

ON THE TECHNOLOGY AND ANATOMY OF SOME SILKY OAK TIMBERS.

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With Plates XVII - XXIX.

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Introduction.

This common name is applied in the Australian timber trade to quite a variety of timbers, each having a distinct specific origin, and yet all possessing one common character viz., very pronounced rays, or in trade terms a "large silver grain," whilst they all differ in colour, weight, hardness and anatomical structure. It was this confusion which produced the incentive to see if something could be done to scientifically classify these timbers, and at the same time find out some character which would help the trade to differentiate them, and also to introduce a common name at least to each for the benefit of timber dealers and users. The use of scientific names would at once rectify the trouble, and the author makes a special plea to the technologist to give his aid to the introduction of such, and to help scientific industry by placing it on a correct natural basis.

As things are at the present time, if an order be placed for "Silky Oak," several different kinds in colour at least, would probably be supplied, various species being included under the name. The result of using such a variety of timbers in a single house decoration or suite of furniture is not by any means a colour triumph, and such cases have occurred. However great their specific and generic differences, they have at least one thing in common, and that is they all belong to the same Family,—Proteaceæ. New

common names have been introduced into this paper in an endeavour to assist the trade, and these could be used till such time as scientific names are employed.

Histological study has opened up a new feature, and attention is drawn to the fact that the preponderance of the rays in the wood material appears to break up the usual uniformity of concentricity of annual rings, so characteristic of dicotyledonous stems, into arcs on a transverse section. In the case of "Bull Silky Oak" the rays in a cross section are so broad and numerous as to make up quite half of the surface. It is the long straight and numerous rays that give the wood of these oaks its radial fissility. The ray feature is so characteristic of the Family that it differentiates the Proteaceæ from all others except the Casuarinaceæ.

The deep broad rays have given rise to the common name of Oak to these timbers, which correspondingly give the well known figure to the silver grain of the European or northern hemisphere oaks, *Quercus*. But here the similarity ends so far as wood structure is concerned. Some of these Oaks can be determined microscopically at once by their cell contents, especially *Orites excelsa*.

The timbers are, with one exception, comparatively light in weight yet comparatively strong, and are regarded mostly as excellent cabinet woods, although they are much appreciated in several trades, such as for coach building, cooperage, dairy utensils, saddle-trees particularly so, as in the case of *Grevillea robusta* and *Orites excelsa*, no timber mentioned in this paper holds nails so well as these. I am informed by Mr. T. I. Wallas "that silky oak timbers have been used in cooperage on the Northern Rivers district, N.S.W. for many years, and also all dairy utensils,—churns, tubs, basins, wine casks, meat pickling tanks and buckets were made of silky oak timber." These would probably be *G. robusta* or *Orites excelsa*. In Queensland *Cardwellia sublimis* is the more generally used Oak.

The characteristic features of each species are shown in the macroscopical and microscopical illustrations. The most remarkable will be seen in the transverse sections, which show the rays dividing the other wood elements into segments, which have their concavity outwards, *i.e.*, towards the bark, an arrangement which is now found to obtain in all the genera of Proteaceæ except Persoonia. In no other Family was this found in any timbers examined, not even the Casuarinaceæ, which has equally as large rays as the Proteaceæ. The small globular bodies found in the wood elements of the several species is a unique feature in timbers and has taxonomic value, in which direction can also be used the disposition of the fibres and wood parenchyma in the several species, and this should aid specific determination.

This paper covers investigations on the timbers of the following species:—*Grevillea robusta*, Silky Oak; *G. Hilliana*, Red Silky Oak; *Embothrium Wickhami*, Satin Silky Oak; *Cardwellia sublimis*, Bull Silky Oak; *Orites excelsa*, Pink Silky Oak.

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GREVILLEA ROBUSTA A. Cunn., Silky Oak, (B. Fl. v, 459).

Remarks.—This was probably the first tree to receive the name of Silky Oak, or at least the name was first associated with this species, and it has been customary by the uninitiated, to give the name *Grevillea robusta* to every timber in the Sydney market called commercially Silky Oak.

Range.—Richmond and Tweed Rivers, New South Wales, also the coastal districts of Queensland.

Timber.—(a) *Macroscopical.*—*Physical Properties.*

Colour.—It is the palest of all the Silky Oaks here described, and more nearly approaches in colour that of the true oaks *Quercus*, than any other. The rays, although distinct, are the same tint as their setting, their distinctiveness being caused by the contrasting plane.

Figure or Silver Grain.—It possesses a very attractive figure which more nearly resembles that of *Quercus* than any of the other Silky Oaks. The rays are a very prominent feature on the quarter or silver grain, being broad and of good length, and the fibres often wavy between them add to the beauty. In the tangential section, the ends of the numerous rays give a lace-like appearance to the surface, and in this end-on-view the rays are more pronounced than in the common oak.

Texture and Grain.—The grain may be said to be straight, although at the prominent rays the fibres are bent, but this does not affect the planing or dressing of it, and viewed longitudinally in any cut it would be classed as open. Transversely the texture is close, the fibres predominating and forming a close compact mass between the well defined rays. It works and planes well and takes a good polish.

Transverse Tests.—(The following were made upon selected timber of standard size 38 in. $\times$ 3 in. $\times$ 3 in., and the same remark applies to the other tested pieces.)

	No. 1.	No. 2.	No. 3.
Breaking load	1,890	2,370	7,000
Modulus of rupture in lbs. per sq. in.	3,720	4,650	14,237
Modulus of elasticity „ „	483,000	486,000	1,700,000
Rate of load in lbs. per minute ...	250	428	875

Weight.—40 lbs. 6 ozs. per cubic foot.

(b) *Microscopical.*

Transverse.—There are four main features in this section which characterise the field of vision in a low power objective, viz, the medullary rays, fibres, parenchyma and pores, and each occupies about an equal area. The wide multiseriate rays are especially conspicuous, running in broad lines through the picture, with uniseriate ones intervening. Between the broad rays the other organs mentioned above occur, the fibres and parenchyma alternating in well marked loops with the concave side outwards, towards the bark. Interspersed amongst the parenchyma, but close up to the fibres are pores, mostly empty; tyloses and resin were not seen.

Radial Section.—When cut clear of the rays, the salient feature is the columns of fibres separated by their thin walled cells from the xylem, parenchyma and vessels. There are two kinds of rays, broad and narrow, the latter showing to better advantage in a micro-section. Both vary in height according to the number of cells in the vertical plane, they naturally form a pronounced feature in the section; most of the cells contain either an amorphous substance or silica, in fact the amount of silica detected in this species exceeded that found in any Silky Oak or other species examined. Small globular bodies were seen in a few of the cells of both the ray and wood parenchyma. Vessels with innumerable bordered pits on the walls form a very attractive object in the field of vision. The wood parenchyma appears to be of a tracheidal nature, the cells showing bordered pits in the radial walls. The fibres run in regular columns alternately with parenchyma tissue, and scattered vessels. The lumen of the fibres is exceedingly narrow owing to the thickened walls of these wood elements.

Tangential Section.—The salient features in this section are the multiseriate rays which occupy a large portion of

the field, and which at the broadest part number from 50 to 100, or even more, a few uniseriate occur amongst the fibres. The radial walls of the parenchyma cells show bordered pits in section, and these very numerous markings of the vessels look very beautiful under a high power.

GREVILLEA HILLIANA F.v.M., Red Silky Oak, (B.Fl. v, 463).

Remarks.—This comparatively common name of Red Silky Oak is fairly well chosen, for it is certainly the darkest of them all, although dark brown in a colour scheme would more correctly describe it. It is not so common on the market as the others, and the colour is not so pleasing, although some perhaps would prefer it when furnishing in a dark brown study.

Range.—North Coast districts of New South Wales and the coastal districts of Queensland.

Timber.—(a) *Macroscopical.*—*Physical Properties.*

Colour.—As already stated the colour is dark—a true brown, and in a colour scheme can easily be distinguished from the other Silky Oaks.

Figure.—The bulk of this wood seems to be made up of small rays, which are finer than those of the other species, consequently the figure in any but a radial section is very small and is not nearly so attractive. In a radial section the whole figure is one mass of fine rays, resembling somewhat ringed or fiddle-backed Blackwood, *Acacia melanoxylon*.

Texture and Grain.—This is the closest grained of all the Silky Oaks, and is characterised by a greasy feel which with the colour differentiates it from all its class. It is consequently easy to work and dress. The pores are almost equal in number to those of *Orites excelsa*, and less numerous than in the other three.

<i>Transverse Tests.</i> —	No. 1.	No. 2.	No. 3.
Breaking load	9,760	9,440	9,660
Modulus of rupture in lbs. per sq. in.	19,520	18,880	19,320
Modulus of elasticity „ „	2,964,705	2,677,640	2,734,177
Rate of load in lbs. per minute ...	813	944	805

Weight.—62 lbs. per cubic foot.

(b) *Microscopical.*

Transverse Section.—A very beautiful figure is obtained from this section when stained with malachite green. The rays form attractive green bands across the fields of varying thickness according to the number of cells, many of which contain a deposit in amorphous form or spherical. Between these occur wood parenchyma, fibre and vessels, the first two arranged in concentric loops, concave always towards the bark. The fibres occupy by far the biggest area, being only separated by the narrow band of wood parenchyma, one, two or three cells wide. The walls of the fibres are very thick, and so only a very small lumen obtains; the cell walls are not numerous. The wood parenchyma cells have the long axis in some few instances in the arc of their disposition, and are almost all filled with a coloured deposit, which makes them still more conspicuous. The vessels are irregularly distributed throughout.

Radial Section.—A section of this face shows clear of the rays a rather regular structure, the columns of fibres alternating with the parenchyma and vessels. The rays, especially the multiseriate ones, are very pronounced, and show globular and amorphous cell contents, the former occurring also in the cells of the wood parenchyma and in the vessels, the only species in which they were so found in the latter. Silica was also detected.

Tangential Section.—The compact mass of fibres and spindle shaped end-on view of the large and small rays, with their varied cell contents are characteristics of this view.

EMBOTHRIUM WICKHAMI F.v.M., Satin Silky Oak, Red Silky Oak. (See Bailey's "Queensland Flora," iv, 1358).

Remarks.—This is easily distinguished from the other Silky Oaks by its specific gravity being the lowest. The first common name well describes the face of a planed surface.

Range.—Brushes of the North Coast of New South Wales and the coastal districts of Queensland.

Timber.—(a) *Macroscopical.*—*Physical Properties.*

Colour.—A pale pink.

Figure.—This has quite a different facies from any described Silky Oaks. The figure is a decidedly "Oakly" one, and its sheen adds to its beauty. The rays are prominent, but the open texture along with the sheen rather adds to the ornamentation of the timber. It is the most porous timber of them all; most of the fibres occur in bundles.

Texture and Grain.—This is the most open grained of all the Silky Oaks and naturally the specific gravity is the lowest, and although the rays are very prominent, yet it is not interlocked, the fibres running quite straight, and so it is easy to plane. The rays are of a darker shade or colour than the other wood elements, which possess such a very high sheen or satin surface that in cabinet work, especially panelling, there would be no necessity to polish it. It planes and works very easily.

Weight.—30 lbs. per cubic foot.

(b) *Microscopical.*

Transverse Section.—This is quite unlike in structure any of the other Silky Oaks described in this paper, in fact, unlike any other Proteaceæ so far examined by me. The

fibres occupy a large area of the wood structure, and having a large lumen and comparatively thin walls give quite a uniformity of structure, almost similar to that of a conifer; the wall perforations are very rare. The rays too are not by any means broad, and the parenchyma is most limited and not difficult to discern in this section, the cells being filled with an amorphous deposit. The vessels are numerous and mostly didymous and tridymous.

Radial Section.—In places the fibres make quite a solid face and the wood parenchymatous cells are a less significant feature of the section. The ray parenchyma cells are characterised by a brown substance which quite fills them and gives the appearance of a brick wall to this portion of the slide, but this substance occurs in the vertical parenchyma and is only rarely in the vessels. A few specimens of silica were seen.

Tangential Section.—Only in this view is the character of a Proteaceous timber seen, the multiseriate rays and fibres almost making up the whole structure. The fibres appear as very compact, in strong lines around the rays, and few pits were detected. It will be noted from the figure that it is the outer cells of the rays that contain the red colouring substance. Uniseriate rays are small and fairly distributed, whilst vertical parenchyma is a conspicuous feature.

CARDWELLIA SUBLIMIS F.v.M., Bull Silky Oak, Silky Oak,
Gold-sprinkled Silky Oak. (B. Fl. v, 538).

Remarks.—The origin of the first common name given above is difficult to trace, and may possibly be used as a term of comparison in regard to the size of the medullary rays, as obtains in a similar case of a Casuarina (*C. Luehmanni*), which is known as "Bull Oak," the rays in this case being more pronounced than in any other species of that

genus, and probably of the whole vegetable kingdom, just as the rays of *C. sublimis* are larger than those of any other of its congeners. According to Mr. R. H. Cambage, "Bull Oak" (*Casuarinaceæ*) also occurs near the coast in North Queensland,¹ where both these trees go under the name of "Bull Oak" and "Bull Silky Oak" respectively, and probably because they both have such pronounced figures. The rays are prominent in every section of the wood, and can sometimes be shown in a radial section a foot long and half an inch high, when that portion of the ray can be caught in a straight line when cutting.

Timber.—(a) *Macroscopical.*—*Physical Properties.*

Colour.—Brick red, and quite distinguishable from the others described in this paper. It is open in the grain with a comparatively small sapwood in full grown trees, but larger in the younger trees; the neighbourhood of the cambium is generally darker than the other parts of the wood.

Figure.—This wood has certainly the most showy figure of the Silky Oaks, especially when cut on the quarter, the height and length of the rays leaving little of the other wood elements exposed. The figure of course varies according to the angle the timber is cut to the rays. The vessels give it an open grain effect, a neat figure is shown when cut tangentially, and in a transverse section the rays are of course the salient feature.

Texture and Grain.—This is the second coarsest grained species described in this paper, *Embothrium Wickhami* being perhaps somewhat coarser; the large diameter of the vessels and exceptionally wide rays give it this character. The end grain is especially marked by the long distinct numerous lines of the rays which show more clearly than

¹ This Journal, XLVIII, 278 (1914).

in any other species of Silky Oak. The grain may be described as straight, the timber planing easily and a smooth surface is obtained. The silver grain is very fine, due to the large rays, and from which the tree derives its name of "Bull Oak." There is, however, one slight defect in it, namely, occasionally black streaks running through it longitudinally.

Transverse Test.—

Breaking load	...	...	...	...	5,680
Modulus of rupture in lbs. per square inch					11,360
Modulus of elasticity	„	„	„		1,344,000
Rate of load in lbs. per minute	...		...		560

Weight.—36 lbs. per cubic foot.

(b) *Microscopical.*

Transverse Section.—The area of an average field of observation is seen to be evenly occupied in amount by the rays, parenchyma, fibres and pores. In general, the section more nearly approaches that of *Grevillea robusta*, but the fibres are more regularly arranged in parallel or concentric curves (convexity inwards), than in that species, and the same remarks apply to the parenchyma throughout, which is scattered; pores are numerous, containing in some cases material not yet identified. The walls of the fibres are much thinner than in *G. robusta*, and are remarkable for the paucity of perforations. The rays are very prominent, containing minute globular substances in some of the cells.

Radial Section.—The regularity of structure of this species is well seen in this section, the columns of fibres alternating with the wood parenchyma, giving it a tracheidal appearance, and in most instances with spherical bodies in the cells of both forms of parenchyma. The two kinds of rays are well seen; the multiseriate lacking the regularity of the uniseriate, which shows very clearly the outline of each

cell, whilst in the former the cell walls are so numerous as to make the structure appear lost in so many lines. Amongst them appear at rare intervals cylindrical or elongated bodies with processes scattered over the surface, a transverse section showing them to be amorphous; therefore they can hardly be classed as sclerenchymatous bodies, but are in all probability silica. Very small spherical bodies are also seen in the cells. The bordered pits of the parenchyma are well seen in section in both the end and side walls. The wood parenchyma is the only instance in which the small spherical bodies were detected.

Tangential Section.—The most conspicuous objects in this view are, the transverse sections of the multiseriate rays, the uniseriate rays being quite insignificant compared to these. The other structure calls for no remarks, being explained in the radial section. A brown amorphous substance is in evidence in several of the vessels which have scalariform septa.

ORITES EXCELSA R. Br., Prickly-leaved Silky Oak. (B. Fl. v, 411).

Remarks.—This species is best known in the bush by the above name, but when cut into planks and placed on the market has the same common designation as *Grevillea robusta*, viz. "Silky Oak," although there really is little difference in the colour of the wood, but microscopically and chemically the differences are very marked.

Range.—Brushes of the North Coast of New South Wales and coastal districts of Queensland.

Timber.—(a) *Macroscopical.*—*Physical Properties.*

Colour.—It falls, like most of the "Silky Oaks" described in this paper, in a class of browns, this being pale but a shade darker than *Grevillea robusta*, or perhaps light pink would nearly describe it.

Figure.—The rays are a little darker in colour than the rest of the timber, but are fairly deep, perhaps deeper than *Grevillea robusta*, and nearly equal in size to those of *Cardwellia sublimis*. The “oak figure” is of course best seen in the radial surface as obtains in all this class of woods. A neat figure is found when the wood is cut tangentially or at right angles to the rays, which then appear as innumerable flecks on the surface.

Texture and Grain.—It is rather open in texture, but yet closer than that of any other described in this paper except *Grevillea Hilliana*. It planes easily, and is free working, but the prominent rays give trouble in dressing as they easily tear out. It looks well polished or waxed, but when so treated the colour changes to a dark, dirty tint.

<i>Transverse Test.</i> —	No. 1.	No. 2.	No. 3.
Breaking load in lbs.	5,550	5,850	4,750
Modulus of rupture in lbs. per sq. in.	10,744	11,397	9,238
Modulus of elasticity „ „	1,561,234	1,293,231	...
Rate of load in lbs. per minute ...	504	390	327.6

Weight.—37 to 40 lbs. per cubic foot.

(b) *Microscopical.*

Transverse Section.—The unstained section is one of the prettiest specimens of timber to be seen under a microscope. The natural colour a pale brown, brings the whole structure into good definition. The rays are naturally a prominent figure, and are very attractive by the presence of a small globule of an unidentified substance in almost every parenchyma cell, and in the uniseriate rays they look exactly like a string of beads. The fibres are seen to predominate in amount over that of the other elements, occurring in concave masses with the concavity outwards, and simple pits are fairly numerous. These are separated by mostly single rows of pores, and one or two rows of small parenchyma cells.

Radial Section.—In this species the wood parenchyma is very little in evidence, the columns of fibres being separated fairly regularly by the vessels. The multiseriate rays are conspicuous objects, and this is specially emphasised by the globules of a brown substance giving it a bead work appearance; they are also tracheidal in some instances. Sparsely scattered in the rays are a few sclerenchymatous stone, octangular cells, a distinct specific character.

Tangential Section.—The dense masses of fibres are the salient feature of this view, and next to these the multiseriate rays showing the brown globules in the cells and some octagonal sections of sclerenchyma cells, a feature which makes the specific distinction from that of any other found in this series of “Silky Oaks.”

EXPLANATION OF PLATES.

Plate XVII.—Transverse sections of *Grevillea robusta*, *Grevillea Hilliana*, *Embothrium Wickhami*, *Cardwellia sublimis* and *Orites excelsa* (all natural size).

- „ XVIII.—Radial sections of the above.
- „ XIX.—Tangential view of timber next to bark of the above.
- „ XX.—Transverse section of *Grevillea robusta* (in colour).
- „ XXI.—Radial and tangential sections of *G. robusta*.
- „ XXII.—Transverse section of *G. Hilliana* (in colour).
- „ XXIII.—Radial and tangential sections of *G. Hilliana*.
- „ XXIV.—Transverse section of *Embothrium Wickhami* (in colour).
- „ XXV.—Radial and tangential sections of *E. Wickhami*.
- „ XXVI.—Transverse section of *Cardwellia sublimis*.
- „ XXVII.—Radial and tangential sections of *C. sublimis*.
- „ XXVIII.—Transverse section of *Orites excelsa* (in colour).
- „ XXIX.—Radial and tangential sections of *O. excelsa*.

SUMMARY.

Species.	Colour.	Order of Hardness.	Weight per cubic foot.	Breaking weights on standard size	Salient feature, Macroscopical.	Salient feature, Microscopical.	Bark.
<i>Grevillea robusta</i> ...	pale brown	3	40 lbs.	7,383 lbs.	Light colour and rays	Minute spherical bodies in wood parenchyma and amorphous substance in ray parenchyma, swag arrangement, of fibres and wood parenchyma transversely.	Most furrowed of all the species, especially so in cultivated trees, much like English oak bark.
<i>Grevillea Hilliana</i> ...	dark reddish-brown	1	62 lbs.	9,620 lbs.	Colour, weight and hardness	Spherical bodies in parenchyma and vessels, preponderance of fibres over other wood elements.	Much like <i>Orites excelsa</i> on outer coating, but otherwise far more compact and hard, similar to wattle bark, <i>Acacia decurrens</i> .
<i>Embothrium Wickhami</i>	light brownish-pink	5	30 lbs.	...	Lightness in weight, high sheen, open texture	Tracheidal appearance in cross section, red substance in parenchyma.	l'esselated with small tessellations, thin.
<i>Cardwellia sublimis</i> ...	brick-red or light terra-cotta	4	38 lbs.	5 680 lbs.	Colour and pronounced rays	Large vessels or pores, equal proportion of wood parenchyma and fibres, minute presence of spherical bodies.	Somewhat resembling <i>Orites excelsa</i> but rougher.
<i>Orites excelsa</i> ...	pale brown or pinkish	2	37½ lbs.	5,383 lbs.	Large rays and colour	Numerous large spherical bodies, parenchyma and compact fibres.	Smooth, whitish, thin skin over red under-bark, thick, compact towards the cambium.



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