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DISTINGUISHING THE WOODS OF ARAUCARIA CUNNINGHAMII (HOOP PINE) AND ARAUCARIA BIDWILLI (BUNYA PINE)

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SUMMARY

Araucaria today is endemic to the Southern Hemisphere, with three species in Australia. *Araucaria cunninghamii* Ait. ex D.Don (Hoop Pine) and *A. bidwilli* Hook. (Bunya Pine) were cut in the past and marketed together as Colonial Pine. Today only *A. cunninghamii* is cut commercially, mainly from plantations established in the last few decades.
For the most part the two timbers are indistinguishable and have very similar properties. Generally, descriptions of the wood anatomy of *A. cunninghamii* and *A. bidwilli* do not enable a clear distinction to be made between the species. Although the heartwood of *A. bidwilli* can be distinguished from *A. cunninghamii* using chemical tests, it is always desirable to have a ready means of distinguishing between timbers using anatomical characters as heartwood is often very difficult to recognize in sawn wood. This study found differences in these two species in cross-field pit size and number, and ray size. In *A. cunninghamii*, the number of cross-field pits is (2–)3–9(–13) and average ray height is 18 cells, with a maximum of 30 cells; in *A. bidwilli*; the number of cross-field pits is 2–6(–9) and average ray height is 12 cells, with a maximum of 25 cells. The technological properties and the utilization potential of the two species are reviewed.

Key words: *Araucaria*, Araucariaceae, wood identification.

INTRODUCTION

Araucaria cunninghamii occurs in the forest of coastal ranges of eastern Australia. Its southernmost limit is the Dorrigo Plateau in New South Wales to as far as Rockhampton in the Cape York Peninsula. It also occurs in the high country of Papua New Guinea (PNG) on Mount Obree and in association with *A. hunsteinii* K. Schum. The tree attains a height of 60 m and diameters between 0.6 m and 2 m in Queensland and up to 3.5 m in PNG (Kingston 1953). The mature tree is often free of branches for two thirds of its height. The upper third yields knotty timber that was used extensively for cases and boxes, building timber and, in small sizes, for joinery and furniture. The trunk is normally straight and cylindrical and has a thin papery bark with a papery outer layer which shows horizontal bands or 'hoops' which, when the bark peels, curl up at the ends.

Araucaria bidwilli has a more limited range than *A. cunninghamii*, and it occurs sparsely in south-eastern Queensland, between Brisbane and Maryborough, generally in association with *A. cunninghamii*. It is a stouter tree than *A. cunninghamii*, growing to 35–45 m in height, with branches starting lower and producing a shorter clear length of bole. The species appears to be fairly frost-resistant and has been grown in Australian State capital cities of Hobart and Canberra (Boland et al 1992). The tree produces edible nuts in large football-like cones. The timber from top logs is extremely knotty.

The timbers of *A. cunninghamii* are yellowish white to light brown in colour, while those of *A. bidwilli* tend to be more pinkish than *A. cunninghamii*. The woods of the two species are for the most part indistinguishable and for that reason in the past they were sold together under the name 'Colonial Pine'. The woods are typically straight grained, fissile, with a close and even texture producing a plain figure. The wood from both species has characteristic fine pin knots, which, in sawn wood, provide a good way of differentiating *Araucaria* from the very closely related *Agathis* species. *Araucaria bidwilli* is somewhat lighter than *A. cunninghamii*, the air-dry densities are 460 kg/m^3 and 530 kg/m^3, respectively. Both species shrink around 4% tangentially and about 2–2.5% radially (green to air-dry) (Kingston & Risdon 1961).

Although two simple chemical tests can be used to separate heartwood of *A. cunninghamii* and *A. bidwilli*, both tests have been shown only to work positively (Cohen 1933), i.e., only a positive result indicates the specific species. Boas (1947) also described one of these chemical tests, and indicated that "there are other microscopic means of distinguishing between the species", but, unfortunately, he did not indicate what the anatomical differences were, or where such information might be found. The aim of this paper is to elucidate the nature of the anatomical differences between the two species.

MATERIALS AND METHODS

Wood samples and slides from the CSIRO Dadswell Memorial Wood Collection (FPAw) were used in this study, and the FPAw material covered the geographic distribution of the species. The following specimens were studied: *A. bidwilli* (10 samples): FPAw 1610, 1630, 1801, 1803, 2242, 2243, 2244, 2245, 2246, 2247; *A. cunninghamii* (11 specimens): FPAw 562, 740, 1586, 1628, 1738, 1739, 1740, 1840, 2977, 2978, 2981.

Burning splinter test was carried out on match-sized samples according to the method prescribed by an IAWA list (IAWA 1989).

RESULTS

Description of the woods

Macroscopic characteristics of the woods — Growth rings often barely visible to sometimes moderately distinct in both species, sometimes quite distinct in *A. bidwilli*, transition from earlywood to latewood gradual; rays fine, barely visible to the naked eye numbering 6–8/mm, usually pale and not very prominent on the radial surface.

Resin canals absent. Match-sized splinters burn to a partial or full ash varying in colour from white to bluish grey to buff (yellow-brown).

Microscopic characteristics of the woods — Tracheids 3.5–6 mm long, often poorly aligned radially, generally polygonal to irregular in shape, 25–55(–65) μm in diameter, earlywood to latewood transition gradual, indicated by reduced radial cell diameter and an increasing wall thickness, pitting on radial walls of tracheids alternate, 1–2 (–3) rows mainly on radial walls, more numerous near tracheid ends, rounded to hexagonally compressed when in multiple rows, 13–22 μm in diameter, apertures round to oval, though sometimes with a vague opposite tendency, pit borders round or oval when in uniseriate arrangement, sometimes compressed or hexagonal when in two or three rows, pit apertures rounded to lenticular, 's'-shaped and extended well past the border, in severe compression wood. Resin plugs variable, present to absent. Parenchyma absent. Rays uniseriate sometimes biseriate, with biseriate portion sometimes, 2 to 4 cells high, mean ray height 12–18 cells, up to a maximum of 30 cells. Cross-field pits 2–13 per cross-field, half-bordered, circular or slightly distorted when crowded, borders 8.5–12.5 μm in diameter, apertures lenticular frequently extending past border in compression wood zones; usually free of resin. Ray tracheids absent. Compression wood common.

DISCUSSION

The woods of the two species are for most part indistinguishable; however, some anatomical differences were found; these are illustrated in Figure 1 and summarized in Table 1. Latewood tracheids are usually less prominent in *A. cunninghamii*, but they are often distinctly thicker walled in *A. bidwilli* (Fig. 1a, d) and appear more distinct in narrower growth rings where the transition is abrupt. Radial tracheid pit diameter is generally greater in *A. bidwilli* (see Table 1).

Table 1. Differences between *Araucaria cunninghamii* and *A. bidwilli*.
(Ranges represent the most frequent range of the feature measured).

	Araucaria cunninghamii	*Araucaria bidwilli*
Number pits/cross-field	3–9(–13)	2–6(–9)
Cross-field pit diameter (μm)	7–10	10–12
Tracheid pit diameter (μm)	13–15	15–22
Ray height: mean (and max.) number of cells)	18(–30)	12(–25)
Growth ring distinctness	indistinct to rarely moderately distinct	indistinct to moderately distinct
Density (kg/m^3)	460	530
Wood colour	yellowish to light brown	yellowish to light brown, often pinkish (pink streaks)
Incidence of compression wood	frequent	infrequent
incidence of wetwood	occasional	rare

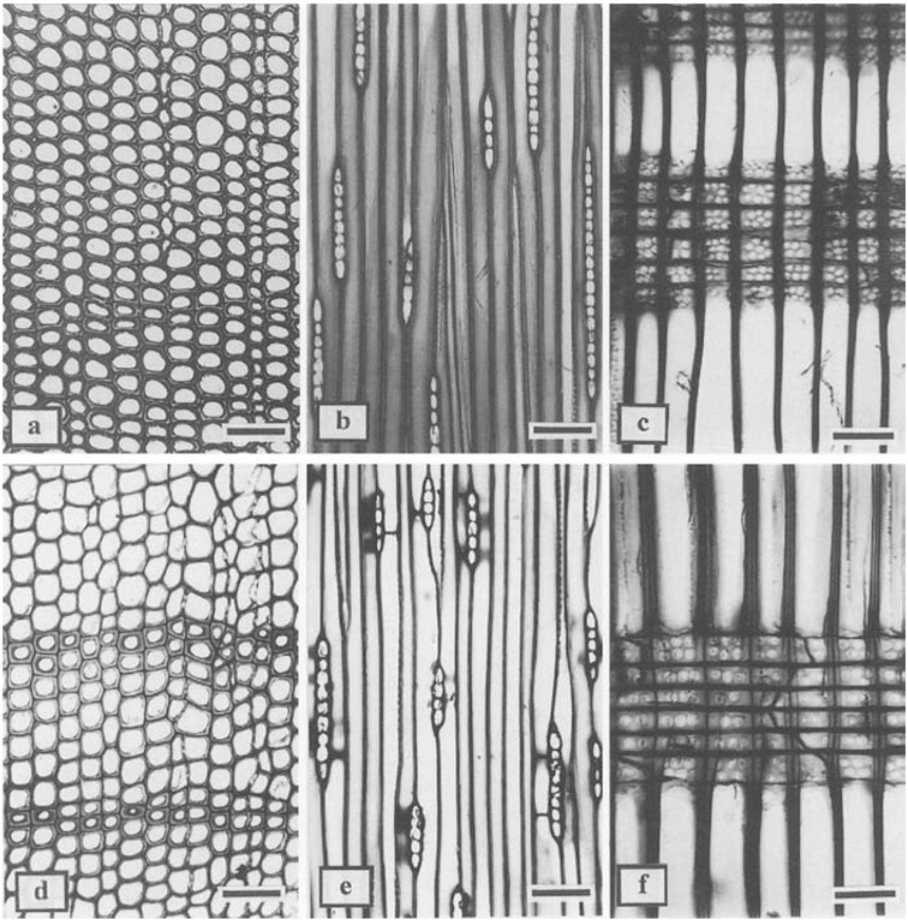

Fig. 1. — a–c. *Araucaria cunninghamii* (Hoop Pine); a: typical arrangement of tracheids, often radial alignment is less pronounced than in *A. bidwilli*, TS; b: typical height of rays, TLS; c: cross-field pitting half-bordered, numerous and small, TLS. — d–f. *A. bidwilli* (Bunya Pine); d: arrangement of tracheids, with distinctly thicker walled latewood cells TS; e: typical height of rays, with shorter rays compared with Hoop Pine shown in a, TLS; f: cross-field pits half-bordered, fewer and larger than in Hoop Pine shown in b, TLS. — Scale lines a, d = 200 µm; b, e = 125 µm; c, f = 30 µm.

The major difference between the two species is in the size and number of cross-field pits in normal wood. The cross-field pits of *A. bidwilli* are 10–12.5 µm in diameter, with 2–6, up to 9, per cross-field, and less contiguous than in *A. cunninghamii*. The cross-field pits of *A. cunninghamii* are 8.5–10 µm in diameter, with 2–13, mainly 3–9 pits per cross-field, and the pit borders are somewhat compressed and smaller (Fig. 1c). The cross-field regions used for pit counts were in earlywood, and from centrally located cells in rays more than 4 cells high. Cells in shorter rays tended to have larger axial dimensions and more pits than the smaller centrally located cells of taller rays. Marginal ray cells also are axially enlarged. The pit apertures are lenticular to slit like in both species. The occurrence of piceoid cross-field pits in *A. cunninghamii* reported by Phillips (1948) was found to be of little diagnostic value. The apparent occurrence of piceoid cross-field pits, it is suggested, is related to the greater incidence of compression wood in *A. cunninghamii*, which has the effect of making the pit apertures more slit-like (piceoid-like) depending on the level of severity of the compression wood.

Ray height is also a useful feature to help differentiate the two species, but on its own it was less reliable than the cross-field pitting. Moreover, considerable difficulty was experienced in obtaining reliable counts of ray height due to terminal confluence (vertical fusion) and torn ray cells. The rays are mainly uniseriate in *A. bidwilli*, mean ray height is 12 cells, with maximum height up to 25 cells, while in *A. cunninghamii*, the mean ray height is 18 cells with a maximum height up to 30 cells.

Although the number and the size of cross-field pits is far more reliable for differentiating the species than ray height, a combination of the two features in addition to the chemical tests provides the best means of differentiation. Characteristics of the two species are summarized in Table 1. The wood structure is similar in Australian grown specimens of *A. cunninghamii* and those grown outside of Australia.

The presence of resin plugs (Fig. 1b) in *Araucaria* and *Agathis* is regular enough to be noted, but it is of very little diagnostic value. In general, resin plugs are more abundant in *Agathis* than in *Araucaria*. The resin plugs (or sometimes called 'resin plates') often occur in tracheids near rays. Chemically, they are unusual in that the 'resin' is barely affected by common solvents, e.g., ether, benzene, ethanol etc.; the resin plugs are resistant to hot NaOH, and only become soluble in boiling ethanol-NaOH mixture. Welch (1927) indicated that chemically the compounds resemble alteration products of highly polymerized polyphenolic compounds found in many phloem parenchyma cells which originally contained water soluble tannins. It is very likely that the frequency and distribution of the resin plugs is responsible for the poor impregnation of plantation grown *A. cunninghamii* (Dr. H. Greaves, personal communication), furthermore it is likely that they are also associated with the highly impermeable wetwood regions.

REVIEW OF TECHNOLOGICAL PROPERTIES

Compared with *A. cunninghamii*, *A. bidwilli* has some desirable characteristics, one of these being a lower incidence of compression wood. Kingston (1953) stated that *A. bidwilli* has physical and some strength (mechanical) properties which are slightly inferior to *A. cunninghamii*. The wood from both timbers has been used for manufacture of plywood and indeed the Australian plywood industry has grown up on these species particularly owing to their fine, close, and even texture, creamy colour, light weight in relation to strength, stiffness and firmness. The timbers are not durable in contact with the ground. However, they saw and dress easily and are therefore highly suitable for joinery work and fine furniture. These woods exhibit a high strength to weight ratio, and so they are probably suitable as substitutes for spruce. *Araucaria cunninghamii* and *A. bidwilli* are stronger in bending than spruce. The elastic modulus/density^2 ratio of spruce is only about 20% higher than that for *A. cunninghamii*, and about 10% higher than that for *A. bidwilli* (Kingston 1953). This may have interesting implications for the use of the wood for musical instruments and it may well form the basis for an alternative species, as good quality spruce becomes more difficult to obtain.

Much is known about *A. cunninghamii* regeneration and silviculture compared to many other timber species. Extensive plantations have been established and they produce a large amount of timber. Although numerous trial plantings of *A. bidwilli* have been made in several tropical and subtropical countries and they have given excellent results (Dallimore & Jackson 1966), in Australia the species has not been favoured for plantations as it is difficult to regenerate; often the large seeds are eaten by animals and the trees need greater moisture than *A. cunninghamii*. However, because of its greater frost tolerance and attractive tree form, *A. bidwilli* has been planted ornamentally. Dallimore and Jackson (1966) suggest that it should be grown under forest conditions in countries with moist and well drained loamy soils where softwoods are in demand, and the true pines do not thrive.

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