

## The Gloomy Future of the Broom Rust as a Biocontrol Agent

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### Abstract

The European woody leguminous shrub Scotch broom (*Cytisus scoparius* (L.) Link; Genisteeae, Fabaceae) is a serious weed in several countries including Australia, New Zealand, Canada and the USA. A rust fungus was found on Scotch broom in France in 1995, where it was infecting stems and leaves, causing severe dieback of branches. Depending on the taxonomic authority, the rust fungus found on Scotch broom is referred to as *Uromyces pisi-sativi* (Pers.) Liro, *Uromyces laburni* (DC.) Oth, *Uromyces genistae-tinctoriae* (Pers.) Wint. f. sp. *scoparii* or *Uromyces sarothamni* Guyot and Massenot. Preliminary host-specificity testing was undertaken to determine the suitability of this rust as a biological control agent. Tagasaste (*Chamaecytisus palmensis* (H. Christ) F.A. Bisby and K.W. Nicholls) and two lupin species (*Lupinus polyphyllus* Lindley X Russel; *L. arboreus* Sims) that belong to the subtribes Genistinae and Lupininae respectively, within the tribe Genisteeae, were selected for testing. Tagasaste was found to be highly susceptible to the rust and developed many uredinia that sporulated abundantly. Several uredinia also developed on old leaves of *L. polyphyllus* X Russel but they were smaller than on broom plants and only produced a limited amount of urediniospores. *Lupinus arboreus* was the only species resistant to the rust, with only chlorotic spots, slight necrosis and no uredinia produced. The broom rust will not be further investigated for biological control in Australia because it developed extensively on tagasaste, a species that is used as a fodder plant particularly in Western Australia.

**Keywords:** Scotch broom, rust, host-specificity, classical biological control

### Introduction

The European woody leguminous shrub Scotch broom, henceforth broom, *Cytisus scoparius* (Genisteeae) is a serious introduced weed in several countries including New Zealand, Australia, the USA and Canada (Parsons and Cuthbertson 1992, Bossard and Rejmánek 1994, Peterson and Prasad 1998). It grows more vigorously in the countries where it has been introduced than in Europe, and is spreading rapidly. In New Zealand, broom infests large areas of wasteland, riverbed and native grassland, and is a problem in pasture and plantation forests (Bascand and Jowett 1982, Syrett 1989). In Australia, the most severe broom infestations are found at Barrington Tops in New South Wales (Smith 1994). Absence of natural enemies is believed to be an important factor that influences the

weediness of broom in its introduced range (Fowler *et al.* 1996, Rees and Paynter 1997, Paynter *et al.* 1998).

Over the years, several arthropods have been investigated as classical biological control agents for broom and four species (*Exapion fuscirostre* Fabricius, *Leucoptera spartifoliella* Hübner, *Bruchidius villosus* Fabricius, *Arytainilla spartiophila* Förster) have been intentionally introduced into the USA, New Zealand and/or Australia (Syrett *et al.* 1999). It has now become more difficult to find arthropod species that are sufficiently host-specific to be considered as biological control agents. A few pathogens have been considered for the biological control of broom. In an extensive survey of diseases of broom in New Zealand, Johnson *et al.* (1995) identified two pathogens, *Pleiochaeta setosa* (Kirkner) S. Hughes and *Gibberella tumida* P.G. Broadh. and P.R. Johnston (anamorph: *Fusarium tumidum* Sherb.) with potential for development as bioherbicides (Johnston and Park 1994).

Populations of a rust fungus were discovered in the Pyrénées in France in 1995, where it was infecting stems of broom, causing severe dieback of branches. Leaf infections were later found to be abundant in the Cévennes in autumn. Depending on the taxonomic authority, the rust found on broom is referred to as *Uromyces pisi-sativi*, *Uromyces laburni*, *Uromyces genistae-tinctoriae* f. sp. *scoparii* or *Uromyces sarothamni* (Macdonald 1946, Guyot and Massenot 1958, Gäumann 1959, Wilson and Henderson 1966, Henderson and Bennell 1979).

This paper reports on results of preliminary host-specificity testing undertaken to determine the suitability of this rust as a biological control agent. Tagasaste (or tree lucerne) (*Chamaecytisus palmensis*) and two lupin species, *Lupinus polyphyllus* X Russel and *Lupinus arboreus* (tree lupin) that belong to the subtribes Genistinae and Lupininae respectively, within the tribe Genisteae, were selected for testing. These species are the most phylogenetically related plant species to Scotch broom occurring in Australia and New Zealand. Tagasaste is used as a drought-resistant fodder crop in Australia (McGowan and Mathews 1992). In New Zealand it is planted in some areas to prevent erosion and encourage regeneration of native vegetation (Fowler *et al.* 2000). *Lupinus polyphyllus* X Russel is common as a garden ornamental in both countries. *Lupinus arboreus* is used by the forestry industry in New Zealand to stabilise sand dunes and fix nitrogen (Fowler *et al.* 2000). It is also a key test plant of the broom biological control program in the USA.

## Material and Methods

**Plant production.** Seeds of broom (ex. Mandagout, France), tagasaste (ex. Queanbeyan, Australia), *L. polyphyllus* X Russel (commercially available seeds) and *L. arboreus* (commercially available seeds) were used to produce plants. Broom and tagasaste seeds were scarified with sandpaper before use. All seeds were soaked in water for 24 h before planting. Seeds were sown in trays containing a mixture of vermiculite-perlite (1:1) and grown in the glasshouse (at 18–29°C). The seedlings were transplanted in a potting mix-sand mixture (1:1) contained in 9'x9'x9' cm plastic pots (one per pot).

**Production of rust inoculum.** Leaves with uredinia were collected from infected broom plants growing near Mandagout (44°01'N, 3°38'E; altitude *c.* 500m; Gard, France). Spores were dislodged from uredinia by scraping the surface with a scalpel under a dissecting microscope. Uredinia infested with the hyperparasitic fungus *Sphaerellopsis filum* (Biv. Ex Fr.) B. Sutton [*Darlucal filum* (Biv. Ex Fr.) Castagne] were discarded. Two-month old broom plants were inoculated by applying a mixture of urediniospores and tal-

cum powder (1:29) onto the upper surface of the leaves with a small paintbrush. Inoculated plants were misted with water and placed in dark humid chambers at 20°C for 16 h and then transferred to the glasshouse. One month after inoculation, spores were harvested from uredinia using a spore-collector and were used in the preliminary host-specificity test.

**Preliminary host-specificity testing:** Fifteen plants each of tagasaste (9-14 leaf stage), *L. polyphyllus* X Russel (3-6 leaf stage) and *L. arboreus* (5-8 leaf stage), and nine broom plants (2-months old) were inoculated as above but with a more concentrated mixture of urediniospores and talcum powder (1:14). Post-inoculation conditions were similar to those described above. Plants were examined for macroscopic symptoms of the disease at 12, 18, 22 and 35 days after inoculation and rated for susceptibility at the end of the experiment.

## Results

All broom plants inoculated with the rust became infected and developed several uredinia which produced large amounts of urediniospores (Table 1). Tagasaste was also found to be highly susceptible to the rust and developed many uredinia that sporulated abundantly. Several uredinia developed slowly on old leaves of *L. polyphyllus* X Russel but they were smaller than on broom plants and only produced a limited amount of urediniospores. Young leaves of *L. polyphyllus* X Russel developed chlorotic spots at 22 days after inoculation. At 35 days after inoculation, a few uredinia had developed on the chlorotic spots of some of these leaves. *Lupinus arboreus* was the only species resistant to the rust, with only chlorotic spots, slight necrosis and no uredinia produced.

**Table 1.**  
Symptoms of test plants at various intervals after inoculation with the broom rust and overall susceptibility ratings.

Plant species	Plants with uredinia (% of total number inoculated)				Macroscopic symptoms	Susceptibility rating
	Days after inoculation					
	12	18	22	35		
<i>Cytisus scoparius</i> (Scotch broom)	100	100	100	100	Numerous normal uredinia, Abundant sporulation	Highly susceptible
<i>Chamaecytisus palmensis</i> (tagasaste)	93	100	100	100	Numerous normal uredinia, Abundant sporulation	Highly susceptible
<i>Lupinus polyphyllus</i> X Russel	0	53	67	73	On old leaves: numerous small uredinia, restricted sporulation On young leaves: chlorotic spots, few small uredinia at 35 days after inoculation	Moderately susceptible
<i>Lupinus arboreus</i>	0	0	0	0	Chlorotic or necrotic spots, no uredinia	Resistant

## Discussion

Rust fungi have been used successfully as biological control agents worldwide. In South Africa, for example, the Australian rust fungus *Uromycladium tepperianum* (Sacc.) McAlp. reduced the density of *Acacia saligna* (Labill.) Wendl. trees by 80% within 7 to 8 years (Morris 1997). Such spectacular success has led to an increasing interest in rusts of other exotic and invasive weeds.

The broom rust is closely related to rusts found on gorse (*Ulex europaeus* L.), *Genista* and *Laburnum* species (Macdonald 1946, Guyot and Massenet 1958, Wilson and Henderson 1966). Macdonald (1946) described the rusts found on gorse, broom and *Genista anglica* L. as three specialised races within the species *Uromyces genistae-tinctoriae*. Macdonald's proposed nomenclature was based on slight morphological differences in the urediniospores of each rust and results from cross-inoculation studies which showed that each of the three rusts was restricted to its host plant. Subsequently, Guyot and Massenet (1958) carried out a thorough morphological study of rusts on *Genista* and *Cytisus* species and as a result created the new binomial *Uromyces sarothamni* which distinguished the rust on broom from rusts found on other *Cytisus* species. The name *Uromyces sarothamni*, however, is invalid (*nomen invalidum*) according to the International Code of Botanical Nomenclature, because the original description of this 'new' species was not published in Latin (H. Evans, personal communication). Other taxonomic authorities includes all these rusts and other closely related rusts occurring on Fabaceae under the collective name *Uromyces pisi-sativi* (Wilson and Henderson 1966, Henderson and Bennell 1979).

*Uromyces pisi-sativi* is reported as having a complex life cycle with spermatogonia and aecia developing on *Euphorbia cyparissias* L., and uredinia and telia on the Fabaceae hosts (Wilson and Henderson 1966). However, Macdonald (1946), in his comparative studies of the rusts on gorse, broom and *Genista anglica* L., observed that the aecial stage was rarely found on *Euphorbia* in the field, probably because the rusts produce very few teliospores and overwinter mainly as urediniospores.

The rust isolate from Mandagout investigated in this study successfully infected and developed on broom and tagasaste, and to a lesser extent on *L. polyphyllus* X Russel. The last species has also been found to be susceptible to the gorse rust in host-specificity tests conducted in Hawaii (E. Killgore, personal communication). In the Hawaiian tests, none of the *Cytisus* and *Genista* species was susceptible to the gorse rust. These findings concur with Macdonald's (1946) observations that different specialised races of the rust occurred on *Ulex*, *Cytisus* and *Genista* species. Nevertheless, our study on the broom rust and the Hawaiian tests on the gorse rust demonstrate that the host-ranges of both these rusts extend to other species within the tribe Genisteae.

The broom rust will not be further investigated for biological control in Australia because it developed extensively on tagasaste, a species that is used as a fodder plant particularly in Western Australia (McGowan and Mathews 1992). In New Zealand, the prospect of considering this rust for biological control of broom is uncertain because it infects tagasaste, a species that is valued by interest groups in parts of the country (Fowler et al. 2000). However, the rust could still be considered as a potential biological control agent in the USA where tagasaste is not of a concern, since it only caused a few chlorotic spots and slight necrosis, and did not develop uredinia on *L. arboreus*. If it is to be considered further for the USA, future investigations should include a revision of the taxonomic status of the rust, comprehensive host-specificity testing and a detailed study of its life cycle.

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