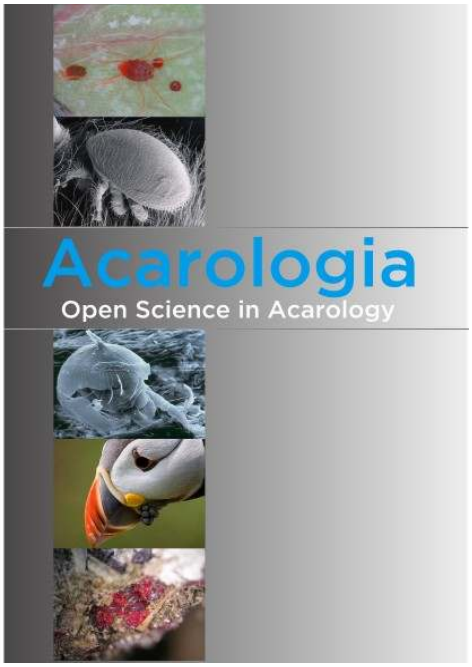

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A DEMOGRAPHIC STUDY OF THE GROWTH RATE OF THE RED SPIDER MITE *OLIGONYCHUS COFFEAE* (NIETNER) ON TWO VARIETIES OF TEA

BY

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INTRODUCTION

Although considerable information is available on the biology of the spider mite, *Oligonychus coffeae* (Nietner), on tea (DAS 1955 : BANERJEE 1965), a demographic analysis of its population has not so far been attempted. Such analysis has, however, been used with advantage to study the age-specific fertility and population growth rates in several acarine species (WATSON 1964 : LAING 1968, 1969 : DAVIS & BROWN 1969). Considering the importance of this approach in the population dynamics of tea pests, this paper describes the intrinsic rate of increase and associated population parameters of *Oligonychus coffeae* on China and Assam varieties of tea (*Camellia sinensis* L. Var *sinensis* and *assamica*).

MATERIALS AND METHODS

O. coffeae from a common parental stock reared in the laboratory was used. The females used were one day old : this was achieved by sorting out the females emerging on different dates. A basic unit of 500 females, in groups of 50, on 10 fresh shoots of Assam and China varieties of tea were maintained at $30 \pm 3°C$; 85 ± 5 % R.H. The basal part of the stem of the shoots was kept in tubes half filled with water to prevent dessication. There were five replicates. Simultaneous observations on Assam and China varieties of tea could not always be made, but attempts were made to take all observations within the shortest possible time to avoid seasonal effects.

Tea leaves were examined for 12 consecutive days for red spider eggs, which were removed with a fine camel hair brush and counted. The survivorship curve, age-specific fertility, net reproductive rate, capacity for increase and intrinsic rates of increase were determined according to standard statistical procedures as discussed by BIRCH (1948), ANDREWARTHA & BIRCH (1954), and SOUTHWOOD (1966).

The terms Assam and China varieties in the following text will mean red spiders on Assam and China varieties of tea respectively.

TABLE 1. — Fecundity table for *Oligonychus coffeae* (Nietner) on China variety of tea at 30 ± 3.0c; 85 ± 5 % RH.

Pivotal age	Proportion of females alive at age x	Age-specific fecundity		
x	l_x	m_x	$l_x m_x$	$x\ l_x\ m_x$
1	1.00	0.00	0.00	0.00
2	0.96	3.5	3.36	6.72
3	0.93	3.0	2.79	8.37
4	0.77	3.0	2.31	7.24
5	0.60	2.5	1.50	7.50
6	0.55	2.5	1.38	7.68
7	0.51	2.5	1.28	9.96
8	0.41	2.0	0.82	6.56
9	0.33	1.5	0.50	4.50
10	0.18	1.5	0.27	2.70
11	0.08	1.0	0.08	0.00
12	0.04	1.0	0.04	0.00
			Σ 14.33	Σ 61.23

TABLE 2. — Fecundity table for *Oligonychus coffeae* (Nietner) on Assam variety of tea at 30 ± 3°C: 85 ± 5 % RH.

Pivotal age	Proportion of female alive at age x	Age specific fecundity		
x	l_x	m_x	$l_x\ m_x$	$x\ l_x\ m_x$
1	1.00	0.00	0.00	0.00
2	1.00	2.5	2.50	5.00
3	0.85	2.5	2.12	6.36
4	0.64	3.5	2.24	8.96
5	0.54	4.0	2.16	10.80
6	0.46	2.5	1.15	6.90
7	0.29	2.0	0.58	4.06
8	0.26	2.0	0.52	4.16
9	0.15	1.5	0.22	1.98
10	0.04	1.0	0.04	0.40
11	0.22	0.5	0.01	0.11
12	0.008	0.5	0.004	0.04
			Σ 11.53	Σ 33.77

Results

A. *Survivorship and age-specific fecundity*

Age-specific survivorship is the number of females alive during a given age interval as a fraction of initial population of one. The survivorship curve of red spider on Assam and China varieties of tea is shown in Fig I. On both varieties the female survivorship and age-specific fertility (Tables 1 and 2) went down with age : the decrease was near linear.

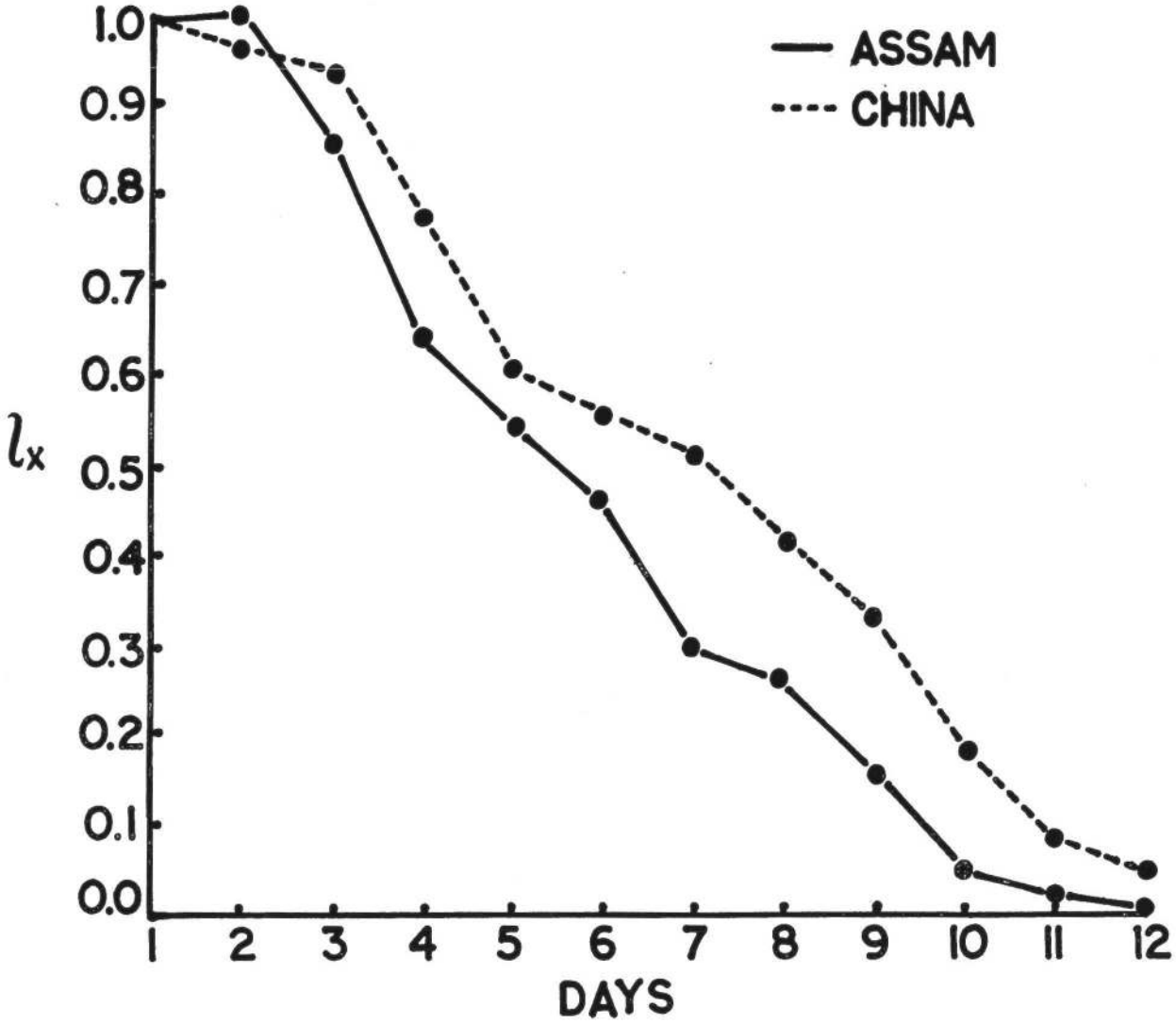

Fig. 1. — Survivorship probability for *Oligonychus coffeae* on Assam and China varieties of tea.

B. *Net reproductive rate*

The net reproductive rate (R_0) is the number of times the population multiplies in a generation. This is determined from the relationship

$$R_o = \int_o^{\alpha} l_x m_x d_x \qquad (1)$$

or

$$R_o = \Sigma\, l_x m_x \qquad (2)$$

where l_x = age specific survivorship of the female
m_x = age specific fecundity of the female

Solving the equation with the basic data in Tables 1 and 2

R_o = 14.33 for China variety

and

R_o = 11.53 for Assam variety.

C. *Capacity for increase*

The rate of multiplication of the mite is its capacity for increase (LAUGHLIN 1965). This may be expressed as

$$r_c = \log_e R_o\, T_c \qquad (3)$$

where R_o is the net reproductive rate.

T_c is determined from the relationship,

$$T_c = \frac{\Sigma\, l_x m_x x}{\Sigma\, l_x m_x} \qquad (4)$$

= 4.41 for China variety and 2.84 for Assam variety.

The values of r_m (equation 3) were thereafter estimated to be 0.60 and 0.85 for China and Assam varieties of tea respectively.

D. *Intrinsic rate of increase*

The intrinsic rate of increase (r_m) is the instantaneous growth coefficient of the population under a specified constant environment and with no mortality other than the physiological ones (BIRCH 1948). This gives a more accurate description of the population growth than the capacity for increase. Under the conditions specified above

$$\int_o^{\alpha} e^{-r_m x} l_x m_x d_x = 1 \qquad (5)$$

which is approximated to

$$\Sigma\, e^{-r_m x} l_x m_x = 1 \qquad (6)$$

where e = base of natural logarithm
X = age of the individuals in days
l_x = number of females alive at age x as a proportion of one
m_x = number of females produced by each female at each age interval

The equation can be solved by iteration taking different arbitrary values of γ_m. But an easier solution is obtained by multiplying both sides of the equation by a power e^7 (WATSON 1964).

Thus

$$e^7\, \Sigma\, e^{-r_m x} l_x m_x = e^7 \qquad (7)$$

TABLE 3. — Calculation of the intrinsic rate of increase of *Oligonychus coffeae* (Nietner) on China variety of tea at 30 ± 3°C with 85 ± 5 % RH.

r^m = 0.86				r_m = 0.80			
r_mx	$7-r_mx$	e^{7-r_mx}	$e^{7-r_mx}l_xm_x$	r_mx	$7-r_mx$	e^{7-r_mx}	$e^{7-r_mx}l_xm_x$
0.86	6.14	444.86	0.00	0.80	6.20	492.75	0.00
1.72	5.28	181.27	598.19	1.60	5.40	221.45	730.79
2.58	4.42	81.45	219.92	2.40	4.60	99.48	268.60
3.44	3.56	36.15	83.15	3.20	3.80	44.70	102.81
4.30	2.70	14.88	22.30	4.00	3.00	20.08	30.12
5.16	1.84	6.29	8.18	4.80	2.20	9.08	11.73
6.02	0.98	2.66	3.19	5.60	1.40	4.05	4.86
6.88	0.12	1.12	0.90	6.40	0.60	1.82	1.46
7.74	-0.74	0.47	0.24	7.20	-0.20	0.81	0.41
8.60	-1.60	0.26	0.05	8.00	-1.00	0.36	0.07
9.46	-2.46	0.08	0.00	8.80	-1.80	0.16	0.00
10.32	-3.32	0.03	0.00	9.60	-2.60	0.07	0.00
			Σ 936.02				Σ 1150.85

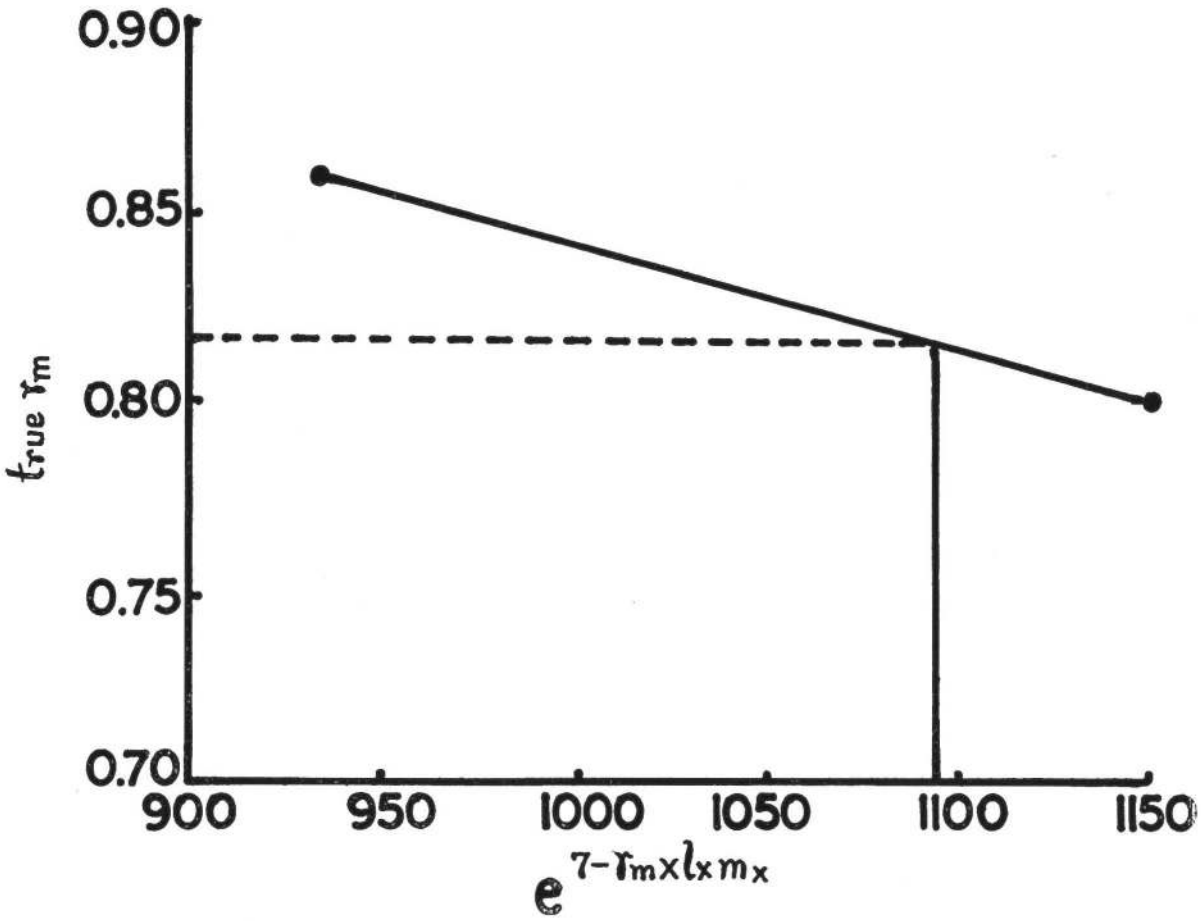

FIG. 2. — Graphical estimation of true r_m of *Oligonychus coffeae* on China variety of tea.

or

$$\frac{^{7-}r_m x}{e\, l_x m_x} = 1096.6 \qquad (8)$$

The trial values of r_m for China variety were $r_m = 0{\cdot}86$ and $r_m — 0{\cdot}80$. The steps in the numerical solution of equation (8) by using these formulae are shown in table 3. The final results were

$$\frac{^{7-}r_m x}{e\, l_x m_x} = 936.02 \text{ when } \underline{r_m} = 0.86 \qquad (9)$$

and

$$\frac{^{7-}r_m x}{e\, l_x m_x} = 1150.85 \text{ when } \underline{r_m} = 0.80 \qquad (10)$$

Since none of these values was even a close approximation to the expected 1096.6, true r_m was determined graphically (Fig. 2) plotting the two trial values of r_m against $\Sigma e^{7-\gamma_m} X \int_x m_x$ of table 3. The two points were then joined to give a line which was intersected by a vertical line drawn from the desired value of $\Sigma e^{7-\gamma_m} X \int_x m_x$ i.e. 1096.6. The point of intersection gave the accurate value of r_m as 0.81.

For the Assam variety, the trial values were 0.74 and 0.72 (table 4), and with these $\Sigma e^{7-\gamma_m} X \int_x m_x$ came to 1045.91 and 1092.21 respectively. Since 1092.21 was very close to the expected 1096.6, $r_m = 0.72$ was considered to be near accurate.

TABLE 4. — Calculation of the intrinsic rate of increase of *Oligonychus coffeae* (Nietner) on Assam variety of tea at 30 ± 3°C with 85 ± 5 % RH.

$r_m = 0.74$				$r_m = 0.72$			
$r_m x$	$7-r_m x$	$e7-r_m x$	$e7-r_m x l_x m_x$	$r_m x$	$7-r^m x$	$e7-r_m 7$	$e7-r_m x l_x m_x$
0.74	6.26	492.75	0.00	0.72	6.28	492.75	0.00
1.48	6.52	244.69	611.72	1.44	5.56	244.69	611.72
2.22	4.78	109.95	233.09	2.16	4.84	121.51	257.60
2.96	4.04	54.59	122.28	2.88	4.12	60.34	135.16
3.70	3.30	27.11	58.55	3.60	3.40	29.96	64.71
4.44	2.56	12.93	14.86	4.32	2.68	14.58	16.67
5.18	1.82	6.17	3.57	5.04	1.96	7.09	4.11
5.92	1.08	2.94	1.52	5.76	1.24	3.45	1.79
6.66	0.34	1.40	0.30	6.48	0.52	1.68	0.36
7.40	-0.40	0.67	0.02	7.20	-0.20	0.13	0.005
8.14	-1.14	0.31	0.003	7.92	-0.92	0.39	0.003
8.88	-1.88	0.15	0.00	8.64	-1.64	0.19	0.00
			Σ 1045.913				Σ 1092.218

Using these statistics the finite rate of increase, that is, the number of times the population multiplies per unit time was determined from the relationship

$$\lambda = \frac{N_t + 1}{N_t} = \frac{r_m}{e} = \text{antilog } \frac{r_m}{e} \qquad (11)$$

which was 6.53 for China tea and 5.24 for Assam tea.

The population parameters are summarised in table 5.

TABLE 5. — Population parameters for *Oligonychus coffeae* (Nietner) on China and Assam varieties of tea at 23 ± 3°C : 85 ± 5 % RH.

Parameters	China tea	Assam tea
Net reproductive rate R_o	14.33	11.53
Intrinsic rate of increase r_m	0.81	0.72
Finite rate of increase λ	6.53	5.24
Generation length $T = \log e R_o r_m$	3.28	3.38
Capacity for increase r_c	0.60	0.85
$T_c = \frac{\Sigma l_x m_x x}{\Sigma l_x m_x}$	4.41	2.84

DISCUSSION

The growth parameters, particularly the intrinsic rate of increase, r_m, of animals vary with the physical environment to which they are exposed (DUMIMRE 1960 : FRENCH & KAAZ 1968). Temperature influences the intrinsic rate of increase of *Tetranychus urticae* (LAING 1969), whereas vapour pressure deficiency modifies the value of r_m for the grain mite *Acarus siro* (DAVIS & BROWN 1969).

According to WATSON (1964), the age of host plant is of consequence in the population growth of *Tetranychus urticae*. This could also be true for *Oligonychus coffeae*, but the major factors that influence its population growth on tea appear to be the morphological and biochemical characteristics of the Assam and China varieties (WIGHT 1961 : BARUA 1963).

Photosensitivity of *Oligonychus coffeae* (BANERJEE & DAS 1969), however, suggests that under field conditions light distribution within the bushes (HADFIELD 1964) possibly act confounded with the " characteristics " of host plants in influencing the population growth of the mite on tea.

SUMMARY

Population parameters for the red spider mite, *Oligonychus coffeae* (Nietner), on Assam and China varieties of tea are given. Age-specific survivorship and fecundity are higher on China variety than on Assam variety of tea. The net reproductive rate (R_o), capacity for increase (r_c), intrinsic rate of increase (r_m), and finite rate of increase (r), follow the similar trend. Since the physical environment for the growth of the mite population was maintained fairly uniform, morphological and biochemical nature of the two varieties of tea leaves are considered to have influenced the differential population growth rate.

ABSTRACT

The growth potentialities of the red spider mite *Oligonychus coffeae* (Nietner) at 30° ± 3°C ; 85 ± 5 % R. H. on Assam and China varieties of tea were measured. The intrinsic rate of increase and other population parameters of the mite were higher on China variety than on Assam variety of tea.

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