FEM077

Recognising the symptoms of *Armillaria* root disease in karri and wandoo forest

Richard Robinson

Forest Management Series

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GOVERNMENT OF WESTERN AUSTRALIA

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Cover images:
Left: *Armillaria luteobubalina* fruiting bodies.
Right: *Eucalyptus diversicolor* (karri) regrowth stump showing symptoms of *Armillaria* infection
(Photos: courtesy of Richard Robinson and Mike Stukely, Department of Biodiversity, Conservation and Attractions)

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Introduction

Armillaria luteobubalina, the Australian honey fungus, is a widespread, endemic pathogen of native forest, woodland and coastal shrub communities in the southwest of Western Australia. It is the causal agent of *Armillaria* root disease (ARD) and associated with deaths of karri (Figure 1) (*Eucalyptus diversicolor* F. Muell.), wandoo (*E. wandoo* Blakely) and jarrah (*E. marginata* Donn ex. Sm.) trees in forests and woodlands, *Banksia spp*. in coastal woodlands as well as exotic eucalypts planted on mine-sites and in plantations. Disease impact may range from single dead plants to complete devastation of understorey and overstorey species (Figure 2). At epidemic levels, disease is easily detectable and distinguishable from Phytophthora Dieback. However, symptoms may also express in a single plant or disease may be incipient.

Figure 1 Armillaria *root disease centre in 80 year old karri forest at Big Brook.*

Figure 2 Wandoo treed dead and dying in Bowelling State forest block (Photo: Peter Blankendaal).

In Australia there are six known species of *Armillaria*. *Armillaria luteobubalina* is the only species known to occur in Western Australia. In healthy undisturbed environments ARD is generally not the primary cause of death in forest or woodland trees. Trees weakened by competition, age-related decline or environmental stress and disturbance are more likely to succumb to the disease. In disturbed or intensely managed environments, however, *A. luteobubalina* can become a particularly aggressive pathogen. The list of susceptible hosts is extensive and is likely to include all native shrub and tree species as well as all introduced species.

A. luteobubalina infects the roots of living trees, spreads towards the root collar below the bark and eventually kills the tree when it girdles the root collar. Seedlings and saplings are most susceptible to infection; however, healthy vigorous trees older than about 20 years have some resistance and develop callus tissue at the margin of lesions. Callus reactions result in the formation of inverted V-shaped scars at the base of infected stems. Infection spreads to neighbouring healthy trees by root-to-root contact. Factors such as drought or fire may cause stress which will lead to infection in otherwise healthy trees.

The life cycle of the fungus consists of a parasitic phase during which the host is infected and killed followed by a saprophytic phase during which the root system and stump of the dead host is used as a food base. In this manner *A. luteobubalina* has the ability to persist in an infected root system for decades during which time surrounding regrowth is also susceptible to infection.

1 Detecting Armillaria luteobubalina Infection

Symptoms of ARD may include;

- crown deterioration (including chlorosis of foliage)
- inverted V-shaped scars
- bark fissuring and/or kino exudation at the base of the stem
- the presence of white mycelial fans below the bark at the base of the stem (Figure 3, Figure 4 and Figure 5)
- fruit bodies (mushrooms) of *A. luteobubalina* at or in closer proximity of the root collar
- wet stringy white rot in the wood of the roots or at the root collar which may contain thin black zone lines or plates.

Most species of *Armillaria* produce rhizomorphs (black boot-lace-type organs) but *A. luteobubalina* rarely produces rhizomorphs in the field. Short rhizomorphs are occasionally seen on the surface of the bark of infected roots or at the root collar but *A. luteobubalina* will readily produce them when it is isolated and grown on artificial media in the lab.

Where ARD is suspected, dead plants (*Xanthorrhoea preissii, Banksia grandis*) can be pushed over or pulled up, exposing the roots so they may be examined for Armillaria mycelium. Excavation can be done around larger trees, particularly marri and wandoo, which may reveal white mycelium below the soil (Figure 3).

Fronds and stems emanating from ground level from plants such as *Xanthorrhoea gracilis* may be examined by carefully extracting (pulling) a frond, groups of fronds, or stem from the centre of the dead plant, taking care to retrieve the longest and deepest possible section. In an Armillaria-affected plant, small traces of white mycelium may be visible at the base of stems or fronds (Figure 4).

The fronds and roots in the photographs have been carefully extracted. Keeping roots intact, as much as possible, enables easier recognition of affected parts.

Figure 3 Subterranean Armillaria luteobubalina mycelium under bark of a Eucalyptus wandoo (Bowelling block, State forest) (Photo: Peter Blankendaal).

Figure 4 Armillaria mycelium at the base Xanthorrhoea preissii fronds (Photo: Peter Blankendaal).

Figure 5 Armillaria mycelium on the roots of Banksia sessilis (Photo: Peter Blankendaal).

Young trees and shrubs may die suddenly with their crowns intact and growth is often unaffected until immediately prior to death. In older trees bark fissuring and kino exudation at or immediately above the root collar are common symptoms of *Armillaria* infection. Older trees may also undergo gradual crown deterioration, although crown wilt may occur suddenly. Root infection is generally followed by the development of characteristic infection scars at the base of the stem. Infection results in root death and subsequent root and butt rot makes trees susceptible to wind throw (especially after thinning in regrowth karri). Infected roots have a characteristic white rot and white fan-like mycelial growth under the bark (Figure 5).

In coastal habitats, large disease centres may develop. They are characterised by a high number of dead shrubs surrounded by chlorotic or dying shrubs and plants. The disease can be recognised by removing dead shrubs and looking for sheets of mycelium under the bark of dead roots or around the root collar of dead plants.

1.1 Recognising the fruit bodies of *Armillaria luteobubalina*.

Fruit bodies may also be referred to as basidiomes, basidiocarps, sporocarps or simply mushrooms. *A. luteobubalina* fruit bodies are a “typical” mushroom, consisting of cap, gills and stem (Figure 6). They are generally short-lived (lasting around a week) (Figure 11) and are produced in clusters at the base of infected trees (Figure 7, Figure 9 and Figure

10), or sometimes on the stem up to three metres above the ground, in mid-late autumn or early winter.

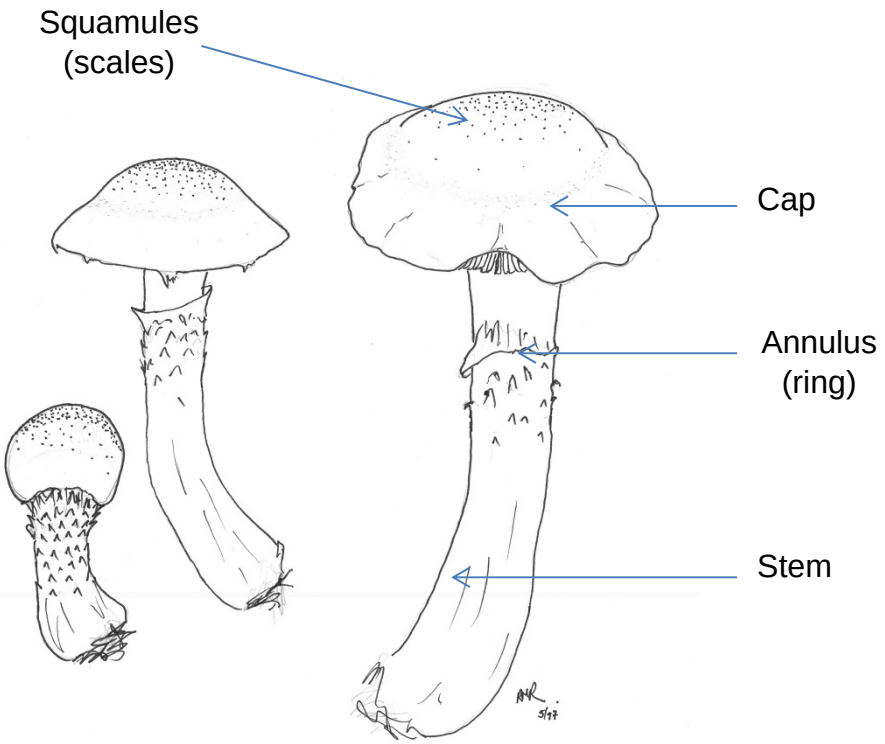


Figure 6 Armillaria luteobubalina *fruit bodies. In the "button" stage (left) the cap margin is not yet detached from the annulus, and the stem is distinctly floccose. Small dark brown to black squamules (scales) cover the centre of the cap. As the cap expands (centre) the margin may have remnants of the annulus attached and the remaining annulus material can be seen attached to the stem forming a distinct ring. The stem is floccose (covered in delicate cottony scales) only below the annulus. Mature caps (right) are generally flat but may have a distinct umbo (shield-shaped swelling) in the centre and a wavy (sometimes upturned) margin. The small bark brown to black squamules persist on the umbo, but may be washed off with age.*

1.1.1 Caps

Caps range from 4-10cm in diameter and are firm and fleshy. Initially they are convex and become flat as they expand. The colour may vary but is generally lemon-yellow to honey-brown. The central disc of the cap is covered in small brown-black squamules (scales) (Figure 8) which become sparse towards the margin. The squamules give the cap surface a rough texture. The flesh is white and has a lingering bitter taste.

1.1.2 Gills

Gills are found on the underside of the cap. They are crowded and of uneven length, fleshy and pliable, attached to the stem near the apex, white to pallid when young and become cream-brown or pink-brown with age. The spore print is cream to white. A dusting of white spores is often seen on the cap surface of the fruit bodies at the bottom of a cluster.

1.1.3 Stem

Generally 4-10cm (may be up to 15) long and 1-2cm thick, centrally attached to the underside of the cap, solid, generally thickened towards the base and has a persistent annulus (ring) attached just below the gills. Below the annulus the stem is distinctly floccose (covered in coarse scales). The colour ranges from a light pinkish-brown near the apex to dark brown at the base. The flesh of the stem is white and generally stringy.

1.2 Summary – characteristic features of *Armillaria* fruit bodies

- Fruit bodies often develop in clusters (Figure 7)
- Lemon-yellow to honey-brown caps
  - small bark brown to black squamules cover the central disc (Figure 8)
  - cap surface feels rough (like cats tongue)
- Persistent ring around stem (Figure 6 and Figure 7**Error! Reference source not found.**)
- Floccose (shaggy) stem immediately below the ring
- Cream-white gills changing to pink-brown with age
  - White spores - often seen on the cap surface of the fruit bodies in the bottom of a cluster
  - Flesh has a bitter taste

1.3 Summary – characteristic symptoms of ARD

- Inverted V-shaped scar at base of tree; often with lateral callusing and open base (Figure 12 and Figure 13)
- White mycelial fans below the bark (Figure 14)
- Wet, stringy yellow-white rot in roots and base of tree (Figure 14).

2 Armillaria root disease – visual symptoms

Figure 7 A cluster of Armillaria luteobubalina *fruit bodies.*

Figure 8 Dark scales on the top of Armillaria luteobubalina caps.

Figure 9 Left: Clusters of Armillaria luteobubalina fruit bodies can be found either on the ground or at the base of infected trees and shrubs in the autumn. Right: Huge clusters of fruit bodies can also develop on infected stumps.

Figure 10 Colony of Armillaria luteobubalina basidia (in situ) (Photo: Peter Blankendaal).

Figure 11 Decaying Armillaria luteobubalina basidia (in situ) (Photo: Peter Blankendaal)

Figure 12 Left: Infection scar at base of 25-year-old karri regrowth tree caused by Armillaria luteobubalina spreading from the stump in the foreground. Right: Close-up of infection scar in the bark of a 25-year-old karri regrowth tree.

Above left: Callus surrounding an occluded scar.

Above right: Callus and scaring showing occlusion at top of scar and an open base.

Left: Active infection is often distinguished by black ribbon-like bark associated with either open or callused scars.

Figure 13 Vigorous trees respond to infection by developing callus around infected tissues.

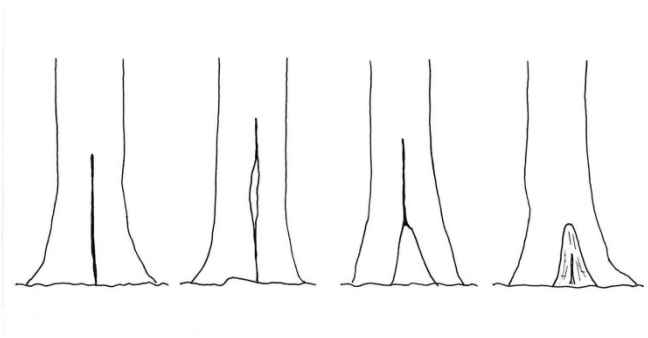
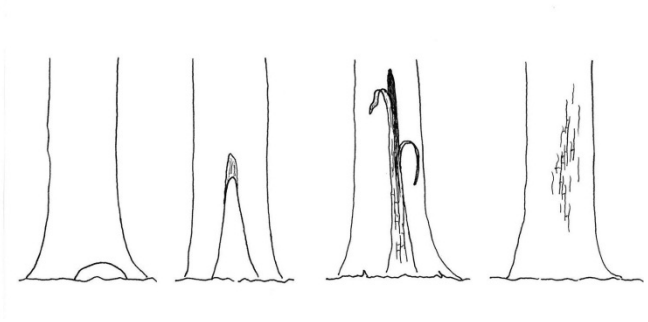
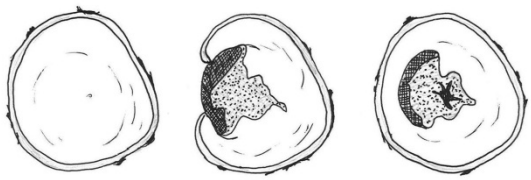
Figure 14 Left: Stringy white rot in the sapwood at the base of an infected karri. The rot is typically very wet and "mushy" in the winter and dry and "crackly" in the summer. Top right: Sheets of white mycelial "fans" under the bark of an infected root. Right: Typical white rot and zone lines in infected wood

Figure 15 Typical rot and scar formation on the surface of a karri stump infected with Armillaria luteobubalina (Photo: M. Stukely).

3 Scoring system for symptoms of Armillaria root disease on trees and stumps

When surveying for *Armillaria* in karri forest, scores may be given which relate to the severity of symptoms of ARD. The table below gives a standardised scoring system to use.

Table 1 Armillaria root disease symptoms and severity chart

<table>
<tr><th colspan="4"><u>Trees</u></th><th>Symptoms</th></tr>
<tr><td colspan="4">  </td><td rowspan="2">0. No symptoms.
1. Fully occluded scar.
2. Occluded scar, ± open along its length.
3. Occluded scar, open at base.
4. Basal scar superficially callused over.</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td colspan="4">  </td><td rowspan="2">5. Isolated basal lesion.
6. Scar with lateral callus, active apex.
7. Fresh active scar.
8. No scar, dried cracking bark with mycelium spreading freely under bark.
9. Tree dead, with ARD symptoms.
10. Tree dead, <u>NO</u> ARD symptoms.</td></tr>
<tr><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><th colspan="4"><u>Stumps</u></th><th>Symptoms</th></tr>
<tr><td colspan="4">  </td><td rowspan="2">0. No symptoms of infection.
1. Active infection - visible external symptoms.
2. Active infection – internal symptoms.</td></tr>
<tr><td>0</td><td colspan="2">1</td><td>2</td></tr>
</table>

4 Further reading

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