SEASONAL DIFFERENCE OF PHOTOTACTIC RESPONSE IN THREE SPECIES OF SPIDER MITES
(ACARINA: TETRANYCHIDAE)

By

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INTRODUCTION

In a previous paper the author reported that the larvae just hatched from winter eggs of *Panonychus ulmi* (*Metatetranychus ulmi*) form noteworthy aggregations upon the pruned branches of apple trees in the orchard. It has been ascertained by experiment that the above phenomenon is caused by some physiological sources, first of all by the positive phototaxis of the mites (MORI 1955). According to that experiment, the susceptibility to light of *P. ulmi* varies with the developmental stages or the change of physiological condition such as satiation and hunger. Namely, the ranking of the minimum illuminations causing the phototactic response in mites is as follows: Larva just after hatching (unfed)>Adult (unfed)> Larva (engorged)>Adult (engorged).

The present investigation has been undertaken in order to compare the phototactic response of three species of spider mites to white light, according to species and also to ascertain any seasonal change of phototactic response of the mites.

MATERIALS AND METHODS

The experiments were carried out from June to October, 1959. Details of the experiments on each species are as follows: *Panonychus ulmi*, summer adults (female, male) July 13–July 24, larvae July 15–July 16, winter adults (female, male) Sep. 29–Oct. 1. *Tetranychus viennensis*, summer adults (female, male) June 30–July 16, winter adults (female, male) Sep. 23–Sep. 25. *Tetranychus telarius*, summer adults (female, male) June 30–July 5, winter adults (female, male) Oct. 20–Oct. 27. In this manner, the adults of *P. ulmi*, *T. viennensis* and *T. telarius* were used in experiments at two different seasons namely from June to July and from September to October.

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The materials were collected from the orchard on the University campus in Sapporo. They were kept on potted apple trees for one day in the laboratory. Before starting the experiments the mites were put into the dark room for several hours in order to engender the dark adaptation in them. The mites of each species were divided into two groups in feeding. The one consisted of unfed adults while the other was made up of engorged adults.

The reaction of mites to white light was investigated by exposing them to diffuse horizontal beam. In Figure 1, a view of "the tunnel-apparatus of light." showing an end, side and top is given. This apparatus was divised so

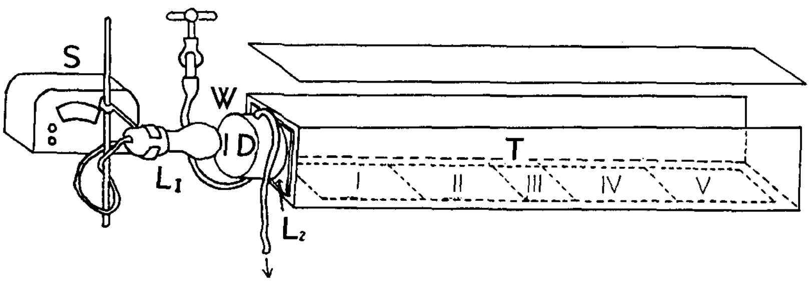

Fig. 1. The tunnel-apparatus of light.
L_1, 1st light source; L_2, 2nd light source; ID, iris diaphragm; W, water bath; S, stabilizer; T, tunnel of light; I–V, section in arena.

as to give one-way light from one terminal. The lamps were equipped with a transformer and a stabilizer in order to get a constant voltage of 100 volts. The phototactic box was made of wood of a size approximately $435 \times 20 \times 19$ cm, and the cover was removed at the time of putting in and taking out of the mites from the box. The interior wall was painted opaque black to prevent reflected light as much as possible.

The arena (10×90 cm) on which the mites were tested was a sheet of graph paper placed on the bottom of the box. At the edge of the arena, a tangle-foot (adhesive) of black colour was applied to prevent the escape of mites. The arena was divided into five sections for convenience of observation as illustrated in Figure 1. The size of each section was 20×10 cm, except section III which was 10×10 cm in size. As the 1st light source, a "mazda" lamp of 60 watts was employed having been placed horizontally at the height of 10 cm from the bottom. At one side of the arena a piece of frosted glass was placed as the 2nd light source. The intensity of radiation was regulated with a iris diaphragm and several process dry-plates which were exposed to light for varied times.

These experiments were conducted in a dark room kept constantly at 25°C. and at approximately 76–95 per cent R.H. The influence of heat from the lamps was minimized by a water bath placed between the light source and the frosted glass.

RESULTS

During the experiments, several mites were put on the centre of section III. The number of dispersed mites on the arena was counted after 90 minutes. As the preliminary examination, the unfed larvae and engorged adults of *P. ulmi* were exposed to a single light beam with the luminosity of 60 watts, 100 volts, in order to test the relations of the elapsed time of experiment to the dispersed feature of the mites in the arena (Tables 1 and 2). It was ascertained from these data that the reaction of mites to light stimulus is steadied at 90 minutes after the beginning of the experiment.

TABLE 1. The dispersed position of the unfed larvae in the arena

Time after biginning of experiment (min.)	Number of mites	Dispersed position of mites				
		I	II	III	IV	V
0	15	—	—	15	—	—
30	15	2	10	3	0	0
60	15	11	3	1	0	0
90	15	14	1	0	0	0
120	15	14	1	0	0	0
150	15	13	2	0	0	0

TABLE 2. The dispersed position of the engorged adults in the arena

Time after beginning of experiment (min.)	Number of mites	Dispersed position of mites				
		I	II	III	IV	V
0	15	—	—	15	—	—
30	15	6	5	3	1	0
60	15	9	4	1	1	0
90	15	13	2	0	0	0
120	15	14	0	1	0	0
150	15	13	2	0	0	0

The phototactic responses of the mites under various illuminations are explained by two formulae as follows:

$$P/(P+N)>0.50 \quad \text{or} \quad P/(P+N)<0.50$$

Here, P is the dispersed number of mites in sections I and II. N is the dispersed number in sections IV and V (IYATOMI 1935).

Thus, it is clear from the above formulae that the former expresses the positive phototaxis of mites whilst the latter shows the negative. The experiment aims to compare the minimum illuminations causing phototaxis among three species of mites.

Panonychus ulmi

Several mites were subjected to a single light beam which varied in intensity from 120 lux to 0.1 lux at the central point of section III. The results are presented in Table 3.

From Table 3, the minimum illumination causing the phototactic response in each experimental series may be presumed as follows; in summer adults*, the minimum illumination value of the engorged females was below 0.1 lux, and that of the engorged males was approximately 1.2 lux.

It is clear that unfed summer females responded to the illumination of 0.1 lux and less. The engorged larvae which were collected together with the summer adults showed positive phototaxis at an illumination of 0.1 lux. Next, in the winter adults**, both the engorged females and males had 2.7 lux for the minimum value of illumination.

The author has deduced from his experiment that there is no difference between female and male of the species as for the phototactic trend (MORI 1955). However, it was shown by the present comparative experiment that between the two sexes the phototaxis was different in intensity in summer adults, but in winter adults there was almost no difference.

It is noted that the summer adults differs from the winter adults in the intensity of phototactic response. That is to say, there is seasonal difference in susceptibility to light even in the same developmental stage. This fact supports evidently the assumption previously mentioned by MORI (1955). Namely "generally the stage of development or the physiological change accompanied by metabolism seems to generate the change of their susceptibility to light."

Tetranychus viennensis

Experimental materials of *T. viennensis* were collected from both summer adults and winter adults. In the former, the body of females are blackish red in colour and they laid non-diapause eggs. In the latter, the females are bright scarlet and enter diapause in the adult stage without egg-layed during the winter.

* The females laid non-diapause eggs only.

** All females laid diapause eggs.

TABLE 3. The dispersed position of *Panonychus ulmi*

Illumination in section III (lx.)	Number of mites	I	II	III	IV	V	P	P+N	P/(P+N)
(A) In the case of engorged summer females									
120	10	6	2	2	0	0	8	8	1.00
78	14	11	1	1	1	0	12	13	0.92
2.7	14	11	1	0	1	1	12	14	0.86
1.2	12	7	4	1	0	0	11	11	1.00
0.1	10	2	3	1	4	0	5	9	0.56
(B) In the case of engorged summer males									
120	10	6	2	1	1	0	8	9	0.89
8	10	5	2	1	2	0	7	9	0.79
2.7	10	2	3	1	4	0	5	9	0.56
1.2	11	3	1	4	2	1	4	7	0.57
0.1	10	2	2	2	3	1	4	8	0.50
(C) In the case of unfed summer females									
2.7	11	8	2	0	1	0	10	11	0.91
1.2	10	6	1	2	1	0	7	8	0.88
0.1	10	1	3	4	2	0	4	6	0.67
(D) In the case of engorged larvae									
120	15	10	4	1	0	0	14	14	1.00
2.7	14	11	1	2	0	0	12	12	1.00
1.2	16	6	1	8	1	0	7	8	0.88
0.1	17	3	6	6	2	0	9	11	0.82
(E) In the case of engorged winter females									
120	12	9	1	1	1	0	10	11	0.91
2.7	11	8	1	1	0	1	9	10	0.90
1.2	12	3	3	0	5	1	6	12	0.50
0.1	11	2	2	4	2	1	4	7	0.36
(F) In the case of engorged winter males									
120	8	7	0	1	0	0	7	7	1.00
2.7	8	3	3	2	0	0	6	6	1.00
1.2	8	0	1	5	1	1	1	3	0.33

TABLE 4. The dispersed position of *Tetranychus viennensis*

Illumination in section III (lx.)	Number of mites	I	II	III	IV	V	P	P+N	P/(P+N)
(A) In the case of engorged summer females									
120	11	8	1	1	1	0	9	10	0.90
8	10	5	2	2	0	1	7	8	0.88
2.7	12	6	3	1	1	1	9	11	0.82
1.2	11	5	0	1	1	4	5	10	0.50
0.1	17	6	1	0	4	6	7	17	0.41
(B) In the case of engorged summer males									
8	9	5	1	3	0	0	6	6	1.00
2.7	8	6	0	2	0	0	6	6	1.00
1.2	8	1	1	4	2	0	2	2	0.50
0.1	8	1	2	2	2	1	3	6	0.50
(C) In the case of unfed summer females									
8	10	8	1	1	0	0	9	9	1.00
2.7	10	8	2	0	0	0	10	10	1.00
1.2	10	5	2	3	0	0	7	7	1.00
0.1	15	5	0	5	4	1	5	10	0.50
(D) In the case of unfed summer males									
8	8	8	0	0	0	0	8	8	1.00
2.7	10	8	0	2	0	0	8	8	1.00
1.2	10	6	3	0	1	0	9	10	0.90
0.1	9	3	3	3	0	0	9	9	1.00
(E) In the case of engorged winter females									
120	11	3	3	1	3	1	6	10	0.60
78	10	2	1	1	4	2	3	9	0.33
2.7	12	0	0	0	7	5	0	12	—
1.2	12	1	3	1	2	5	4	11	0.36
(F) In the case of engorged winter males									
120	8	7	0	1	0	0	7	7	1.00
78	8	3	4	1	0	0	7	7	1.00
2.7	8	8	0	0	0	0	8	8	1.00
1.2	8	2	1	1	3	1	3	7	0.43

From Table 4, it is recognized that there is clear difference in susceptibility to light between summer and winter females. In the summer adults, the minimum illumination causing the phototactic response is 2.7 lux in both the females and males. It is 120 lux in the winter females and 2.7 lux in the winter males.

Comparing the phototactic responses between the engorged adults and the unfed ones, it may be concluded that the unfed adults have higher susceptibility

TABLE 5. The dispersed position of ***Tetranychus telarius***

Illumination in section III (lx.)	Number of mites	I	II	III	V	IV	P	P+N	P/(P+N)
(A) In the case of engorged summer females									
120	10	8	2	1	0	0	10	10	1.00
8	10	8	0	1	0	1	8	9	0.89
2.7	10	1	2	2	5	0	3	8	0.38
1.2	12	3	0	1	2	6	3	11	0.27
(B) In the case of engorged summer males									
120	10	10	0	0	0	0	10	10	1.00
8	10	7	2	1	0	0	9	9	1.00
2.7	10	3	1	2	2	2	4	8	0.50
1.2	10	3	0	3	2	2	3	7	0.43
(C) In the case of unfed summer females									
8	8	7	1	0	0	0	8	8	1.00
2.7	10	9	0	0	1	0	9	10	0.90
1.2	10	2	3	3	0	2	5	7	0.71
0.1	8	0	3	1	4	0	3	7	0.43
(D) In the case of engorged winter females									
120	10	5	2	1	2	0	7	9	0.78
78	10	3	2	2	1	2	5	8	0.63
8	8	1	2	1	2	2	3	7	0.43
2.7	8	0	3	0	3	2	3	8	0.38
(E) In the case of engorged winter males									
120	10	4	2	2	2	0	6	8	0.75
78	10	2	3	3	0	2	5	7	0.71
8	8	2	2	0	2	2	4	4	0.50
2.7	8	1	2	3	3	1	3	7	0.43

to light than the engorged ones. Namely, the minimum illumination values resulting in phototactic reaction of engorged summer females, engorged summer males, unfed summer females and unfed summer males were 2.7 lux, 2.7 lux, 1.2 lux and below 0.1 lux respectively.

There is a difference in phototactic trends between the two sexes in the winter adults. In the present experiment, the males usually show higher susceptibility to light than the females, viz., the minimum illumination is 120 lux in the engorged females and 2.7 lux in the engorged males.

As for the dispersed figure of the mites in the arena, it was recognized that many winter males drifted toward the light-side in the cases of 120 lux, 78 lux and 2.7 lux respectively. On the contrary, many winter females were distributed evenly on the arena or sometimes rather preferred the dark side of the arena under the same illumination. No such difference according to sexes was found in the case of summer adults.

Tetranychus telarius

A series of experiments was made with several groups of *T. telarius*. These groups consisted of engorged summer females and males, unfed summer females, engorged winter females and males. From Table 5, it will be noted that the minimum illuminations at which they showed response, were 8.0 lux, 8.0 lux, 1.2 lux, 78 lux and 78 lux respectively. No difference was found in this species as to sensibility to light between sexes in the summer adult and nor in the winter one.

It may be concluded from the present data that the summer adult is more sensitive to light-stimulus than the winter adult without regard to the sex. Likewise it may be concluded that the unfed adult is more sensitive in this respect than the engorged adult.

SUMMARY

Three species of spider mites, *Panonychus ulmi*, *Tetranychus viennensis* and *Tetranychus telarius*, show positive phototaxis irrespective of the sex, their conditions of feeding and the season at which they are collected. It can be said from the present results of experiments on the minimum illumination causing the phototactic response in three species of spider mites that the summer adult responds more sensitively to a white light beam than the winter adult. There is no difference in susceptivity to white light between the sexes in *T. telarius*. However, the winter male of *T. viennensis* is more susceptible to white light than the female. On the contrary, in the case of *P. ulmi*, the summer female is more sensitive than the male.

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LITERATURE

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