Establishment, initial impact and persistence of parthenium summer rust

*Puccinia melampodii* in north Queensland

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**Summary** The parthenium summer rust (*Puccinia melampodii* Dietel & Holway, Uredinales), native to Mexico, is a host-specific and highly damaging pathogen suited to warmer weather conditions. Field release of the summer rust in north Queensland commenced in January 2000. Monitoring at Plain Creek and Cardigan Station confirmed field establishment of the summer rust within three weeks after field release. Prevalence of rust infection increased on parthenium (*Parthenium hysterophorus* L., Asteraceae) as the plants matured. By the end of autumn, 71% of the plants were infected with 52% of the leaf area covered with rust. However, the negative impact of summer rust on seedling establishment, plant height, flower production, plant biomass and plant density at Plain Creek at the end of the first year was not significant. Dry summers over the subsequent years (2004–2006) resulted in low levels of rust incidence, culminating in negligible impact on the weed.

**Keywords** Biological control, summer rust fungi, *Parthenium hysterophorus*, establishment, impact.

**INTRODUCTION**

Parthenium is a weed of national significance in Australia, and causes severe economic, health and environmental problems in Queensland (Navie et al. 1996). Parthenium has been a target for biocontrol in Australia since the mid-seventies and, since then, nine species of insects and two rust fungi have been introduced (Dhileepan and McFadyen 1997, Dhileepan 2003). The majority of the agents have established, but only in central Queensland which appears to have favourable weather conditions (Dhileepan et al. 1996). In north Queensland where hot and erratic weather conditions prevail, many of the agents either did not establish or have not had any major negative impact on the weed (Dhileepan 2003).

The winter rust *Puccinia abrupta* var. *parthenicolata* (Jackson) Parmelee (Uredinales) (Parker et al. 1994) is one of the agents that did not establish in north Queensland (Dhileepan et al. 1996). This agent, introduced from high-altitude (>800 m a.m.s.l) regions of Mexico (Parker et al. 1994), became established only in a few localised areas in central Queensland (Dhileepan and McFadyen 1997) with long dew periods and cooler temperatures (Fauzi et al. 1998). Hence, the summer rust *Puccinia melampodii*, an agent more suited to areas in Queensland with hot and dry weather conditions, was introduced from low-altitude regions of Mexico (Evans 1997, Seier et al. 1997, Tomley 2000). In this study we report its field establishment, impact during early stages of establishment and persistence at two sites in north Queensland.

**MATERIALS AND METHODS**

**Agent release and monitoring** Field release of the summer rust in Queensland commenced in January 2000. Since then, releases have been made at more than 50 parthenium infested sites (Figure 1). This includes 30 sites in north Queensland where a total of 259 rust-infected plants were field planted during the summer–autumn period (January to May 2000). Release sites at Plain Creek (21.49°S, 146.67°E) and Cardigan Station (20.23°S, 146.65°E) were visited at monthly intervals and the levels of rust incidence, culminating in negligible impact on the weed.

**Initial impact assessment** At Plain Creek and Cardigan Station, 15 plots of 0.25 m² each were randomly sampled in April 2000, and the following parameters were recorded: number of rosettes, pre-flowering and flowering plants; number of leaves per plant; and number of leaves with rust infection. Total leaf area with infection on each plant was scored between zero and 100% on a visual basis.

**Exclusion studies** At Plain Creek, eight plots of 2.25 m² each were maintained free of biocontrol agents (parthenium summer rust and stem-galling moth *Epiblema strenuana* (Walker)) and eight plots of 2.25 m² each were left exposed to biocontrol agents (Dhileepan 2003).
In biocontrol plots, a fungicide and insecticides were applied at fortnightly intervals to maintain parthenium free of summer rust and the stem-galling moth. The fungicide Mancozeb® (2.4 kg a.i. ha⁻¹) and the systemic organophosphate insecticide monocrotophos (600 g a.i. ha⁻¹) were foliar sprayed onto plants. Granules of carbofuran, a broad-spectrum carbamate insecticide, were spread on the soil (3 kg a.i. ha⁻¹). In plots with biocontrol, equal amounts of water were applied. The trial site was visited at monthly intervals and the density of seedlings, rosettes, pre-flowering and flowering plants were recorded along with rust incidence levels (proportion of plants with rust infection, proportion of leaf area (%) with rust infection). At Cardigan Station sampling was carried out in April 2005, February 2006 and May 2006.

**Analysis** Variations in the incidence of summer rust (proportion of leaves with rust infection and proportion leaf area with rust infection) in relation to stages of plant growth (rosette, pre-flowering and flowering stages) and locations (Plain Creek and Cardigan Station) was analysed using two-way ANOVA. Variation in individual plant parameters (i.e. plant height, flower production and biomass) and plant populations between plots with biocontrol and plots excluded from biocontrol were analysed using one-way ANOVA and the means compared using a Tukey test. Regression analysis was employed to study the interactions between the proportion of leaf area with summer rust, and plant height, flower production and plant biomass.

**RESULTS**

Field establishment of the summer rust was evident in 88% (N = 34) of the release sites (Figure 1). Monitoring at Cardigan Station and Plain Creek in north Queensland confirmed the field establishment of the summer rust within three weeks after field release. At Plain Creek the rust became established in Feb 2000, a month after field release, and by the end of autumn (May) 71 ± 14% of the plants had the rust infection (Figure 2) with 52 ± 3.7% of the leaf area infested.

Prevalence of rust infection (per cent of leaves with rust) was significantly higher at Plain Creek (49.4 ± 4.5%) than at Cardigan Station (32.3 ± 3.3%) (F₁,₉₁ =

![Figure 1. Summer rust release sites (● = rust established sites; ○ = rust establishment is not known) in Queensland.](image)

![Figure 2. Introduction (↓) and field establishment of summer rust (Mean ± SE) at Plain Creek.](image)
9.36, P = 0.003). At both properties, the proportion of leaves with rust infection was greater in flowering (51.5 ± 4.5%) and pre-flowering (39.2 ± 4.9%) plants than in rosettes (31.6 ± 5.2%) (F2,91 = 4.5, P < 0.01) (Figure 3). The proportion of leaf area with summer rust was also significantly greater in flowering plants (58.8 ± 3.6%) than in pre-flowering plants (46.3 ± 3.9%) and rosettes (42.4 ± 4.2%) (F2,91 = 4.96, P < 0.01), but did not differ significantly between the two sites (F1,91 = 2.17, P = 0.12). The level of rust incidence (proportion of leaves, R2 = 0.01, F95 = 0.98, P = 0.35; proportion of leaf area, R2 = 0.01, F95 = 0.44, P = 0.51) was not dependent on parthenium density.

At Plain Creek, the negative impact of summer rust on seedling establishment rate (F = 2.26, P = 0.21), plant height (F = 0.81, P = 0.39), flower production m-2 (F = 0.39, P = 0.56), plant biomass m-2 (F = 0.17, P = 0.71) and plant density m-2 (F = 1.35, P = 0.31) at the end of parthenium growing season in 2000 was not significant. Plant height declined with an increase in the proportion of leaves with rust (y = 95.02 − 0.33x, R2 = 0.24, F27 = 8.37, P = 0.01), but the relationship between the proportion of leaves with rust, and flower production (R2 = 0.07, F27 = 2.1, P = 0.16) and total biomass (R2 = 0.03, F27 = 0.82, P = 0.38) was not significant.

At Plain Creek, the level of rust incidence declined from 71 ± 14% in 2000 to 4.76 ± 3.44% in 2004. Rust incidence was not evident in the summer of 2005 and 2006. Though the summer rust reappeared in mid-autumn of 2006 (Figure 4A), the proportion of leaves with rust remained low (8.7 ± 5.1%). The changes in the rust incidence levels appear unrelated to parthenium weed availability (Figure 4B). At Cardigan Station no summer rust incidence was evident during the 2005 and 2006 summer season.

DISCUSSION

As predicted, the summer rust became established immediately, but with higher prevalence and intensity in north Queensland than in central Queensland. Within three months after introduction, more than 70% of the plants showed rust infection. The successful establishment of the summer rust at Plain Creek was attributed to the above average rainfall received (27%) coupled with prolonged dew periods (>6 h) in 1999–2000 (Dhileepan 2003). However, the rate of spread within these sites was slow. This was possibly due to dense grass, which protected the rosettes and shorter pre-flowering plants from dew and minimised the rust spore movement. This is further evident from lower levels of rust incidence on pre-flowering and rosette stage plants, which had shorter stems and less leaf area than flowering plants.

In glasshouse trials, the summer rust had a significant negative impact on the vigour of young parthenium plants (Seier 1999). In contrast, at Plain Creek, the summer rust had no impact on plant vigour and weed population density in the first year of field establishment. This was possibly due to the late establishment of the rust, with the majority of plants able to become well established before being infected. Some had even started producing flowers. Previous studies have suggested that biocontrol agents have no negative impact on pre-flowering and flowering stages of parthenium (e.g. Dhileepan 2003, Dhileepan and McFadyen 2001).
The summer rust is adapted to areas with high temperatures and limited periods of humidity (Seier 1999). During dry periods, it was assumed that the pathogen would maintain sufficient residual inoculum on the infected plants (Seier 1999). Hence, it was anticipated that the surviving rust spores on dead, dried plants would help to infect newly emerging seedlings in the following year. The reappearance of the summer rust infection at Plain Creek in the autumn of 2006 confirms the above prediction.

Rainfall appears to be the major factor affecting the effectiveness of biocontrol (Dhileepan 2003). Higher rust infection in the summer of 2000 and its reappearance in the autumn of 2006 were possibly due to higher rainfall, coupled with prolonged dew periods in the study sites. In future, introduction and distribution of the summer rust will be undertaken with help from community groups only in years with favourable weather conditions.

ACKNOWLEDGMENTS
We thank Marie Vitelli, Paul Horrocks, Catherine Setter (Tropical Weeds Research Centre), Wilmot Senaratne, Mariano Trevino (Alan Fletcher Research Station) and Scott Dearden (Parthenium Action Group, Rolleston) for their support in field releases and monitoring.

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