EFFECT OF TWO INSECT PESTS ON *ACACIA AURICULIFORMIS* TREE GROWTH AND FORM IN AUSTRALIA'S NORTHERN TERRITORY

K. D. Montagu[+] & K. C. Woo*

School of Biological Science, Faculty of Science, Northern Territory University, Northern Territory 0909, Australia

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MONTAGU, K. D. & WOO, K. C. 1999. Effect of two insect pests on *Acacia auriculiformis* tree growth and form in Australia's Northern Territory. The occurrence and damage caused by two insect pests of *Acacia auriculiformis* was assessed four months after planting in two clonal seed orchards containing trees from the Queensland, Papua New Guinea and Northern Territory provenances. The effect of insect damage on tree growth and form was subsequently measured over a 16-month period. Four months after planting, when the trees averaged 1.3 m in height, the insects *Platymopsis humeralis* F. (Coleoptera, Cerambycidae) and *Mictis profana* F. (Hemiptera, Coreidae) were present on 8 and 36% of the trees respectively. However, both the insects caused damage to more than 50% of the trees at the two sites. *Platymopsis humeralis* girdled the main stem of the juvenile trees which reduced tree height growth by 0.4–0.5 m in the six months following girdling. *Mictis profana* caused the death of 10–15% of the tree shoot tips, but this had no measurable effect on tree growth. No provenance variation was observed in either the degree of insect attack or effect on tree growth or form. Twenty months after planting there was no apparent effect on tree form and no further reduction in tree height growth.

Key words: Insect damage - *Mictis profana* - *Platymopsis humeralis* - *Acacia auriculiformis*

MONTAGU, K. D. & WOO, K. C. 1999. Kesan serangan dua serangga perosak terhadap pertumbuhan dan pembentukan pokok *Acacia auriculiformis* di Wilayah Utara Australia. Kejadian dan kerosakan yang disebabkan oleh dua serangga perosak *Acacia auriculiformis* ditaksirkan empat bulan selepas penanaman di dua kebun biji benih yang diklonkan mengandungi pokok daripada provenans Queensland, Papua New Guinea dan Wilayah Utara. Kesan kerosakan oleh serangga terhadap pertumbuhan dan bentuk pokok kemudiannya diukur di sepanjang tempoh 16 bulan. Empat bulan selepas penanaman, apabila pokok mencapai ketinggian purata 1.3 m, serangga *Platymopsis humeralis* F. (Coleoptera, Cerambycidae) dan *Mictis profana* F. (Hemiptera, Coreidae) hadir masing-masing pada 8 dan 36% pokok. Bagaimanapun, kedua-dua serangga menyebabkan kerosakan kepada lebih 50% daripada pokok-pokok di kedua-dua tapak. *Platymopsis humeralis* menggelangi batang utama pokok-pokok muda yang mengurangkan pertumbuhan ketinggian pokok sebanyak 0.4–0.5 m dalam masa enam bulan selepas penggelangan. *Mictis profana* menyebabkan

**Correspondence address : Faculty of Science, Northern Territory University, NT 0909, Australia.*
[+]*Present address: Forest Research and Development Division, State Forests of New South Wales, P.O. Box 100, Beecroft, NSW 2119, Australia.*

kematian 10–15% hujung pucuk pokok tersebut. Bagaimanapun, ia tidak memberikan kesan terhadap pertumbuhan pokok. Tiada perubahan provenans dicerap dalam tahap serangan serangga atau kesan terhadap pertumbuhan atau bentuk pokok. Dua puluh bulan selepas penanaman tiada kesan ketara terhadap bentuk pokok dan tidak lagi berlaku pengurangan dalam pertumbuhan ketinggian pokok.

Introduction

Due to the rapid reduction in natural forests in Asia there has been widespread expansion of plantation forestry to meet the needs for fuelwood and industrial wood. In the decade 1982 to 1992 the area of plantation forestry increased from 3.2 to 25 million ha (Day *et al.* 1994). This rate of increase shows no sign of slowing. In more recent years, acacia species have been favoured in these plantation programmes. In Indonesia alone, 375 000 ha of *Acacia mangium* was planted between 1992 and 1996 (Turnbull *et al.* 1997). In Northern Australia, where many of the acacia species originate, there is also interest in the establishment of tropical hardwood plantations. However, there is widespread concern from forest managers, farmers and the local communities that the rapid expansion of tropical acacia plantations may lead to major pest and disease outbreaks.

Acacia auriculiformis A. Cunn. *ex* Benth. is one of the tropical species utilised for both plantation forestry and reforestation throughout Southeast Asia, China and India (Pinyopusarerk 1990). There are reports on potential insect pests of the species from both areas where it occurs naturally (Wylie *et al.* 1997), and in countries where it has been introduced (Meshram *et al.* 1985, Hutacharern 1987, Puriyakorn & Luangviriyasaeng 1988, Neupane 1992, Wylie *et al.* 1997). However, there is little quantitative data on the impact of insect pests on tree growth and form. Within Australia serious damage to small *A. auriculiformis* plantings has occurred in the Northern Territory (Harwood *et al.* 1991) and Queensland (Wylie *et al.* 1997), while in countries where the species is an exotic, insect attacks have been sporadic and not considered to caused serious damage to acacia plantations to date (Wylie *et al.* 1997).

There are three main provenances of *A. auriculiformis* [Queensland (Qld), Papua New Guinea (PNG) and Northern Territory (NT)], which differ in their morphology (Pinyopusarerk *et al.* 1991), growth rate and form (Nor Aini *et al.* 1994, Venkateswarlu *et al.* 1994), and physiology (Cole *et al.* 1994). There are, to our knowledge, no studies on the susceptibility or tolerance of the three provenances of *A. auriculiformis* to insect attack.

In this paper the occurrence and damage caused by the insects *Platymopsis humeralis* F. (Coleoptera, Cerambycidae) and *Mictis profana* F. (Hemiptera, Coreidae) to *A. auriculiformis* was determined four months after planting in two trials near Darwin, Australia. The impact of insect damage on subsequent tree growth and form was assessed over a 16-month period. Furthermore, we determined if there was any provenances variation in the susceptibility or tolerance of *A. auriculiformis* to insect attack.

Materials and methods

Two *A. auriculiformis* clonal seed orchards containing 46 clones (27 from Qld, 16 from PNG and 3 from NT) were established in the Northern Territory of Australia, at Berrimah (12° 26'S, 130°54'E, 10 km south of Darwin) and Humpty Doo (12° 34'S, 131°8'E, 30 km southeast of Darwin) in December 1993. Clones were propagated from 46 phenotypically superior trees selected from a total of 1200 trees in a 3.5-y-old *A. auriculiformis* provenance/progeny trial (Harwood *et al.* 1991, Montagu *et al.* 1996). The design of the orchard planting was a randomised complete block with six replicates. Each clone was represented in each block by a single tree plot. Prior to planting the top 0.6 m of the ground was loosened and trees were planted at a 5 × 5 m square spacing. Fertiliser at 400 g (NPK 14:14:12) per tree was applied in the first four months. The two sites have a tropical climate characterised by heavy summer rainfall (1659 mm, November-March), and extreme drought and low relative humidity in the dry season (Figure 1). At the Berrimah site only, trees were drip irrigated during the dry season.

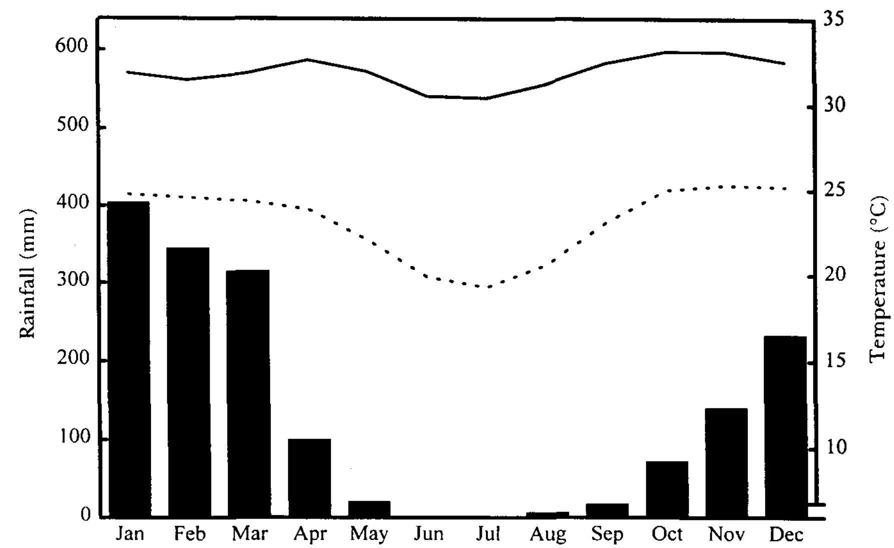

Figure 1. Average monthly rainfall, and maximum (—), and minimum (- - -) temperatures at Darwin, Northern Territory, Australia. Data are 45-year means.

A field survey of the trees at both sites was undertaken in March (end of wet season). For each tree the numbers of *P. humeralis* and *M. profana* adults were determined visually and trees were assessed for damage as described by Flanagan *et al.* (1990). The percentage of trees damaged by each insect was determined for each block. For those trees attacked by either insect the percentage of branches or shoot apical tips damaged was determined.

The effect of the insect damage on tree growth and form was assessed over a 16-month period. Trees were assigned to either a damaged or undamaged category, based on assessment at 4 months after planting, and tree height measured at 4, 10, 15 and 20 months after planting. Tree height was measured to the top of the living leader using height poles. Twenty months after planting, tree form was assessed as follows. Bole length was measured to the first fork (defined by the presence of a second leader more than two-thirds of the diameter of the main-stem) and if no forking occurred, the bole length was set at 75% of total height. The straightness of the bole was assessed visually using a four-point scoring system as follows: 4=excellent, 3=above average, 2=below average, 1=very poor (Cotterill & Dean 1990). The number of branches arising from the main stem was measured at 4 and 20 months after planting.

Data were analysed using analysis of variance to determine significant differences between dependent variables using Statistic V5.0 (StatSoft Inc., USA). Analysis of provenance variation was undertaken using data from the Qld and PNG provenances only due to the insufficient number of trees from the NT provenance. Percentage data were arc-sine transformed prior to analysis. Protected LSDs were used to determine differences between means. Data are presented as means ± standard errors.

Results

Insect occurrence and tree damage

At the end of the wet season, adult *P. humeralis* were found on 10 and 6% of trees at Berrimah and Humpty Doo respectively (Table 1) at an average of 1.3 ± 0.1 insects per tree. However, approximately a half or more of the trees had been girdled by *P. humeralis* (Table 1). Trees at the Berrimah site had higher levels of girdling ($p = 0.02$) than those at Humpty Doo. At each site there was no difference between the PNG and Qld provenances, except with regard to *P. humeralis* feeding damage which was higher in the PNG provenance at Berrimah (Table 2).

Table 1. The occurrence of the insects *Platymopsis humeralis* and *Mictis profana* on *Acacia auriculiformis,* four months after planting at two sites near Darwin, Australia. Values are means ± standard errors.

Insect	Trees infested with insects (%)		Trees damage by insects (%)	
	Berrimah	Humpty Doo	Berrimah	Humpty Doo
P. humeralis	10 ± 1	6 ± 1	61± 5	48 ± 3
M. profana	39 ± 6	33 ± 5	79± 6	69 ± 8
n =	187	199	187	199

Table 2. Damage to Queensland (Qld) and Papua New Guinea (PNG) provenances of *Acacia auriculiformis* by the girdling insect *Platymopsis humeralis*, four months after planting at two sites near Darwin, Australia. Values are means ± standard errors. Within rows values followed by the same letter(s) do not differ significantly ($p < 0.05$).

Insect damage	Berrimah		Humpty Doo	
	Qld	PNG	Qld	PNG
Trees with main stems girdled (%)	60 ± 6^{a}	71 ± 8^{a}	50 ± 5^{b}	46 ± 6^{b}
Trees with feeding damage (%)	59 ± 7^{b}	80 ± 4^{a}	48 ± 4^{bc}	41 ± 5^{c}
Feeding damage per tree (% of branches damaged)	21 ± 8^{a}	15 ± 4^{ab}	12 ± 5^{b}	8 ± 3^{b}
n =	103	67	96	61

Mictis profana was present in a greater number of trees than *P. humeralis* at the time of sampling. *Mictis profana* was observed in 39 and 33% of trees at Berrimah and Humpty Doo respectively (Table 1), at an average of 5.2 ± 0.6 insects per tree. More than double the number of trees had visible signs of *M. profana* damage (Table 1). Both the Qld and PNG provenances were equally attacked by *M. profana* (Table 3).

Table 3. Damage to two provenances of *Acacia auriculiformis* by the sap-sucking insect *Mictis profana*, four months after planting at two sites near Darwin, Australia. Abbreviations are as for Table 2. Values are means ± standard errors. Within rows values followed by the same letter(s) do not differ significantly ($p < 0.05$).

Insect damage	Berrimah		Humpty Doo	
	Qld	PNG	Qld	PNG
Trees with shoots damaged (%)	79 ± 4^{a}	78 ± 6^{a}	65 ± 10^{a}	71 ± 6^{a}
Shoot tips damaged per tree (% of tips damaged)	14 ± 2^{a}	15 ± 1^{a}	15 ± 2^{a}	10 ± 1^{a}
n =	103	67	96	61

Effect of insect damage on tree height

Tree height and form varied significantly among the three provenances at Berrimah (Table 4). At Humpty Doo there was no provenance or insect effect on tree form or height (data not shown). At both sites there were no insect x provenance interactions for either tree height or form parameters. Consequently, data from the three provenances were pooled at each site to evaluate the impact of insect damage on tree growth and form.

Table 4. Tree growth and form of three provenances of *Acacia auriculiformis* 20 months after planting at Berrimah. Trees had either girdling by *Platymopsis humeralis* 4 months after planting or remained ungirdled. Abbreviations are as for Table 1. Values are means ± standard errors. Values followed by the same letter(s) do not differ significantly ($p < 0.05$).

Provenance	Tree height (m)		Bole length:height ratio	
	Girdled	Ungirdled	Girdled	Ungirdled
Qld	4.0 ± 0.1[a]	4.0 ± 0.1[a]	0.51 ± 0.03[a]	0.53 ± 0.03[a]
PNG	3.6 ± 0.2[b]	3.8 ± 0.1[ab]	0.38 ± 0.03[b]	0.43 ± 0.03[b]
NT	3.6 ± 0.2[b]	3.5 ± 0.1[b]	0.37 ± 0.13[b]	0.23 ± 0.04[c]

Platymopsis humeralis preferentially attacked the larger trees at each site ($p < 0.01$), with the girdled trees 20–70% taller than ungirdled trees 4 months after planting (Figure 2). In the following 6 months, which coincided with the dry season (Figure 1), this height difference between girdled and ungirdled trees decreased due to the lower and sometimes negative growth rates of girdled trees (Figure 2). During this period girdled trees at Humpty Doo (unirrigated) had a growth rate of -0.03 m month^{-1} compared to 0.03 m month^{-1} for ungirdled trees. At the Berrimah site (irrigated), the growth rate of girdled trees was 60% lower than that of ungirdled trees (0.06 and 0.14 m month^{-1} respectively). Between 10 and 20 months after planting, no additional effects of girdling on tree height growth were observed at either Berrimah (0.19 and 0.17 m month^{-1} girdled and ungirdled, respectively) or Humpty Doo (0.13 and 0.12 m month^{-1} girdled and ungirdled respectively).

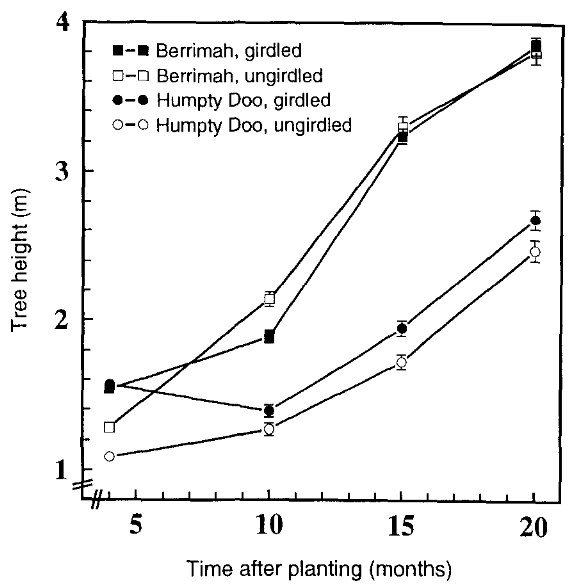

Figure 2. Height of *Acacia auriculiformis* trees which had either been girdled by the insect *Platymopsis humeralis* (girdled) or not girdled (ungirdled), four months after planting at two sites near Darwin, Australia. Vertical bars indicate standard errors.

Tree height growth was not reduced by *M. profana* activity either in the period immediately following insect feeding or in the long term (Figure 3). Again a preference ($p < 0.01$) for the larger juvenile trees was observed for trees attacked by *M. profana* at the Humpty Doo site.

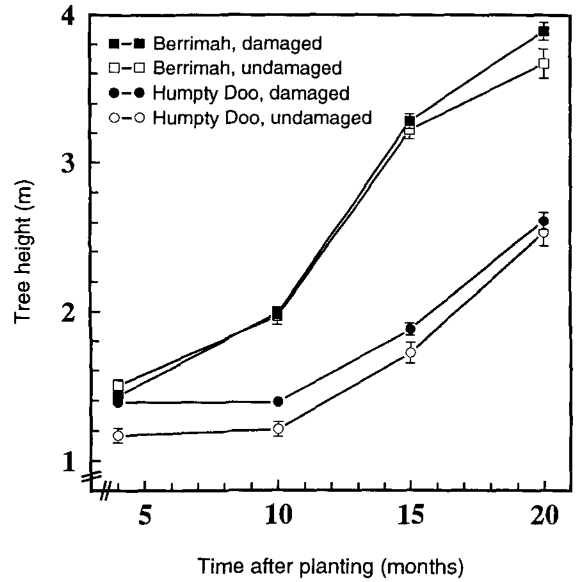

Figure 3. Height of *Acacia auriculiformis* trees either attacked by the apical shoot tip feeding insect *Mictis profana* (damaged) or not attacked (undamaged), four months after planting at two sites near Darwin, Australia. Vertical bars indicate standard errors.

Tree form was not affected by the feeding/breeding activity of either insect, 20 months after planting (Tables 5 and 6). Girdling of the main stem of the juvenile trees by *P. humeralis* did increase branch number immediately following girdling, but this effect did not persist (Table 5).

Table 5. Effect of stem girdling by *Platymopsis humeralis* at four months after planting, on the tree form of *Acacia auriculiformis* grown at two sites near Darwin, Australia. Values are means ± standard errors. Within rows values followed by the same letters do not differ significantly ($p < 0.05$).

Tree parameter	Months after planting	Berrimah		Humpty Doo	
		Girdled	Ungirdled	Girdled	Ungirdled
Branch number	4	9.0 ± 0.3^{b}	8.3 ± 0.4^{b}	11.1 ± 0.4^{a}	7.1 ± 0.4^{c}
	20	54 ± 2^{a}	59 ± 2^{a}	33 ± 1^{b}	33 ± 2^{b}
Bole length: height ratio	20	0.47 ± 0.02^{a}	0.47 ± 0.02^{a}	0.33 ± 0.02^{b}	0.34 ± 0.03^{b}
Bole form	20	2.7 ± 0.09^{a}	2.4 ± 0.13^{a}	2.6 ± 0.12^{a}	2.8 ± 0.13^{a}
n =		114	73	95	104

Table 6. Effect of shoot tip damage by *Mictis profana* four months after planting, on the tree form of *Acacia auriculiformis* grown at two sites near Darwin, Australia. Values are means ± standard errors. Within rows values followed by the same letter do not differ significantly ($p < 0.05$).

Tree parameter	Months after planting	Berrimah		Humpty Doo	
		Damaged	Undamaged	Damaged	Undamaged
Branch number	4	9.0 ± 0.3^a	7.6 ± 0.5^b	9.6 ± 0.4^a	7.7 ± 0.6^b
	20	55 ± 2^a	58 ± 3^a	33 ± 1^b	33 ± 2^b
Bole length: height ratio	20	0.47 ± 0.02^a	0.46 ± 0.03^a	0.32 ± 0.02^b	0.36 ± 0.03^b
Bole form	20	2.6 ± 0.09^a	2.5 ± 0.14^a	2.6 ± 0.11^a	2.8 ± 0.14^a
	n =	148	39	137	47

Discussion

More than half the juvenile trees in the two *A. auriculiformis* field trials were damaged by the insects *P. humeralis* and *M. profana* by the end of the first wet season, 4 months after planting (Table 1). In Australia both of these insects have previously been recorded as pests of *A. auriculiformis* (Wylie *et al.* 1997), and other acacia spp. (Van Den Berg 1980, 1982, Radunz & Allwood 1981). Girdling of *A. auriculiformis* has also been reported in Thailand (Hutacharern 1983, 1987), but by a different insect (*Sinoxylon* sp.) However, the impact of insect damage on tree growth and form of *A. auriculiformis* has not been assessed.

In this study tree growth was reduced only by *P. humeralis* damage (Figure 2). However, because the larger trees were selected for girdling this effect was somewhat obscured. The impact of *P. humeralis* on tree growth was limited to the 6 months following girdling during which time the girdled stem died. No longer term effect on tree growth could be detected. This would be expected if the loss of apical dominance, caused by girdling of the main stem, resulted in the growth and persistence of a number of lateral branches, i.e. girdled trees becoming more "bushy". Clearly, growth rates of ungirdled and girdled trees were similar between 10 and 20 months after planting.

The crusader bug *M. profana* is a known pest of acacias in Queensland, Australia, where in one trial almost all trees were affected and around 25% of shoot tips attacked, but no measurements of tree growth were reported following this insect attack (Wylie *et al.* 1997). In our study fewer trees were affected and the amount of damage to each tree was also less (Table 3). This level of insect attack did not reduce tree growth (Figure 3).

In this study we could not detect any change in tree form 20 months after planting, even when the main stem was killed by girdling (Table 5). The only impact of girdling on tree form was an initial increase in branch number due to the loss of apical dominance (Table 5). While insect damage did not appear to alter tree form, differences between the three main provenances were observed at Berrimah (Table 4, Montagu *et al.* 1996). Thus trees from the NT provenance were multi-stemmed and of poor form irrespective of the occurrence of insect damage. Likewise, irrespective of the occurrence of insect damage, trees from the Qld provenance were of the best form. We acknowledge that this trial contains only a limited range of genetic material of *A. auriculiformis*, particularly from the NT provenance and no assessment of individual clones was possible. However, genetic difference is greatest at the provenance level in this species (Wickneswari & Norwati 1993). Thus if genetic differences between provenances existed, in either the attractiveness of the trees to insects or the tolerance of the damage sustained, some indications of these differences should have been observed in this study. No clear difference between the Qld and PNG provenances was observed in this trial (Tables 2, 3 & 4). Instead, both provenances displayed a tolerance to quite severe insect damage.

Juvenile *A. auriculiformis* trees are most vulnerable to insect attack, particularly girdling by *P. humeralis*, in the first year following planting. At this age the main stem is the only stem of a size suitable for girdling. Consequently, girdling has a negative impact on tree height growth in the first year. In recent plantings of *A. auriculiformis* we have developed a control strategy to counter the attack by *P. humeralis*. Seedlings of *A. auriculiformis* are planted into rows pretreated with herbicide. Native sorghum grasses (*Sorghum* sp.) are allowed to grow to a height of 2.5–4 m between the rows of acacia seedlings. By the end of the wet season, when insect numbers are at their greatest (Flanagan *et al.* 1990), the acacia seedlings are screened from the "view" of the insects and consequently insect damage is greatly reduced in the first year. In subsequent years, when the trees have outgrown the sorghum cover crop, insect attack would recur but it would potentially have less impact on tree growth than the damage in the first year. This strategy does pose some risks due to the higher fuel load associated with the sorghum grasses during the dry season. On experimental plots we have reduced this risk by slashing the sorghum grasses in the early dry season.

The high incidence of trees damaged by *M. profana* and *P. humeralis* in this study may in part be due to the small size of the plantings (200–400 trees). The colonisation of new plantings by polyphagus (multiple-host) insects, such as *M. profana* and *P. humeralis*, has been suggested to follow a pool exhaustion model (Flanagan *et al.* 1990). This model suggests that the in-flight of insects to new plantings is determined by the number of insects on alternative host plants in the surrounding area. Thus small new plantings may be more affected by polyphagus insect damage due to the concentration of insects from the surrounding area onto few trees. This may partly explain the lower incidence of *P. humeralis* damage observed at the Humpty Doo site where additional plantings of *A. auriculiformis* doubled the tree number compared to that present at the Berrimah site. The model also suggests that large commercial plantings would sustain lower levels of insect damage than that reported in this study. Further studies are required to determine the incidence of insect damage in larger plantings. However, there is the possibility that insect numbers may increase during the first rotation and could pose a greater risk to subsequent rotations.

In conclusion, the insects *P. humeralis* and *M. profana* caused considerable damage to juvenile trees of *A. auriculiformis*. In the most severe attack, girdling of the main stem resulted in a decrease in tree height of 0.4–0.5 m. Surprisingly there appeared to be no long term effect of insect damage on tree growth or form. In addition, no provenance variation could be detected with respect to either the attractiveness of trees to insects or tolerance of the insect damage.

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