Diseases of Black Wattle in South Africa – A Review

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SYNOPSIS

Black wattle (*Acacia mearnsii*) is an economically important plantation tree in many parts of the world. In South Africa it is mainly planted for the production of tannins and high quality pulp. Wattle trees are affected by various diseases, some of which have led to devastating losses and the termination of planting programmes. The potential threat of new black wattle diseases in South Africa is of concern. The threat of disease is enhanced by the fact that *A. mearnsii* is planted in monoculture. This review provides a summary of *A. mearnsii* diseases caused by fungi, with special reference to the South African situation.

INTRODUCTION

Acacia mearnsii de Wild (Black wattle) is native to Australia and has been planted in many parts of the world. Wattles are leguminous plants and play an important role in nitrogen fixation. It is, therefore, often planted in rotation with other crops (Sherry, 1971). *A. mearnsii* is used in soil reclamation, in wind breaks and the wood is a valuable source of fuel, mining timber and pulp (Acland, 1971; Anonymous, 1993; Annecke, 1978; Gibson, 1975; Rusk *et al.* 1990; Sherry, 1971). One of the most important characteristics of *A. mearnsii* is in the bark, which is one of the richest known sources of vegetable tannins. These tannins have various industrial uses, including leather tanning (Acland, 1971; Keet, 1938; Sherry, 1971).

Acacia mearnsii trees are planted in a monoculture system in South Africa, with a relatively uniform genetic base. As exotics, they have been introduced to new enemies against which they lack natural resistance. These facts potentially increase the risks associated with disease (Wingfield, 1984; Wingfield, 1987a; Wingfield, 1987b). A knowledge of all pathogens occurring on *A. mearnsii*, particularly in South Africa, will enable us to evaluate the disease situation and to adapt breeding programs to minimise losses. Various fungi have been found on, or isolated from diseased *A. mearnsii* during the past century, most of which are saprophytes. A number are, however, well recognised pathogens (*Table 1*). This review will focus on those fungi that are known pathogens and that are also believed to have some economic significance.

DISEASES OCCURRING WORLD WIDE

Stem and foliage diseases

Pink disease, caused by *Corticium salmonicolor* Berk. and Br., has been recorded on *A. mearnsii* in Malaysia, Indonesia and Mauritius. This disease has also been recorded on other *Acacia* species elsewhere in the world (Bakshi, 1976; Gibson, 1975; Sherry, 1971). In Kerala (India), it is the cause of severe disease on *Acacia auriculiformis* A. Cunn.: Benth. (Florence and Balasundaran, 1991). This fungus has also been reported on *A. mearnsii* in South Africa (Bakshi, 1976; Roberts, 1957). Pink disease causes death of branches, accompanied by leaf cast due to the girdling of the branches. Some of the earliest symptoms are the exudation of gum, followed by the growth of mycelia on the bark of the tree. As the infected bark dies, patches of pink mycelium appear on the bark surface. The fungus affects trees of all ages and is a serious pathogen on various other plantation species, including *Hevea* and *Eucalyptus* (Gibson, 1974; Wingfield and Kemp, 1993).

Black spots on the foliage and sunken lesions on green twigs of *A. mearnsii* in India have been attributed to the pathogen, *Cercosporella theae* Petch (Gibson, 1974). Other leaf and stem diseases include a leaf spot caused by *Camptomeris albiziae* (Petch) Mason (Sherry, 1971; Wingfield and Kemp, 1993). In Sri Lanka and India *Calonectria indusiata* Seaver causes brown to black spots on leaves of *A. mearnsii*. This disease was so severe in certain areas that it resulted in complete defoliation of trees. In Sri Lanka it was also found to cause stem cankers on young *Acacia decurrens* (Wendl.) Willd. (Bakshi, 1976).

Physalospora abdita (Berk. and Curt.) N.E. Stevens can cause severe disease on previously wounded trees. This normally saprophytic fungus can cause cankers, leaf blight and root rot of weakened trees (Gibson, 1975; Spaulding, 1961). *Glomerella acaciae* (K. Ito and Shibukawa) K. Ito was described as the cause of anthracnose of *Acacia dealbata* Link and *Acacia mearnsii* in Japan. During wet periods it caused lesions on leaves, stems and petioles of seedlings. In severe cases young shoots were girdled, leading to defoliation (Hodges,

TABLE 1: List of pathogens of A. mearnsii, *with associated symptoms and distribution.*

PATHOGEN	SYMPTOM	DISTRIBUTION	REFERENCE
Amauroderma rude (Berk) G. H. Cunn.	Root disease	South Africa	Sherry, 1971
Amauroderma rugosum (Blume and Nees) Torren	Collar rot	South Africa	Gibson, 1964; Spaulding, 1964
Calonectria theae Loos	Leaf spot	Sri Lanka, India	Bakshi, 1976
Ceratocystis sp.	Die-back, pith discolouration, blisters, lesions	South Africa, Brazil	Ribeiro *et al.*, 1985 Morris *et al.*,1993 De Beer, 1994
Camptomeris verruculosa (Syd.) Bessey	Spots	Dominica, Kenya, South Africa, Sudan	Gibson, 1975
Cercosporella theae Petch	Leaf spot, lesions on twigs, defoliation	India	Gibson, 1974
Coriolus hirsutus (Wolf. ex Fr.) Quél.	Wood rot	South Africa	Doidge, 1950 Sherry, 1971
Corticium salmonicolor Berk and BR.	Stem and twig cankers	Malaysia, Mauritius	Sherry, 1971, Gibson, 1975 Bakshi, 1976
Cylindrocladium scoparium Morgan	Root disease	South Africa	Doidge, 1950 Spaulding, 1964,Sherry, 1971 Gibson, 1975, Bakshi, 1976 Crous *et al.*, 1991
Ganoderma applanatum (Wallr.) Pat.	Heart rot	Australia, Sri Lanka, India Portugal, South Africa, Sri Lanka, New Zealand	Doidge, 1950 Spaulding, 1964 Sherry, 1971, Bakshi, 1976
Ganoderma lucidum Karst.	Root disease Heart rot	Taiwan, India, Java, South Africa	Doidge, 1950 Spaulding, 1964, Sherry, 1971 Bakshi, 1976
Glomerella acaciae (K. Ito and Shibukawa) K. Ito	Anthracnose, lesions, defoliation	Japan	Hodges, 1961
Lasiodiplodia theobromae (Pat.) Griff. and Maubl.	Root disease	South Africa	Gibson, 1975
Macrophomina phaseolina (Tassi.) Goid.	Root disease, die-back, gummosis	South Africa, Sri Lanka	Gibson, 1975 Bakshi, 1976, Foreman, 1987
Phoma herbarum Westend.	Twig die-back	Kenya	Olemba, 1972 Gibson, 1975
Physalospora abdita (Berk. and Curt.) N.E. Stevens	Stem and twig cankers Leaf blight, Root rot	Australia, India, North America, South Africa	Spaulding, 1964, Gibson, 1975; Bakshi, 1976
Phytophthora parasitica (Dastur.) Waterhouse	Black butt	South Africa	Zeijlemaker, 1969, 1971 Sherry, 1971; Gibson, 1975 Bakshi, 1976
Polystictus subiculoides Lloyd	Heart rot	India, South Africa, Sri Lanka	Doidge, 1950 Gibson, 1975
Poria albobrunnea Petch	Heart rot	Sri Lanka	Gibson, 1975
Rhizoctonia lamellifera Small	Wilting, die-back	South Africa	Doidge, 1950 Gibson, 1964
Trametes cingulata Berk	Heart rot	South Africa	Doidge, 1950 Gibson, 1975
Trametes meyenii (Klotzch) Lloyd	Heart rot	Kenya, South Africa	Doidge, 1950 Gibson, 1975 Van der Westhuizen and Eicker, 1994
Trametes roseola Pat. et Har.	Heart rot	South Africa	Doidge, 1950 Gibson, 1975
Uromycladium bisporum McAlp.	Leaf and twig rust, stem swellings	Australia, New Zealand	Gibson, 1975 Bakshi, 1976; Dick, 1985
Uromycladium notabile (Ludwig) McAlp	Galls	Australia, New Zealand	Gibson, 1975 Dick, 1985
Uromycladium tepperianum (Saccardo) McAlp	Galls	Australia, New Caledonia, New Zealand	Sherry, 1971 Bakshi, 1976 Dick, 1985
Uromycladium alpinum McAlp	Leaf rust	South Africa, Australia	Morris *et al.*, 1988 Wingfield and Kemp, 1993

1964):

In Kenya, *Phoma herbarum* Westend. was described as the cause of die-back after it had consistently been isolated from diseased *A. mearnsii* trees. Experiments, however, showed that new infections by *P. herbarum* can only be initiated through wounds (Gibson, 1975; Olembo, 1972).

Rusts

Uromycladium notabile (Ludw.) McAlp. affects the seed pods and distal ends of branches. The disease is characterised by the formation of galls and leads to the eventual death of branch tips, as well as to a reduction in viable seed production (Sherry, 1971). It can cause blister-like galls on leaves and petioles and in severe cases, death of young trees. Galls restrict water transport within trees and this leads to the die-back of the branches. In the 1920's it caused severe losses of *A. decurrens* in New Zealand (Dick, 1985).

Another rust fungus, *Uromycladium bisporum* McAlp. [=*U. acaciae* (Cooke) P. and H. Sydow] was reported on *A. mearnsii* and *A. dealbata* in New Zealand and Australia (Bakshi, 1976; Dick, 1985). This rust causes small depressed cankers or swollen distorted areas on branches and stems, where on leaves it causes brown powdery patches on the lower surfaces. It is, however, not considered to be of economic importance in New Zealand (Dick, 1985). In South Africa *Uromycladium alpinum* McAlp causes leaf rust of *A. mearnsii* (*Figure 1*). This pathogen has also been reported from Australia (Morris et. al. 1988). *Uromycladium tepperianum* (Sacc.) McAlp. was also reported from Australia as the cause of gall formation on branches, but Morris *et al.* (1988) questioned this report (Sherry, 1971; Bakshi, 1976; Dick, 1985).

Root disease

Fungi commonly recognised as root pathogens on *A. mearnsii* include *Cylindrocladium scoparium* Morgan and *Phytophthora parasitica* (Dastur.) Waterhouse. In South Africa, *C. scoparium* has been isolated from the roots of *A. mearnsii* and is considered to be the cause of root diseases of *A. mearnsii* in this country (Crous *et al.* 1991; Doidge, 1950; Spaulding, 1961; Wingfield; 1987b). *C. scoparium* has also been found to cause leaf spot and blight on *Acacia longifolia* (Andr.) Willd. in South Africa (Hagemann and Rose, 1988) as well as damping-off of *A. dealbata* (Bakshi, 1976).

Phytophthora parasitica was isolated from *A. mearnsii* with stem gummosis and black butt in South Africa (*Figure 4*) (Gibson, 1975; Sherry, 1971; Zeijlemaker, 1971; Zeijlemaker and Margot, 1971). Another root pathogen, *Macrophomina phaseolina* (Tassi) G. Goid., has lead to serious losses in forest nurseries. The latter pathogen occurs world-wide and on a wide range of hosts, including various species of *Pinus*, *Eucalyptus* and *Acacia* (Bakshi, 1976; Hodges, 1964). Symptoms of root diseases caused by *M. phaseolina* include stunting of seedlings, chlorosis and death of the foliage, while necrotic lesions are formed on the roots. Eventually the tree may die (Foreman, 1985). *M. phaseolina* has been reported on *A. mearnsii* and *A. decurrens* in Indonesia, Malawi, south Zimbabwe and Tanzania (Bakshi, 1976). Species of *Amauroderma*, *Armillaria*, and *Ganoderma lucidum* (Fr.) Karst. are probably the most widely occurring root pathogens on any tree species in the world, including *A. mearnsii* (Bakshi, 1976; Gibson, 1975; Sherry, 1971; Spaulding, 1964).

DISEASES IN SOUTH AFRICA

Gummosis

The term gummosis refers to a disease condition where gum is exuded from the tree. This exudation of gum is an inherent reaction of the tree to stressful conditions, either from external injury such as mechanical damage or pruning, factors affecting the growth of the tree or to infection by a pathogen. It should, however, be regarded as a disease symptom and not as a disease in itself (Sherry, 1971; Zeijlemaker, 1968). In South Africa and other countries, where *A. mearnsii* is planted commercially in plantations, gummosis is a serious problem, because it reduces bark quality and hinders stripping of the bark (Haigh, 1993; Sherry, 1971).

In South Africa the term gummosis has been applied to a complex of diseases associated with *A. mearnsii*. These include the following:

a. **Speckled gummosis:** This symptom is characterised by a large number of small lesions on the bark (*Figure 2*). Drops of gum are exuded from each of these lesions. Small cracks or holes are left in the bark if the tree recovers (Zeijlemaker, 1968). It has been suggested that this symptom is due to a genetic disorder, rather than a pathogen (Anonymous, 1959; Zeijlemaker, 1967).
b. **Blister lesions:** This symptom is characterised by the formation of blister lesions due to the accumulation of gum under apparently healthy bark (*Figure 7*). Gum is exuded when these blisters rupture (De Beer, 1994; Zeijlemaker, 1968).
c. **Mottled disease:** Symptoms of this disease are darkly coloured areas of dead and dying tissue, often on green bark (*Figure 3*). These spots can spread and form patches that eventually cover a large part of the stem. In isolated patches, cracks may develop through which gum is exuded (Kotzé, 1935; Sherry, 1971; Van der Byl, 1914; Zeijlemaker, 1968; Zeijlemaker, 1971). The disease appears to be most severe in young, vigorously growing trees, just after rains and following prolonged drought. Evidence from field observations suggests that the disease is most severe when trees are actively growing (Van der Byl, 1914). Isolations from these symptoms have yielded various fungi of which a *Phytophthora* sp. was most abundant (Zeijlemaker, 1963).
d. **Black butt:** One of the easiest symptoms to detect in *A. mearnsii* plantations is the extension of black flares of dead bark that spread upward from the base of stems (*Figure 4*). This symptom is also characterised by cracks starting at ground level and the exudation of gum

(Kotzé, 1935; Sherry, 1971; Zeijlemaker, 1968; Zeijlemaker, 1971). The causative agent of this disease was identified as *Phytophthora parasitica* (Zeijlemaker, 1971).

e. Blind pocket disease: In this case, sunken pits are formed in the stem giving rise to an undulating appearance, due to the inhibition of growth in some areas of the cambium (Bakshi, 1976; Zeijlemaker, 1967; Zeijlemaker, 1968).

Gummosis is most severe under moist conditions, especially in summer rainfall areas when conditions are optimal for fungal growth (Sherry, 1971; Stephens and Goldschmidt, 1938). Vigorous growth of trees apparently enhances the occurrence of symptoms. This has particularly been seen in experiments evaluating fertiliser applications on growth and bark production. The application of superphosphate and lime gave rise to a significant correlation with the severity of gummosis. The addition of superphosphate increased the occurrence and severity of gummosis, while the application of lime suppressed disease. This is ascribed to the fact that superphosphate increased growth of the trees, while lime slowed growth (Beard, 1962; Schönau, 1970; Sherry, 1971; Sherry and Schönau, 1967). The worst cases of gummosis have been recorded on trees growing on shallow or sandy soils (Ledeboer, 1940).

Gummosis has previously been ascribed to a combination of biological and physical factors (Gibson, 1975). In commercial plantations *A. mearnsii* is selected for higher yields and increased performance. To achieve this, as many sources of competition as possible are removed. Plantations are cleaned of weeds and thinned to densities that decrease competition, but still give high yields. These management strategies increase growth but also lead to higher incidences of gummosis (Sherry, 1971; Stephens and Goldschmidt, 1938; Zeijlemaker, 1971).

Van der Byl (1914) was first to investigate the possibility that a pathogen might be the cause of gummosis. Various fungi have been isolated from symptomatic tissue, including *Phytophthora parasitica var. parasitica* [= *P. parasitica* Dastur.) Waterhouse] from "mottled" and "tongue" lesions, a *Pestalotia* sp. from various symptoms and *Fusarium* and *Rhizoctonia* species from "black butt" and "mottled" symptoms. No single organism has, however, been associated with a specific symptom (Sherry, 1971; Stephens and Goldschmidt, 1938; Van der Byl, 1914; Zeijlemaker, 1968; Zeijlemaker, 1969).

Black butt

Black butt is characterised by a black discoloration of the bark at the base of trees (*Figure 4*). This discoloration spreads upwards along the stem through the extension of brown to black flare-like lesions. This is accompanied by the exudation of gum through cracks that form in the bark (Wingfield and Kemp, 1993; Zeijlemaker, 1971; Zeijlemaker and Margot, 1971). Black butt has been considered as one of the major symptoms in the gummosis complex. It was thought that the black butt symptoms appear in trees tolerant to gummosis. Black butt was thus considered as a secondary stage of gummosis (Zeijlemaker, 1963). It is economically important because it affects the thickest, most valuable bark at the base of trees. It also reduces the ease of bark stripping and leads to a reduction in bark yield. In severe cases it can also lead to the death of trees (Haigh, 1993; Moffet and Nixon, 1963; Sherry, 1971).

Phytophthora parasitica has been isolated from black butt and mottled lesions on the stems of symptomatic trees. It was therefore speculated that both the tongue lesions, extending from the base of the trees, and the mottled lesions are part of the black butt disease condition. Artificial inoculation with *P. parasitica* reproduced the symptoms of black butt and the organism was later re-isolated from the inoculated trees (Bakshi, 1976; Margot, 1971; Zeijlemaker, 1969; Zeijlemaker, 1971; Zeijlemaker and Margot, 1970; Zeijlemaker and Margot, 1971). The appearance of two different symptoms (black butt and mottled) caused by the same organism was ascribed to varying climatic conditions after a period of low temperatures (<6 °C). The black lesions extending from the base of the tree were thought to be due to mycelial growth in the tissue (Zeijlemaker, 1971).

Recently it was stated that the exact cause of black butt (black discoloration at the base of trees) is unknown (Wingfield and Kemp, 1993). These authors speculated that it is a complex disease condition, as suggested by Zeijlemaker (1968), and not due to the effect of any single pathogen. Infection by *P. parasitica* might provide entry sites for opportunistic pathogens. These secondary pathogens could then be responsible for the black lesions that spread towards the terminal growth point of the tree (Wingfield and Kemp, 1993). This hypothesis is based on the fact that *P. parasitica* is usually isolated only from the base of trees (Authors, unpublished).

Albert falls disease

Albert Falls disease derives its name from the area in Natal in which it was first reported between 1932 and 1935 (Stephens and Goldschmidt, 1938). The disease was characterised by yellowing and withering of the foliage or death of some of the branches. This was followed by the death of trees within five to fifteen days. The disease affected trees of all ages, but mainly those between one and five years of age (Ledeboer, 1940; Sherry, 1971; Stephens and Goldschmidt, 1938).

The disease in the Albert Falls area occurred in heavily thinned stands and it was suggested that it had always been present in the country. Fungi isolated from diseased trees included species of *Rhizoctonia*, *Phoma*, *Mucor*, *Trichoderma*, *Pestalotia* and *Fusarium*. It was however, thought that of these organisms, *Rhizoctonia lamellifera* Small was the primary cause of tree death (Doidge, 1950; Gibson, 1964; Lückhoff, 1964; Sherry, 1971). According to more recent reports the cause of Albert Falls disease is *Macrophomina phaseolina* (Gibson, 1975). *M. phaseolina* occurs on *A. mearnsii* and *A. decurrens* and has been reported as a root pathogen of *Acacia* spp. in Sri Lanka and other parts of Africa. Symptoms include die-back and gummosis of the stem and death of the roots (Bakshi, 1976; Gibson, 1975).

Ceratocystis wilt

This disease was first reported in 1989 from the Natal Midlands in a stand where all the trees had been mechanically damaged by the lopping of branches (Morris *et al.* 1993). Symptoms include wilting, die-back and eventually death of trees (*Figure 5*). Gum exudes from affected stems and branches, and the bark covered by red-brown to black discoloured areas (*Figure 6*). There are blisters or swollen gum pockets with yellow discolouration along the edges (*Figure 7*). Brown streaking is often evident in the wood (*Figure 8*) (De Beer, 1994; Morris *et al.*, 1993; Wingfield and Kemp, 1993).

The causal agent of this disease has been identified as a new species of *Ceratocystis*, which has yet to be named. It was first tentatively identified as *Ceratocystis fimbriata* Ell. and Halst., but after more detailed studies it was shown to represent a distinct taxon (De Beer, 1994). These studies included pathogenicity tests showing that the organism requires wounds to infect trees. Such wounds can originate from insect damage, environmental factors such as wind and hail or silvicultural practices. It is possible that this pathogen is spread by insects, which is typical of this group of fungi (De Beer, 1994; Morris *et al.*, 1993; Wingfield and Kemp, 1993; Wingfield *et al.* 1993).

A disease that could be the same as Ceratocystis wilt in South Africa, was described in Brazil by Ribeiro (1985) on *A. decurrens* (green wattle). The symptoms include wilting and death of branches, splitting of the wood and pith discolouration. The fungus isolated from diseased material was identified as *C. fimbriata* (Ribeiro *et al.* 1985). A wilt disease, characterised by the reddening of the bark followed by wilting of the foliage, was reported on *A. mearnsii* in South Africa (Bakshi, 1976). This author stated that the cause of the disease is unknown. It is, however, possible that this could have been either Ceratocystis wilt or Albert Falls disease. It is also speculated that the two diseases might be the same, although this supposition has not been substantiated.

Wood rot

Root collar rot was first reported on black wattle in 1930 and is characterised by the rotting of roots in the region of the root collar (Stephens and Goldschmidt, 1938). This disease weakens trees, which are then easily blown over by wind (Ledeboer, 1940). Wind blown trees are usually the first indication of the disease. Earlier symptoms include a blackening, cracking and exudation of gum from the base of trees, just above ground level. Mycelial growth is often evident in the cracks. Affected trees range from one to three or four years of age. The disease was thought to be caused by a *Rhizoctonia* species, although *Diplodia natalensis* Pole Evans [= *Lasiodiplodia theobromae* (Pat.) Griff. and Maubl.] were also reported from symptomatic tissue (Ledeboer, 1940; Sherry, 1971; Stephens and Goldschmidt, 1938). Lückhoff (1964) as well as Gibson (1964), however ascribed the cause of collar rot to *Ganoderma rugosum* Blume et Nees.

Laughton (1937) described a root disease of black wattle that affects the whole root system. The disease spread upwards along the stem forming black cankers. *Lasiodiplodia theobromae* was isolated from the symptomatic roots. It was thought that this fungus infects the roots after they were weakened by *Rhizoctonia*, a condition similar to that found in citrus (Laughton, 1937). *Schizophyllum commune* Fries has also been reported as a wound pathogen causing the withering and trunk rot of black wattle (Ledeboer, 1946; Spaulding, 1961).

Various fungi have been described as the cause of heart rot of *A. mearnsii*. In South Africa, fungi associated with this symptom include *Ganoderma applanatum* (S.F. Gray) Pat., *Polystictus subiculoides* Lloyd, *Trametes cingulata* Berk., *T. meyenii* (Klotzsch) Lloyd and *T. roseola* Pat. et. Har. and species of *Amauroderma* (Doidge, 1950; Gibson, 1975; Spaulding, 1964; Sherry, 1971). *Coriolus hirsitus* (Wolf. ex Fr.) Quél. has also been recorded as the cause of wood rot of *A. mearnsii* in South Africa (Doidge, 1950; Sherry, 1971).

Leaf diseases

In South Africa only three leaf diseases are known that affect black wattle in plantations (Wingfield and Kemp, 1993). The first is a leaf spot caused by *Camptomeris albizziae* (Petch) Mason (= *Stigmina verruculosa* Syd.) and the other a rust caused by *Uromycladium alpinum* Mc Alpine (*Figure 4*) (Gibson, 1975; Morris *et al.*, 1988; Wingfield and Kemp, 1993). The third disease is powdery mildew caused by an undetermined species of *Oidium*, which can be serious on young seedlings (Sherry, 1971).

CONCLUSIONS

The wattle industry in South Africa is an important source of employment and export capital. Diseases of *A. mearnsii* have, in the past not been considered to be of particular importance. This situation appears to be changing and is likely to continue to do so in the future. The potential for serious outbreaks of Ceratocystis wilt is great, although this primary pathogen has not had a serious impact as yet. This, combined with diseases such as black butt will have a negative effect on wattle production in the country. The threat of diseases entering South Africa from other countries must also receive serious consideration.

No comprehensive survey of black wattle diseases has been undetaken in South Africa. Such a survey is urgently required and will undoubtedly lead to the discovery of additional pathogens and lend perspective to our knowledge regarding their relative importance. It will also provide a foundation to clarify the cause of diseases such as black butt and gummosis.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Foundation for Research Development and the South African Wattle Growers Union for financial support during this study.

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