BIOLOGICAL STUDIES OF SPIDER MITES (ACARI: TETRANYCHIDAE)
INFESTING VEGETABLE CROPS

Objectives:
1. To conduct a survey on the tetranychid mites infesting important vegetable crops.
2. To identify the common and dominant species of local importance.
3. To study the feeding habits of selected species of tetranychid mites and assess the damage potential qualitatively and quantitatively.
4. To elucidate the breeding habits of species under study.
5. To study the impact of different temperature – relative humidity parameters on developmental strategies of selected species.
6. To study the relative abundance, seasonal distribution and host range of the mite species under study.
7. To elucidate the population distribution pattern on the leaves of the host plant.

Importance of the Investigation:
Agriculture plays an important role to determine the economy of Kerala. Being primarily an agricultural state, contribution of Kerala to the vegetable crop industry is a crucial one. However, despite the rich diversity of our vegetable crops, knowledge on their faunal composition, particularly of mites as pests and other related details remains very much limited. In recent years due to random use of chlorinated hydrocarbons for control of general pests, which in turn kill their natural enemies, and because of using high yielding varieties and improved agricultural practices, many mite species which were of less importance or of no value at all during the past have assumed the status of major pests. These, among other factors have further aggravated the situation of the problem of mites as pests. The plant feeding mites cause various types of direct damage like loss of chlorophyll, appearance of striplings or bronzing of foliage, stunting of growth, formation of galls and erineal patches thereby causing an array of deformities and reduction of yield. Apart from direct damages, many are known to act as vectors of plant viral diseases causing more potential loss to growers. In many instances, lack of
information about the correct identity of mites, their biology and ecology caused serious consequences to agriculture.

In view of their importance in agriculture, the present study is thought to be highly warranted, as it will be an attempt to provide a general awareness on the developmental parameters of important acarine plant pests. It is envisaged with a view to carry out an in-depth investigation into the breeding aspects of tetranychid mites infesting our important vegetable crops under different temperature-humidity conditions and estimation of damage induced.

**Details of the Procedure:**

Aerial parts of the plants, especially the leaves and leaflets that showed mite infestation were collected with the help of a scissors and transferred to polythene bags, labelled and transported to the laboratory. The collected samples were examined individually under a stereo zoom microscope. Live mites were either transferred to 70% alcohol for further processing or to fresh leaves for biological studies. Rearing of species of interest for in-depth studies on feeding were made by culturing them on artificially set up experimental and control plots. Studies on the life history parameters were initiated by raising laboratory cultures of the mites by rearing them on leaves of their respective host plant as food. The cultures were maintained at different sets of temperature-humidity conditions viz., 25 ± 2°C & 80 ± 5% RH, 30 ± 2°C & 70 ± 5% RH and 35 ± 2°C & 60 ± 5% RH and daily observations were made on the mode of feeding, damage and breeding of the mites. The damage potential of individual species was evaluated through different approaches like estimation of loss of chlorophyll content, estimation of phenol content, estimation of protein profile and transmission electron microscopic studies. Post-embryonic studies of the selected species were made and illustrations of the developmental stages were provided with morphological descriptions supported by camera lucida drawings. Data on mating, oviposition, hatching, duration of nymphal stages, quiescence, moultng and total duration were recorded. Results gathered on various aspects of the study have been presented in appropriate chapters, with special emphasis on the survey of acarine fauna associated with 40 species of vegetable crops cultivated in 25 different localities covering 6 districts of Kerala and
biological studies of 5 species of spider mite pests belonging to 3 different genera. Field studies on seasonal abundance, distribution pattern and host range of the selected species of spider mites were also carried out and the results of which have been recorded and presented.

**Results:**

In the present study, 40 species of economically important plants, especially vegetable crops belonging to 36 genera and 22 families cultivated in agricultural fields, home yards and kitchen gardens in 25 different sites covering 6 districts of Kerala viz., Malappuram, Kozhikode, Kannur, Wayanad, Palakkad and Thrissur were surveyed for revealing the faunal diversity of mites associated with them. However, detailed studies were initiated on 7 species of host plants duly considering their availability, supreme status and severity of mite infestation on them.

Results of field survey on the acarine fauna revealed the occurrence of members belonging to 3 orders, Prostigmata, Mesostigmata and Oribatida. Prostigmata comprised the maximum acarine inquilines recognised under 3 superfamilies, Tetranychioidea, Tarsonomoidea and Eriophyoidea, and their presence was recorded in all of the 25 collection sites, thereby claiming maximum diversity. This was closely followed by members of Mesostigmata and Oribatida. Of the various species of Prostigmatids recovered, 5 species of mites representing 3 genera viz., *Tetranychus, Eutetranychus* and *Oligonychus* of the family Tetranychidae were considered for detailed biological studies. The above 5 species were *Tetranychus neocaledonicus* Andre, *T. ludeni* Zacher, *T. cinnabarinus* (Boisduval), *Eutetranychus orientalis* (Klein) and *Oligonychus biharensis* (Hirst).

The seasonal distribution of the selected species of mites during the study period revealed their presence throughout the year at peak, moderate or scanty levels. *T. neocaledonicus, T. cinnabarinus, E. orientalis* and *O. biharensis* occurred at peak levels mainly during summer from February to April or May while *T. ludeni* showed its presence at peak levels from May to July. Study of relative abundance of the spider mite species revealed variations at interspecific and intraspecific levels. Of the 5 species, *T. ludeni* was found to be the most abundant species in terms of population density, followed by *T. cinnabarinus, T. neocaledonicus* and *O.
biharensis and E. orientalis, which happened to occur only at low to scarce levels. Differential distribution pattern of the spider mites evidenced the occurrence of E. orientalis and T. ludeni on the upper leaf surface, T. neocaledonicus and T. cinnabarinus on the underside while O. biharensis on the other hand showed equal distribution on both sides of the leaf blade.

Results of the feeding experiments conducted in the laboratory on T. neocaledonicus infesting Vigna unguiculata and Amaranthus tricolor; T. ludeni on Mucuna deeringiana; T. cinnabarinus on Carica papaya and Dolichos lablab; E. orientalis on Moringa oleifera and O. biharensis on Manihot esculenta leaves reflected on active feeding by the different life stages by piercing the leaves and sucking the cell contents. Combined and extensive feeding by the mites resulted in acute chlorosis of the leaves. Estimation of the damage potential of the above species through analysis of chlorophyll content of the leaves, in terms of percentage loss of chlorophyll 'a' and 'b', respectively yielded 47.58 ± 2.1 % and 48.30 ± 2.2 % for T. neocaledonicus, 34.57 ± 2.2 % and 43.32 ± 3.3 % for T. ludeni, 41.07 ± 2.1 % and 50.81 ± 1.6 % for T. cinnabarinus, 36.26 ± 0.99 % and 35.40 ± 2.0 % for E. orientalis and 29.40 ± 1.6 % and 46.03 ± 1.0 % for O. biharensis. Interestingly enough, this loss was found to reach 80% levels in cases of severe infestations. Analysis of total phenolics revealed an increase of about 2 - 2.5 mg phenol/100 gm plant material following T. neocaledonicus infestation and 10 – 12 mg phenol/100 gm plant material following infestation by O. biharensis. Preliminary studies on the protein profile of M. esculenta leaves following infestation and damage by O. biharensis revealed 5 prominent bands with invariably higher protein concentration on uninfested samples. This reflected a decrease in the protein concentration in the mite-infested leaves though no significant change in the protein profile could be recorded. Probably, endogenous degradation of existing proteins might have occurred following mite infestation. Cytological alterations resulting from feeding of O. biharensis on M. esculenta using electron microscopy showed reduction in the number of cells and chloroplasts, alterations in cell structure, increase in space in the spongy layer, extensive disruption of the mesophyll cells and even reduction of chloroplasts in adjacent unpunctured cells. The overall impact of spider mite feeding
had resulted in the total destruction of the photosynthetic machinery of the plant leading to its final collapse. These results have clearly established the potentiality of the leaf sucking forms in damaging the host plants.

Post-embryonic developmental studies of the above 5 species involved a larval and 2 nymphal stages prior to attaining adulthood. Each instar was constituted by an active period followed by a quiescent period, which then moulted to successive stages of development. The process of sperm transfer was achieved through mating which occurred immediately after moultling of the female deutonymph and the process lasted for 2-3 minutes. The egg deposited by the mated females developed into both females and males whereas unmated females gave rise to male progeny alone. Thus parthenogenetic development could also be recorded in all the 5 species of spider mites.

An interesting observation made during the development of *T. ludeni* was the detection of a phenomenon of aggregation during quiescent periods of the immatures. Detailed studies on the mechanism of the process indicated that the process was initiated by few individuals of the colony and the removal of these individuals disrupted the aggregation and continuation of the process. Existence of a pheromonal communication was also evidenced in the present study. The production of two types of faecal pellets by *T. ludeni* was another special feature which was not observed in the current study in any other spider mites. A yet another interesting finding emerged during the present study was the cannibalistic nature of males of *T. cinnabarinus* who fed on the females of the same species after their death immediately after egg laying. A worth mentioning aspect of the study was the incidence of *E. orientalis* on *M. oleifera* and *T. ludeni* on *M. deeringiana*, both of which were new records of host plants, so far unreported from India. Further investigations should aim at providing undisputable evidence of new host plants yet to be explored thereby necessitating further attention to be focussed on this aspect.

A comparison of the total duration of life cycle of *T. neocaledonicus* on *A. tricolor* under different temperature-humidity conditions enabled to record shorter duration of development (12.85 ± 0.14 days) at 35 ± 2°C & 60 ± 5% RH and a
longer duration at $25 \pm 2^\circ C \& 80 \pm 5\% \text{ RH}$ (16.83 ± 0.2 days). At the same time, *T. neocaledonicus* produced more generations on *V. unguiculata* at $30 \pm 2^\circ C \& 70 \pm 5\%$ within a short span of time (10.25 ± 0.08 days) proving *V. unguiculata* as the more preferred host for the mite. The developmental period of *T. cinnabarinus* on *C. papaya* (6.62 ± 1.8 days) and on *D. lablab* (6.27 ± 0.15 days) at $35 \pm 2^\circ C \& 60 \pm 5\%$ RH enabled to record *D. lablab* as the more susceptible host for the mite. The most favoured temperature-humidity combinations of *T. ludeni* on *M. deeringiana* was recorded to be $30 \pm 2^\circ C \& 70 \pm 5\% \text{ RH}$ (9.54 ± 0.18 days), of *E. orientalis* on *M. oleifera* (8.27 ± 0.14 days) was $30 \pm 2^\circ C \& 70 \pm 5\% \text{ RH}$ and of *O. biharensis* on *M. esculenta* (6.83 ± 0.10 days) was $35 \pm 2^\circ C \& 60 \pm 5\% \text{ RH}$.

The shorter developmental period ranging from 6–12 days for the above 5 species helped them in successfully completing 2-5 generations per month during favourable conditions corresponding to the temperature-humidities as reflected from the present investigation. These conditions could be identified as the ideal conditions for the population build up of the mite in field conditions also. This seems to explain why these spider mites multiply and attain pest status especially during the drier and hotter months of the year in Kerala.