OVERWINTERING BEHAVIOUR OF STRAINS OF GORSE SPIDER MITE IN NEW ZEALAND

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ABSTRACT

Overwintering behaviour of the gorse spider mite (*Tetranychus lintearius*) was determined both by population simulation and by following the development of cohorts of two strains of mites released in the field. The model predicted completion of one generation in Lincoln between late March and late August, which was confirmed by the field data. It predicted two generations to occur in Auckland during the same time, but low recoveries of mites from the field could not confirm this. Differences in overwintering phenology were also found between strains and are discussed with respect to the establishment of the mite in New Zealand.

Keywords: gorse spider mite, biological control, modelling, strains, overwintering.

INTRODUCTION

The gorse spider mite, *Tetranychus lintearius* Dufour (Acari:Tetranychidae) was the first of several agents imported recently into New Zealand for the biological control of gorse (Hill *et al.* 1991). Strains of gorse spider mite originating from the U.K. and from coastal Spain and Portugal were introduced into New Zealand between 1989 and 1991 (Hill *et al.* 1993). A population model of the U.K. strain of the mite (Hayes *et al.* 1996) was constructed retrospectively as a tool for understanding the establishment and population dynamics of this introduced biological control agent. The model is a stage-structured simulation model incorporating temperature-dependent development and survival of eggs, nymphs, pre-oviposition females and ovipositing females. It includes functions for temperature-dependent oviposition and operates on a time step of one hour. Laboratory studies into temperature-dependent oviposition have revealed that a strain from Cambados in Spain produced a greater number of eggs than the U.K. strain at constant low temperatures (Hayes *et al.* 1999) and in fluctuating temperatures with overnight lows around 7°C (Miller 1993). Hence overwintering dynamics could result in differential establishment success between strains. In this study, the overwintering behaviour of gorse spider mite populations was investigated both by simulation and by following the development of cohorts of mites released in the field. We wanted to find out if the overwintering behaviour of the strains differed, and to compare overwintering phenology of gorse spider mite in a cold winter (Lincoln) and warmer winter (Auckland).

METHODS

Field study

Populations of two strains of gorse spider mite (Cambados and U.K.) were obtained in March 1997 from separate sites on the outskirts of Dunedin where they were released in 1993. The sites were approximately 5 km apart, and no known mixing of strains had occurred. The Cambados strain was selected to compare with the U.K. strain as it was the one that behaved most differently from the U.K. strain in the laboratory (Hayes *et al.* 1999) and that performed best in the field (Hill *et al.* 1993). For each strain and for each location, a total of 20 terminal shoots of gorse approximately

10 cm long were cut from gorse bushes (ie. 80 shoots in total) and the stems placed in orchid tubes filled with water. Forty adult female mites (of mixed ages) were transferred onto each gorse shoot using a fine paintbrush, and kept at 20°C for 3 days prior to release. During this time, densely webbed colonies were formed on each shoot, consisting of approximately 35 adult females and between 20 and 40 eggs.

The 'cold'-winter release site was a lightly grazed paddock containing gorse at Burnham near Lincoln, Canterbury. Colonies were released there on 20/3/97. The 'warm'-winter release site was an area of gorse at Hays Creek Dam, a water catchment area in the Hunua Ranges, south of Auckland. These colonies were released on 27/3/97. Twenty colonies of each strain were released at each site by enclosing the release shoot and tube with three stems of one of the gorse bushes and tying the stems together tightly with cotton. The position of each colony was marked with plant tags.

Initially at 2-week and then at approximately 3-week intervals, between April and August, two or three randomly assigned colonies of mites were collected from the release sites and the number of mites of each stage determined by microscopic examination. The numbers of eggs, nymphs and adults in the colonies were expressed as a percentage of the total mites in the sample, and in this way the change in population structure of the colonies through autumn and winter was revealed. There was little evidence of predation in the colonies and it was assumed not to affect population structure.

Model simulations

The phenology of the mites was simulated with the population model using as inputs 35 adult females and 35 eggs and running the model for 150 days. For the Lincoln simulation, the temperature inputs were hourly measurements of gorse foliage temperature from a Campbell CR10 data logger, and for Auckland, local Meteorological Station temperatures were adjusted with a regression equation used to predict gorse plant temperature from air temperature (Hayes *et al.* 1996). Output from the model was the number of mites of each stage at the end of each day, and the average oviposition rate per female per day.

RESULTS

The numbers of both strains of mites recovered from the Auckland site, increased initially (up to 360 mites), but after early May, fewer than 30 mites were recovered at each sample date. In Lincoln, colonies containing more than 200 and up to 750 mites were recovered throughout the winter. Rainfall is known to be a cause of mortality, but is unlikely to be the cause of the decline in this case, as there was an extended dry period in Auckland following release. Predatory mites (mainly *Typhlodromus* species) were found on the gorse occasionally in Auckland, and more frequently in Lincoln, but in very low numbers and with little evidence of feeding on gorse spider mites. Since the disappearance of the mites in Auckland coincides with the emergence of the next generation of adults, it seems likely that dispersal from the release bushes is the reason for the low number of recoveries.

The field data are not suitable for making quantitative comparisons, but the model (based on temperature alone) predicts much greater potential population growth in Auckland than Lincoln. The population is predicted to increase in Auckland 250-fold during the autumn and winter compared to only 3-fold in Lincoln.

The model for the U.K. strain predicted that two generations of gorse spider mite would be completed in Auckland between March and August, but that only one generation would be completed in Lincoln during the same time. Essentially, the field results (Fig. 1) for both strains confirmed this for Lincoln, but in Auckland recoveries of mites beyond one month after release were too low to reliably determine phenology (Fig. 2). However, there was good agreement between simulated and field phenology for the first month after release.

As predicted by the model, field results showed that, in Lincoln, nymphal development continued over autumn and winter with adult mites maturing throughout winter (Fig 1c). In Auckland, the model predicted oviposition to continue throughout the winter months. In Lincoln, the model predicted that oviposition would be virtually

FIGURE 1: Simulated change in population structure of colonies of gorse spider mite released in Lincoln on 20/3/97 compared to colonies of the U.K. strain and Cambados strains.

FIGURE 2: Simulated change in population structure of colonies of gorse spider mite released in Auckland on 27/3/97 compared to colonies of the U.K. and Cambados strains. Field data for the first 4 samples only shown as the total number of mites recovered for later samples was very low.

zero during June and July because of low temperatures, but then increase again in August as temperatures warmed up in late winter. This lack of oviposition and the slow development of the immatures over autumn and winter serves to synchronise the population in Lincoln, so that it consists mainly of adults and young eggs by late winter (Fig. 1). In contrast, the Auckland populations are predicted contain all stages, but mostly eggs and nymphs by late winter (Fig. 2).

The field data revealed differences in the overwintering phenology of Cambados and U.K. strains in Lincoln, with the decrease in the proportion of eggs in April occurring about 2 weeks ahead of the U.K. strain (Fig. 1a). By changing parameters in the population model, which was developed for the U.K. strain of mites, we attempted to explain differences in phenology of the Cambados population. The earlier decline in the proportion of eggs may be explained by the Cambados strain having faster egg development than the U.K. strain, or by the adult females in the introduced cohorts by chance being older and hence laying eggs for a shorter time. These differences have yet to be investigated in the laboratory. Another more notable difference was that the big increase in the proportion of eggs in late winter also occurred about three weeks earlier in the Cambados population than in the U.K. population (Fig. 1a). This could not be explained in the population model simply by plugging in the oviposition function (Hayes *et al.* 1999) for Cambados, but increasing the survival of eggs of the Cambados strain at low temperatures did bring about the earlier increase.

DISCUSSION

The model has accurately simulated the overwintering phenology of the gorse spider mite in 'cold' and 'warm' winters. The very low population growth predicted in a cold winter suggests overwintering could be critical in the establishment process. The results presented here and earlier trials (Hayes *et al.* 1999; Hill *et al.* 1993) suggest that populations of the Cambados strain will show earlier numerical increase than the U.K. strain in spring, making them less susceptible to extinctions due to heavy rainfall or predation. Although not confirmed by the field experiment, the model also suggests greater population growth of the Cambados strain throughout winter in Auckland.

Four years after the release of the Cambados strain, it still appears to behave differently from the U.K. strain. Specific differences in oviposition at low temperatures have already been determined in the laboratory and it would be interesting to find out if differences between strains in egg development and survival (as suggested by the model) could also be identified.

The initial releases of the gorse spider mite were of a strain from the U.K., but repeated releases over three seasons did not result in establishment in the north of the North Island and West coast of the South Island. Since the introduction of strains from Portugal and Spain, gorse spider mite has become widely established around Northland and Auckland and it seems more likely to be due to establishment of the Cambados or a similar strain rather than the original strain from England.

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