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Some Problem Weeds in Tropical and Sub-Tropical Australia and Prospects for Biological Control using Fungal Pathogens

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The weeds which are currently under investigation include: *Parthenium hysterophorus*, *Cryptostegia grandiflora*, *Lantana camara* and *Ambrosia artemisiifolia*, listed in order of project advancement. The bioeconomic profiles of these weeds are discussed and their associated fungal pathogens are assessed for their biological control potential. In the case of *P. hysterophorus*, a sub-tropical rust *Puccinia abrupta* var. *partheniicola* has been released in the field in Australia following 5 yrs research on its biology and host-specificity. Studies on a tropical rust from Madagascar, *Maravalia cryptostegiae* for the control of *Cryptostegia grandiflora* are nearing completion, and problematical aspects of the novel life-cycle and host range are discussed. Preliminary surveys have been undertaken in Brazil to determine the pathogenic mycoflora associated with *L. camara*. Field assessments indicate that the rust, *Prospodium tuberculatum*, and the hyphomycete *Mycovellosiella lantanae* are both damaging and apparently host-specific pathogens in southern Brazil; whilst *Puccinia lantanae* and a new web blight disease (*Ceratobasidium* sp.) are similarly damaging in tropical central and northern Brazil. Laboratory and greenhouse studies are underway to determine their biology and immediate host range. The project on *A. artemisiifolia* is still in the provisional stages, but an *ad hoc* survey in the southern USA has revealed the presence of a seemingly rare microcyclic rust within the *Puccinia xanthii* complex, which has proved extremely damaging in greenhouse tests.

Introduction

In Australia, the use of plant pathogens for the classical biological control of weeds is now gathering momentum. Until now, the use of insects has enjoyed much more attention. The simple reason for this may be that the latter as a group have always been perceived as the safer option, although at the time of the prickly pear campaign in the 1920s, several pathogens were studied and some were subsequently introduced into Australia (Mann 1970).

In nature, each living species has its accompanying diverse guild of parasites. Perhaps it is more due to good luck than good management that human endeavour could select just one of these and achieve adequate control of a weed in its exotic range. The weeds discussed below have all been the subject of extensive exploration for insect agents. Unfortunately, this effort has not produced the desired result. To date, the strategy seems to have been to check out all the insects, then have a look at the pathogens. It would appear rather more sensible to adopt a more holistic approach.

Parthenium Weed (*Parthenium hysterophorus* L.; Heliantheae, Compositae)

Parthenium weed is a native of the countries and islands bordering the Caribbean, and has spread throughout the southern USA, Mexico and Brazil (Towers 1981). In Australia, it is an

aggressive annual or ephemeral weed, which can flower within 6 wks of germination, then remain in flower for a further 6-8 months if conditions are suitable. Large plants can produce up to 15,000 seeds of high viability. There is no dormancy mechanism and seed will germinate in any season when conditions are favourable. The seed is transported primarily by man as a direct contaminant of fodder, seed, machinery and livestock, and is also dispersed by water. While Parthenium weed does best on alkaline to neutral clay soils (Dale 1981), it will also survive and reproduce on a wide range of other soil types. In the rosette stage, it is resistant to frost. Invasion of ecosystems is facilitated by disturbance. In summer-growing pastures, it can become dominant due to overgrazing or when winter rainfall favours its growth. In cultivation, it over-winters in fallowed summer crop land, and must be controlled before these crops can be planted. Since its accidental introduction in pasture seed in 1958, the weed has spread over 129,000 km^2 and has been found 1,400 km south of its original point of introduction. Parthenium weed is generally unpalatable, but sheep and cattle eat it when food is scarce. It produces unacceptable taints in mutton (Tudor *et al.* 1981), and causes acute allergic eczematous dermatitis in humans (Towers 1981). Parthenium weed was recently identified by central Queensland farmers as their worst annual weed (Pope, V., personal communication, 1991). A detailed economic survey of the weed's importance is in progress, however estimated losses of A $1.5 M in direct control, plus A $5.0 M in lost production are considered to be conservative.

Puccinia abrupta *Diet. & Holw. var.* partheniicola *(Jackson) Parmelee (Uredinales, Pucciniaceae)*

This macrocyclic, autoecious rust from Mexico was noted by an entomologist near Monterey in 1981. Only the telial and uredinial stages were observed in the field, but Evans (1987) successfully germinated teliospores in the laboratory, and was able to demonstrate the specificity of the spermogonial and aecial stages. Detailed host testing in the UK on 113 different plants including 17 commercial varieties of sunflower confirmed that the host range was not any wider than that stated in the literature. Permission to import and release the rust in Australia was given by the Australian Quarantine and Inspection Service in April 1991. Since then, it has been released at *ca.* 150 sites in and around central Queensland. Infection of plants in the field has been easily achieved, however due to severe drought, there has been little or no dispersal from the release points at this stage.

Rubber vine (*Cryptostegia grandiflora* Roxb. ex R.Br.; Periplocoidea, Asclepiadaceae)

Rubber vine, a native of Madagascar, is a vigorous perennial vine deliberately introduced into Australia as an ornamental in the late nineteenth century. It has 2 growth forms depending on shading. Under a canopy, it adopts the habit of a vigorous climber, smothering supporting trees up to 30 m tall, whereas in full sunlight it is somewhat self supporting forming a low straggly shrub. In both situations, because of its rapid growth rate, it can become the dominant vegetative component of the landscape. Infestations originate along streams spreading out into adjacent pasture (McFadyen and Harvey 1990). Rubber vine produces large numbers of pappus-bearing seeds which are commonly borne high on the plant. The seeds are transported over considerable distances by the wind (Tomley and McFadyen 1989). In the State of Queensland, infestations occur in the tropical north within an area of 300,000 km^2 (McFadyen *et al.* 1991).

The plant is poisonous, containing cardenolides (cardiac glycosides) (Aebi and Reichstein 1950, Doskotch *et al.* 1972), and feeding tests have demonstrated that the leaves were toxic to cattle, horses, goats and sheep, horses being particularly susceptible. Fortunately it is not normally eaten by stock (McGavin 1969, Everist 1974).

Rubber vine is both an agricultural and an ecological problem. It seriously inhibits the day-to-day management of cattle which can hide in dense thickets along water courses. Mustering costs are almost doubled and cattle are lost, which, apart from the direct economic loss, makes disease control and maintenance of herd quality unattainable. In addition, there is the

direct loss of pasture. Rubber vine also seriously damages native plant communities (Stanton, J., personal communication, 1986). Humphries *et al.* (1991) identified rubber vine as the most critical of all weeds in a study of exotic plants which are invading Australian ecosystems. In a recent economic study by Chippendale (1991), the annual cost of rubber vine to the cattle industry alone was estimated to be in excess of A $8 M. Using isohyets and isotherms, he predicted the existence of a potential distribution zone comprising 20% of the area of northern Australia. More work is needed using stochastic models to refine this prediction (Chippendale, J., personal communication, 1991)

A second species, *Cryptostegia madagascariensis* (Bojer ex Decne.) is also naturalised in Australia, with occasional specimens being grown in gardens. This species appears to have none of the weedy characteristics of *C. grandiflora* though their comparative biology has not been studied.

Maravalia cryptostegiae *(Cummins) Ono, Rubber vine Rust*

In a 3-yr study of the insects and pathogens of rubber vine in Madagascar, this rust appeared to be the most damaging agent. The taxonomic position of *M. cryptostegiae* remained somewhat confused until it was critically re-examined by Ono (1984), in his monograph of the genus Maravalia (Evans 1988*a*).

A detailed host testing programme based on a list of plants approved by the Australian Quarantine and Inspection Service is almost completed. Apart from weak sporulation on one Australian native species, *Cryptolepis grayi* Forster, the rust appears to have a restricted host range. The infection *of C. grayi* is considered to be a "new encounter" rather than a "jump" as described by Savile (1969). Field observations in Madagascar revealed that another species of *Cryptolepis* and the closely related genus *Gonocrypta* were additional hosts.

Like the related coffee leaf rust (*Hemileia vastatrix* Berk. ex Broome), the life-cycle of *M. cryptostegiae* is proving difficult to unravel. Both fungi produce urediniospores and thin walled teliospores on their hosts, but, so far, basidiospore inoculations of their respective hosts have failed to demonstrate the presence of pycnia and aecia within the life-cycle. An obvious interpretation, therefore, is that these rusts are heteroecious and possess an alternate host. However, following cytological studies, a working hypothesis has been proposed in which the "urediniospores" are multifunctional (uredinioid teliospores), replacing the primitive teliospores which have become genetically unstable and non-functional.

Lantana (*Lantana camara* L.; Verbenaceae)

Lantana, which originated in south or central America, is an abundant weed along the East coast of Australia. Horticultural hybrids were introduced in the mid nineteenth century, and *Lantana* was subsequently recognised as a pest by Bailey in 1883 (Swarbrick 1986). There are 30 or so taxa of *Lantana* naturalised in Australia, but to date, only 9 are pests.

The weedy lantanas of coastal Queensland and New South Wales probably descend both directly and indirectly from the thorny varieties originally introduced to southern areas of Australia for hedging purposes, where, because of climate, their growth was not weedy (Swarbrick 1986). The common pink variety is the most abundant and widespread, with the white flowered and red flowered varieties occurring in more restricted areas. It is a shrub which grows up to 5 m in height and forms dense impenetrable thickets on the edges of rainforests and in wet and dry sclerophyll forests, and is a problem on hillsides, along creeks and in gullies, where it changes the nutrient status of the soil, the seeds are spread by birds and the canes can take root by layering (Buchanan 1989).

It is also a serious weed of the valuable dairy and beef pastures of eastern Australia, forming dense thickets, crowding out pasture plants and reducing productivity. In commercial forests, it competes for moisture and nutrients thus reducing timber yields. It has not been widely declared noxious, because it is seen as uncontrollable on a large scale. While it can be controlled with herbicides, the cost is often not worthwhile as the potential productivity of the land is low. Some varieties of lantana including

the "pink edged red" of southern Queensland and New South Wales and containing various triterpines are poisonous to stock (Everist 1974). According to Harley (1974), 1000-1500 cattle are lost annually in Australia due to poisoning.

Almost 4 million ha are now affected in Australia (Buchanan 1989). In Queensland alone, an estimated A $17 M is spent annually on clearing operations.

Prospodium tuberculatum *(Speg.) Arthur and* Mycovellosiella lantanae *(Chupp) Deighton*

Two field surveys have been undertaken in southern Brazil. In Rio de Janiero State, a number of localities in 7 climatic-vegetation zones ranging from sea level to a height of 1,200 m a.s.l. have been surveyed. Sites in Sao Paulo and Parana States, the areas in which collections of lantana pathogens were made by CSIRO entomologists in the 1970s were also visited.

The autoecious, subtropical-tropical rust *P. tuberculatum*, was collected from various locations in all 3 States at altitudes ranging from 300 m a.s.l. to 990 m a.s.l. Records of the International Mycological Institute (IMI, Kew) indicate that this genus is restricted to the Bignoniaceae and Verbenaceae and further, that *P. tuberculatum* is found only on the genus *Lantana* (Evans 1989). Leaf infection causes orange to dark purplish brown, irregular, spreading and coalescing lesions leading to severe defoliation. Distribution of the hyphomycete *M. lantanae* was ubiquitous and it appeared to be restricted to *L. camara.* Infection of leaves is characterised by the presence of initially light coloured, discrete lesions becoming silvery grey and coalescing, eventually causing defoliation.

Both pathogens were found to be common and damaging at altitudes above 300 m in southern Brazil, and the continued effect was often dramatic. Lantana was not a prominent plant in the landscape and did not appear vigorous, often exhibiting evidence of defoliation and stunting (Evans 1989).

Puccinia lantanae *Farlow and* Ceratobasidium *sp.*

A recent survey in northern (Amazonia) and central Brazil has revealed that other pathogens become dominant in these humid tropical areas. The microcyclic rust, *P. lantanae*, which was infrequently recorded in subtropical southern Brazil, was much more common and damaging in the tropics, particularly in the States of Parana and Bahia. A disease, not previously reported on *L. camara* (Evans 1988*b*), was collected in both Bahia and Amazonia (Amazonas State), inducing shoot die-back and leaf death. A white mycelial mat, typical of the web blight fungi (*Ceratobasidium*; Corticiaceae), develops on stems and along petioles, but sporulation occurs only on the lower surface of young leaves.

Annual ragweed (*Ambrosia artemisiifolia* L.; Heliantheae, Compositae)

Ragweed is an annual herb native to tropical and temperate North America, introduced to Australia in the northern New South Wales region early this century. The mode of introduction is unknown. The florets are in unisexual heads, mature plants can grow 3-4 m high and seed production is prolific. It is an aggressive and fast-growing weed of roadsides, creek banks and pastures, which it invades and suppresses (Stanley and Ross 1986). By 1940, it was recorded in several localities in south east Queensland and northern New South Wales from where it has increased in area and density (McFadyen 1984). It has now become an abundant and common weed in this region. The seed is spread by machinery, on the coats of animals and by floodwater. Annual ragweed is a successful weed in urban areas where it is spread in soil. The pollen is a potent allergen causing hayfever and asthma. It is known to be an extremely powerful sensitising agent and its adverse effects on health are well documented in the USA.

Annual ragweed is declared noxious in Queensland, but not in New South Wales. In Queensland, it is estimated to cost about A $2 M annually. As yet, no economic survey has been conducted, however studies are under way to

identify key areas for loss assessment to develop the necessary methodology.

Puccinia xanthii *Schw.*

This rust was identified from specimens forwarded to IIBC by Dr. W Palmer of the Queensland Department of Lands North American Field Station in Texas, USA. *P. xanthii* is also listed as attacking *A. artemisiifolia* in Florida (Alfieri *et al.* 1984). Narrow host range tests carried out in the UK with the material sent, showed that it did not infect *Calendula officinalis* L. (Asteraceae) as did the *P. xanthii* present on *Xanthium occidentale* L. (Asteraceae) in Australia (Alcorn 1975). Inoculation of *A. artemisiifolia* showed the rust to be extremely damaging. It would appear, therefore, that this recent collection is a separate race or *forma specialis* of *P. xanthii*, as proposed by Batra (1981) for a strain of this rust attacking giant ragweed (*Ambrosia trifida* L.), and warrants closer attention.

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