Spread, epidemic development and impact of the bridal creeper rust in Australia: summary of results

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Summary Following extensive testing for specificity, the South African rust fungus *Puccinia myrsiphylli* was approved for release in Australia in June 2000 for the control of the environmental weed, bridal creeper. The rust completes its entire life cycle on bridal creeper, infecting leaves and stems. It obtains nutrients and water from the plant, thus limiting resources available for the production of stems, fruits and tubers. It also destroys leaf tissue by reducing the photosynthetic surface of the plant, causing severely diseased plants to shed infected leaves prematurely. Detailed monitoring carried out at three sites in southern NSW has shown that rust epidemics can be severe and destructive on bridal creeper, but that spread is slow; up to about 30 m in the first four months after release. During the two growing seasons since its release, the rust has been established in collaboration with State and local government agencies and community groups, at more than 250 sites across southern Australia. A glasshouse experiment showed that the size of root tubers, the number of tubers and the length of the rhizome on plants infected with the rust for a period of only 20 weeks were reduced by 31%, 62%, and 61%, respectively. Commensurate with these reductions in root growth, the shoot biomass of infected plants was reduced by 61%.

Keywords Biological control, rust fungi, *Asparagus asparagoides*, epidemiology, *Puccinia myrsiphylli*.

INTRODUCTION

Bridal creeper, *Asparagus asparagoides* (L.) Druce, invades native vegetation and establishes in relatively undisturbed vegetation by seed dispersed by birds (Scott and Kleinjan 1991, Raymond 1999, Stansbury 2001). The plant establishes a rhizome and tubers which results in most of the biomass being underground. The underground reserves enable the plant to survive over summer (in winter rainfall regions) and to compete against other vegetation. The climbing habit enables establishment in dense vegetation. Bridal creeper is also found in citrus orchards across southern Australia, where chemical control is difficult. Control by intensive methods such as herbicides or mechanical methods have proved uneconomical or inappropriate for most areas.

Surveys for biological control agents in South Africa, the centre of origin of *A. asparagoides*, identified the rust fungus *Puccinia myrsiphylli* (Thuem.) Wint. as a potential biological control agent for bridal creeper in Australia (Doidge 1926, Scott and Kleinjan 1991). In 1998, the rust was imported into a high security quarantine facility in Canberra to select a suitable isolate for biological control, to study its biology and to demonstrate its specificity towards the target weed.

Puccinia myrsiphylli requires at least eight hours of leaf wetness to infect bridal creeper (Morin unpublished). Infection is optimal between 16 and 20°C, but completely inhibited at 25°C. In host-specificity tests designed to demonstrate the safety of *P. myrsiphylli*, bridal creeper was the only species that was susceptible to the rust and on which uredinia developed successfully. All other species tested were either immune or highly resistant to the rust. Although the rust successfully penetrated the stomata of some of the test plant species, no infection hyphae, haustorium mother cells or haustoria ever developed, and hence macroscopic symptoms were absent. Based on these results, *P. myrsiphylli* was approved for release in Australia in June 2000.

This paper presents a summary of data on the spread and epidemic development of the rust since its release at three field sites in south-east NSW. It also provides a summary of results from a glasshouse experiment that was established to measure the impact of the rust on the growth and development of bridal creeper roots and shoots. Full data will be reported elsewhere.

MATERIALS AND METHODS

Spread and epidemics – field monitoring Detailed monitoring of the spread and epidemic development of the rust was carried out from July 2000 to November 2001 at three sites in south-east NSW; Scheyville National Park near Windsor (33°58'S 150°90'E), Eurobodella National Park near Moruya (35°98'S 150°15'E), and Bar Beach near Narooma (36°20'S

150°13'E). At each site the rust was released in a central 50 cm^2 quadrat. The sites were visited at regular intervals during the growing season to monitor the level of rust infection in the central release quadrat and in a series of permanent study quadrats scattered throughout the sites.

At each visit, 40 leaves, sampled along a 'W'-shaped transect within each study quadrat, were assessed for rust incidence. The severity of symptoms on the first 10 infected leaves sampled was also assessed using a pictorial key that had been designed and standardised against infected leaves. A disease index was then calculated for each quadrat by multiplying disease incidence with mean disease severity data.

Impact – glasshouse experiment A glasshouse experiment was conducted to determine the impact of the rust on various indices of bridal creeper's root growth. Individual plants, each with the same number of tubers, were inoculated with the rust every second week for a period of 20 weeks to simulate a situation that likely occurs in the field. Half of the control and treated plants were harvested after that period to compare growth indices (number and size of tubers, length of rhizome and dry weight of shoots). The shoots of remaining control and treated plants were then cut to soil level to simulate senescence and the plants left to re-grow for another 20 weeks. This re-growth occurred without any inoculation with rust, to enable investigation of the impact of rust on the ability of previously infected plants to re-grow. After this re-growth phase of the experiment, the remaining plants were harvested and assessed as in the first harvest.

RESULTS

Spread and epidemics and epidemics – field monitoring In the months following release, the rust established and spread at each of the three study sites in southern NSW until bridal creeper began its annual senescence in late November 2000. The rust successfully survived the 2000/2001 summer and naturally reappeared on a few scattered pockets of new shoots at Bar Beach in April 2001 and at the Eurobodalla and Scheyville sites in late May 2001.

In the following, we present a detailed summary of results from the Bar Beach site. As noted above, full results of all study sites will be presented elsewhere.

At Bar Beach, the rust had spread to all adjacent quadrats and up to 18 m downwind of the central release quadrat by late September 2000, 76 days after release (Figure 1). By the end of the bridal creeper growing season (November 2000, 139 days after the rust's release at the site) the rust had spread an additional 12 m. In total, the rust had spread about 30 m from the point of release over the four months of the 2000 season. In the 2001 growing season, the rust recolonised bridal creeper in all but one of the 53 permanent study quadrats at Bar Beach. It was also found at least 200 m from the site on plants growing near an adjacent road.

As well as spreading, the intensity of the rust within infected quadrats increased steadily during each of the two growing seasons after the release was made (Figure 2). In the period from July to November 2000, the incidence and severity of the rust in the central release quadrat increased steadily, ultimately killing bridal creeper shoots before the end of the season (Figure 2a). In contrast, rust epidemics did not reach such a high level in the surrounding quadrats.

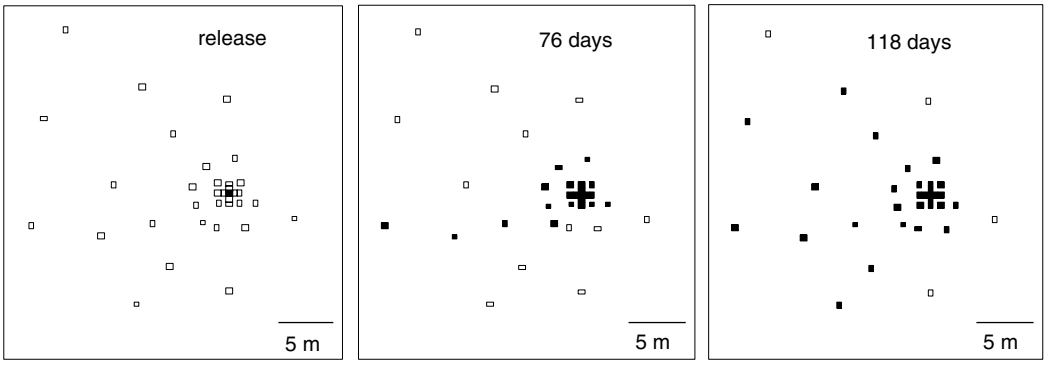

Figure 1. Spread of *Puccinia myrsiphylli* on the bridal creeper infestation at Bar Beach near Narooma, at 76 and 118 days after it was released in the central quadrat on 12 July 2000. Solid squares indicate quadrats where the rust has been recorded. Only the core of the site, which comprises 34 of the 53 permanent study quadrat is presented here.

Rust epidemics in the core study quadrats reached higher levels of severity in the following growing season in 2001 (Figure 2b). By the end of this second season, bridal creeper shoots in the central quadrat, and adjacent quadrats up to 1.5 m away, had been killed by the rust. The rust epidemic was also severe in quadrats located 2–3.5 m from the central release quadrat.

Impact – glasshouse experiment The number of tubers, rhizome length and shoot mass were reduced by about 60% in the infected plants, in comparison to the control plants, at the time of the first harvest (Figure 3). Reductions in each index of bridal creeper growth were even more dramatic at the second harvest (Figure 4). In part, this was because most infected plants did not re-grow during the second phase of the experiment. Consequently, differences between the treated plants and the controls, which generally re-grew vigorously, were marked.

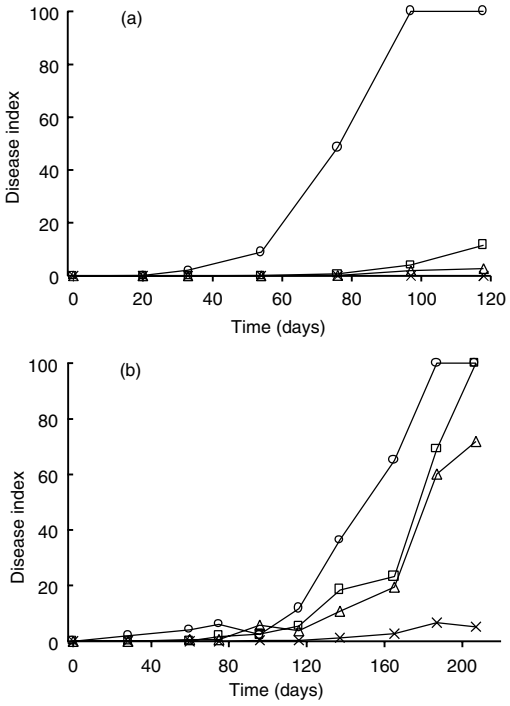

Figure 2. Epidemic development of *Puccinia myrsiphylli* at Bar Beach near Narooma during the 2000 (a) and 2001 (b) bridal creeper growing seasons, where the first readings (time 0 day) correspond to 12 July and 29 March, respectively. ○ = central quadrat, □ = mean data for quadrats located 1–1.5 m from central quadrat, Δ = mean data for quadrats located 2–3.5 m from central quadrat, × = mean data for quadrats located 8–9.5 m from central quadrat.

DISCUSSION

Knowledge of the colonisation process and epidemic development of a newly introduced pathogen for weed control is central to the development of an effective strategy for broad-scale releases of the biological control agent. The monitoring study summarised in this paper highlights the relatively slow dispersal capabilities of *P. myrsiphylli* within and between bridal creeper infestations. This contrast with rusts used in other weed biological control programs such as *Puccinia chondrillina* Bubák and Syd. on skeleton weed, which spread 320 km from the point of release in one year (Cullen *et al*. 1973). Low wind turbulence and high moisture levels characterise bridal creeper habitats during winter in southern Australia when dispersal of the rust is expected. It is probable that these climatic

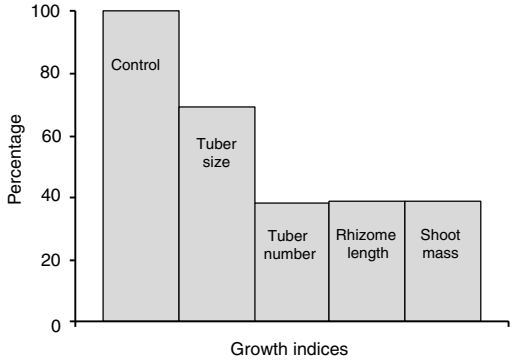

Figure 3. Growth indices, as percentages of control plants, of standardised bridal creeper plants infected with *Puccinia myrsiphylli* after 20 weeks of fortnightly inoculation with the rust.

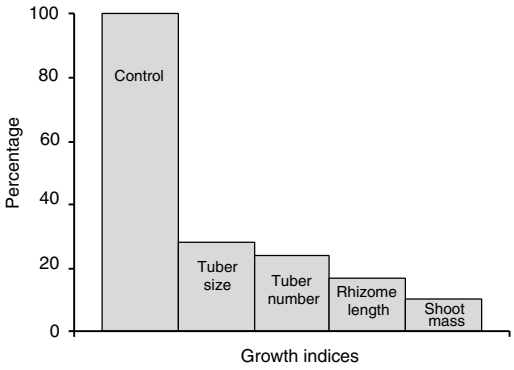

Figure 4. Growth indices, as percentages of control plants, of standardised bridal creeper plants infected with *Puccinia myrsiphylli* for 20 weeks, then cut, and left to re-grow for another 20 weeks.

conditions have prevented long-distance spread of the rust from the central foci of our experimental infections (Aylor 1990). Nevertheless, these conditions, combined with the cool winter temperatures, have been ideal for the development of severe epidemics of *P. myrsiphylli* in infected patches of bridal creeper. The build-up of resistant, oversummering inoculum has enabled the rust to survive the harsh, dry summer and to reappear naturally the following growing season.

One of the main goals of the biological control program against bridal creeper is to reduce populations below the ecological threshold at which infestations of the weed threaten native biodiversity. To achieve this goal, biological control agents for bridal creeper must exert a significant impact on the weed's root system. This is because bridal creeper's extensive system of below-ground rhizomes and tubers can comprise more than 90% of total plant biomass (Raymond 1999). The root system therefore represents a particularly efficient means of buffering plants from above–ground disturbance, including the action of natural enemies.

Puccinia myrsiphylli infects leaves and stems and can cause severe defoliation of bridal creeper plants. Like other rust fungi, it obtains nutrients and water from the plant, thus limiting resources available for the production of vegetative and reproductive organs (e.g. Paul and Ayres 1987, Morris 1997). It also destroys leaf tissue by reducing the photosynthetic surface of the plant, causing severely diseased plants to shed infected leaves prematurely. Results from the glasshouse experiment presented here confirm that *P. myrsiphylli* has the potential to drastically reduce the size and regeneration capability of bridal creeper both above, and below-ground, within a short period of 20 weeks. A similar impact of the rust on rhizomes and tubers is likely to occur in the field during the bridal creeper growing season when conditions are ideal for rust epidemics. However, when considering the existing mass and extent of rhizomes and tubers at established infestations of bridal creeper, it will probably take several years for the rust to reduce below-ground biomass to a level that ultimately decreases the number of shoots and, thereby, the weed's ability to compete with native plants for light and space, above-ground.

As has been shown for other rust-weed systems (Morris 1997), long-term monitoring of bridal creeper populations in the field is required to document the impact of the rust fully. In collaboration with researchers across the country, we have set up permanent trellises to gather data on vegetative growth and reproduction of bridal creeper populations before and after the release of biocontrol agents. This work is in progress; we currently have three years of pre-release data and one year post-release.

Puccinia myrsiphylli has established successfully in the Australian environment and has already shown that it is capable of causing severe and destructive epidemics on field infestations of bridal creeper. During the two growing seasons since its release, the rust has been established at more than 250 sites across southern Australia, in collaboration with State and local government agencies and community groups. Redistribution of the rust and of another biocontrol agent for bridal creeper, the leafhopper *Zygina* sp., by CSIRO and the Weed CRC has been enhanced with Natural Heritage Trust funding in 2002 (see Batchelor and Woodburn, and Woodburn *et al.* these Proceedings).

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