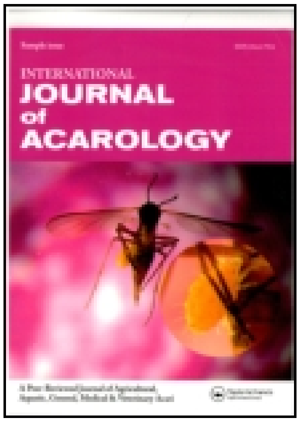


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# Effects of pesticides on the spider mite predators, *Scolothrips takahashii* (Thysanoptera: Thripidae) and *Stethorus japonicus* (Coleoptera: Coccinellidae)

K. Mori [a] & Tetsuo Gotoh [b]

[a] Research Institute of Japan Plant Protection Association, Ushiku, Ibaraki, 300-1212, Japan E-mail: kmori@poppy.ocn.ne.jp

[b] Laboratory of Applied Entomology and Zoology, Faculty of Agriculture, Ibaraki University, Ami, Ibaraki, 300-0393, Japan E-mail: gotoh@msv.ipc.ibaraki.ac.jp

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# EFFECTS OF PESTICIDES ON THE SPIDER MITE PREDATORS, *SCOLOTHRIPS TAKAHASHII* (THYSANOPTERA: THRIPIDAE) AND *STETHORUS JAPONICUS* (COLEOPTERA: COCCINELLIDAE)

**K. Mori[1] and Tetsuo Gotoh[2,*]**

*1. Research Institute of Japan Plant Protection Association, Ushiku, Ibaraki 300-1212, Japan, e-mail: kmori@poppy.ocn.ne.jp; 2. Laboratory of Applied Entomology and Zoology, Faculty of Agriculture, Ibaraki University, Ami, Ibaraki 300-0393, Japan, e-mail: gotoh@msv.ipc.ibaraki.ac.jp. *To whom correspondence should be addressed.*

**ABSTRACT** - The toxicity of 15 pesticides to spider mite predators was examined with second-stadium larvae of the predatory thrips, *Scolothrips takahashii* Priesner, and the acarophagous lady beetle, *Stethorus japonicus* Kamiya. Acephate, acetamiprid, halfenprox, imidacloprid, lufenuron and spinosad were toxic to both insect predators. In contrast, the two predators were tolerant to bifenazate, buprofezin, fluacrypyrim and pymetrozine; the $LC_{50}$ was more than triple the recommended field concentration for each of these chemicals. Similarly, the predatory thrips were tolerant to acequinocyl and pyrimidifen, and the acarophagous lady beetles were tolerant to chlorfenapyr and etoxazole.

**Keywords** - *Scolothrips takahashii*, *Stethorus japonicus*, pesticide, acaricide, resistance.

## INTRODUCTION

Synthetic pesticides have been intensively and extensively used to control agricultural pests for half a century. These chemicals may have side effects on non-target organisms including the natural enemies of target pests. This notion has contributed to increased interest in the use of selective pesticides that are compatible with natural enemies and present minimal risk to the environment and human health (Banken and Stark, 1998; Smith and Krischik, 2000; Tanaka *et al.*, 2000). The International Organization for Biological Control (IOBC) has developed a procedure for assessing the impact of pesticides on non-target organisms (Hassan, 1989). The protocol prescribed by the IOBC is based on the assumption that pesticides found to be harmless to the biological control agents in laboratory bioassays will also be harmless to the same organisms in the field (Hassan, 1989).

The predatory thrips, *Scolothrips takahashii* Priesner, and the acarophagous lady beetle, *Stethorus japonicus* Kamiya, are both indigenous mite predators. They are highly specialized and important predators of tetranychid mites and widely found on various crops and weeds in Japan, as well as in other countries (Tanigoshi and McMurtry, 1977; Gordon and Chapin, 1983; Gilstrap, 1995; Obrycki and Kring, 1998). The biological traits of these two predators have been studied relatively little in Japan (Tanaka, 1966; Nakagawa, 1993). To more effectively utilize these natural enemies as biological control agents, we should acquire information on their susceptibility to pesticides. In this study, we tested the effect of fifteen pesticides on *S. takahashii* and *S. japonicus*. The chemicals tested are grouped as insecticides, acaricides and insect growth regulators (IGRs).

## MATERIALS AND METHODS

**Insects tested** - Adults of *S. takahashii* and *S. japonicus* were collected from kudzu vine, *Pueraria lobata* (Willd.), in Ami, Ibaraki, in July-September 1998. Each insect species was maintained on leaf discs of the kudzu vine (June-October) or on lima bean, *Phaseolus lunatus* L. (November-May), heavily infested with spider mites. For thrips, the leaf discs were placed on agar (0.5%, 10 mm thick) including 1% gentian violet, in plastic cups (80 mm (top) x 55 mm (bottom) x 55 mm high). The lid

Table 1. Susceptibility of second-stadium larvae of *Scolothrips takahashii* and *Stethorus japonicus* to pesticides: estimation of $LC_{50}$ (ppm) and slope.

| Pesticide | Recommended concentration (ppm)[a] | *Scolothrips takahashii* | | | | | | *Stethorus japonicus* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $N$[b] | $LC_{50}$ (95% CI) | Slope±S.E. | $R^2$ | $x^2$ | df | $N$ | $LC_{50}$ (95% CI) | Slope±S.E. | $R^2$ | $x^2$ | df |
| INSECTICIDES | | | | | | | | | | | | | |
| Acephate | 500 | 82 | 48.85 (35.23-67.73) | 2.83±0.40 | 0.9608 | 0.426 | 2 | 73 | 19.18 (10.1-36.3) | 2.07±0.41 | 0.9286 | 0.588 | 2 |
| Acetamiprid | 200 | 79 | 4.34 (2.52-7.47) | 2.36±0.53 | 0.9080 | 2.805 | 2 | 84 | 2.31 (1.34-3.96) | 2.15±0.43 | 0.9269 | 1.267 | 2 |
| Chlorfenapyr | 50 | 89 | 2.00 (1.67-2.41) | 15.88±3.14 | 0.9276 | 1.938 | 2 | 62 | 172.83 (90.63-329.56) | 1.56±0.21 | 0.9642 | 0.043 | 2 |
| Emamectin-benzoate | 10 | 95 | 4.24 (2.28-7.86) | 2.14±0.31 | 0.9594 | 1.149 | 2 | 86 | 10.95 (6.55-18.32) | 3.06±0.70 | 0.9048 | 1.179 | 2 |
| Imidacloprid | 100 | 80 | 1.81 (0.88-3.75) | 1.93±0.06 | 0.9980 | 0.019 | 2 | 75 | 0.60 (0.31-1.13) | 1.55±0.14 | 0.9836 | 0.260 | 2 |
| Spinosad | 100 | 85 | 5.01 (3.09-8.11) | 2.97±0.57 | 0.9326 | 0.799 | 2 | 82 | 70.41 (44.25-112.0) | 3.49±0.74 | 0.9172 | 1.126 | 2 |
| ACARICIDES | | | | | | | | | | | | | |
| Acequinocyl | 150 | 33 | > 450 (2/33)[c] | | | | | 79 | 17.24 (9.14-32.53) | 2.14±0.29 | 0.9474 | 0.515 | 3 |
| Bifenazate | 200 | 40 | > 600 (1/40) | | | | | 39 | > 600 (2/39) | | | | |
| Etoxazole | 100 | 96 | 20.73 (14.08-30.51) | 2.99±0.59 | 0.9277 | 1.482 | 2 | 42 | > 300 (3/42) | | | | |
| Fluacrypyrim | 150 | 40 | > 450 (0/40) | | | | | 35 | > 450 (5/35) | | | | |
| Halfenprox | 100 | 79 | 6.57 (3.27-13.20) | 1.78±0.18 | 0.9809 | 0.497 | 2 | 100 | 7.74 (4.21-14.23) | 1.81±0.17 | 0.9825 | 1.474 | 2 |
| Pyrimidifen | 40 | 83 | 152.46 (63.2-367.7) | 0.83±0.14 | 0.9461 | 0.326 | 2 | 90 | 16.28 (8.60-31.00) | 1.14±0.25 | 0.9154 | 0.776 | 2 |
| INSECT GROWTH REGULATORS (IGRs) | | | | | | | | | | | | | |
| Buprofezin | 200 | 48 | > 600 (1/48) | | | | | 94 | 694.89 (463.7-1041.3) | 1.61±0.21 | 0.9680 | 0.214 | 2 |
| Lufenuron | 50 | 93 | 25.23 (17.66-36.03) | 3.23±0.33 | 0.9793 | 0.573 | 2 | 100 | 5.25 (2.99-9.22) | 2.09±0.05 | 0.9990 | 0.019 | 2 |
| Pymetrozine | 125 | 55 | > 375 (2/55) | | | | | 33 | > 375 (2/33) | | | | |

[a] This is the commercially used concentration of chemicals.

[b] Total number of insects tested.

[c] Number of dead insects to total number of insects tested at three times the registered concentration. At this concentration, nine or twelve replicates were carried out to confirm no effect of the chemical. No insects killed at the lower concentration.

of each cup was perforated (30 mm) and covered with fine nylon mesh to allow ventilation. Environmental conditions were adjusted to 25±1°C with a photoperiod of 16L:8D. Lady beetles were maintained on infested leaf discs, which were directly put in a plastic cup with a lid. As prey of the predators, the two-spotted spider mite, *Tetranychus urticae* Koch (red form) was cultured on leaf discs (ca. 16 $cm^2$) of kudzu vine or lima bean placed on a water-saturated polyurethane mat in a Petri dish (9 cm diam.). When mite densities reached acceptable levels, the leaf discs were added to plastic cups.

**Pesticides** - The pesticides tested were acephate (50% wettable powder, WP), acequinocyl (15% suspension concentrate, SC), acetamiprid (20% water soluble powder, SP), bifenazate (20% SC), buprofezin (20% SC), chlorfenapyr (10% SC), emamectin-benzoate (1% emulsifiable concentrate, EC), etoxazole (10% SC), fluacrypyrim (30% microcapsule, MC), halfenprox (5% MC), imidacloprid (10% WP), lufenuron (5% EC), pymetrozine (25% WP), pyrimidifen (4% SC) and spinosad (25% water dispersible granule, WDG). These chemicals were suspended in distilled water.

**Toxicity tests** - Second-stadium larvae were chosen to evaluate the toxicity of the chemicals, because larvae usually are more susceptible to pesticides than adults (Colburn and Asquith 1971, 1973). Five second-stadium larvae of either thrips or the lady beetle were transferred from the laboratory culture to a new kudzu vine leaf disc (ca. 16 $cm^2$) with abundant prey on a water-saturated polyurethane mat in a Petri dish (9 cm diam.). After 24h, dead or injured individuals were removed and the pesticide suspensions (4.3 $mg/cm^2$) were sprayed onto the leaf disc with insects using a spraying machine (DIK-7320 manufactured by Daiki Rika Kogyo Co., Ltd., Tokyo, Japan). After treatment, insects were kept on the leaf disc at 25±1°C and a 16L:8D photoperiod for 48h, except for the IGRs (buprofezin, lufenuron and pymetrozine) and slow-acting chemicals (acequinocyl and etoxazole), which were checked after 72h. Four to five concentrations per pesticide with three to five replicates each were tested. Control leaf discs were sprayed with distilled water. Insects that failed to move their legs when touched with a fine brush were scored as "dead". Pooled data were subjected to Probit analysis and $LC_{50}$ was estimated (Finney, 1971) using Abbott's correction for natural mortality (Abbott, 1925).

## RESULTS AND DISCUSSION

Table 1 shows the $LC_{50}$ of the fifteen pesticides for both insect predators. Except for chlorphenapyr and emamectin-benzoate, the insecticides exhibited strong negative effects on both insects. Chlorfenapyr was hardly toxic to the lady beetle larvae with an $LC_{50}$ more than three times higher than the recommended concentration, whereas thrips larvae were highly susceptible to chlorphenapyr. This chemical is also effective on spider mites of the genus *Tetranychus*, but not on *Panonychus* species. Such difference in toxicity among genera may relate to the difference in susceptibility in the two insects tested. Thrips were mildly susceptible to emamectin-benzoate, while the lady beetle was tolerant, although it suffered some reduced survival and its $LC_{50}$ (10.95 ppm) was similar to the recommended concentration (10 ppm). The lady beetle was less susceptible to spinosad than thrips, but $LC_{50}$ (70.41 ppm) was still less than the recommended concentration (100 ppm).

The acaricides bifenazate and fluacrypyrim were nontoxic to thrips and the lady beetle, while halfenprox was very harmful to both insects. Acequinocyl and pyrimidifen had no effect on thrips, even when three times the recommended concentration was sprayed, but were toxic to the lady beetle. Etoxazole was nontoxic to the lady beetle (i.e., mortality was only 7% when sprayed at triple the recommended concentration), but it was quite toxic to thrips.

Of the IGRs tested, lufenuron was toxic to both thrips and the lady beetle. Buprofezin and pymetrozine had no effect on the two insect predators.

The present study shows that bifenazate, fluacrypyrim, buprofezin and pymetrozine were nontoxic to the second-stadium larvae of both *S. takahashii* and *S. japonicus*. The predatory thrips was also tolerant to acequinocyl and pyrimidifen, while the lady beetle was tolerant to chlorfenapyr and etoxazole. The $LC_{50}$ of the second-stadium larvae was more than triple the recommended field concentration for each of the chemicals they tolerated. These pesticides are potentially usable under IPM programs in the field.

Three *Stethorus* species appearing in apple orchards were tolerant to 12 of 27 chemicals tested at field concentration (Walters, 1976). Colburn and Asquith (1971, 1973) showed that 43 out of 54 chemicals tested exhibited moderate or low toxicity to *Stethorus punctum*. Smith and Krischik (2000) checked the effect of four biorational pesticides (horticultural oil, soap, azadirachtin, *Beauveria* sp.) on four commercially available lady beetles. They reported that all biorationals caused low mortality but reduced survival rate of some of the four species tested, except horticultural oil, which had no effect on beetle survivorship. In a cotton field, predatory thrips were tolerant to some insecticides used, and there was no effect on the reproductive rates of the exposed females (Sengonca and Kroeger, 1990). Thus, several chemicals have been considered as candidates for use in field IPM programs so far. However, it is difficult to compare our results with the published data for two reasons (van Lenteren and Woets, 1988; Robb *et al.*, 1995; Gotoh and Hong, in press). First, chemicals may vary from one country to another, depending on chemical registration status and economic development. Second, they have frequently led to the development of pesticide resistance and to harmful effects on environment and human health, often resulting in withdrawal from the market. New chemicals frequently act selectively on certain orders of insects (e.g., chlorfenapyr, acequinocyl, etoxazole and pyrimidifen), unlike conventional and almighty pesticides such as acephate. Therefore, the investigation of their toxicity to major predators associated with target pests is necessary on a case-by-case basis, before their potential use in field IPM programs can be concluded.

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