# Plant pathogens and biological control of weeds in South Africa: a review of projects and progress during the last decade

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The use of plant pathogens for biological control of weeds in South Africa was reviewed in 1991. In this review we focus on subsequent progress and projects, in particular the programmes against *Acacia mearnsii* De Wild., *A. pycnantha* Benth., *Hakea sericea* Schrader, *Eichhornia crassipes* (Mart.) Solms-Laub., *Chromolaena odorata* (L.) King & Robinson, *Lantana camara* L., *Myriophyllum aquaticum* (Velloso) Verdcourt and *Rubus cuneifolius* Pursh. Two mycoherbicides were registered, namely (i) a formulation of *Cylindrobasidium laeve* (Pers.: Fr.) Chamuris (Stumpout®), which kills cut stumps of *A. mearnsii* and *A. pycnantha* and (ii) a granular formulation of *Colletotrichum gloeosporioides* (Penz.) Sacc. (Hakatak®), which kills mainly seedlings but also adult plants of *H. sericea.* Studies on locally occurring pathogens included (i) the newly described fungus, *Ceratocystis albofundus* Wingfield, De Beer & Morris, on *A. mearnsii* and (ii) a strain of the bacterium *Xanthomonas campestris* (Pammel) Dawson on *M. aquaticum.* Owing to a lack of host specificity, the rust *Gymnoconia nitens* (Schw.) Kern & Thur. was rejected for introduction against *R. cuneifolius.* The South American leaf pathogen, *Mycovellosiella lantanae* (Chupp) Deighton var. *lantanae,* proved host specific to *L. camara* and clearance for release in South Africa is pending. Several isolates of *Septoria ekmaniana* Petr. & Cif. and *Mycovellosiella perfoliata* (Ellis & Everh.) Munt.-Cvetk. from South and Central America were screened on the South African form of *C. odorata,* but none were pathogenic. Studies on local pathogens of *E. crassipes* included the newly recorded *Acremonium zonatum* Sawada & Gams, *Alternaria eichhorniae* Nag-Raj & Ponnappa and *Cercospora piaropi* Tharp, while the Brazilian rust fungus *Uredo eichhorniae* Fragoso & Ciferri, was introduced into quarantine for host-specificity studies.

Key words: biological weed control, mycoherbicides, plant pathogens.

The use of plant pathogens for biological control of weeds in South Africa was first reviewed by Morris (1991) and covered projects undertaken during the 1980s. In this review, we focus on subsequent progress and projects against terrestrial and aquatic weeds and include research that was either initiated just prior to the previous review, completed during the 1990s or which is still in progress. In particular, we focus on the programmes against *Acacia mearnsii* De Wild., *Chromolaena odorata* (L.) King & Robinson, *Eichhornia crassipes* (Mart.) Solms-Laub., *Hakea sericea* Schrader, *Lantana camara* L., *Myriophyllum aquaticum* (Velloso) Verdcourt and *Rubus cuneifolius* Pursh. Most of these weeds are also reviewed elsewhere in this volume and introductory details are thus only provided for species not otherwise covered (*e.g. R. cuneifolius*). Projects incorporating mostly unpublished information are discussed in greater detail. The biocontrol programme involving the use of the gall-forming rust fungus, *Uromycladium tepperianum* (Sacc.) McAlp. against *Acacia saligna* (Labill.) Wendl. is reviewed elsewhere (Morris, this issue).

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## ACACIA MEARNSII AND A. PYCNANTHA

The economic importance of *A. mearnsii* (black wattle) as a timber crop in southern Africa has dictated that research on plant pathogens be limited to locally occurring species. Studies have thus focussed on two fungi, *Ceratocystis albofundus* Wingfield, De Beer & Morris, and *Cylindrobasidium laeve* (Pers.: Fr.) Chamuris, neither of which were previously recorded in southern Africa.

### *Ceratocystis albofundus*

*Ceratocystis albofundus* was first isolated in 1990, from a tree exhibiting gummosis and die-back symptoms in the upper reaches of the Umkomaas valley in KwaZulu-Natal Province. The fungus was readily isolated from affected tissue and reinoculation of young trees resulted in the typical

gum exudation from cracks in the bark of the stems and branches and ultimately the death of the trees (Morris *et al.* 1993). The fungus was initially identified as *Ceratocystis fimbriata* Ell. & Halst., but was since described as *C. albofundus* (Wingfield *et al.* 1996).

The fungus readily produces conidia in culture and these were used for a series of field trials at several localities in the Western Cape and KwaZulu-Natal Provinces. Inoculation methods included (i) agar culture pieces placed under the bark of stems, (ii) conidial suspensions in distilled water placed into holes drilled into the stem or into a thin cut made around the circumference of the tree and (iii) cut stump treatments. These inoculations were repeated on different batches of trees, at 2–3-month intervals throughout the year. Besides the cut stump treatments, most of the inoculations were successful. The highest mortality rates (80–100 %) were achieved when conidial suspensions were inoculated into thin cuts around the trees' circumference during spring or early summer. Inoculations at other times of the year were less successful.

Despite its impact, *C. albofundus* is not currently used in wattle clearing programmes for several reasons. Inoculation is labour-intensive, only effective on standing trees and thereby inappropriate in dense, young stands where trees are felled to allow access. Because mortality rates are only suitably high when the fungus is applied in spring or early summer (when most farm labour is otherwise engaged), the fungus has not featured in the clearing programmes of the 'Working for Water' Programme, which are active throughout the year. Finally, the South African Wattle Growers Union is concerned about the possibility of increased fungal infections in plantations close to inoculated infestations. Indeed, gummosis and subsequent mortality has been a major problem in commercial wattle plantations for decades (Stephens & Goldschmidt 1939; Roux *et al.* 1995), although the cause of this was unknown. The present studies have confirmed that *C. albofundus* is the causative agent, although other physiological and environmental factors may also play a role, and breeding programmes aimed at reducing this problem have since become more focussed and accelerated.

### *Cylindrobasidium laeve*

When felled, the stumps of young wattle trees often coppice to form multi-stemmed trees that are more difficult to control than the original trees. Stump treatments with various herbicides, often in a diesel carrier, have thus accompanied clearing operations. However, these treatments are undesirable along water courses or in catchment areas, where many *A. mearnsii* infestations occur, necessitating alternative stump treatments.

Field trials on the efficacy of *Ceratocystis albofundus* as a stump treatment, at a site near George (Western Cape Province), revealed that almost all of the untreated and treated stumps had died after 4–8 months, even though they had started coppicing. This unexpected mortality was caused by a fungus, later identified as *C. laeve,* which formed a white hymenial layer covering parts of the stumps. Subsequent observations in the George area indicated that all cut stumps of *A. mearnsii* trees had died due to natural infection by *C. laeve.* Conditions of high rainfall and high humidity in the *A. mearnsii* stands probably favoured the sporulation and spread of the fungus. The fungus was later isolated from a naturally infected stump in the Joubertina area (Eastern Cape Province).

The fungus was isolated from infected stumps into pure culture. During preliminary trials, it readily reinfected and killed cut stumps of *A. mearnsii* saplings. A range of media and environmental conditions were tested to induce production of basidia and basidiospores for use as inoculum. Optimal basidiospore production was obtained by first growing *C. laeve* on a modified Potato-Marmite-Dextrose medium (Smash® 15 g, Marmite® 40 g, dextrose 7.5 g, agar 15 g, per 1 l water) for three days at 25 °C and then transferring small blocks of this agar to Petri dishes containing small, autoclaved discs of *A. mearnsii* wood (2–3 cm diameter, 2 mm thick), cut from young saplings, on a water agar (1.5 %) layer. A hole (1.5 × 1.5 cm) was cut in the lids of the Petri dishes, over which was pasted autoclaved pieces of filter paper (Whatman's No. 1), for aeration of the cultures (Adams & Butler 1983; Murray 1984). These plates were incubated at 19 °C and a 12-hour photophase under fluorescent and near-UV light.

The basidiospores are small, thin-walled and short-lived and several storage methods, aimed at extending their period of viability, were evaluated. These included dry storage on the wooden discs and storage in sterile, distilled water, concentrated sucrose solution, glycerol, mineral oil, sunflower oil, olive oil and soybean oil. Storage in mineral oil proved the most effective and a viability of over 50 % could be maintained for one year when stored in the refrigerator at 5 °C. The spores are

harvested by removing the colonized wooden discs from the Petri dishes, allowing them to dry for 30 minutes on a laminar-flow bench, immersing them in mineral oil and shaking well. As the spores have a tendency to form clumps and are not readily redispersed, talc is added to the oil as a dispersant. The solution is then dispensed into small plastic sachets of approximately 10 ml, with a final minimum concentration of $2 \times 10^6$ basidiospores/ml.

During field trials on *A. mearnsii* in the Stellenbosch, Wellington, Heidelberg and George areas and on *Acacia pycnantha* Benth. (golden wattle) in the Bredasdorp and Stellenbosch areas (all Western Cape Province), cut stump surfaces were treated with approximately 0.3–1.0 ml (depending on tree diameter) of a basidiospore suspension. In earlier trials, the spores were suspended in distilled water, but in later trials the mineral oil suspension (see above) was diluted with sunflower oil (10 ml sachet in 200 ml; approximately $1 \times 10^5$ spores/ml) and applied to the stump surface with a small brush. In each trial, 100 stumps were treated with 100 untreated stumps as controls. Treated stump mortality was mostly around 80–100 %, while untreated stump mortality was usually 30–60 %, but on occasion up to 90 %, probably because of natural colonization by decay fungi. However, mortality was always higher on the stumps that were treated with *C. laeve.* Treatments applied throughout the year appeared to be equally effective.

The above formulation was thus registered in South Africa (as Stumpout®) for the treatment of *A. mearnsii* and *A. pycnantha* stumps, to prevent resprouting. A small laboratory and growth room was set up on the PPRI's premises at Stellenbosch for production, formulation and packaging of the fungus and the product is now available for distribution. This is the second mycoherbicide registered worldwide for biological control of a tree weed. A formulation of *Chondrosteum purpureum* (Pers.: Fr.) Pouzar (BioChon®, Koppert Biological Systems) was approved for use in the Netherlands to prevent regrowth of cut stumps of various hardwoods, and is currently under development in Canada for use on woody weeds in forestry (Wall 1994; Prasad 1996).

*Cylindrobasidium laeve* is known from North America, where it colonizes fallen decaying branches and felled logs causing a white rot (Ginns & Lefebvre 1993). As the fungus is already present in South Africa, where it may have occurred for some time, it is not considered to pose a threat to commercial fruit-tree orchards, forestry plantations or indigenous forests. Several risk analysis studies for *C. purpureum* similarly concluded that it is safe for use, even though it is known as a minor tree pathogen and infects several non-target species (De Jong *et al.* 1990, 1996; Gosselin *et al.* 1995; Wall 1997).

### HAKEA SERICEA

Research on the use of the fungus *Colletotrichum gloeosporioides* (Penz.) Sacc. for the biocontrol of *H. sericea* (silky hakea) was reviewed by Morris (1991). The success of a dried preparation of fungal-colonized wheat bran pieces for the treatment of seedlings (Morris 1989), led to an investigation by private industry on the mass production and registration of a suitable inoculum formulation for the treatment of young seedlings. A granular product has since been developed by National Chemical Products, a division of Sentrachem. The granules comprised a gluten core around which a soybean flour and *C. gloeosporioides* mycelium coating is added, and are incubated for several days to allow fungal colonization before drying. This product was granted provisional registration (as Hakatak®) in 1990 for use in South Africa.

A unique method of application was devised by the Cape Nature Conservation Department and involved the use of large water buckets used for fire fighting that are suspended below a helicopter. The buckets were adapted by fitting a wind-driven revolving disc below their outlets, to facilitate an even distribution of granules. Using this method, granules were applied to 80 ha of seedling-infested mountainside. Like the fungus-colonized wheat bran flakes (Morris 1989), the granules relied on re-wetting by rain to induce fungal sporulation on the granule surfaces and rain-splash for spread to adjacent seedlings.

However, the registration was allowed to lapse in 1991 for two reasons. Budget cuts by the only user, Cape Nature Conservation, caused the *H. sericea* control programme to be suspended and production was stopped by National Chemical Products, because of rationalization and the limited market for the product. This situation is indicative of the experiences of bioherbicide researchers worldwide (Third International Bioherbicide Workshop, Stellenbosch, 1996) that the market for host-specific bioherbicides is too small to be of much interest to industry at large. The production of bioherbicides seems better suited to smaller companies that can target niche markets.

Recently, a dried spore preparation of the

fungus was supplied, by the PPRI, to a small, but growing, number of users. The dried spores are re-suspended in water and wound-inoculated into the lower stems of stands of *H. sericea* trees. Either all the trees, or a zigzag pathway of trees, are inoculated in a stand allowing the disease to spread naturally. The fungus grows through the bark around the stems and kills the trees. This product has not been registered and is provided free of charge. The design of a simple hand-held applicator which wounds the tree lightly and applies the fungus at the same time is also supplied to users.

## EICHHORNIA CRASSIPES

Although research on *E. crassipes* (water hyacinth) was ongoing at the time, the results were not included in the previous review (Morris 1991). Before the initiation of these studies in the 1980s, no pathogens were known to occur on *E. crassipes* in South Africa.

### *Acremonium zonatum*

Naturally infected plants with the typical large zonate leaf lesions of *Acremonium zonatum* Sawada & Gams (Rintz 1973) were collected from the Enseleni River in northern KwaZulu-Natal in 1996. There are no other records of the disease in South Africa and this appears to be the first occurrence of the pathogen in the country. Infected plants were also observed in Zambia (M.P. Hill, pers. comm.) and it appears that the pathogen has only recently moved southwards into South Africa.

### *Alternaria eichhorniae*

Since 1985, *Alternaria eichhorniae* Nag-Raj & Ponnappa has been recorded on *E. crassipes* at sites in the Western Cape, KwaZulu-Natal and Gauteng Provinces, suggesting that it is more widespread in South Africa. This pathogen causes red-brown leaf lesions, varying in size and with indistinct margins (Nag-Raj & Ponnappa 1970), and has probably been in South Africa for much longer. Although the pathogen may be widespread in an area and may cause the death of entire leaves, it appears to affect mainly the older leaves with little effect on the size and density of the plants.

### *Cercospora piaropi* and *C. rodmanii*

*Cercospora piaropi* Tharp was first recorded in South Africa in 1986, from a small farm dam near Hectorspruit in Mpumalanga Province (Morris 1990). The disease became fairly severe and was linked with the decline of the weed on that dam. The pathogen may have been inadvertently introduced via a shipment of *Neochetina eichhorniae* Warner weevils from Australia, which were released on the dam several months before the disease was observed. However, the dam is close to the Mozambique border and the pathogen may have arrived via that country. The pathogen causes numerous small dark-brown leaf spots on the leaves and petioles, which may coalesce and kill entire leaves. *Cercospora piaropi* was established at other localities in the Gauteng, Eastern Cape, KwaZulu-Natal and Western Cape Provinces, by the translocation of naturally infected or inoculated plants.

The closely related *Cercospora rodmanii* Conway is regarded as being more virulent and damaging than *C. piaropi* (Freeman & Charudattan 1984) and a culture of this species was introduced from Florida, USA, in 1988. A comparison of symptoms of the two pathogens revealed that *C. rodmanii* attacked slightly younger leaves than *C. piaropi* (McLennan, unpubl.). Some of the tests used to determine the host range of *C. rodmanii* (Conway & Freeman 1977) were repeated in South Africa (McLennan, unpubl.) and this pathogen was later released at several localities. Some of the characteristics used to separate *C. piaropi* and *C. rodmanii* (*e.g.* the degree of development of the stroma at the base of the conidiophores) (Conway 1976), proved to be variable (Morris 1990) and the pathogens may thus represent a single species. These similarities have also made it impossible to determine which isolate or species is present in a given area in South Africa. Although these pathogen(s) occur extensively on *E. crassipes* in the Western Cape, there has been no significant decline in weed populations.

A study was undertaken to increase the effectiveness of *A. zonatum, A. eichhorniae* and *C. piaropi* by applying them in dual combination trials. Results showed that when applied together, lesion diameter increased twofold compared to single pathogen inoculations. To achieve the sustainable, practical levels of control necessary for water hyacinth, the use of dual combinations are essential to increase the plant's level of biotic stress so that its capacity for compensatory growth and population resurgence is curtailed.

### *Uredo eichhorniae*

In a combined project with the University of Florida (Florida, USA), plants infected with the rust fungus *Uredo eichhorniae* Fragoso & Ciferri were introduced into quarantine in South Africa in


**Fig. 1**
***Rubus cuneifolius.***
(Drawn by M. Steyn; commissioned by Plant Protection Research Institute.)

1997. By continuous transfer, a culture of the rust is being maintained on plants in the greenhouse and studies to determine its life cycle and host range are in progress. However, progress on the rust fungus has been limited by the lack of consistent and viable uredospores and further searches will be made in Brazil to find the aecial stage (or alternate host) in the field. Studies on the effects of temperature changes on the rust pustule and uredospore development will be initiated with a view to optimizing uredospore production.

## *MYRIOPHYLLUM AQUATICUM*

Wilted aerial shoots of the aquatic weed *M. aquaticum* (parrot's feather) were first observed near Bronkhorstspruit in Mpumalanga Province in 1990 and similar symptoms were subsequently observed in most areas infested by the weed. Scattered, individual aerial shoots wilt from the tip downwards for about 10 cm and assume a greyish colour. Microscopical examination of infected shoots revealed that the xylem vessels of the stems and leaves were filled with bacterial cells. The causal bacterium was isolated into pure culture and identified as a strain of *Xanthomonas campestris* (Pammel) Dawson (Fouche 1994).

Although natural infection seldom exceeds 1 % of the aerial shoots, plots sprayed with a suspension of the bacterium ($10^8$ cfu/ml) suffered 100 % shoot infection when the plants were sprayed early in the morning, when guttation droplets were still present on the leaves. Although all the above-water parts of the plants died, about six weeks later new shoots appeared from the submerged stems and the plants recovered. Microscopical examination suggested that the bacterium does not penetrate into the older underwater stems, thereby negating its potential as a bioherbicide.

## *RUBUS CUNEIFOLIUS*

*Rubus cuneifolius* Pursh (American bramble; Fig. 1) is a sprawling, thorny shrub from the southeastern USA, that has become naturalized throughout the Provinces of KwaZulu-Natal and Mpumalanga (Fig. 2). It forms dense, impenetrable thickets along roadsides and in natural grassland and is particularly problematic in commercial forests in the KwaZulu-Natal midlands, where it hampers forestry operations and requires expensive control measures (Erasmus 1984; Byford-Jones 1990). *Rubus cuneifolius* is one of several species and forms of *Rubus* (of both European and American origin) that were introduced into South Africa for berry production, and some of these continue to be farmed in small-scale but profitable enterprises (Brasé 1995). However, some species have become weedy (Spies & Du Plessis 1985; Henderson 1995).

In South Africa, *R. cuneifolius* is characterized by two forms. The smaller form, with upright standing canes, occurs mostly in the higher lying areas (above 1000 m), while the larger, sprawling form occurs in lower lying areas (below 1000 m).

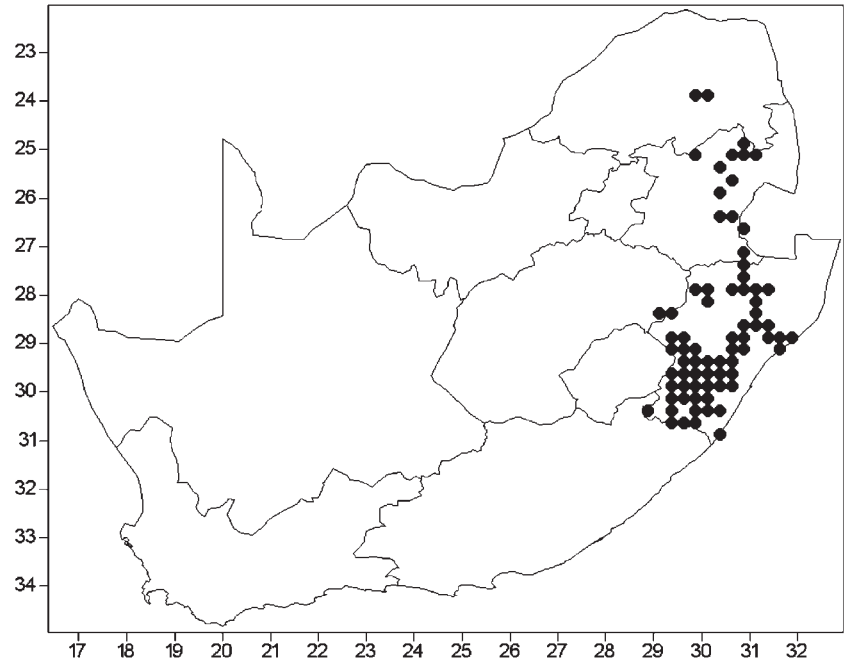


**Fig. 2**

**Distribution of *Rubus cuneifolius* in South Africa.**

(Drawn by L. Henderson, Plant Protection Research Institute, Pretoria.)

Although both forms are regarded as the same species (Erasmus 1984; Spies & Du Plessis 1985), we believe that they may represent two distinct species because of differences in susceptibility to the pathogens *Gymnoconia nitens* (Schwein.) F. Kern & H.W. Thurston (see below) and *Kuehneola uredinis* (Link) Arth. (McLennan, unpubl.). *Kuehneola uredinis,* which is widespread on *Rubus* species in South Africa (Van Reenen 1995), was thought to contribute to the weed's control (Wager 1947), but only attacks the upright form (McLennan, unpubl.). This rust is also widespread in Hawaii, but does not cause sufficient damage to warrant its use for biocontrol (Gardner & Hodges 1983).

## 'Orange rust'

These fungi cause one of the major diseases of *Rubus* species in the USA and limit the cultivation of certain species. The fungi grow systemically, infecting the young sprouting canes early in the growing season and then spreading throughout the canes and root system. Infected canes are rendered sterile and the plants become weakened and may die (Kleiner & Travis 1991). The undersides of the leaves on affected canes become almost entirely covered with large orange spore-producing structures, giving rise to the common name. 'Orange rust' occurs in several forms in North America and on several *Rubus* species. These forms are often, but not always, given different species names.

*Arthuriomyces peckianus* (Howe) Cumm. & Y. Hirat. is the long-cycled form that develops spermogonia, aecia and telia and whose teliospores germinate to produce four basidiospores. *Gymnoconia nitens* (Schw.) Kern & Thur. is a short-cycled form that produces only spermogonia and aecial-telia, the spores of which are morphologically identical to the aeciospores of *A. peckianus,* but function as teliospores by germinating to produce two or four (or more) basidiospores (Kunkel 1913; Dodge & Gaiser 1926). *Rubus cuneifolius* is one of several recorded hosts of *G. nitens* (Arthur 1917; Kunkel 1920).

Plants of *R. cuneifolius* infected with *G. nitens,* the short-cycled form, were introduced into quarantine in South Africa from Gainesville (Florida, USA) in 1994. The plants were potted and allowed to grow out in a greenhouse at 18–25 °C. The first shoots produced were etiolated and small-leafed with pustules of aecial-teliospores developing on the leaf undersurfaces, and forms producing both two or four basidiospores were found. Potted

*R. cuneifolius* plants, collected near Richmond (all sprawling forms), Cedara, Kranskop and Mooi River (all upright forms) in KwaZulu-Natal, were cut back to soil level to induce new shoot formation. New shoots (2–4 cm long) were inoculated with fresh aecial-teliospores, suspended in distilled water and Tween 80 (0.01 %), using a soft paint brush. The inoculated plants were covered with a plastic sheet and incubated in the dark at 20–21 °C for three or four days, after which the sheet was removed and the plants returned to the greenhouse. Typical etiolated shoots with sporulating leaves developed on some of the sprawling-type plants from Richmond and systemic infection was confirmed by microscopical examination of transverse sections of roots, stems and leaves. By contrast, no symptoms developed on any plants of the upright form of *R. cuneifolius* and the fungus was not detected in sections from these plants.

Sporulation on plants is normally seasonal, occurring in the spring and summer (Kleiner & Travis 1991). However, under laboratory conditions, sporulating shoots were induced on infected *R. cuneifolius* plants by cutting them back to soil level, incubating them at 10 °C for two weeks and then returning them to the greenhouse. Within 6–8 weeks, sporulating shoots developed and spores could be harvested and used for inoculation experiments.

Host-specificity trials incorporated several commercial berry varieties (blackberries, black raspberries and red raspberries) as well as indigenous and weedy *Rubus* species. Young shoots were inoculated and examined for symptoms and systemic infection. Several plants of Boysenberry, a minor commercial variety of blackberry, became systemically infected, although no symptoms developed and no sporulation was induced on these plants. Stems of Loganberry (blackberry) became swollen and cracked at the site of inoculation, but the infections remained localized and hyphae did not reach the pith. Localized systemic infections, manifested as small, thickened side-shoots (1–2 cm long), also developed around the inoculation sites on the stems of the native *R. rigidus* Sm., although these shoots grew no further and no sporulation occurred on them. Abnormal localized infections, comprising misshapen leaves with thickened petioles, also occurred on inoculated stems of the native *R. pinnatus* Willd. and *R. ludwigii* Eckl. & Zeyh.

It was decided that the current strain of *G. nitens* should not be released in South Africa because the rust isolates only infected the sprawling form of *R. cuneifolius,* systemically infected one commercial variety and partially infected one native species. Similar studies on strains of *G. nitens* in Hawaii also culminated in rejection because of a lack of host specificity and infection of indigenous species (Gardner *et al.* 1997).

### *CHROMOLAENA ODORATA*

Surveys for strains of the pathogens *Septoria ekmaniana* Petr. & Cif. and *Mycovellosiella perfoliata* (Ellis & Everh.) Munt.-Cvetk., which are pathogenic to the South African form of *C. odorata,* have been conducted since 1987. Some 54 collections of *S. ekmaniana* and 39 collections of *M. perfoliata* were obtained over a wide geographical range from South and Central America and isolated into pure culture. Most isolates were reinoculated onto the South African form of *C. odorata.* A few of the isolates of *S. ekmaniana* caused small necrotic lesions, but colonization was limited to only a few host cells. Most isolates caused no visible symptoms and although spores germinated, no penetration took place. Similarly, a few of the isolates of *M. perfoliata* also caused small necrotic lesions, eventually producing shot-hole symptoms. These results have again questioned the identity of the South African plants, particularly since plants with the same leaf shape, colour and odour as those in South Africa have not yet been located during our surveys in the Americas. However, these studies are ongoing, with many isolates still to be tested. Both pathogens are considered to be promising biocontrol agents for *C. odorata* (Elango *et al.* 1993; Barreto & Evans 1994).

### *LANTANA CAMARA*

Samples of diseased *L. camara* leaves were collected during several surveys in South and Central America from 1987 to 1997. The fungus *Mycovellosiella lantanae* (Chupp) Deighton var. *lantanae,* which causes necrotic leaf spots and extensive defoliation in some areas, was the most promising potential agent (Evans 1987; Barreto *et al.* 1995). Isolates from different localities were inoculated onto the different colour varieties of *L. camara* from South Africa. An isolate from Florida was particularly virulent to the orange-flowered form, forming numerous large chlorotic lesions on the young leaves within 10 days of inoculation. The lesions later became partly necrotic, causing the infected leaves to abscise. Fewer and smaller chlorotic lesions developed on the pink-flowered form after about 21 days.

The Florida isolate was also screened on several ornamental and native species within the family Verbenaceae and typical lesions only developed on *L. camara.* On one occasion, two small fungal colonies typical of *M. lantanae* var. *lantanae* were observed microscopically in a cleared and stained leaf of the native *Lantana rugosa* Thunb., but these failed to sporulate when the leaf was incubated on moist filter paper in a Petri dish. No further colonies were observed on *L. rugosa* during subsequent inoculations, suggesting that *M. lantanae* var. *lantanae* is suitable for release in South Africa. Other isolates are being screened to identify those that are more pathogenic to the other colour forms of *L. camara.*

## OTHER PROJECTS

A new project that commenced recently involved a survey for natural enemies of the troublesome alga, *Cladophora glomerata* (L.) Kütz, which is a cosmopolitan inhabitant of alkaline streams and lakes. In South Africa, the alga forms extensive growths in irrigation canals where it causes blockages of canal structures and pump equipment, leading to extensive water losses and damage to equipment. Control operations currently include mechanical and chemical methods and the surveys were thus initiated to determine the feasibility of biological control in the irrigation schemes.

The invasive tree *Acacia cyclops* A. Cunn. ex G. Don. is the most common woody weed in the southern and southwestern regions of South Africa. However, the trees are an important source of fuel wood and income for poor communities in these areas, thereby limiting the options for biological control. A locally occurring die-back disease presents an opportunity to develop a bioherbicide that can be used in conservation areas, with minimal risk to tree stands that are being utilized. Although a complex of pathogenic organisms appears to be involved, an unidentified basidiomycete has been isolated and has proven to be highly pathogenic in laboratory trials. Field trials are currently in progress to assess its potential.

## CONCLUSIONS

Programmes involving plant pathogens have covered a wide range of organisms on a wide range of weeds. Some projects have provided practical solutions to problems *e.g.* the development of Stumpout® for the treatment of wattle stumps and the use of *C. gloeosporioides* for the control of *H. sericea.* Other projects have been less successful and have culminated in the rejection of potential agents for various reasons and these include *C. albofundus* on *A. mearnsii, X. campestris* on *M. aquaticum* and *G. nitens* on *R. cuneifolius.* However, permission for the release of *M. lantanae* var. *lantanae* against *L. camara* is pending and several other projects are ongoing. Biocontrol projects involving pathogens in South Africa have mostly been successful and several priorities for the future have been identified. Of particular importance are (i) the discovery of an isolate of a pathogen that attacks the South African form of *C. odorata* and (ii) evaluation of the Brazilian rust *U. eichhorniae* for the control of *E. crassipes.*

## ACKNOWLEDGEMENTS

We thank J. Uys and G.A. Samuels for technical help with all of the above projects. W. Fouche initiated the studies of *X. campestris* on *M. aquaticum,* while S. McLennan conducted the initial work on *Rubus* diseases and M. Serdani assisted with the *C. odorata* and *L. camara* work. The identity of *C. laeve* was determined by J. Ginns (Biosystematics Research Institute, Ottowa, Canada). We thank R. Charudattan (University of Florida, Gainesville, USA) for supplying the cultures of *C. rodmanii* and *G. nitens,* and H.C. Evans and C.A. Ellison (International Institute of Biological Control, Ascot, UK) for providing samples of *S. ekmaniana* and *M. perfoliata.* C.J. Cilliers and M.P. Hill provided the first record of *A. zonatum* in South Africa. We are also grateful to M.P. Hill and T. Olckers for reviewing earlier drafts of the manuscript.

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