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Blackberry decline: a major disease of *Rubus anglocandicans* in south-west Australia

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Summary *Rubus anglocandicans* is the most common species of European blackberry in Western Australia (WA) and one of the few weeds of national significance in the south-west of WA. It is a major weed of conservation areas, forestry and agriculture. Exotic strains of the blackberry rust *Phragmidium violaceum* have been introduced to WA as biological control agents, but in most areas it seems that they are not effective, possibly due to climate.

In 2007 while monitoring establishment of the released rust strains, unexplained dead and diseased blackberry plants were discovered at two locations, along the Warren River near Pemberton and the Donnelly River near Manjimup in the south-west of WA. The extent of the disease, with noticeable landscape changes due to the removal of dense blackberry infestations, has lead to it being called 'blackberry decline'. The organism or organisms responsible for killing the blackberry plants are so effective that within a couple of years previously impenetrable stands of well established blackberry have been completely killed for at least several kilometres from the initial sightings of disease symptoms. We outline the history of the 'decline' phenomenon on blackberry in the south-west of WA and discuss some of the possible causes.

Keywords Blackberry, *Phytophthora bilorbang*, plant pathogen, *Rubus fruticosus* agg., soil borne disease.

BLACKBERRY IN WESTERN AUSTRALIA

European settlement of Western Australia (WA) started in 1829 and blackberries were probably introduced soon afterward. At least three species of weedy *Rubus* (blackberry) are established in the south-west of WA; *R. anglocandicans* A. Newton, *R. laudatus* A. Berger and *R. ulmifolius* Schott (Evans *et al.* 2007). In addition, the cultivated species *R. loganobaccus* L.H. Bailey (loganberry) is locally established (Evans *et al.* 2007) and a population of a different *Rubus* species has been recently discovered and is in the process of being identified (Fontanini unpublished observations).

Rubus anglocandicans is the most widespread *Rubus* species over all of Australia (Evans and Weber 2003) and the most common in WA. It originates from England so it was probably the first species to be introduced into WA. American blackberries (includes *R. laudatus*) were present by 1875 (Anon. 1875), but their distribution is more localised, being found mainly north of Bunbury (Yeoh *et al.* 2006b). *Rubus ulmifolius* is widespread, but only in small populations.

In general, blackberries are found along water courses in WA and most of the impact and threat is in these areas (Hancock *et al.* 1996). The most important recreational fishing in rivers is for marron (freshwater crayfish) and the dense thickets of blackberry prevent access by people. *R. anglocandicans* has also been reported to reduce plant biodiversity by about 50% when compared to non invaded sites (Yeoh *et al.* 2006a).

Away from the river bank, *R. anglocandicans* is also a weed, albeit minor, of agriculture and plantation forestry. Crackel and Roberts (1987) in a cost benefit analysis concluded that it was not economical to control blackberry in WA using Government resources.

Herbicides and cultural control methods are generally ineffective, or require multiple applications; however, the weed is often located within inaccessible areas, which limits control options. Therefore, biological control has been identified as the main strategy for control of blackberry.

In 2007 P.B. Yeoh and L. Fontanini noticed that blackberry plants in the Donnelly and Warren River catchments (Figure 1) were dying in a spectacular manner in areas that they were monitoring following the release in previous years of additional strains of the rust *Phragmidium violaceum* for blackberry biological control. This became known as the disease 'blackberry decline'. This paper describes the discovery of this disease. We also discuss some of the hypotheses that could explain the presence of the disease in these areas.

BIOLOGICAL CONTROL OF BLACKBERRY

Recent biological control of blackberry in WA has focused on releases of additional strains of the rust fungus *Phragmidium violaceum* (Morin *et al*. 2011). Initially, single releases of the nine rust strains were made in autumn 2004 at a site on Lefroy Brook, a

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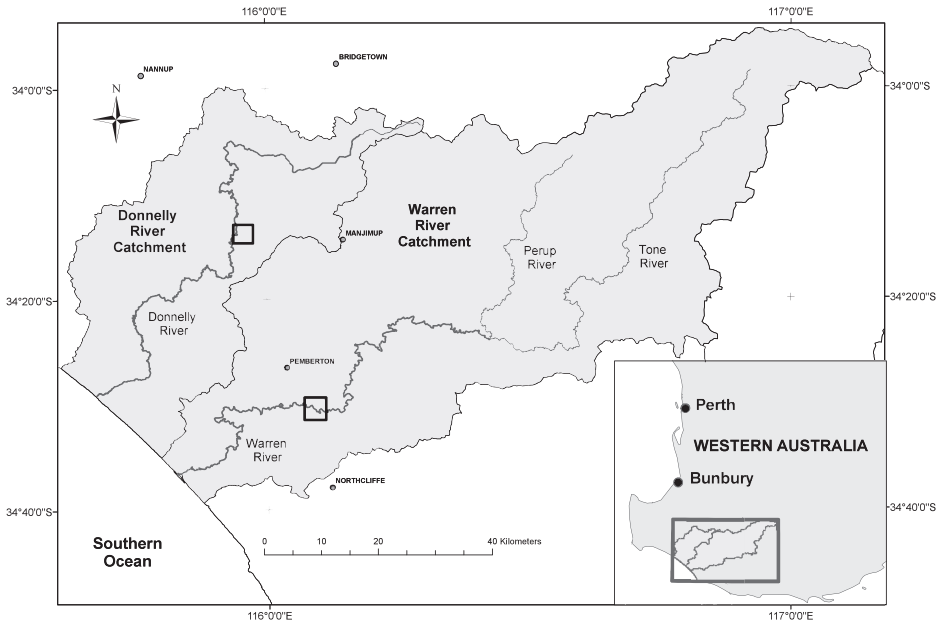

Figure 1. Location of the Donnelly and Warren River catchments in Western Australia, including their main rivers, towns and the two sites (black open squares) where blackberry decline was first recorded. Blackberry is found along all rivers and tributaries apart from the upper reaches of the Donnelly, Perup and Tone.

tributary of the Warren River and in spring 2004 at a tributary of the Donnelly River.

Both 2004 release sites, as well as an additional eight release sites established in 2005, consisted of dense stands of healthy *R. anglocandicans*. Plant densities and sizes were measured at all sites established during 2005. At the start of the growing season (spring) there were on average 9 canes m^{-2} or 5.4 plants m^{-2}. Plants outside of the experimental plots at all these sites appeared healthy the following summer. A random collection of these plants found they averaged approximately 12 m of stem material, 95 fruit and 1800 seed (Yeoh *et al.* 2006 unpublished data).

In spring 2006, a subset of the eight experimental sites setup in 2005 was used for new experiments designed to measure the impact of the blackberry rust. It was when one of these experimental sites needed to be re-located (October 2007) that P.B Yeoh and L. Fontanini first noted the blackberry decline phenomenon. It was at one of the sites on the Warren River.

DISCOVERY OF BLACKBERRY DECLINE

In November 2006, at the Warren River 'decline site', canes throughout the site looked normal but not particularly healthy and at the time it was assumed that plants were just slower to regrow after winter senescence. Cane densities were still 73% of that observed at the same time of the season in the previous year. Cane densities at the other three healthy sites on same river were approximately the same as in the previous season.

Being a semi-deciduous plant, foliage cover varies throughout the year, peaking each summer and senescing each winter. In our study area, new season foliage started to be produced in October. The 'decline site' differed slightly from the healthy sites in November 2006 because not as many new leaves had reappeared on the previous year's canes at the start of the new season. In November 2006 plants in the decline site only had 10% of the foliage cover seen the previous summer in contrast to the other healthy sites that at the same time, all had over 60% of their previous summer foliage levels.

In October 2007 the blackberry population at the 'decline site' had crashed (Figure 2a,b) and the initial reaction was to assume that the plots had been sprayed with herbicide rather than reacting to the rust. Dead canes were everywhere. The defoliation was more severe and rapid than anything we had observed before, even when plants were inoculated with high densities of rust spores under optimal laboratory conditions. The few new primocanes produced at the decline site the following season were thin and weak and surviving floricanes failed to produce fruit. Dead stems fell to the

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Figure 2. Site on the Warren River, WA in October 2005 before blackberry decline symptoms were observed (A) and in October 2007 (B) following the peak of the decline, which killed most blackberry canes.

ground, rotted quickly and disappeared within a year, in contrast to those at healthy sites, or at sites sprayed with herbicide, where dead stems often stayed hard and upright for several years. Even the hard woody crowns of the decline plants rotted quickly and disappeared. The possibility of herbicide use was excluded after a search found lack of vehicle evidence on site, investigation with local authorities, the remoteness of locations, absence of non-target damage and differences of symptoms.

After detecting the decline at the Warren River site, we re-visited all our previous release sites (November 2007). Decline at this time was also evident at the site of the 2004 spring release on the Donnelly River. We had no previous plant density or cover records for this site, but like the decline site on the Warren River site, areas that were impenetrable previously could now be comfortably traversed. As of 2012 the decline of blackberry has spread extensively along the Donnelly and Warren rivers.

DISCUSSION

Surveys of blackberry were made throughout the south-west of WA during 2004 prior to the releases of additional strains of the rust fungus (Batchelor *et al.* unpublished). This involved obtaining 432 samples for 93 locations by 30 collectors (mostly land managers), without any reports of unusual mortality of blackberry. In the following years 'rust release kits' containing the nine rust strains were sent to 116 people throughout the south-west of WA between October 2006 and November 2008. It would be expected that unusual deaths of blackberry would have been reported at that stage because people were monitoring their rust release sites, but none were reported. Blackberry decline has so far only been reported in relatively inaccessible sites and appears to have been active along the Donnelly River before or at a similar time to the release of the additional rust strains in 2004. For these reasons we believe that blackberry decline is a relatively recent phenomenon.

Related species There are no native *Rubus* species in south-west Australia (Evans *et al.* 2007, Wheeler *et al.* 2002), indeed the only native species in the family Rosaceae in the south-west is *Acaena echinata*, which possibly originates from eastern Australia (Wheeler *et al.* 2002). Thus it seems unlikely that the pathogen causing blackberry decline is a native species associated with the Rosaceae.

Aside from *Rubus*, the introduced Rosaceae established in south-west Australia are in the genera (number of species) *Aphanes* (1), *Acaena* (1 or 2), *Cotoneaster* (2), *Prunus* (1), *Rosa* (5) and *Sanguisorba*

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(1) (Wheeler *et al.* 2002). The area also has many species of Rosaceae in horticulture and grown as ornamental species (peaches, roses etc). There have been no reports so far of these introduced species exhibiting decline symptoms similar to that of blackberry, including among commercial *Rubus* crops. Thus there is no evidence of a source host from amongst the introduced species.

Phytophthora bilorbang Recently we have shown the association of *Phytophthora* species, including the new species *P. bilorbang* (Aghighi *et al.* 2012), with the blackberry decline syndrome. This is a new pathosystem that at this stage appears to explain the decline syndrome. However, the origin, spread and history of the pathogen is unknown and undergoing further investigation.

CONCLUSIONS

The appearance of 'blackberry decline' offers possible opportunities for the biological control of blackberry in WA. At present it is only known from the Warren and Donnelly Catchments. A considerable amount of research is needed to answer all the questions raised by the appearance of 'blackberry decline'. What organism/s including *P. bilorbang* is/are causing the decline? Where do these organisms originate from? What are their host ranges? How do they spread and how far? It is important to solve these and other questions before we can address the question about the potential to use blackberry decline for biological control.

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