptible and tolerant types of WCT and Komadan. Thus the present study showed that, age of button / nut was the most critical factor in the study of population dynamics.

4. Highest population of *A. guerreronis* in fifth bunch of susceptible type in WCT was noticed in nuts sampled during October and lowest in November. However in tolerant types, highest population was noticed in March and lowest in December. But in the variety Komadan, highest population from fifth bunch was noticed in nuts sampled during September in susceptible types and June in tolerant type. However, population was lowest in December in susceptible type and during February in tolerant types. These results indicated that it could not be possible to identify any specific period having peak population which invariably depends on the degree of susceptibility of the palms observed.

5. Correlation studies between population and weather parameters revealed that relative humidity prevailed at the stage of mite entry into the young nuts had a positive correlation with population in susceptible type of Komadan.

6. Study on severity of infestation as influenced by arrangement of tepals revealed that mite infestation started from the edge of tepals where two tepals overlapped and the maximum population was under the fourth tepal.

7. There was no significant variation in susceptibility of nuts having different colour towards mite infestation. Nut colour which was attributed as a factor by earlier workers failed to show evidence in the present study.

8. Elongated nuts were more susceptible to attack than round or oblong ones. A length to circumference ratio ranging from 1:1.90 to 1:2.29 suffered less damage and recorded 77 per cent damage free nuts.

9. Significant reduction in size was noticed only in nuts coming under category 4 and 5 and the reduction was evident only after attaining the age of eight month. The age of bunch at which the colonization started was the most critical factor in deciding whether the nut will finally become economically damaged (category 4/5) or not. Apart from initiation of colonies, the number of colonies in the young nuts was also a factor determining severity of infestation. Young nuts having 3-4 colonies in the fourth bunch stage obviously fell under damage categories 4 and 5. This indicated the need for redefining a scoring index which could be worked out as early as third to sixth bunch stage with out waiting up to the harvest stage as per the present scoring.

10. No significant variation in the per cent reduction in yield parameters among cultivars could be observed. However, Dwarf Orange had the lowest per cent reduction in yield parameters.

11. Correlation studies between population of *A. guerreronis* and loss in yield parameters showed that mite population had high positive correlation with per cent reduction in weight of opened nut (0.5733), husk (0.6588), copra (0.7267) and area of lesion (0.6149).

12. The per cent reduction in weight of opened nut , husk and copra was much higher in susceptible types than in tolerant types in both WCT and Komadan.

13. Study on the assessment of increased labour for dehusking infested nuts showed that additional time taken for dehusking 100 number of the damaged nuts coming under damaged categories 4 and 5 as compared to healthy nuts was 41.75 and 25.05 minutes respectively.

14. Infestation of mites on husk badly affected both quality and quantity of husk, fibre and coir. Similarly, maximum reduction (53 per cent) in length of fibre was noticed in nuts coming under damage category 5. A maximum of 40.13 per cent reduction in weight of husk was noticed due to mite injury in damage category 5.

The study indicated that susceptibility of individual palms and growth stage of the nuts were the critical factors contributing to economic loss due to mite injury. Results also demonstrate that the youngest three or four bunches should be given maximum protection. The correlation studies between population of *A. guerreronis* and yield loss due to its infestation would help to decide economic threshold / gain threshold. The present result of bio-ecology, mite-host interaction, yield loss and variability in susceptibility of nut towards mite infestation would be useful to decide on a safe, eco-friendly and cost effective management strategy to tackle the mite problem in the near future.

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BIO-ECOLOGY OF COCONUT ERIOPHYID MITE, *Aceria guerreronis* Keifer AND YIELD LOSS DUE TO ITS INFESTATION ON POPULAR COCONUT CULTIVARS

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ABSTRACT OF THE THESIS
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ABSTRACT

Studies were conducted to understand the biology, ecology, population dynamics and mite-host interactions of *A. guerreronis* and to assess the yield loss on popular cultivars of coconut as influenced by nut characters and weather parameters. An abstract of the work done and the results are given below.

Biology of *A. guerreronis* was studied under both laboratory and field conditions. The study indicated that a total period of 9.8 days was required for completing one generation under laboratory condition.

Population dynamics of *A. guerreronis* in young buttons of susceptible and tolerant palms of variety WCT and Komadan was studied from February 2000 to January 2001. Population of mites under each tepal was counted by using cello tape embedding method. The results revealed that the population was the highest in nuts sampled from fifth bunch followed by fourth and sixth bunches in both susceptible and tolerant palms. The present study indicated that age of developing nut was the most critical factor in the study of population dynamics. Monthly mean population of *A. guerreronis* was correlated with weather parameters *viz.*, temperature, relative humidity and rainfall prevailed during the time of sampling, probable time of mite entry and the total duration of critical age of the bunch. The results indicated that the relative humidity prevailed at the probable time of mite entry alone had a positive correlation with population in the susceptible type of Komadan.

The length to circumference ratio of young nuts and its influence on mite injury was observed. The results showed that round nuts having a length to circumference ratio of

1:1.90 to 1:2.29 suffered less damage. The study gave an indication that elongated nuts were more susceptible to mite attack than round ones.

The expansion of feeding scar on coconut husk due to mite injury in relation to growth of nuts was studied in young nuts with different degree of injury in terms of number of triangular lesions. The study indicated that the age of buttons / nuts at which the colonization started was the most critical factor in deciding whether the nut will finally become economically damaged (category 4 and 5) or not.

Yield loss studies were carried out from the nuts obtained from ten consecutive harvests by categorizing them into five damaged categories and the yield loss was calculated by deducting actual yield from potential yield. No significant variation was observed among the five varieties studied, viz. WCT, Komadan, T X YD, Laccadive Ordinary and Dwarf Orange Yield loss in terms of reduction in weight of copra ranged from 11 to 39 percentage and reduction in weight of husk ranged from 12 to 40 percentage.

Additional labour requirement for dehusking infested nuts was studied in a separate experiment. Study revealed that an extra time of 25.05 to 41.75 minutes was required to dehusk 100 damaged nuts over healthy nuts.

Another experiment was conducted to assess the effect of mite injury on the quality and quantity of fibre and coir. Husk obtained from fifty harvested nuts representing the damage categories 1 to 5 were subjected to natural retting practices. Fibre obtained from nuts coming under damage category 4 and 5 resulted in 47-53 per cent reduction in length.