Annual Life Cycle of the Spider Mite, *Eotetranychus uncatus* Garman (Acarina: Tetranychidae)

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The annual life cycle and diapause characteristics of the *Eotetranychus uncatus* Garman population on white birch, *Betula platyphylla* var. *japonica* (Mitq.) were studied in Sapporo. The mite appeared on leaves in early May, and the occurrence ended in late September (1981) or in early November (1982) when leaves of white birch completely changed from green to yellow. The population passed through 4 or 5 generations during the season. Predators associated with this population were mainly phytoseiid mites. They appeared from mid-May to mid-September or late October, and their occurrence followed that of the mites, with a time lag of about 10 days.

Photoperiodic response curve on diapause induction was the long day type, and its critical photoperiod was between 14.0 and 14.5 hr at 18°C. Diapause was induced in early September in the field. Part of the diapausing females collected in early October began to oviposit when incubated at 25°C and 15L:9D. The number of days required for the reactivation gradually decreased towards April. Proportion of laying females, on the contrary increased.

INTRODUCTION

Most studies and discussions on the life cycle and seasonal strategies of tetranychid mites have so far been based on studies on only part of the life cycle. But such an approach hinders our understanding of their seasonal strategies, because information concerning the 'complete' life cycle of representative species is lacking. I am comparing life cycles and diapause characteristics of several multivoltine spider mite species taking into consideration their host plant traits (e.g., phenology), which are their habitats. The present paper deals with the annual life cycle of *Eotetranychus uncatus* Garman on white birch.

*Eotetranychus uncatus* causes injuries to apple, pear and plum as well as *Alnus*, *Betula*, *Juglans*, *Quercus*, *Tilia* and a medical plant *Bauhinia variegata* L., and distributes in North America, Europe and Asia (Reeves, 1963; Ehara, 1970; Skorupska, 1976; Lal and Mukharji, 1979; Gutierrez and Helle, 1981). Adult females overwinter (Ubertalli, 1955; Gutierrez and Helle, 1981) and 4 or 5 generations appear in a year in a sprayed apple orchard of Wisconsin (Oatman, 1973). In Massachusetts, Utah, California and Maine, on the other hand, *E. uncatus* is not found in commercial apple orchards but in abandoned ones at low densities (Croft and Jorgensen, 1977; Hislop and Prokopy, 1979; Berkett and Forsythe, 1980). Little is known about population density and

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the annual life cycle of this species in the natural ecosystem.

MATERIALS AND METHODS

Rearing. Adult females of the spider mite were collected from white birch, *Betula platyphylla var. japonica* (Miq.) in a forest on the campus of Hokkaido University, Sapporo, on July 4, 1980. These mites were reared on leaf discs from the same host in petri dishes (9 cm diam.) at 25±1°C and 15L–9D.

Developmental stage and population density. The developmental stage and population density of the *E. uncatus* population on white birch leaves were observed in 1981 and 1982. Observations were made every 5–10 days from late April to early November each year. Every stage of the mite and predators was counted on all leaves of two and four marked twigs of 2 (1981) and 4 (1982) trees, respectively, with a magnifying glass (×10 or ×20). Each twig and all leaves of the twigs were numbered, and new and fallen leaves were recorded as well as the degree of leaf senescence. The maximal number of leaves observed on twigs was 215 in 1981 and 585 in 1982. About 20 leaves with predacious mites were irregularly sampled from the field for identification of the phytoseiid mites.

Induction and termination of diapause. Diapausing adult females of *E. uncatus* are characterized by a distinct change in the body colour from yellowish-green in the summer form to a uniform bright yellow, and they do not feed at all once the colour has changed, nor does oviposition occur.

To examine the effect of photoperiod on diapause induction, groups of adult mites, each consisting of 10 females and 5 males, were taken from a laboratory culture that had passed at least 2 generations. They were then exposed to various photoperiods from 0 to 24 hr in lightproof cardboard boxes (ca. 0.2 m³) placed in environmental chambers controlled at 18±1°C. Illumination was supplied by a 6W fluorescent tube. All the females were allowed to lay eggs on a white birch leaf placed in a petri dish for 48 to 72 hr. The individuals were kept in each photoperiod until they reached adulthood, and females thus obtained were placed singly on fresh leaf discs (ca. 4 cm²) in petri dishes to assess whether or not they were in diapause. Fifty to sixty females were examined in each photoperiod.

In order to know when mites enter diapause in the field, about 40 females were collected from white birch leaves at intervals of about 10 days between August and October from 1980 to 1982. They were individually kept on leaf discs in petri dishes at 25°C and 15L–9D. These mites were reared on leaves of white birches, which were grown in a greenhouse. If females whose body colour was yellowish-green laid eggs within 7 days after collection, they were judged as summer females.

To determine the time when diapausing females start to lay eggs, about 40 diapausing females were sampled from loose bark scales of the trunks of white birches every 10 days during the period from late November, 1980 to late April, 1981, and from early October, 1981 to late April, 1982. They were kept singly on fresh birch leaves at 25°C and 15L–9D and checked daily. The study was continued until all the females had oviposited or died.
RESULTS

The stage structure and seasonal occurrence of the mites

Figure 1 shows the seasonal changes in the abundance and stage structure of the *E. uncatus* population and the abundance of phytoseiid mites on white birch leaves. Females began to appear and oviposit on leaves in early May when they were just opened (see also Fig. 2). The occurrence ended in late September (1981) or in early November (1982), corresponding with the time when white birch leaves completely changed to yellow, although the defoliation patterns were the same in both years. Based on the seasonal changes of stage structure, it was estimated that there were 4 generations in 1981 and 5 in 1982.

The density of the mites per leaf (all stages inclusive) remained at a low level throughout the season in 1981 (Fig. 1). But in 1982, the population began to increase in late June when the first generation females laid eggs, and reached the first peak (2.7 mites/leaf) in early July. The maximal density (3.9 mites/leaf) appeared in early August and then gradually decreased.

*Eotetranychus uncatus* usually lives on the undersurface of a leaf (*Ubertalli*, 1955; Gutierrez and Helle, 1981), but in 1982 some individuals colonized on the upper-surface, as was observed on apple leaves by *Ubertalli* (1955). Population on the upper-surface appeared from late July to early October, and the proportion to the total number of mites reached about 30% (ranging from 26.7 to 35.8%). Their occurrence,
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![Graph showing seasonal changes in the number of leaves](image1)

Fig. 2. Seasonal changes in the number of leaves (relative to the maximum) of white birch in Sapporo (the maximal number of leaves = 215 in 1981, 585 in 1982). Arrows show the time of complete leaf senescence.

![Graph showing photoperiodic response curve](image2)

Fig. 3. Photoperiodic response curve for the production of diapausing females of *E. uncatus* reared at 18°C.

![Graph showing seasonal changes in diapause proportion](image3)

Fig. 4. Seasonal changes in the proportion of diapausing females in *E. uncatus* in Sapporo. Each point is based on about 40 females collected from the field and kept at 25°C and 15L-9D.

However, was limited to leaves slightly curled towards the upper surface.

Predators associated with this population were phytoseiid mites (*Amblyseius longispinosus* (Evans), *Typhlodromus soleiger* (Ribaga) and *Typhlodromus vulgaris* Ehara; Fig. 1) and a small number of gall midges, chrysopids and syrphids. The latter two predators seemed to appear in relation to the occurrence of aphids on the white birch leaves. The phytoseiid mites appeared from mid-May to mid-September (1981) or late October (1982). Their density was much lower in 1981 than in 1982. In 1982, phytoseiid mites reached the highest density (0.2/leaf) in early September and then rapidly decreased. This peak followed that of *E. uncatus* with a time lag of about 10 days. Phytoseiids overwintered in loose bark scales of white birches with the spider mites.

**Induction and termination of diapause**

Figure 3 shows the photoperiodic response curve of *E. uncatus* at 18°C. The proportion of diapausing females was 100% in photoperiods ranging from 0 to 13.0 hr and 0% in photoperiods of 14.5 hr and longer. The critical photoperiod appeared to be between 14.0 and 14.5 hr, which occurs in mid-August in Sapporo.

In the field population, diapausing females began to appear in late August or early
September, and their proportion reached 50% in early September each year (Fig. 4). Once the diapausing females appeared, their percentage in 1980 and 1981 increased more rapidly than that in 1982.

Twenty (54%) out of 37 diapausing females collected in early October in 1981 were reactivated by long days at 25°C (Fig. 5), and the remainder died within 60 days after incubation started. The percentage of females that laid eggs increased gradually with some fluctuation.

The number of days from the start of incubation to oviposition was 35 on the average with a large variation in October, and then both the average and range declined continuously with a small fluctuation until April (Fig. 5). In late April, almost all the females laid eggs within 5 days. Thus, the reactivation period was shortened gradually with the advance in season.

In the field, diapausing females overwintered in a cluster in a cocoon-like shelter spun by themselves under loose bark scales of white birch.

**DISCUSSION**

The population density of *E. uncatus* in the present study was higher in 1982 than in 1981. The discrepancy could be due to the difference in the amount of available heat for development. The cumulative amount of temperature above 10°C from May to September in 1982 was 1,224 day-degrees, which was 209 day-degrees higher than that in 1981 (Sapporo District Meteorological Observatory, 1981, 1982).

The number of generations in the present study was also greater in 1982 than in 1981. This is considered to be due not only to the difference of the amount of available heat for development mentioned above, but also to the difference of the time of leaf senescence between the two years. Senescence of all leaves in 1981 occurred in late September, which was about a month earlier than that in 1982, and the occurrence of the mites ended about a month earlier in 1981 than in 1982. Thus the duration of
summer generations of the mites is influenced by the time when leaf senescence occurred.

The photoperiodic response curve of the tested population of *E. uncatus* was similar to that of *Tetranychus viennensis* ZACHER on deciduous oak time in Sapporo, except for the response at continuous illumination (LL), when a small number of the latter females entered diapause (GOTOH, 1984).

The induction time of diapause in the field population of *E. uncatus* corresponded well with the timing predicted by the critical photoperiod, when twilight hours were taken into account (BECK, 1980). The difference of the induction time in the field among the three years was very small, suggesting that photoperiod played a major role in the induction of diapause.

Females of *E. uncatus* collected in October required about 35 days to lay eggs after incubation at 25°C and 15L:9D. This period was three times as long as that in the Sapporo population of *Tetranychus urticae* KOCH on red currant plant (12 days; GOTOH, 1986). However, reactivation of *E. uncatus* was earlier than that of *T. viennensis*, in which no females oviposited until November (GOTOH, 1984). Since the number of days required to oviposit in *E. uncatus* decreased continuously as the season progressed, the time of diapause termination could not be determined. This is closely similar to the results in *T. viennensis* and *T. urticae* (GOTOH, 1984, 1986), which had overwintered in the female adult stage.

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