The effect of *Phragmidium violaceum* (Shultz) Winter (Uredinales) on *Rubus fruticosus* L. agg. in south-eastern Victoria

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Summary
The introduced blackberry rust fungus, *Phragmidium violaceum*, was first recorded in Australia in 1984 on *Rubus ulmifolius* hybrid at Foster, south-east Victoria. This strain was believed to be introduced illegally and although its spread across Australia was rapid, its virulence to the most widespread species of blackberry naturalized in Australia was low. Releases of a more virulent strain of rust from central France were made in Victoria in 1991 and more widespread releases followed in 1992. Monitoring the impact of *Phragmidium violaceum* on two blackberry species, *R. polyanthemus* and *R. ulmifolius* began in 1984 and 1986 respectively at two sites in south-east Victoria and has continued spasmodically since. A reduction in total biomass of 56.2% for *R. polyanthemus* and 38% for *R. ulmifolius* was observed. A common effect of the rust on both blackberry species was the significant reduction in daughter plant production, especially *R. polyanthemus* where daughter plant production was reduced by 95.8%. Since the release of the blackberry rust, winter defoliation to varying degrees occurs every year, an event which did not occur prior to the rust's release.

Introduction
Blackberry, *Rubus fruiticosus* L. aggregate (Rosaceae) is a major weed of both agricultural and non-agricultural land in south east Australia, particularly in areas with an annual rainfall of at least 760 mm (Amor and Richardson 1980). A survey of the total blackberry infestation in Victoria undertaken in 1975 estimated that 43% (285 000 ha) was inaccessible to chemical control due to terrain, forest cover and limited road access (Amor and Harris 1977). These inaccessible infestations mostly occurred in Gippsland, the north-eastern ranges and the Otway Ranges. Biological control was considered to be the only feasible method of controlling the weed in these areas.

Studies by Bruzzese (1980) of potentially damaging organisms associated with *R. fruticosus* agg. in Victoria found 42 species of arthropods and 8 pathogens. Damage by these plant parasites and pathogens was considered minor and Bruzzese concluded that blackberry was introduced from Europe without specific insect pests (Amor and Richardson 1980). In contrast, surveys conducted in Europe by the Commonwealth Institute of Biological Control recorded 144 arthropod species, 15 fungi, one bacterium and one virus on *R. fruticosus* agg. (CIBC, unpublished report).

Of the many organisms found on blackberry, the autoecious, macrocyclic rust, *Phragmidium violaceum* (Schultz) Winter, was selected for further investigation as a biological control agent for blackberry in Australia because it was showing considerable promise for controlling blackberry in Chile (Oehrens and Gonzalez 1974, 1977). Evaluation of this pathogen for virulence and specificity commenced in 1978 in a joint project by the Victorian Department of Crown Lands and Survey (now the Department of Natural Resources and Environment) and the CSIRO Division of Entomology (Bruzzese and Hasan 1986). Fifteen isolates of the rust were tested and the results showed that two isolates, F15 and BG25, were highly pathogenic to the four most widespread species of blackberry naturalized in Australia. Widespread releases of F15 were conducted in summer 1991 and 1992. Prior to the release of F15, a strain of *P. violaceum* had been introduced illegally to southern Victoria and was first discovered in 1984 (Marks *et al.* 1984). The illegally introduced rust strain, however, has been found to be less damaging to the main blackberry species than the F15 strain (Bruzzese and Lane 1996).

Phragmidium violaceum attacks the leaves of blackberry. The most susceptible leaves are the youngest, fully opened leaves at the cane tips. It can also infest buds, unripe fruit and the green parts of growing canes. In summer and early autumn, uredineospores appear as bright yellow powdery pustules on the underside of leaves. Several generations of these 'summer' spores may lead to an epiphytotic of rust and cause repeated defoliation. In late summer and through autumn, black, sticky teliospores are produced which remain attached to the lower surface of older leaves throughout winter. The 'winter' spores germinate in spring to begin a new cycle of infection.

Similar information is not available for other blackberry species; therefore this paper presents results from a study conducted in south-eastern Victoria to investigate the effects of *P. violaceum* on populations of *R. polyanthemus* Lindeb. and hybrid *R. ulmifolius* Schott.

Materials and methods
Impact assessment studies of the rust were conducted on *R. polyanthemus* at Callignee in the Strzelecki Ranges and on *R. ulmifolius* at Foster in central Gippsland. The Callignee study site is located on vacant, ungrazed land, and the Foster site is in a gully on farmland grazed with sheep.

The sites were monitored in winter at irregular intervals over a twelve year period after the peak yearly rust epidemic and after leaf senescence. At each monitoring occasion, ten 1 m^2 plots of the blackberry infestation were pegged out. Data on the number and length of canes, number of daughter plants, number of inflorescences per floricane, total dry weight of roots and root crowns and total dry weight of canes were collected from each plot.

To obtain cane dry weight, canes were mulched and dried in an oven at 70°C for 6 weeks. The dried material was then cooled for one hour prior to being weighed. Dry weight data for roots and root crowns were obtained by removing all roots and root crowns from each plot to a depth of 50 cm. Soil was washed from the material before it was dried and weighed in the same manner as for the canes.

Results
Callignee
At Callignee, the overall mean biomass of canes, roots and crowns per m^2 of *R. polyanthemus* was reduced by 56.2% over a 12 year period of infection with rust (Figure 1). The first rust epidemic on *R. polyanthemus* at Callignee occurred in 1985. In that year an increase in root and cane biomass per m^2 was observed (Figure 2). The increase in cane biomass was due to an increase in the number of inflorescences on floricanes (Figure 5) although a decrease in the average number of canes (Figure 3), cane length (Figure 4) and daughter plants (Figure 6) was recorded. Increases in biomass occurred in 1988 and again in 1996 which is attributed to a very dry spring and summer in those years that inhibited a full rust epidemic.

The average number of canes per m^2 in years of severe rust epiphytotics was considerably lower than in the years of no rust (1984) and years when rust epiphytotics had little impact, such as 1988 (Figure 3). A steady decline in cane length averaging approximately 4% per year (Figure 4) was recorded while an increase of 55% in inflorescence numbers per floricane occurred over the 12 year period (Figure 5).

The most significant effect of *P. violaceum* on *R. polyanthemus* was the reduction in the number of daughter plants per m^2 by 95.8% (Figure 6). In years of severe rust epiphytotics, the rust can halt all daughter plant production. This was observed in 1985 and 1996. Even in drier years when conditions do not favour major rust outbreaks, the production of daughter plants was still greatly reduced.

Foster

The collection of data at Foster did not commence until 1986, two years after the first rust epidemic was reported. Hence, a comparison of *R. ulmifolius* hybrid before and after rust impact cannot be made as has been done for *R. polyanthemus* at Callignee. However, a consistent decline totalling 38% from 1986 to 1992 in the mean biomass of canes, roots and root

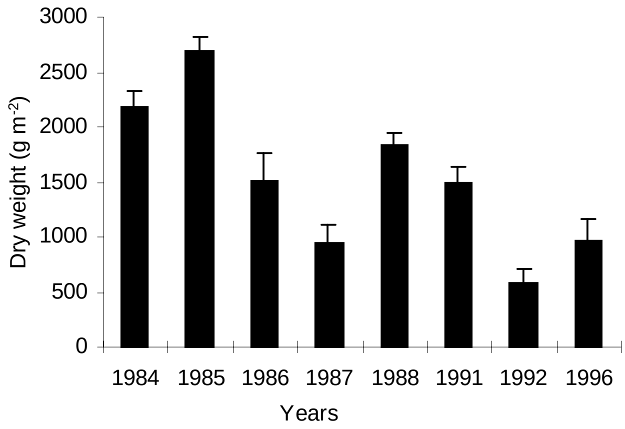

Figure 1. Effect of *Phragmidium violaceum* on *Rubus polyanthemus* average (± SE) dry weight m^{-2} at Callignee.

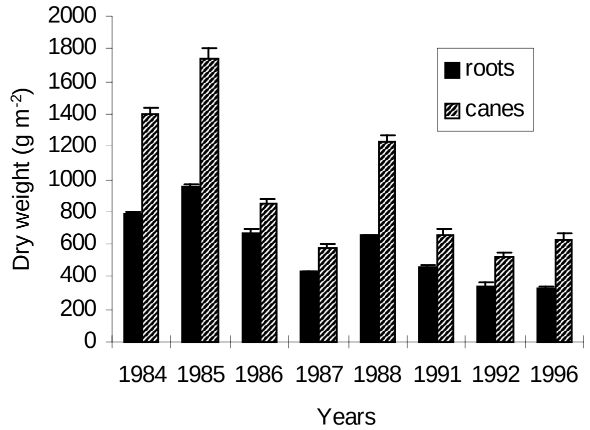

Figure 2. Effect of *Phragmidium violaceum* on *Rubus polyanthemus* average (± SE) root/crown and cane dry weight m^{-2} at Callignee.

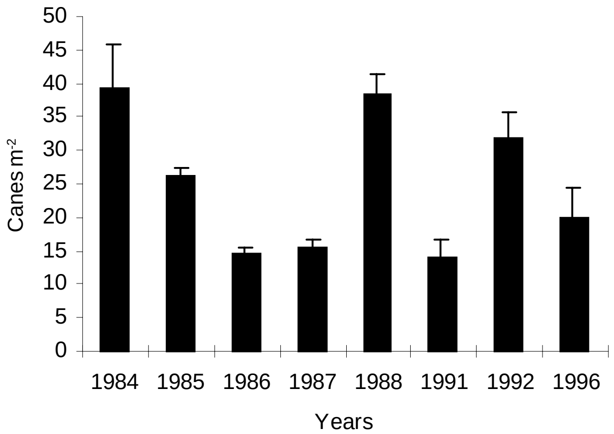

Figure 3. Effect of *Phragmidium violaceum* on *Rubus polyanthemus* average (± SE) number of canes m^{-2} at Callignee.

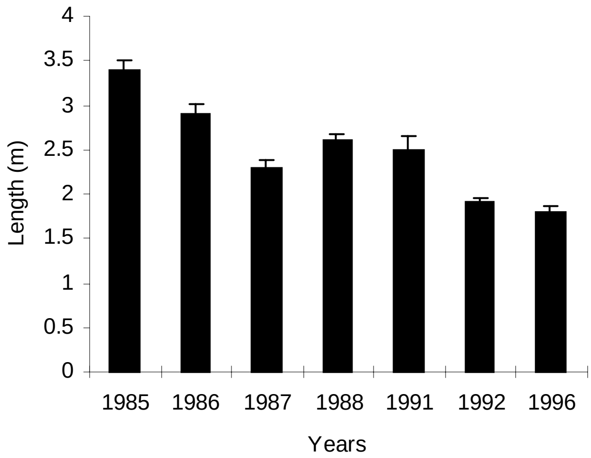

Figure 4. Effect of *Phragmidium violaceum* on *Rubus polyanthemus* average (± SE) cane length m^{-2} at Callignee.

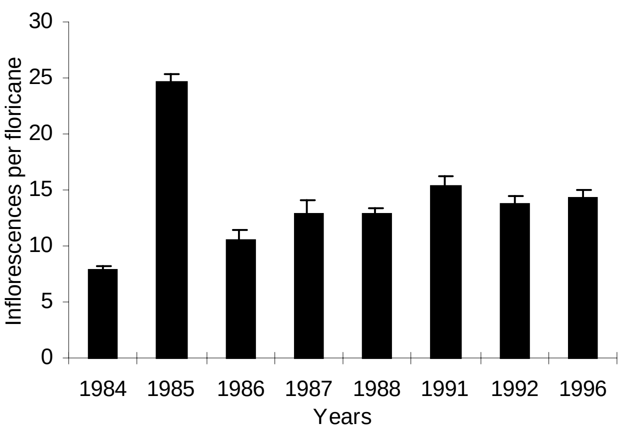

Figure 5. Effect of *Phragmidium violaceum* on *Rubus polyanthemus* average (± SE) number of inflorescences per floricane at Callignee.

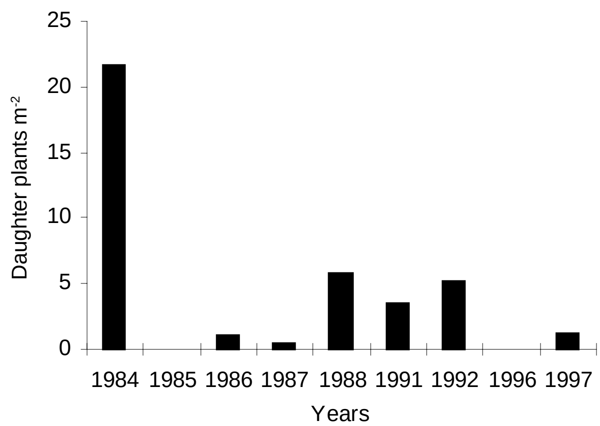

Figure 6. Effect of *Phragmidium violaceum* on *Rubus polyanthemus* average (± SE) number of daughter plants m^{-2} at Callignee.

crowns per m² of *R. ulmifolius* hybrid was observed (Figure 7). The reduction in cane biomass per m² was greater than that for root and root crown biomass per m² (Figure 8).

The average number of canes per m² (Figure 9) remained fairly constant, whilst there was an overall decrease in cane length per plot of 18% (Figure 10). Inflorescence numbers per floricane did not change over the six year period except for 1988 when it decreased (Figure 11). No data were collected prior to the release of the illegal strain of rust so it is difficult to determine the impact of rust on daughter plant production. However, the number of daughter plants per m² in years of

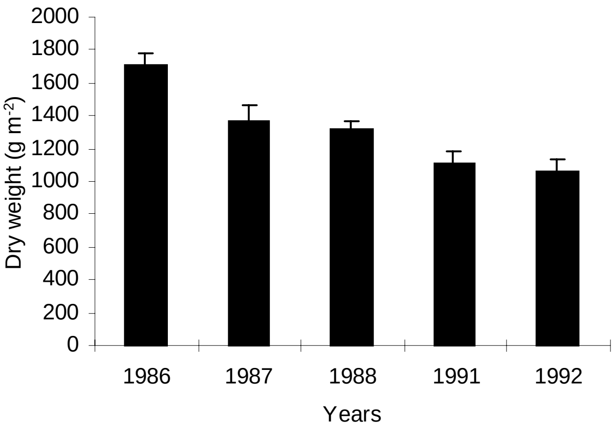

Figure 7. Effect of *Phragmidium violaceum* on *Rubus ulmifolius* average (± SE) dry weight m^{-2} at Foster.

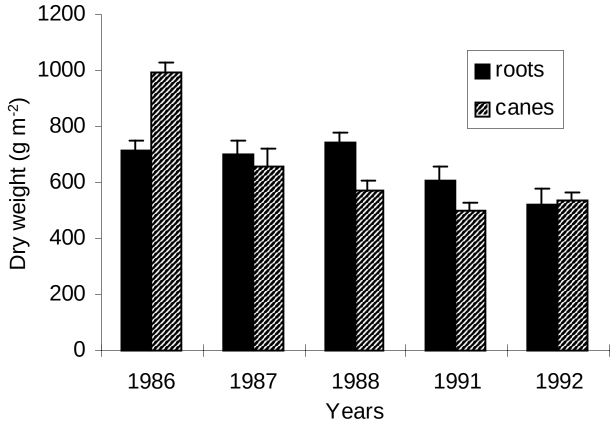

Figure 8. Effect of *Phragmidium violaceum* on *Rubus ulmifolius polyanthemus* average (± SE) root/crown and cane biomass m^{-2} at Foster.

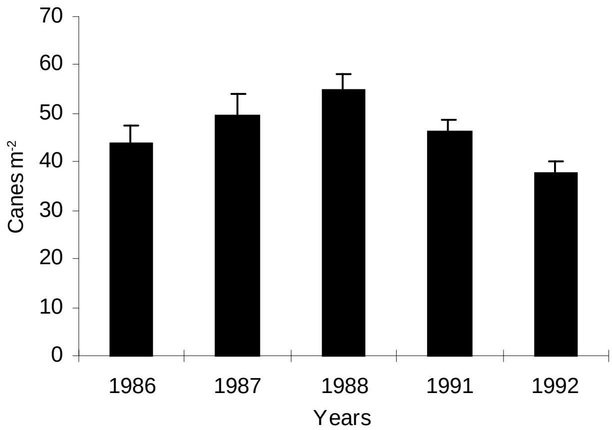

Figure 9. Effect of *Phragmidium violaceum* on *Rubus ulmifolius* average (± SE) number of canes m^{-2} at Foster.

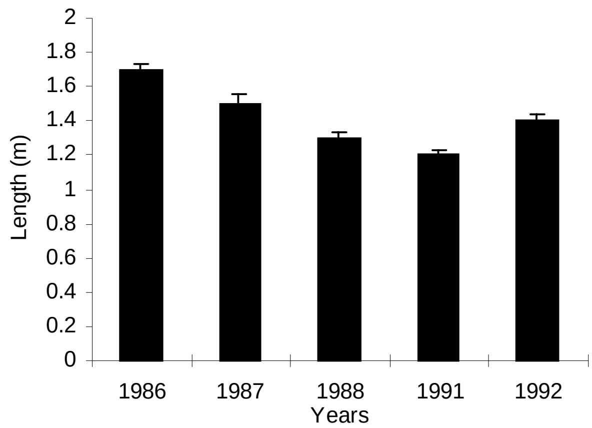

Figure 10. Effect of *Phragmidium violaceum* on *Rubus ulmifolius* average (± SE) cane length m^{-2} at Foster.

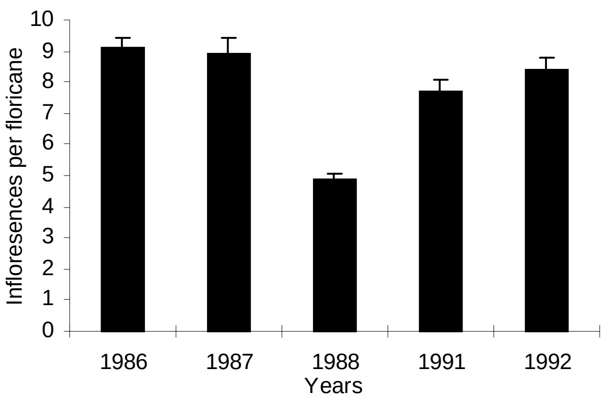

Figure 11. Effect of *Phragmidium violaceum* on *Rubus ulmifolius* average (± SE) number of inflorescences per floricane at Foster.

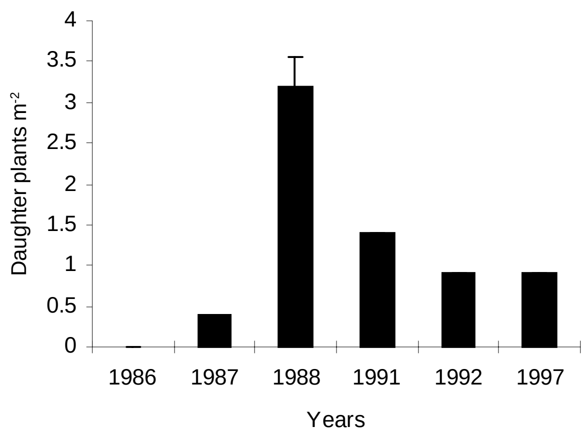

Figure 12. Effect of *Phragmidium violaceum* on *Rubus ulmifolius* average (± SE) number of daughter plants m^{-2} at Foster.

severe rust epiphytotics was significantly lower than in 1988 when a weak rust epiphytotic was observed (Figure 12).

Discussion and conclusions

Prior to the release of the illegal strain of rust at the two sites, blackberry remained in leaf all year round, thereby suppressing the growth of other plant species directly beneath its canopy. One of the main effects of *P. violaceum* is to cause summer, autumn and winter defoliation of blackberry. Repeated defoliation allows more light to reach the soil below the thicket, enabling seed from other plant species to germinate and grow up through the blackberry stand. This is being observed at Callignee and in other parts of the Strzelecki Ranges where blackberry is being overtaken by the native groundsel, *Senecio linearifolius* (Bruzzese and Lane 1996). This change is a slow and gradual process and it has taken more than ten years until other species may become competitive.

Although rust epiphytotics can look spectacular, blackberry is a very vigorous plant which requires repeated rust attacks over a number of years to have an impact on the root system. The most important effect of *P. violaceum* on blackberry has been the reduction in tip rooting, evident by the reduction in daughter plant production. *Rubus polyanthemus* in particular appears to be compensating for the reduction in vegetative reproduction by increasing the production of inflorescences.

The blackberry rust has been highly successful in attacking these two widespread species of blackberry naturalized in Australia. Rust impact seems to be greatest in the higher rainfall areas south of the Dividing Range in south eastern Australia. Impact, however, varies from one blackberry species to the other, one location to the next and from year to year. Information is required on the effect of *P. violaceum* on all naturalized blackberry species, and on the factors influencing the epidemiology and impact of the rust. Further investigation of *P. violaceum* strains suited to conditions where the current strains are less effective is imperative in order to increase the overall effectiveness of the biological control of blackberry in south eastern Australia.

References

Amor, R.L. and Harris, R.V. (1977). Survey of the distribution of blackberry (*Rubus fruticosus* L. agg) in Victoria and the use and effectiveness of chemical control measures. *Journal of the Australian Institute of Agricultural Science* 45, 260-3.

Amor, R.L. and Richardson, R.G. (1980). The biology of Australian weeds. 2. *Rubus fruticosus* L. agg. *Journal of the Australian Institute of Agricultural Science* 46, 87-97.

Bruzzese, E. (1980). The phytophagous insect fauna of *Rubus* spp. (Rosaceae) in Victoria, a study on the biological control of blackberry (*Rubus fruticosus* L. agg.). *Journal of the Australian Entomological Society* 19, 1-6.

Bruzzese, E. and Hasan, S. (1986). The collection and selection in Europe of isolates of *Phragmidium violaceum* (Uredinales) pathogenic to species of European blackberry naturalized in Australia. *Annals of Applied Biology* 108, 527-33.

Bruzzese, E. and Lane, M. (1996). 'The blackberry management handbook'. (Keith Turnbull Research Institute, Frankston).

Marks, G.C., Pascoe, I.G. and Bruzzese, E. (1984). First record *of Phragmidium violaceum* on blackberry in Victoria. *Australasian Plant Pathology* 13, 12-13.

Oehrens, E.B. and Gonzalez, S.M. (1974). Introduction de *Phragmidium violaceum* (Schultz) Winter como factor de control biologico de zarzamora (*Rubus constrictus* Lef. et M. y *R. ulmifolius* Schott). *Agro Sur* 2, 30-33.

Oehrens, E.B. and Gonzalez, S.M. (1977). Dispersion, ciclo biologico y danos causados par *Phragmidium violaceum* (Schulz) Winter en zarzamora (*Rubus constrictus* Lef. et M. y *R. ulmifolius* Schott) en la zonas centro-sur de Chile. *Agro Sur* 5, 73-85.