SUPPRESSION OF TETRANYCHID POPULATIONS USING THE PREDACIOUS MITE *PHYTOSEIULUS PERSIMILIS* ATHIAS-HENRIOT IN SOME AGROECOSYSTEMS OF HOKKAIDO[1] (ACARINA: TETRANYCHIDAE, PHYTOSEIIDAE)

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Received Jun. 16, 1975

Introduction

Interest in biological control of the spider mites on various crops in the horticultural facilities was stimulated by the introduction of the predacious mite *Phytoseiulus persimilis* A.-H.[4] into Europe from Chile by Dr. G. D. DOSSE (1958). Within a few years several workers demonstrated experimentally the efficiency of the phytoseiid predator as a control of *Tetranychus urticae* Koch on red kidney beans or cucumbers and *T. cinnabarinus* on peach (CHANT, 1961; BRAVENBOER, 1969; BRAVENBOER and DOSSE, 1962). Subsequent workers have also been convinced of the efficiency of *P. persimilis* as a predator under indoor conditions viz. glasshouses, laboratories, or growth chambers (HUSSEY and PARR, 1963; BEGLJAROV, 1967; Gould, HUSSEY and PARR, 1969; LAING and HUFFAKER, 1969; MORI and MORIYAMA 1970). There is little information on the effectiveness of this natural enemy under outdoor conditions. SMITH *et al.* (1963) reported an effective control of populations of *T. urticae* on outdoor rose plants at Beltsville, Maryland, following the release of *P. persimilis* adults. OATMAN *et al.* (1966, 1967, 1968) studied the biological and integrated control of *T. urticae* on strawberry fields in southern California by means of mass releases of *P. persimilis*.

1) Special Project Research supported by the Ministry of Education "Studies on the Dynamic Status of Biosphere." This study was made as part of JIBP. A part of this paper was cited from MORI (1975).

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4) *Phytoseiulus persimilis* was first collected in Algeria and described by ATHIAS-HENRIOT (1957). DOSSE (1958) independently described a specimen of Phytoseiidae from Chile as *Phytoseiulus riegeli*, but *P. riegeli* was synonymized with *P. persimilis* (CHANT, 1959; KENNETT and CALTAGIRONE, 1968).

A culture of *P. persimilis* that originated in Chile was obtained from the Department of Biological Control, University of California, Riverside and has been maintained in the Institute of Applied Zoology, Faculty of Agriculture, Hokkaido University, since 1966 (MORI, 1967).

The present paper deals with the following three experiments, which were undertaken to determine the feasibility of utilizing *P. persimilis* for the control of tetranychid mites in three types of agroecosystem of Hokkaido. The biological control experiments were carried out on the following semi-outdoor or outdoor conditions ; (1) greenhouse (vinylhouse) cucumbers, (2) blackberries grown in the field, (3) soy bean plants grown in the field. All experiments were conducted in 1972 and 1973 at the Hokkaido National Agricultural Experiment Station, Sapporo.

The authors are very grateful to Dr. K. YASUMATSU, Professor Emeritus of Kyushu University, for his kind support and aid in various ways during the course of JIBP study. Their thanks are also due to Dr. Y. SAKURAI and Mr. H. HORIGUCHI, Department of Plant Pathology and Entomology, Hokkaido National Agricultural Experiment Station, for their encouragement and advice. They are also obliged to Miss M. KIZAWA, Mr. Y. SAITO, Mr. H. SHIBATA for their assistance in carrying out this work.

Methods

Expeirments on greenhouse cucumbers in 1972 and 1973

Experiments were made in two or three small vinylhouses (Greenhouse A and B in 1972 ; Greenhouse A, B and C in 1973), each containing eight cucumber plants. The interior dimensions of each house were 4.0×4.0 m which allowed the planting of two rows (an interval of 160 cm) of four cucumber plants each separated by a distance of 80 cm.

1972. On June 6 each cucumber plant was infested with ten females of two-spotted spider mite *T. urticae* in greenhouse A and twenty females in greenhouse B. According to the leaf damage index by HUSSEY and PARR (1963), the assessments of mite damage were made at weekly intervals by checking all leaves. On July 14, when the mean leaf damage index on the plants in greenhouses A and B reached about 2.0 and 3.0 respectively, ten females of *P. persimilis* were placed on one leaf of one middle plant in each row in greenhouses A and B. The active stages (except the larvae) of *P. persimilis* and *T. urticae* were counted using a hand lens at weekly intervals for all leaves on all cucumber plants in greenhouses A and B.

1973. On June 25 each cucumber plant was infested with five females of *T. urticae* in greenhouse A, and ten females in greenhouses B and C respectively. Assessments of leaf damage index were made by the same method as 1972. On July 13 when the mean leaf damage index reached about 1.0 and 2.0 in greenhouses A and B respectively, ten females of *P. persimilis* were released in the same manner as the previous year in both greenhouses. However, the plants in greenhouse C were left without predators at this time. An assessment of predator and prey populations (except the larvae and eggs) for both mites was made every 7 days by examining a random sample of 15 leaves from three different height zones on the plants. In each year, all other insects and mites on the cucumber plants were removed by handpicking.

Experiments on field grown blackberries

This experiment was carried out from June to October, 1972, using six blackberry shrubs which were 4 years after the transplants in the field. The planting was one row with six plants 2 m apart. Pesticides were not applied during the year of experiment.

On June 5, the first natural infestation of *T. urticae* was found only on the lower-zone leaves of the blackberries. On July 13, 100 adults of *P. persimilis* were released on the lower leaves in each of three blackberries. At this time, *T. urticae* populations on the lower, middle and upper zones of the plants averaged 115 active stages, 23 actives and 2 actives/leaf respectively. No phytoseiid predators were released on the other three blackberry shrubs which served as checks for the experiment. Observations of the prey and predator populations along with the leaf damage index were made at weekly intervals during eleven weeks by examining a random sample of 30 leaves from three different height zones on the blackberries. Active stages of prey and predator mites on the sample leaves were counted using a binocular microscope. The leaf samples were placed back in respective sampling sites after observation to prevent the adverse effects of progressively reducing the prey and predator populations. Five degrees of leaf damage of the blackberries were selected by means of the damage index which were used for the assessment of mite damage to cucumber leaves by HUSSEY and PARR (1963).

Experiment on soy bean grown in the field

This experiment on soy bean was carried out from August to September, 1972. The soy bean field consisted of 12 plots, each 2 square meters with 3 rows of 30 plants. There were twelve plots in four rows, leaving 2

meter of bare ground between each plot. Four blocks were established in a randomized complete block design with 3 replicates. The adult females of both *P. persimilis* and *T. urticae* were released on a plant of each row in 4 blocks on July 26 at the following densities: (block-A) 1 *P. persimilis*+0 *T. urticae*; (block-B) 1 *P. persimilis*+8 *T. urticae*: (block-C) 1 *P. persimilis*+64 *T. urticae*; (block-D) 1 *P. persimilis*+256 *T. urticae*. Random samples of 20 leaflets per plot were taken at about one week intervals from August 3 through September 29. The active stages of *T. urticae*, naturally infesting tetranychid mites, and *P. persimilis* were counted directly by examining each leaflet under a binocular microscope. After observation the leaf samples were placed back in their respective plots.

Results and Discussion

Observations on greehouse cucumbers

Figures 1 and 2 show the population fluctuations of *P. persimilis* and *T. urticae* on cucumber plants and changes in the mean leaf damage indices in greenhouses A and B in 1972 and 1973. Both two years, despite the difference in the initial population of the prey between the two greenhouses, the high densities of the prey at the second or third week were dramatically reduced upon introduction of *P. persimilis* into the predator-prey system. In both greenhouses the prey was reduced to very low levels within 4 or 5 weeks after the beginning of the experiment. With the exception of the predator-released plants on greenhouse A in 1972 and the predator-free plants on greenhouse A in 1973, the predator density reached its maximum one week after the density of the prey had reached its peak on all plants. At this time almost all adult and nymphal stages of the predators fed heavily on the prey.

During the experiments the temperatures of greenhouses ranged from 20°C to 27°C in 1972 and from 24°C to 30°C in 1973. BRAVENBOER and DOSSE (1962) reported the optimal temperature for *P. persimilis* as between 25°C and 30°C from the standpoint of developmental time, reproductive capacity, and number of prey consumed. However, Force (1967) found that excellent biological control of *T. urticae* by *P. persimlis* occured at 20°C, and somewhat poor control at 15°C and 25°C. From the results of the present experiments, it maybe said that *T. urticae* populations in a semi-outdoor condition such as the vinylhouse are eliminated by introduction of the predacious mite *P. persimilis* within 4～5 weeks at 20°C to 30°C.

In England, HUSSEY and PARR (1963) established that the critical level

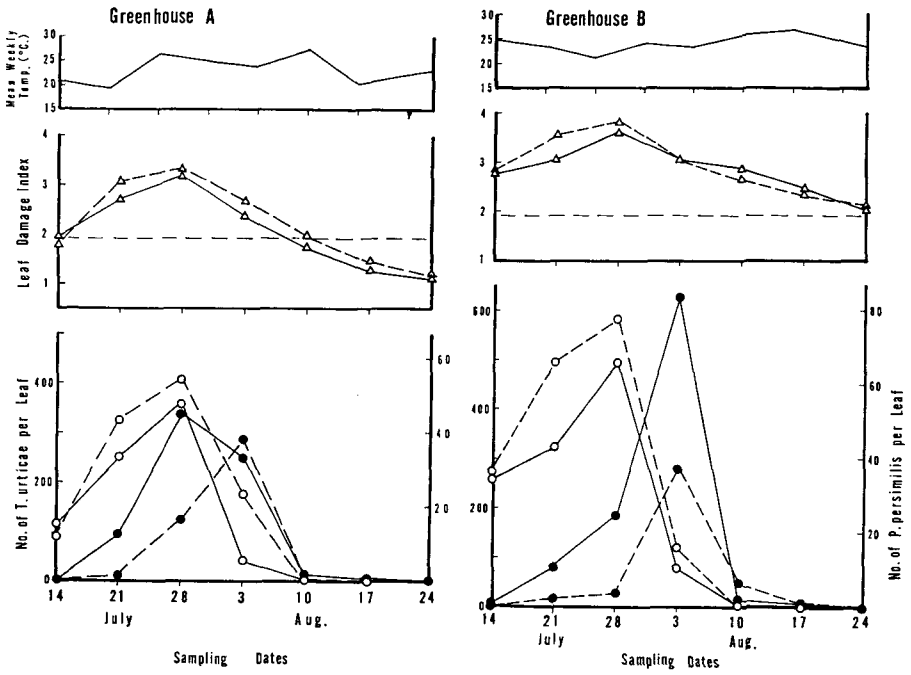

Fig. 1. Population development of *T. urticae* and *P. persimilis* and changes in leaf damage index on cucumber plants of greenhouses A and B in 1972.

○———○ *T. urticae* on predator-released plants
○– – –○ *T. urticae* on predator-free plants
●———● *P. persimilis* on predator-released plants
●– – –● *P. persimilis* on predator-free plants
△———△ Mean damage index of predator-released plants
△– – –△ Mean damage index of predator-free plants
— — — — Critical level

of leaf damage which can be tolerated without harm to the cucumber crop is equivalent to a mean damage index of 1.9. Fig. 1 shows, in experiment 1972, throughout the course of the experiment the mean leaf-damage index on all plants of greenhouse B exceeded the critical level, but in greenhouse A, the plants recovered from initial high leaf damage to a sub-critical damage level. In experiment 1973, the pattern of leaf-damages index following introduction of predator in greenhouses A and B was similar to greenhouse A's in the previous year. No *P. persimilis* was released in greenhouse C, which served as a check for the experiment, however, the predator accidentally became established on the check plants. As indicated in Fig. 2, *P. persimilis* were first recovered from the greenhouse C on

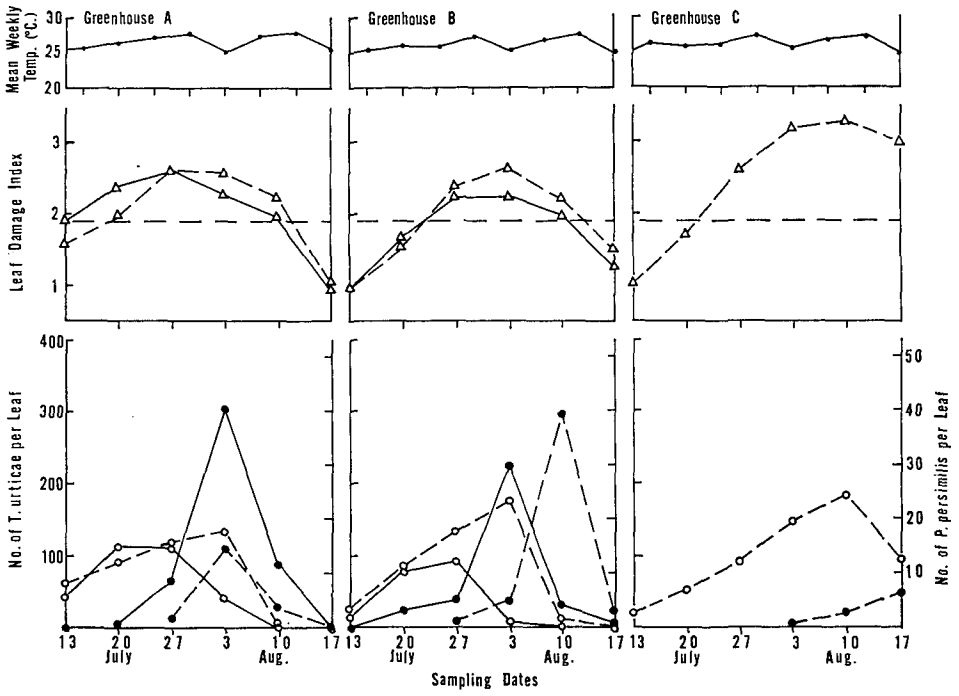

Fig. 2. Population development of *T. urticae* and *P. persimilis* and changes in leaf damage index on cucumber plants of greenhouses A, B (receiving releases of *P. persimilis*), and C (receiving no releases) in 1973. (*P. pensimilis* accidentally became established in greenhouse C.). For legends cf. Fig. 1.

August 3, the predator population steadily increased on the check plants in mid-August. The peak population of the prey in greenhouse C occurred 1 or 3 weeks later than those of greenhouses A and B which received the predators at early dates. The data indicate that the prey population

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○———○ *T. urticae* on upper leaves
○— — —○ *T. urticae* on middle leaves
○- - - -○ *T. urticae* on lower leaves
○·····○ *T. urticae* on leaves of new cane
●———● *P. persimilis* on upper leaves
●— — —● *P. persimilis* on middle leaves
●- - - -● *P. persimilis* on lower leaves
●·····● *P. persimilis* on leaves of new cane
△———△ Mean damage index of upper leaves
△— — —△ Mean damage index of middle leaves
△- - - -△ Mean damage index of lower leaves
△·····△ Mean damage index of leaves of new cane

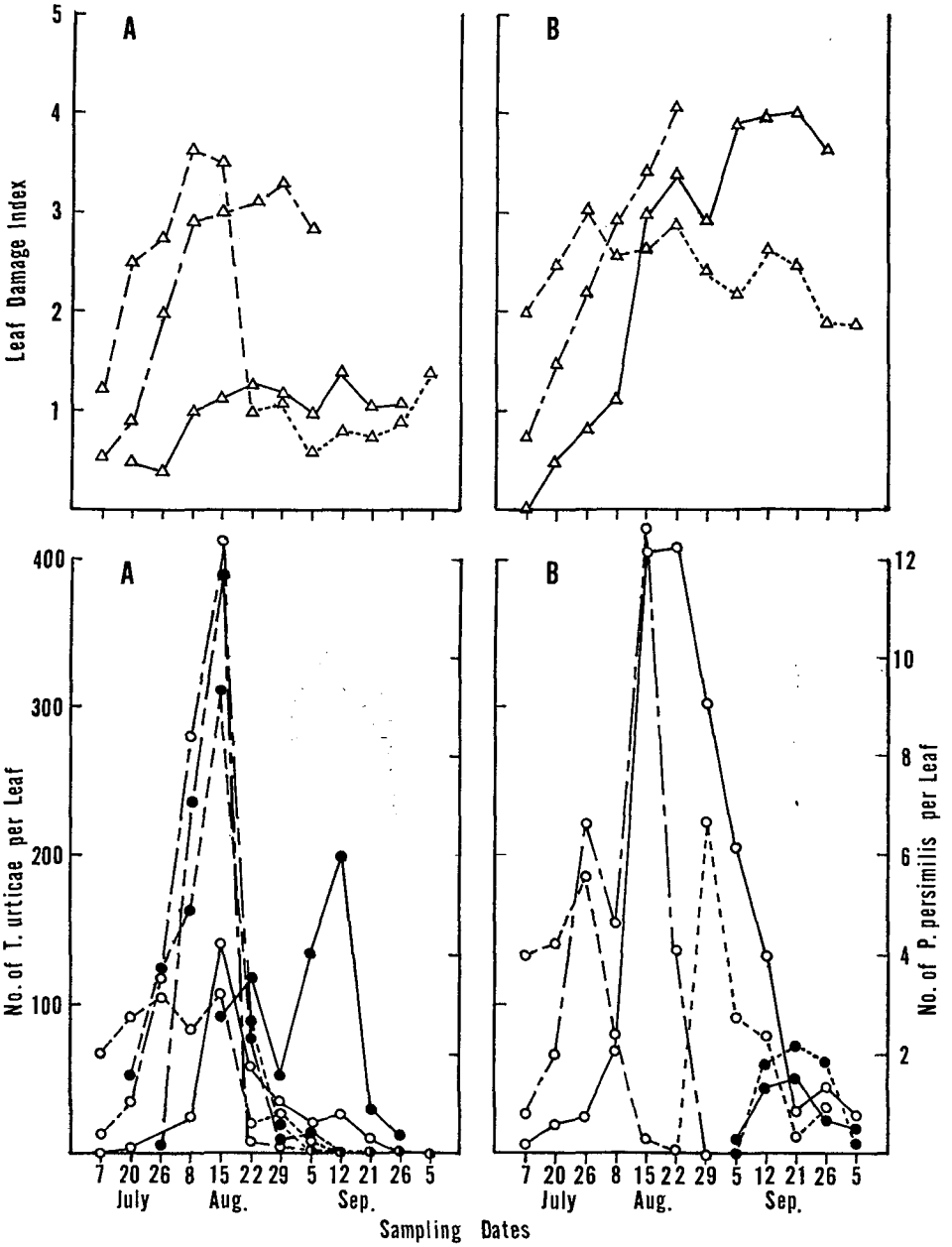

Fig. 3. Population development of *T. urticae* and *P. persimilis* and changes in leaf damage index on field grown blackberries. (A: experimental treatment, B: control). Cf. footnote on page 276.

in the check plants of greenhouse C was probably suppressed by the predacious mite. Excepting the first week, the mean mite damage index on check plants exceeded the critical level during the course of the experiment.

Little is known about the dispersal of *P. persimilis* under natural conditions. OATMAN *et al.* (1967) stated that the presence of *P. persimilis* in nonrelease plots on strawberries 2~3 weeks after the initial release is additional evidence of their ability to quickly spread over considerable distances in search of prey, since the release sites were 5–10 ft from the nearest strawberries in the nonrelease plots. They also reported that where sufficient two-spotted spider mites are present, *P. persimilis* becomes widely dispersed over 20 ft, reaches its peak population, and suppresses the prey population on rhubarb within 6~8 weeks after the initial releases. Figures 1 and 2 suggest that the natural dispersal of *P. persimilis* on cucumber plants in greenhouses was sufficient to control the prey on neighboring plants. The predators remained on the released leaves for a few days, then they quickly move to the other leaves or adjacent plants and within two weeks will be widely distributed.

Observations on field grown blackberries

Fig. 3 (A, B) indicates that there was a marked suppressive effect by *P. persimilis* on the tetranychid mite on the upper leaves of the blackberries. On the other hand, *P. persimilis* did not appear to be effective in lowering the peak of the prey on the middle leaves of the plants. Even though the predator reached its highest density in the middle leaves on August 15, it was not able to suppress the prey population, which reached a peak as higher as that in the check. Although there was no evidence that the predator protected the leaves from severe damage by spider mites in the lower zones of the plants. However, in the later part of the experiment, the predator effectively controlled the prey on the leaves of new canes that are grown from the root during the summer.

The temperature during early July to early October was 11°C to 27°C.

Observations on field grown soy bean plants

As indicated in Fig. 4–A, the natural infestation of tetranychid mites remained at a low level until the middle of August. At this time the population of tetranychid mites consisted of *T. urticae* and *T. kanzawai*, but the latter species was present in very low numbers. However, both species increased at the beginning of September. In all experiments, there was a distinct numerical response between prey and predator. The prey density reached a peak at the fifth or sixth week, and with a one-week lag, the

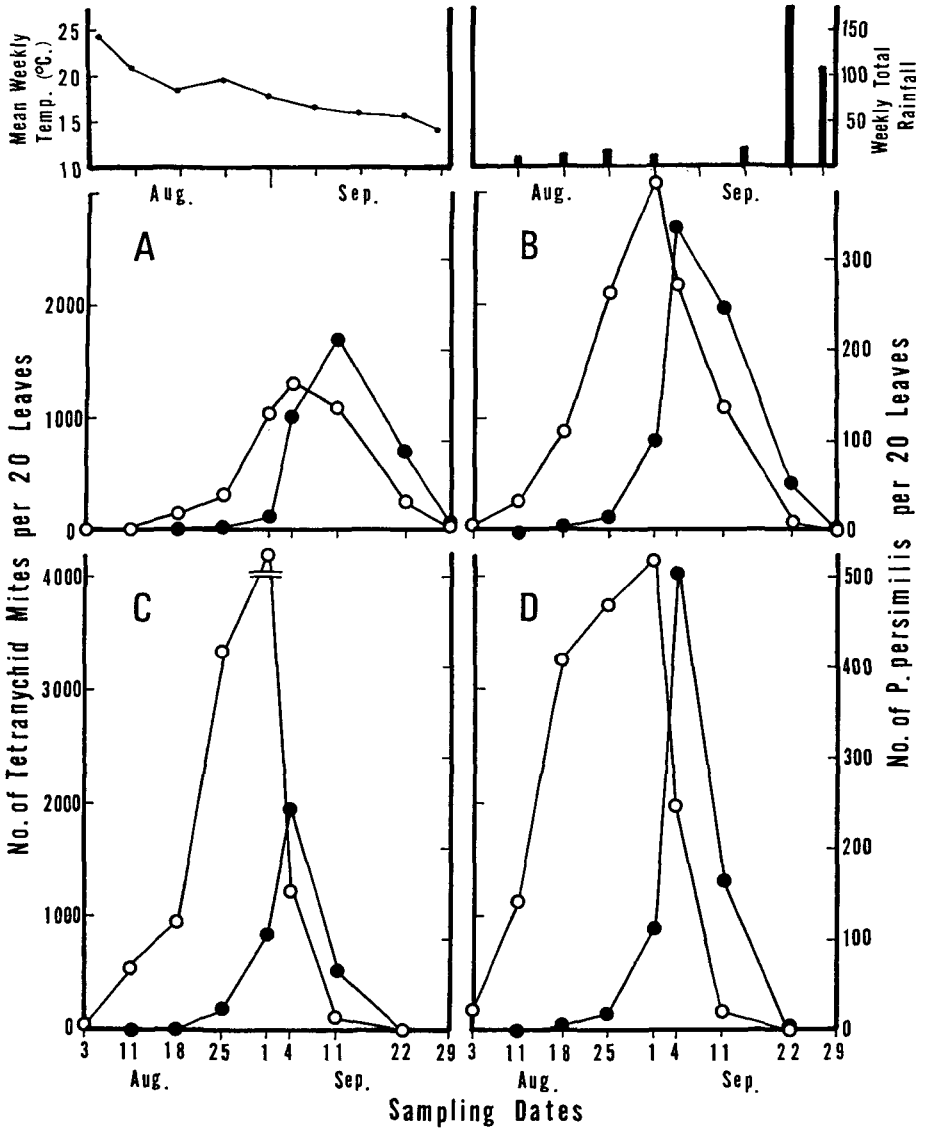

Fig. 4. Population development of tetranychid mites, *T. urticae* and *T. kanzawai*, and *P. persimilis*, on field grown soy beans.

○——○ *T. urticae* and *T. kanzawai*

●——● *P. persimilis*

predator density reached its peak at the sixth or seventh week after introduction. Finally, the population of the prey was reduced by the predator to very low levels within seven or nine weeks in all experimental blocks (Fig. 4). Up to the middle of the experiment, predation was so intense that many dead prey were found on the leaves, but towards the end of the experiment no newly killed prey was found as both species had approached extinction. Outside of the experimental area, it was observed that the population density of tetranychid mites on soy bean plants was still high during the middle of September in fields in which there were no releases of *P. persimilis*.

The temperature ranged from 16°C to 24°C during early August to mid-September. From the study reported here, we may conclude that the weather of late summer in Sapporo was favorable for the control of tetranychid mites by *P. persimilis* on soy bean plants in the field.

Several other predators, including native phytoseiid mite, *Amblyseius longispinosus*, *Stethorus* sp., *Chrysopa* spp., *Orisu* sp., and *Oligosita* sp. were observed in small numbers during the course of the experiment on soy bean plants, but their efficiency as predators of tetranychid mites is the subject for future study.

Summary

The effictiveness of the predacious mite *Phytoseiulus persimilis* A–H. imported as a predator of the tetranychid mites was studied on three types of agroecosystem in Hokkaido. Excellent biological control of tetranychid mites (mainly *Tetranychus urticae*) was observed on greenhouse (vinylhouse) cucumbers and field grown soy beans but somewhat poorer control occurred on field grown blackberries.

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