INTEGRATED CONTROL OF APPLE PESTS IN
NEW ZEALAND
15. INTRODUCTION OF TWO PREDACIOUS PHYTOSEIID
MITES

W. P. THOMAS and LINDA M. CHAPMAN

Entomology Division, DSIR, Lincoln Research Centre,
Christchurch

Summary

Control of phytophagous mites on apples has relied heavily on the repeated use of miticides in conjunction with insecticides and fungicides against other pests and diseases. The continued use of organophosphates for caterpillar control has enabled resistance to develop in predatory mite populations in several countries, including New Zealand. Two organophosphate-resistant predatory mites, *Amblyseius fallacis* and *Typhlodromus occidentalis* have been introduced recently to augment the activities of azinphos-methyl-resistant *T. pyri*, now used against European red mite in Nelson. The introduced species, reared continuously on two-spotted mite have been successfully established in some pome-fruit orchards in New Zealand under reduced miticide schedules. Rearing programmes and initial release of the predators are described and discussed.

INTRODUCTION

During the last decade much attention has been focused on predacious mites of the family Phytoseiidae, because of their role in controlling phytophagous mites in commercial orchards. Their importance in integrated mite control programmes is evidenced by the rapidly expanding literature on the subject. The origin of this widespread interest lies in the fact that several phytoseiid species have become resistant to various broad-spectrum insecticides, especially organophosphorus compounds. Species reported to have developed resistance include, *Typhlodromus occidentalis*, *T. pyri*, *T. caudiglans*, *Amblyseius fallacis* and *A. hibisci* as reviewed by Croft (1976).

Organophosphate insecticides, such as azinphos-methyl, are used extensively in pome-fruit orchards for the control of various lepidopterous pests. The commercial spray schedule recommended by the New Zealand Ministry of Agriculture and Fisheries includes azinphos-methyl but its previous history of use in orchards varies considerably according to locality.

The phytoseiids in New Zealand orchards include *T. pyri*, *T. caudiglans*, *T. occidentalis*, *A. longispinosus*, *A. cucumeris*, *A. perlongisetus* and more rarely other species (Collyer pers comm). Of these, *T. pyri* is the only species reported to have developed resistance to azinphos-methyl sufficient to enable it to be incorporated into an integrated mite control programme in Nelson (Penman *et al* 1976; Wearing *et al* 1978). Hoyt (1972) recorded a 10-fold level of resistance to azinphos-methyl in this species and concluded that this level was not adequate for the implementation of integrated mite control. Later

Proc. 31st N.Z. Weed and Pest Control Conf.

Integrated Control

investigations by Penman *et al* (1976) showed that the resistance of *T. pyri* had increased markedly in Nelson populations after more than 10 years exposure to the chemical.

Because of the findings of Hoyt (1972) for *T. pyri* arrangements were made by Entomology Division for the importation of *Amblyseius fallacis* from Michigan. This highly resistant species was providing phytophagous mite control in the more humid Central and Eastern States of North America and Canada (Croft and Nelson 1972). Through the courtesy of Dr B. A. Croft, Michigan State University, a consignment was forwarded to Nelson in 1972. Due to the poor survival rate, this consignment failed. From the same source, additional shipments were received at Lincoln on 15.9.73 (47 active stages plus 1 egg); 1.10.73 (49 active stages); 29.10.73 (90 active stages); 29.9.75 (116 active stages plus 5 eggs). The mites were airfreighted in short lengths of plastic drinking straws with aeration slits and packed according to the method of Croft (1976).

In 1972 organophosphate-resistant *T. occidentalis* were imported to Australia from the United States of America. With the assistance of Dr J. L. Readshaw (CSIRO, Canberra) this species was introduced to New Zealand in May 1976 for the control of two-spotted mite, TSM (*Tetranychus urticae*). The culturing of both species and initial field release programme for *A. fallacis* are described.

Quarantine

Both predatory species were reared initially in 9mm petrie dishes for three generations on excised bean leaves infested with TSM, under strict quarantine, in compliance with regulations. During quarantine it became evident that excised lima bean leaves (*Phaseolus lunatus*) were superior to French dwarf varieties (*P. vulgaris*) for rearing *A. fallacis* because of the absence of hooked hairs on the ventral surfaces. The hooked hairs often trapped active stages of this predatory mite causing considerable mortality. The less active *T. occidentalis* and active stages of TSM were not affected in this manner.

Mass rearing

Predatory mites have been mass-reared on TSM infested bean plants, lima beans or more recently broad beans (*Vicia faba*) cultivar, 'Exhibition Long Pod' and the French dwarf bean cultivar 'Seminole'. Bean plants, pruned to retain cotyledon growth only, were used to rear *A. fallacis* while whole plants of 'Seminole' were used for *T. occidentalis*. Separate prey and predator populations have been maintained continuously in growth rooms held at about 25°C in a 16:8 hour, light:dark, photoperiod regime. Plants and infestations received fortnightly applications of azinphos-methyl at 0.05%.

In Auckland predators were reared in plastic containers sealed with 'Gladwrap'. Ten to 12 TSM infested subterranean clover (cv 'Mt. Barker') leaves were added twice weekly to one side of a container and old mouldy leaves were removed from the opposite side. Predator eggs on old leaves were retained. Throughout the handling procedures it has been necessary to maintain a high hygiene standard to prevent contamination of cultures. Releases have been made directly from the container. Dr Penman, Lincoln College, is now culturing *T. occidentalis* according to a modification of the method described by Tanigoshi *et al* (1975).

Field releases of *A. fallacis* at Nelson

During the summer seasons 1973-1976 weekly shipments of *A. fallacis* were airfreighted to Nelson for release at the Appleby Research Orchard. In 1973-74 releases were made on the cultivars 'Dunn's Favourite' and 'Delicious' (old trees). Later releases were made on the

Integrated Control

cultivars 'Hawkes Bay Red Delicious' and 'Sturmer Pippin' (young trees). The trees were infested principally with European red mite, ERM (*Panonychus ulmi*).

One hundred active stages of the predators were sucked by vacuum pressure into each 5 cm length of plastic straw sealed at one end by 200 mesh stainless steel gauze and later stoppered at the other end. The modified straw container appeared superior to that described by Croft (1976) and did not allow mites to escape. Straws were packed in plastic bags and enclosed in cylindrical cardboard canisters. For mite release the straws were stapled to branches of the trees.

Despite the high rate of survival of the predators in transit and a high weekly rate of release (100-200 per tree), *A. fallacis* failed to establish at the Appleby Research Orchard. *T. pyri* was also present on the trees.

Croft and Nelson (1972) discussed the movement of *A. fallacis* from ground cover vegetation to trees during mid-season, the reverse movement in late autumn and the need for alternate food during the winter to spring period. It is probable that the lack of suitable ground cover vegetation under the trees and the general absence of two-spotted mite infestations in this vegetation and in the trees, decreased the chances of establishment of *A. fallacis* in this orchard.

Field releases of *A. fallacis* at Lincoln

Releases of *A. fallacis* were made from straws onto young apple trees (cv 'Cox's Orange Pippin') at the Lincoln College Research Orchard during 1973-74 and in other blocks in later years. The results of this research will be reported fully elsewhere. However, from previous work it was known that predatory mites were absent or rarely observed in this orchard (D. Penman pers comm). Phytophagous mite populations comprised mixed populations of ERM and TSM. During the first season of release *A. fallacis* established successfully on the trees and a noticeable decrease of the phytophagous prey mites was recorded. By the end of the season the release trees remained green with little movement of predators to surrounding trees, while the control trees (no release) showed severe feeding damage with consequent bronzing of foliage. Although the population of *A. fallacis* on the release trees persisted into the autumn, high overwintering mortality meant that the predators did not re-invade the trees from the ground until very late in the following season. A similar situation has existed in later years.

In Canterbury and elsewhere ground cover control in orchards commonly consists of strip-spraying the vegetation along the tree rows. This management practice was applied initially to the Lincoln College orchard but during the last 3 years the ground cover has been manipulated to promote the growth of white clover (*Trifolium repens*) under the trees. TSM infestations have been augmented to enhance the survival of *A. fallacis* and the success of this procedure is currently under investigation (Penman pers comm).

Field releases of *A. fallacis* at Rangiora

At Rangiora releases of *A. fallacis* have been made in a mature orchard with trees over 25 years in age. This orchard has a history of serious phytophagous mite problems with mixed populations of both ERM and TSM. Strip herbicide treatment and trickle irrigation were practiced. The releases of *A. fallacis* commenced in November 1975 when a large single release of 5000 (all stages) per tree was made from bean foliage placed beneath each of eight trees (cv 'Ames'). Season long protection from mite problems was provided on these trees without the need for intervention with miticides. Detailed counts of the mite numbers were not

Integrated Control

taken, but the trees remained green with few phytophagous mites persisting into the next season. Predatory mites spread to other trees within the block and the application of miticides to this block has not been necessary. In 2 additional blocks consisting of the cultivars 'Sturmer Pippin', 'Richared' and 'Hawkes Bay Red Delicious', initial releases of *A. fallacis* were made during 1976-77 and 1977-78 respectively. Regular counts and estimates of mites were made on samples of 50 leaves per block using a mite brushing machine (Figs. 1 and 2). All the trees received an

FIG. 1: Comparisons of population estimates of *P. ulmi*, *T. urticae* and *A. fallacis* on cultivars 'Sturmer' and 'Richared' for multiple release and no-release trees at Rangiora 1976-77. Arrows indicate release (R) or miticide applications (P = cyhexatin and O = propargite). All trees received regular azinphos-methyl sprays during summer.

Integrated Control

intermediate oil spray at green-tip. Because the release trees of 'Sturmer Pippin' and 'Richared' represented only a small percentage of the total trees in one block, the two cultivars had sometimes to be sprayed with miticide whether or not this was warranted on the release trees. However, in the block of 'Hawkes Bay Red Delicious' a small experimental plot was used for various independent treatments.

FIG. 2: Comparisons of population estimates of *P. ulmi*, *T. urticae* and *A. fallacis* on a single cultivar, 'Hawkes Bay Red Delicious' at Rangiora 1977-78. Group 1 — no *A. fallacis* releases and no miticides. Group 2 — two *A. fallacis* releases (R) and no miticides. Group 3 — five *A. fallacis* releases (R) and no miticides. Group 4 — three *A. fallacis* releases and one miticide (P = cyhexatin) application. All trees received regular azinphos-methyl sprays during summer.

Integrated Control

A single cyhexatin spray was applied at the beginning of December to 'Sturmer Pippin' but the 'Richared' trees received a second application 10 days later (Fig. 1). Two propargite sprays were applied during late January and early February to both cultivars. Multiple releases (R) of predators on bean leaves with TSM prey, were made on the release trees on the dates shown (Fig. 1). On each occasion approximately 200 predators were released on each tree. While the single early cyhexatin spray on the 'Sturmer Pippin' trees reduced both phytophagous mite species to a suitable ratio with predators, the two sprays on 'Richared' were more extreme particularly in reducing TSM. Because of the high ERM numbers on the no-release trees in late January 1977, two propargite sprays were applied. These led to an immediate reduction in phytophagous mites in both the release and control (no-release) trees, but unfortunately the effect on the release trees was so extreme that those predators which survived were in a starved condition at the commencement of winter. Many moved onto the control trees where prey mites existed in higher numbers (Fig. 1).

In the 'Hawkes Bay Red Delicious' experimental block four groups of trees received different treatments (Fig. 2). Group 1, the control, did not receive predators or selective miticides. *A. fallacis* appeared late in the season when phytophagous mite populations were high and the predator did not contribute significantly to their control. Severe bronzing of the foliage occurred.

Group 2 received two small releases of *A. fallacis* in early November and early December. Their numbers increased from December to mid-March before declining with the prey populations. ERM reached very damaging levels in late February, which led to severe bronzing of the foliage, before numbers decreased sharply as mites moved off the foliage to lay winter eggs. TSM did not reach damaging numbers.

In group 3 where five separate releases of predators were made, TSM was held below damaging levels but ERM was again not controlled by the predators and bronzing of the foliage resulted.

In group 4 where three releases were made, a single cyhexatin application in late December reduced ERM and TSM to low levels. This also depressed the predator population. ERM did not reach more than nine per leaf and TSM peaked at around 40 per leaf, higher than occurred in group 2 or 3. Thus, the miticide prevented severe bronzing by controlling ERM but disrupted TSM control by the predator.

Field releases of *T. occidentalis*

Organophosphate-resistant *T. occidentalis* have established in release orchards in Nelson (Wearing pers comm), Hastings (Walker pers comm), Waimate, Loburn and Lincoln. The results of these introductions will be reported in detail elsewhere.

DISCUSSION

Investigations on the suitability of *A. fallacis* and *T. occidentalis* to establish and control phytophagous mites in New Zealand orchards have been confined as yet to a few experimental blocks. Both species have been cultured and established successfully but their commercial potential cannot yet be assessed fully.

The data presented here, although covering introductory years only, indicates that *A. fallacis* is most closely correlated with TSM numbers and is most effective in late summer, so that a miticide spray is probably necessary to reduce ERM numbers in early summer. It appears essential, to time any selective miticide so that rather than eliminating the prey populations, a low level of both predator and prey are maintained.

Integrated Control

Subsequent work at Rangiora (unpublished) has indicated that satisfactory control of phytophagous mites may be achieved by *A. fallacis* with the aid of a single early summer cyhexatin application. Releases of *A. fallacis* in a Blenheim orchard have also indicated a preference by this species for TSM rather than ERM (Gunson pers comm).

Other management practices being investigated to assist *A. fallacis* include alterations in the ground cover and the provision of protective shelters to enhance overwintering survival. Observations in Canterbury in July have confirmed that overwintering females of the imported strain of *A. fallacis* continue to feed and oviposit where hibernating aggregations of TSM provide sustenance under loose bark or in artificial shelters. The availability of prey mites in early spring is then an important factor in their survival at this time. Increased winter survival of *A. fallacis* would be gained by encouraging suitable ground cover vegetation rather than bare ground. Croft (1975) and others have shown that a 25% under-tree vegetative cover is necessary to promote survival of *A. fallacis*. The ground cover may prove to be a successful early spring feeding ground for *A. fallacis* if TSM is also present and beginning to reproduce there. However, Croft and McGroarty (1977) have found that the presence of ground cover supporting a TSM population may delay the movement of *A. fallacis* from the ground cover to the tree. The judicious use of herbicides in early summer, which would produce a temporary 'burn-off' of vegetation, may be a means of hastening the movement of the *A. fallacis* into the trees before the ERM has increased substantially. This and other aspects of the behaviour of the predator will be investigated.

In the brief period since the release of organophosphate-resistant *T. occidentalis* this predator has increased dramatically on TSM populations in the field and has been observed to feed on ERM. This predator species, which overwinters on the trees, may prove more easily managed than *A. fallacis*.

The phytophagous mites ERM and TSM differ in their significance in the different fruit-growing areas of New Zealand which vary climatically. The predatory phytoseiid most suitable for integrated mite control may also be expected to vary between districts and this can be determined only by release and assessment. In Canterbury and further south, where insecticide-resistant predators do not occur in commercial orchards, the widespread release and establishment of the most effective phytoseiids will be needed before integrated mite control could be adopted on a large scale.

ACKNOWLEDGEMENTS

The authors wish to thank Mrs Pamela Smith for much of the quarantine handling and distribution of early consignments; Dr D. Penman for discussions and use of the Lincoln College Orchard; Mr R. Chambers, Rangiora, for co-operation in the use of his orchard. Dr C. H. Wearing supplied information on Auckland rearing methods.

REFERENCES

- Croft, B. A., 1975. Integrated control of apple mites. *Bull. E-825 Mich. State Coop. Ext. Ser.*, 12 pp.
- Croft, B. A., 1976. Establishing insecticide-resistant phytoseiid mite predators in deciduous fruit orchards. *Entomophaga* 21: 383-399.
- Croft, B. A. and McGroarty, D. L., 1977. The role of *Amblyseius fallacis* (Acarina : Phytoseiidae) in Michigan apple orchards. *Michigan Agric. Exp. Station East Lansing Res. Rep. 333*: 22 p.

Integrated Control

- Croft, B. A. and Nelson, E. E., 1972. Toxicity of apple orchard pesticides to Michigan populations of *Amblyseius fallacis*. *Environ. Entomol.* 1: 576-579.
- Hoyt, S. C., 1972. Resistance to azinphos-methyl of *Typhlodromus pyri* from New Zealand. *N.Z. J. Sci.* 15: 16-21.
- Penman, D. R., Ferro, D. N. and Wearing, C. H., 1976. Integrated control of apple pests in New Zealand. VII. Azinphos-methyl resistance in strains of *Typhlodromus pyri* from Nelson. *N.Z. Jl. Exp. Agric.* 4: 377-80.
- Tanigoshi, L. K., Hoyt, S. C., Browne, R. W. and Logan, J. A., 1975. Influence of temperature on population increase of *Metaseiulus occidentalis* (Acarina: Phytoseiidae). *Ann. Entomol. Soc. Ann.* 68: 979-986.
- Wearing, C. H., Walker, J. T. S., Collyer, E. and Thomas, W. P., 1978a. Integrated control of apple pests in New Zealand. 8. Commercial assessment of an integrated control programme for European red mite, *Panonychus ulmi* (Koch) using an insecticide-resistant predator. *N.Z. Jl. Zool.* 5: (in press).
- Wearing, C. H., Collyer, E. and Thomas, W. P., 1978b. Integrated control of apple pests in New Zealand. 12. Commercial implementation of integrated control of European red mite in Nelson. *Proc. 31st N.Z. Weed and Pest Control Conf.*