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Biological control of redlegged earth mite and lucerne flea by the predators *Anystis wallacei* and *Neomologus capillatus*

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Summary

Anystis wallacei **preferred redlegged earth mite and *Neomulgus capillatus* preferred lucerne flea in the insectary. Feeding tests showed that 100 *A. wallacei* per square metre can kill 16 000 redlegged earth mites in one pest generation. Two types of field trials were conducted using a novel barrier system. The addition of both predators into ungrazed plots reduced peak pest numbers by more than two thirds, while vegetative and seed yields were more than doubled. Pest numbers were low in mown plots but peak populations of redlegged earth mite and lucerne flea were reduced by 80 and 60% respectively. *A. wallacei* was reared in field cages for two years at greater densities than naturally occurring in the field. Predators survived in much greater numbers than pests after sprays of common pesticides.**

Introduction

Control of redlegged earth mite (*Halotydeus destructor*) and lucerne flea (*Sminthurus viridis*) would increase pasture, animal and crop production but farmers have largely decided against the chemical control option. Continuously operating and compatible control strategies such as resistant varieties and biological control would be the ideal alternative to chemical control.

Wallace (1981) collected *Anystis wallacei* Otto and *Neomolgus capillatus* (Kramer), releasing them separately in a few locations in Western Australia. He had observed them as predators around the Mediterranean where they coexist in some areas. He examined the effects of each introduced predator in Australia and concluded that they are useful control agents of redlegged earth mite and lucerne flea.

It was demonstrated that colonies of these predators could be established in new areas where they would spread slowly. Evidence that the predators reduced pest numbers was also reported (Michael *et al.* 1991a).

This project was commenced with the major objective of accelerating the spread of the two predators. Further assessments on predator effectiveness were also planned and sites for this had been established. However the emphasis of this project was altered substantially following the presentation of research findings at the previous National Workshop (Michael *et al.* 1991a). The new objectives became:

i. to determine the impact of the two predators on the pests in the insectary and in the field,
ii. to assess the effect of the predators on pasture production and quality,
iii. to develop techniques for continuous small-scale predator rearing,
iv. to determine predator survival after treatment with insecticides commonly used on pasture,
v. to monitor predator survival and spread at release sites.

Methods

Insectary feeding trials

In view of the large range of possible prey types and combinations of prey for the feeding preference work, only simple testing of a few prey types was undertaken. This was performed in small tubes, allowing careful counting of the individual predators and prey as they were added and as they were recovered after the feeding period. Predators were separated and starved 24 hours prior to testing. A second method was to count redlegged earth mite and *A. wallacei* into boxes with growing pasture plants. The invertebrates were removed with a suction sampler at the end of the test. Conditions in the insectary were standardized for all the testing at 13°C and 70% humidity.

Field trials testing predator effectiveness

The two types of field trials set up to determine the effects of the predators on pest populations and pasture were complete block designs with four replications and the same treatments: chemical control, untreated and biological control.

i. The 'Addition' trial had 2 × 2 m plots which were separated so that they could be managed totally from the outside. The same plots were used over two years. Predators were collected from elsewhere and counted before adding them to the biological control treatment.
ii. The 'Elimination' trials had contiguous 10 × 10 m plots separated only by a common barrier. One of these trials was located on an area colonized by *A. wallacei* and the other was on an area

colonized by *N. capillatus*. Predators were to be eliminated from the 'untreated' after which the whole complement of pasture invertebrates without the predators was to be reintroduced.

Barriers around the plots were constructed of sheet metal dug into the ground 10 cm and joined at the corners with Liquid Nails®. The same glue was used to fix a continuous strip of carpeting on the top of the metal. A continuous aluminium capping was glued onto the carpeting to protect it from the sun and rain. Repellent was then repeatedly applied in oil to the carpeting to dissuade invertebrates from crawling over the barriers. As a further deterrent, a very sticky material Bird-off® was repeatedly applied as a continuous strip to the underneath edges of the capping.

Two chemicals were each applied on two occasions in 250 L ha^{-1} of water to eliminate the predators. Methomyl and methidathion were applied at the rates of 450 g ha^{-1} and 800 g ha^{-1} respectively. This continued for several weeks, followed by the reintroduction of pasture invertebrates. Omethoate was applied as necessary in the chemical control treatment.

To ensure that pests were present in adequate numbers, they were collected and added to each unsprayed plot in equal numbers at the commencement of each season of the Addition trial and for the second season in the Elimination trials. In each year of the Addition trial, redlegged earth mite and lucerne flea were added at the rates of 7500 m^{-2} and 5000 m^{-2}. For the *N. capillatus* Elimination trial, lucerne flea was added at 2000 m^{-2} and the predator was added to the biological control treatment at the rate of 10 m^{-2}. In the *A. wallacei* Elimination trial, the redlegged earth mite was added at 3200 m^{-2} and the predator was added at 8 m^{-2}. Predators were added to the Addition trial to maintain numbers at around 100 m^{-2}.

A cylinder mower was taken over the barriers in the Elimination trials, using a ramp system. Plots were mown approximately weekly to encourage the growth of legumes and to measure the pasture growth in the second year. Mowings were weighed and adjusted for the moisture content after samples had been dried.

In the Elimination trials, a calibrated visual rating system was used to estimate the amount of pasture remaining under the mower. Fifteen pasture cores totalling 0.11 m^2 were also taken from each plot to estimate plant composition by number and weight. Vegetative yields and composition were estimated in the small trial by harvesting 0.75 m^2 before senescence. Legume seeds were extracted from the cores and another set was taken in summer to give the weight of seed set in one season.

Suction sampling was used to estimate numbers of invertebrates in the plots. The area sampled was 0.3 m^2 and 0.2 m^2 in the large and small trials respectively.

Invertebrate rearing

Small-scale rearing was undertaken to provide prey for the feeding tests. Boxes 0.1 m^2 in area were used for rearing invertebrates. Plants were grown in these for rearing pests while springtails and *A. wallacei* were reared without lights on moistened plaster and organic material.

Table 1. Mean pest numbers in the 'Addition' trial in spring 1992.

Treatment	Transformed *H. destructor*	*H. destructor* m^{-2}	Transformed *S. viridis*	*S. viridis* m^{-2}
Chemical	2.03	107	-0.30	0
Untreated	4.55	35 074	3.95	8871
Biological	4.08	12 077	2.87	744
s.e.d.	0.11		0.095	

Table 2. Mean numbers of lucerne flea in the 'Addition' trial in spring 1993.

Treatment	Transformed *S. viridis*	*S. viridis* m^{-2}
Chemical	3.63	5
Untreated	4.70	45 818
Biological	4.24	13 279
s.e.d.	0.09	

Table 3. Mean yields of legume herbage and seed in the 'Addition' trial in 1993.

Treatment	Herbage kg ha^{-1}	Seed transformed	Seed kg ha^{-1}
Chemical	6695	30.88	906
Untreated	1528	15.01	177
Biological	3360	22.53	460
s.e.d.	460	1.87	

Chemical trials against predators

Treatments were applied once to unreplicated blocks 25 × 25 m in the first year and to 8 × 8 m plots in a complete block design with four replications in the second year. A hand boom was used to deliver approximately 200 L ha^{-1}. The chemicals and rates used per hectare in the first year were pirimicarb 75 g, phosmet 53 g, alphamethrin 5 g, dimethoate 90 g and omethoate 29 g and in the second year were phosmet 53 g, dimethoate 34 g and omethoate 29 g. Invertebrates were suction sampled for population estimates at intervals after the chemicals were applied.

Monitoring of predator establishment and spread

Release sites were visited each year and suction sampled. Few releases were made except at Waddi Forest where much of this work was done. Information from other States was provided by Mr. John Heap, Department of Primary Industries, South Australia, Mr. Bill Gardner, a consultant at Horsham, Victoria, Mr. Graham Thwaite, New South Wales Agriculture, and Dr. John Ireson, Department of Primary Industries, Tasmania.

Results and discussion

Predator feeding trials

Lucerne flea was more readily killed by *N. capillatus* than *Entomobrya* spp. which were suitable alternative prey. Kill rates recorded on lucerne flea ranged from 1.0–3.5 per day depending on the relative size of predator and prey and whether alternative food was available. The rate was not diminished significantly on a second day of feeding.

More redlegged earth mite were killed by *A. wallacei* than other prey although lucerne flea was readily taken and *Entomobrya* spp. were also killed. The feeding rate on redlegged earth mite varied from 1.3–7.4 per day. Sizes of predators and prey were again important in determining the numbers killed, with the combination of small predators and small redlegged earth mite giving the highest kill rate.

The box trials with *A. wallacei* demonstrated that the kill rate for redlegged earth mite was sustained in a realistic situation. One trial represented a field situation where in five days, 12 000 mites per square meter declined naturally to 11 142. With 100 or 400 *A. wallacei* per square meter, the pest declined substantially to 8930 and 6708 respectively. At this rate, 100 *A. wallacei* per square meter would kill 16 000 redlegged earth mite in one pest generation.

Field trials testing predator effectiveness

The barriers were very successful in the small trial as no predators were found in other plots. The repellent in oil appeared to prevent the invertebrates from walking past onto the sticky material. Predators were found in the 'untreated' plots of the large trials, but it is probable that they were not eliminated by the sprays. Soil shrinkage and consequent cracking at the end of the season could have allowed some movement of invertebrates between the plots especially in the large trials in which adjacent plots had a common barrier.

'Addition' trials. Redlegged earth mite and lucerne flea numbers in the biological control treatment were approximately one third and one tenth of the untreated in the spring of the first year ($P<0.001$) (Table 1).

Lucerne flea was the dominant pest in the next year and probably prevented the spring peak of redlegged earth mite. Its numbers in the biological control treatment in spring were approximately 0.3 of the untreated ($P<0.001$) (Table 2).

The losses to pests in legume herbage and seed yields were approximately 80%. Biological control increased legume herbage and seed yields by factors of 2.2 and 2.6 over the untreated ($P<0.001$) (Table 3). There are obviously large potential benefits from the predators in such situations.

'Elimination' trials. Multiple sprays in the first year of the trials using high rates of chemicals and water greatly reduced predator numbers but did not eliminate them. Predators were therefore able to breed in the 'untreated' plots in the second year and numbers increased, especially in the *N. capillatus* trial and pest numbers were reduced. Predators did not affect pasture yield, composition or quality. The necessity to spray the 'untreated' for most of the first year gave that treatment an advantage and pest numbers were low, due to the mowing.

In the *A. wallacei* trial, there was an 84% reduction in the numbers of redlegged earth mite in spring. The large reductions in pest numbers in these two trials could be expected in situations with low pest numbers. The increase in lucerne flea numbers could be the result of reduced competition from redlegged earth mite as has been suggested previously (Michael *et al.* 1991b). It did not result from differences in the numbers of *Bdellodes lapidaria* Kramer as these were low and there were no differences between treatments. The lack of any pasture differences is explained by the low pest numbers. There was a 57% reduction in lucerne flea numbers in spring in the *N. capillatus* 'Elimination' trial despite predators being present in the 'untreated' and being in low numbers in the biological treatment. The chemical control plots were visually better pasture with a mat of healthy medic plants under the mower. Higher digestibility and nitrogen content of the chemical treatment reflected the change in composition.

Invertebrate rearing

Rearing of *A. wallacei* was shown to be feasible, without the necessity of growing plants for phytophagous pests, as rearing boxes contained up to the equivalent of 5000 m^{-2}. Several species of Collembola were reared on damp organic material. Modest shipments of the predator, free of pest species, could therefore be made, but it would still be labour intensive to produce the large numbers required for field release programs and which could be collected from established colonies.

Attempts to rear *N. capillatus* on alternative prey suggested that Sminthuridae would be required for rearing strong colonies. Species other than lucerne flea may not require living plants but these were not investigated.

Observations on *A. wallacei* showed that the life cycle is long, so that rapid responses to prey numbers could not be expected. The egg stage was, however, found to be versatile and capable of hatching immediately or after brief or prolonged dry periods. This predator has sometimes been found in the field well before pest species have hatched, as well as after the pests have died at the end of season.

Chemical tolerance trials

Omethoate and dimethoate reduced numbers of *A. wallacei* two days after spraying but neither predator was affected at seven days and a large proportion survived. There was evidence that many *A. wallacei* may not have been killed but moved into the adjacent phosmet and unsprayed plots where numbers increased by factors of 1.3 and 1.5 respectively.

A composite index of survival indicated that predators had a greater survival when compared to the pest species or springtails. When all invertebrate species are considered, omethoate was the most toxic of the chemicals at the rates tested.

Monitoring of predator establishment and spread

There are now many strong colonies in Western Australia where the predators may be collected. It will be several years before *A. wallacei* will be available in other States and the number of colonies is likely to be lower. The property owners at Waddi Forest have shown that effort and care is likely to result in strong colonies.

Industry implications and recommendations

These results confirm and expand the knowledge on predator effectiveness in reducing pest numbers. They also provide evidence that control of the pests by predation can increase legume herbage and seed yields. No doubt this would lead to increased animal production and further yield increases of pasture and crops as the increased nitrogen became available.

The trials reported here confirm that chemical control may provide large legume yield increases. Farmers are reluctant to resort to the application of toxic chemicals on a regular basis, and are often unsure of the need to control these pests, or are preoccupied with other important tasks at critical times. Biological control therefore has particular value.

Because of the complexity of factors affecting pasture and animal production, it is not possible to put precise values on the effect of predators. It may be assumed that 0.8 extra sheep per hectare may be carried through the control of these pests (Wallace and Mahon 1963). The trials in this project suggest that predators may provide up to 80% control of the pests. This could lead to reductions in losses of up to 30% depending on the situation.

For the future, the value of the predators should be publicised and demonstrated for farmers on release paddocks through pest counts and pasture measurements. Establishment of the predators is quite feasible, as has been shown, and larger distribution programs are warranted using self-propelled machines to accelerate the collection of these predators. Supply of predators to interested farmers through commercial operators would be ideal. Predator paddocks may have to be leased and managed to maximize production.

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