Tea Q. 44 (1), 47-58. 1974. Printed in Sri Lanka.

# †THE EFFECTS OF RAINFALL AND SHADE ON THE OCCURRENCE OF THREE MITE PESTS OF TEA IN CEYLON

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Outbreaks of the red spider mite (*Oligonychus coffeae* Nietn.), the purple mite (*Calacarus carinatus* Green) and the scarlet mite (*Brevipalpus californicus* Banks) of tea were closely associated with the monthly rainfall pattern. Peak numbers occurred during the intermonsoonal dry periods. The relationship between mite numbers and the rainfall pattern suggests that control measures should commence at the end of the first month after the dry reason begins. More red spider mites, but fewer purple mites, occurred on tea grown under shaded conditions. Observations on the relationship, between scarlet mite numbers and shade were inconclusive. It is suggested that, in addition to direct effects of rainfall and shade, mite numbers ard determined by certain biochemical processes that take place within the tea leaves.

The red spider mite (*Oligonychus coffeae* Nietn.—Tetranychidae), the scarlet mite (*Brevipalpus californicus* Banks—Tenupalpidae) and the purple mite (*Calacarus carinatus* Green—Eriophyidae) are important pests of tea in Ceylon and India. In Ceylon the outbreaks are particularly serious in the Uva district, which receives only the north-east monsoon rains. Mites are dry-weather pests with outbreaks occurring during the intermonsoonal dry periods (Cranham 1966), but there has been no previous investigation of this relationship. The six experiments reported in this paper were carried out to examine the relationship between mite outbreaks and the north-east monsoon rains in the Uva district. The effects of shade trees were studied in two of these experiments as it has been stated that unshaded tea is more severely attacked by the red spider mite (Das 1959) and that shade trees carry potential infestations of the scarlet mite (Baptist & Ranaweera 1955).

The bionomics of the red spider mite have been studied by Das (1959, 1960), that of the scarlet mite by Baptist & Ranaweera (1955) and that of the purple mite by King (1937) and Das & Sengupta (1962). Red spider mite is found on the upper surfaces of mature leaves. The colonies are present in shallow depressions of the leaf surface under webbing spun by the mites. Scarlet mite occurs on the underside of mature leaves, mainly along the petiole and the midrib. Purple mite is found on both surfaces of the leaves, with initial attacks heavier on the undersurface. The older leaves are preferred by this mite, except in heavy infestations when the younger leaves and buds are also attacked. All three species cause severe defoliation. Repeated heavy attacks lead to general debiliation of bushes so that the new wood growing after pruning is spindly and weak.

†Reprinted from the *Annals of Applied Biology* by courtesy of the Authors and Editors.

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TABLE 1 — *The list of experiments*

| Expt no. | Site | Location | Duration |
|---|---|---|---|
| 1 | Downside Estate | Welimada | 15 June 65 to 21 Dec. 69 |
| 2 | Liddesdale Group No. 2 Field | Halgranoya | 14 June 67 to 21 Dec. 69 |
| 3 | Liddesdale Group No. 5 Field | Halgranoya | 18 July 67 to 26 Nov. 69 |
| 4 | Ambagasdowa Estate | Welimada | 24 Sept. 68 to 4 Nov. 69 |
| 5 | Glennanore Estate | Haputale | 3 Aug. 68 to 25 July 69 |
| 6 | Gonamotawa Estate | Haputale | 1 Sept. 68 to 19 Oct. 69 |

TABLE 2 — *Correlation between mite numbers and monthly rainfall*

| Site | Current month's rainfall | Prevoius month's rainfall | Rainfall 2 months previously |
|---|---|---|---|
| Red spider mite: | | | |
| Downside | –0.217 NS | –0.353* | –0.225 NS |
| Liddesdale No. 2 Field | –0.245 NS | –0.388* | –0.286 NS |
| Liddesdale No. 5 Field | –0.322 NS | –0.473** | –0.479* |
| Ambagasdowa | 0.065 NS | –0.951*** | –0.161 NS |
| Glennanore | –0.157 NS | –0.624* | –0.374 NS |
| Gonamotawa | 0.081 NS | –0.17 NS | 0.025 NS |
| Scarlet mite: | | | |
| Downside | 0.045 NS | –0.104 NS | –0.093 NS |
| Liddesdale No. 2 Field | –0.274 NS | –0.233 NS | –0.457 NS |
| Liddesdale No. 5 Field | –0.220 NS | –0.352* | –0.266 NS |
| Ambagasdowa | 0.107 NS | –0.201 NS | –0.029 NS |
| Glennanore | –0.409 NS | –0.185 NS | –0.279 NS |
| Gonamotawa | 0.364 NS | –0.051 NS | –0.277 NS |
| Purple mite: | | | |
| Liddesdale No. 2 Field | –0.37* | –0.524** | –0.439* |
| Liddesdale No. 5 Field | –0.503** | –0.537** | –0.401* |
| Glennanore | –0.215 NS | –0.618** | –0.426* |

Significant at $P < 0.05$*, $P < 0.01$**, $P < 0.001$***.

TABLE 3 — *Correlation between mite numbers and previous month's rainfall*

| Site | Correlation coefficients: 10-year average rainfall | Correlation coefficients: Average rainfall for period of experiment |
|---|---|---|
| Red spider mite: | | |
| Downside | –0.744** | –0.353* |
| Liddesdale No. 2 Field | –0.836*** | –0.388* |
| Liddesdale No. 5 Field | –0.795** | –0.473** |
| Ambagasdowa | –0.725** | –0.951*** |
| Glennanore | –0.629** | –0.624* |
| Gonamotawa | 0.115 NS | –0.17 NS |
| Purple mite: | | |
| Liddesdale No. 2 Field | –0.841*** | –0.524** |
| Liddesdale No. 5 Field | –0.837*** | –0.537** |
| Glennanore | –0.878*** | –0.618** |

Significant at $P < 0.05$*, $P < 0.01$**, $P < 0.001$***.

Mite damage is insidious and difficult to assess. Recently it was shown that even a moderate attack by the red spider mite could cause crop losses in the region of 5%, so making control measures economic (Danthanarayana & Ranaweera 1970). According to Rao (1970) crop losses in India are estimated to be about 25%. Since mites are inconspicuous, outbreaks usually become apparent only after damage has been caused and defoliation begun. There is thus a need for prophylactic measures,

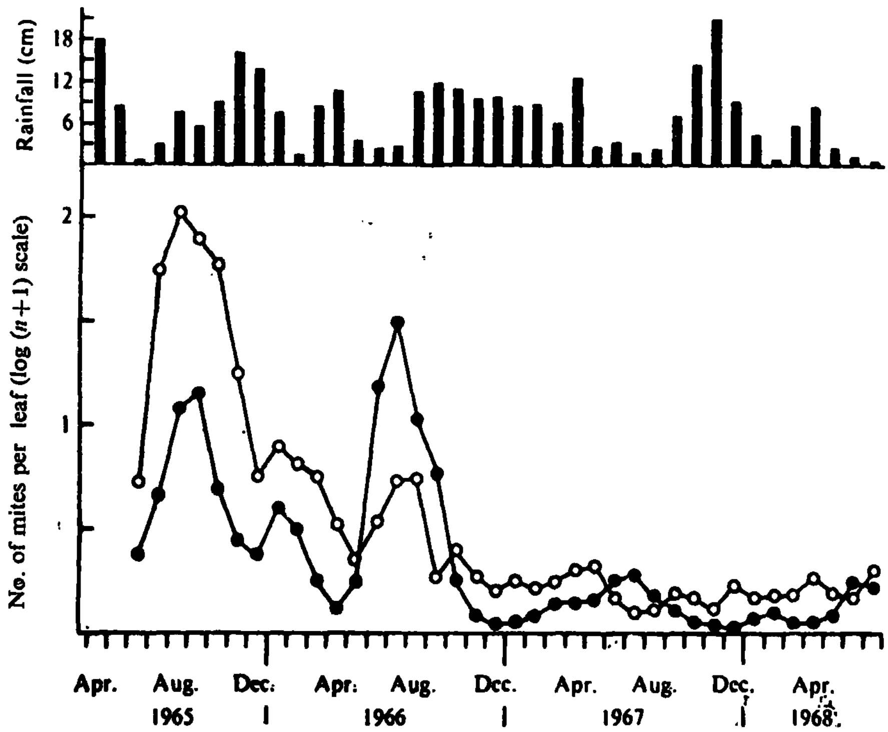


FIG. 1—*Seasonal changes in the numbers of the red spider mite (solid circles) and the scarlet mite (open circles) in Expt 1 at Downside Estate.*

especially in tea fields known to be prone to mite damage and also in certain tea-growing districts, such as the Uva, where mites are a perennial problem. From the results of the experiments reported here it is possible to time such prophylactic treatments. At present, non-chemical methods are not available for the control of mites infesting tea; biological control attempts have so far been ineffective (Cranham 1966; F. J. Simmonds personal communication).

## METHODS

Six experiments were undertaken (Table 1). Experiments 1 and 2, to observe effects of rainfall, temperature and shade, had a split-plot design with six replicates. Each block had eight plots, each $\frac{1}{30}$ acre (0.013 ha) in extent, split with two densities of shade, no shade and normal shade. The tea bushes had been planted in cross rows 1 m apart. In Expt No 1, *Grevillea robusta* A. Cunn. at a spacing of 20x20 m, *Gliricidia sepium* H. B. & K. at 9x6 m and *Erythrina lithosperma* Blume at 9x9 m were used as shade. In Expt no. 2, *Grevillea robusta* at 14x9 m, *Acacia pruinosa* A. Cunn. at 15x4 m and *Erythrina lithosperma* at 9x9 m were used as shade. This is the usual type of shade in the Uva district, providing both high and low moderate, but evenly distributed, shade.

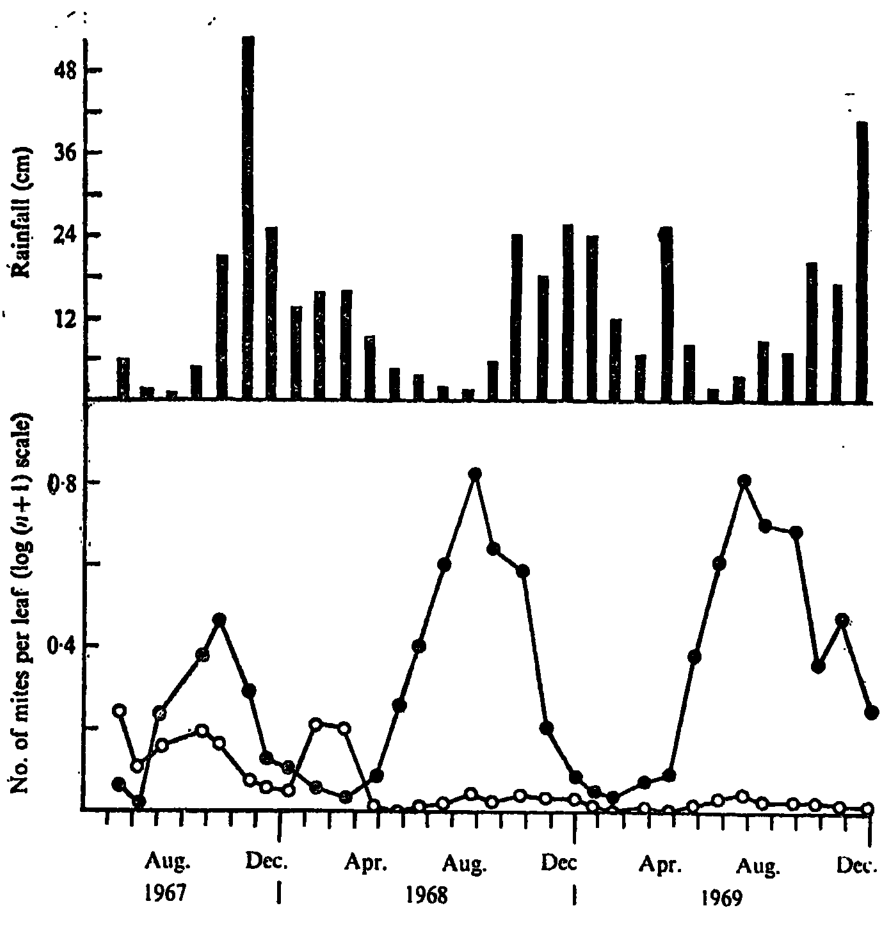


FIG. 2—*Seasonal changes in the numbers of the red spider mite (solid circles) and the scarlet mite (open circles) in Expt 2 at Liddesdale Group No. 2 Field.*

In Expts 3-6 only the effects of rainfall and temperature were evaluated. All were arranged in a randomized block design with a block of four plots (each $\frac{1}{30}$ acre) each replicated four times. All the fields used in these experiments were unshaded.

Mite numbers were assessed at monthly intervals by taking a sub-sample of fifty leaves from each of two lots of 500 leaves at random from each plot. The mites were brushed separately on to two freshly varnished cardboard disks in the field using a battery-operated version of the Henderson & McBurnie (1943) mite-brushing machine. The mites were counted under low-power microscopes. Red spider and scarlet mite attacks developed in all six experiments. Purple mite outbreaks developed only in Expts 2, 3 and 5. Records were maintained of the maximum and minimum daily temperature and rainfall.

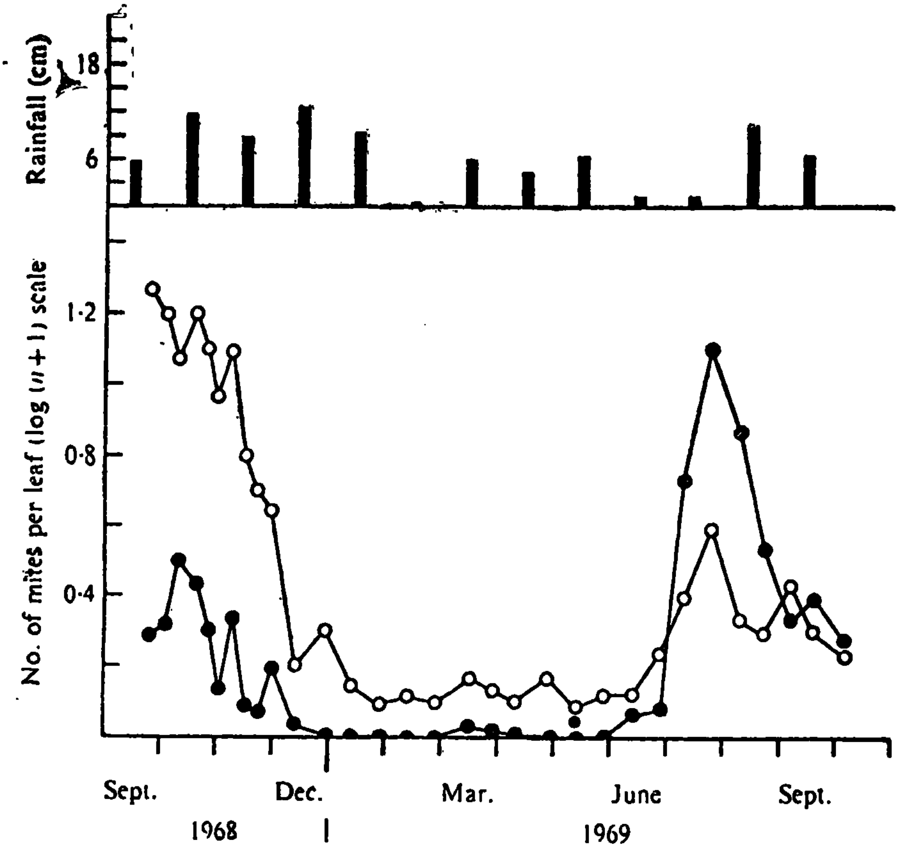


FIG. 3—*Seasonal changes in the numbers of the red spider mite (solid circles) and the scarlet mite (open circles) in Expt 4 at Ambagasdowa Estate.*

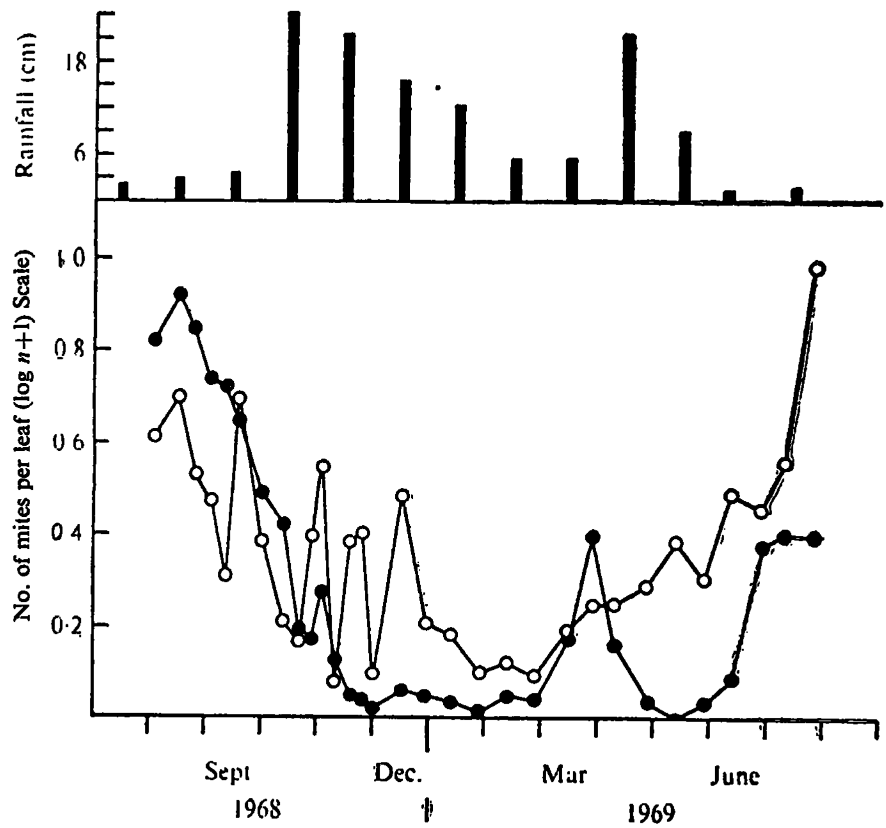


FIG. 4—*Seasonal changes in the number of the red spider mite (solid circles) and the scarlet mite (open cricles) in Expt 5 at Glennanore Estate.*

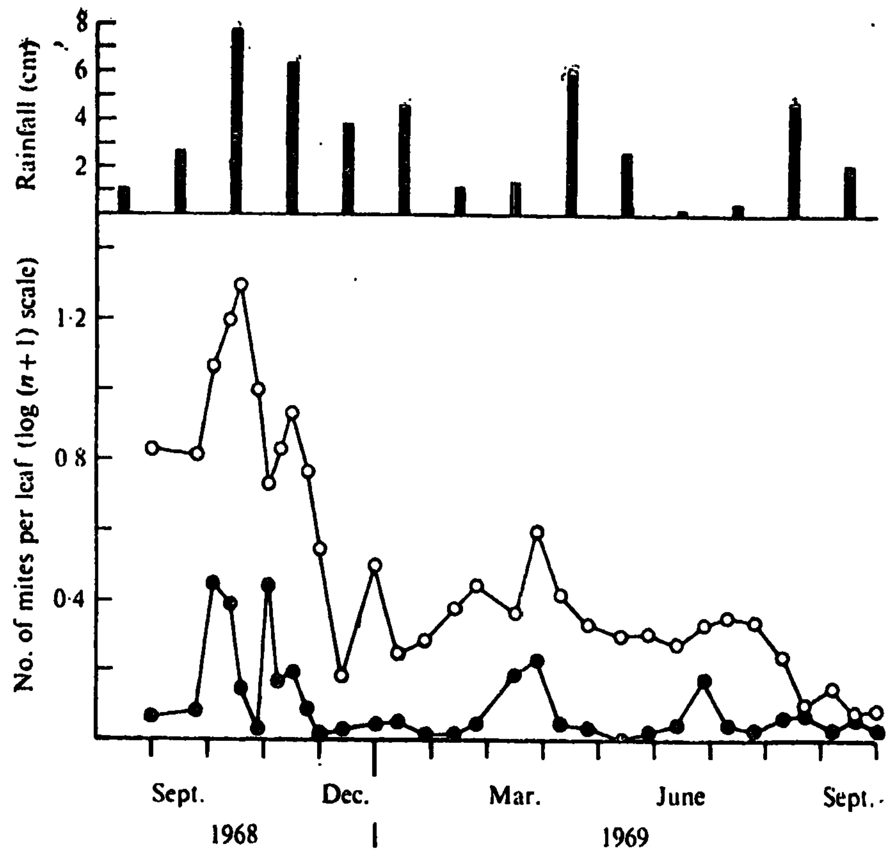


FIG. 5—*Seasonal changes in the numbers of the red spider mite (solid circles) and the scarlet mite (open circles) in Expt 6 at Gonamotawa Estate.*

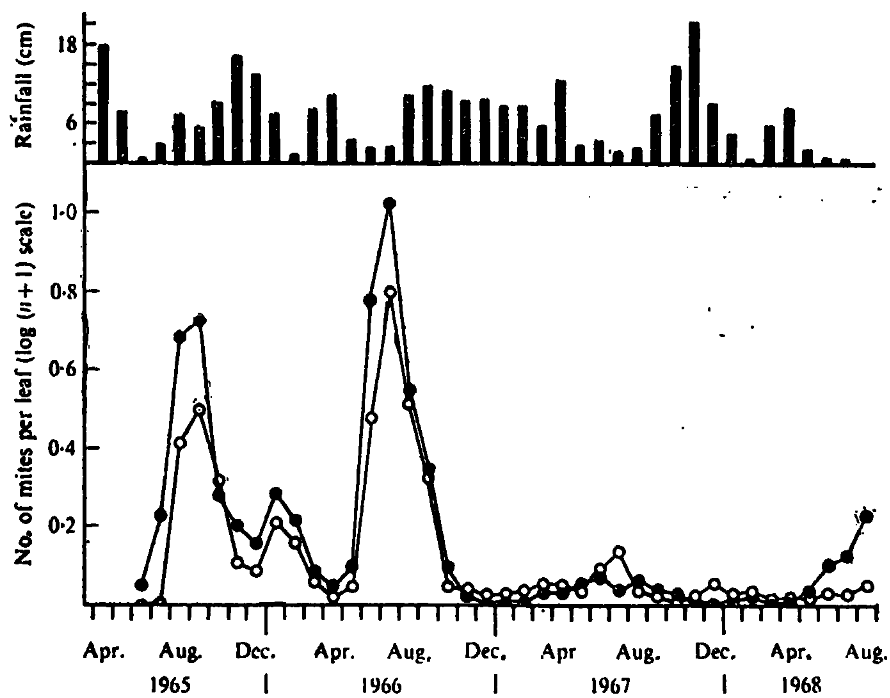


FIG. 6—*Seasonal changes in the numbers of the red spider mites in shaded plots (solid circles) and unshaded plots (open circles) in Expt 1 at Downside Estate.*

## RESULTS

There were marked fluctuations in mite numbers, and since there appeared to be negative relationships between these and the rainfall data (Figs. 1-11), correlation coefficients were calculated for (1) the current month's rainfall, (2) the previous month's rainfall and (3) the rainfall 2 months previously (Table 2). Temperature did not show any relationship with the mite numbers and is not indicated. The results of Expt. no 3 are not illustrated as they were very similar to those of Expt no. 2.

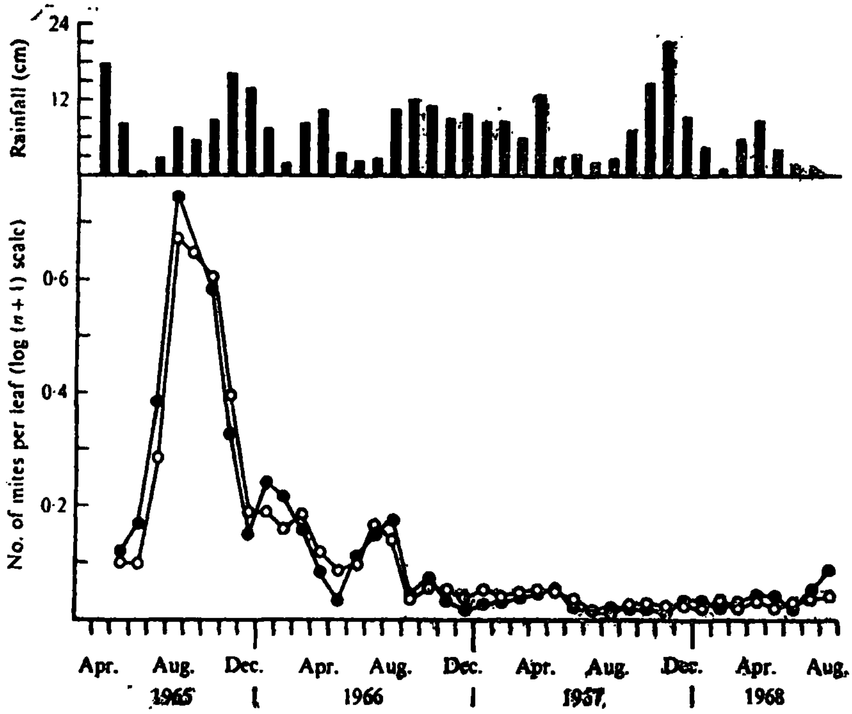


FIG. 7—*Seasonal changes in the numbers of the scarlet mite in shaded plots (solid circles) and unshaded plots (open circles) in Expt 1 at Downside Estate.*

In five out of six experiments red spider mite numbers were significantly negatively correlated with the previous month's rainfall. When considering a large number of coefficients of correlation (in this instance 18), the significance (or non-significance) in one experiment could be due to random error. Hence it is possible to ignore the significance of correlation found between scarlet mite numbers and the previous month's rainfall in Expt no. 1. Although the graphs indicate a negative relationship between the numbers of this mite and rainfall, the relationship is not supported by the statistical analysis. In the three experiments in which the purple mite numbers were assessed, there were significant negative correlations between mite numbers and the previous month's rainfall. The relationship was so close that significant coefficients were also given of the rainfall for the current month and for 2 months previously (Table 2).

The relationship between the mite numbers and the previous month's rainfall was then considered in relation to the average monthly rainfall over the previous 10 years (1961-70). The results indicate highly significant ($P < 0.01$-$0.001$) negative relationships (Table 3).

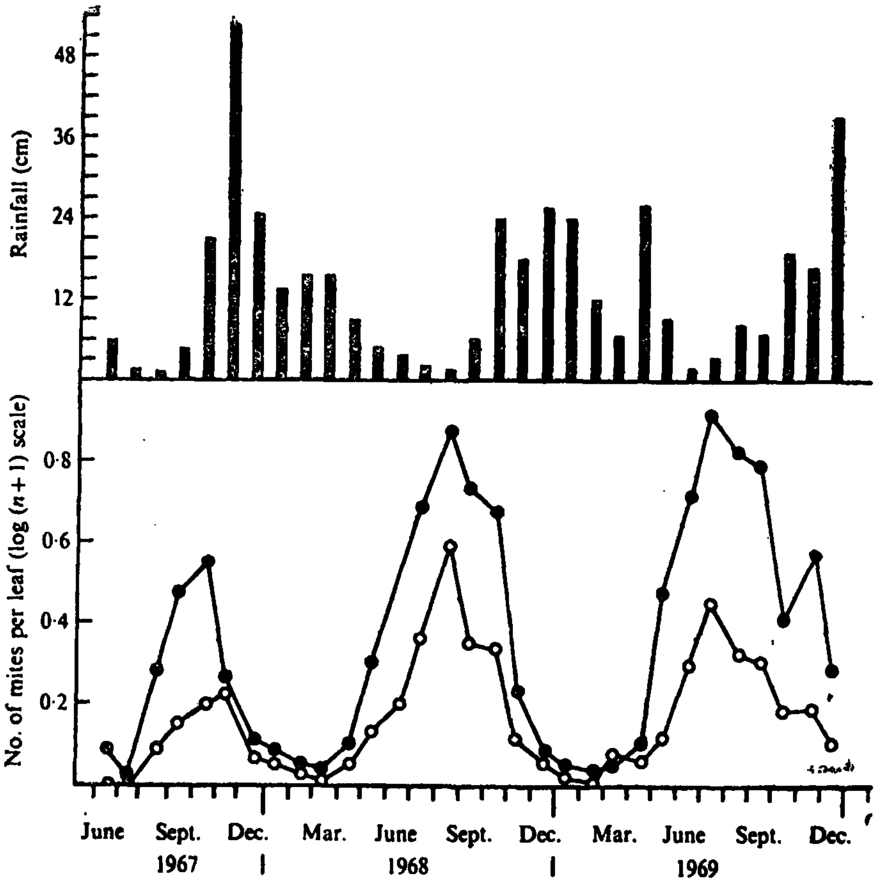


FIG. 8—*Seasonal changes in the numbers of the red spider mite in shaded plots (solid circles) and unshaded plots (open circles) in Expt 2 at Liddesdale Group No. 2 Field.*

The changes in numbers of mites in the shaded and unshaded plots are compared in Figs. 6-10. Shaded plots harboured significantly more red spider mites ($P < 0.001$) but there was no significant difference in the populations of scarlet mite between shaded and unshaded plots in Expt 1. In this experiment an outbreak of purple mite did not develop. In Expt 2 there were significantly more scarlet mites ($P < 0.05$) and purple mites ($P < 0.001$) in the unshaded plots.

## DISCUSSION

The results show conclusively that numbers of red spider and purple mite are significantly negatively correlated with the previous month's rainfall. Heavy monsoon rains wash off mites. Rainwater collected under tea bushes contained large numbers of red spiders, an observation confirmed by Das (1959), in India. The scarlet mite, which occupies the lower surfaces of leaves is protected from rain and so less affected. Also, since more red spider mites, which live on upper leaf surfaces, were found on tea grown under shaded conditions, it appears that shade trees provide a rain break and so protect the mites.

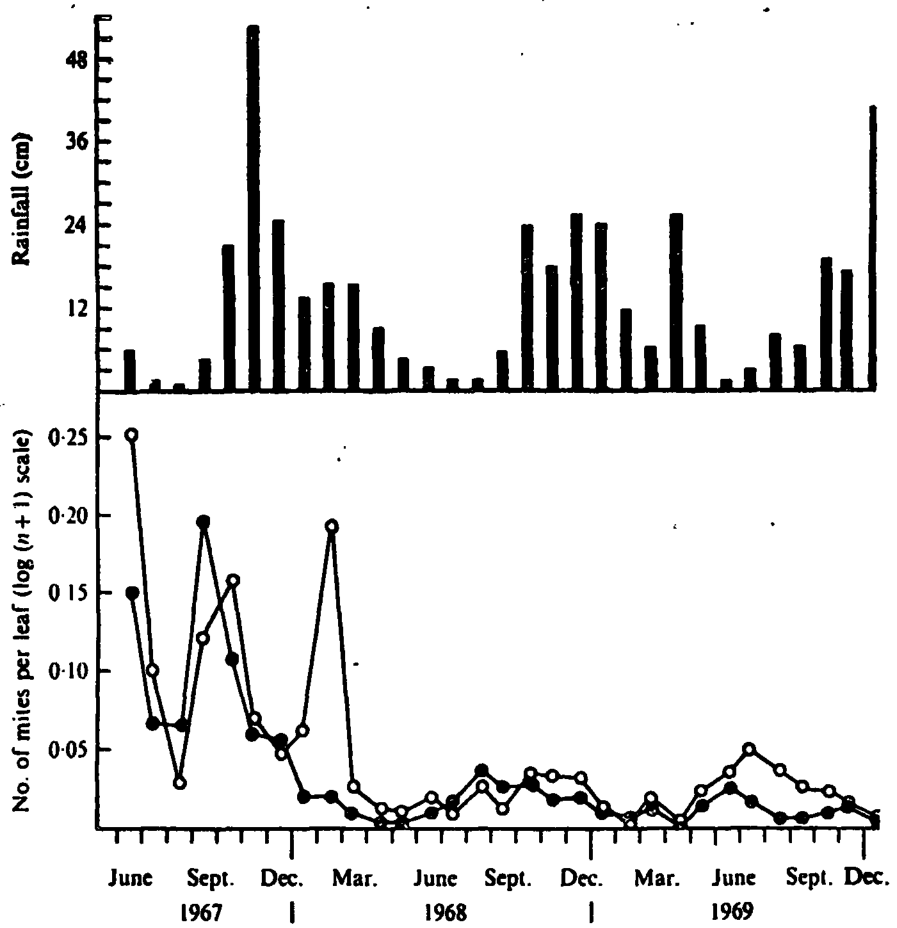


FIG. 9—*Seasonal changes in the numbers of the scarlet mite in shaded plots (solid circles) and unshaded plots (open circles) in Expt 2 at Liddesdale Group No. 2 Field.*

Work carried out previously by Fernando (1967; cf. Danthanarayana 1969) shows that rainfall has a far more important, but indirect effect on mite numbers. The red carotenoid pigment rhodoxanthin, which is found in the red spider mite, also occurs in the leaves of tea bushes which are susceptible to attack. Rhodoxanthin is, however, absent both from leaves of bushes which are not colonized by the mite and from the leaves of susceptible bushes during the monsoon rains. The pigment appears to be synthesized in tea leaves during the dry months of the year and probably acts as a phagostimulant or a reproductive stimulant. The amount of rhodoxanthin present could thus affect the build-up of mite numbers during the dry months.

Experiments show that larger red spider mite outbreaks could be expected when tea is grown under shaded conditions. This finding disagrees with the observations of Andrews (1920), Harrison (1938) and Das (1959), who have stated that the red spider mite prefers bright sun. The present investigations, however, strongly suggest that the above view is incorrect, for this is the first quantitative determination of shade on mite numbers. It is of interest to note that on jute, *Corchorus capsularis* Linn., the tea red spider mite almost invariably colonizes the undersurfaces of leaves (Das 1959). This contrasted behaviour may be associated with the biochemistry

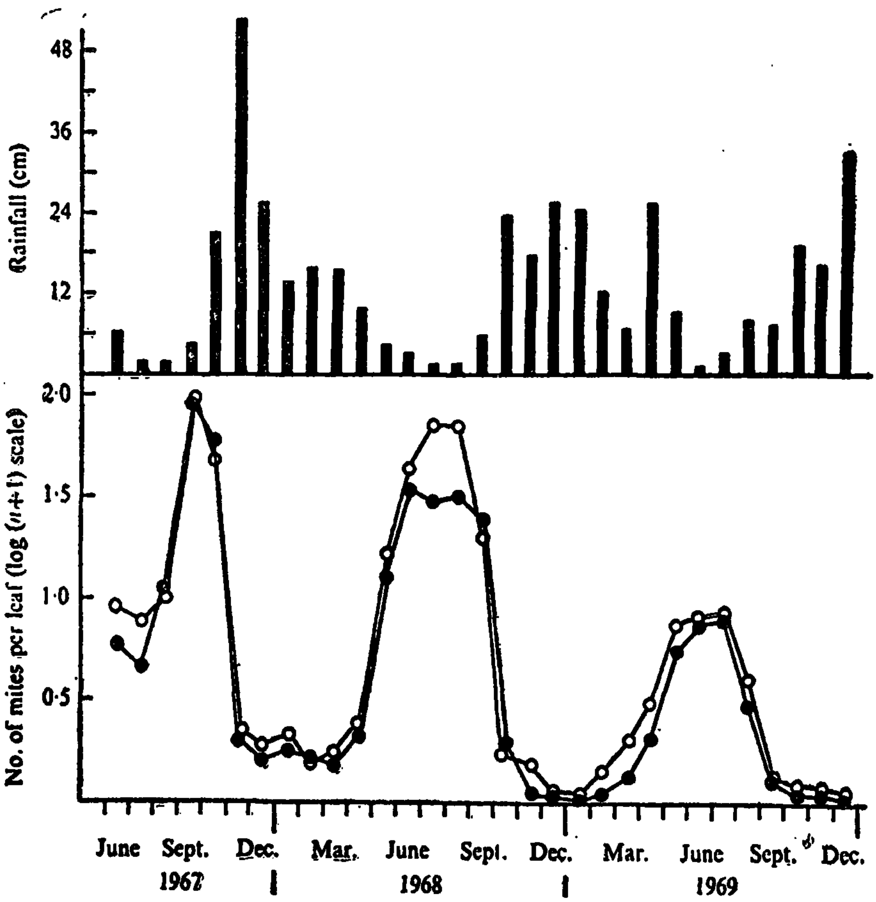


FIG. 10—*Seasonal changes in the numbers of purple mites in the shaded plots (solid circles) and unshaded plots (open circles) in Expt 2 at Liddesdale Group No. 2 Field.*

of the leaves as discussed above. According to Huffaker, Vrie & McMurty (1969) the presence or absence of shade could affect tetranychid mite populations directly through their nutrition. Since significantly more purple mites were found in unshaded plots ($P < 0.001$) it would appear that the nutritional requirements of this species are different from those of the red spider mite.

The evidence presented here suggests that it is inadvisable to plant tea under shaded conditions in areas where the red spider is a serious problem. The question of planting shade trees in tea fields is a very controversial subject (cf. Joachim 1961; Visser 1961 *a*, *b*; McCullough, Pereira, Kerfoot & Goodchild 1965, 1966). Recent experiments on the biology of the twig caterpillar (*Ectropis bhurmitra* Wkr.—Geometridae) showed that since the bark of shade trees provides oviposition sites, outbreaks of this pest do not occur in unshaded tea fields (Danthanarayana & Kathiravetpillai 1969). The present investigations on the red spider mite provide further support to the argument that from an entomological point of view it is disadvantageous to grow tea under shaded conditions.

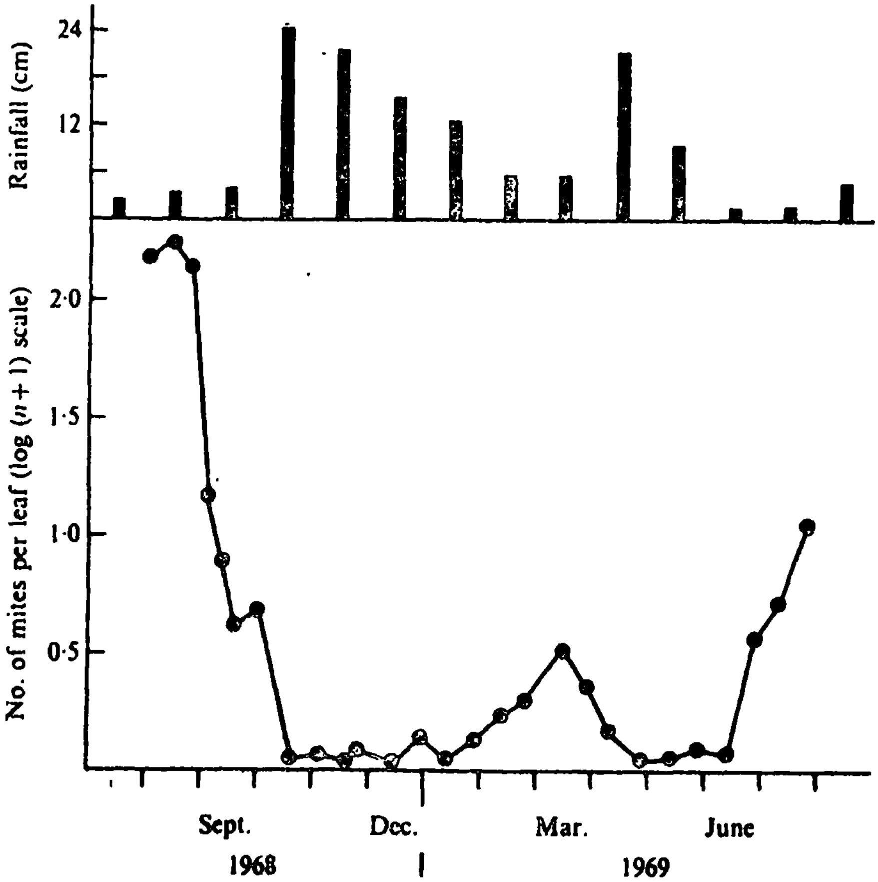


FIG. 11—*Seasonal changes in the numbers of purple mites in Expt 5 at Glenmanore Estate.*

As outbreaks of the red spider and purple mites are closely associated with the previous month's rainfall, prophylactic chemical control can now be planned efficiently. The recommended acaricides in Ceylon are dicofol (Kelthane) and quinomethionate (Morestan). Both these chemicals are persistent and effective for up to 3 months (Danthanarayana & Ranaweera 1970).

A single application after the first month of drought should provide control throughout the dry season. The 10-year rainfall data indicate that the approach to mite control proposed is reliable and obviates the necessity of more than one acaricide application.

## ACKNOWLEDGEMENTS

We wish to express our gratitude to Dr J. E. Cranham (now at East Malling Research Station), who started Expt no. 1. We thank Messrs K. D. Bandularatne, S. N. Fernando, A. Kathiravetpillai and C. Shanmugam for laboratory and field assistance and Dr T. R. New for reading the manuscript. The secretarial assistance of Miss S. Grounds is gratefully acknowledged.

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