The role of natural enemies in regulating populations of biocontrol agents on gorse (Ulex europaeus L.)

Jamie T. Davies1, John E. Ireson1 and Geoff R. Allen2

1Tasmanian Institute of Agricultural Research, 13 St. Johns Avenue, New Town, Tasmania 7008, Australia
2School of Agricultural Science, University of Tasmania, GPO Box 252-54, Hobart, Tasmania 7001, Australia

Summary Natural enemies can regulate populations of phytophagous arthropods. In weed biological control programs, natural enemies may either prevent agents from establishing or reduce their impact on the target weed. A study of the development time for Phytoseiulus persimilis at two temperatures on gorse spider mite (Tetranychus lintearius) and the pest mite T. urticae indicates P. persimilis will develop as fast, or faster, on the gorse spider mite as it does on pest mites. This suggests that P. persimilis is likely to have a negative impact on gorse spider mite populations. In addition, a survey of the arthropod fauna on gorse identified a range of potential natural enemies, consisting mainly of generalist predators, which could reduce the impact of the gorse thrips and provide an explanation for its slow dispersal rate.

Keywords Biological control, gorse, natural enemies, Sericothrips staphylinus, Tetranychus lintearius, Ulex europaeus, Phytoseiulus persimilis.

INTRODUCTION
Host specific phytophagous arthropods are often introduced as biological control agents for invasive weeds. Natural enemies often play a key role in regulating populations of phytophagous arthropods and are extensively utilised for the biological control of agricultural and horticultural pests. However, in weed biological control, natural enemies may reduce the population size and therefore the effectiveness of weed biocontrol agents (Goeden and Louda 1976, McFayden and Spafford-Jacob 2004).

Gorse, Ulex europaeus L. (Fabaceae), is a leguminous European woody shrub that has become invasive in many temperate regions of the world. In Australia, gorse is a Weed of National Significance (Thorp 1999) seriously affecting agricultural and environmentally significant regions in south eastern Australia. As part of an integrated management strategy, a guild of host specific biological control agents is currently being introduced to gorse in Australia (Ireson et al. 2004).

The gorse thrips, Sericothrips staphylinus Haliday (Thysanoptera: Thripidae) was introduced to Australia from New Zealand and released in 2001 (Ireson et al. 2004). In a glasshouse environment this species reduced the growth of gorse seedlings and also reduced seedling survival when combined with other management practices (Davies unpublished data). Although populations of S. staphylinus developed rapidly in the protected environment of a glasshouse, populations have been very slow to increase to high densities in the field and disperse (Ireson et al. 2004). One possible explanation is that an ecological factor, such as natural enemy attack, is responsible.

This paper provides a summary of two studies that investigated potential natural enemies of T. lintearius and S. staphylinus. In the P. persimilis development study we compared the development of two strains of...
Phytoseiulus persimilis on diets of a pest and a beneficial Tetranychus spp. (T. urticae and T. lintearius respectively). The natural enemy survey identified potential natural enemies of S. staphylinus on the fauna inhabiting gorse.

MATERIALS AND METHODS

Phytoseiulus persimilis development study Two strains of Phytoseiulus persimilis were reared from egg to adult on two diets in a randomised factorial design. The experiment was conducted in two separate controlled environment cabinets, which maintained the chosen temperatures (14 ± 0.7°C and 24 ± 0.7°C) and a daily photoperiod of 16 hours.

Rearing was conducted in perspex arenas similar to Perring and Lackey (1989). Individual Phytoseiulus persimilis eggs, less than two hours of age, were placed into each arena. Arenas were housed within 35 × 27 × 19 cm translucent plastic boxes containing 2 litres of saturated NaCl solution, which maintained relative humidity between 75 and 76% at both temperatures (Winston and Bates 1960).

The two strains of Phytoseiulus persimilis differed in their source location and original host Tetranychus species. The ‘Tas’ strain was sourced from a field site at Stonehenge, Tasmania (42°24’S, 147°37’E) from within T. lintearius colonies on gorse. This strain appears to have naturalised and had been observed feeding on T. lintearius for more than 18 months (Ireson et al. 2003). The ‘NSW’ strain was supplied by the ‘Beneficial Bugs Co.’ (www.beneficialbugs.com.au) and reared on T. urticae colonies on bean (Phaseolus vulgaris) at Richmond, NSW. Eggs of Phytoseiulus persimilis were collected using the method detailed in Perring and Lackey (1989). At each temperature 40 Phytoseiulus persimilis eggs of each strain were used.

Diets consisted of eggs of either T. lintearius or T. urticae, which were reared and extracted from either gorse or bean respectively using a method detailed in Ireson et al. (1999). Half of each Phytoseiulus persimilis strain (20) were allocated to each diet.

Development times from egg through to adult were determined by counting the number of cast skins in each arena at each observation every 12 hours. Mites that died during or just after a moult were considered to have achieved the more advanced life stage.

Statistical tests were performed using GENSTAT 6th edition. Data on the development time of Phytoseiulus persimilis were independently subjected to ANOVA for each temperature and LSD’s were calculated to separate treatment means.

Natural enemy survey Gorse plant material, from a field site near Lymington, Tasmania (43°11’S, 147°01’E), was destructively sampled at an interval of 2–4 weeks for 12 months between December 2002 and December 2003. To ensure that a range of microhabitats were sampled (including flowers/fruit, new foliage and older growth) lower, mid and upper plant parts were collected from each of six plants on each sampling date.

Plant material was then subjected to Tullgren funnel extraction for three days to remove arthropods, which were collected into 120 mL plastic tubes containing 30 mL of 70% alcohol and a drop of glycerol.

Samples of mites (Acari) and thrips (Thysanoptera) were cleared in Konos solution and slide mounted in Berlese medium. All other arthropods were identified from alcohol preserved specimens. All arthropods, except for microhymenoptera (several families in the hymenopteran suborder Apocrita), were identified to family. Insects were identified using the relevant keys in Naumann (1991) and mites (Acari) using keys in Krantz (1978). Those families (and microhymenoptera) that included other arthropods in their diet (Naumann 1991, Krantz 1978) were classified according to their feeding habits: generalist predators – feed across a range of arthropod genera; specialist predators – feed on arthropods within a genus; parasitoids – feed and develop within an arthropod host resulting in its death; omnivores – feed on both arthropods and plant material.

RESULTS AND DISCUSSION

Phytoseiulus persimilis development study There was a significant difference in the development rate between the two strains at 14°C (P <0.05). However, separation of means showed that a significant difference between the strains occurred only on a diet of T. urticae (Table 1). On this diet the ‘Tas’ strain completed its development approximately half a day earlier than the ‘NSW’ strain. Diet had no effect on the development rate at this temperature. In contrast, the development rate at 24°C was significantly affected by diet (P <0.05, Table 1) and not by strain. At this temperature, both strains completed their development half a day earlier on a diet of T. lintearius.

One of the reasons that particular specialist natural enemies such as Phytoseiulus persimilis, other phytoseiid mites and certain parasitic Hymenoptera are successful biological control agents of agricultural pests is because they develop at a rapid rate relative to their prey (Dixon et al. 1997). Tetranychus lintearius completes its pre-adult development in 38.2 days at 15°C and 15.3 days at 25°C (Stone 1986). However, we have shown that Phytoseiulus persimilis completes its development in less than half this time at slightly lower temperatures.
Fourteenth Australian Weeds Conference

Pels and Sabelis (1999) found predation of *T. urticae* by *P. persimilis* resulted in localised extinction, but in a natural environment prey dispersal and asynchrony in predator and prey populations will result in a patchy equilibrium, with alternating prey overpopulation and localised extinction occurring. As *P. persimilis* will develop on a diet of *T. lintearius* at a similar or more rapid rate than it would on a diet of the pest *T. urticae*, we predict similar predator-prey dynamics to occur. Therefore, we expect that *P. persimilis* is having a negative impact on *T. lintearius* populations, resulting in a reduction of the efficacy of this weed biological control agent.

**Natural enemy survey**  A number of potential natural enemies were collected from gorse during the course of this study (Table 2). Of these, members of the following families are reported as predators of members of the family Thripidae, of which the biocontrol agent *S. staphylinus* is a member: Phlaeothripidae, Thripidae, Phytoseiidae, Cheyletidae, Anystidae and Erythraeidae (Sabelis and Van Rijn 1997). In addition, hymenopteran egg and larval parasitoids also attack members of the family Thripidae. Those reported are all members of the superfamily Chalcidoidea (Loomans et al. 1997), many species of which are microhymenopterans.

The interaction between plants, phytophagous arthropods and generalist predators or omnivores is highly complex and therefore difficult to predict. However, these interactions could affect the population dynamics of phytophagous arthropods used as weed biological control agents. Both individual species and groups of generalist predators have been shown to reduce both arthropod numbers and plant damage (Symondson et al. 2002). Similarly, omnivores that include arthropods as part of their diet can contribute to the stability of phytophagous arthropod populations (Coll and Guershon 2002). In fact, there is evidence to suggest that local generalist predators can result in the extinction of certain introduced weed biological control agents in the country of release (Ireson et al. 2002).

Populations of *S. staphylinus* have established in Tasmania, however, they have been slow to spread and have been found only within a few metres of the central release point up to three years after release (Ireson et al. 2004). Perhaps the range of potential natural enemies identified during this study are having an impact on the efficacy of this agent and could explain the slow spread if they are attacking newly established *S. staphylinus* colonies. A natural enemy exclusion experiment is needed to test this hypothesis.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Strain</th>
<th>Diet</th>
<th>T. urticae</th>
<th>T. lintearius</th>
</tr>
</thead>
<tbody>
<tr>
<td>14°C</td>
<td>NSW</td>
<td></td>
<td>18.0 ± 1.2 a’ (13)</td>
<td>18.0 ± 1.3 a (10)</td>
</tr>
<tr>
<td></td>
<td>Tas</td>
<td></td>
<td>17.4 ± 1.0 b (16)</td>
<td>17.7 ± 1.1 ab (15)</td>
</tr>
<tr>
<td>24°C</td>
<td>NSW</td>
<td></td>
<td>6.0 ± 0.6 a (18)</td>
<td>5.6 ± 0.6 b (15)</td>
</tr>
<tr>
<td></td>
<td>Tas</td>
<td></td>
<td>6.1 ± 0.6 a (18)</td>
<td>5.6 ± 0.6 b (17)</td>
</tr>
</tbody>
</table>

1 Means with the same letters for each temperature are not significantly different (P <0.05; LSD).

<table>
<thead>
<tr>
<th>Arthropods</th>
<th>Natural enemy classification¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GP</td>
</tr>
<tr>
<td>Insects: Phlaeothripidae</td>
<td>X</td>
</tr>
<tr>
<td>Thripidae</td>
<td></td>
</tr>
<tr>
<td>Microhymenoptera</td>
<td></td>
</tr>
<tr>
<td>Mites: Tydeidae</td>
<td></td>
</tr>
<tr>
<td>Phytoseiidae</td>
<td>X</td>
</tr>
<tr>
<td>Cheyletidae</td>
<td></td>
</tr>
<tr>
<td>Anystidae</td>
<td>X</td>
</tr>
<tr>
<td>Erythraeidae</td>
<td>X</td>
</tr>
<tr>
<td>Ascidae</td>
<td>X</td>
</tr>
<tr>
<td>Bdellidae</td>
<td></td>
</tr>
<tr>
<td>Cunaxidae</td>
<td></td>
</tr>
</tbody>
</table>

¹ GP = generalist predator; SP = specialist predator; Om = omnivore; Par = parasitoid.

---

Table 1. Mean ± SE egg to adult development time (days) for ‘NSW’ and ‘Tas’ strains of *P. persimilis* reared on diets of *T. urticae* (two-spotted mite) and *T. lintearius* (gorse spider mite) at 14°C and 24°C. The numbers in parentheses represent the number of individuals comprising the mean.

ACKNOWLEDGMENTS

We thank Richard Holloway (Tasmanian Institute of Agricultural Research) for technical support, Andy Ryland (Beneficial Bugs Co.) for providing the NSW strain of Phytoseiulus persimilis and Lynne and David Dowe for providing access to the study site for the natural enemy survey. Funding assistance was provided by the CRC for Australian Weed Management.

REFERENCES


