QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 300

OVERWINTERING BEHAVIOUR OF TETRANYCHUS TELARIUS (L.) IN THE STANTHORPE DISTRICT, QUEENSLAND

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SUMMARY

A single polyphagous strain of *Tetranychus telarius* (L.) is present in the Stanthorpe district.

On deciduous hosts this mite enters the non-feeding winterform, while on evergreen hosts it persists as the active two-spotted form.

Nutritional factors are decisive in inducing the winterform. Photoperiod is of only slight importance.

The winterform could be induced to feed and to commence egg-laying at any time and is considered to represent a quiescence rather than a true diapause.

Data on the survival of the winterform under controlled temperature conditions were in general agreement with field observations that only a small percentage of these individuals successfully overwinter in the Stanthorpe district.

I. INTRODUCTION

During the summer, *Tetranychus telarius* (L.) is present in the Stanthorpe district in the active two-spotted form. In the autumn, certain females cease feeding and assume an orange colouration. They persist during the winter in this stage, which is termed the winterform.

The work of Lees (1953) and van de Bund and Helle (1960) in Europe indicated that the winterform in the species *T. telarius* represents a true diapause. The presence of diapause is in fact one of the reasons given by van de Bund and Helle (1960) for accepting *Tetranychus cinnabarinus* Boisd. as a species distinct from *T. telarius*.

Bondarenko (1950), working with Russian material, indicated the importance of photoperiod in inducing the winterform. Lees (1953) established definite conditions of photoperiod, temperature and nutrition that were required to induce the winterform in English material. Bondarenko and Kuan (1958)

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reported that different critical photoperiods applied for material from different latitudes and that a maximum of 90 per cent. of winterform individuals was produced in material from lower latitudes (42°) even under short day length conditions. Helle (1961) and Saba (1961) both established that some strains, presumably from Holland, did not produce the expected percentage of diapause under short day length conditions and both suggested that this characteristic is linked to organophosphorus resistance. It is not clear from available literature whether these strains produce winterform individuals under field conditions.

Deciduous fruit trees in the Stanthorpe district constitute an unusual habitat in that the deciduous habit is maintained in a relatively low latitude (28°S.). It appeared profitable, therefore, to examine the overwintering behaviour of the species under these conditions.

II. FIELD BEHAVIOUR

Observations were made on the field behaviour of the species during the 1960–1962 seasons

On deciduous hosts, chiefly trees in commercial apple orchards, some winterform individuals were observed during all months of the year, but they occurred in appreciable numbers only from mid March onwards into the winter months (June–August). These winterform individuals migrate towards the base of the tree and were found either on the tree or in litter close to its base. A substantial mortality occurred in these individuals, so spring populations were normally low. On evergreen hosts, the species persisted as the active two-spotted form throughout the year, although a variable number of winterform individuals was observed during winter months. A similar dual overwintering behaviour has been recorded by other workers, among them Cagle (1949) in America and Fenner (1962) in South Australia.

During the current work, mites from apples were colonized on bean, strawberry, violet, cotton, clover and marshmallow. Mites collected in the field from these various hosts were successfully bred on apple. Linke (1953) and van de Bund and Helle (1960) also indicated that the species is truly polyphagous.

Mite-free violets in earthenware pots were infested with material of the two-spotted form from a commercial apple orchard. The pots were kept on a wooden bench exposed to natural weather conditions at Stanthorpe. The transfer was made in March 1962 and the experiment continued until October 1962. During this time the mites remained in the two-spotted form and eggs, together with all active stages, were present throughout the entire period.

The evidence suggests that a single polyphagous strain of *T. telarius* is present in the Stanthorpe district and that the dual method of overwintering is influenced largely by differences in the available hosts.

III. INDUCTION OF THE WINTERFORM

Controlled-temperature work was undertaken to determine the conditions under which the winterform is produced.

All mites used were taken from a stock colony maintained on beans in a glass-house. This stock colony had been established by a field collection from a commercial apple orchard. Larvae for the experiment were transferred to leaf discs on moist cotton wool in half petri dishes. The leaf discs were replaced as required, the mites being transferred to new discs in the same dish.

Contrasting nutritional conditions were obtained by providing either young mature bean leaves or senescing apple leaves. These are later referred to as adequate nutrition and marginal nutrition respectively. The various photoperiods were obtained by opening and closing the lids of light-tight boxes in which the appropriate material was held. Illumination was provided by twin 20-W and 40-W fluorescent tubes. All experiments were carried out in a constant-temperature room which was maintained at $15 \pm 1 \cdot 5$°C throughout the experiment.

Adult females were classified as either summer females or winterform. An average of 20 females was used for each set of conditions.

Results are given in Table 1 and Figure 1.

TABLE 1

INDUCTION OF WINTERFORM—*Tetranychus telarius*

Percentage winterform at 15°C

Material	Photoperiod (hr/24 hr)						
	0	4	8	12	16	20	24
Adequate nutrition	0	26	19	3	0	0	0
Marginal nutrition	12	88	71	61	17	10	12

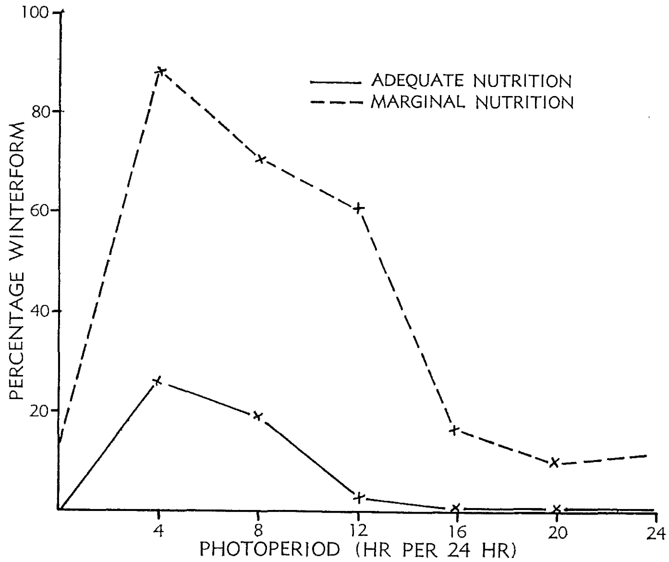

Fig. 1.—Induction of winterform of *Tetranychus telarius* at 15°C.

Only a low percentage of winterform females was induced under the various photoperiods tested when nutrition was adequate. A temperature of approximately 15°C and a photoperiod reducing from 14 to 12 hr occurs under natural conditions in the Stanthorpe district when the induction of the winterform is at its maximum (Bengston 1965). The results shown in Table 1 indicate therefore that photoperiod is not the decisive factor in inducing the winterform under field conditions. A much higher but somewhat variable percentage of winterform females was induced when nutrition was marginal. The variability probably reflects the difficulty of maintaining a precisely marginal nutrition. From these data it appears that nutrition is the dominant factor in inducing the winterform.

IV. NATURE OF THE WINTERFORM

An experiment was initiated to determine the chilling required to terminate the supposed diapause in winterform material. At the first withdrawal date, however, the results indicated that the material was not in diapause. Accordingly the experiment was continued with the modified aim of determining whether a true diapause was induced at any stage and of determining the effect of temperature on survival.

Winterform material was collected in the autumn from litter at the bases of trees in a commercial apple orchard. Dead leaf tissue carrying approximately 400 mites was placed in a 4 in. x 1 in. corked test-tube. The entire top of the tube, including the cork, was then dipped in paraffin to ensure a complete seal. Four such tubes were then placed under each set of experimental conditions, ranging from —12°C to 13°C. Temperatures were maintained with an accuracy of ± 1°C. The controlled-temperature rooms were in use for other purposes and for this reason Treatment B (Table 2) was 4°C from April 2 to June 25 (84 days) and was then raised to 7°C for the remainder of the experiment. Control material was kept in a Stevenson screen fully exposed to natural weather conditions at Stanthorpe. Tubes were removed at appropriate intervals and the mites were incubated on bean foliage for 4 days at a temperature of 30°C. At the end of that period the mites were examined under a binocular microscope and were classified visually as feeding, non-feeding and dead. Individuals which had commenced feeding exhibited various degrees of colour change from the bright-orange non-feeding individuals. Individuals were classified as dead if they failed to move when gently touched with a mounted needle. This test was necessary only in doubtful cases.

The percentages of mites which resumed feeding are given in Table 2 and Figure 2.

TABLE 2

SURVIVAL OF WINTERFORM

Percentages of mites which resumed feeding

Treatment (temperature)	Period Exposed (Commencing April 2)											
	7 days (Apr. 9)		28 days (Apr. 30)		57 days (May 25)		84 days (June 25)		112 days (July 23)		140 days (Aug. 20)	168 days (Sept. 17)
	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Trans. Mean	Equiv. Mean	Mean	Mean
H Stanthorpe	1·006	71	0·318	10	0·266	7		0·2*		0*	0	0
A 13°C	0·737	45	0·567	29	0·241	6		1*		0·2*	0	0
B 4 and 7°C	0·886	60	0·561	28	0·452	19	0·423	17	0·062	0·4	0·1	0
C 2°C	0·900	61	0·766	48	0·767	48	0·528	25	0·244	6	2	0·3
D 1°C	0·743	46	0·823	54	0·658	37	0·495	23	0·308	9	13	0·1
E 0°C	0·785	50	0·698	41	0·603	32	0·423	17	0·286	8	10	1
F − 1°C	0·829	54	0·659	37	0·601	32	0·490	22	0·409	16	14	2
G − 12°C	0·716	43		0·1*		0*		0*		0*	0	0
s.e.	0·0399		0·0489		0·0506		0·0809		0·0491			
Differences necessary for significance 5%	0·117		0·145		0·150		0·249		0·151		No analyses warranted	
Differences necessary for significance 1%	0·160		0·199		0·206		0·349		0·212			
	H> >A, D, E, F, G; H>B; C> >A, G; C>D; B> >G; B>A, D		A, B, C, D, E, F > >H; C, D> >A, B; D>F		C, D> >H, A, B; E, F> >H, A; B> >A; C>E, F; E, F>B>H		No significant differences		D, E, F> >B; C>B; F>C			

* Mean excluded from analyses

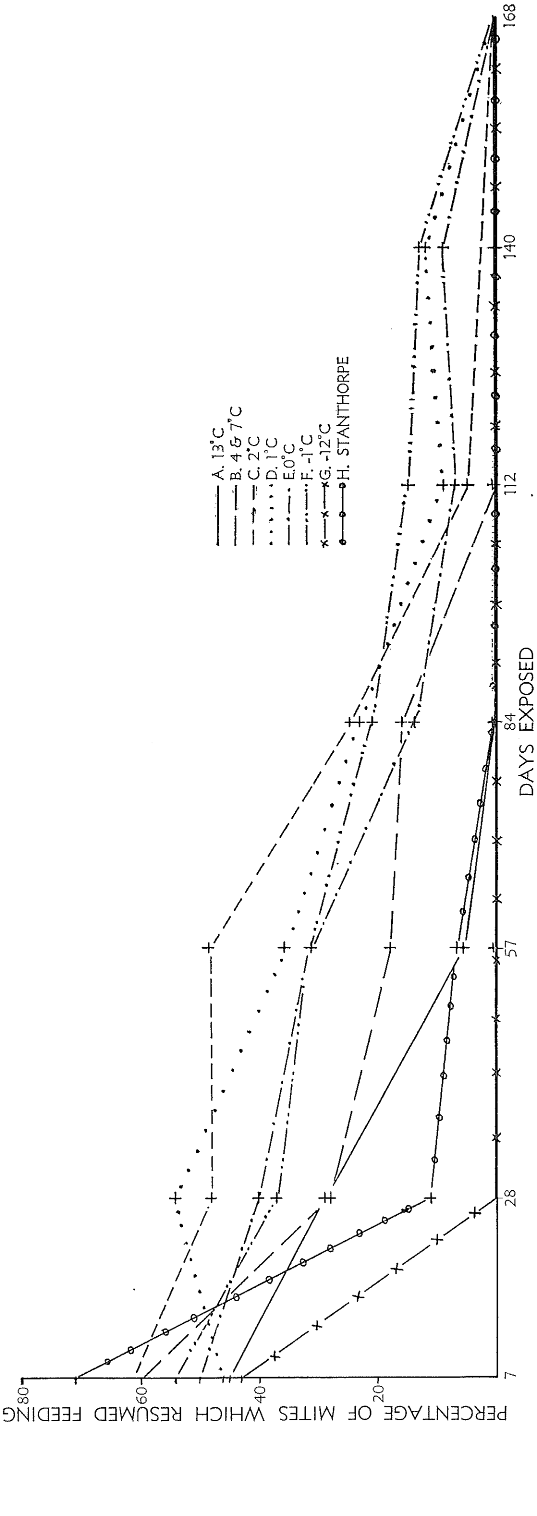

Fig. 2.—Survival of winterform of *Tetranychus telarius.*

A small percentage of mites was classified as non-feeding. This was greatest in the sample examined 7 days after the commencement of the experiment, but even here it averaged only about 2 per cent. of the total. The death of a sample of these non-feeding individuals when incubated for 14 days suggests that these merely represent moribund individuals.

It is evident that a true diapause did not occur either initially or at any stage during the low-temperature treatments. The winterform could be induced to feed and lay eggs at any time. Quiescence is probably a better term to describe the phenomenon.

Treatment H, approximating field conditions at Stanthorpe, was not particularly favourable. A few individuals survived 84 days but none 112 days. Treatment A (13°C) was parallel to Treatment H. Under both conditions mites remained relatively active and produced considerable webbing. This evidently resulted in an exhaustion of their reserves. The percentage surviving the initial 7 days (mean temperature 20°C) in the screen at Stanthorpe was significantly higher than in most other treatments, suggesting that there was an initial cold effect associated with the somewhat lower controlled temperatures.

Treatments C, D, E and F (2°, 1°, 0° and —1°) showed minor differences but were roughly parallel. About 1 per cent. of individuals survived 168 days. These were the optimum survival temperatures and they coincide with the optimum temperatures for commercial cool storage of apples. It has been observed that winterform individuals survive extended periods of cool storage in the stem or calyx end of commercial fruit. It suggests a further avenue for the free spread of the various strains of this complex in the course of normal trade movements of cool-stored fruit.

Treatment G (—12°C) allowed mites to survive 7 days but none survived 28 days. Grass temperatures in Stanthorpe may fall to about this level but normally they persist for only a few hours each winter.

These data on the survival of the winterform are in general agreement with the field observation that only a small percentage of such individuals of this species of mite successfully overwinters in the Stanthorpe district. They suggest that the earlier the winterform is induced the lower will be the percentage survival.

V. GENERAL CONCLUSIONS

It is apparent that *Tetranychus telarius* (L.) is a polytypic species. The presence of a quiescence rather than a true diapause in the strain currently investigated is in conformity with the closely related *Tetranychus cinnabarinus* Boisd. rather than with the true *T. telarius*. The quiescent winterform, although sufficiently cold-tolerant to survive the winter in the Stanthorpe district, lacks the cold-hardiness of strains of *T. telarius* from other cold areas (Lees 1953; van de Bund and Helle 1960).

The mechanism whereby nutritional factors are more important than photoperiod in inducing the winterform is flexible in that it ensures synchronization of the species with foliage development of deciduous hosts and at the same time allows continuous development on evergreen hosts.

VI. ACKNOWLEDGEMENT

The analyses shown in Table 2 were carried out by the Biometrics Branch.

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(Received for publication July 30, 1964)