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Quambalaria species: increasing threat to eucalypt plantations in Australia

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Spotted gum (*Corymbia citriodora* subsp. *variegata* and *C. maculata*) is a valuable source of commercial timber and suitable for a wide range of different soil types in eastern Australia. The main biological constraint to further expansion of spotted gum plantations is Quambalaria shoot blight caused by the fungus *Quambalaria pitereka*. Surveys conducted to evaluate the impact of Quambalaria shoot blight have shown that the disease is present in all spotted gum plantations and on a range of *Corymbia* species and hybrids in subtropical and tropical regions surveyed in eastern Australia. More recently, *Q. eucalypti* has also been identified from a range of *Eucalyptus* species in these regions. Both pathogens have also been found associated with foliage blight and die-back of amenity trees and *Q. pitereka* in native stands of *Corymbia* species, which is the probable initial infection source for plantations. Infection by *Q. pitereka* commonly results in the repeated destruction of the growing tips and the subsequent formation of a bushy crown or death of trees in severe cases. In comparison, *Q. eucalypti* causes small, limited lesions and has in some cases been associated with insect feeding. It has not been recorded as causing severe shoot and stem blight. A better understanding of factors influencing disease development and host–pathogen interactions is essential in the development of a disease management strategy for these poorly understood but important pathogens in the rapidly expanding eucalypt (*Corymbia* and *Eucalyptus* spp.) plantation industry in subtropical and tropical eastern Australia.

Keywords: *Corymbia*, Quambalaria shoot blight

Introduction

There are a number of factors that make the establishment and successful management of eucalypt plantations in Australia more difficult than elsewhere. The most important of these factors are: (1) generally poor soil fertility, (2) low and irregular rainfall, and (3) the presence of endemic pests and diseases. Although many pests and diseases have been described from native eucalypts in Australia, their significance and impact on the development and long-term success of eucalypt plantations has yet to be fully appreciated.

Within Australia, particularly in the tropical and subtropical regions, there is limited knowledge regarding the complexities of matching species to sites or the management strategies required to reduce the impact of diseases (e.g. see Carnegie 2007b). Many of the species grown in plantations in these regions also occur in natural stands, including spotted gum (includes *Corymbia citriodora* subsp. *citriodora* [hereafter referred to as *C. citriodora*], *C. citriodora* subsp. *variegata* [hereafter referred to as *C. variegata*], *C. henryi* and *C. maculata*), *Eucalyptus dunnii*, *E. pilularis* and *E. grandis*. These native stands are likely to harbour diseases that act as sources of inoculum for plantations in close proximity. The expansion of eucalypt plantations has resulted in the rapid emergence of such pathogens. Thus identification and management of pathogens that threaten these plantations is paramount to the success of the industry in Australia.

Spotted gum, one of the main plantation species in eastern Australia, has experienced significant disease problems due to Quambalaria shoot blight caused by the fungus *Quambalaria pitereka* (J. Walker and Bertus) J.A. Simpson, formerly known as *Ramularia pitereka* J. Walker and Bertus. There is, however, little understanding of the biology of this pathogen or the impact that the associated disease could have on the development of hardwood plantations using spotted gum in subtropical and tropical regions of Australia. This review discusses the increasing significance of Quambalaria shoot blight and the impact of this disease on the establishment and profitability of spotted gum plantations in Australia.

Quambalaria species and symptoms

The genus *Quambalaria* presently includes five species, namely *Q. pitereka*, *Q. eucalypti*, *Q. cyanescens*, *Q. coryecup* and *Q. pusilla*, all of which have been identified from eucalypts (either *Eucalyptus* or *Corymbia* spp.) (Walker and Bertus 1971, Bertus and Walker 1974, Wingfield et al. 1993, Simpson 2000, Carnegie 2007a, 2007b, Paap et al. 2008, Pegg et al. 2008). However, only three of these species appear to be pathogens of significance with *Q. cyanescens* generally regarded as a saprophyte, and the taxonomic status of *Q. pusilla* remains unresolved (de Beer et al. 2006). Only *Q. pitereka*, *Q. eucalypti* and *Q. cyanescens* have been detected from subtropical and tropical regions of eastern Australia (Pegg et al. 2008).

Quambalaria pitereka has been isolated from foliage, stems and woody tissue of species in the genera *Corymbia*, *Blakella* and *Angophora* in Australia (Walker and Bertus 1971, Bertus and Walker 1974, Simpson 2000, Roux et al. 2006, Carnegie 2007a, 2007b, Pegg et al. 2008). *Quambalaria pitereka* affects the new flush of *Corymbia* foliage causing spotting, necrosis and distortion of expanding leaves and green stems (Figure 1). Diseased shoots are shiny white in appearance due to the presence of many white pustules rupturing through the waxy leaf cuticle. These pustules are composed of a dense layer of conidiophores borne on a plectenchymatous stroma. On leaves, conidiophores emerge in clusters through stomates, with hyaline conidia borne singly at the tips of the conidiophores (Walker and Bertus 1971, Pegg et al. 2008). Large irregular masses can occur along the edges of leaves or on the midribs, with brown-coloured lesions up to 20 mm long occurring as the disease advances. More recently, Pegg et al. (2008) identified *Q. pitereka* on *C. torelliana*, which was previously reported to be resistant, and from lesions on older foliage of *C. torelliana* × *C. variegata* and *C. torelliana* × *C. citriodora* hybrids in tropical regions of eastern Australia.

Quambalaria eucalypti has been detected on *E. grandis*, *E. longirostrata*, *E. grandis* × *E. camaldulensis*, *E. microcorys* and *E. dunnii* in commercial plantations, species trials and residential gardens in subtropical and tropical regions of Australia (Pegg et al. 2008). Infection is characterised by restricted amphigenous lesions that are irregular in shape and size with white pustules predominantly present on the abaxial leaf surfaces. On expanding juvenile foliage of *E. grandis*, pustules occur on the adaxial and abaxial leaf surfaces and they can be associated with leaf distortion or buckling. *Quambalaria eucalypti* has been detected only on juvenile foliage and it is often associated with wounding caused by weevil (*Oxyops* spp. and *Gonipterus* spp.) and flea beetle (*Chaetocnema* sp.) feeding damage. Small elongate lesions have also been observed on small green stems, which often resulted in a split in the stem (Pegg et al. 2008).

Geographic distribution

Old (1990) described *Q. pitereka* as being endemic to the coastal forests of eastern Australia where seedlings and young trees of *Corymbia* species can be severely damaged. Simpson (2000) suggested that the expansion of eucalypt plantations in New South Wales and Queensland would result in a high incidence of shoot blight caused by *Q. pitereka* in young *Corymbia* plantations. *Quambalaria pitereka* has been identified from all *Corymbia* commercial and trial plantings surveyed in subtropical and tropical regions of eastern Australia (Pegg et al. 2008). The pathogen has also been reported causing shoot blight in *C. maculata* plantings in Western Australia (Paap et al. 2008). *Quambalaria pitereka* was initially only found in Australia, but a recent report of shoot blight on *C. citriodora* in China has been attributed to *Q. pitereka* (Zhou et al. 2007).

Quambalaria eucalypti was first reported (as *Sporothrix eucalypti*) in South Africa on *E. grandis* (Wingfield et al. 1993). In that country, it was associated with leaf spots and serious shoot infections (Roux et al. 2006). It has subsequently been reported in Brazil causing stem girdling on seedlings of *E. globulus* and leaf and shoot blight on mini-stumps of *E. saligna* × *E. maidenii* hybrids (Alfenas et al. 2001). It has also been identified from twig lesions on *E. globulus* in Uruguay (Bettucci et al. 1999). While *Q. eucalypti* is considered to be a destructive pathogen in Brazil (Alfenas et al. 2001), Wingfield et al. (1993) did not consider it a serious pathogen in South Africa. However, during recent disease surveys in South Africa, Roux et al. (2006) identified *Q. eucalypti* as the causal agent of extensive shoot and leaf dieback as well as stem cankers on one-year-old *E. nitens*. This was the first record of the disease occurring on trees outside the nursery and in a temperate climate in South Africa. Pathogenicity tests indicated that *Q. eucalypti* has a wider host range within *Eucalyptus*, including *E. dunnii* and *E. smithii*, and the pathogen is now considered a significant cause of disease within South Africa (Roux et al. 2006). More recently, Pegg et al. (2008) found that *Q. eucalypti* was widespread in subtropical and tropical regions of eastern Australia, occurring on a range of *Eucalyptus* species in commercial plantations and residential gardens.

Impact of Quambalaria shoot blight on spotted gum

The implementation of hardwood plantation programs in subtropical regions of eastern Australia gave rise to the widespread use of spotted gum for high-value solid wood products. Quambalaria shoot blight was infrequently observed during the first few years of plantation development but soon afterwards it was found to be widespread and causing significant damage (Self et al. 2002, Carnegie 2007b). Severe damage resulting in poor tree form, and in some cases tree death, resulted in the reduction in the use of spotted gum as a priority species in the subtropics. Infection by *Q. pitereka* has a significant effect on the growth and form of young spotted gum trees, particularly in the first two years of growth (Self et al. 2002). Carnegie (2007b) reported that in most cases older plantations (>5 years old) had low percentages of trees with significant damage; however, a small number of these older plantations had up to 25% of trees severely, and repeatedly, damaged.

In order to gain improved insight into the impact of Quambalaria shoot blight on plantation management, Self et al. (2002) assessed a number of provenances and species in artificially inoculated field trials. The impact of infection on growth was assessed and it was found that there was a reduction in height increment with increasing severity of *Q. pitereka* infection. Stone et al. (1998) also found that all species and provenances of *Corymbia* in trial sites in New South Wales suffered repeated infections by *Q. pitereka*, resulting in a significant loss of height increment and stem form. They also noted an increase in apical branching. Mature foliage was also affected by *Q. pitereka* at these sites.

Figure 1: *Quambalaria pitereka* affects new flushes of foliage causing spotting, necrosis and distortion of (a) expanding leaves and (b) green stems. Diseased shoots are covered in white masses of conidia and conidiophores rupturing through the waxy leaf cuticle

Due to severe and repeated damage from Quambalaria shoot blight during the early years of plantation establishment, the planting of spotted gum was significantly reduced in New South Wales (Carnegie 2007b) and Queensland (Dickinson et al. 2004) for several years. Dickinson et al. (2004) reported significant variation in tolerance to Quambalaria shoot blight within spotted gum provenances; *C. variegata* provenances originating from high-rainfall areas, closer to the coast, were less susceptible to *Q. pitereka* than provenances collected from inland areas where annual rainfall levels were lower. This trend was observed in a large number of trials established with a range of taxa and provenances over a large range of site and soil types. Their results also indicated that *Q. pitereka* infection was closely associated with local climatic conditions with site mean average rainfall (MAR) a good indicator of potential risk for disease development. The incidence and severity of *Q. pitereka* was minimal on sites with <750 mm MAR but increased markedly on sites with 750–800 mm MAR. As a result, planting of spotted gum continued, using less-susceptible provenances (Carnegie 2007b, Lee 2007).

Conclusions

Very little is known regarding the biology of species of *Quambalaria*. Their specificity to species of *Eucalyptus* and *Corymbia*, apart from *Q. cyanescens*, is poorly understood. Wingfield et al. (1993), Roux et al. (2006) and Zhou et al. (2007) have suggested that Australia is the most likely centre of origin of *Q. pitereka* and *Q. eucalypti*, with no variation detected when comparing the rDNA from isolates in South Africa and China. More recently, Pegg et al. (2008) found a high degree of variability in populations of *Q. pitereka* and *Q. eucalypti* collected from subtropical and tropical regions of eastern Australia supporting the view that the pathogen is native in this region.

It is unknown how *Quambalaria* spp. are moved over long distances. The appearance of both *Q. pitereka* and *Q. eucalypti* in areas where eucalypts are non-native provides clear evidence that these important pathogens are moving globally. A likely pathway of movement is via eucalypt seed that is traded globally. However, as the disease and life cycles of *Quambalaria* are poorly understood, this hypothesis remains to be rigorously tested.

It is unknown what influence plantation expansion will have on the incidence and severity of Quambalaria shoot blight. The plantation area in eastern Australia is rapidly expanding with spotted gum a priority species and planted area expected to exceed 31 000 ha by 2011 and 110 000 ha by 2016 (GSP unpublished data). Carnegie (2007b) reported a significant increase in Quambalaria shoot blight with the rapid expansion of spotted gum plantings in New South Wales. The implementation of a hybrid breeding program in Queensland also presents a number of other questions, especially with the recent identification of shoot blight on *C. torelliana*, which was considered to be resistant (Pegg et al. 2008). The increase in plantation area is likely to mean an increase in the fungal population which, when considering the potential impact on native spotted gum, must be taken into consideration. In addition, the presence of host–species specificity within the pathogen population, and their evolutionary potential to be able to cause disease on a wide range of *Corymbia* species and their hybrids used for plantation development, must be given serious consideration.

The development of management strategies for Quambalaria shoot blight to date has been done without an understanding of the pathogen biology and the nature of host–pathogen interactions or host specificity. The reported basis of tolerance (Dickinson et al. 2004) within provenances of spotted gum is unknown. Knowledge of the pathogen biology, including the population biology, infection process, disease cycle, host specificity, epidemiology and environmental influences is key to the development of effective disease management strategies.

References

Alfenas AC, Zauza EAV, Rosa OPP, Assis TF. 2001. *Sporothrix eucalypti*, um novo patógeno do eucalipto no Brasil. *Fitopatologia Brasileira* 26: 221.

Bertus AL, Walker J. 1974. *Ramularia* on *Eucalyptus* and *Angophora*. *Australasian Plant Pathology Society Newsletter* 3: 3.

Bettucci L, Alonso R, Tiscornia S. 1999. Endophytic mycobiota of healthy twigs and the assemblage of species associated with twig lesions of *Eucalyptus globulus* and *E. grandis* in Uruguay. *Mycological Research* 103: 468–472.

Carnegie AJ. 2007a. Forest health condition in New South Wales, Australia, 1996–2005. I. Fungi recorded from eucalypt plantations during forest health surveys. *Australasian Plant Pathology* 36: 213–224.

Carnegie AJ. 2007b. Forest health condition in New South Wales, Australia, 1996–2005. II. Fungal damage recorded from eucalypt plantations during forest health surveys and their management. *Australasian Plant Pathology* 36: 225–239.

Dickinson GR, Lee DJ, Huth JR. 2004. Early plantation growth and tolerance to Ramularia shoot blight of three spotted gum taxa grown on a range of sites in Queensland. *Australian Forestry* 67: 122–130.

de Beer WZ, Begerow D, Bauer R, Pegg GS, Crous PW, Wingfield MJ. 2006. Phylogeny of *Quambalariaceae* fam. nov. including important *Eucalyptus* pathogens in South Africa and Australia. *Studies in Mycology* 55: 289–298.

Lee D. 2007. Development of *Corymbia* species and hybrids for plantations in eastern Australia. *Australian Forestry* 70: 11–16.

Old K. 1990. Diseases caused by fungi. In: Cremer KW (ed.), *Trees for rural Australia*. Melbourne: Inkata Press. pp 210–216.

Paap T, Burgess TI, McComb JA, Shearer BL, Hardy GEStJ. 2008. *Quambalaria* species implicated in canker and shoot blight diseases causing decline of *Corymbia calophylla* and *C. ficifolia* in the southwest of Western Australia. *Mycological Research* 112: 57–69.

Pegg GS, O'Dwyer C, Carnegie AJ, Burgess TI, Wingfield MJ, Drenth A. 2008. *Quambalaria* species associated with eucalypt plantation development. *Plant Pathology* 57: 702–714.

Roux J, Mthalana BL, de Beer ZW, Wingfield MJ. 2006. Quambalaria leaf and shoot blight on *Eucalyptus* in South Africa. *Australasian Plant Pathology* 35: 427–433.

Self NM, Aitken, EAB, Dale MD. 2002. Susceptibility of provenances of spotted gums to Ramularia shoot blight. *New Zealand Plant Protection* 55: 68–72.

Simpson JA. 2000. *Quambalaria*, a new genus of eucalypt pathogens. *Australasian Mycologist* 19: 57–62.

Stone C, Simpson JA, Eldridge RH. 1998. Insect and fungal damage to young eucalypt trial plantings in northern New South Wales. *Australian Forestry* 61: 7–20.

Walker J, Bertus AL. 1971. Shoot blight of *Eucalyptus* spp. caused by an undescribed species of *Ramularia*. *Proceedings of the Linnean Society of New South Wales* 96: 108–115.

Wingfield MJ, Crous PW, Swart WJ. 1993. *Sporothrix eucalypti* (sp. nov.), a shoot and leaf pathogen of *Eucalyptus* in South Africa. *Mycopathologia* 123: 159–164.

Zhou X, de Beer W, Xie Y, Pegg GS, Wingfield MJ. 2007. DNA-based identification of *Quambalaria pitereka* causing severe leaf blight of *Corymbia citriodora* in China. *Fungal Diversity* 25: 245–254.