Technological Museum, New South Wales.

A RESEARCH
ON THE
PINES OF AUSTRALIA

BY

RICHARD T. BAKER, F.L.S.,

AND

HENRY G. SMITH, F.C.S.

With the Authors' Compliments.

Technological Museum.
Sydney,
Australia.

A RESEARCH ON
THE PINES OF AUSTRALIA.

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Under Secretary:

PETER BOARD, ESQ., M.A.

Chief Inspector of Schools:

JAMES DAWSON, ESQ., M.A.

A Research on
The Pines of Australia.

"So then Deliberation takes place in such matters as are under general laws but still uncertain how in any given case they will issue, i.e., in which there is some uncertainty: and for great matters we associate coadjutors in counsel, distrusting our ability to settle them alone."

—*ARISTOTLE*

Acknowledgments.

In the prosecution of this research every help and assistance has been rendered by the higher officers of the Department of Public Instruction, an encouragement which has tended to lighten the tediousness of the work.

By the willing assistance of the Public School Teachers under this Department, the geographical distribution of the Pines in New South Wales has been somewhat completely arranged. The location of these officers throughout the length and breadth of the State has given them an unique opportunity to assist in the Botanical Survey of this important group of our indigenous Plants. Their names are listed towards the end of this work, together with those of other correspondents who assisted.

We are also grateful to the authorities of the various European Herbaria, especially those of Kew, British Museum, Cambridge, Edinburgh, Paris, Brussels, Berlin, Leyden, and Boissier for every possible assistance; and also to the Governments of the Australian States who have assisted by providing material, and in other ways. This action has helped to give this work a Commonwealth character—a Federal spirit worthy of all commendation.

This opportunity is also taken to thank the following gentleman who have rendered botanical and other assistance, viz.:—Dr. J. A. Battandier, Algiers; Mr. R. H. Cambage, F.L.S., Sydney; Mr. J. E. Carne, F.G.S., Assistant Government Geologist, Sydney; Professor A. J. Ewart, D.Sc., Melbourne; Mr. W. Gill, F.L.S., Conservator of Forests, South Australia; Mr. N. Holtze, Port Darwin; Mr. D. E. Hutchins, Conservator of Forests, British Africa; Professor E. C. Jeffrey, Harvard University; the late Mr. J. G. Luehmann, Melbourne; Mr. P. MacMahon, Director Botanic Gardens, Brisbane; Mr. J. H. Maiden, F.L.S., Director Botanic Gardens, Sydney; the late Dr. Masters, London; Dr. A. Morrison, Perth; Mr. L. Rodway, Government Botanist, Hobart; Dr. L. Trabut, Algiers; and Dr. J. C. Willis, Director, Botanic Gardens, Ceylon.

To Mr. W. A. Gullick, the Government Printer, our thanks are due for the interest he has taken in the work, and for numerous suggestions during its publication.

Mr. F. H. Taylor, of this Museum, has rendered much assistance, especially in the preparation of sections for the micro-photographic plates. Some of the other Photographs were also taken by him.

Mr. J. Nangle, of the Sydney Technical College, and his assistants, Messrs J. Farrell and A. H. Martin, undertook the testing of the timber specimens, a work done specially for this research.

Our appreciation is also due, for assistance rendered in various ways, to the following gentlemen:—Mr. J. Sharpe, Ballina; Mr. J. Dawson, Rylstone; Mr. H. King, Glen Regis; Mr. T. B. Osborne, Lismore; Mr. J. B. McDougall, Casino; Mr. M. Haskett, Cape York; Mr. T. W. Hewetson, Sandilands; and Mr. J. Wardman, Botanic Gardens, Hobart. Also to the following members of the Museum Staff:—Messrs. C. F. Laseron (for care in collecting material), G. Beyer, M. F. Connelly, J. Cram, D. Cannon, W. Rutherford, and A. J. Holloway.

Preface.

THE economics of the Australian Pines have long been a subject of inquiry by many Museum correspondents, and it was to ascertain the extent of the commercial possibilities of these trees that this research was undertaken.

The collection of so much material upon which the results are founded, necessarily extended over a number of years, but the time taken for these investigations has been much longer than we could have wished; for in addition to carrying on this work, the ordinary routine duties of the Museum have taken up most of the official hours, so that we had to encroach largely upon our private time.

To arrive at the economic results now offered for industrial application, it was, of course, necessary that pure science should be made the foundation upon which all the superstructure could be built, and, hence, this portion of the work forms a large part of the whole; for pure and applied science are largely interdependent, and it is only by such an association that satisfactory results can be obtained.

This research, as in our work on the Eucalypts, has been a combined one, in that, botany, in its various branches of morphology, anatomy, physiology, &c., has been linked with chemistry; and naturally so, we think, for it is only thus that affinities and differences can be ascertained with the greatest degree of accuracy.

The coalescing of these two sciences characterises the whole scheme of these investigations.

The material upon which these results have been obtained is preserved in this Museum for reference and use of future students and workers.

The skill of the botanical draughtsman has not been laid under tribute on this occasion, as most of the plants and their parts, requiring to be illustrated, were too fine for pencil work, so that with one or two exceptions the aid of photography was requisitioned for the illustrations, and in this way nature itself has been more faithfully reproduced.

In order to more particularly differentiate the respective plant tissues in some cases, than that obtainable by ordinary black and white photographs, the modern process of natural colour photography has been employed. As this method of reproducing micro-sections of plants is comparatively new, some little difficulty was experienced at first, but soon overcome, and now the results, we think, justify our venturesomeness in this direction, for by careful manipulation on the part of the

photographer and printer, the cutting out of anatomical details by the colour screens has been quite obviated; whilst the colours aid in differentiating the various tissues and structures—the cell walls in the most minute cases being well defined.

The genus *Callitris* has been dealt with somewhat more fully than the others, for the reason that, next to *Eucalyptus*, of the Myrtaceous Order, it is probably the most important in Australia, having a more extensive geographical distribution than any other genus of Australian Conifers. It has thus been possible to obtain more comprehensive material from its several species, and so have been exploited nearly all the known species of *Callitris* growing in Australia and Tasmania, whilst material of some of them has been procured from remote localities, and has been collected at various times of the year. By working in so extensive a field it has been possible to determine the correlation of the several species, to rearrange their scientific sequence, and to far more widely extend their economic possibilities.

Other important genera, such as *Araucaria*, *Agathis*, *Dacrydium*, *Phyllocladus* and *Podocarpus*, have also been extensively treated.

Although it has been possible to show a probable evolution in the species of *Callitris*, yet, as regards the sequence of the several genera, it was found not so easy, in view of the absence of a number from this continent; but we have little doubt that when the whole of the genera belonging to the Coniferæ shall have been investigated on similar lines, a table of origin for the whole family will be evolved.

We have endeavoured, so far as the material and time would allow, to point out the several stages through which a genus has developed, to locate distinct botanical and chemical characteristics, and to determine those peculiar to, and distinctive of, any particular species.

By such a method as here adopted it may eventually be possible, with extended investigation, to discover the laws governing the formation of species, to indicate their evolutionary processes, and thus to locate their correct place in nature.

We are not insensible of some imperfections in this work, but it is felt that the time has arrived when the results so far obtained should be published. The doubtful points awaiting solution are many, and too diverse for us to hope to solve them during our short lives.

That we might add some new scientific facts to the world's knowledge, and assist in the development of the natural resources of Australia has been the incentive throughout this work.

R.T.B.
H.G.S.

Technological Museum, Sydney.
June, 1910.

Contents.

CONIFERÆ.

Introduction

BY THE

MINISTER OF PUBLIC INSTRUCTION.

NOT without some degree of diffidence, hardly of my own free will, do I come forward as official sponsor for this work on Australian Pines. I feel rather as one who would prefer, so to speak, to bring the authors before the footlights, introduce them to the audience, make his bow, and retire. Nor is it necessary to say much in recommending the work to public notice But having put my hand to the pen, I wish to express my gratification at the eminently satisfactory manner in which Messrs. Baker and Smith have carried out their self-imposed and arduous task.

Whether from a scientific or a commercial point of view, this work on our Pines must be regarded as one of very great value. It is the first of its kind. The authors have entered upon quite a new field of scientific investigation. While they have proceeded on lines somewhat similar to their earlier work on "Eucalypts and their Essential Oils," they have dealt more exhaustively with individual species, treating, indeed, of the whole natural order of Coniferæ.

No such purpose had before this been attempted. As may be seen from a perusal of the work, the Pines of Australia are a great national asset, whose value to the Commonwealth has never been generally realised. Their distribution over almost all parts of the continent opens up a vista of commercial possibilities now for the first time brought into prominence.

It can no longer be overlooked that the future supply of soft-woods is becoming a source of concern in many parts of the world. Comparatively little of our soft-woods, it is true, are exported, but the local demand is ever on the increase, and is rising at an accelerated rate. To Australia any deficiency in this respect would be a serious drawback to our national progress.

Soft-woods are so absolutely necessary in all works of construction, in the manufacture of pulp, and for general use, that a dearth would press on enterprise with scarcely less severity than a drought. Such varieties of indigenous timber as Hoop Pine, Bunya Bunya, Stringybark Pine, Huon Pine, and indeed all rapid-growing trees, with their wide distribution, under an adequate system of re-afforestation, might even enable Australia to become independent of outside sources of supply and meet our own needs for all time. The timber popularly

known as Cypress Pine has a special value, not easily overrated, by reason of its immunity from the ravages of the white ant.

But besides their value as timber, our Pines have other claims to consideration from the commercial point of view. They possess important chemical properties, yielding essential oils, perfumes, sandaracs, tan barks.

The main object of this publication is to stimulate a more lively and more permanent interest among the general community in the scientific and commercial possibilities of this particular section of our native flora.

No country can afford to neglect the study of its indigenous vegetation. In that of Australia, whether for the chemist, the scientist, the statesman, the journalist, or the builder, the study of our native trees should be a subject of perennial interest. Here, then, is presented for study a field of inexhaustible wealth.

Readers of this work will find treated aspects of the subject never before touched upon with the same directness and completeness.

Some interesting information on our forests has been collated by the Royal Commission on Forestry, and incidentally the distribution and quantity of the Cypress Pine and Hoop Pine are tabulated. But in the present volume the subject is comprehensively dealt with. The work is profusely and finely illustrated. It cannot fail to be of great assistance to all interested in the study of Australia's Pines, their classification, and the great variety of uses to which the timber and by-products may be put.

J. A. HOGUE.

Sydney, June, 1910.

ERRATA,

Facing page 40. Fig. 12. For "hæmatoxylon" read "hæmatoxylin,"
Page 42. Fig. 13. For "sections" read "section."
Page 46. Fig. 26. For "early" read "mature."
Page 117. Fig. 64. For "transverse" read "longitudinal."
Facing page 136. Fig. 78, is stained with hæmatoxylin and safranin.
Pages 148-149. Bendolba and Clareval should be under *C. calcarata.*
Page 323, Fig. 230. For "normal" read "abnormal."
Page 324. Fig. 235. For "longitudinal" read "transverse."

Polished Columns showing Natural Grain of Timber.

Podocarpus elata, R.Br.
"Brown Pine."

Callitris glauca, R.Br.
"White" or "Cypress Pine."

THE PINES OF AUSTRALIA.

Australian Coniferæ.

INTRODUCTION.

THE Gymnosperms find their greatest representation in Australia and Tasmania in the Natural Order Coniferæ,—one of the most widely distributed botanical divisions scattered over the earth—being represented in both the Northern and Southern Hemispheres, although less so in the latter, and of the thirty-two genera described in Bentham and Hooker's "Genera Plantarum," eleven are found in Australia and Tasmania, viz.:—

TRIBE I.—Cupressineæ.

*1. *Callitris.*
2. *Actinostrobus.*
3. *Fitzroya.*

TRIBE II.—Taxodieæ.

11. *Athrotaxis.*

TRIBE III.—Taxeæ.

16. *Phyllocladus.*
17. *Dacrydium.*
18. *Pherosphæra.*

TRIBE IV.—Podocarpeæ.

19. *Microcachrys.*
21. *Podocarpus.*

TRIBE V.—Araucarieæ.

23. *Agathis.*
24. *Araucaria.*

In all, six tribes are listed by those authors, and it will be seen that five of these are found in the Australian and Tasmanian Flora.

* These numbers are those of Bentham and Hooker, *loc. cit.*, and give the systematic sequence of the genera in that work.

It is, however, worthy of remark that although tribe VI—*Abietineæ* contains the genus having the greatest geographical range of the whole order, viz., *Pinus* with its seventy species, yet, occurring as it does in Europe, Asia, and America, strange to say, it has not a single representative in these parts of the world, and so could not be included in this research.

The genera *Callitris, Actinostrobus, Athrotaxis, Pherosphæra,* and *Microcachrys* are quite endemic, whilst *Fitzroya* occurs in Tasmania and Patagonia, and *Podocarpus* is distributed nearly all over the tropical and sub-tropical regions of the world, as well as in Australia and Tasmania.

Agathis is represented by only the two species which occur in Queensland, and so this genus may perhaps be more regarded as a native of New Zealand, Malaya and Fiji. Two species of *Araucaria* find a home in this island Continent, although the genus, however, extends to New Caledonia, Chili, Bolivia, and Brazil.

The Australian members of the Order range in size from small prostrate, straggling shrubs, as *Pherosphæra,* to gigantic forest trees such as *Agathis* or *Araucaria*, and are found to occur in a variety of situations, such as the arid interior, the depths of the gullies, and on the very mountain tops. Naturally, under so extensive and diversified a geographical area there has been evolved varying plant structures of self-adaptation to environment, although, on the other hand, it has to be recorded that some of the species possess functional organs similar to those that existed in plant life far back in geological times.

It may be stated that, as a general rule except in the case of *Microcachrys*, their fruits, leaves, mode of fertilisation, and pollination present a similarity such as obtains amongst their congeners in other parts of the world.

This investigation, in addition to the new economics brought to light, has also resulted in revealing some new and important anatomical, physiological, and organographical features, as well as producing further evidence upon which some phylogenetic hypotheses can be advanced concerning the age of the Australian Pines, and in the case of *Callitris* we perhaps have the oldest living representative of the Order.

Much systematic work, founded on morphological characters only, has been undertaken at various times on these Conifers, by such botanists as Robert Brown, A. Cunningham, Hooker (father and son), Parlatore, Miquel, Endlicher, Dr. Masters, Bertrand, Van Tieghan, and Baron von Mueller. These scientists have added much to our knowledge of the Australian Pines. Little research, however, appears to have been done previously as regards investigating their histology, physiology, phylogeny, embryology, and chemistry.

DESCRIPTION OF NATURAL ORDER.

This is so well and fully given in Bentham and Hooker's "Genera Plantarum," Vol. III, p. 420, that it would be superfluous to repeat it here.

FORESTRY.

In this direction the commercial importance of the genera might perhaps be arranged in the following order:—

1. *Callitris*, principally for timber, bark, oil, and sandarac (resin).
2. *Araucaria*, principally for timber, and oleo-gum-resin.
3. *Agathis*, principally for timber, " oil of turpentine," and resin.
4. *Athrotaxis*, principally for timber and oil.
5. *Dacrydium*, principally for timber and oil.
6. *Phyllocladus*, principally for timber and bark.
7. *Podocarpus*, principally for timber.

CHEMICAL CONSTITUENTS.

The oils, oleo-resins, oleo-gum-resins, gums, and resins, whilst corresponding in some respects to those of non-Australian Pines, yet present some new and most interesting differences in chemical characters, which are fully detailed under the respective species.

ORDER OF INVESTIGATION.

The following is the order upon which the investigation of each species has been undertaken, or at least every effort was made to carry it out in these directions, the omissions being where material was unprocurable. This arrangement holds throughout the work.

I. Historical Botany of the Species.

II. Systematic Descriptions

III. Leaves and Fruits:

- (*a*) Economics.
- (*b*) Anatomy.
- (*c*) Chemistry of the oils.

IV. Timber:

- (*a*) Economics.
- (*b*) Anatomy.
- (*c*) Chemistry of its products.
- (*d*) Forestry.

V. Bark:

- (*a*) Economics.
- (*b*) Anatomy.
- (*c*) Chemistry of its products.

VI. Illustrations, to aid in the study of the letterpress.

RESULTS.

Botanically the results of the research were generically greater than those specifically, for the peculiarities of structure were found to be quite characteristic of, and differing considerably from, those of cognate genera.

Chemically and economically they promise to be of great importance, and to open up new fields for commercial enterprise.

Vide detailed results *infra*.

SYSTEMATIC CLASSIFICATION ADOPTED.

A classification similar to that laid down by us in our work on "The Eucalypts and their Essential Oils," has been followed in this work, and the taxonomic status of the species here recognised is supported by,—

1. A field knowledge of the trees.
2. Morphology of fruits, leaves, inflorescence, and their functions.
3. Anatomy of these organs.
4. Anatomy, nature, and character of the timber and bark.
5. Chemical properties and physical characters of the oils, gums, oleo-resins, oleo-gum-resins, resins, tans, &c., and other evidences that will assist in establishing natural affinities or differences in species.

Species so founded give practically constant results, and preserve specific characters throughout their geographical distribution, and so we here again record our faith in taxonomic work based on such principles.

It may be noted that no reference is made in the above to the distribution of the resin cavities, as Engelman and others have done ; these, however, were found to occur irregularly in the leaf tissue, so that they were practically useless for systematic classification.

SUMMARY OF RESULTS FROM THIS RESEARCH.

Callitris.

1. A re-classification of the genus *Callitris* and its separation from *Widdringtonia* and *Tetraclinis*, which genera we find are restricted to South and North Africa, respectively.

2. A new sequence of the species of *Callitris* founded upon the broad grounds of botany, chemistry, and other cognate sciences—a system even more enlarged than that laid down in our previous work, "Eucalypts and their Essential Oils," is advanced.

3. The restoration of almost all Robert Brown's and Allan Cunningham's species of *Callitris* to specific rank.

4. The *Callitris* pines have been found to retain an intimate connection, both in botanical and chemical characters, throughout their geographical distribution.

5. A remarkable constancy of morphological characters was found to be preserved amongst the species of *Callitris*.

6. There is a singular absence of varietal forms amongst the *Callitris*.

7. Phylloclades are not found in *Callitris*.

8. The cause of the decurrence in the leaves of the *Callitris*, and the effect of climatic conditions in the disposition of the stomata of *Callitris* species, are suggested.

9. It is shown that a similar arrangement of the stomata obtains in *Callitris* as existed in the leaves of *Lepidodendron Hickii*, of the Carboniferous period.

10. That similar papillose projections surrounding the stomata in certain species of *Callitris* occur also in the genus *Sciadopitys*, of Japan.

11. The anatomy of the leaves of the *Callitris* is fully detailed.

12. A general conformity holds in the structure of the leaves of *Callitris* species, only minor differences in specific characters, being recorded.

13. Features distinctive from those of other Coniferæ occur in *Callitris* leaves.

14. The presence of a manganese compound, probably the "resin" of previous workers, in some of the timber cells of the Australian Coniferæ, as well as in the leaves and bark of *Callitris*, is recorded. This substance is found to occur also in the lamella of the *Callitris*.

15. The appearance of the manganese compound in these timbers, shows a strong resemblance to that in fossil woods of past geological times. The anatomy of the timber of living *Callitris* agrees in a remarkable degree with that figured by Baron von Mueller as *Spondylostrobus Smithii*, Plate XX, Geological Survey of Victoria, "Observations on new Vegetable Fossils," 1874. The cells here contain a dark substance corresponding to that in living *Callitris*, and which is now thought to be a manganese compound.

16. That a concurrence appears to exist between the anatomical characters of the leaves of the several species of *Callitris*, and the chemical constituents of their leaf oils.

17. The cells of the medullary rays are all parenchymatous in character, both inner and outer.

18. Microscopical sections of the timber of *Callitris* show, in their general structure, marked resemblances to those figured by Arber from the Nicol collection, under *Dadoxylon australe* of the Palæozoic period.

19. The rotation of the terpenes of the oil from the leaves of some species of *Callitris* is in the opposite direction to that obtained from the fruits, even if collected from the same tree.

20. The acetic ester of geraniol is more pronounced in the leaf oils than is that of borneol, and it continues to increase in the several members of one section, until a maximum of over 60 per cent. is reached in the oil of *C. Tasmanica*.

21. An ester of terpineol was found in the leaf oil of *C. gracilis*.

22. The limonenes and dipentene occur in the leaf oils, the dextro-rotatory form reaching a maximum in *C. arenosa*, and the lævo-form in *C. intratropica*. In these oils is seen a well-defined illustration of the formation in nature of the two active forms of limonene in the same plant, as well as the racemic modification.

23. The leaf oil of *C. Macleayana* contains a constituent which has a marked resemblance to menthene, and is apparently a member of that group of hydrocarbons.

24. The leaf oil distilled from some species of *Callitris* is comparable with the best "Pine-needle oils" of commerce.

25. The oil obtained by steam distillation from the timber of the *Callitris* generally, contains the sesquiterpene alcohol Guaiol in some quantity; the sesquiterpene is also present.

26. The characteristic odour of *Callitris* timber is due to a phenol. This has distinctive colour reactions and is evidently new. It appears to be the constituent which renders *Callitris* timber objectionable to white-ants. The name Callitrol is proposed for it.

27. *Callitris* resins are shown to vary somewhat in character in the different species, but several of them agree, and are of equal value with the sandarac resin of commerce.

28. The barks of some *Callitris* species are of excellent quality as tanning materials, and often contain abundance of tannin. Here has been discovered a new national asset in the vast supply of a valuable material for the leather industry.

29. That the *Callitris* should rank as one of the most important of Australian pines for forest culture, not only for timber, the chief feature of which is its immunity from the attacks of termites. but also for other economics such as oils, barks, sandarac, &c.

Actinostrobus.

30. Additional evidence is adduced to further strengthen the claims, if any doubt existed, of these pines to generic rank, and to emphasise their isolation from their congener *Callitris*; and it is now proposed to place them in botanical sequence, in proximity to *Araucaria* and *Agathis*, by regarding the bracts of the cones as sterile sporophylls.

31. The principal constituent of the leaf oil is pinene, which has a very high dextro-rotation .

32. There appears to be an entire absence of limonene in the leaf oil, thus markedly separating it from those of the *Callitris*.

33. The ester in the leaf oil is almost entirely geranyl-acetate. In this respect it shows a relationship with the oils of certain *Callitris*.

Athrotaxis.

34. The chief constituent of the leaf oil of this tree is a highly dextro-rotatory limonene, the specific rotation being 112.2 degrees.

35. Dipentene is quite absent in the leaf oil, and in this respect it differs entirely from those of the *Callitris*.

Araucaria.

36. A very marked botanical difference exists between the two species recorded for Australia, viz., *A. Cunninghamii* and *A. Bidwilli*, the latter showing, as far as we have been able to investigate, a much closer connection with *A. imbricata* of South America than with the former.

37. The characteristic structure of the barks shows anatomical features distinctive from that of any other Australian Conifer.

38. The results here recorded further emphasise the great value of these trees for forest cultivation. Being endemic to the Continent, they would provide a splendid supply of soft-wood timber for future use by proper sylviculture.

39. The oil obtained from the latex of *A. Cunninghamii* contained a hydrocarbon of the $C_{10}H_{20}$ series, and possibly of the $C_{10}H_{18}$ also.

40. Some of the chemical compounds of this plant are evidently formed, or at any rate the process completed, in the root portion of the tree, as the supply continued after the upper portions of the trees had been cut down.

41. The resin from the latex of *A. Cunninghamii* closely approaches, in appearance, the sandarac resin from the *Callitris*. It consists largely of two acids, one of which is identical with one of the acids in the resin of *Agathis robusta*.

42. Manganese was present in the latex of *A. Cunninghamii* and was precipitated by alcohol together with the gum. It changed, however, to the higher oxide on drying the gum precipitate.

43. The gum of the latex closely approaches that of gum-arabic, and differs in some respects from that of *A. Bidwilli*.

44. The exudation of *A. Bidwilli* consists almost entirely of a carbohydrate allied to ordinary gum. Although soluble in water, it was rendered quite insoluble by agitation with ordinary ether, a reaction which does not appear to take place with the gum of *A. Cunninghamii*.

45. Resins and essential oils were almost absent in the exudation of *A. Bidwilli*.

Agathis.

46. That a close botanical alliance exists between the Australian species *A. robusta* and those of the Pacific Islands and of New Zealand.

47. The microscopical sections of the timber show features which bear some resemblance to those of *Araucaria*, but yet have some points of difference.

48. The exudation of this tree consists of an oleo-resin, containing some gum, and the essential oil is practically identical with ordinary American oil of turpentine.

49. The exudation also contains a manganese compound precipitated with the gum, and it thus agrees, in this respect, with the latex of *Araucaria Cunninghamii*.

50. The resin consists principally of two new acids.

Dacrydium.

51. A strong botanical resemblance of this Pine was found to those of the same genus growing in the Pacific Islands.

52. The principal constituent of the leaf oil is a terpene, which appears not to have been previously recorded.

53. The methyl-ether of eugenol occurs in the leaf oil of this species.

54. The steam-distilled oil from the timber of this tree, and to which the odour of the wood is due, is composed mostly of the methyl-ether of eugenol.

Pherosphæra.

55. A further extension of the geographical range of this genus in New South Wales is shown.

56. The principa' constituent of the oil of this delicate prostrate Conifer is pinene.

57. The sesquiterpene cadinene is also a pronounced constituent of the oil.

Phyllocladus.

58. The morphological, anatomical, chemical, and foliaceous character of the Phylloclades are fully detailed, and as the leaves are quite degenerate organs in the species, their functions are thus performed by proxy as it were.

59. The substance of greatest interest occurring in the leaf (phylloclade) oil of this tree is a solid, readily crystallisable diterpene; it is dextro-rotatory, and melts at 95° C. The name Phyllocladene is proposed for it.

60. Pinene occurs in quantity in the leaf (phylloclade) oil and practically in a pure condition.

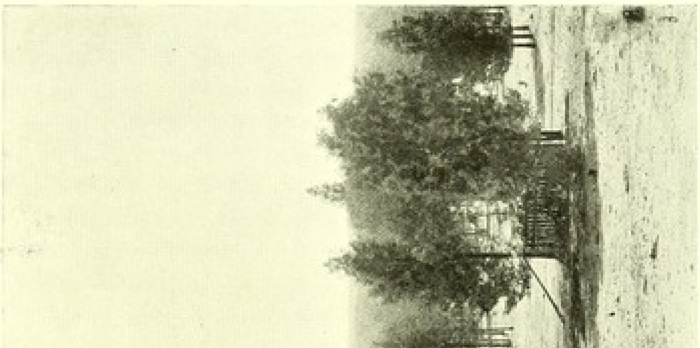
61. The bark contains both tannin and a glucoside having dyeing properties.

Podocarpus.

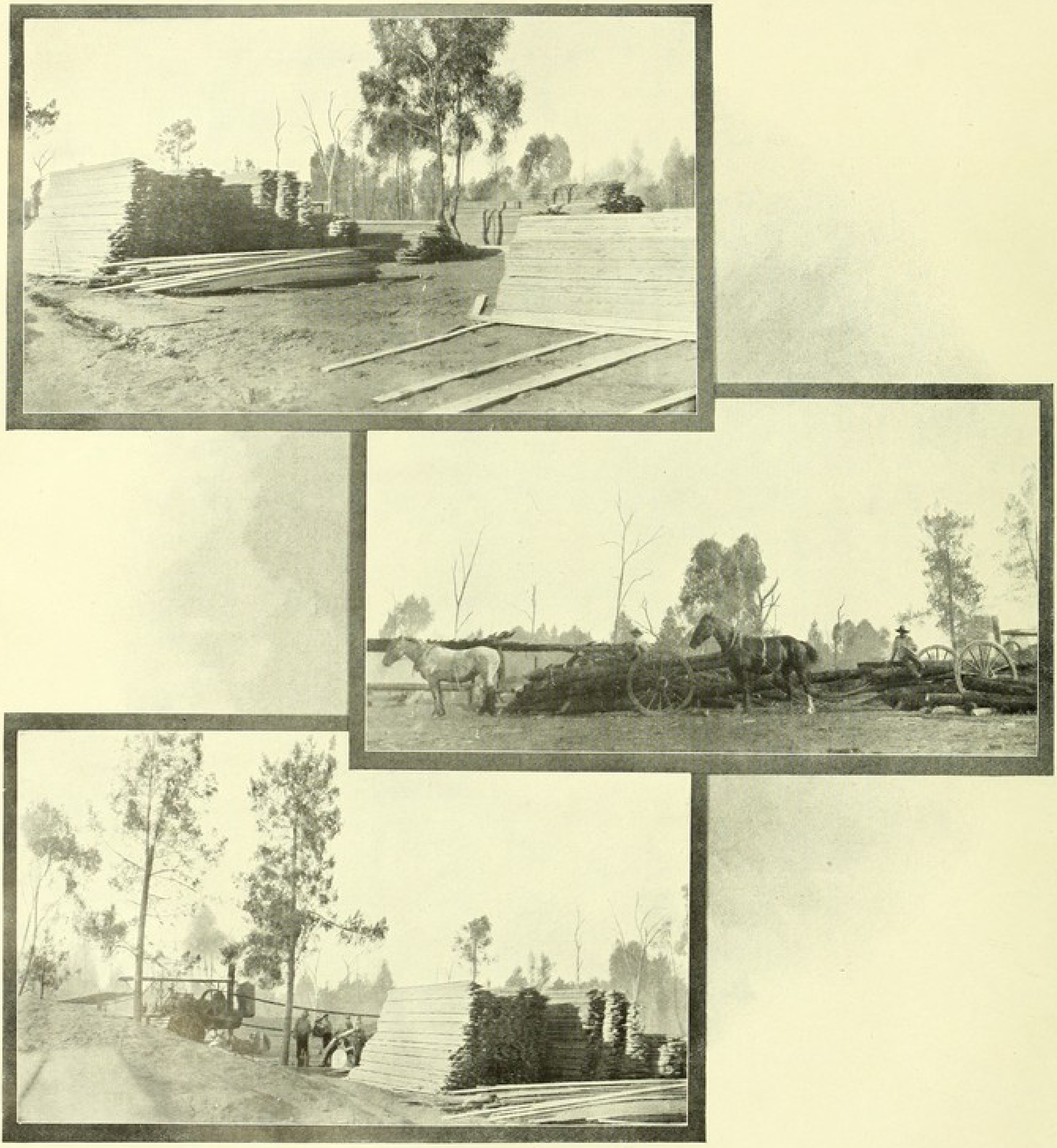
62. The microscopical character of this timber differs from that of *Araucaria*, or of *Agathis*, but resembles more generally that of *Callitris*. Macroscopically it differs from them all.

General.

63. A botanical survey of the Pines of New South Wales is now given for the first time.



TYPICAL PINE COUNTRY OF THE INTERIOR. (*Callitris glauca*, R.Br.)



Preparing Pine Timber in the Interior for Market. (*Callitris spp.*)

THE GENUS CALLITRIS.

Vent. Decad. (1808), 10.

THE AUSTRALIAN CYPRESS.

(Syn.:—*Frenela*, Mirb.; *Fresnelia*, Steud.; *Leichhardtia*, Shep.; *Pachylepis*, Brongn.; *Octoclinis*, F. Muell.; *Parolinia*, Endl.)

LIST OF HEADINGS OF ARTICLES:—

8. *C. gracilis*, R. T. Baker.
9. *C. calcarata*, R.Br.
10. *C. rhomboidea*, R.Br.
11. *C. Tasmanica*, Nobis.
12. *C. Drummondii*, Benth. et Hook. f.
13. *C. Roei*, Endl.
14. *C. Morrisoni*, R. T. Baker.
15. *C. Muelleri*, Benth. et Hook. f.
16. *C. oblonga*, Rich.
17. *C. Macleayana*, Benth. et Hook. f.
18. *C. sp. nov.*, Nobis. Not placed.

I. HISTORICAL.

THIS genus was established by Ventenat in 1808, but there is nothing, or rather no specimen extant, to show upon which Australian pine the name was bestowed, as he mentioned no species, and so it is not now known upon which tree he founded the genus. It is, however, conjectured by several authors to be *C. cupressiformis* which is now recognised as *C. rhomboidea* of Robert Brown.

Mirbel, of the Paris Herbarium, thinking Ventenat's name of *Callitris* too closely resembled in sound that of Labillardiere's genus *Calythrix* of the Myrtaceous Group of plants, substituted the name of *Frenela*, but this has not found acceptance with recent botanists, nor can it stand by the law of priority, and so it has to give place to the older nomenclature.

It was originally intended to include under *Callitris* the North African pine *Thuja articulata*,—the *C. quadrivalvis* of Richard, and *Frenela fontanesii* of Mirbel, but after examining complete botanical material of this tree we were convinced that the differences were so important as to be worthy of generic classification—an agreement quite in accord with the researches of Masters ("Jour. Linn. Soc., Lond.," Bot., Vol. XXX, No. 205, p. 14), who also regarded it as distinct under the genital name of *Tetraclinis articulata*, following the sectional name *Tetraclinis* of Bentham and Hooker, "Gen. Pl." In fact, Dr. Masters, *loc. cit.*, also supports the separation of the South African species of pines from the North African and Australian, under Endlicher's name of *Widdringtonia*.

To Mr. D. E. Hutchins, Director of Forests of South Africa, we are much indebted for material of the pines of South Africa, for comparison with the Australian *Callitris*; the result of our examination is that we are in accord with Dr. Masters' views, as his classification appears to be a rational one, for no plant with the actual characteristics of the Australian *Callitris* has so far been recorded from either North or South Africa, or, in fact, from any part of any other continent but this.

The name *Callitris sinensis* given by A. Tschirch (Die Harze und die Harzbehälter, p. 536), and occurring in other technological works, probably refers to *Cunninghamia sinensis*, as the Kew authorities inform us that they have no record of such a species as *Callitris sinensis*.*

II. SYSTEMATIC.

The following is our synopsis of the three cognate genera :—

I. **Tetraclinis.** North Africa.

Cone valves—4, thin, small, free ends of valves more obtuse than in *Callitris*.
Branchlets—flattened.
Leaves—small, decurrent, in whorls of 4.

II. **Widdringtonia.** South Africa.

Cone valves—4, very thick, free ends of valves truncate.
Branchlets—terete.
Leaves—opposite, decussate.

III. **Callitris.** Australia and Tasmania.

Cone valves—6–8, thick, free ends of valves pointed or acute.
Branchlets—terete.
Leaves—small, decurrent, in whorls of 3.

The *Callitris* are either trees or shrubs and rarely attain a great size; the ultimate branchlets being ridged by the decurrence of the leaves.

The bark is mostly hard, compact, furrowed, persistent, and extends to the branchlets; it is, however, loosely fibrous in *C. Macleayana*.

The normal leaves are in regular whorls of threes and almost wholly decurrent, only a small triangular portion at the upper end being free, and which is either incurved or appressed; the primordial leaves are triangular in section, with only a small portion attached to the stem.

The flowers are monœcious. The male amentum solitary, or in twos or threes at the end of the branchlets. It is cylindrical, oblong, or ovoid, the sporophylls being imbricate in whorls of three or four, and having an ovate, orbicular, or slightly peltate scale-like apex, with the anther cells varying in number from two to four.

*After the above was in print Dr. Stapl informs us that this name has no foundation whatever, and that he intends to write a note on this subject in the *Kew Bulletin*.

The female amentum consists of six or eight sporophylls arranged in two whorls, with several orthotropous ovules arranged in three or more vertical rows on the upper surface at the base of the sporophyll.

Bracts are quite absent.

The fruiting cone varies in size according to the species, the prevailing forms being globular, then ovoid or pyramidal; valves are united at the base in the same plane into a single whorl, the alternate ones are mostly smaller, valvate, rarely overlapping, dehiscent, and pointed at the apex, just below which is a dorsal point, more or less developed in each species.

The seeds are fairly numerous in each cone, numbering from 25 to 40. Their disposition in the sporophyll has already been given. Both fertile and sterile seeds have either two or three wings, and it is not easy to differentiate, morphologically, one from the other. The hard integument so protects the cotyledons that it requires at least many months before they germinate in the soil.

The genus has a geographical range extending throughout Australia and Tasmania, the most widely distributed of the genus being the White or Cypress Pine, *C. glauca*, R.Br., and the Black or Cypress Pine, *C. calcarata*, R.Br. Commercially, therefore, these are the best-known trees, the former taking pride of place as regards its timber, and the latter for its valuable bark. Other data of a scientific and economic nature are given under the respective species.

Bentham in the "Flora Australiensis" reduces the number of species to nine for the whole of Australia and Tasmania, whilst Baron von Mueller in his second "Census," by restoring *C. verrucosa* and *C. columellaris* to specific rank and synonymising the two species of *Actinostrobus* under this genus, enumerates twelve species.

As the result of this investigation we find the genus divides itself into eighteen species, *i.e.*:—

1. *C. robusta*, R.Br.
2. *C. tuberculata*, R.Br.
3. *C. verrucosa*, R.Br.
4. *C. propinqua*, R.Br.
5. *C. glauca*, R.Br.
6. *C. arenosa*, A. Cunn.
7. *C. intratropica*, Benth. et Hook. f.
8. *C. gracilis*, R. T. Baker.
9. *C. calcarata*, R.Br.
10. *C. rhomboidea*, R.Br.

11. *C. Tasmanica*, Nobis.
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It was expected that a number of varieties would have been found amongst these species, extending as they do over very wide geographical areas, but such is not the case, and no genus could have less varietal forms, or more well-defined species than *Callitris*. But in this connection it must not be forgotten that this wide geographical area does not present in some instances great environmental differences, a correlation, so to speak, of circumstances which no doubt accounts for uniformity or constancy of species of the genus—a character also common to our Eucalypts, as shown in the "Research on the Eucalypts and their Essential Oils." A *status quo* extending over an enormous period of time probably produces such a constancy.

Excluded Species.

The following species are given in the "Index Kewensis," Fas. I. 389, as Australian species, but as no literature or material of them appears to be extant, or at least in any of the herbaria visited by us, and as Heynhold only gave names, they may be regarded as *nomena nuda*, and so have been excluded from this work.

C. conglobata, Sieber ex Heynh. Nom. i, 148. There is a seedling specimen in the Brussels Herbarium, labelled "*C. conglobata*, Herb. Martii. 1826." It is too immature for systematic placing.

C. elegans, Sieber ex Heynh. Nom. i, 149.

C. montana, Sieber ex Heynh. Nom. i, 149.

III. THE ARRANGEMENT OF THE *CALLITRIS* SPECIES IN ORDER OF SEQUENCE.

In working out the taxonomy of the species of this genus, advantage was taken to employ the aid, where possible, of the several cognate branches of science in order to establish a classification founded as near as possible on a natural basis, and thus *not* relying alone on one special set of characters or features.

In this particular instance, morphology, chemistry, ecology, physics, and anatomy were laid under tribute, and the result is given in the table below.

It will be noticed that an attempt has been made to associate the morphology and histology of the leaf with the chemical constituents of the oil occurring in the respective oil cavities of the different species. Owing to the leaves being so small, and the absence of veins on their surfaces, this field of observation was wanting, and it was further found that no help was given by the disposition of the leaf bundles, as indicating the characteristic chemical constituents of the oil, as was shown by us to obtain in the genus *Eucalyptus*. Botanical instances of agreement with the oil had therefore to be looked for in another direction, and by studying the anatomical structure it was found, in the material examined by us, that the species divided themselves fairly well, both botanically and chemically, into groups, according as certain recognised bodies that generally go to make up leaf substance were absent, present, or in abundance in the leaf tissue. Thus, those species having abundant transfusion tissue, and little or no sclerenchymatous or stone cells in the leaf substance, had the predominant limonene in the leaf oils in the dextro-rotatory form. This group included—

C. robusta.
C. verrucosa.
C. propinqua.
C. glauca.
C. arenosa.

The next class includes—

C. intratropica.
C. gracilis.
C. calcarata.
C. rhomboidea.
C. Tasmanica,

in which the transfusion tissue is less developed, or the cells not so numerous, while the sclerenchymatous or stone cells gradually begin to appear amongst the parenchymatous tissue, in a small cluster between the phloem of the leaf trace and the oil cavities of the first group, and then gradually increase in number in the succeeding species, where they are conspicuous figures in the spongy portion of the mesophyll, and reach their maximum in *C. rhomboidea*. In this class the predominant limonene in the leaf oil is lævo-rotatory.

In the remaining species—

C. Drummondii,
(*C. Roei*),
(*C. Morrisoni*),
C. oblonga,
C. Muelleri,
C. Macleayana,

these special cells occur largely in the mesophyll, although gradually diminishing in number till *C. Macleayana* is reached, when they appear in both forms of the mesophyll, and most pronounced amongst the parenchymatous cells in the neighbourhood of the leaf bundle and oil cavity, which mode of occurrence adds another evidence of the isolation of this species from its congeners. The principal terpene in the leaf oil of this group is pinene.

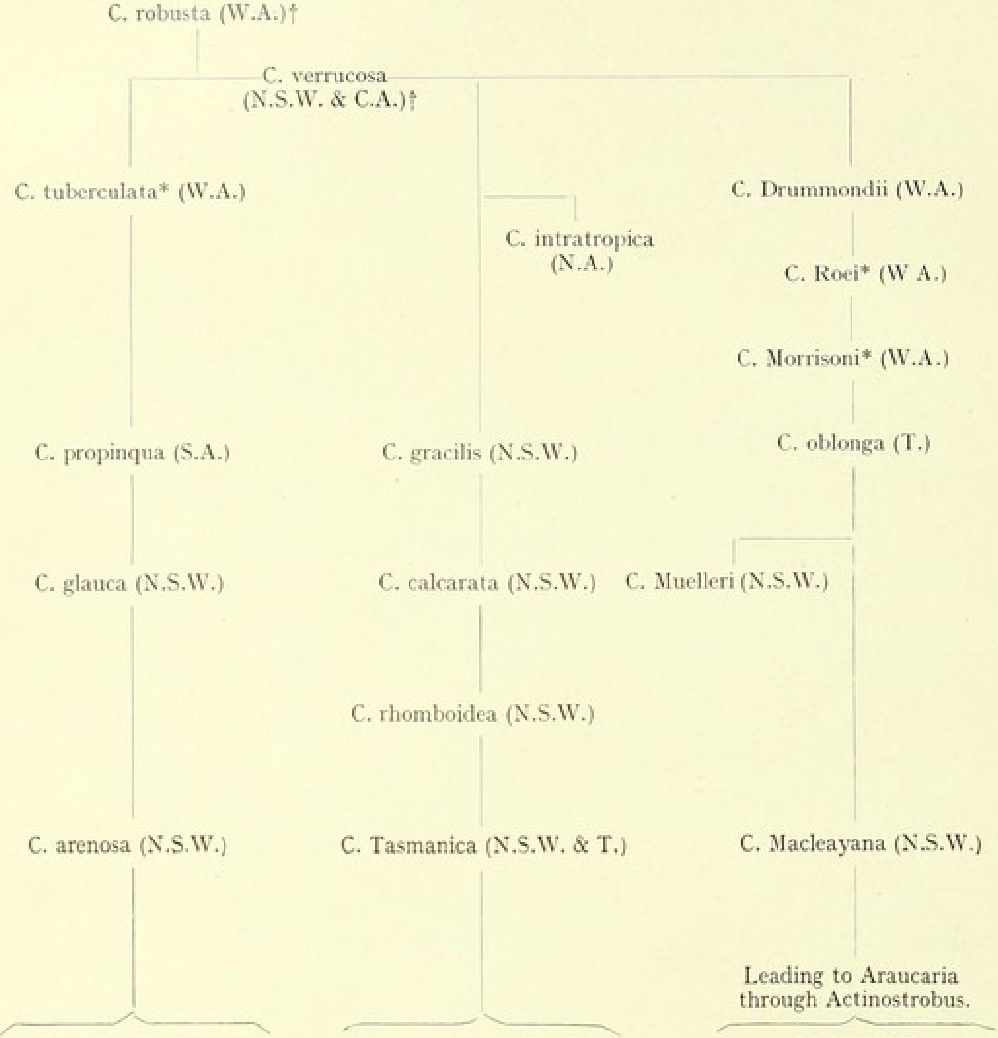
From these observations it would appear that there exists some connection or agreement between these bodies which go to make up the leaf substance, and the chemical constituents of the oil, and it is scarcely to be expected that those *Callitris* species, whose leaves give an oil in which the dextro-rotatory limonene predominates are identical in all their structural characters with those species in which the predominant limonene is lævo-rotatory. The maxima of the rotations of the limonenes in these trees are reached by slow gradations through the several species, and this evidently indicates constructive peculiarities in the leaf arrangement, even if not in the structure of the whole tree.

The method by which living plants construct the various asymmetric chemical substances is at present practically unknown, but there seems no reason why systematic study in this direction should not eventually be rewarded with as satisfactory a result as has been the investigation of the asymmetric compounds themselves. In whatever direction the forces of nature have exerted their influence in the construction of these active forms, it can hardly be without leaving a corresponding impression upon the plant tissue itself, so that a close connection between the chemical and botanical phenomena of the leaves of the several species of *Callitris* must be present, and its identification is here attempted. To successfully trace the evidence leading to the selective formation of these asymmetric terpenes in the several species of the *Callitris* would add considerably to our knowledge in this direction. Since the time when Pasteur advanced his views upon this question of optical activity, a considerable amount of work has been undertaken in the endeavour to add to our knowledge in this direction, but, so far, with no very certain results.*

There appears to be a considerable break, both botanically and chemically, in the sequence connecting *C. Macleayana* with the other *Callitris*, and this "Stringybark Pine" is evidently located at the end more nearly approaching the *Araucarias*. Whether *Araucaria* is the older genus or not, there is at present insufficient evidence to decide, but the distance separating these two genera is not great. They are both of considerable age on this continent.

* References to much of this work, together with a bibliography, are given by A. W. Stewart in his work on Stereo-chemistry, London, 1907. We would also direct attention to the address on this subject by Professor F. R. Japp, before the British Association in 1898, and the subsequent criticisms thereon, published in "Nature," Vols. 58 and 59

TABLE showing the probable evolution of *Callitris* species, as indicated by the morphological, anatomical, and chemical results obtained during this research.



GROUP I.

More or less tuberculate fruits, and a convex dorsal leaf surface. Sclerenchymatous or stone cells are mostly absent in the leaf tissue.

The predominant limonene in the leaf oils is dextro-rotatory.

GROUP II.

Generally smooth fruits and angular or rounded dorsal leaf surface. Sclerenchymatous cells in the leaf tissue are in excess of the species in Group I.

The predominant limonene in the leaf oils is lævo-rotatory.

GROUP III.

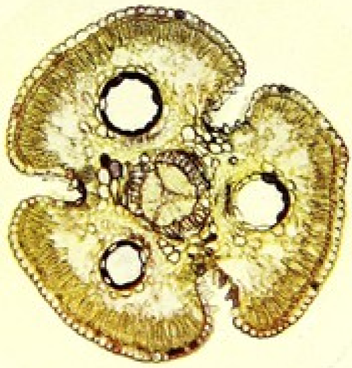
Generally smooth fruits, and angled dorsal leaf surface. Sclerenchymatous cells occur plentifully in the leaf tissue, especially in *C. Macleayana*.

The principal terpene in the leaf oils is pinene.

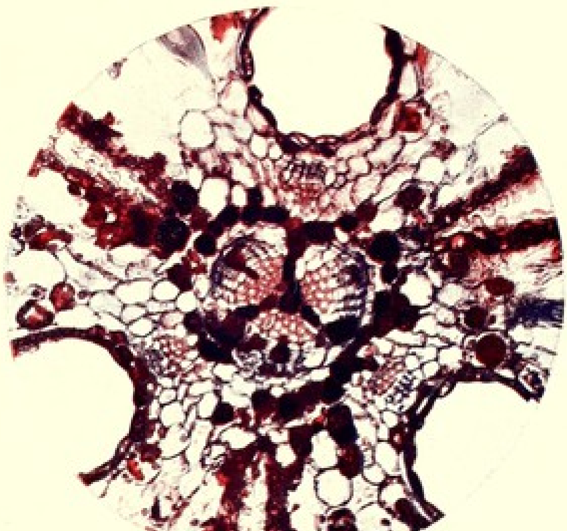
†N.S.W. = New South Wales. W.A. = West Australia. S.A. = South Australia. T. = Tasmania. N.A. = North Australia. C.A. = Central Australia.

* Placed tentatively, as it was not possible to obtain material for chemical investigation.

Group I.



Cross Section through decurrent leaves and branchlet of *C. propinqua*. x 70. No sclerenchymatous cells are seen. Very faintly stained with hæmatoxylin.

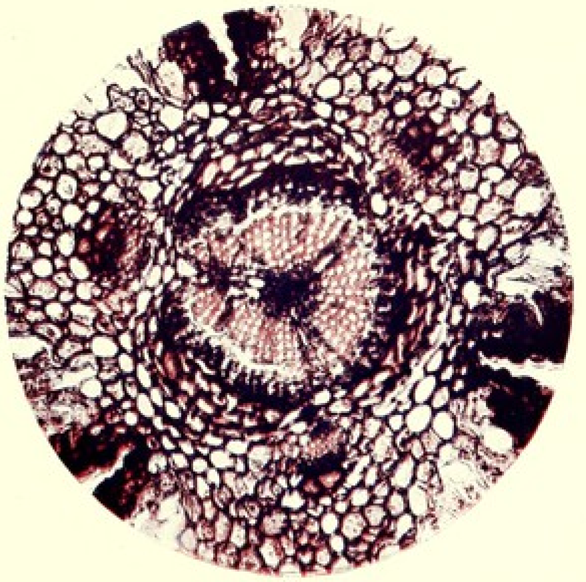


Cross Section through the ventral portions of decurrent leaves and branchlet of *C. arenosa*. x 190. No sclerenchymatous cells are seen. The dark-brown contents of certain cells is the manganese compound. The cells with small circles (pits) in them, mark the tracheids of the transfusion tissue. Stained with hæmatoxylin and safranin.

Leaf anatomy illustrating the arrangement of species in Table,—The probable evolution of the Callitris.

Group II.

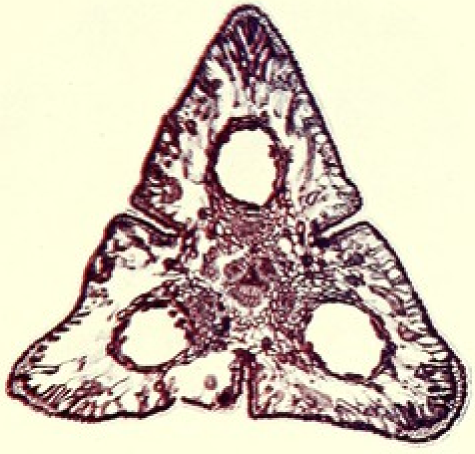
Cross Section through decurrent leaves and branchlet of *C. calcarata*. x 73. Sclerenchymatous cells are seen at the outer edge of the phloem of the leaf bundle. Stained with hæmatoxylin and safranin.



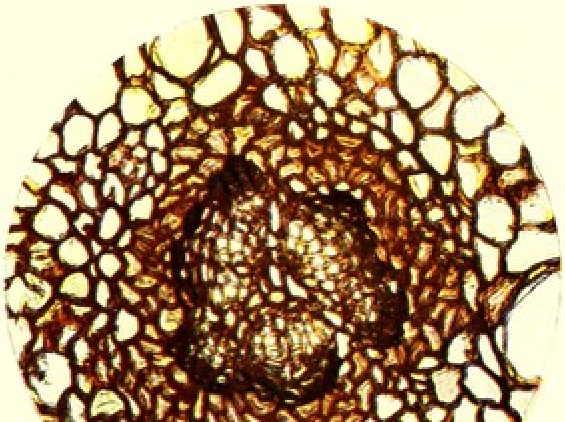
Cross Section through the ventral axis (branchlet) and attached portions of decurrent leaves of *C. calcarata*. x 150. Sclerenchymatous cells of the complete section above are here more distinctly brought into vision. The cells with the small circles (pits) in them, mark the transfusion tissue. Stained with hæmatoxylin and safranin.

Leaf anatomy illustrating the arrangement of species in Table,—The probable evolution of the Callitris.

Group III.



Cross Section through decurrent leaves and branchlet of *C. Drummondii*, x 40. Sclerenchymatous cells are here seen distributed throughout the whole mesophyll tissue and cut at various angles. The transfusion tissue is not a strong feature. Stained with hæmatoxylin.



Cross Section through branchlet and base of decurrent leaves in *C. Macleayana*, x 280. This illustrates the encircling of the central axis by numerous sclerenchymatous cells. Only a few transfusion tracheids are seen. Stained with hæmatoxylin.

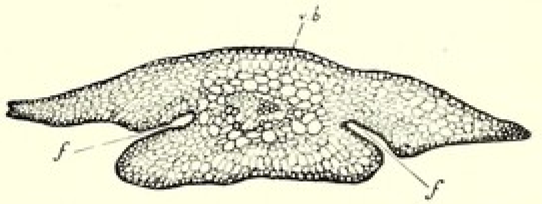
Leaf anatomy illustrating the arrangement of Species in Table,—The probable evolution of the Callitris.

IV. COMPARATIVE ANATOMY AND PHYLOGENY OF THE GENUS *CALLITRIS.*

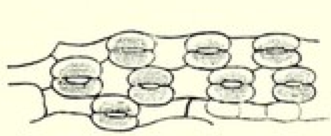
A large amount of histological work has been done by European and American botanists on the various groups and genera of Conifers, but the Australian genera in general, and this genus in particular, have received least attention of all. This, is probably due to the remoteness of this continent from the centre of old-world scientific activity, and also the difficulty presented to them of obtaining material; consequently, any descriptions of the anatomy of these groups of Gymnosperms will, no doubt, prove of interest, covering as they do quite new ground.

The investigations in this direction were not undertaken so much from a phylogenetic point of view, as to ascertain whether or not anatomical characters would prove of assistance in systematic work, *i.e.*, differentiation of species, for in this work, as stated previously, the species are founded on even a broader basis than that laid down in the previous published work, "Eucalypts and their Essential Oils."

The results will be found under each species, but they have not rendered all the assistance anticipated from a taxonomic point of view, nevertheless they have produced some novel features most interesting in themselves, for instance, (1) the showing of a similar disposition in some of the stomata of the species to those of *Lepidodendron Hickii*, as figured by Scott ("Studies in Fossil Botany," Pt. I, p. 160), (2) the proving of the secretory bodies to be cavities in form, and not canals, as obtains in exotic pines, (3) the identification of a manganese compound in the various plant tissues, probably the "resin" of former workers in Conifers, as already stated, and (4) the uniformity of the ray cells.

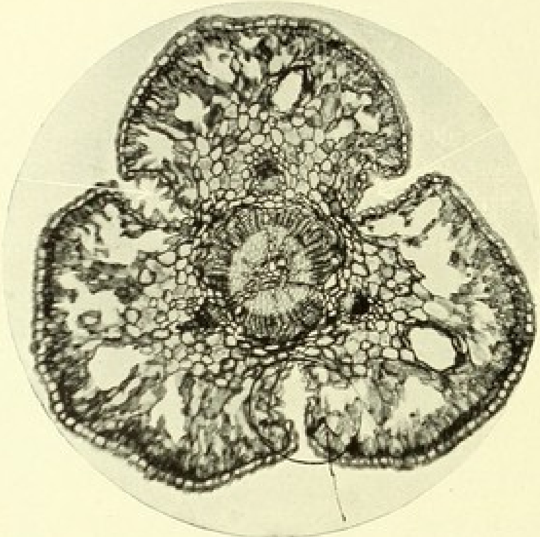


Lepidodendron Hickii. Transverse section of leaf. *v.b.*, vascular bundle some of the large elements round it constitute the transfusion-tissue; *f*, furrows in which the stomata are placed. × 60. S. Coll. 51. (G. T. G.) After Scott

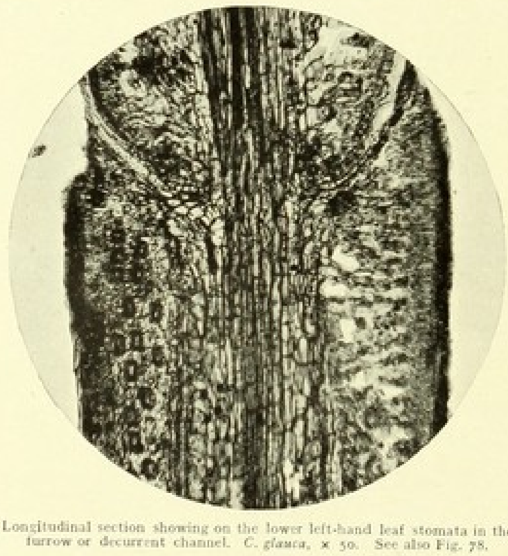


Lepidodendron Hickii. Epidermis of leaf, with stomata. × about 300. S. Coll. 51. (G. T. G.) After Scott.

The occurrence of this manganese compound or so-called "resin" in the cells of the medullary rays of *Callitris* timber finds a parallel in the Cretaceous *Pityoxyla* of North America, as illustrated by Jeffrey and Chrysler ("Bot. Gaz.," 42., 1–15 July, 1906).



Furrows or decurrent channels in which the stomata occur in *Callitris glauca*, are marked in this cross section by arrows, × 80.



Longitudinal section showing on the lower left-hand leaf stomata in the furrow or decurrent channel. *C. glauca*, × 50. See also Fig. 78.

Sections of Callitris leaves showing the disposition of stomata to be identical with that of Lepidodendron Hickii of the Carboniferous period.

Macroscopically the timbers of the respective species present no characteristic features that render identification easy under all circumstances, and microscopically, also, there appears to be only minor points of differences.

Evidences of the geological age of the genus are not, so far, very many, and what there are rather point to an origin probably older than the *Araucarias*, and we are inclined to think that further palæontological researches will reveal a much older age than that now assigned to the genus. Ettingshausen ("Tertiary Flora of Australia," p. 90, pl. viii) records it under *C. prisca*, from Vegetable Creek, Emmaville, New South Wales, in the Tertiary Period. According to Masters, Unger records it as Eocene.

V. FOLIATION.

After the cotyledons burst forth through the testa, the plumule gives place to a cluster of small pyramidal-shaped leaves which may be classed as primordial; these, with the growth of the central stem, are developed at diminishing intervals in whorls of threes, having a maximum length of 1½ inch, and it is this characteristic leaf that obtains during this period of the life history of practically all the species of the genus.

When the young plant has grown to the size of 3 or 4 inches, and as the stem develops, the length of the leaves appears to become less in each whorl, but this diminution in length is rather apparent than real, for it is not that the leaves are so much shorter, but that a much larger proportion of the leaf has become decurrent or concrescent on the central stem.

The normal leaf has, therefore, a very large proportion of its length running down, or adnate to the stem, this part being called by some authors the concrescence; in fact, the free portion regarded by some as the true leaf, forms only a very small fraction of the leaf substance, and is sometimes designated "leaf scale." The leaf, however, as understood by us, includes the whole of the decurrent or concrescent portion as well as the free end, the former certainly, as that has a true leaf origin and contains as well the essential organs of a true leaf, such as a vascular bundle, the transpiration and assimilating surfaces, chorophyll cells, oil glands, &c.; the free-end portion is certainly wanting in some of the most essential of these organs that go to make true leaf structure (*vide* numerous figures given under the species to illustrate these remarks), and so cannot be classed as a leaf.

Under certain, or most favourable, conditions the three concrescences of the whorl coalesce into one whole, forming as it were a kind of pyramidal compound leaf, and almost a perfect triangle in section, just as in some instances of the genus Pinus, *i.e.*, *P. cembra*, *P. Donnel-Smithii*, &c., as shown by Masters,

(" Linn. Soc. Journ." Vol. XXXV, No. 248). Such an arrangement produces a flat, exposed, transpiratory surface, as distinct from the concave, cryptic surfaces usually obtaining in the concrescent leaves of the whole genus.

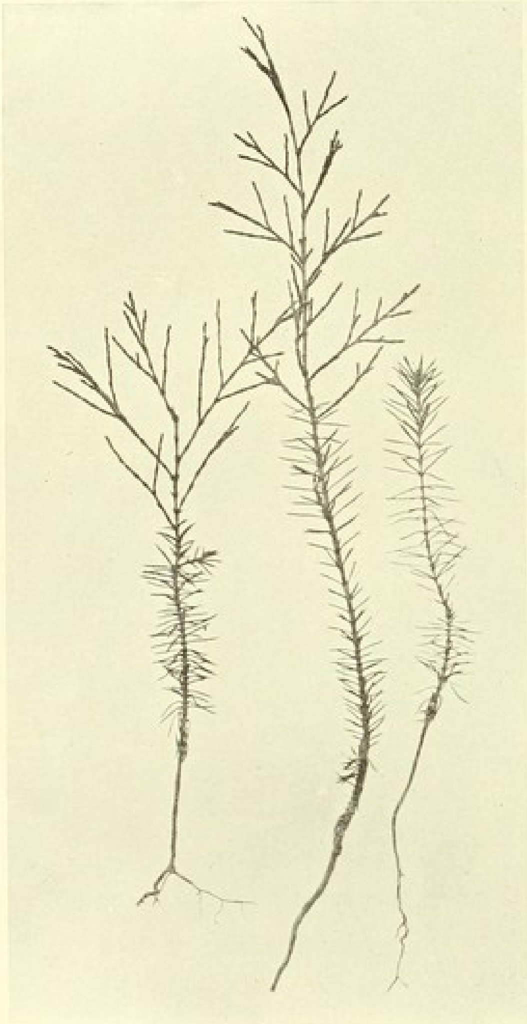


Figure 1.—One-year old *Callitris*, showing how early in the plant's life is the transition from free leaves to decurrent ones. Nat. siz.

Callitris trees, however, growing under the usual climatic conditions prevailing in Australia, have leaves characterised by a marked concrescence or decurrence on a central stem, and each leaf separated by a narrow passage formed by the ventral surfaces, the edges of which appear to have the power of opening and closing the channel thus formed, and exposing the stomata to light and air, or shielding them according to the exigencies of favourable or adverse climatic changes.

Several theories have been advanced to explain the reason for this decurrence in plants, more especially in Conifers, and according to Masters ("Journ. Linn. Soc." Vol. XXVII, Bot. No. 183–184) Mechan "considers that this adnation is specially characteristic of vigour, while the free leaves indicate a state of weakness and arrested growth"; and Masters agrees with this view and then states, "But if the distinction between growth and development be kept in mind, it would seem that the concrescence is an indication of arrested and irregular *development* associated with disproportionate rapidity of *growth*. In the free leaves the balance between growth and development is preserved, the base of the leaf is symmetrical and the parts are all in regular proportion."

Whilst agreeing in a measure with the opinions of these authorities, yet, to us it appears that the physiological significance of this leaf decurrence, is a provision of nature to ensure protection against excessive transpiration by the stomata, and so prevent a loss of water through the activity of these organs. This furnishes another illustration of adaptation to physical conditions or environment. It is only on some coast varieties that the decurrent channel is absent.

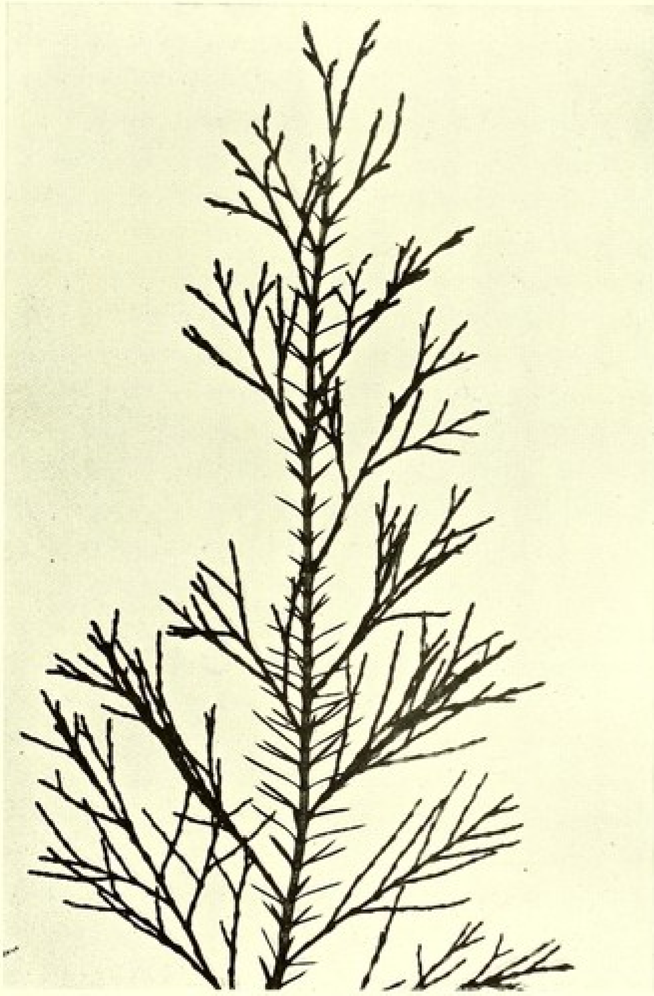


Figure 2.—A more advanced plant than Figure 1, showing a longer period of retention of primordial leaves on the central axis. Nat. size.

By such an arrangement, a too energetic transpiration can be obviated during times of drought, when the soil has scarcely sufficient moisture for the tree's requirements, for the leaves, by taking a decurrent form, place the stomata surfaces on a fixed under side, and at the same time are further protected, if necessary, by the edges of the concrescence acting as a door to the channels thus formed, a movement which would also, most probably, be brought into use during wet weather.

The absence of palisade parenchyma and the finer structure of the type material, of the ventral surface, are aiding factors in this instance of leaf movement. As we see that nature responds to climatic adversities in xerophilous plants by

developing forms of vestiture such as pilosism, wax, &c., or creating an essential oil in the leaf texture, so in this section of Conifers a concrescence of the leaf gives the desired security, and consequently these trees can, and do exist in the arid interior of this Continent, where other trees not so provided by nature, might perhaps die. (*Vide* remarks under *C. glauca* re movement of leaves of *Pinus halapensis* under climatic influences, and also remarks to account for the decurrence of *Callitris* leaves).

Such a security is not by any means novel, for, as stated above, *Lepidodendron Hickii* of the Carboniferous period shows similar furrows in which stomata are placed as in our *Callitris*. Does this feature point to a similar climate in those bygone ages as that existing with our *Callitris* to-day, viz., that of a comparatively arid nature?

Figure 3.—An early branchlet showing gradation from tree to decurrent leaves of a *Callitris*. Nat. size.

The free portion of the leaf would appear to vary in length in proportion to its exposure to light, for it is found that the long, pyramidal leaves occur only in the lower, shaded branches, or on trees overshadowed by larger ones; the small, appressed, free portion of the leaf occurring wherever the branchlets are exposed to the full light of day.

Venation as understood in phanerogams is practically wanting in the leaves of the *Callitris*, there being an entire absence of surface veins such as is found in the usual lamina or blade of an ordinary leaf. The mid-rib is indicated by the very small vascular bundle at the base of the concrescence portion, and midway between the two lower concave surfaces. The leaves of *Callitris* may, therefore, be regarded as homomorphic, the apparent dimorphism being due to a long or short attachment to the stem, or perhaps, more correctly in this case, the stele, and, as stated previously, primordial leaves proportionately, have just as small a decurrent portion as the normal leaves have a free end.

Morphologically the primordial leaves may be described as pyramidal, and in section triangular throughout, although in the case of the concrescent leaf it is really only the free end that retains that form.

As regards adnation applying to the normal form of leaf, *C. Macleayana* in some instances forms an exception to the rule, as free, pyramidal leaves obtain almost throughout the whole life of a tree in some cases, so that it is perhaps hardly correct to designate these leaves as primordial, in fact, it was

this condition of affairs that led to the recording of *C. Parlatorei* and *C. Macleayana* as distinct species, the former species having trees placed under it, which had not the *long* pyramidal free portion described under the latter Pine; the environment and other causes in each case, no doubt, favouring the growth of each particular form of leaf.

This decurrent portion of the leaf may be described as having three sides, that is excluding the attached one,—the latter portion, adnate to the branchlet not be'ng regarded as a side in this case, and the former part may be said to have two concave ventral surfaces and a double convex dorsal one, or in section the whole pentagonal. In the earliest leaves the junction of the dorsal and ventral sides in each whorl are approximate, and at certain times touch, but as the branchlets increase in circumference, the decurrent portion increases in length, in some cases up to 1½ inches, and, at the same time, becomes more and more removed from its previous contiguous sister leaves, and remains on the stem as longitudinal green stripes for an almost indefinite period.

The maximum length probably occurs in the "Weeping Pine," and the minimum in *C. glauca*. The decurrent portion of the leaf is very persistent and retains its chlorophyll for three or four years, or even longer.

VI. PHYLLOTAXIS.

The arrangement of the leaves of the several species of this genus needs only a few remarks, for without exception they are homotaxis, in regular successive alternate whorls either in the spreading, horizontal, free stage, or in the decurrent condition. In no instance are they spiral. Each whorl invariably consists of three leaves.

VII. HISTOLOGY OF THE LEAF.

Here was found a new field for study, as very little if any research appears to have been undertaken in the past on the anatomy of the *Callitris* leaf, for most of the work on Conifer genera deals with material other than this Australian genus.

The part of our investigations on this organ at first presented some difficulties, as the free ends were taken for examination, and like previous systematists, we had regarded these as the true leaves. But one mm. being the maximum breadth, it was found that in this small area the variety of cell structure is very limited, there also being an absence of certain leaf essentials. Attention was next turned to the concrescence in the search for these missing elements, and there they were found.

The histological investigations of the leaf scale, or free portion of the leaf, were discarded for the true leaf, *i.e.*,—that which included the free as well as the decurrent portion, the latter being the leaf proper and upon which the results recorded under each species are founded.

It was hoped that at least one purpose would be served by investigating the structure of the leaves, viz., that some assistance would be rendered the systematist in the differentiation of species by employing the aid of histological structure, but the results were not quite so fruitful as expected.

The sections examined showed morphological differences,—the contour of the decurrent portions varying in different species, but these variations were not sufficiently constant for a systematic reliance to be placed upon them in all cases.

One of the principal features brought to light was that the outer or dorsal surface of the leaf was almost invariably assimilatory, and that correspondingly the ventral surfaces were transpiratory,—the stomata being arranged along the under surface in the passages formed by the overhanging edges of the concrescence, and only a few were found on the inner surface of the free end at the base, their presence in this position evidently accounting for the incurving of this portion of the leaf as a means of protection. The outer convex surface of the leaves of the interior species may, therefore, be said to be devoid of stomata. Where no decurrent channel exists, the stomata are found on the lateral surfaces below the dorsal ridges, as in the case of the "Weeping Pine."

One, or rarely more rows of epidermal cells characterise the cuticle, these being superimposed upon single or double rows of hypodermal cells. This again is subtended by the mesophyll consisting of palisade cells containing chloro-plastids, followed by loose parenchyma through the centre of which in the upper portion of the leaf is mostly situated an oil cavity or reservoir, fusiform in shape.

At the point of approach of the two surfaces of the leaf in the concrescent portion, it was found that the cuticle begins to alter in character from that of the dorsal surface, and this changed feature characterises the ventral surfaces, with the exception of one or two species. The cuticle here becomes broken or changes into elongated, conical bodies or papillose projections, whose function is probably to act as secondary guard cells to the stomata. A similar character is recorded and figured by E. G. Bertrand ("Ann. des Sc. Nat.," 5e Ser. Bot. Tome, 20., Pl. 10) as occurring in the Japanese genus of Conifers,—*Sciadopitys*.

The palisade cells are quite absent below the ventral surfaces of the inland species, *C. glauca*.

The oil cavity or reservoir, supported by secretory cells, is nearly always found in the upper portion of the decurrent section, and between the phloem of

the leaf bundle and the palisade layer and in the centre of the spongy mesophyll tissue, but surrounded by parenchymatous endodermal cells. Longitudinal sections invariably showed them to be cavities rather than glands, certainly not canals or ducts as obtains in non-Australian genera of the Order. They appear to be of lysigenous origin.

Below each gland is a small bundle with a normal orientation, the phloem having thin-walled cells irregularly arranged, the xylem having thicker-walled cells, disposed in a more regular, radial series than those of the phloem, the whole being accompanied more or less by transfusion tissue.

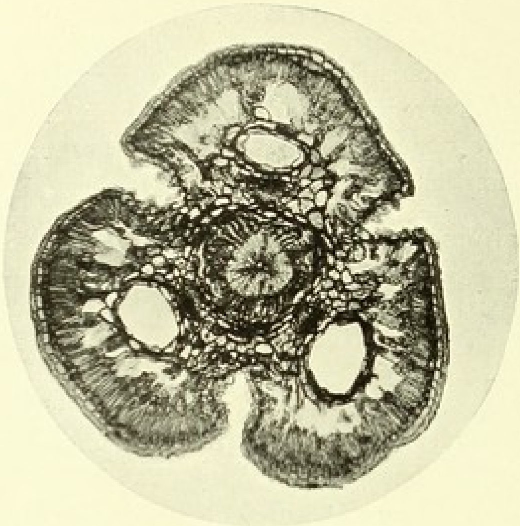
For anatomical descriptive purposes it was found to be much more satisfactory to take a section through the extremity of a branchlet just below the internode, and through the three concrescences, rather than through an individual concrescence, for such a section is found to be most symmetrical, and in outline forms geometrically an almost perfect trefoil.

This geometrical outline in a measure corresponds in a general way to that of some forms of *Pinus* leaves which have two bundles, whilst in this instance the stele, being the branchlet, contains three or more, and having central radiating cells dividing it into the wedge-shaped bundles of the branchlet or central column.

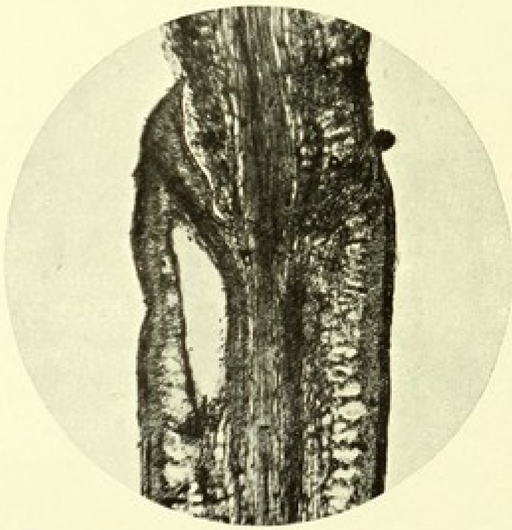
Such sections have been taken when describing and figuring the leaf anatomy of each species, as they give a better idea of the correlation of each leaf to the stem structure, and also their correlation in performance of functional work to each other.

Viewed then as a whole, the leaf sections present some interesting features, as for instance, the variation in the disposition of the parenchymatous transfusion tracheids, the stone, as well as the endodermal cells, which are well shown in the illustrations, and when there is no oil cavity these latter occur in a group in each foil; but as an oil reservoir gradually comes into the vision, it is seen to separate them, and they then form an encircling ring around it, as well as the stele, and so with each oil cavity of the corresponding leaf. The parenchymatous cells containing the manganese compound are more numerous below the junction of the foils where the epidermal and chlorophyll parenchymatous cells are absent. This latter arrangement has already been fully discussed.

The anatomical characters of the leaf of *Callitris*, such as the arrangement of (1) assimilatory and transpiratory surfaces, (2) the palisade cells, (3) cells of the fundamental tissues, and (4) sclerenchymatous cells, render some aid in systematic work; whilst the position of the oil cavities may practically be said to be common to all the species, for whatever little variation there is in connection with these, it is of too minor a nature upon which to found specific differences.



Cross section showing how deeply placed is the oil cavity in each leaf, × 80.



This longitudinal section also illustrates the hidden nature of an oil cavity in a leaf, × 55.

Sections to illustrate the remarks on the leaf oils of Callitris species.

Some workers on Pines have brought to their aid in this connection the position and number of the oil canals (Engelmann), or the number of parts of the vascular bundle (Coulter and Rose); such, however, cannot be used similarly in the species of *Callitris*, but only as aids to systematic work in conjunction with other features.

VIII. MOVEMENT OF LEAVES.

Some reference has already been made to this subject under Article V, Foliation, and a theory advanced.

No opportunity occurred of studying the movements of the leaves in nature, or rather in the field, to verify our opinion, but indications would suggest that the two ventral surfaces are protected by a closing of the decurrent channel, by an expansion or contraction or coming together of the longitudinal edges of the leaves. (*Vide* physiological significance of this movement of leaves under Foliation.)

By a closing of this entrance the stomata are protected from light, hot winds, rains, &c., so that no twisting is required as in the leaves of some species of *Picea* and *Pinus*.

The free ends evidently have the power of spreading or becoming appressed according to weather conditions, *vide* also remarks under *Araucaria Cunninghamii*.

IX. GENERAL REMARKS ON THE LEAF OILS.

The chemical results for the leaf oils of the several species of *Callitris* recorded in this work are somewhat comprehensive, and the data given are representative of the individual species. The full results will be found under each species.

The material was all distilled at the Museum, and in several instances gathered over a great extent of territory, and during a period of several years. Particularly was this the case with *C. glauca*, because this tree is the common species, and is the most extensively distributed. In a lesser degree accumulated results have been obtained with *C. calcarata*, *C. verrucosa*, *C. arenosa*, &c.

The object of this was to ascertain, from material belonging to well-defined species, the influences of locality, soil, and climate, on the chemical constituents of the tree. It has been advanced by some writers that these have considerable action upon plants generally, and that, therefore, constancy of results could hardly be expected.

Our researches on the oils of the Eucalypts showed a remarkable constancy in the chemical constituents of individual species of that genus. With the oils of the *Callitris* the same practical uniformity of constituents exists, although not so markedly as with the Eucalypts, as the rotation figures show more variation.

The distillation of the leaves and terminal branchlets was, in most cases, continued for six hours, as it was found that a fair quantity of oil came over during the fifth hour. The difficulty of obtaining the oil from the leaves by steam distillation appeared to be due to the hidden nature and position of the oil glands, as shown in numerous illustrations. The structure and contour of these may also be seen from the microphotographs of the leaves under the several species. The distillations were carried out on material collected similarly to what would be done in practice, so that the yield of oil obtained with each species may be taken as the commercial one. *C. intratropica* is the only exception, as with this material most of the coarser branchlets had been stripped.

The crude oils were usually but little coloured, due to the fact that the amount of free acid in the terpene oils was very small indeed. Those oils containing an increased amount of esters were usually darker in colour, and the free acid was more pronounced. On keeping these oils, the slow alteration of the geranyl-acetate caused them to become even more acid. When redistilled under atmospheric pressure, the esters partly decomposed at the temperature required, with the separation of a portion of the acetic acid, but for comparative purposes this had little influence on the results. The oils were all colourless when redistilled, or when purified by steam distillation.

No indications were obtained in any of the oils for either sylvestrene, phellandrene, or cineol. The leaf oil of one species, *Callitris Macleayana,* contained a hydrocarbon, most probably belonging to the $C_{10}H_{18}$ series, and when isolated in as pure a condition as possible, by fractional distillation, it resembled ordinary menthene, both in odour and appearance. The physical properties of the oil of this species were distinctly different from those of the oils of the other species of *Callitris*, due evidently to the presence of an increased amount of this constituent in the oil, and which reduced the specific gravity of the crude oil considerably. We have isolated a hydrocarbon of the $C_{10}H_{20}$ series from the latex of *Araucaria Cunninghamii* (see under that species in this work), and in which material a member of the $C_{10}H_{18}$ group probably also occurred. The resins isolated from the latex at the same time, strongly resembled the sandarac resins from the *Callitris ;*

so that the idea suggests itself that the formation of the characteristic resin known as sandarac is primarily due to the alteration in some way, perhaps by oxidation or condensation, of these hydrocarbons in association with the terpenes.

Apparently the origin of the sandarac resins is different from that of the ordinary *Pinus* resins, and in both *Pinus* and *Callitris* the oils of some species consist largely of pinene, and yet the resins are not similar.

From chemical evidence *C. Macleayana* and *Araucaria Cunninghamii* are somewhat closely related, and this is also supported botanically.

It has been determined that all constituents occurring in the oils of the *Callitris* reach a maximum in that of one species, although perhaps present only in traces in some of the others. It is assumed, therefore, that a hydrocarbon of the $C_{10}H_{18}$ series may occur at some time in the oils of the *Callitris* generally. The difficulty of detecting this, when only occurring in small amount in association with pinene and similar terpenes is apparent, and it was thus fortunate that *C. Macleayana* supplied evidence in this direction.

The leaf oils of the *Callitris* all contain, either in large or small amounts, pinene (both modifications), limonene (both forms), dextro-rotatory borneol and its acetic acid ester (perhaps with the exception of *C. Tasmanica*), and geraniol and its acetic acid ester. The ester of terpineol, the acid of which is probably butyric, is present in some species, if not occurring in traces in all of them. Although the constituents in all the oils appear to be the same, they vary in amount in each well-defined species, thus corresponding to the morphological differences of the plants themselves, and in this respect are comparatively constant, so much so, that each species has its own characteristic oil, and the determination of the amount of its chemical constituents is sufficient to indicate its origin in most cases. We have gone to considerable trouble in the endeavour to decide this point, and the results herewith published show distinctly that the influences which were instrumental in bringing about distinctive characteristics for each species, also acted directly upon the character of the oil constituents in a corresponding degree.

Whether the predominant constituent in the oil of the original ancestor of the genus, was the terpene pinene, or limonene, it is not now possible to decide, but it is apparent that changes have been active with the several members of the genus *Callitris*. The time necessary for the accomplishment of this alteration, through varieties to distinct species, must have been of an extended nature, and, consequently, for this and other reasons, we assume that the *Callitris* of Australia is an ancient genus.

In two instances evidences have been found indicating a close botanical and chemical connection between *Callitris* somewhat closely related, and showing, as it were, a branching off from a species. These were, firstly *C. rhomboidea* of

the eastern coast of New South Wales, with *C. Tasmanica* the closely related species of the elevated country of the Rylstone district of New South Wales and the corresponding Tasmanian trees, and secondly, the South Australian species, *C. propinqua*, with *C. glauca*.

In whatever direction the results are considered, it is found that the several constituents in *Callitris* oils continue to increase with each well-defined species, in the individual groups, until a maximum is reached in one of them. With dextro-rotatory pinene the maximum is with *C. Drummondii*; with dextro-rotatory limonene it is with *C. arenosa*, where it occurs together with dipentene, and not less than 85 per cent. of this oil consists of the limonenes. The lævo-rotatory form of limonene is most pronounced with *C. intratropica*, in the oil of which limonenes also occur in considerable amount. The geranyl-acetate continues to increase in the several species, until the maximum is reached with *C. Tasmanica*, practically the same result being obtained with both the Rylstone and the Tasmanian trees, and in which over 60 per cent. of this ester was present. Borneol increases in the same ratio, but not to the same extent as the geraniol, and does not appear to be present alone in any one species, nor does the lævo-rotatory form occur. Free borneol is found to only a small extent in many of the species. Terpineol was found in the greatest quantity in the oil of *C. gracilis*, but even there it was only present in a comparatively small amount. The determination of butyric acid in the oil of this species indicated that it was present with the terpineol, and as butyric acid has also been detected in small amount in the oils of several species, it is probable that this ester occurs in the oils of most *Callitris*, the exception being those in which geraniol is in greatest abundance, and also in those oils very poor in ester. No butyric acid could be detected in the ester of *C. Tasmanica*, as the theoretical result for acetic acid was obtained.

The dextro-rotatory pinene, taken at its maximum in the oil of *C. Drummondii*, had a very high specific rotation $[a]_D = + 49{\cdot}77°$, but the lævo modification increasing in other species reduced this activity to the right, until with *C. Muelleri* it was only slightly dextro-rotatory. The limonenes appear to be always present in both forms; with some species the predominant one is the dextro-rotatory modification, while in others, it is the lævo-rotatory limonene which is in excess. The melting point of the tetrabromides formed with the limonenes of the *Callitris* oils was always high, and in this respect differed entirely from that formed with the dextro-rotatory limonene occurring in the oil of "King William Pine," which gave a tetrabromide melting at 104° C.

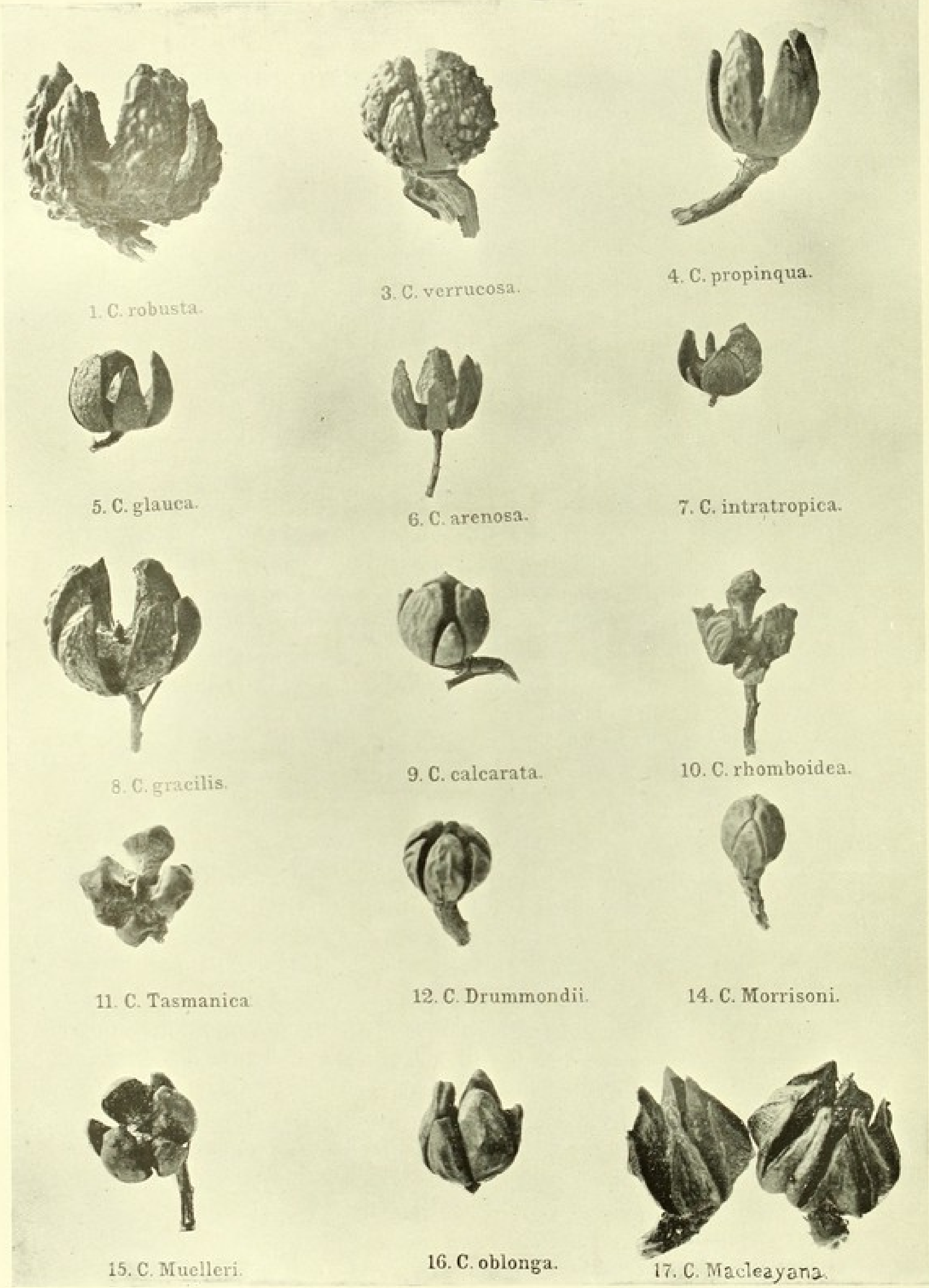
It will be observed that the optical activity of some of the *Callitris* oils, is not of a constant character for all times of the year. This is due to two causes: (1) With some species the oil obtained from the fruits has a markedly different rotation from that of the leaves, even if obtained from the same tree, although the terpenes are the same in character. The amount of ester is less also. This

is notably the case with *C. robusta* and with *C. verrucosa* (both species with warted fruits), and also with species closely allied with these. With *C. Drummondi*, the oil, both from the leaves and from the fruits was similar, and this was also the case with *C. calcarata*. The dry fruits of those species whose leaves give an oil consisting of geranyl-acetate without borneol, do not contain an essential oil, or, if so, it is present only in a very small amount. This is the case with *C. Tasmanica*, and with *C. rhomboidea*. This peculiarity of terpenes with different rotations in the leaves and fruits of the same tree, is of some scientific interest, particularly as this peculiarity does not occur with all the species. It will be noticed that in the results obtained with the material of *C. glauca* from Narrandera, the oil from one large tree (kept separate) varied by 6·7 degrees from that obtained from trees growing alongside, and that the ester was also less in amount. The branchlets from the single tree had numerous fruits, and considerably more than were present on the general material.

(2) Again, the predominance of a particular limonene, of which the rotation may be either dextro or lævo, is not constant for all times of the year, so that the rotation of the oil of these species varies in agreement. This is notably the case with *C. calcarata* and with *C. arenosa*. The pinenes do not appear to vary in this respect to the same extent as do the limonenes, although it is evident that both forms are present in the oils of most species. Although the rotation of the limonenes is thus not constant, yet the other physical characters of the oils are not influenced by the particular activity of the predominant limonene alone; so that the composition of the oil of each species, when once determined, is found to be always characteristic of it.

The ester content of the individual oils appears to be far more constant in character, and the indicative value of the cold saponification in following the increase of geranyl-acetate in the several oils, has been most helpful. By this means it was also possible to show that the free alcohol in the oil of *C. Tasmanica* was almost entirely geraniol. It is possible that a quantitative value might thus be evolved for some of these esters, if investigations in this direction were undertaken.

The solubility in alcohol of the crude oils of the *Callitris* does not appear to be of a very constant nature, because the oils of the group to which *C. glauca* belongs become much less soluble in alcohol on keeping, and many of them slowly deposit an insoluble resin, which attaches itself to the sides of the bottles in which the oils are stored. Those oils richest in limonene only deposit this resin in very small amount, and those in which the ester of geraniol is present in quantity have not deposited any. The formation of this resinous substance may have some bearing upon the natural preparation of certain of the resin acids found in sandarac, and it is thus evident why the sandarac resins from some *Callitris* species are more soluble in alcohol than are those from other species.



Frank H. Taylor, Photo. *Nat. size.*

CONES OF THE SEVERAL SPECIES OF *Callitris*, ARRANGED IN THE ORDER OF SEQUENCE DETERMINED BY THIS RESEARCH.

[2. *C. tuberculata* and 13. *C. Roei*, are not shown.]

The sesquiterpenes, or allied bodies, only occur as a rule in small amount in the leaf oils of the *Callitris,* those of *C. Macleayana, C. robusta* and *C. verrucosa* containing the greatest quantity.

Phenols do not occur in the *Callitris* leaf oils to any great extent, as only in two species was an indication for a phenol obtained, these were *C. gracilis* and *C. rhomboidea,* but the amount present was too small for determinative purposes. Of course the phenol found in *Callitris* timber (callitrol) may extend to the wood of the branchlets, and traces might thus be found with the leaf oils.

The specific gravity of the oils was taken in comparison with that of water at 15° C. in all cases.

X. THE CONE.

The distinctive characteristics of this organ of the *Callitris* have already been given under Article II. The fruits occur generally below the male inflorescence, which is a natural arrangement, as thus pollination is, in a certain measure, assured.

The cone may be said to be almost uniformly spherical in shape, and also to consist of an equal number of valves, the one exception being *C. Macleayana* which has 6–8 valves and is pyramidal in form.

The general contour of the cone may thus be said to differ from that of any living Conifer, certainly from *Tetraclinis* and *Widdringtonia,* of North and South Africa respectively.

They vary in size from half an inch in the case of *C. intratropica* to over an inch in *C. robusta,* whilst the pyramidal cone of *C. Macleayana* may be said to average quite an inch in height.

The nature or character of the external surface can be used in a measure as a taxonomic aid, for dividing the species into classes; *C. robusta, C. verrucosa, C. tuberculata, C. glauca, C. intratropica, C. arenosa, C. propinqua,* have all more or less worted surfaces, whilst *C. calcarata, C. Muelleri, C. oblonga, C. Drummondi,* have them either smooth or even shining.

In their mature condition they are hard and almost ligneous.

Figure 4.—Longitudinal section through the end of a branchlet, showing terminal leaves at their earliest stage of growth, as sporophylls. *C. calcarata*, × 70.

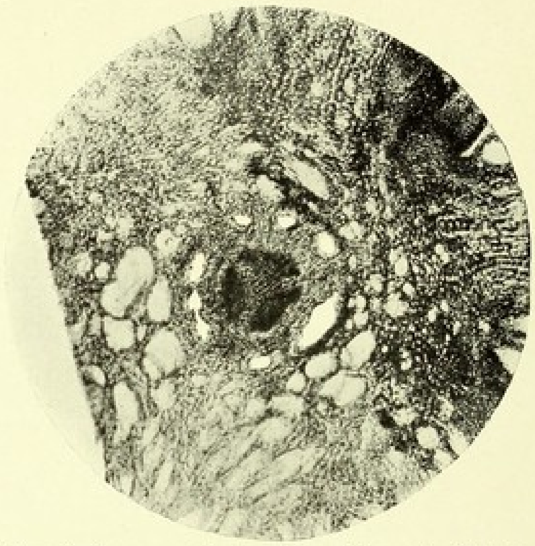


Figure 6.—Transverse section through base of ♀ amentum, but at a later stage than in Figure 5. Oil cavities are seen to be numerous. *C. rhomboidea*, × 32.

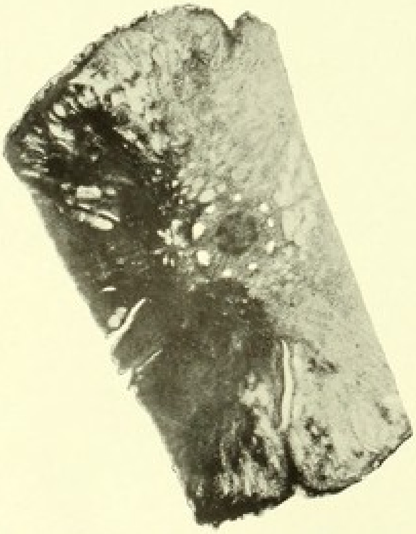


Figure 5.—Transverse section through base of ♀ amentum, showing circle of oil cavities around the median bundles of the branchlet, similar bodies being continued into the inner structure of the sporophylls. *C. rhomboidea*, × 15.

Figure 7.—Transverse section through base of early cone, showing attachment of four of the valves to the central axis (branchlet). *C. rhomboidea*, × 17.

Sections to illustrate the life history and anatomy of the Cone Valves.

XI. THE CONE VALVES.

The structure of the valves composing the cone has not occupied much attention in the field of research in the past; and, although *apparently* simple enough organs in themselves, yet, their true relative position in the plant's life history has remained in a measure an unsolved problem.

Working in this remote part of the world great difficulty has been experienced in obtaining access to the cognate literature, but in all the works examined little or no reference could be found bearing on the origin of the cone scales or valves of our Australian *Callitris*.

These organs may be divided into two periods of life history, viz.:—herbaceous and indurated. During the first of these conditions they have all the characters of the ordinary leaf of the genus, *i.e.*, the mesophyll with its palisade parenchyma and spongy tissue, parenchymatous cells, together with a primary bundle, oil cavities, assimilatory and transpiratory surfaces,—structures which make them practically, to all intents and purposes, leaves of two terminal whorls. Starting life thus with all the morphological, functional, and anatomical characters of a leaf, the period of their metamorphosis into sphorophylls is marked structurally by a numerous subdivision of the bundles of the central axis and the pith cells or tissue, and these branches at once ramifying at first into the upper portion of the leaf, but eventually push back and replace the parenchymatous cells and spongy tissue. These bodies or cells as they emerge from the stele are found to be well charged with starch grains, and especially so as the sporophyll becomes almost entirely composed of cells similar to those which are in direct communication with the ovules, whose whole structure is also formed of them. Whilst this cell development is taking place, numerous bundles are ramifying through the sporophyll structure generally, at first, in a row just below the inner surface, from which are sent branches in the dorsal direction. Oil cavities are also formed both at the inner and outer surfaces. As these organs mature they gradually again metamorphose, but into a hardened body, and yet meanwhile, or for a time, preserve one or two of the main characters of a leaf;—the arrangement of the bundles, &c., reminding one of the midrib and lateral veins of an Angiosperm leaf, and the chlorophyll performing its function till near the time of dehiscing.

As soon as the ovules are fertilised, the lower portion of the macrosporophyll gradually commences to thicken and close over them, thus forming a cryptic character, as stated under article "The Origin of the Spur on the Cone Scale."

After the closing period the sporophylls thicken until the full size of the cone is reached. This process of thickening is marked by the bundle shown in the various micro-leaf sections, commencing to be augmented and increasing in

Figure 8.—Transverse section (portion of) through base of ♀ amentum, showing oil cavities near the assimilatory surface; the dark patches in the macrosporophyll texture are vascular bundles. *C. rhomboidea*, × 32.

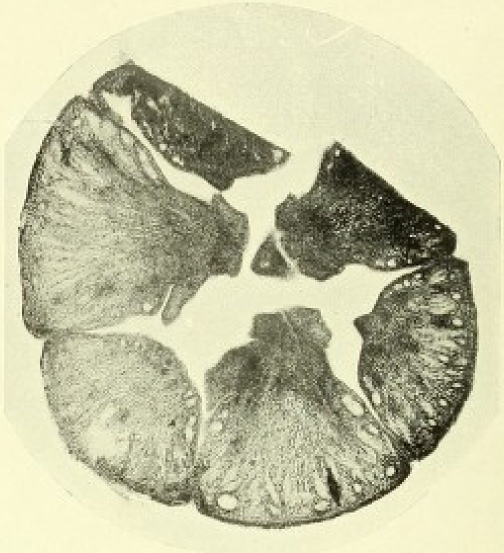


Figure 10.—Transverse section through middle of young cone. Two large and two small valves are perfectly sectioned. *C. rhomboidea*, × 19.

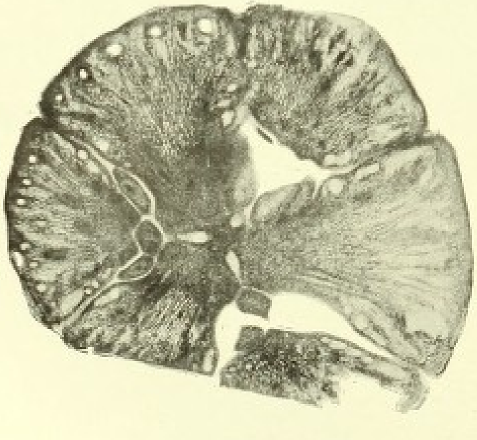


Figure 9.—Transverse section through base of young ♀ amentum, showing attachment to median bundles by the three larger valves. *C. rhomboidea*, × 19.

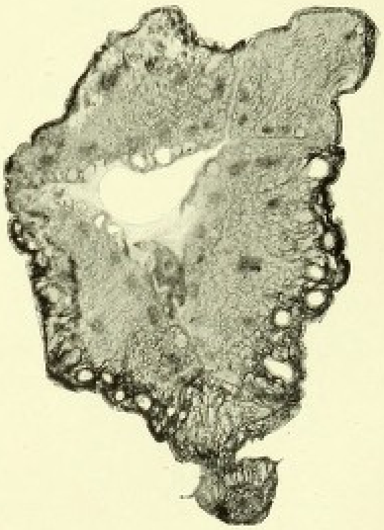


Figure 11.—Transverse section through the upper portion of a very young cone, the alternate large and small valves can be identified, as well as the preponderance of oil cavities in the former. *C. calcarata*, × 20.

Sections to illustrate the life history and anatomy of the Cone Valves.

Figure 12.—Transverse section through the upper portion of a very young cone, showing the alternately large and small valves, and mode of lateral attachment. Oil cavities are seen on both dorsal and ventral surfaces. The darker patches in the tissue are vascular bundles. The four irregular isolated bodies in the central cavities are sections of individual zygotes. Stained with hæmatoxylon. *C. calcarata*, × 20.

size, next forms a series of bundles, and then secondary bundles or branches in the valves, which ramify through the whole substance.

In the case of *C. Macleayana*, and others, these bundles are more numerous, and form a continuous line parallel to the inner surface and bounding the median tissue of the sporophyll on that side, and through which substance, composed of the irregular thin-walled cells originated from the pith, occasionally occur, however, a few detached bundles.

The chlorophyll parenchyma retains its character till the seeds have matured, when the fundamental tissue having performed its functions, loses its vitality, indurates into a granular, brownish-coloured ground mass with bundles, and eventually atrophies. In a measure the whole period of the life history of the cone corresponds to that of the stages of a *Eucalyptus* fruit, which in its early growth is quite green (the calyx), and which eventually hardens into the fruit capsule.

The following are given to graphically illustrate the varying stages of the different parts in this life history of a cone:—

Figure 4 is a longitudinal section through the very earliest indications of the formation of sporophylls, and when the leaves which go to form these organs are not yet in the same plane as eventuates in a later stage of the cone's life history. Figure 5 is a transverse section at the base of the cone in its earliest stages, the outer portions being cut off; the point desired to be illustrated is the attachment of the sporophylls to the central axis which is surrounded in this case by a ring of nine oil cavities, and which number is found later to increase on the inner side of the cone valves. Portions of the six cone-valves can be traced. This plate is likewise interesting as it shows the lysigenous origin of the oil cells or cavities on what is later, the inner surface of the valve. Eventually oil cavities are formed throughout the fundamental tissue, but more especially located near the outer edge of each valve, and even in the case of *C. robusta* and *C. verrucosa* amongst the epidermal cells.

The occurrence of oil cavities in the cones is marked by two features—their numbers, and the chemical characters of the oil contents—and as regards the latter, it is shown under *C. robusta* and *C. verrucosa* that the oil of the cone valves is optically, at least, distinct from that of the leaves. The cause of this variance is a problem still to be settled by the physiologist; but perhaps in the formation of resin in the fruits one active form has been utilised more than the other. The comparative abundance of oil cavities in the valves may be a provision of nature to provide protection to the maturing seeds by lessening or warding off the power of the solar heat rays in dry-country species. Figure 6 is a 32-magnification of a similar transverse section to Figure 5, but in this case the central axis

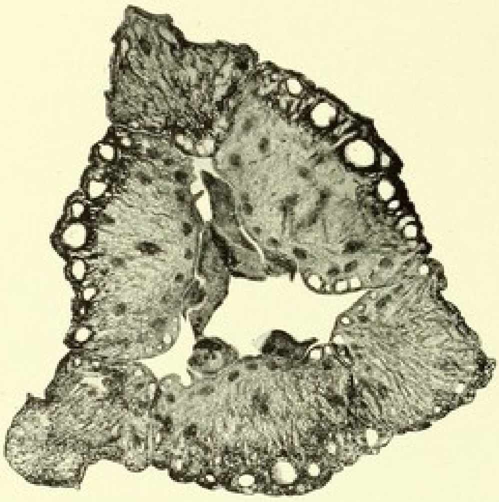


Figure 13.—Transverse sections through the upper portion of early cone clear of the central columella, and yet cross-cutting some of the early seeds of the three larger sporophylls. The dorsal oil cavities are prominent, whilst the black patches in the tissue are vascular bundles. *C. calcarata*, × 20.

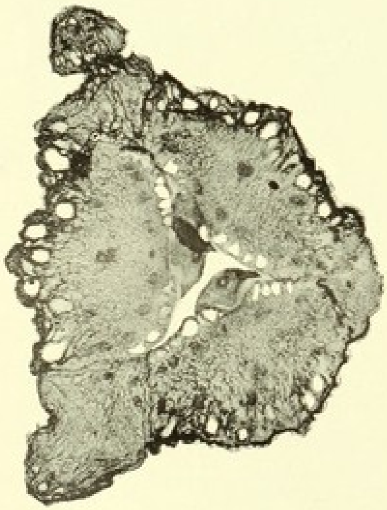


Figure 14.—Same as Figure 13, but cut lower down and showing somewhat greater detail of structure and more zygotes. *C. calcarata*, × 20.

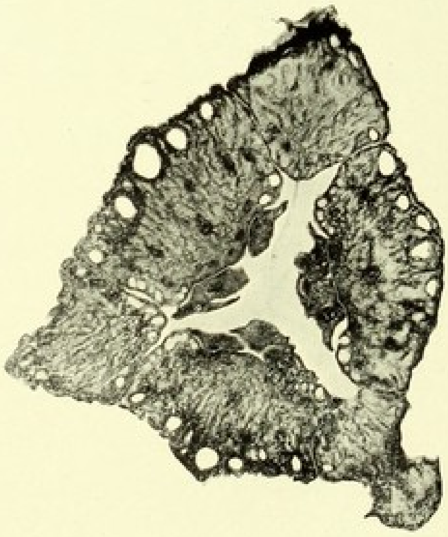


Figure 15.—Transverse section near the top of seed cavity, showing alternate larger and smaller valves and the row of oleo-resin cells on the ventral and dorsal surfaces of the former. The tops of three early seeds are shown. *C. calcarata*, × 20.

Sections to illustrate the life history and anatomy of the Cone Valves.

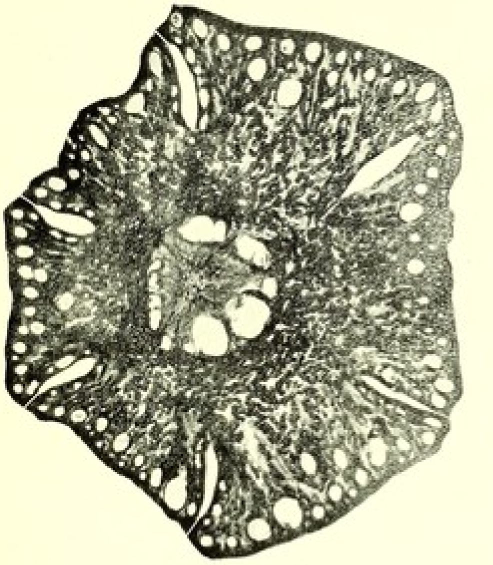


Figure 16.—Transverse section through the base of a very young cone. In this case the six valves are separated internally at this period, except at the outer edge. All the cavities are oil cells. *C. Macleayana*, × 15.

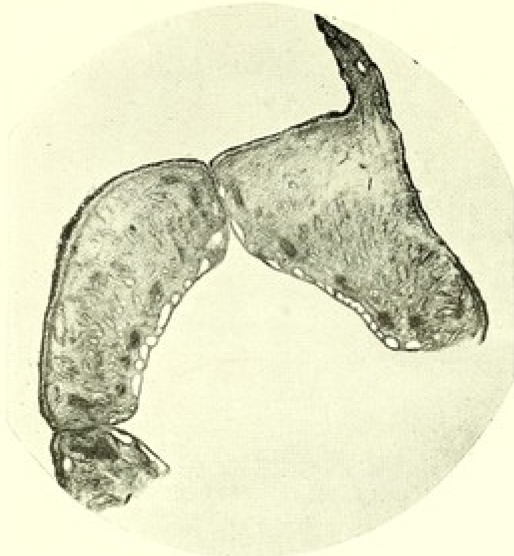


Figure 18.—Longitudinal section through the dome of seed cavity, showing the junction of ventral surfaces of two sporophylls to form a roof over the fertilised seeds or zygotes. A spur is well shown on the right. A feature is the row of oil glands (white) backed by an uneven row of bundles (dark patches). *C. rhomboidea*, × 13.

Figure 17.—Transverse section through the junction of two valves of Figure 16. The papillose projections (now teeth-like) of the ventral surfaces of the sporophylls, which close the separating space to the outer world, are clearly seen, as also are the oil glands. The smaller bodies are parenchymatous cells. *C. Macleayana*, × 55.

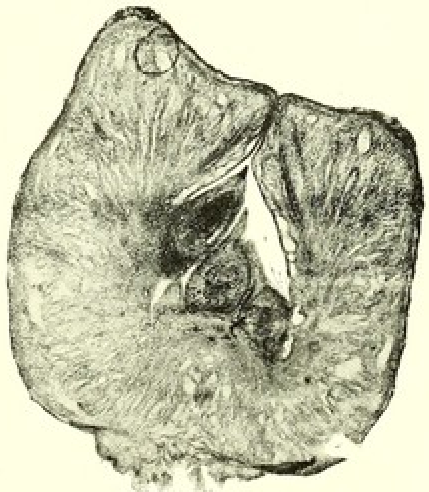


Figure 19.—Longitudinal section through the early stage of cone formation, the space containing the fertilised ovules being now quite a complete cavity. *C. rhomboidea*, × 13.

Sections to illustrate the life history and anatomy of the Cone Valves.

is more distinctly seen and consists of three bundles, and the empty spaces are oil cavities cut at varying angles. Figure 7 shows portion of a transverse section cut clear of the central axis and just below the columella. The ring of bundles can just be seen in the centre of the picture, while others may be observed in the sporophyll tissue and denoted by the dark spots (transverse) and dark radial lines (obliquely cut). Figure 8 is a 32-magnification of the upper portion of Figure 7; the bundles are more distinctly seen, and the row of oil cavities on the dorsal surface form a conspicuous feature. In Figure 9 is given a cross section a little higher up than the last figure and through the columella. Two of the three larger valves are in the field of vision, and also two of the smaller valves, only portions of the other two being seen. Cross sections of a few zygotes are shown at the base of the scales, the darker spots denoting the bundles, and the spaces in the leaf tissue are empty oil cavities on the dorsal and ventral surfaces. Figure 10 gives a view of a section just clear of the columella. Two large and two small valves are perfect. In Figures 11 to 15 these cross sections have been taken at various intervals above the last and below the dome. The dorsal oil cavities are specially well defined, the ventral cavities being less conspicuous, the dark spots in the sporophyll tissue are the bundles, whilst the irregularly-shaped bodies in the middle seed cavity are the cross sections of the maturing seeds or zygotes. Figure 16 is a cross section at the base of the early cone of *C. Macleayana* and shows the attachment of the valves to the central axis,—surrounded in this case by some proportionately larger oil cavities, and a row of these bodies occurs just below the dorsal surfaces of the six alternate cone valves, and separated by radial slits or sections of the ventral channels. Figure 17 shows a 55-magnification of the surrounding tissue of an individual ventral decurrent channel between two valves. It is interesting as illustrating how the papillose projections surrounding the stomata interlock like the teeth of a cog-wheel as the valves come together to form the cavity for maturing seeds; oil cavities are seen to be numerous, as well as the sporophyll tissue consisting also in these parts of starch-filled cells (not seen in plate) and the filled parenchymatous cells. Figures 18–24 are longitudinal sections of a fruit cone in its early stage, soon after the closing over of the thickened portion of the sporophylls. Figure 18 shows the dome with one spur on a scale, and also the ventral oil cavities with their subtending bundles (the black markings). In Figure 19 is given a 13-magnification of a longitudinal section just clear of the spurs. Figure 20 is taken from a larger stage of growth, and three fertilised ovules are well defined standing erect in the central cavity, domed by the enlarged portion of the sporophyll—the lower surface of which is lined with oil cavities, and near which are bundles differing in shape owing to the obliquity of the various angles of section. Figure 21 is a longitudinal section of a fruit cone through the columella, showing fertilised and sterile ovules, and Figure 22 is a higher magnification through these latter organs, which are seen to be similar in structure to the sporophyll tissue, so that Figure 22 is the enlarged centre of 21. Figures 23 and 24

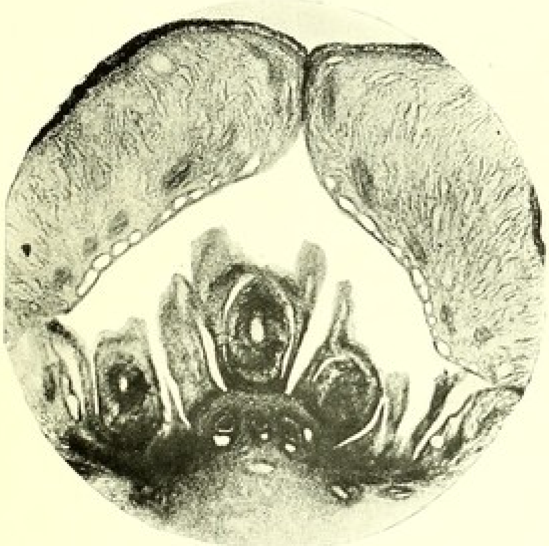


Figure 20.—Longitudinal section through the dome of the early fruit, showing the junction of sporophyll enlargements and so forming the seed cavity; the white spaces close to the ceiling of the dome are oil cavities, and these are backed by a row of bundles,—the darker patches. *C. rhomboidea*, × 16.

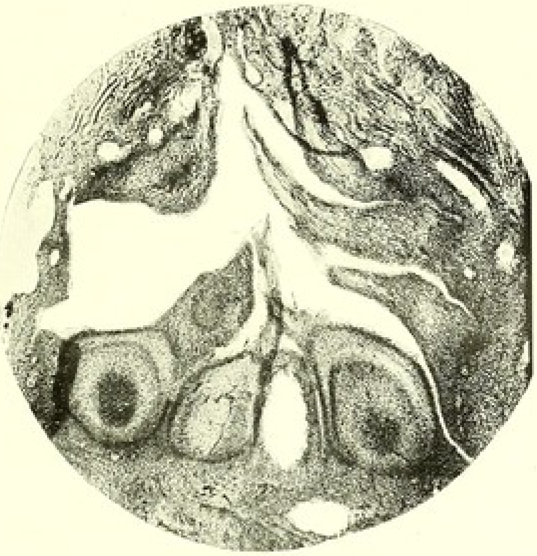


Figure 22.—Longitudinal section through the columella and adjacent zygotes at the bottom of the cavity. *C. rhomboidea*, × 20.

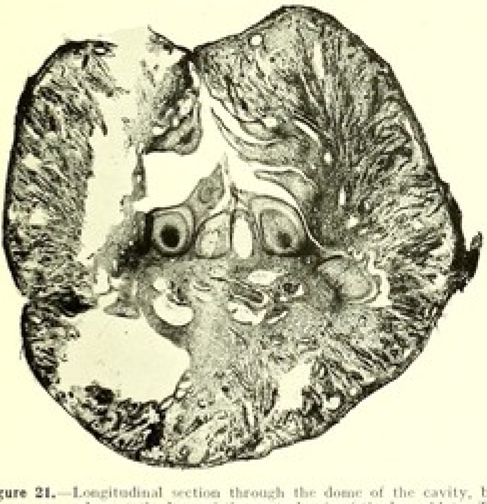


Figure 21.—Longitudinal section through the dome of the cavity, but clear at the base of the central axis of the branchlet. The columella is well seen separating the two central fertilised ovules. The material has broken away in the left of the picture. *C. rhomboidea*, × 8.

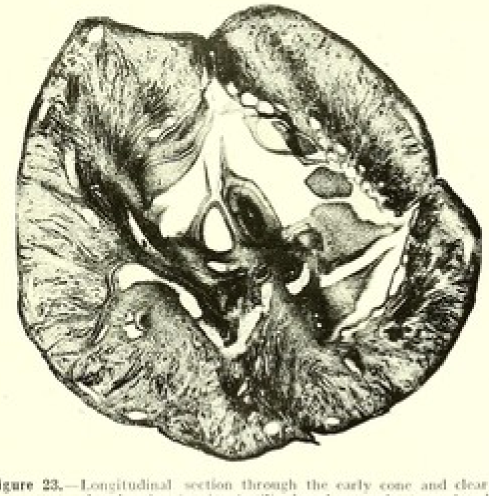


Figure 23.—Longitudinal section through the early cone and clear of basal axis, showing fertilised ovules completely enclosed by the sporophylls. The columella is triangular in shape and empty, and has a perfect fertilised ovule on the right. *C. rhomboidea*, × 8.

Sections to illustrate the life history and anatomy of the Cone Valves.

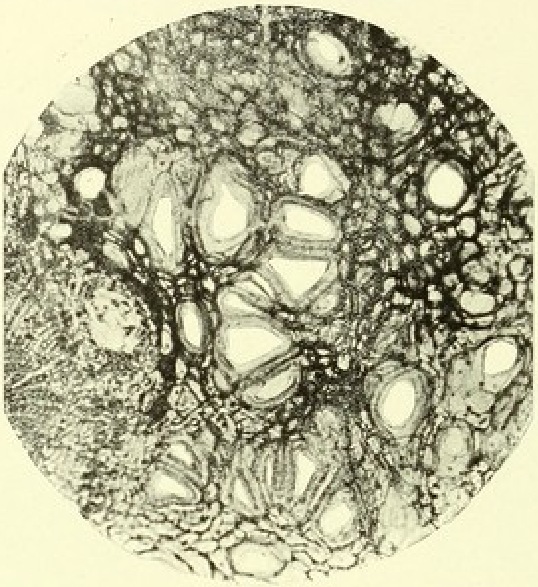


Figure 25.—Transverse section through the base of a macrosporophyll at the junction with the central axis—shown on lower left corner. The thick-walled bodies are the sclerenchymatous cells scattered in the tissue of this organ. *C. rhomboidea*, × 80.

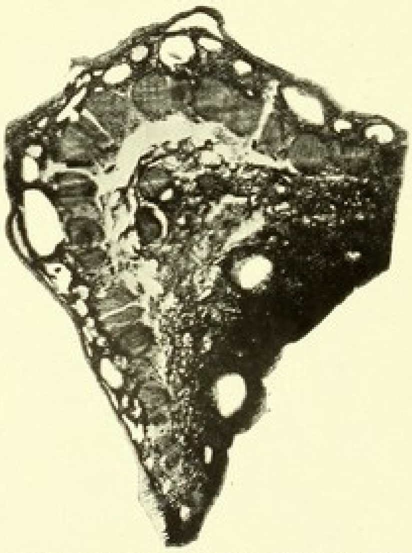


Figure 26.—Transverse section through an early fruit valve. Below the ventral (convex) surface is a series of oleo-resin cavities of various sizes, and these are subtended by a continuous row of bundles, a feature quite unique amongst *Callitris*. *C. Macleayana*, × 8.

Sections to Illustrate the life history and anatomy of the Cone Valves.

Figure 24.—Longitudinal section through the seed cavity of an early cone. One full-sized, fertilised ovule is seen in the centre of the picture, having on its left the columella, the interior of which is one large oleo-resin cavity, and on the left of this again is a wing in section of another of the fertilised ovules, followed by others on the left wall. Oil cavities are numerous on the walls of the macrosporophylls forming the dome. Stained with hæmatoxylin. *C. rhomboidea*, × 20.

are similar sections in a series with Figures 21 and 22. Figure 25.—This plate is given to show the predominence of sclerenchymatous cells in the valve tissue on *C. rhomboidea*, and which is quite a specific difference; they are the larger bodies in the picture with thickened walls. Figure 26 is a cross section of a valve of a mature fruit of *C. Macleayana*, and depicts the row of comparatively large bundles near to, and parallel with the ventral surface, and below the row of oil cavities.

XII. ORIGIN OF THE SPUR ON THE VALVES OF THE CONES.

One of the species of the genus received its systematic designation from the presence of a spur or point on the upper dorsal surface of each cone valve, but during this investigation it was found that such a character was common throughout, and as they could not all be one and the same species, as has been suggested, it was decided to investigate the origin of this feature, for no explanation of it was found in the literature at hand, although the figure of *Tetraclinis* (*C. quadrivalvis*) in Sach. 2nd edition, p. 517, shows one stage of its development.

At first it was searched for at the very earliest stage of the life history of the leaf, and at an apparently corresponding spot where it occurs in the mature valve, near the top of the dorsal surface of the sporophyll, but without success, and so it was not until the whole life history of the fruit valve was studied that its origin was discovered.

The female amentum, which may here be said to start life from the last two whorls of leaves, the smaller ones being the lower trio, are found at the extremities of the branchlets.

After the ovules are fertilised and as the valves develop, these two whorls gradually merge into one whole at the base, where they then radiate in the same plane from the axis.

It is near the base on the upper surface of these seminiferous valves or open carpels, if one may so designate them, that the ovules are borne and developed; and as soon as these are fertilised, the leaf, now a sporophyll, gradually thickens in the centre just above the last or highest row of ovules as in Figure 27, *c* and *d*.

This thickening proceeds quickly after fertilisation, on the upper surface till quite a protuberance is formed, which eventually exceeds in height that of the *original apex of the sporophyll, and which latter is now thrown back* as it were,—Figure 27, *e* to *h*.

This embonpoint now rapidly increases in height, and inwards, towards similar features on the corresponding opposite sporophyll, and finally, they all valvate, the three larger meeting in what is now the apex of the cone, and together with the three lower or smaller ones form a cavity over and enclosing the fertilised ovules, or zygotes.

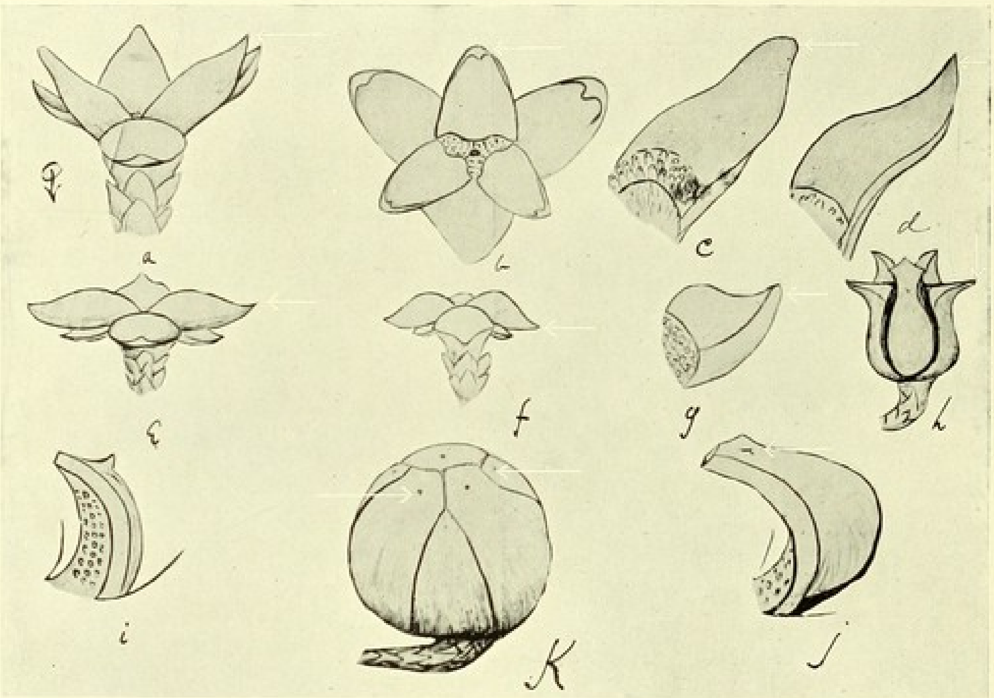


Figure 27.—Diagrammatic series showing the origin of the "spur" on the valves of the cone, the process being marked by the arrows from Figure A to Figure K.

The original free end of the sporophyll has in the meantime become less and less prominent, as it recedes from the newly formed apex, and finally exists only as a spur or dorsal point towards the top of each valve, as in *C. calcarata*, or *C. glauca* (Figure 27 *k*), respectively, whilst in *C. oblonga* its absorption into the scale has been less, and so is a prominent systematic character in that species.

This phenomenon can be traced in Pines other than Australian.

Figures 28 to 33 reproduce a longitudinal series from original material intended to illustrate this gradual thickening of the sporophylls at their lower middle, after fertilisation of the ovules, and which thickening can be traced gradually, till it eventually forms a dome over the macrosporangia, whilst

Figure 28.—Longitudinal section through ♀ amentum and subtending whorls of leaves, illustrating the orthotropous character of the ovules on the sporophylls prior to thickening. *C. Muelleri*, × 13.

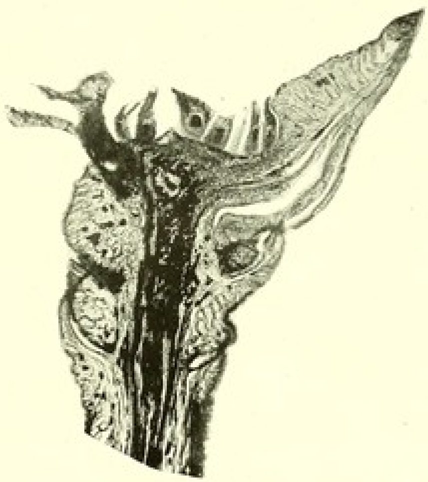


Figure 29.—Longitudinal section through ♀ amentum. The thickening on the ventral surfaces of the sporophyll—shown on the right at the top—is just commencing, and one large and two small oil cavities in this sporophyll are cut longitudinally. *C. Muelleri*, × 21.

Figure 30.—Longitudinal section through ♀ amentum showing gymnospermous orthotropous ovules and the development of the inner portion of the sporophylls to form the enclosing dome after fertilisation. *C. Muelleri*, × 21.

Sections illustrating the growth of the ventral side of the sporophylls, until a dome is formed over the zygotes.

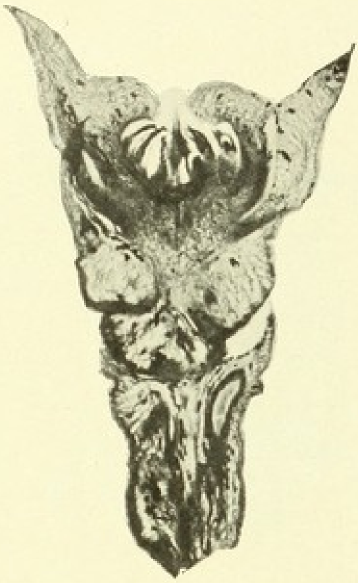


Figure 32.—Longitudinal section through ♀ amentum, showing considerable central development of two sporophylls, the expanded ventral surfaces of which extend almost over the fertilised ovules or zygotes. *C. Muelleri*, × 21.

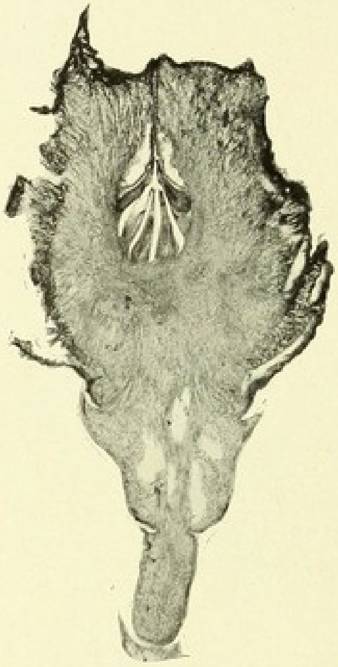


Figure 33.—Longitudinal section through the earliest stage of cone formation, showing the fertilised ovules quite enclosed by the thickening of the central ventral portion of the macrosporophylls. *C. calcarata*, × 20.

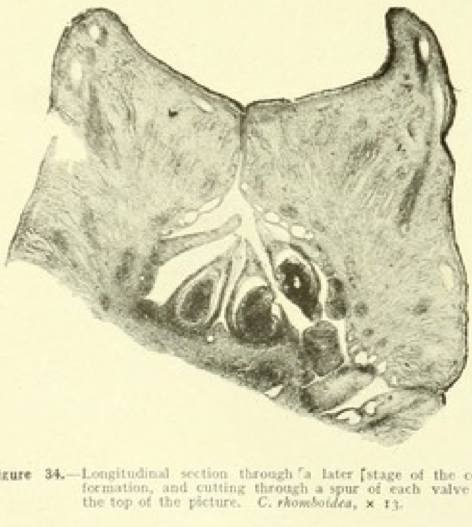


Figure 34.—Longitudinal section through a later stage of the cone formation, and cutting through a spur of each valve at the top of the picture. *C. rhomboidea*, × 13.

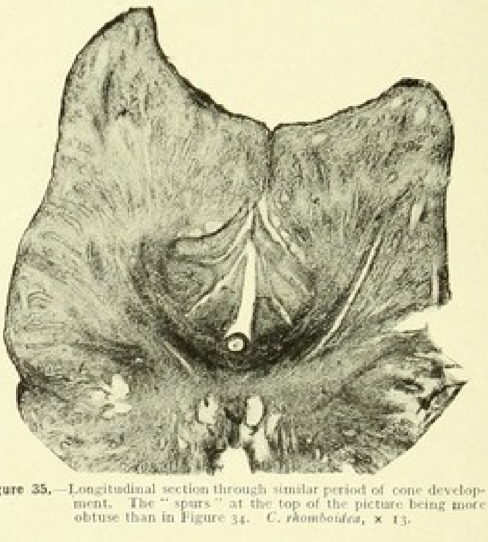


Figure 35.—Longitudinal section through similar period of cone development. The "spurs" at the top of the picture being more obtuse than in Figure 34. *C. rhomboidea*, × 13.

Sections illustrating the growth of the ventral side of the sporophylls, until a dome is formed over the zygotes.

Figure 31.—Longitudinal section through a ♀ amentum showing two sporophylls thickening inwards in the process of forming the dome or roof over the fertilised ovules or zygotes, and so producing an enclosing cavity. Stained with Erlich hæmatoxylin. *C. Muelleri*, × 19.

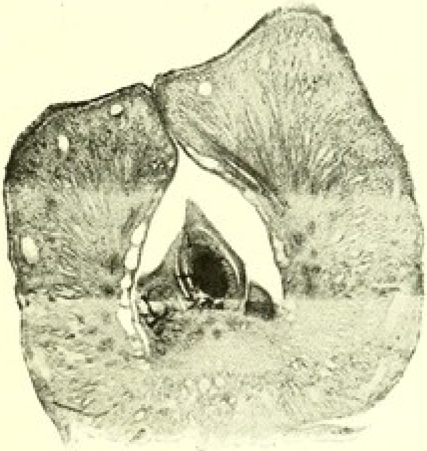


Figure 36.—Longitudinal section through a stage of a cone formation, showing the roofing over of the fertilised and sterile ovules by the inner growth at lower portion of the sporophylls. *C. rhomboidea*, × 13.

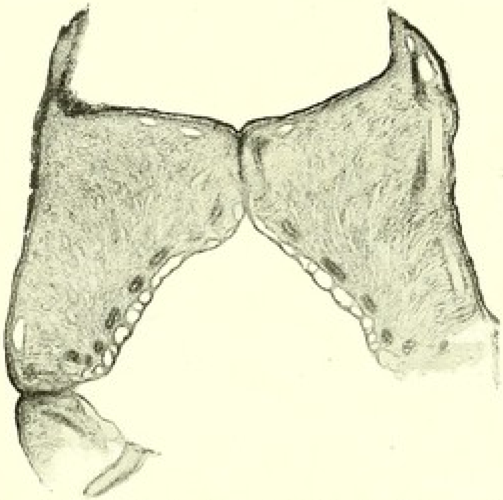


Figure 37.—Longitudinal section showing the junction of the expanded portions of two sporophylls which form the dome of the seed cavity. Oil cavities backed by a row of bundles are seen near the inner surface. *C. rhomboidea*, × 13.

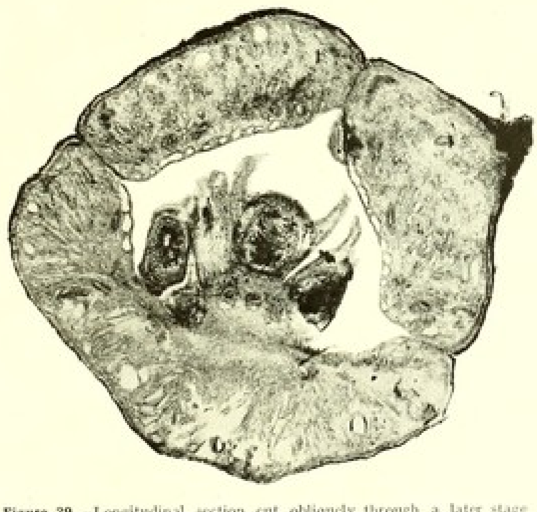


Figure 39.—Longitudinal section cut obliquely through a later stage of growth of cone than in Figure 38. One spur is shown to the right. *C. rhomboidea*, × 13.

Sections illustrating the growth of the ventral side of the sporophylls, until a dome is formed over the zygotes.

during the process, the free end of the original leaf is thrown back and forms the spur on the dorsal surface on each valve of the cone, as shown in these figures. The gradation of such processes is complete from Figures 29 to 33, in which latter only one spur has been dissected. In every case a number of subtending leaves are shown.

Figures 34 to 37 give a similar series, but taken from a more advanced cone, and show, besides the above features, the complete closing in of the fertilised ovules or zygotes *in situ*.

Figures 37, 38, and 39 are given to show (1) the junction of enlarged portion of the sporophylls at the apex or dome of the cavity, and (2) the spurs nearing their final stages in the cone's life history. These are also interesting as they show the row of oil cavities on the inner and outer surfaces, the former being backed by a row of bundles—marked by dark oval patches. Some also are seen behind the oil cavities below the dorsal surface.

XIII. PROBABLE FUNCTION OF THE CENTRAL COLUMELLA OF THE CONE OF *CALLITRIS*.

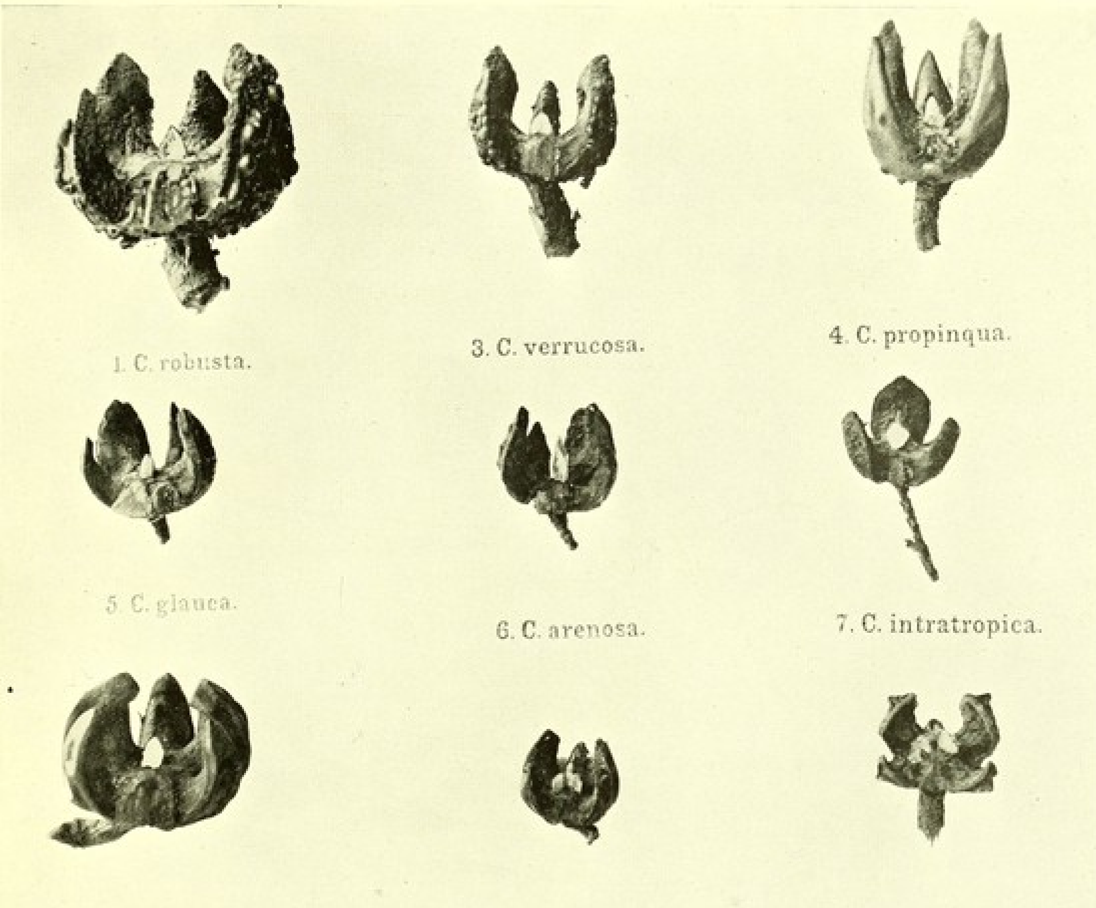
In all species of this group there is present in the inside at the bottom of the cone a central column, sometimes simple in form when it is pyramidal, and at other times compound or three-lobed, but varying in length in individual species.

As far as our knowledge goes no function has been assigned to this body, nor could any reference be found accounting for its origin except a remark by Bentham, who, in the "Flora Australiensis" (VI, p. 234), states that "they are sometimes apparently formed of abortive ovules."

The inference from this statement is that it is not a *regular character*, but should only be found when abortion occurs, but this is not borne out by facts, as it always occurs in the cones, and may, therefore, be regarded as a persistent character, and is generally of a uniform shape and length in each species, so that if formed by chance, such as fertilisation or non-fertilisation of ovules, its occurrence would be occasional, but such is not the case.

Anatomically, both before and after the dehiscent period of the cone, it is identical in structure with the inner portion or ovule-bearing area of the sporophyll, as well as that of the ovules. In the first of these stages the columella is composed of nucleated, closely packed, irregular parenchymatous, starch-containing cells, which have their origin in the centre of the branchlet from whence they emerge, and form, not only the tissue of the columella, but also the bulk of the substance or structure of the sporophylls, or what are later the six cone valves.

Figure 38.—Longitudinal section through an early stage of a cone, showing attachment of zygotes to the elongated base of the macrosporophyll, in the centre of the seed cavity. Stained with hæmatoxylin. *C. rhomboidea*, × 13.



Frank H. Taylor, Photo.

Callitris CONES WITH ONE VALVE REMOVED TO SHOW THE COLUMELLA (WHITENED) OF THE SEVERAL SPECIES.

It therefore, partakes of the structural character of the ovules (Figures 24 to 41) and of the scales, but is more closely allied to the latter as it encloses an oil cavity from its very earliest stage of growth, and so is, perhaps, either a rudimentary organ with a past function or an intermediary organ between some higher development not yet evolved, and thus its exact function to-day is not easy to determine (*vide* remarks under Angiosperms *v.* Gymnosperms). After dehiscence it is generally found to have developed at least one large oil cavity, and sometimes one or two smaller ones, the contents of which resinises as the fruit ages.

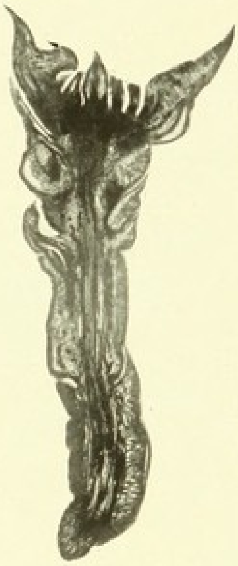


Figure 40.—Longitudinal section through ♀ amentum and subtending decurrent leaves. The central columella is seen to be more developed than the ovules at this stage, and to exceed the height of the thickening of the left sporophyll. *C. Muelleri*, × 13.

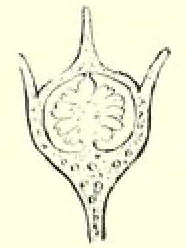
Figure 41.—Longitudinal section—further illustrating feature of Figure 40. *C. Muelleri*, × 13

(See also columella in Figures 21–4.)

The position of these columella, it would seem, may be said to correspond with that of the placenta of some Angiosperms; and for the ovules in the process of time to extend beyond the base of the sporophyll and become adnate to this central partition for preference does not require, to our mind, a botanical cataclysm of nature, but rather an easy process.

It may, therefore, be possible that we have here, either by evolution or mutation, the forerunner in the origin of some of the organs of reproduction of the Angiosperms, more especially the placenta, and, by a process of elongation, perhaps, the pistil.

In the case of *C. arenosa* the columella is so much lengthened as to almost touch the top of the incurved portion of the valves, and, if lengthened in course of time so as to protrude beyond the dome so formed by this incurving, it would occupy a similar position to the pistil of the angiosperms, and further, a development of the free end (spur) of the sphorophyll would produce a feature, calyx-like in character; so that it is possible we may be viewing here the prototype of a capsule, say, identical with those of our Eucalypts, or some other Myrtaceous genera. The sections given under the origin of the cone valves certainly resemble a section of a capsule of a *Eucalyptus* species after the fertilisation of the ovules, for Figures 32, 40, and 41 illustrate a form of the central column almost approaching the above conditions, the columella being abnormally developed.



Longitudinal section of *Eucalyptus* capsule after fertilisation of ovules. (Enlarged).

XIV. ANGIOSPERMS *v.* GYMNOSPERMS.

From the previous account here given of the life history of the cone of the *Callitris*, there are certain analogies one notices between corresponding structures in the two large groups of the vegetable kingdom, *i.e.*, the Angiosperms and the Gymnosperms.

In the case of the former division, the ovules are, as well known, completely enclosed previous to fertilisation, and during the whole period of maturation afterwards as seeds, whilst in the case of the latter division it is only in the prefertile condition that the ovules are gymnos.

As soon as pollination is completed in *Callitris*, the thickening of the lower portion of the sporophylls, as described above, takes place rapidly, and in a very short space of time a closed cavity is formed—a condition of things identical with what is from the first in the Angiosperms, the ovary. The newly thickened portions of the sporophylls now form the dome of this cavity, and the free ends being thrown back or spreading, resemble, as it were, or perhaps more correctly speaking, correspond in this position to the sepals in Angiosperms; in fact, one might almost say that in the early stages of maturation, the thickened portions of the sporophylls and their free ends are homologous respectively to the dome of the ovary and the sepals in the Angiosperms. Here then, perhaps, are the prototypes of the enclosed ovary, and the floral structure (sepals) of the Angiosperms.

Then again, the period of maturation having been completed, a dehiscence takes place similar to that of the Angiosperms.

XV. TIMBERS.

(a) Macroscopical.

In regard to colour, the timbers may be divided into two classes, viz., those having a pale or white heartwood, and those with a coloured duramen.

The latter class is quite limited in its number of species, including as it does only two, viz.:—

C. intratropica.
C. arenosa.

While the former includes:—

C. glauca.
C. calcarata.
C. Macleayana.
C. rhomboidea.
C. gracilis.
C. Tasmanica.
C. verrucosa.
C. Muelleri.

Too much reliance, however, must not, in this connection, be placed on colour, as it varies in depth in the same species, and is then largely due to the presence of an excess of chemical bodies peculiar to these timbers.

As a systematic classification this feature is of little use, for dark and light coloured timbers may be found in trees of the same species, and specimens illustrating this feature are exhibited in this Museum.

The lighter shade of timber hardly resembles in character that of the *Pinus* of commerce, being a closer-grained and harder wood, whilst the darker-coloured varieties are still heavier and more ornamental; both characters are dealt with more fully under the respective species.

(b) Microscopical.

A microscopical examination of the permanent or secondary tissue of these Conifers shows it to consist almost entirely of prosenchymatous cells or typical sclerenchymatous tissue, but parenchymatous tissue is found scattered throughout the tracheids in the rays, the right-angled end walls being seen in the sections of these medullary rays, with their uniform cell structure. Pitted cells in single rows in the radial walls form a characteristic feature of all the tracheids.

The disposition of the pitted cells present no variation from those of non-Australian Conifers, or other plants having this characteristic cell-wall structure;

the sections cut showing them to be exactly opposite those of the cells contiguous to each other, the pits being closed by a middle lamella, which no doubt fills the function as laid down by Gardiner, *i.e.*, permitting the passage of protoplasmic fibrils connecting the energids of the respective cells. On the other hand they probably play an important part in the forming of syncytes, although no actual case was met with in the material examined.

The presence of a dark-coloured substance, a manganese compound, in the lumina of the tracheids of the different forms, is a feature in the wood of most *Callitris* species.

(*c*) Economics.

Callitris trees are an inestimable asset to Australia and should be closely conserved or reafforested, as they are invaluable in the interior where the termite (white ant) is found; for their timbers are, owing to the presence of a phenol, and other chemical bodies, able to resist to a large extent the depredations of this enemy to mankind, and every effort should be made to propagate our Cypress Pines under a scientific system of forestry.

As showing the value of pine plantations to a country, the following excerpt from the *Cape Times*, and written by D. E. Hutchins, Conservator of Forests, may not be out of place:—

It is worth a long journey to Genadendal to witness the natural regeneration of the cluster-pine. Between 1825 and 1830, *i.e.*, about seventy years ago, a small area at the foot of the mountain near the picturesque old churchyard was trenched and sown with cluster-pine seed. None of these seventy-year-old pines now remain, though one or two of their broad stems can still be identified. From these trees the cluster pine has spread, self-sown, up the rocky face of the mountain and into the rugged Genadendal Valley, presenting most picturesque and remarkable effects: now subduing the moorland veld, and anon covering with ample humus the bare rocks. No sight has so impressed me since my first view of Table Mountain from a Wynberg window at daybreak on a serene winter's morning. The Genadendal Valley runs into the heart of the highlands for 4 or 5 miles. To the east rises the Genadendal Mountain, 5,000 feet high. From this valley issues the stream that waters the station, and some distance up, on both sides of the water, extend these natural woods of cluster-pine, unsurpassed in their sylvan beauty, and in their lesson of potential forest wealth, by anything else at a distance from Table Mountain. Mr. Vedemann pointed out to me a spot on the east side of the valley where, when he left Genadendal in 1881, there was only a scattered growth of pine, which was traversed by a veld fire five years afterwards, in 1886. Nevertheless, the whole of this area is now covered with a sufficient stock of young self-sown pine, with larger pines scattered among them, showing by their blackened stems where the fire had passed. On the west side of the valley the pine woods are intersected by winding paths. It is necessary from time to time to clear these paths of the young pines, which would otherwise soon obliterate them. Wherever any opening lets in a little light young pines make their appearance, exactly as in Scotch-pine forests in Europe. . . . . The country must have pine plantations. Dr. Schlich, in a recent able paper read before the Imperial Institute, has shown how the pine timber supplies of the world are reaching a visible termination. The present importation of pine wood to South Africa must considerably exceed in value a quarter of a million pounds sterling.

Speaking of cluster-pine plantations, it was shown in my last annual report that for every £1 spent now the country should reap an annual revenue of £1 in thirty-five or forty years. And, perhaps even better than this, the quarter of a million pounds sterling or more, now paid yearly to the foreigner, would be kept in the country. It has been computed that nine-tenths of all the wood used in the world is pine, or wood of that class.

During 1896 the quantity of pine wood and wood of that class entered at the ports of Cape Colony amounted to 4,967,945 cubic feet, valued at £215,693. It is certain that cluster-pine, properly grown in close plantations (and this is a very important and imperative proviso) would supply the greater part of the present demand for pine wood. At present we have the pick of the pine forests of the world, at prices so low that they cannot last long. In the future there is a certain market for colonial pine wood. And, just as the worthy missionaries at Genadendal are now thanking the foresight of their predecessors in planting the cluster-pine seventy years ago, so in another forty years will the colonists of the future be indebted to those who plant cluster-pine now.

And to these remarks we would add, the Australian of the future will feel grateful to those who to-day have the foresight in planting *Callitris* and other indigenous pines for the use of posterity; and in regard to pine forestry, the time is evidently not far distant, when action will have to be taken in regard to the depletion of pines in New South Wales and Queensland, by the wholesale destruction of these forests now taking place.

In this connection, perhaps, no stronger argument can be advanced as to the value of the Australian Pines as a national asset than the following, which we have extracted from "The Australian Insurance and Banking Record," 21 December, 1909, p. 1016:—

The Queensland Government has lately sold some fair-sized forest areas. On 29th November the biggest area yet offered in the State was offered. The sale was of the standing timber on 10,000 acres in the parish of Cooyar, on the route of the railway now being built to connect the Southern Burnett with Brisbane, the quantity of Pine being estimated at 40,000,000 feet, with ten years for removal. A condition was imposed providing for the erection of £10,000 worth of plant on or near the area within two years, and the upset price was 1s. 6d. per 100 super. ft. The minimum quantity of timber to be removed is 300,000 feet monthly, and the maximum 6,000,000 feet per annum. The Queensland Pine Company, Limited, successors to Millar's Jarrah Company in Queensland, were the purchasers at the upset. The Cooyar Scrub is said to be one of the best timber areas in Queensland, and the Government estimate is that it contains altogether 250,000,000 feet of Pine.

Mr. MacMahon, the Director of Forests, Queensland, informs us that the pine timber growing in this area is *Araucaria Cunninghamii*.

The market price of this timber 12 in. x 1 in. in Sydney to-day is quoted at £1 4s. 6d. per 100 feet, and the contract price to the New South Wales Government is 12½ per cent. discount off that amount; so that the value of the Pine timber estimated to be growing on the Cooyar Scrub alone—at the price to the consumer—represents a sum of over £3,000,000.

The "White," "Black," and other *Callitris* Pines of Australia yield a resin quite similar to the sandarac of commerce. As only few sandarac-yielding pine species occur beyond Australia, that is to say in Africa, more sandarac resin could be collected in this part of the globe than elsewhere. (See article on the *Callitris* resins in this work.)

In addition to yielding a valuable building timber, resin, and oil, there remains the bark, which, with some species of *Callitris*, contains an abundance of tannin of excellent quality and colour, and is an important addition to the raw material required in the tanning industry.

Although pines might yet be disseminated naturally in some localities to the extent of intrusion in pastures, yet fine uniform trees should not be wantonly cleared off. In view of the economics enumerated above, it would, perhaps, pay better on loose soil to raise the "Murray Pine," as it can resist unhurt the greatest heat of the interior, than to convert such tracts into pasture lands; and, further, all must lament when these trees are seen to disappear, root and branch, in these regions, where their scenic effect is so splendid and unique in the landscape.

A correspondent writing from Pleasant Hills, County Mitchell, states that "Nothing has been done on the part of the settlers to provide for a future growth of the timber, while at the same time they admit its value; but it has to make way for the wheat fields, the duration of which latter, considering the light nature of the soil, and the wearing-out system persevered in by our up-country farmer, is problematical, and it is an open question in view of the large demand for Cypress Pine whether it would not be to the best interest of the community generally if some steps were taken for the propagation of this pine in a district which is its home and where it will grow to perfection."

Another correspondent writing from Stockinbingal, County Bland, says:— "The wholesale destruction of various kinds of pines in this district is lamentable and is carried on with no apparent forethought."

In this connection the results to be derived from the recent Forestry Commission, N.S.W., will be watched with interest by all who have the welfare of our timber industry at heart.

XVI. THE PHENOL, AND THE DETERMINATION OF THE OIL FROM *CALLITRIS* TIMBERS.

The characteristic odour of *Callitris* wood is due principally to the presence of a phenol which is retained in the oily portion of the distillate when the wood is steam distilled. This phenol occurs in the timber of some species in larger quantity than in others, and it is, perhaps, due to its presence that *Callitris* timber is so objectionable to the white ants or termites. It apparently also acts as a preservative to the timber when placed in the ground, thus corresponding, in this respect, to other similar phenolic bodies.

The timber of *C. glauca* was taken for the purpose of this investigation, but the wood of most other species, such as *C. calcarata*, *C. intratropica*, &c., would have answered just as well, and have given the same results. The timber of *C. gracilis* might, perhaps, be an exception in some respects, as the odour of the wood is somewhat different. Even from the unpromising timber of *C. Macleayana* both Guaiol and the phenol were isolated, so that it is not likely that marked differences will be detected in the constituents of the wood of any of the species of *Callitris*.

The liquid portion of the distillate was removed from the Guaiol by squeezing it through linen. It was a somewhat thick, viscous and heavy oil, but no signs of crystallisation were detected in it even on standing for months. It was dark-coloured, and had the characteristic odour of "Cypress Pine" wood strongly marked. For commercial purposes, where this peculiar and somewhat agreeable odour is desired, this oil might be a useful article. In localities where the wood of these trees is in common use, the aroma in the houses built of it, is considered by many to be quite pleasant, as is also that given by the wood when it is burned for domestic purposes. The specific gravity of this liquid portion at 16° C. was 0·9854. The rotation could not be determined as the light did not pass through the tube. It was soluble in an equal volume of 70 per cent. alcohol, but became turbid and milky with three or more volumes, but it was easily soluble in 80 per cent. alcohol, and became but slightly turbid with eight volumes.

The ester content was high—the saponification number being 106·6. The acid number was also high, 68·8, but this was largely influenced by the presence of the phenol and other allied substances, as well as by any free acid. On distillation, the greater portion came over within a comparatively small range of temperature. Nothing distilled below 248° C. (cor.) except a little acid water; 60 per cent. distilled between 248–255° C. As the oil distilling at the latter temperature became blue, the receiver was changed, and 21 per cent. of a bright blue oil was obtained, distilling between 255–265° C. The third fraction, 10 per

cent., distilling between 266–296° C., was a deep indigo-blue oil. The first fraction was again distilled, when most of it came over between 250–252° C.; this was but little coloured, was insoluble in 90 per cent. alcohol, had specific gravity 0·9266 at 15° C., and the refractive index, at the same temperature was 1·4926. Although evidently consisting largely of a sesquiterpene, yet, owing to the method of preparation, it must necessarily have been far from pure.

When determining the acid value in the ordinary way the separated oil formed a crystalline mass after standing for some hours. The crystals were found to be Guaiol, and these had evidently been held in solution by the substances acted upon directly by potash, or, more probably, were in combination with them. The oil separated from the saponification determinations after boiling with alcoholic potash, also crystallised readily on standing. These crystals were Guaiol also.

To isolate the constituents indicated by the determinations given above, a larger quantity of the oil was saponified with alcoholic potash by boiling; water was afterwards added in quantity, and the separated oil allowed to crystallise. The crystalline cake was then separated, and the solution slowly evaporated down to remove the alcohol. It was then filtered and rendered acid by sulphuric acid, when a dark-coloured oil, which was acid to litmus, separated in some quantity. This was well washed and treated with an aqueous solution of carbonate of soda, when a portion of an acid nature went into solution. The solution was then thoroughly extracted by ether, and the ether evaporated. The oil thus obtained was but little coloured, was thick and somewhat viscous, and evidently, from the mode of extraction and marked colour reactions, was a phenol. When placed on ice it did not crystallise, although it thickened considerably. It had most markedly the odour so characteristic of *Callitris* timber. When dissolved in alcohol, a solution of ferric chloride gave practically no reaction. When the phenol was dissolved in alcohol and bromine added, no colour was produced, but after the alcohol had evaporated, the phenol changed to a deep purple colour; this colour was again destroyed by addition of alcohol. When dissolved in acetic acid and bromine added, the colour changed to red at once, quickly becoming a rich purple. On standing some time in the air it became an indigo-blue colour, and the colour was not changed by boiling. This colour reaction is probably due to the formation of a trace of hydrobromic acid given off in the formation of the bromide, because both hydrobromic and hydrochloric acids gave a similar reaction, although slower. The colour was destroyed on the addition of water, a turbid solution being formed by the precipitation of the bromide. When the phenol was dissolved in strong aqueous alkalis and afterwards acidified with hydrochloric acid, a red colour was also produced. When dissolved in acetic acid and a few drops of sulphuric acid added, the solution changed immediately to dark red, soon becoming deeper in colour; eventually the colour became a rich deep purple, which was permanent for some days. When a drop of nitric acid was added with the

sulphuric acid the changes through red to plum colour were more rapid, but eventually the same result was obtained. To a portion of the original phenol placed on a watch-glass, a drop of sulphuric acid was added, a red colour was produced, eventually becoming purple on the edges as with the acetic acid solution. When a little of the phenol was dissolved in acetic acid on a watch glass, and the vapour of bromine passed over it, a purplish colour instantly formed, soon becoming a rich purple. This reaction is very delicate, and by its aid it is possible to determine the presence of the phenol in *Callitris* timber, the shavings being treated with ether-alcohol, and the solution evaporated to dryness before dissolving in the acetic acid. The difference in odour, in consistency, reactions with ferric chloride, together with its other marked colour reactions, show this phenol to be distinct from carvacrol. The marked colour reactions point to the origin of the indigo-blue oil obtained when redistilling the crude product.

When the original thick crude oil was agitated with a 10 per cent. solution of aqueous soda, a semi-solid mass was at once produced. After some time water was added and the mixture agitated, but the bulk of the oil still remained as a pasty mass, and this was filtered off and washed. It was readily soluble in ether, and on evaporating the ether a thick oil remained which soon crystallised, and from which Guaiol was obtained. When the alkaline filtrate was treated with a large quantity of water, it was partly decomposed, a small quantity of oil separating.

After standing some time with repeated agitation, the aqueous liquid was filtered and thoroughly extracted with ether. On evaporating the ether the phenol was obtained. This gave all the reactions, and had the characteristic odour of the phenol as obtained previously by saponification. The phenol is readily soluble in acetic acid, in ether, alcohol, chloroform, and in the usual organic solvents.

If on further investigation this phenol is found to be new, as appears to be the case, then the name Callitrol is proposed for it.

The oily distillate from the timber of *C. Macleayana*, from which the Guaiol had been removed, was of a deep red colour; it was slightly more aromatic than the oil from *C. glauca*. It was soluble in an equal volume of 80 per cent. alcohol, and remained clear with excess. It was soluble in two volumes 70 per cent. alcohol, but became turbid with five volumes. The saponification number of the esters was 22·34, while the acid value was 7·4. The phenol was extracted in the manner previously described, and although somewhat small in amount, yet it was identical with that obtained from the timber of *C. glauca*. Guaiol was also obtained from the product of saponification as with the latter species.

The characteristic colour reaction for Callitrol could not be obtained from the timber of *Widdringtonia* from South Africa; so evidently that phenol is absent.

XVII. THE OCCURRENCE OF GUAIOL IN THE TIMBERS OF *CALLITRIS* SPECIES.

The odour given by the wood of the *Callitris* generally, with perhaps the exception of *C. Macleayana*, is quite pleasant, somewhat aromatic, and characteristic. It is distinct from that of any other timber known to us, and the wood of *Tetraclinis quadrivalvis* from North Africa, has a different odour.*

To obtain the volatile constituents, the ordinary methods of steam distillation were employed. The log was cut into planks, and these were then run through the planing machine, and the shavings thus obtained were utilised for the purpose. The substances which distilled, separated upon the surface of the condensed water in a semi-solid mass, and were easily skimmed off. The material had a marked odour of the Australian "Cypress Pine" wood itself. This odour is given by the liquid portion of the product, as shown in the previous article, and when the solid substance was obtained pure, it was practically odourless.

The distillations in most instances were continued for eight or nine hours, but even then the shavings had a strong odour of the wood, and it is thus evident that more crude material would have been obtained by longer distillation.

The timber of *C. glauca* was taken for the main investigation and four distillations were made, giving a mean yield of 0·82 per cent. The crude semi-solid oily product was squeezed through cloth, by which means the greater portion of the solid was retained. The cake of stearoptene was then placed between drying paper and subjected to pressure in a screw press. A solid hard cake was thus obtained, and this was dissolved in cold 90 per cent. alcohol, filtered, and allowed to crystallise. The crystals which formed were hexagonal prisms, terminated by obtuse rhombohedrons, and some were of considerable size, of a brilliant nature and glistening in appearance. After repeatedly crystallising from alcohol, the material was again dissolved in alcohol, and water added to slight turbidity; crystallisation then rapidly took place, most of the material separating out in small crystals. This appeared to be a very good method whereby to purify the crystals, as they were thus obtained free from enclosures. They were finally re-crystallised from alcohol.

The facility of crystallisation of this substance may be illustrated by melting it either on water or on mercury, and allowing it to cool slowly; as it cools, a minute trace of the solid is added, when crystalline threads shoot out in all

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*M. Grimal (Compt. rend., 1904, 927) has investigated the steam-distilled oil from the wood of the North African species of *Tetraclinis*. He records the phenol which it contains as carvacrol, and the crystalline body as thymohydroquinone.

directions, making a very fine exhibit. The melting point of the pure crystals was 91° C. On analysis the following results were obtained:—

0·2273 gram gave 0·2385 gram H_2O, and 0·6756 gram CO_2.
H = 11·66 and C = 81·07 per cent.
$C_{15}H_{26}O$ requires H = 11·71 and C = 81.08 per cent.

A second analysis gave corresponding results. A sesquiterpene alcohol was thus indicated.

The crystals were readily soluble in alcohol, even when this was somewhat dilute; they were also soluble in ether, in petroleum ether, in glacial acetic acid, in chloroform, in acetic ether, and other organic solvents. The crystals were lævo-rotatory, and 0·5 gram dissolved in 10 c.c. alcohol, had a rotation in a 1 dcm. tube — 1·45°, the specific rotatory power from this is $[a]_D = -29°$.

When boiled with acetic anhydride in the usual way, only a liquid acetate was obtained.

When the crystals were heated with zinc chloride at 170–180° C., water added when cold, and the solution steam-distilled, a blue oil was obtained; this was at first a little green, but it became bright blue on standing some hours. The blue colour slowly faded if the air had full access.

When the crystals were gently heated with phosphoric anhydride, the colour changed to bright red and purple. With concentrated sulphuric acid the crystals were dissolved easily to a yellow colour which soon became orange, and on standing, to a pink colour on the edges. When the dehydration was somewhat complete, a thick liquid separated. With strong nitric acid the crystals became an oily mass, which after a short time were deep crimson, and purple to violet on the edges, the colour eventually fading away.

The above results show the crystallised portion of the oil of *Callitris* wood to be the sesquiterpene alcohol, Guaiol. Guaiol was originally isolated from the oil of guaiac, or guaiacum, which was first prepared commercially by Schimmel & Co., and brought into commerce as a perfumery oil. This oil was distilled from the wood of *Bulnesia sarmienti*, Lor., a tree belonging to the N.O. Zygophyllaceæ, which is known as "Palo balsamo," in Argentina, and supplied under that name*. A portion of this substance was kindly sent to us by Messrs. Schimmel & Co., and it gave identical reactions with our Guaiol.

The timber of the "Stringybark Pine," *Callitris Macleayana*, was treated similarly to that of *C. glauca*, and a semi-crystalline product obtained by steam distillation. This was of a deep red colour, and in odour was less distinctive

* Schimmel and Co.'s Reports, April, 1898, p. 28, and October, 1898, p. 29. Also Gildemeister & Hoffmann, "The Volatile Oils," p. 453.

Frank H. Taylor, Photo. *Nat. Size.*

TRANSVERSE SECTION OF *Callitris* TIMBER SHOWING GUAIOL CRYSTALLISED NATURALLY ON THE SURFACE.

than the oil of *C. glauca*. The yield was 0·558 per cent. The crystalline constituent was separated from the oily portion in the manner previously stated, and when purified was found to be Guaiol. It was similar in crystalline form, melted at 91° C., and altogether was identical with the substance isolated from the wood of *C. glauca*.

The timber of *C. Macleayana* has little resemblance to the hard compact wood of the *Callitris* generally, so that from this result, it may be assumed that Guaiol will be found occurring in the wood of all the species of Australian *Callitris*.

The timber of *C. intratropica* received from Port Darwin, had the characteristic odour of the Australian *Callitris* wood most marked. When cut, the Guaiol was so pronounced a constituent that it crystallised upon the planed surface of the wood itself, and sufficient material was obtained to chemically identify it as Guaiol; so that it was not even necessary to steam-distil the wood. It was thought better, however, to isolate it in the ordinary way, and both Guaiol and Callitrol were obtained. Guaiol often crystallises out on the freshly-cut surfaces of the timber of other species of *Callitris*.

It is, perhaps, worthy of note that this substance is contained in the wood of trees so far removed as the *Callitris* (Coniferæ) of Australia, and the Zygophyllaceæ of South America.

No other crystalline substance than Guaiol has been detected in the steam-distilled products of *Callitris* timber.

XVIII. BARK.

Microscopical.

The bark of the *Callitris* in a general sense may be described as consisting of alternating concentric rings of (1) uniseriate sclerenchymatous, elongated, thick-walled fibrous cells,—the bast fibres, (2) a row of parenchymatous cells between, (3) two rows of sieve tubes each adjacent to the bast fibres, and (4) bands of several layers of cork cells or periderm in the outer cortex.

These various structures characterise both the inner and outer cortex. Running radially through these are the parenchymatous-celled medullary rays, dividing the whole into bast rays which correspond to the equivalent rays and strands of the wood.

Throughout are scattered in an irregular manner numerous oleo-resin vities. Stone cells were not found.

Such uniformity of structure is not unusual amongst Conifers according to De Bary "Comp. Anat. Phan. and Ferns" (*Juniperus communis*, p. 494), but E. S. Bastin and H. Trimble in their work on Coniferæ ("Amer. Journ. Pharm.," 1896-7) show hardly such regularity in the number of plates depicting bark structure of certain genera of this natural order, such as *Pinus, Picea, Abies, Tsuga*.

XIX. THE TANNING VALUE OF THE *CALLITRIS* BARKS.

This investigation of the barks was undertaken in the endeavour to arrive at the possible economic value in this direction of the several species of *Callitris* growing in Australia and Tasmania.

The barks of the following species have been investigated:—

C. calcarata,	from	five localities in New South Wales.
C. arenosa,	,,	Northern New South Wales.
C. glauca,	,,	three localities in New South Wales.
C. verrucosa,	,,	interior of New South Wales.
C. gracilis,	,,	Rylstone, New South Wales.
C. rhomboidea	,,	Sydney, New South Wales.
C. Muelleri,	,,	Sydney, New South Wales.
C. robusta,	,,	Western Australia.
C. intratropica	,,	Port Darwin, Northern Territory.
C. propinqua,	,,	South Australia.
C. Tasmanica	,,	Tasmania.

The above list includes most of the *Callitris;* the barks of the few remaining species were not available, but there is no reason to suppose that their tannins would differ materially from those which have been determined. The bark of *C. Macleayana* is composed almost entirely of a mass of fibre, and appeared to contain such a small amount of tannin, that it was not analysed.

In many parts of the world, barks obtained from the Coniferæ are extensively used in the leather industries. Particularly is this the case with the bark of the Hemlock (*Tsuga Canadensis*), a species which, both in America and in Canada, is still largely used for tanning purposes, as well as for supplying the raw material in the manufacture of its tanning extract. Not many years ago it formed the staple material for the purpose of the tanner in America, and according to Davis, (p. 118) the greater portion of the sole and heavy leathers was tanned with it.

Professor Trimble ("Journ. Soc. Chem. Industry," 1898, 558) publishes the results of an investigation which he had undertaken on the barks of several Indian trees belonging to the Coniferæ, one of which, *Pinus longifolia*, is used for tanning in that country, and which is stated to contain about 13 per cent. of tannin in the air-dried bark.

Professor Trimble summarises his results in the following statement:—

"These Conifer barks from India have been found to contain tannins identical with those found in the barks derived from the same natural order in America; therefore, so far as studied geographically, distribution has caused no variation in the tannins of the Conifers."

Now that most of the Conifer barks of Australia have been investigated this conclusion may be broadly supported, so far as the general results refer to the *Callitris* barks. Although there are differences shown by the tannins of the several species themselves, yet, broadly they all agree with the tannin of hemlock, as well as with that of other Coniferous trees of America and India, and may, therefore, be considered as somewhat closely related to oak-bark tannin.

The general results obtained from this investigation are most promising, and show that some of the *Callitris* barks, especially those of *C. arenosa* and *C. calcarata*, have a considerable value as tanning materials. Throughout Australia enormous quantities of *Callitris* barks are procurable, at present going to waste, which might with advantage be turned to profitable use in the leather industry.

Besides the local use for the barks themselves, the extensive and increasing demand for tanning extracts in Europe and America, makes the possibility of utilising these vast resources of *Callitris* barks of Australia, in this direction, almost beyond question, and it may be assumed, that eventually a considerable industry will be established in Australia, in the manufacture of tanning extracts from the *Callitris* barks. There seems no reason, why, from the barks of these trees, results even more satisfactory than those obtained with hemlock, should not be secured, particularly as some species are so rich in tannin.

In the "Leather Trades Review" (1899, 32, 542) it is stated, "That tanners allege that 1 lb. of 'hemlock extract' will go as far as 1½ lb. of oakwood or chestnut extract, that it will do more work, and will produce 1 to 2 lb. more leather per hide." The objectionable features ascribed to hemlock, such as those of colour, have been largely overcome in American practice, and little difficulty is now experienced in manufacturing a good leather from it.

From their chemical reactions it is seen that the tannins of the *Callitris* barks belong broadly to the catechol group. The reactions which they give with ferric-alum, ferric chloride, and with copper sulphate and ammonia in excess, are not similar with all the species, and these reactions separate somewhat sharply the tannins of two of the most important and, perhaps, abundant species, *C. calcarata* and *C. glauca*. The reactions given with the tannin of *C. glauca*, as well as with that of most of the other species of *Callitris*, agree fairly well with those given with the tannin of hemlock, but the tannin of *C. calcarata* differs from these

in some respects, while that of *C. arenosa* gives reactions somewhat intermediate between these two.

The tannin in the bark of *C. calcarata*, in some of its reactions, approaches somewhat closely that contained in wattle bark, (*Acacia spp.*) and in this respect differs from hemlock. With some of the general reactions, however, there is a similarity with all three, as they all belong to the same broad group. The aqueous extracts from the barks of *C. calcarata* and *C. arenosa* do not possess the deep red colour usually given by wattle bark containing a similar amount of tannin, and would apparently make a lighter coloured leather.

Those chemical reactions in which the tannin of *C. calcarata* resembles somewhat that of wattle bark are the following; (*Acacia pycnantha* bark was taken for comparison):—

(*a*) When a dilute solution of ferric-alum is added to a very dilute solution of the aqueous extract, in a test tube, and allowed to fall through the solution, a somewhat closely agreeing purplish-grey colour is obtained, and eventually a purplish precipitate forms. With both hemlock and *C. glauca* this reaction gives a greenish colouration, and greenish-black precipitates. With stronger solutions, *C. calcarata* gives a greenish-brown colour, and a dark purplish-grey precipitate. Ferric chloride gives a more marked green colouration with *Callitris* tannins than that obtained with ferric-alum.

(*b*) With sulphate of copper and ammonia in excess, both wattle-bark tannin and that of *C. calcarata* give dense precipitates, the filtrates from both being bright blue. The copper salt with hemlock tannin is soluble in an excess of ammonia, and that of *C. glauca* almost entirely so, the filtrate of the latter being of a purplish-brown colour if the copper salt is not in large excess. With *C. arenosa* the copper salt is only partly soluble, the filtrate being greenish.

(*c*) With a crystal of sodium sulphite on a white tile, the reaction with wattle-bark tannin and that of *C. calcarata* are similar; they both give reddish colours at once, in which one drop of dilute ammonia placed near the salt, produces at first a yellow colour, and after some time crimson bands are formed in places. With hemlock tannin, and with those of *C. glauca* and *C. arenosa*, the yellow colour is scarcely produced, nor are the crimson streaks obtained, the colour being more of an orange red.

With the other general reactions *Callitris* tannins agree with that of hemlock, and the coniferous barks generally. Nitrous acid does not give a colour reaction, but only a brown precipitate. The insolubility of the copper salt in excess of ammonia with *C. calcarata*, shows the tannin of this tree to differ in some respects from those of the pines generally, and it is the only species of *Callitris* showing this reaction so distinctly.

Commercial Value of Callitris Barks.

The commercial value of the *Callitris* barks may be suggested from the following:—The material available is very abundant; the tannin content is good, often very good, as in *C. arenosa* and *C. calcarata;* the colour of the aqueous solutions is not very dark; the action of the tannin on hide is rapid and complete; while the soluble non-tannins extracted by cold water are at a minimum. The amount of resin in the bark is but small, and sparsely distributed, and should hardly cause trouble.

With the bark of *C. calcarata* there seems to be a difference in the deposition of tannin under certain conditions, and the thickest bark investigated, collected at Woodstock, New South Wales, in May, 1907, gave 31·17 per cent. of tannin in the air-dried bark when finally extracted with hot water, and 27·8 per cent. when extracted entirely with cold water. A somewhat thick bark of this species, however, collected at Wellington, New South Wales, in September, 1903, nearly six years ago, gave only 14·1 per cent. of tannin, whilst a specimen from a medium-sized tree, collected at Grenfell, New South Wales, in March, 1909, gave 19 per cent. tannin; one from a small tree collected in June, 1909, at Warialda, New South Wales, gave 30·93 per cent. tannin; and one from a very young tree, collected at Wyalong, New South Wales, July, 1909, gave 25·19 per cent. of tannin.

By referring to the information given under the distribution of the several species, it will be seen how plentiful *C. calcarata* is, and as its natural habitat is on the hills, which are naturally not so valuable for agriculture as are the plains, it is at once apparent that with a little care and attention, practically a permanent national plantation of enormous dimensions, containing an excellent tan bark, is available at once for use, and one that with ordinary precautions can never be exhausted. The young material, too, can also be readily stripped, as the bark peels very easily, so that in the thinning process the material removed could be utilised with advantage. As the greatest amount of tannin occurs in the living portion of the bark, there seems little advantage in allowing it to grow to a large size, and trees 3 or 4 inches in diameter would give probably the best bark for tanning. As the tree grows older the outer cortex thickens, forming deep furrows, and the tannin is not then so good either in quality or in colour.

As only one sample of the bark of *C. arenosa* was procured, comparative results with this species were not obtained.

All the results were determined on the air-dried barks.

It is thus possible that the best results would be obtained if the barks were collected at that time of the year when the tannin content is at a maximum. It

may be assumed, too, that location and environment influence to some extent the formation of the tannin, as the moss-grown bark is less rich. To obtain the required data to decide these points, a considerable amount of work would be necessary, although these, and similar problems, would not be difficult to solve.

With *C. glauca* there does not appear to be the same variation in the amount of tannin deposited under varying conditions, as with *C. calcarata*, because a specimen from a medium-sized tree, collected at Narrandera, New South Wales, n March, 1909, gave 14·7 per cent. tannin; a very thick bark collected at the same place in April, 1907, gave 14·6 per cent. tannin; and a bark from a medium-sized tree, collected at Narrabri, New South Wales, in June, 1909, gave 10·5 per cent. tannin.

Phot. C. F. Laseron.

A "PINE RIDGE," SHOWING HOW *Callitris calcarata* GROWS ON HILLS, MICHELAGO, N.S.W.

The thick barks of *C. calcarata* and *C. arenosa* were readily powdered, although shortly fibrous, and the greater portion of the tannin was easily extracted from them with cold water. When the final extraction had been made with hot water, the amount of non-tannins increased somewhat, although it was still comparatively small, but the tannin had not increased in proportion. The liquor had darkened by the hot extraction, as a larger proportion of the red constituents of the bark had been dissolved. When cold water alone had been used, the colour was very satisfactory. By this method, too, only a very small amount of substances other than tannin was extracted from the powdered bark.

The phloroglucol reaction (with a pine shaving and hydrochloric acid), was obtained with the extract of all the *Callitris* barks, although with some of them it was but slight.

This reaction with *C. glauca* was less pronounced than with either *C. calcarata* or *C. arenosa*; and all the barks belonging to the group of which *C. glauca* is the type, did not give the reaction at all strongly. It was not given with the filtrates after treating with hide powder, except when these were considerably concentrated, so that the constituent to which this reaction is due was largely removed by that substance.

The colour reaction with stannous chloride and hydrochloric acid was marked with most samples of *C. calcarata,* although *C. arenosa* hardly showed any reddening. The remaining barks all gave a red colour more or less distinctly, but the test has little distinguishing value.

To arrive at the value or otherwise of the outer cortex of the barks of *C. calcarata* and *C. arenosa,* as well as that of the softer external portion of *C. glauca,* it was decided to submit the bark of the same tree, from these three species, to a double determination. In one case the whole bark was taken, and then a portion was "rossed," the outer layer being removed until a smooth surface was obtained. In this way the barks were reduced to about half their thickness. With *C. calcarata,* the bark, taken from a tree 3 to 4 inches in diameter, gave with the whole bark 30·93 per cent. of tannin, while the "rossed" bark gave 36·1 per cent., showing that a lesser amount of tannin was contained in the outer corky layer. There was not much difference, however, in the colour of the hide powder obtained from either extract.

With *C. arenosa* the thick whole bark gave 25·1 per cent. tannin, and the inner "rossed" bark 34.77 per cent. The same "rossed" bark extracted entirely by cold water, during eighteen hours, gave 28·5 per cent. of tannin. It is thus evident that the outer cortex contains considerably less tannin than the inner portion. In section, there was but little difference in the appearance of the inner and outer cortex of *C. calcarata* and *C. arenosa,* although the latter seems to be distinguished in the freshly stripped green bark, by a more marked crimson band next to the corky layer; this, however, becomes lost on drying, and it does not seem to have any darkening effect on the extract.

With *C. glauca* the whole bark gave 10·5 per cent tannin, and the inner "rossed" bark 12·8 per cent. so that it would be hardly worth the trouble to remove the outer bark of this species; besides there would be much loss in the process.

The modern chromed hide-powder method was that adopted in these analyses, the air-dried bark being somewhat finely ground.

The following summary of the tannin content in the bark of each species of *Callitris*, gives their comparative values for tannin purposes, and shows, at the same time, what a very valuable asset Australia has in some of these *Callitris* barks, and also indicates their usefulness towards furthering a very important industry. The extent of the distribution of the Northern New South Wales species, *C. arenosa*, is not at present known, but it is possible that extensive areas of it will be found to exist in Southern Queensland, as well as in Northern New South Wales.

The description of the several barks, together with the results of their analyses, will be found under their respective species in this work.

Table, giving percentages of tannin in the air-dried *Callitris* barks, and thus indicating their relative values for tanning purposes.

Name.	Locality and date of collection.	Percentage of tannin in the air-dried barks.
C. calcarata	Warialda, N.S.W., June, 1909	30·93 per cent.
	Do inner "rossed" bark	36·10 ,,
Do	Woodstock, N.S.W., May, 1907	31·17 ,,
	Do cold-water extraction	27·81 ,,
Do	Grenfell, N.S.W., March, 1909	18·98 ,,
Do	Wellington, N.S.W., September, 1903	14·11 ,,
Do	Wyalong, N.S.W., July, 1909	25·19 ,,
C. arenosa	Ballina, N.S.W., June, 1909	25·10 ,,
	Do inner "rossed" bark	34·77 ,,
	Do inner bark by cold-water extraction ...	28·50 ,,
C. glauca	Narrandera, N.S.W., March, 1909	14·68 ,,
Do	Narrandera, N.S.W., April, 1907	14·60 ,,
	Do by cold-water extraction	10·25 ,,
Do	Narrabri, N.S.W., June, 1909	10·52 ,,
	Do inner "rossed" bark	12·79 ,,
C. verrucosa	Shuttleton, N.S.W., 1903	8·40 ,,
C. gracilis	Rylstone, N.S.W., 1905	12·29 ,,
C. rhomboidea ...	Sydney, N.S.W., 1907	4·00 ,,
C. Muelleri	Sydney, N.S.W., 1907	11·90 ,,
C. robusta	West Australia, 1903	8·66 ,,
C. intratropica ...	Port Darwin, 1903	10·72 ,,
C. propinqua	South Australia, 1909...	12·63 ,,
C. Tasmanica	Tasmania, 1909	17·36 ,,

The following table gives the general reactions obtained with the aqueous extracts of the several species. The strength was that given by 25 grams air-dried bark per litre. The reactions with the iron salts were determined with avery much more diluted solution.

GENERAL REACTIONS WITH *CALLITRIS* BARKS.

Species.	Bromine water.	Copper sulphate and ammonia in excess.	Ferric-alum.	Stannous chloride and hydrochloric acid.	Pine-wood shaving and hydrochloric acid.	Lime water.	Sulphuric Acid.	Sodium sulphite.
Callitris calcarata	Precipitate	Very dense precipitate, filtrate bright blue.	Purplish-grey colour, and purplish precipitate.	Bright red colour and precipitate.	Violet colour well marked.	Purplish-brown precipitate.	Crimson, dilutes pinkish.	Reddens, NH_3 gives yellow, and crimson streaks eventually.
C. arenosa ...	do ...	Partly soluble, filtrate green.	Green to blackish-green, and grey-purplish precipitate.	Scarcely any colouration.	Violet colour well marked.	Light purplish-brown to grey precipitate.	do ...	Reddens.
C. glauca	do ...	Slight precipitate, filtrate purplish-brown.	Green colour, and greenish-black precipitate.	Pink colour ...	Violet colour ...	Brown precipitate.	do ...	do
C. verrucosa ...	do ...	Slight precipitate.	do ...	do ...	Slight reaction	Brown precipitate.	do ...	do
C. gracilis ...	do ...	do	do ...	do ...	do	Purplish-brown precipitate.	do ...	Darkens, and brown precipitate soon separates.
C. rhomboidea ...	do ...	do	do ...	do ...	Very slight reaction.	Brown precipitate.	do ...	Reddens.
C. Muelleri ...	do ...	Considerable precipitate.	do ...	do ...	Slight reaction	do ...	do ...	Reddens strongly.
C. robusta... ...	do ...	Slight precipitate.	do ...	Bright pink colour.	Violet colour ...	do ...	do ...	Reddens.
C. intratropica ...	do ...	do	do ...	Pink colour ...	Slight reaction	do ...	do ...	do ...
C. propinqua ...	do ...	Slight precipitate, filtrate purplish-brown.	do ...	do ...	Violet colour well marked.	do ...	do ...	do ...
C. Tasmanica ...	do ...	Slight precipitate.	do ...	Dark pink colour.	Violet colour	do ...	do ...	do

XX. THE SANDARAC RESINS OF THE *CALLITRIS*.

The oleo-resin of the *Callitris* is contained in the cells of the inner bark, and when this becomes injured in any way, the oleo-resin slowly exudes, and forms " tears " on the exterior of the trees. This resin is known vernacularly as " Pine resin " or " Cypress Pine resin," and in composition and appearance closely resembles the original sandarac of commerce. With some species of *Callitris*, however, the resin is in larger masses or tears than is common with the African sandarac, and this peculiarity is particularly noticeable with the exudation of *C. calcarata* (Black Pine) and in a lesser degree with that of *C. glauca* (White Pine). The resin from *C. arenosa* is in smaller tears, and very closely approaches the North African sandarac (*Tetraclinis*) in every respect.

So far as we are aware, there has not been devised a method for successfully injuring *Callitris* trees, so that the resin might collect in masses, and thus be easily obtained in quantity. This is probably due to the method of cutting the bark, which, in the past, has been done horizontally, and so only a small number of cavities have been opened at one time. In view of our contention that these trees do not contain resin canals in the bark, but rather cavities or cells, better success might perhaps be obtained by making a long vertical " blaze " through the inner cortex, and so tap at one time a larger number of these cavities, from which a larger flow of resin should be obtained.

The two most widely distributed species of *Callitris* occurring in New South Wales are *C. glauca* and *C. calcarata*, (see map) and it is probably from these species that the greater portion of the sandarac sent from Australia has been obtained. A considerable amount of this resin has been collected at various times, and shipped to Europe; but the collecting has always been spasmodic, and but little systematic effort has, so far, been made to gather it in large quantities, and continuously. From what little has been accomplished, however, in this direction, it seems fair to assume that a considerable quantity of sandarac could be obtained from the Australian *Callitris*, if the collectors were dealt with more fairly as regards price. If some arrangement could be made whereby a fair market value could be assured, then sandarac could be collected in Australia in any desired quantity.

A Sydney collector who undertook to supply two tons of sandarac from the Australian *Callitris*, has given us the results of his experience in this undertaking. His greatest difficulty in collecting this amount of resin was that it could not be made to flow at all quickly by artificial means, so that it was necessary to gather the naturally exuded resin. He found that the young trees as a rule gave the most resin, and that the greatest quantity was obtained from trees which had been ringbarked for one or two years. The resin was obtained principally from the " Black Pine " (*C. calcarata*), as but little had exuded from the " White Pine "

(*C. glauca*). The result was hardly a success, financially, as the price was too low, and 26s. per cwt. does seem an unreasonable price for such material. It may be, too, that the right time of the year for the collecting was not chosen. But, perhaps, the two factors which more than any other go towards making the collecting of this resin a success, are, (1) to discover the best method of causing the resin to exude in quantity, and (2) to find a paying market for the resin when collected, as it is evident that any reasonable demand could be met if the price was remunerative. The resin might, perhaps, also be graded with advantage before being sent away from Australia.

Investigations into the composition of sandarac have been carried out from time to time by numerous chemists, and the results are recorded in the various scientific journals.

One of the earliest chemical researches on the composition of sandarac is that of Johnston (" Phil., Trans.," 1839, 293), who, from his results, considered that it consisted of three resin acids. More recent investigations are those of Tschirch and Balzer (" Archiv. der Pharm.," 1896, 289), who considered that sandarac consists of two acid resins, which they named sandaracolic acid and callitrolic acid. Dr. T. A. Henry, in an extensive research (" Jour. Chem. Soc.," 1901, p. 1144), also showed that sandarac was composed of two acid resins, viz., pimaric acid, $C_{20}H_{30}O_2$, and callitrolic acid, $C_{30}H_{48}O_5$, together with a small amount of an essential oil.

Tschirch and Wolff (" Arch. Pharm.," 1906, 684–712; see also, abst. " Chem. Soc.", 1907, 1, p. 145) publish a later research in which they maintain that sandarac is composed of three acid resins, viz., sandaracic acid, $C_{22}H_{34}O_3$; sandaracinolic acid $C_{24}H_{36}O_3$; and sandaracopimaric acid $C_{20}H_{30}O_2$; besides other allied substances, and a small amount of an essential oil.

From the above it would seem that there is yet some uncertainty as to the real composition of sandarac resin. This may be attributed perhaps to the difficulty of separating the acids of sandarac from each other in an absolutely pure condition, and to the different methods of research employed. Perhaps, too, there may be a want of constancy in the constituents of the sandarac itself, due to the varying length of time between the exudation of the resin and its chemical investigation. The changes from the semi-liquid into the solid constituents must be somewhat rapid at first, and it is a question when absolute finality in this respect is reached under ordinary conditions. This supposition is suggested from the results of our investigation of the resin and oil in the latex of *Araucaria Cunninghamii*, and also of the similar substances in the oleo-resin of *Agathis robusta* (this work).

It is, however, certain that sandarac does contain a small quantity of an essential oil, perhaps the residue of the unaltered terpenes, &c., and at least two

acid resins, the potassium salt of one being mostly insoluble in an excess of alcoholic potash, while the other is soluble.

Dr. Henry's paper (loc. cit. p. 1145), contains the following statement:—"There also appears on the market from time to time a similar resin, which, since it is exported from Australia, is commonly known as 'White Pine resin,' or 'Australian sandarac.' This substance is the natural exudation product of *Callitris verrucosa*, and differs from the common sandarac chiefly in the larger size of the tears and its smaller solubility in alcohol."

This statement may be taken as representing the generally accepted idea in Europe regarding Australian sandarac, and Tschirch ("Die Harze und die Harzbehälter," p. 535), also gives similar information. These authors are, however, in error as regards the origin of the resin, because Australian sandarac is not collected from *C. verrucosa* to any great extent, if at all, for occurring as it does in the far interior of the States, the difficulty of getting the product to market naturally acts adversely to the collection of its resin.

The sandarac so far exported from Australia has been collected from various species, and this is also indicated by the "larger size of the tears, and its less solubility in alcohol" than ordinary sandarac, as mentioned in the above statement. The resin of *C. calcarata* is, perhaps, the least soluble in alcohol, of all the *Callitris* resins, but the exudation of some species is far more soluble in alcohol than is ordinary sandarac, and, as will be seen from the table below, *C. verrucosa* is one of the more soluble of these resins.

While Australian sandarac continues to be collected from various species of *Callitris*, the commercial product will be found to be somewhat variable, particularly as regards solubility. Three samples of resin of *C. arenosa* in our possession have a striking resemblance to African sandarac, and are even more soluble in alcohol than the Museum samples of African sandarac tested at the same time for comparison. These samples were originally received at the Museum as "sandarac, 1st quality," "sandarac, 2nd quality," and "picked Mogadore sandarac." This last specimen is a portion of a "lot" which was sold in London in October, 1894, at 70s. per cwt. It was indeed difficult to detect any difference between this last sample and that of *C. arenosa* collected at Ballina, Northern New South Wales, either in hardness, density, colour, transparency, reactions with alcoholic potash, or in general appearance; only that the solubility in alcohol is in favour of the resin from *C. arenosa*. Supporting the results of solubility in alcohol as shown by the appended table, 1 gram each of the resin of *C. arenosa* and Mogadore sandarac in tears, nearly the same size as possible, was added to 20 c.c. 90 per cent. alcohol, the whole of the tears of *C. arenosa* were dissolved before those of the sandarac. The acid numbers, too, of the resins closely agreed, that of the Mogadore sandarac being 151, and that of the sandarac

of *C. arenosa* 154. We have not been able to obtain the resin of *C. intratropica*, but judging from analogy it may be assumed that this will be found to differ but slightly from the resin of *C. arenosa*, because the terpene in the leaf oil of both species is mostly limonene, although the optical rotations are in opposite directions. If this surmise is correct, then Australian sandarac may be supplied of quite equal value with similar material from North Africa. It is probable, too, that *C. arenosa* has a somewhat extensive range, occurring in many parts of New South Wales and Queensland, as well as on Fraser Island.

The density of the ordinary samples of *Callitris* resins which have been determined, ranged from 1·079 to 1·069 at 16° C. The resin of *C. Tasmanica* from Rylstone was, however, a freshly exuded specimen, and this had a specific gravity as low at 1·058. The density of sandarac thus varies somewhat according to the age of the resin when collected.

It was thought that perhaps some differences could be detected between the *Callitris* resins if their optical rotations were taken, as they were all optically active. Solutions were made with the various resins of the strength of 1 gram picked resin in 5 c.c. acetone, as that substance appeared to be the best solvent for the purpose. Sandarac is easily and entirely dissolved in acetone, and in most instances the reading in a 100-mm. tube with this solution could be taken directly, but where this was not sufficiently distinct, then by adding an equal volume of 90 per cent. alcohol, the reading was rendered quite sharp.

It will be observed that all the samples tested, including those of ordinary sandarac, were dextro-rotatory, and that the specimens from *C. glauca* had generally a higher dextro-rotation than had those from *C. calcarata*. There is but little difference in the rotations of the resins of *C. calcarata* and ordinary sandarac, but there appears to be little agreement between the activity of the resins and their solubility in alcohol. It may, therefore, be assumed that the differences in the amount of the various acid resins and neutral bodies in the exudations of the various species, govern, to a great extent, their relative solubility in alcohol. The acid resin, whose potassium salt is insoluble in an excess of alcoholic potash, varies somewhat in amount with the resins of the various species.

The method adopted in the endeavour to arrive at some conclusion as to the relative solubilities in alcohol of these sandarac resins, was to dissolve 2 grams of the picked resin in 10 c.c. of 90 per cent. alcohol, and then to titrate 5 c.c. of this solution with 75 per cent. alcohol (by weight) with repeated agitation, until a permanent and well defined turbidity was reached. All the determinations were made under identical conditions. This strength of alcohol was found to be more satisfactory for the purpose, than either 70 or 80 per cent. alcohol. It will be noticed that the mean solubility of the three samples of ordinary sandarac, shows that 4·6 c.c. of 75 per cent. alcohol was required to render 5 c.c. of the

90 per cent. alcoholic resin solution permanently turbid; the mean for the six samples of *C. glauca* was 3·6 c.c.; that of the six samples of *C. calcarata* was 3·4 c.c., and that of the three samples of *C. arenosa* was 6·1 c.c. The resins of the other species tested were all more soluble in alcohol than the above. The following table gives the rotation and relative solubility results which were obtained with these resins:—

COMPARATIVE Rotation and Solubility Results with the various *Callitris* Sandarac Resins.

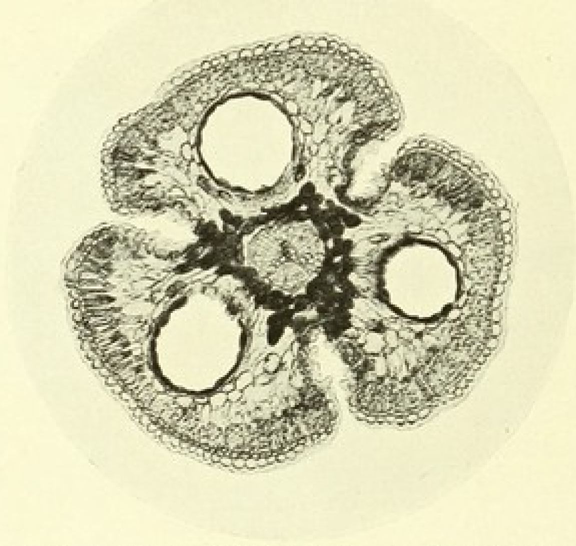
Name.	Locality.	Rotation in 100 mm. tube, 3 grams picked resin in 15 c.c. acetone. — Specific rotations vary between $[\alpha]_D + 25·5°$ and + 47°.		Relative solubility in alcohol. 2 grams picked resin dissolved in 10 c.c. 90% alcohol. 5 c.c. titrated with 75% alcohol till turbid.	
				Required.	
Callitris calcarata ...	Cassilis, N.S.W....	+ 6·0°	Mean specific rotations $[\alpha]_D + 30·08°$	5·0 c.c.	Mean 3·4 c.c.
" " ...	Cooma, "	+ 6·0°		2·4 c.c.	
" " ...	Yarralumla "	+ 6·1°		3·5 c.c.	
" " ...	Dripstone, "	+ 5·9°		3·2 c.c.	
" " ...	Cootamundra, "	+ 6·1°		4·3 c.c.	
" " ...	Canowindra, "	+ 6·0°		2·0 c.c.	
" *glauca* ...	Narrabri, "	+ 8·7°	Mean specific rotations $[\alpha]_D + 36·5°$	4·3 c.c.	Mean 3·6 c.c.
" " ...	Scone, "	+ 6·4°		4·0 c.c.	
" " ...	Eugowra, "	+ 7·2°		3·9 c.c.	
" " ...	Lake Cudgellico, "	+ 7·4°		3·0 c.c.	
" " ...	Pleasant Hills, "	+ 7·2°		2·6 c.c.	
" " ...	Parkes, "	+ 6·9°		3·8 c.c.	
" *rhomboidea* ...	Sydney, "	+ 7·6°		10·2 c.c.	
" *Tasmanica* ...	Rylstone, "	+ 6·1°		12·6 c.c.	
" *arenosa* ...	Ballina, "	+ 6·8°	Mean specific rotations $[\alpha]_D + 38·8°$	5·5 c.c.	Mean 6·1 c.c.
" " ...	Ballina, "	+ 6·8°		5·8 c.c.	
" " ...	Wardell, "	+ 6·7°		7·0 c.c.	
" *verrucosa* ...	Great Victorian Desert, Elder Exploring Expedition.	+ 9·4°		13·0 c.c.	
" " ...	Shuttleton, N.S.W.	+ 6·4°		8·8 c.c.	
" *Macleayana*	Coolongolook, ...	+ 8·1°		14·0 c.c.	
" *oblonga* ...	Tasmania	+ 7·6°		15·2 c.c.	
Sandarac, 1st quality (*Tetraclinis*)	North Africa	+ 5·8°	Mean specific rotations $[\alpha]_D + 27·06°$	3·5 c.c.	Mean 4·6 c.c.
" 2nd " ...	"	+ 5·1°		6·5 c.c.	
" 70s. cwt. ...	"	+ 5·7°		3·8 c.c.	

XXI. OCCURRENCE OF A MANGANESE COMPOUND IN THE AUSTRALIAN CONIFERÆ.

In the anatomical investigations of the timber, bark, and leaves of the various species, there was found to be present, in a more or less degree, a naturally brownish-bronze coloured substance, which invariably stained dark brown or almost black with hæmatoxylin.

It is found to occur in the wood, bark, and leaves of *Callitris* and *Actinostrobus*.

It is not by any means equally distributed in the wood tissues of the various species, being most plentiful in *C. intratropica*, and least abundant in *C. Muelleri;* its presence appears to give the relatively dark and light colour of the timber of the respective species, this being the only method of detecting its presence macroscopically.



Section through a branchlet and decurrent leaves, showing the dark brown substance or manganese compound in the cells surrounding the median axis. *C. robusta*, × 80. (See also coloured plate, Figure 44.)

Microscopically it forms a conspicuous feature in all the timber sections, for it occurs in the lumina of the tracheids, the lamella and septa formed at the junction of the tracheidal walls and the parenchymatous cells of the rays, both inner and outer cells, and sometimes the pith cells.

The darker colour of the wood is, therefore, largely due to the presence of this substance in all these parts in a more or less degree.

Amongst bark cells it is confined mostly to the outer cortex, and is strongly marked in almost all the sections given, and often in the secretory cells of the oleo-resin cavities, and is thus a conspicuous object in bark sections.

In the leaves it occurs in the cells of the parenchymatous vessels clustered below the decurrent channel, often in those enclosing the phloem of the branchlet, and in some of the cross sections of the branchlet and decurrent leaves it is seen to fill the pith cells, the radial cells from these, and also those connecting with them.

In *Athrotaxis*, *Araucaria*, *Agathis*, *Phyllocladus*, and *Podocarpus* it occurs in the timber, and in the last in the least amount.

Jeffrey, in his "Comparative Anatomy and Phylogeny of the Coniferales, Part 1, the Genus *Sequoia*" ("Mem. Boston Soc. Nat. Hist.," Vol. 5, No. 10, 1903), illustrates some transverse sections of timber of this genus, where is shown a substance which we think is similar to that occurring in the Australian Coniferæ; its presence being plainly marked by the black spots occurring amongst the tracheids, so that it at least is indicated in the wood of this genus. It is referred to in the letterpress as a resin cell in contradistinction to other bodies or organs, the resin ducts.*

Jeffrey and Chrysler in a paper on Cretaceous *Pityoxyla* ("Bot. Gaz.," 42, 1–15, July, 1906), refer, under the name of "resin," to what is apparently the same substance occurring in the rays of *Pityoxylon Statenense*, thus indicating that it formed part of the wood substance of these trees of that geological period.

Its presence is also well marked in Figures 40, 41, and 42 (in medullary rays) of *Dadoxylon australe* of the "Glossopteris Flora," by E. A. Newell Arber, British Museum, and which show, in illustration, a marked resemblance to *Callitris* timber.

As no resin or resin cells whatever could be found in the timber of *Callitris*, by blazing or causing injury to the tree, or by chemical or any other tests, an exhaustive investigation into the composition of this supposed resinous substance was undertaken.

That it was not resin was easily placed beyond doubt, for the alcohol used in mounting and preparing the sections failed to dissolve it.

That the dark portions filling these cells in all species of *Callitris*, and similarly also those of *Actinostrobus*, *Araucaria*, *Agathis*, &c., is due to the presence of a manganese compound, would, from the following results, appear to be reasonably proved.

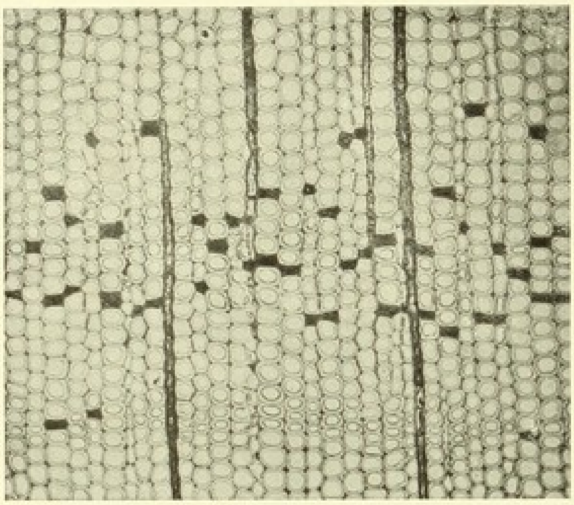
The chemical substances occurring in *Callitris* timber consist principally of the sesquiterpene alcohol, Guaiol, which often crystallises out upon the surface of the freshly cut timber; the phenol, Callitrol (see articles on these substances in this work), a sesquiterpene, and associated products; but resins, as the term is usually understood, appear to be quite absent, and the substance to which this article refers was quite insoluble in all ordinary solvents for resins.

The timber of *Callitris* species is often somewhat dark-coloured in the centre portions of the log, although this darkening does not appear to be characteristic of any particular species, and some specimens of the timber of identical species are often less dark-coloured than are others.

The ash of these darker portions always gave the most marked reactions for manganese, both when fused with sodium carbonate and potassium nitrate, and with Crum's method.

* Solereder ("Systematic Anat. of Dicotyledons") often mentions this brown substance when referring to the researches of the various authors quoted by him.

We have shown in the articles dealing with the freshly exuded oleo-resins of both *Araucaria Cunninghamii*, and *Agathis robusta*, that a manganese compound was associated with these exudations, that it was precipitated by alcohol, together with the gum, and that when thus separated from the other constituents of the exudations, it became dark coloured on drying; with *Agathis* it was quite black; also that this blackening appears to be due to the alteration of the manganese under the influence of the oxygen in the air. The appearance of this dark-coloured gum under the microscope strongly resembled the dark material in the cells of the timber, especially in their lighter portions. The manganese reactions were obtained with the ash of all the species of *Callitris* timber tested, although in some instances the green colour with the alkali test was very faint, and this was always the case with the ash of the lighter-coloured timbers. Those specimens of *C. calcarata* which were tested, usually gave a faint reaction, and the timber was mostly light coloured, although a recent specimen from Wellington, New South Wales, which in the centre of the tree was a little darker in colour, gave a more definite manganese reaction. The timber of *C. glauca* is usually of a darker colour than is that of *C. calcarata*, and consequently it gave the reactions for manganese far more strongly. The ash of the bark of *C. glauca*, too, also gave a marked reaction for manganese, while that of the bark of *C. calcarata* was less marked.



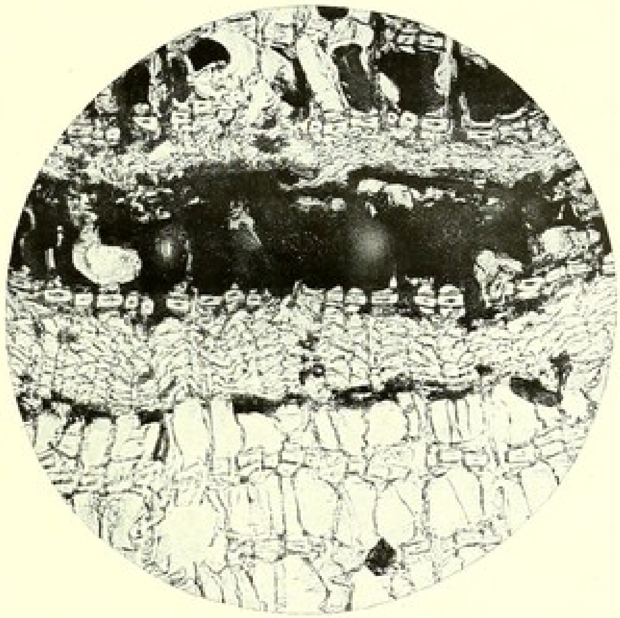
Transverse section of timber. The dark lines are the medullary rays with their manganese compound contents and the rectangular dark markings a similar substance in the tracheids. *C glauca*, × 80.

Callitris calcarata is a species which usually grows on the hilly portion of the country, while *C. glauca* is mostly found growing on the flats and level country.

The timber of *C. intratropica* was quite dark coloured, and consequently the reaction for manganese in the ash was most distinct, the percentage being somewhat high. The timber of *C. verrucosa* was light coloured, and the green colour reaction for manganese difficult to obtain, it being necessary to increase the amount of ash used to twice the ordinary amount. The timber of *Actinostrobus*, although small, was comparatively dark coloured in places, and this portion

under the microscope showed an abundance of cells filled with this dark-coloured substance; a strong reaction for manganese was obtained with the ash of the timber of this tree, and it was even more pronounced than that given with *C. glauca*.

Although the fusion test was sufficient in most cases to determine the presence of manganese, yet, it was hardly distinctive enough with the lighter woods, so that the far more delicate test of boiling the ash with nitric acid and peroxide of lead was adopted; this method was also made of quantitative value. The process was carried out as follows:—0·03 gram of the freshly ignited ash was boiled in a test tube with 2 c.c. nitric acid, 0·5 gram lead peroxide, and 6 c.c. water, until the volume had been reduced about one fourth; it was then stood on one side for some time. The colour of the clear solution in the test tube was then matched by diluting a solution of potassium permanganate, 1 gram per litre, until the required tint was obtained; the two solutions were compared in test tubes of equal diameter.



Transverse section at junction of inner and outer cortex, showing the dark brown substance or manganese compound in the parenchymatous cells. *C. arenosa*, x 100. (See also coloured plate, Figure 105.)

With 0·03 gram of the ash of *C. intratropica* it was only necessary to dilute 1 c.c. of the potassium permanganate solution ten times to obtain the corresponding tint, the wood of this tree, as before mentioned, being quite dark coloured. With the ash of *C. verrucosa* (a very light wood) it was necessary to dilute 1 c.c. seventy times before the tints agreed in depth of colour. The timber of *C. glauca* gave an ash which, when tested as above, required the standard permanganate solution to be diluted twenty times, while the same amount of the ash of *C. calcarata* required it to be diluted seventy times; and so on throughout the whole range of timbers of this group, the darker woods showing the presence of more manganese than the lighter woods.

To test the quantitative value of this method the amount of ash taken was often doubled for the duplicate test, and the results thus obtained were

always fairly satisfactory, and agreed very well with the colour given with known weights of manganese salts. The following is the percentage amount of manganese (Mn) contained in the ash of the timber of the several species of *Callitris* determined as above. The shavings were taken from over the whole surface of the piece of timber, and in no instance was a solid portion of the wood ignited.

Callitris gracilis	=0·230	per cent. Mn.
,, *intratropica*	=0·116	,,
,, *Macleayana*	=0·073	,,
,, *Tasmanica*	=0·064	,,
,, *rhomboidea*	=0·058	,,
,, *glauca*	=0·058	,,
,, *arenosa*	=0·019	,,
,, *verrucosa*	=0·016	,,
,, *calcarata*	=0·016	,,
,, *Muelleri*	=0·015	,,
,, *robusta*	=0·010	,,

To arrive at some conclusion as to the darkening power of a small quantity of oxidised manganese in organic material of this class, the amount of manganese in the precipitated dark gum from *Araucaria Cunninghamii* was determined, and also that in the still darker precipitated gum from *Agathis robusta;* 0·3 gram of the air-dried black gum from *Agathis robusta* was ignited and the ash boiled with the same amount of nitric acid and lead peroxide as in the previous determinations; 1 c.c. of the standard potassium permanganate then required to be diluted to 25 c.c. to match the colour given by the ash of the gum; the amount of manganese in the air-dried black gum of *Agathis robusta* was, therefore, 0·0046 per cent.

With the dark gum of *Araucaria Cunninghamii* the same process was followed, 0·3 gram of the air-dried gum being taken. The standard permanganate then required to be diluted thirty times to obtain the correct tint, so that this black gum contained 0·0038 per cent. of manganese. It is thus seen how small an amount of manganese is required to render the gum precipitate almost black and opaque.

The amount of manganese in the ash of the timber of *Agathis robusta* was 0·145 per cent., and in only one instance was this amount exceeded with the *Callitris*. The ash of the timber of *Araucaria Cunninghamii* contained 0·054 per cent. manganese, while that of the timber of *Araucaria Bidwilli* contained 0·077 per cent. manganese.

With trees belonging to other genera, the ash of the timber of *Actinostrobus pyramidalis* contained 0·077 per cent. manganese, and that of *Podocarpus elata* 0·0024 per cent. With regard to the latter tree it is interesting to notice that the cells containing the dark material, as shown under the microscope, were considerably less in quantity in this timber than in that of any of the species previously mentioned; so that this tree evidently uses manganese in smaller amount than that generally required by its congeners.

The ash of the timber of "Huon Pine," *Dacrydium Franklini*, contained 0·129 per cent. manganese, while that of "Celery Top Pine," *Phyllocladus rhomboidalis* contained 0·145 per cent. The timber of "King William Pine," *Athrotaxis selaginoides*, has a strong resemblance to the "Red-wood" of America, *Sequoia sempervirens*, and when ignited gave but a small amount of ash, this ash contained 0·019 per cent. manganese.

For comparison the ash of a sample of the "Red-wood," *Sequoia sempervirens*, sent to the Museum from America, was found to contain manganese to the extent of 0·012 per cent., while a commercial sample of "American Redwood" obtained from a timber merchant in Sydney, contained 0·077 per cent.

The following is a tabulated list giving the percentage of manganese in the Australian Coniferæ other than *Callitris*:—

Ash of timber of	*Agathis robusta*	=0·145	per cent. Mn.
,, ,,	*Araucaria Cunninghamii*	=0·054	,,
,, ,,	*Araucaria Bidwilli*	=0·077	,,
,, ,,	*Actinostrobus pyramidalis*	=0·077	,,
,, ,,	*Podocarpus elata*	=0·002	,,
,, ,,	*Dacrydium Franklini*	=0·129	,,
,, ,,	*Athrotaxis selaginoides*	=0·019	,,
,, ,,	*Phyllocladus rhomboidalis*	=0·145	,,
Air-dried black gum of	*Agathis robusta*	=0·0046	,,
,, ,,	*Araucaria Cunninghamii*	=0·0038	,,

In the barks of both *Callitris glauca* and *C. calcarata* the amount of manganese was determined; in that of the former the ash contained 0·02 per cent. Mn. and of the latter species 0·013 per cent. In the ash of the bark of *Actinostrobus* there was 0·06 per cent. manganese. The leaves of the *Callitris* also contain manganese in small amount, and the ash of the leaves of *C. glauca* contained 0·029 per cent. Mn, while the ash of the leaves of *C. robusta* gave results which showed that only 0·0012 per cent. Mn. was present. The seeds of *C. glauca* contained 0·023 per cent. Mn in the ash, while the ash of the seeds of *C. calcarata* contained 0·029 per cent. Mn. The amount of ash in the seeds of the latter species was 4·14 per cent., so that the Mn in the air-dried seeds was 0·0012 per cent. The ash of the capsules (without seeds) of *C. glauca* contained 0·011 per cent. manganese. It is thus apparent that manganese occurs more or less throughout the whole plant substance of *Callitris* trees, although variable in amount.

It may be assumed, therefore, that from the consistent occurrence of manganese in all parts of *Callitris* species, and in fact in all the Coniferæ of Australia so far tested, that this element is a necessary constituent towards the production of the most complete growth of these trees. It is also evident that *Callitris* trees will find manganese if it is possible to do so. Even those *Callitris* species growing upon such unfavourable soils for manganese as are the Hawkesbury sandstones

about Sydney, contained that element, and this was the case with both *C. rhomboidea* and *C. Muelleri* collected from this locality. The wood of cultivated trees of *Araucaria Bidwilli*, also growing upon the sandstone formation around Sydney, contained manganese in fair amount, and it was also present in their gummy exudations. Although the manganese may not be considered abundant in comparison with the other elements present, yet it evidently plays some important part in the constructive processes of these plants—a result, the procedure of which is at present little understood.

Pfeffer, when dealing with the food of plants (" Physiology of Plants," 2nd edition, p. 434, Ewart's Trans.), in speaking of the accumulation in plants of non-essential ash constituents, says:—" Such accumulation is an example of selective absorption, and is due to the fact that the substance absorbed is converted into an insoluble form or into a non-diosmosing compound . . . Similarly a plant may accumulate large quantities of poisonous bodies if they are presented in such dilute forms that an injurious concentration is never reached during the eudosmosis through the plasma. The poisonous metallic salts are retained by humus with considerable tenacity and presented to the plant in very dilute form. . . . . Nevertheless non-essential elements frequently become involved in metabolism, and are utilised to a certain extent as is shown by their partial substitution for essential elements and by other facts. Thus the non-essential elements, such as manganese, cobalt, or zinc may in certain cases favour growth . . . . just as calcium is necessary to most plants, but not to all, so also may silicon or similar elements be essential to a few plants only. In a condition of nature, where the competition with other organisms is severe, the trifling assistance afforded by a non-essential substance may be of decisive importance."

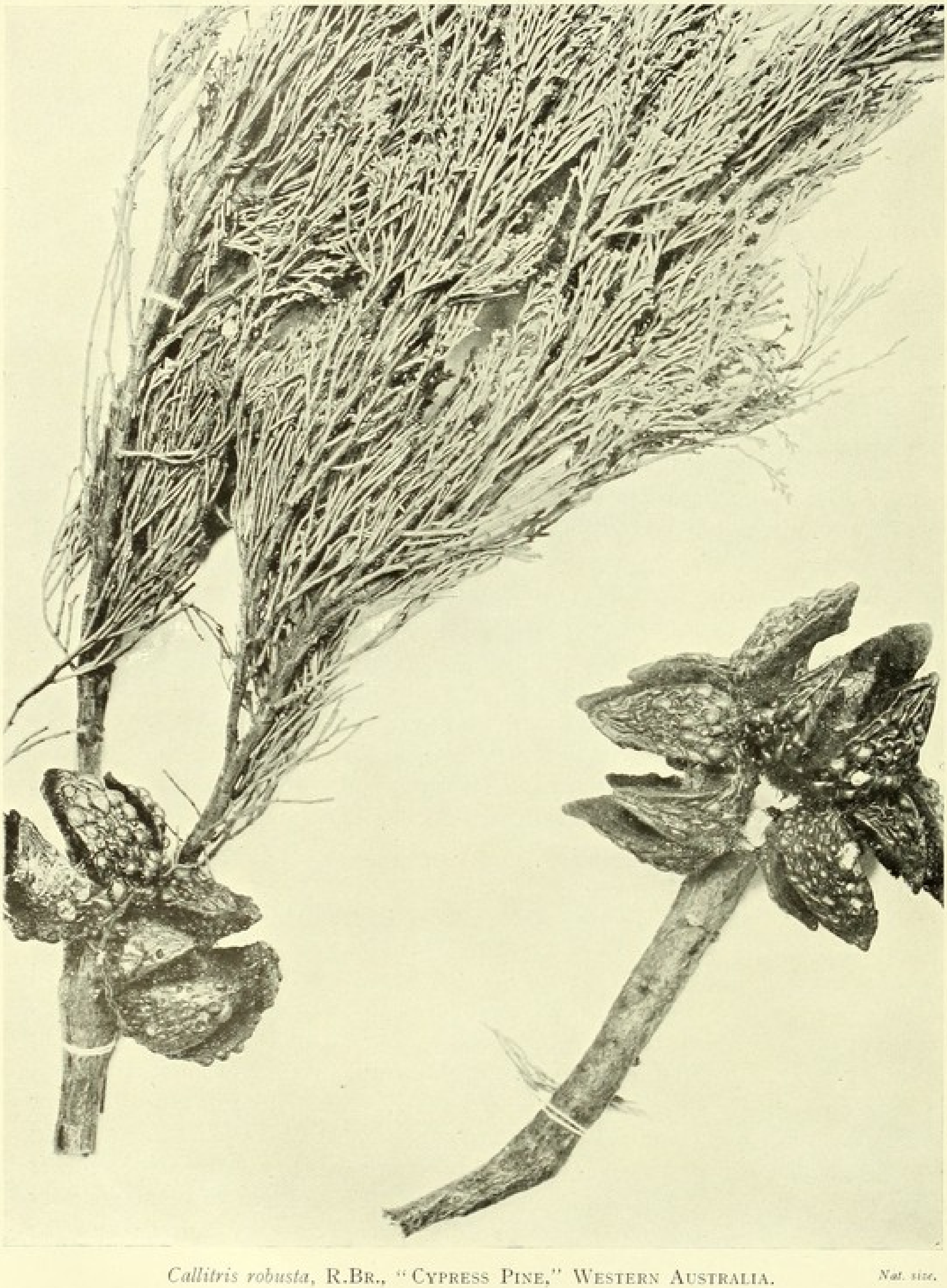
It is already becoming to be recognised from recent experiments that minute traces of manganese do have a marked stimulating effect upon the growth of certain plants. This has been shown by Uchiyama (" Bull. Cent. Exper. Stat.," Japan, 1907); Grégoire, Hendrick, and Carpiaux (" Bull. Inst. Chim. Bact.," Gembloux, 1908); Sutherst ("Transvaal Agric. Journ.," 1908) and others. It would now be interesting to determine the real value of manganese in governing the rate of growth of plants belonging to the Australian Coniferæ, and the results thus obtained would probably help considerably towards arriving at some conclusion as to the real function of small quantities of those metallic salts, which in larger quantities seem to be detrimental to growth; knowledge in this respect is at present very elementary, although a considerable amount of work has recently been undertaken in this and corresponding directions. Bertrand (" J. d'Agric. Pratique," 1906) applied manganese sulphate at the rate of 50 kilos per hectare to land on which wheat was sown, and obtained an increase in the total crop of 22.5 per cent. Dr. Lankester (" Lectures on Food," London, 1861, p. 57) says that manganese

is taken up by the oat plant in Scotland. Katayama, in Japan, recently showed that manganese has a stimulating effect on oats, barley, rice, &c., and still more markedly on the leguminous plants. Using manganese sulphate to the soil in the proportion of 0·015 per cent., the increase was 50 per cent. in the yield of straw, and 25 per cent. in that of the seeds. Quantities of manganese much exceeding the above tended to decrease the yield. Salomone ("Chem. Centr.," 1906), also proved the beneficial influence of a small quantity of manganese on plants, and the toxic action of large amounts.

Kayser and Marchand ("Compt. rend.," 1907) have found that small additions of manganese salts resulted in higher proportions of alcohol, glycerol, and organic acids being obtained from a given weight of sugar. Yeasts that have been habituated to comparatively strong solutions of manganese salts by growing in solutions of gradually increasing strength, become exceedingly active, and will induce a more rapid fermentation, and also push it further, especially if a small quantity of a manganese salt is present in the fermenting liquid.

Several other instances might be mentioned where corresponding results have been obtained, but the above are sufficient to show that small quantities of manganese are undoubtedly beneficial with some plants, and perhaps necessary to obtain the best results with vegetation of various kinds. Whether it is due to an excess or otherwise of manganese in the soil that helps to govern the location of certain species of *Callitris*, and the Australian Coniferæ in general, is a matter for further study and investigation, but that subtle influences are actively at work, governing the growth and distribution of the several species of these genera, can hardly be doubted, and the results so far obtained suggest the idea that the food material of these plants is largely responsible for their distribution. Under natural conditions the selective capabilities of the individual plants appear to be limited, are exceedingly sensitive, and easily upset. It may be, too, that some species are more susceptible to the toxic influences of small quantities of manganese and similar elements than are others. That manganese in small quantity is a common constituent in many plants has been shown, especially by Pichard ("Compt. rend.," 1898, 1882–1885), and perhaps it has *not* yet been proved that these supposed elements of somewhat rare occurrence are non-essential under certain conditions. The common occurrence of an abundance of alumina in *Orites excelsa* (Smith, "Journ. Roy. Soc.," New South Wales, July, 1903) indicates that in this tree, at all events, the element aluminium is an essential constituent, because wherever the tree is grown under natural conditions, alumina is always found in quantity in the ash. Manganese may, therefore, be just as essential to the growth of *Callitris* species and the other Coniferæ of Australia, and its assistance to plant life may be considered to date back to past geological time, as indicated by plates illustrating fossil woods.

See also article on the oleo-resin of *Agathis robusta* in this work.



Callitris robusta, R.Br., "Cypress Pine," Western Australia. *Nat. size.*

XXII. INDIVIDUAL SPECIES OF *CALLITRIS*

1. Callitris robusta.

R.Br., Herb., Mirb., in Mem. Mus., Par. xiii, 74.

(Syn.:—*C. Preissii*, Miq. in Pl. Preiss., i, 643; *C. Suissii*, Preiss's herbarium; *Frenela robusta*, A. Cunn.)

HABITAT.

Western Australia; Rottnest Island (A. Cunningham), Bald Island (Oldfield), and the mainland.

I. HISTORICAL.

The original specimens of Allan Cunningham in the British Museum were collected at Rottnest Island, Western Australia. It also occurs in the mainland, for the specimens sent to us by Dr. Morrison are identical with those of Cunningham. It very probably does not extend to the Eastern half of the continent, as the species in South Australia usually referred to *C. robusta*, R.Br., is distinct from it.

Bentham, in the "Flora Australiensis," Vol. VI, p. 237, gives no less than eleven synonyms in connection with *F. robusta*, but after an examination of the original specimens in the principal herbaria of Europe and Australia, and in the light of the evidence—(1) our own field knowledge of these Pines, and (2) of their morphological, histological, and chemical characters—there remained no alternative but to restore at least four of these to specific rank.

Robert Brown, in addition to having Allan Cunningham's specimens and MS. notes upon which to work when describing his species, was most probably acquainted with the trees in nature, and when we were investigating the genus it appeared to us unusual that so great a botanist should give such names as *C. robusta*, *C. glauca*, *C. verrucosa*, *C. tuberculata*, and *C. propinqua* to one and the same tree.

Had Bentham seen the living trees he would probably have separated the species just as Brown had done.

The name of *robusta* was probably bestowed in reference to a bush character of the tree, but the fruits are the largest of the genus, so that it would be equally applicable in describing them; these latter are so distinct from *C. glauca* and the other species enumerated above, that in our opinion, they justify Brown's classification.

Vide remarks under "Chemistry of the Leaf Oil."

The prominently tuberculated fruits of *C. robusta* at first led us into an error, for we thought that *C. tuberculata* would prove to be that species, but after seeing Brown's original specimens of the species from Middle Island, York Bay, we were compelled to alter our opinion and separate the two (*vide* note under *C. tuberculata*, R. Br.)

The trees cultivated in the Hobart Botanic Gardens and labelled *C. robusta* agree in every particular with A. Cunningham's specimen. The branchlets and leaves never have the bluish-green, or "bloom" characteristics of those of *C. glauca*, R. Br., and of the fruits of *C. propinqua*, R. Br. The fruits are differently shaped and larger than either those of *C. tuberculata*, R. Br. or *C. verrucosa*, R. Br. As the result of these investigations, R. Brown's species *C. robusta* here stands as distinct from those with which it has been synonymised.

*Herbaria Material Examined.

A special visit was made to Europe by one of us, and the heads of the principal institutions kindly placed at our disposal for examination all the *Callitris* in their keeping, and referred to under each species.

Kew,—

A. Cunningham's specimens from Rottnest Island, 1822. Drummond's specimen from Swan River, 1839. Oldfield's specimen from Garden Island.

British Museum,—

A. Cunningham's specimen, ditto, l.c. supra, Paris. Specimen from Western Australia, labelled by Miquel, *C. Preissii*.

Preiss' specimen from Cygnet River district, 1843, labelled, *C. Suissii*.

Cambridge University,—

A. Cunningham's specimens ditto, l.c. supra.

Melbourne,—

West Australian specimens named by Dr. Parlatore. Specimens from Bald Island named *C. verrucosa* by F.v.M.

Sydney,—

The fresh material collected and forwarded to us for investigation by Dr. Alex. Morrison, Botanist, Department of Agriculture, Western Australia, in no way differs from the above original specimens, and so removes all doubt from A. Cunningham's and Robert Brown's species. It also establishes the fact that after nearly a hundred years the species has produced little or no variation.

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* It was originally intended to use the word "types" in preference to "herbaria," but as some botanists in this connection object to types as things frequently imaginary—a type being an aggregation of individuals—the latter word is here preferred. It was only from the examination of a very large quantity of specimens that the original species has been traced.

II. SYSTEMATIC.

A tree of considerable size, often exceeding 90 feet (Fraser) with a hard, dark-coloured, furrowed bark. Branchlets erect, crowded, light-green coloured, not glaucous; leaves decurrent. Male amenta numerous, terminal, in clusters of threes or more, cylindrical, under two lines long, a quarter of a line in diameter. Female amenta not seen by us.

Fruit cones in clusters, from three to more than twelve, either sessile or on stout recurved pedicels, spheroidal, over an inch in diameter—almost 2 inches when expanded, much wrinkled and covered with prominent tubercles filled with oleo-resin; valves alternately less than quarter-inch shorter, valvate, the dorsal point only traceable by the hyaline remains of the apex of the sporophyll; the central columella is a triangular-based pyramid over two lines in height.

Seeds with two brownish wings.

III. LEAVES.

(*a*) Economic. (*Vide* Chemistry.)

(*b*) Anatomy.

Three plates of sections through the decurrent portions of the leaves are given in connection with this species, viz., Figures 42–44.

These were chosen as they convey a good idea of the disposition of the oil cavities in the spongy mesophyll, and also for the reason that they demonstrate that these latter bodies are not ducts or channels as obtains in so many non-Australian genera of Conifers. They also show them to be circular in shape on a cross section, and oval longitudinally, the varying diameters being due to the distance of the part sectioned, from the median area. Figure 42 gives a view through a branchlet showing the decurrent portions of three leaves, with but one leaf only having an oil cavity.

The origin of the oil cavities is lysigenous, and they were found to occupy a central position in the spongy mesophyll near the upper portion of the leaf and near its free end. The epidermal and hypodermal cells are developed in an uniseriate row and found to occur only on the outer convex surface of the leaf.

The under surfaces of the three leaves are shortly concave, and, as such surfaces of separate leaves, are adjacent as in other species, a groove is formed with a narrow opening made by the converging edges of the leaves, and which we call the decurrent channel.

The stomata on these concave surfaces of the leaves, partake of all the characters of those described under *C. glauca*. Certain cells containing the black manganese compound, and which stain the same as some of those of the pith, and

continuous with them, are closely packed round the central column at the lower part of this concavity, probably to counteract the absence of other protective media such as epidermal and hypodermal cells and palisade tissue in this part.

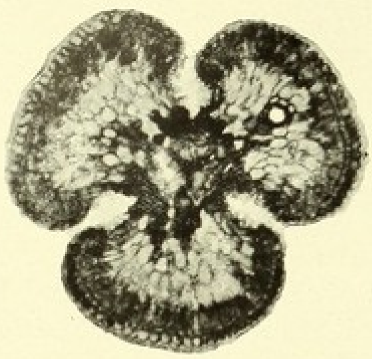


Figure 42.—Transverse section through a branchlet and leaves, with one small oil cavity in one of the leaves. *C. robusta*, × 70.

The central vascular cylinder (branchlet) is single, or branched by medullary pith cells, whilst a branch bundle is present in the inner portion of the leaf.

Endodermal cells occur and surround, when present, the oil gland and cells of the conjunctive or transfusion tissue (which latter is here found in greater proportion than in other species), as well as the phloem of the central axis.

It is interesting to note how in that part of the leaves where no oil gland is present, the cells which eventually become endodermal are clustered in the centre of the spongy mesophyll; and as the oil gland develops, it pushes through the centre of these, which then extend and surround it, the transfusion tissue, and the leaf bundle.

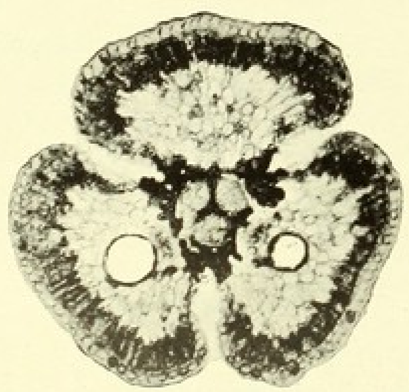


Figure 43.—Transverse section through a branchlet and decurrent leaves, showing an oil cavity in two of the leaves, below which is a bundle. The dark cell content in the pith rays and at the base of the decurrent channel is probably a manganese compound. *C. robusta*, × 70.

Figure 42 is a transverse section through a branchlet and the three decurrent leaves, just below the location of the oil cavity, or at least only just sufficient to cut the base of one as shown in top of the right section. Figure 43 is a cross section higher up than Figure 42. In this case the knife passed through the oil glands, *i.e.*, the circular spaces in the two lower leaves. In the centre of the top leaf is a cluster of thin-walled parenchymatous cells, which are gradually displaced or pushed aside as the oil cavity develops, and in the two lower leaves they can be noted arranged around the oil cavity between which and the central axis is the leaf bundle. The elongated or conical cuticle cells of the transpiratory surfaces can be seen, and a guard to which is formed by the incurved

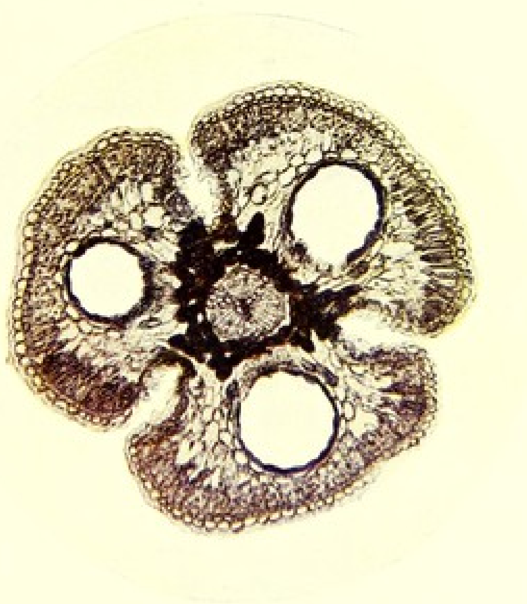


Figure 44.—Transverse section through a central axis (branchlet) and portions of the decurrent leaves at the centre of the oil cavities, one being shown in each leaf. The dark-stained cells surrounding the median axis contain the manganese compound. Below each oil cavity is a bundle with its laterally placed transfusion tissue. The papillose projections of the ventral surfaces in the decurrent channels are distinctly seen. Stained lightly with hæmatoxylin. *C. robusta*, × 80.

edges of the assimilatory surfaces, which are backed by comparatively large epidermal cells, and much larger than the hypodermal. The palisade cells form a good marginal proportion of that part of the leaf substance. The clusters of dark patches at the base of the decurrent channels are the parenchymatous cells containing the manganese compound. In Figure 44 the chief feature of the section, taken just below the free ends of the leaf, is the amount of leaf space occupied by the oil cavity in each leaf, the secretory cells forming a distinct ring. Between the base of the decurrent channel and the central axis, it will be noticed that parenchymatous cells are closely packed, and having the manganese contents staining black.

The trefoil formed by the three-leaf sections varies in shape as in other species.

(c) Chemistry of the Leaf Oil.

This material was forwarded by the Government of Western Australia, and was received on the 15th July, 1903. There were numerous fruits upon the branchlets, but these were removed and distilled separately. This oil is, therefore, that of the leaves with terminal branchlets only. The distillation was continued for six hours, and 287 lb. of material gave 12 oz. of oil, equal to 0·261 per cent. The crude oil was somewhat dark in colour, but it had the odour of the *Callitris* oils generally, particularly those containing a fair amount of the ester of borneol. Up to the present time (1910) it has not deposited a resin on the sides of the bottle, which result distinguishes it at once from all our samples of *C. glauca* and *C. verrucosa*. It is also distinguished from the oil of *C. glauca* by a considerably less rotation, a higher specific gravity, the presence of a sesquiterpene in small quantity, and a less yield. It was also, at this later date, soluble in 10 volumes of 80 per cent. alcohol by weight, and although somewhat less soluble in alcohol than when freshly distilled, yet it did not become insoluble like the crude oils of *C. glauca*. This fact probably accounts for the non-deposition of the insoluble resin. The oil contained a large amount of dextro-rotatory pinene, proved by its chemical combinations; and judging from the results of the specific gravity and the rotation of the larger fraction, together with the results of the redistillation, there is less limonene and dipentene in the oil of this species than in that of *C. glauca* and allied species.

The ester content was fairly high for an oil of this group. It was found to consist principally of the mixed acetic acid esters of borneol and geraniol. It will be observed that the oil distilled from the fruits of this species had an optical rotation in the opposite direction to that from the leaves, and that the ester content was considerably less also.

The specific gravity of the crude oil at 15° C. = 0·8825; rotation, $[\alpha]_D = + 10{\cdot}3°$; refractive index at 19° C. = 1·4752. The saponification number

was 49·59, equal to 17·35 per cent. ester as bornyl-and geranyl-acetates. In the cold, with three hours contact, the saponification number was 22·78, equal to 7·97 per cent. ester. On redistilling, practically nothing came over below 155° C.; between 155° and 160,° 35 per cent. distilled; between 160° and 165,° 17 per cent.; between 165° and 200°, 20 per cent; between 200° and 250°, 12 per cent. The somewhat large percentage of the oil boiling above 250° indicated the presence of a sesquiterpene or allied body, but it was not isolated.

The specific gravity of the first fraction at 15° C. =0·8613; of the second, 0·8616; of the third, 0·8651; of the fourth, 0·907. The rotation of the first fraction α_D = +12·2°; of the second, +12·7°; of the third, +14·15°. With the fourth fraction the light did not pass well, but it was more highly dextro-rotatory than the third fraction, thus indicating the presence of the dextro-rotatory bornyl-acetate, common to these oils. The saponification number for the esters of the fourth fraction was 206·33, equal to 72·2 per cent. of ester. In the separated alcohols both borneol and geraniol were determined. The high percentage of ester in this fraction did not leave much room for the sesquiterpene or similar bodies.

The Oil from the Fruits.

This material consisted of fruits alone, all the leaves having previously been removed; 43 lb. of fruits gave 2½ oz. of oil, equal to 0·363 per cent. The crude oil was dark coloured and had an odour resembling the *Callitris* oils generally. The colour was readily removed with dilute aqueous soda, when it was almost colourless, being slightly tinged yellow. By determining the ester both before and after this treatment, it was found that the free acid had a saponification number of 2·6.

The specific gravity of the crude oil at $\frac{16}{15}$° C. = 0·877; rotation, α_D = −17·9°; refractive index at 18° C., = 1·4774. The saponification number after the removal of the free acid, was 16·8, equal to 5·88 per cent. of ester.

By tabulating the results, the differences between the oil from the leaves and that from the fruit are more easily seen:—

Locality and Date.	Specific gravity. °C.	Rotation α_D	Refractive Index. °C.	Ester, per cent.	Yield, per cent.
Crude Oil from the Leaves of *Callitris robusta* of Western Australia.					
Western Australia 15/7/03	0·8825 @ 15	+10·3	1·4752 @ 19	17·35	0·261
Crude Oil from the Fruits of *Callitris robusta*.					
Do.	0·877 @ 16	−17·9	1·4774	5·88	0·363

IV. TIMBER.

(*a*) Economics.

This is a light-coloured, fairly hard timber, having a good straight grain, and very suitable for house-building, railway sleepers, posts, &c., in the white-ant infested districts of Western Australia, as, like its congeners, the termites do not relish it.

The late Mr. Ednie Brown, Conservator of Forests, Western Australia, spoke well of this timber in this connection, and recommended it on this account for forestry cultivation.

It could be used for panelling and similar purposes to which the *Callitris* of Eastern Australia are put.

Test:—Timber not available.

(*b*) Anatomy.

The specific features characterising the microscopical sections of this wood are, (1) the presence of the dark manganese compound in some of the cells of the secondary xylem or prosenchymatous cells, and its frequent absence in the medullary rays.

The tangential sections shown are characterised by, (1) the absence of the dark brown substance in the lumina,—the knife having cut clear of this compound—(2) the rows of bordered pits in section on the radial walls, (3) the few cells in height of the medullary rays, and (4) the almost entire absence of the manganese compound content compared with those of other species. It must not, however, be concluded that it never occurs in the cells of this timber.

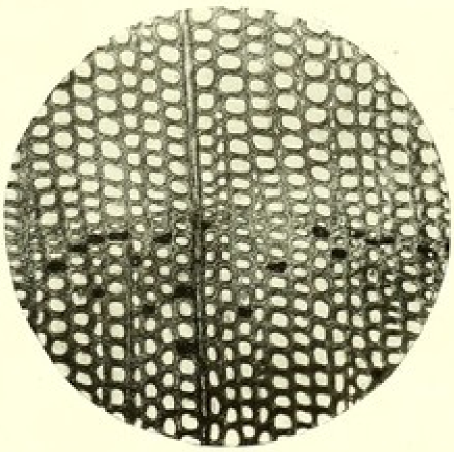


Figure 45.—Transverse section through timber. The one ray in the picture has no cell content. The row of narrow tracheids across the picture marks the limit of autumnal growth. The black cell contents are the manganese compound. *C. robusta*, × 80.

The transverse sections show, however, cells of the xylem containing the manganese compound to be promiscuously distributed throughout the prosenchymatous cells, and scattered irregularly throughout each season's growth of xylem as demonstrated in Figures 45 and 46.

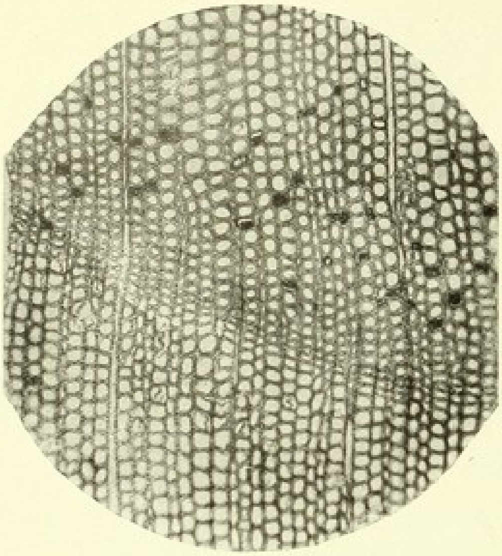


Figure 46.—Transverse section through timber, showing how the manganese (black spots) is further removed from the autumnal growth than in Figure 45. *C. robusta*, × 80.

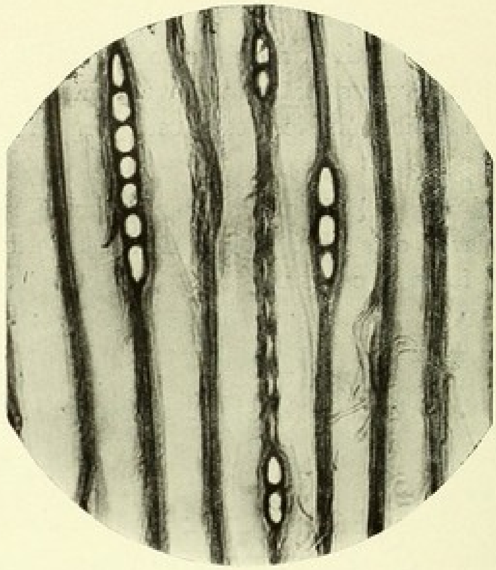


Figure 48.—Tangential section through timber, showing the almost entire absence in this case of the manganese compound in the ray cells. The tracheid wall in the centre of the picture connecting the two-celled rays is strongly marked with pitted cells in section. *C. robusta*, × 210.

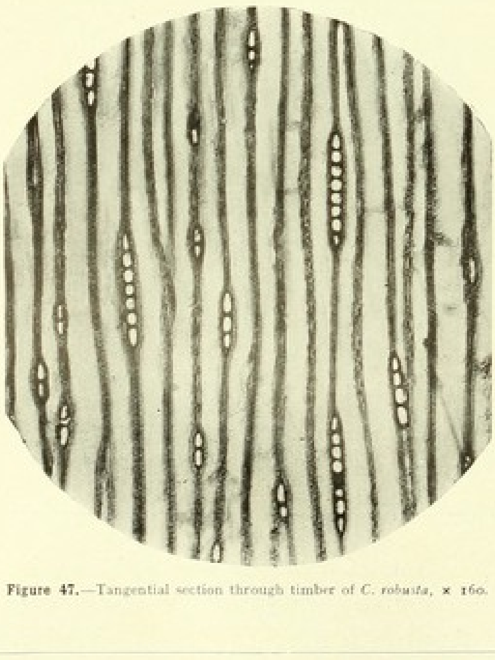


Figure 47.—Tangential section through timber of *C. robusta*, × 160.

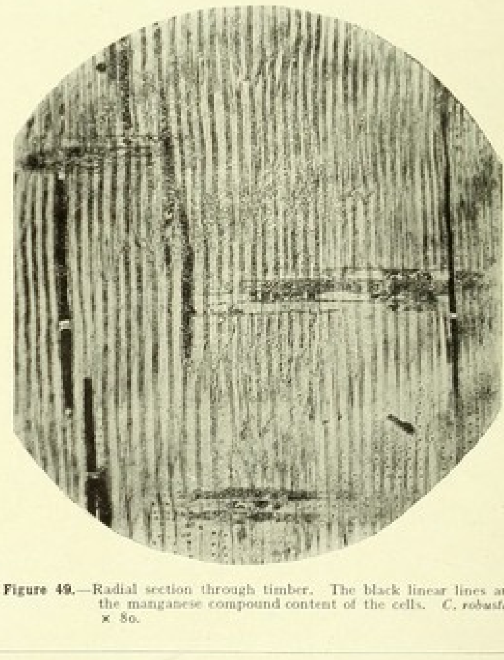


Figure 49.—Radial section through timber. The black linear lines are the manganese compound content of the cells. *C. robusta*, × 80.

Sections of Timber of C. robusta, R.Br.

Bordered pits are very numerous on the radial walls, equalling in diameter that of the lumen. They also form a conspicuous object on these walls in a tangential section, being cut diametrically, the lumella being clearly defined in Figures 47 and 48. These sections also show the cells of the medullary rays to be empty of manganese compound, an exception to the rule.

Figures 45 and 46 are given to illustrate the distribution of tracheids containing the so-called "resin" (indicated by the black spots), in the autumnal and spring growths of the timber. Figure 47 is a tangential section through spring growth; the lumina in this case being free of manganese compound as also are the cells of the rays which are seen to vary in height according to the number of rows of horizontal cells. Several of the radial walls are strongly marked with bordered pits sectioned, and show in this species their disposition in the walls of the tracheidal cells, the prosenchymatous nature of which is shown in several instances. Figure 48 is a 210-magnification of the central portion of Figure 47, and brings out more clearly the structure detailed above. Figure 49 illustrates a radial section of the timber of this species. The dark vertical lines are the manganese compound content of the tracheidal cells. The lighter portion to the right is the spring growth, the central ray extending partly through it and the autumnal growth. The bordered pits in the radial walls are faintly seen. Dr. H. Tassi has microscopically examined the timber of *C. robusta* ("Bull. Lab. Orto Botanico di Siena," Vol. III, Fasc., 1–4, p. 12), but to which species in this work it refers we were unable to ascertain, not having seen the publication.

(*c*) Chemistry.

(See articles on the Phenol and the occurrence of Guaiol, &c.)

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

The inner cortex appears to be free from periderm or cork layers, these occurring only in the outer bark and then in numerous concentric bands.

The cambium is succeeded by regular uniseriate rings of sieve-tubes, parenchymatous cells and bast fibres, and this order of structure is followed in the outer bast, except that at almost regular intervals periderm layers occur.

Oleo-resin cavities are perhaps smaller than those of most species.

Figure 50 is a section taken from the junction of the inner and outer cortex. The former has a regularity of cell arrangement not so well defined as in the latter, where in this instance the resin cells are more numerous. The three light bands running from left to right in the upper half of the picture are the

periderm layers. In the inner bark the bast fibres and uniform parenchymatous cells are the salient features, whilst in the outer, the irregularly shaped parenchymatous cells are more conspicuous.

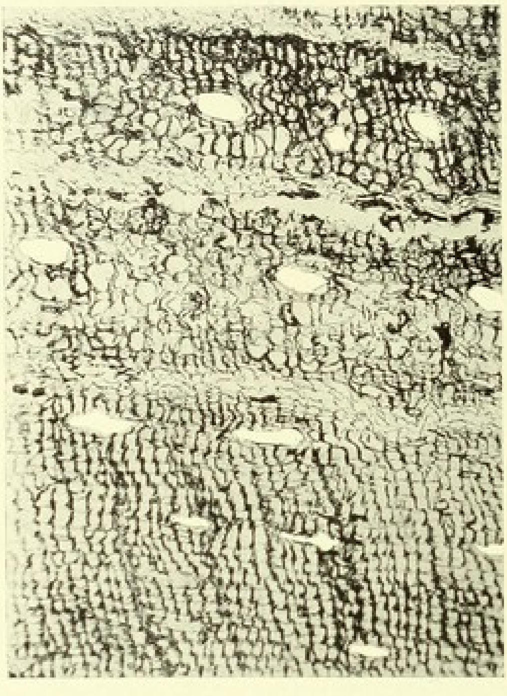


Figure 50.—Transverse section through bark. The three faint bands running across the picture in the top half are periderm layers. *C. robusta*, × 70.

(*c*) Chemistry.

The specimen of bark investigated was received by the Museum from the Government of Western Australia. It was from timber of small dimensions, being only 2 to 3 inches in diameter; so that it can hardly be considered representative of the bark of this species. The thicker bark was not available, but there is no reason to suppose that it will be found to materially differ from the other barks of this class, *C. glauca*, for instance. The bark determined was dark grey externally, fibrous, and not deeply furrowed, as it was too young, and was only from 4 to 6 mm. in thickness.

The following results were obtained with the air-dried bark:—

Moisture	11·4	per cent.
Total extract	13·5	,,
Non-tannin	4·8	,,
Tannin	8·7	,,

2. Callitris tuberculata.

R.Br., Mirb. in Mém. Mus., Par. xiii, 74.

HABITAT.

Middle Island, York Island Bay.

I. HISTORICAL.

This little-known Pine, placed by Bentham in the "Flora Australiensis," Vol. VI, 237, as a synonym of *C. robusta,* is a species of Robert Brown, and probably collected by him on the same trip when he collected the latter *Callitris.* It was this collecting by Robert Brown of his own species that led us to doubt whether this synonymising by Bentham was not open to question.

We have now seen Robert Brown's original specimens of *C. tuberculata* at the British Museum, and find that it possesses characters that warrant, we think, its being placed in specific rank.

II. SYSTEMATIC.

The decurrent leaves have a glaucousness similar to *C. glauca,* as well as terete branchlets formed by these decurrent leaves, but the cones resemble somewhat those of *C. robusta,* except in size, being smaller and more depressed than those of the true *C. robusta* of the same author.

No material was available for detailed investigations.

HERBARIUM MATERIAL EXAMINED.

British Museum,—

Robert Brown's specimens from Middle Island, York Island Bay, 1802.

Callitris verrucosa, R.Br., "CYPRESS," OR "TURPENTINE PINE."

Nat. size.

3. Callitris verrucosa,

R.Br., ex Mirb. in Mem. Mus., Par. xiii, 74.

"CYPRESS" OR "TURPENTINE PINE."

(Syn.:—*F. verrucosa*, A. Cunn.)

Habitat.

The geographical limitations of this tree are well defined in New South Wales, for it is essentially a dry country species, and extends for many miles over the country around Mount Hope and to the westward.

It was also found by the Elder Exploring Expedition in the heart of the continent, and from there it extends into Western Australia to Boorabbin (Dr. A. Morrison).

It is doubtful whether it occurs in Queensland.

I. HISTORICAL.

This was one of the earliest species discovered, even Allan Cunningham's specimens from the Euryalean Scrub being dated 1817. It is easily distinguished from *C. glauca* by its darkly shaded green branchlets and its warty cones, thicker valves, and its low-growing habit. Its vernacular name of "Turpentine Pine" is given to it, according to the teacher of Mount Hope Public School, on account of the large quantity of turpentine contained in the cone tubercles.

It was thought to be the Eastern form of *C. robusta* of Western Australia, or *vice versa* by Bentham, but as Cunningham and Brown saw, collected, and named the trees, and evidently were so impressed with their differences as to give them specific rank, we think that science is better served by following their nomenclature than by generalising on the possibility of variation, especially in view of present facts adduced in this investigation that strongly support constancy of species in the genus. Then again there is *C. tuberculata*, R.Br., which has also warty cones as well as *C. robusta*, R.Br., a tree which has them even more pronounced than any other species.

In the light of the knowledge gained by this research, we think that it is better for pure, and certainly applied science, to separate these species, as did Brown and Cunningham, rather than follow Bentham's classification, for we have not found any intermediate forms either in European herbaria or field specimens sufficient to prove a gradation.

HERBARIA MATERIAL EXAMINED.

Kew,—

A. Cunningham's specimens, from the Euryalean Scrub, N.S.W., 1817.

Müeller's specimens, Sieb, tropical Australia, labelled *C. glaucescens* or *C. glauca*.

Drummond's specimens, Swan River, 1843.

Do do Interior S.W. Australia.

R. Helm's specimen, Elder Exploring Expedition.

Pritzel's specimens, from Coolgardie.

Victorian Expedition, 1872.

British Museum,—

Oxley's first expedition, named by R. Brown.

A. Cunningham's specimens, from Euryalean Scrub.

Do do first voyage of the "Mermaid."

Fraser's specimens.

II. SYSTEMATIC.

This is a stunted tree or shrub attaining a height of 20 to 30 feet with a thick, compact bark. Branchlets, when compared with other species, are short, very numerous, erect, compact, terete, and drying a bright green colour; the internodes are very short, averaging a line long on the penultimate branchlets. Free ends of leaves acute, incurved, the decurrent portion quite rounded on the back, the dorsal ridge being only slightly marked. Male amenta terminal, two to five, but mostly in threes, scarcely exceeding a line in length when mature, ovoid to cylindrical in shape. Antheral bracts ovate-orbicular, ciliate, anthers two to three, about half the length of the bract. Female amentum solitary, about one line in diameter.

Fruit cones solitary, on short thick branchlets, sometimes occurring in clusters, nearly globular, about six lines in diameter before dehiscing, and about 1 inch in diameter when fully opened; valves valvate, the alternate larger ones about twice the width of the shorter, covered, when mature, with large numerous warts; the dorsal point almost entirely absorbed in the indurated sporophyll. The central columella three-sided, pointed, about two lines long. Seeds two-winged.

III. LEAVES.

(*a*) ECONOMIC (*vide* Chemistry).

(*b*) ANATOMY.

In general contour, a cross section through the three decurrent leaves may be said to resemble that of *C. glauca*, but internally the skeletal structure is specifically different, for in this species it is only occasionally that a leaf trace or

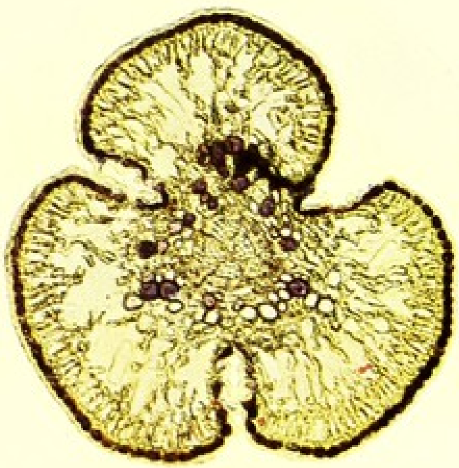


Figure 51.—A cross section through a branchlet, and three decurrent leaves, midway between the nodes, and showing no oil cavity or a leaf bundle in the individual leaf tissue. The endodermal parenchymatous cells occur irregularly around the central axis, some containing the brown substance. In this instance all the epidermal cells are filled with a brown substance, forming a dark border to the trefoil. The hypodermal cells are small, and in only one row. The spongy and palisade parenchyma are well brought out. Very faintly stained with hæmatoxylin. *C. verrucosa*, × 95.

rather leaf bundle is present in the individual foils of the trefoil, the central cylinder apparently doing duty for the whole three leaves when the leaf bundle is wanting.

In the sections reproduced, the stele is mostly divided into three bundles, but there appears no well-defined pericycle, such as in *C. Muelleri*, surrounded by endodermal cells, but instead between the three oil glands and the stele there is a fair amount of sclerenchyma material such as obtains in *C. calcarata*.

Where the oil cavities have not come into view, a few endodermal cells are irregularly scattered at the base of the spongy mesophyll, but when a section is taken through the oil cavities it will be noted that some are arranged around these and so form strengthening cells, and others are clustered crescent-shape at the base of the decurrent channel, as we propose to call this space.

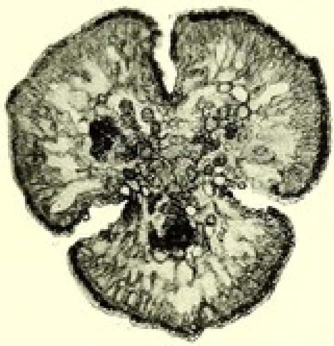


Figure 52.—Transverse section of branchlet, and decurrent leaves cut below the oil cavities. *C. verrucosa*, x 70.

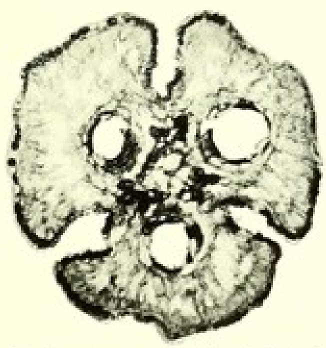


Figure 53.—Transverse section through branchlet and decurrent leaves, higher up than Figure 52, and showing a cross-cut through an oil cavity in each leaf. *C. verrucosa*, x 70.

The palisade cells are only developed at the dorsal side of the leaf and cease at the ventral face, which is the transpiratory surface, for there only do the stomata occur, and which like those of *C. glauca* have similarly developed cuticle projections. The epidermal cells are well developed, and apparently at the expense of the hypodermal, which are quite insignificant. The dorsal surface is sometimes slightly ridged. The secretory cells of the oil cavities are distinctly seen in Figure 53. The spongy mesophyll occupies a rather large proportion of each leaf area.

Figure 51 is a transverse section through branchlet and decurrent leaves, below mid-distance between the nodes, and showing no oil cavities, as they rarely occur in this part of the leaves. Although a low magnification (95), yet the general structure of the fundamental tissue can be traced. No leaf trace is present in any of the sections, but the transfusion tissue is scattered irregularly amongst the parenchymatous endodermal cells, some of which are empty, whilst others

with the manganese compound are stained a dark brown. In Figure 52 similar remarks to No. 51 apply in this illustration, but a dorsal ridge is shown on each leaf, giving a slightly different contour to the trefoil. The central axis is composed of three bundles as against four in Figure 53. Figure 53 illustrates a cross section near the upper portion of the leaves and just clear of their free ends, and where three oil cavities have been sectioned, one in each leaf. It is in this part of the leaves that oil cavities are invariably found. The cuticular projections as in Figures 51–53 can be made out in the ventral surfaces forming the decurrent channel. The dark-stained parenchymatous cells containing the manganese compound here arrange themselves in clusters at the base of the decurrent channels.

(*c*) Chemistry of the Leaf Oil.

The material for this investigation was obtained at Shuttleton, New South Wales, 512 miles west of Sydney. Two consignments were received, in September and December, 1903, and also fruits for separate distillation. The whole of the fruits were removed from the branchlets before distilling, so that the oil here investigated is that from the leaves and terminal branchlets only. The distillations were continued for six hours. The results from the two samples of leaf oil agree very well in most respects, the only difference being that in December (midsummer) there is rather more dextro-rotatory limonene present and a little less pinene. (See also under *C. calcarata*.)

The results thus illustrate the comparative constancy of the chemical products of individual species of *Callitris*. The constituents found were those of the *Callitris* oils generally, although varying in the amount of the individual terpenes and esters from those of the oils of other species. For instance, it varied from the leaf oil of *C. robusta* of Western Australia—another species with warted fruits—in having considerably less ester, a higher dextro-rotation, and a much greater amount of dextro-rotatory limonene. It contained, however, the sesquiterpene or similar body found in the oil of *C. robusta*, and this was present in sufficient amount to raise the refractive index beyond 1·48, a result very unusual with the *Callitris* oils. The esters, although small in amount, consisted principally of bornyl- and geranyl-acetates, the former of which was dextro-rotatory, thus resembling the other *Callitris* oils. A little free borneol was present also, because when the crude oil was acetylated in the usual way, the saponification number had more than doubled the original determination, and a small amount of a crystalline substance was obtained, which was shown to be borneol. The free alcohol usually occurring in the *Callitris* oils of this group has been found to be dextro-rotatory borneol largely, thus differing from the oils of the *C. rhomboidea* group. The terpenes present were principally dextro-rotatory pinene, also the limonenes, of which the dextro-rotatory form predominated. The oil from the fruits was almost inactive, thus differing greatly from that of the leaves, and agreeing in this

respect with the oil from the fruits of *C. robusta*; it had also a less refractive index, but in other respects corresponded to the leaf oil. There was a marked deposit of resin upon the sides of the bottle with the leaf oil of this species, and consequently it soon became insoluble in ten volumes of 90 per cent. alcohol. In this respect it corresponded to the oils of *C. glauca*.

No. 1.—This material was collected September, 1903; 566 lb. of terminal branchlets gave 30 oz. oil equal to 0·331 per cent. The crude oil was amber coloured, and had an odour resembling somewhat the "Pine-needle oils" from species allied to *C. glauca*. The specific gravity of the crude oil at $\frac{23^\circ}{15}$ C. = 0·8596; rotation, $\alpha_D = +44{\cdot}2^\circ$; refractive index at 20° C., = 1·4809. The saponification number was 8·93, equal to 3·13 per cent. of ester as bornyl- and geranyl-acetates. A portion of the crude oil was acetylated by boiling with acetic anhydride and sodium acetate in the usual way. After this treatment, the saponification number had been increased to 21·27, equal to 7.44 per cent. of ester, or 3·4 per cent. of free borneol.

On redistilling, practically nothing came over below 156° C.; between 156° and 165°, 55 per cent. distilled; between 165° and 170°, 20 per cent.; between 170° and 180°, 10 per cent.; between 180° and 220°, 8 per cent. The specific gravity of the first fraction at 23° C. = 0·8522; of the second, 0·8573; of the third, 0·8624; of the fourth, 0·9087. The rotation of the first fraction, $\alpha_D = +43{\cdot}5^\circ$; of the second, $+47{\cdot}5^\circ$; of the third, $+51{\cdot}7^\circ$; of the fourth, $+46{\cdot}7^\circ$. As these results indicated the presence of dextro-rotatory limonene, the tetrabromide was prepared with the third fraction. This melted at 116° C., showing that both forms of limonene were present, as is usual with the leaf oils of the *Callitris* generally. The dextro-rotatory form, however, predominated. A portion distilling between 155–156° C. was separated from the first fraction, and this was shown to be dextro-rotatory pinene as with the other species of *Callitris*. The nitrosochloride was prepared, and this was formed into the nitrolbenzylamine, which melted at 122–123° C.

No. 2.—This material was collected December, 1903; 423 lb. of terminal branchlets, without fruits, gave 18 oz. of oil, equal to 0·266 per cent. The crude oil was identical, both in colour and odour, with that of the previous sample. The specific gravity of the crude oil at 23° C. = 0·8591; rotation, $\alpha_D = +47{\cdot}5^\circ$; refractive index at 19° C. = 1·4809. The saponification number was 10·87, equal to 3·8 per cent. ester. On redistilling, 45 per cent. came over between 156° and 165° C.; between 165° and 170°, 21 per cent.; between 170° and 180°, 13 per cent.; between 180° and 220°, 12 per cent. The specific gravity of the first fraction at 24° C. = 0·8492; of the second, 0·8503; of the third, 0·8592; of the fourth 0·9070. The rotation of the first fraction $\alpha_D = +46{\cdot}4^\circ$; of the second, $+52{\cdot}15^\circ$; of the third, $+58{\cdot}7^\circ$; of the fourth, $+51{\cdot}2^\circ$. The indications were thus for limonene, as in the previous sample, dipentene of course being also present.

The Oil from the Fruits.

The fruits of this species were received from Shuttleton, December, 1903. No leaves were present. The distillation was continued for seven hours, and 71 lb. of fruit gave 5 oz. of oil, equal to 0·44 per cent. The crude oil had a more turpentine-like odour than the leaf oil, and was dark coloured, it was thus necessary to remove the colour with dilute soda to enable the rotation to be taken.

The saponification number for the free acids as thus determined was 0·8.

The specific gravity of the crude oil at $\frac{22^\circ}{15}$ C. = 0·8608; rotation, α_D = + 0·3°; refractive index at 19° C. = 1·4738. The saponification number of the cleared oil was 5·1, equal to 1·78 per cent. ester. The crude oil did not deposit resin on the bottle, thus differing again in this respect from the leaf oil.

Crude Oil from the Leaves of *Callitris verrucosa*.

No.	Locality and date.	Specific Gravity ° C.	Rotation α_D.	Refractive Index ° C.	Ester, per cent.	Yield, per cent.
1	Shuttleton, 23/9/'03	0·8596 @ 23	+ 44·2	1·4809 @ 20	3·13	0·331
2	Shuttleton, 18/12/'03	0·8591 @ 23	+ 47·5	1·4809 @ 19	3·8	0·266

Crude Oil from the Fruits of *Callitris verrucosa*.

Locality and Date.	Specific Gravity, ° C.	Rotation α_D	Refractive index, ° C.	Ester, per cent.	Yield, per cent.
Shuttleton, 4/12/03	0·8608 @ 22	+ 0·3	1·4738 @ 19	1·78	0·44

IV. TIMBER.

(*a*) Economic.

The timber is pale coloured, straight-grained, having a density and texture similar to the other pale-coloured woods of the genus. It is easy to work and is used for house building, especially where the white-ant is found, and in this connection it will no doubt be especially useful for railway sleepers in those parts of the country infested with these destructive insects. It is, therefore, worthy of conservation in the arid interior. It could be used for doors, panelling, wainscoting, &c.

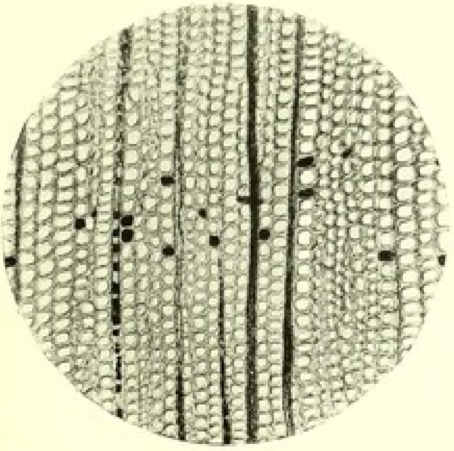


Figure 54.—Transverse section through timber, showing manganese compound in tracheids and parenchymatous cells of rays, the dark lines running from top to bottom of picture. *C. verrucosa*, × 80.

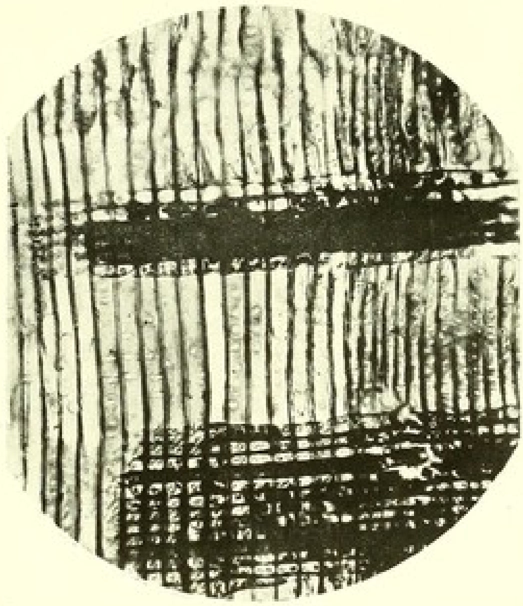


Figure 56.—Radial section of timber. The uniform character of the whole of the cells of the two rays shown is well brought out, as well as their single pits. *C. verrucosa*, × 120.

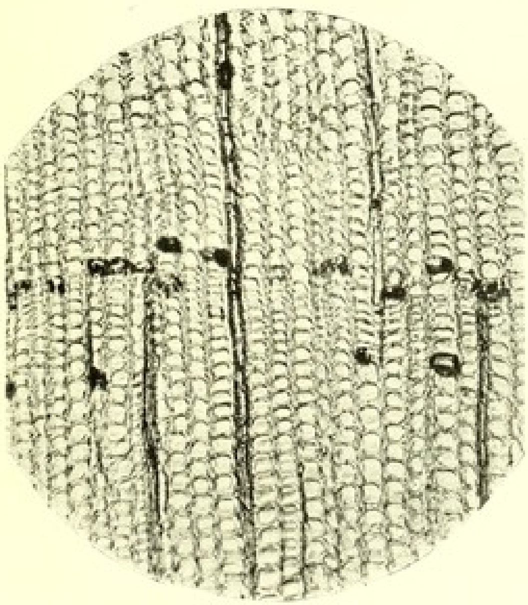


Figure 55.—Same section as Figure 54, but showing two autumnal rings of tracheids across the field of vision. *C. verrucosa*, × 120.

Figure 57.—Tangential section of timber of *C. verrucosa*, × 120.

Sections of timber of Callitris verrucosa, R.Br.

(*b*) Anatomy.

The tracheids of the xylem have a smaller diameter than those of its congeners and also thinner walls, consequently tangential and radial sections look much more delicate objects under the microscope than in the other species.

The medullary rays resemble the prosenchymatous cells in their structure, although, of course, not in form; these parenchymatous cells are very long and narrow, and are fairly distinctive characters of the species, as also are the numerous simple cells with their oblique slits or perforations.

The dark cell substance is only sparsely distributed in the tracheids, but pronounced in the medullary rays. The bordered pits are both numerous and of comparatively large diameter in proportion to the narrow lumina.

Figure 54 shows a transverse section through the timber tracheids, the autumnal growth being indicated by the smaller lumina near the top of the picture, the tracheids having the dark-coloured contents are few in number and scattered irregularly through the centre of the picture. The medullary rays run from top to the bottom of the plate, and all have the manganese compound contents. Figure 55 gives a higher magnification of a similar section to Figure 54, the autumnal wood running across the centre of the picture, but showing less brown contents in the cells. Figure 56 illustrates a radial section more particularly showing two medullary rays—the parenchymatous cells more or less containing manganese compound. No marginal tracheids are present in the rays, and the simple cells of these bodies are clearly seen. The autumnal growth is to the right. This plate also conveys an idea of density over that of its congeners. Figure 57 is a longitudinal tangential section.

V. BARK.

(*a*) Economic.

Owing to the limited amount of tannin in its cells it cannot claim to be a tannin bark of any pretensions.

(*b*) Anatomy.

There are one or two points of differentiation in this bark from its congeners, for instance, it contains less tannin cells than any other species, and there are also fewer strands of cork or periderm cells. Here the bast cells do not preserve in cross section so constant a shape as in other species, where the usual form is consistently rectangular with the long axis tangential, whilst in this species that character obtains near the cambium, yet a gradual shortening outwards of this axis occurs until the long axis is parallel to the medullary rays or radial, and a ring of these can be seen in Figure 58, at the top, although not quite focussed.

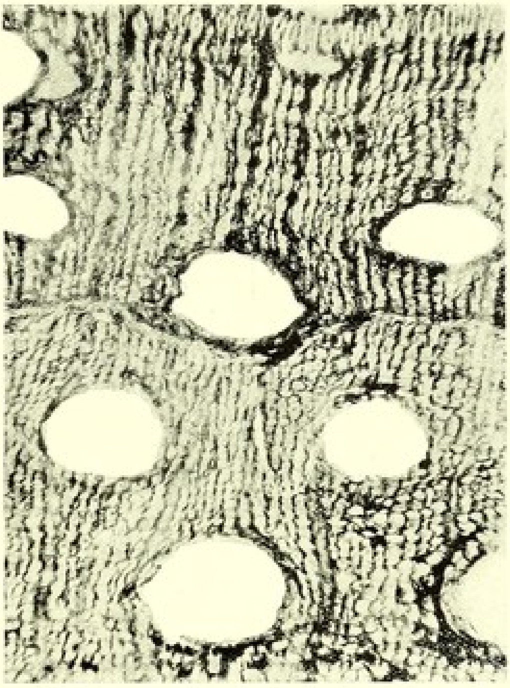


Figure 58.—Transverse section through junction of inner and outer cortex, showing empty oleo-resin cavities, also the changing in section of the long axis of the bast fibres from tangential in the inner to radial in the outer cortex. *C. verrucosa*, × 80.

Figure 59.—Transverse section similar to Figure 58, but at a higher magnification, and so illustrating the remarks under that figure. It further shows, however, the lysigenous origin of the oleo-resin cavities. *C. verrucosa*, × 100.

Sections of bark of Callitris verrucosa, R.Br.

This bark is also otherwise interesting, for it shows that the oleo-resin cavities are of lysigenous origin, as the gradual compression of the juxtaposition cells to permit of the intrusion of the cavity, can be traced in the section, Figure 59.

The structure of this bark otherwise conforms to that of its congeners.

Figures 58 and 59 give transverse sections at the line of intersection of inner and outer cortex. The large empty resin cavities can be seen to be thickly scattered throughout the cortex, whilst another feature illustrated is, that the bast cells have (in section) their long axes radial toward the outer cortex and tangential in the inner bark.

(*c*) Chemistry.

This sample was taken from a log collected at Shuttleton, New South Wales, in 1903. It was 11 inches in diameter, which is rather an unusual size for trees of this species. The bark was grey to brown externally, fibrous and fissured; its greatest thickness was 10 mm. In section the cells containing the dry resin are larger and more numerous than is generally found in these barks.

The following results were obtained with the air-dried bark:—

Moisture	11·6 per cent.
Total extract	13·6 ,,
Non-tannin	5·2 ,,
Tannin	8·4 ,,

Botanical Survey of the Species *C. verrucosa* in New South Wales.

From data supplied by Public School Teachers and other correspondents.

(Where no information is given under Remarks only herbarium specimens were received. The information is given without comment.)

Towns.	County.	Remarks.
Great Central—Mount Hope ...	Blaxland ...	Chiefly confined to the Mallee Districts of this part of New South Wales, extending west and a west-south-west direction to the Murray and Darling, and across the latter river into Mallee country of N.W. Victoria. It covers thousands of acres in this area *Timber.*—In the scrub, the pines grow from 12 to 15 feet high; where trees are isolated they grow from 20 to 30 feet high, and from 2 to 3 feet in diameter. *Resin.*—The pines in this locality exude large quantities of resin, this species being most profuse in its yield. (H. A. Bowyer.)
Coolamon ...	Bourke ...	(J. Benton.)
Lake Cudgellico ...	Dowling ...	(A. C. Carmichael.)

Callitris propinqua, R.Br., "CYPRESS PINE." *Nat. Size.*

4. Callitris propinqua.

R.Br., ex Endl. et Herb.

"CYPRESS PINE."

(Syn.:—*Frenela Moorei*, Parl. Schweinforth.)

HABITAT.

Kangaroo Island; Sandy Creek, Gawler (S.A.); and Bibbenluke (N.S.W.).

I. HISTORICAL.

The distinctive specific position of this tree was first noticed when inspecting the cultivated Pine trees in the Hobart Botanic Gardens when on the way to Europe.

Upon an examination of Cunningham's original specimens and MS. in the British Museum, its specific differences were still further marked, and after comparison with other described species, there could be little doubt as to its systematic position from a morphological standpoint, and so Brown's naming is here restored.

The glaucous fruits are quite characteristic, especially before dehiscing, when the bloom disappears; they also have an elongated shape that differs from that of other species.

The decurrent leaves on the branchlets are light olive-green in colour, similar to those of *C. robusta*, or *C. calcarata*.

Maiden, in his "Forest Flora," places *C. gracilis*, R.T.B., with this species but the differences of the two are very marked morphologically, anatomically, and chemically, and no intermediate forms have yet been recorded.

As far as our researches go, it appears to occur in Kangaroo Island and South Australia (W. Gill), and south-east N.S.W., at Bibbenluke, Quidong (J. H. Maiden).

HERBARIA MATERIAL EXAMINED.

Kew,—

No specimens.

British Museum,—

Brown's original specimens from Kangaroo Island, 1802.

Berlin National Herbarium,—

Schweinforth's specimen labelled "*Frenela Moorei*, Parl." Unfortunately there is no locality given.

Hobart,—

(There is a tree of this species cultivated in the Hobart Botanic Gardens.)

II. SYSTEMATIC.

This tree averages about 60 feet high, with the usual dark, hard, compact bark occurring on *Callitris* trees. Decurrent leaves, compact, very numerous, glabrous, of a light olive-green colour, the internodes terete, very short. Free ends appressed, scarcely acute. Male amenta numerous at the end of the branchlets, short, with few whorls of stamens. Female amenta not seen.

Fruit cones single or in clusters at the base of the second year's growth of branchlets, ovoid-pyramidal or egg-shaped, smooth or slightly rough, over an inch long when opened, glaucous, becoming black by age. Cone scales valvate, the alternate smaller ones only one-fifth shorter than the larger, dorsal point prominent, the central columella short and slender. Seeds mostly two winged.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

A cross section through the three decurrent leaves and branchlet gives a good picture of the structure of these organs and their respective subordinate character in forming, as it were, one whole body in this part of the tree.

The three dorsal surfaces occupy almost the greatest proportion of the outline of the trefoil figure, the three narrow channels being formed by the transpiratory ventral surfaces of the leaves, and the stomata are protected by the elongated cells of the cuticle as in some other species.

The epidermal cells are larger proportionally to the leaf mass than realises in other species, whilst the hypodermal cells are especially small.

These essentials of the assimilatory surface are supported by well-defined palisade cells of the mesophyll, the spongy tissue of which it is loosely composed.

Parenchymatous cells are packed between the base of each channel and the phloem of the central cylinder, and around the oleo-resin cavities where they may be regarded as endodermic.

Each leaf has a bundle at the inner edge of the oleo-resin cavities, and these are supported by cells of the transfusion tissue.

The secretory cells of the oleo-resin cavities are generally filled with the manganese compound substance in the sections, and in that respect resemble those of *C. Drummondii*.

In viewing the sections depicted it will be seen that the three leaves form parts of one whole, and together with the central cylinder formed by the branchlet bundles, no doubt act in unison in the performance of these physiological functions necessary in the life history of the tree or branchlet.

In Figures 60 and 61 several similar features are shown. Figure 60 was cut through the middle of the oil cavities, which latter occupy a goodly proportion of the leaf area; whilst Figure 61 was cut a little lower down the branchlet. The cluster of parenchymatous cells between the central axis and the decurrent channel are almost devoid of contents as obtains in some other species, as for instance, *C. robusta*, or *C. rhomboidea* especially. The palisade cells are seen closely packed and narrow, and the assimilatory surface with its layers of epidermal and hypodermal cells is also well defined. The epidermal cells are much larger than the hypodermal in this instance. A bundle occurs in each leaf on the inner side of the oil cavity, and what is of particular interest in these sections is that they show clearly an extension of the xylem of these bundles into a mass or collection of short tracheids, a feature recorded in "*Taxus*," by Frank, and called by Mohl, transfusion tissue—a term used throughout this work to describe this structure. If examined under a 3-in. or 4-in. lens the details are especially distinct, and will be found to accord with those given under other species.

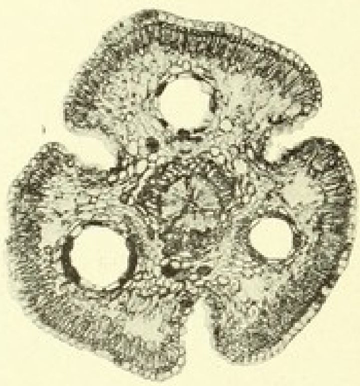


Figure 60.—Transverse section through central axis (branchlet) and three decurrent leaves in the locality of the oil cavities, *C. propinqua*, × 70.

(*c*) Chemistry of the Leaf Oil.

No. 1.—This material was received from South Australia, 18th May, 1905, and was sent to us by Mr. Gill, the Conservator of Forests for that State. The whole of the fruits were removed before distillation, so that the oil is that of the leaves and terminal branchlets only. The distillations were continued for six hours; and 278 lb. of material gave 18 oz. of oil, equal to 0·41 per cent. The crude oil was but little coloured, and had an odour similar to the *Callitris* oils belonging to the *C. glauca* group. It became somewhat insoluble in alcohol on keeping, and did not form a clear solution with ten volumes of 90 per cent. alcohol. During the time which has elapsed since it was distilled, no resin has deposited upon the sides of the bottle as was the case with all our samples of *C. glauca*, and in that

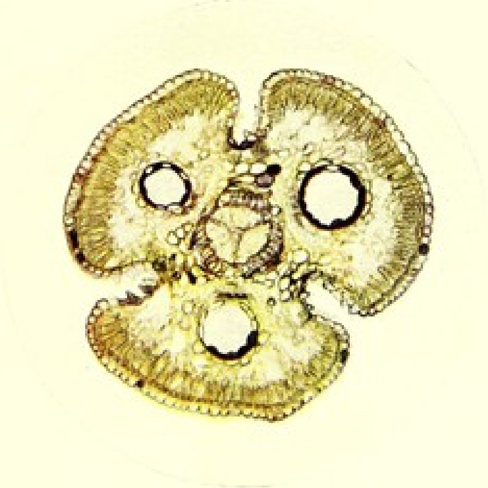


Figure 61.—Transverse section through a branchlet, and three decurrent leaves having an oil cavity and a small subtending bundle in each. The endodermal cells are few, being packed below the bottom of the decurrent channel and in a single ring around the oil cavities. The manganese compound is present in some of the secretory cells. The transfusion tissue is compact on each side of the bundle and on the lower half of the oil cavity. Very faintly stained with hæmatoxylin. *C. propinqua*, x 70.

respect the oils of the two species differ. It is remarkable, however, how closely the oils of *C. propinqua* and *C. glauca* agree in all their characters, with the above exception. As the constituents of the oil of this species are almost identical with those of *C. glauca*, the same remarks will apply to the oils of both species (see, for further details, under *C. glauca*).

The specific gravity of the crude oil at $\frac{19}{15}$° C. = 0·8662; rotation a_D = + 32·4°; refractive index at 19° C. = 1·4752. After boiling with alcoholic potash, the saponification number of the crude oil was 34·88, equal to 12·2 per cent. of esters. In the cold with three hours contact, the saponification number was 25·27, equal to 8·84 per cent. ester.

On redistillation practically nothing came over below 155° C. Between 155° and 160°, 29 per cent. distilled; between 160° and 165°, 32 per cent.; between 165° and 200°, 23 per cent.; between 200° and 225°, 8 per cent.

The specific gravity of the first fraction at $\frac{22}{15}$° C. = 0·8539; of the second, 0·8509; of the third, 0·858; of the fourth, 0·9405. The rotation of the first fraction a_D = + 31·9°; of the second, + 32·6°; of the third, + 35·3°; of the fourth, + 36·2°. The refractive index at 21° C. of the first fraction was 1·4738; of the second, 1·4738; of the third, 1·4744; of the fourth, 1·4733.

No. 2.—Mr. Gill also forwarded to us this material. As there were considerable fruits upon it, it was thought advisable to distil it, and the following results were obtained. In appearance and odour the oil resembled that distilled from the leaves alone; it had a little less rotation to the right than had the leaf oil, thus indicating that the oil from the fruits of this species has a different rotation to that of the leaves. In this respect it agrees with the results obtained with allied species. The ester content was also a little less, as was also to be expected. In every other respect the oils agree. 72 lb. of branchlets with fruits gave 3¾ oz. of oil, equal to 0·326 per cent. The specific gravity of the crude oil at $\frac{20}{15}$° C. = 0·8709; rotation, a_D = + 20·5°; refractive index at 19° C. = 1·4749. The saponification number was 32·24, equal to 11·29 per cent. of esters.

Crude Oil from the Leaves of *Callitris propinqua*.

No	Locality and Date.	Specific Gravity ° C.	Rotation a_D.	Refractive Index ° C.	Ester, per cent. by boiling.	Ester, per cent. in the cold.	Yield, per cent.
1, without fruits.	South Australia, 18/5/'05	0·8662 @ 19	+ 32·4	1·4752 @ 19	12·2	8·84	0.41
2, with fruits.	Do. March, '05	0·8709 @ 20	+ 20·5	1·4749 @ 19	11·29	—	0·326

IV. TIMBER.

This part of the tree was not procurable for investigation.

V. BARK.

(*a*) Economics (*vide* Chemistry).

(*b*) Anatomy.

This bark is fairly even in structure, as will be seen by Figure 62, which is a transverse section through the entire breadth of a piece of the young cortex. The cambium is at the bottom of the picture, and from this the bast fibres recede, at first in regular concentric circles indicated by parallel, broken, dark lines in the figure; this regularity is, however, lost or broken amongst the outer cortex—the top part of the section. Between these are three rows of vessels, the parenchymatous cells being between the sieve tubes, which latter or their sieve plates can be seen in Figure 64 by the aid of a lens. A number of oleo-resin cavities are scattered throughout the bark tissue, and on the outer portion are pale-coloured bands of periderm, whilst Figure 62 shows two of these in the upper part. Figure 64 is a longitudinal section, the left being the inner bark, and the right the outer bark. The long black lines in the left are the bast fibres, between which can be seen the parenchymatous cells, and sieve tubes.

(*c*) Chemistry.

This sample of bark was forwarded to the Museum by Mr. Gill, the Conservator of Forests for South Australia, and was collected in June, 1909. It was from a tree 2 to 3 inches in diameter, so that the bark was somewhat thin, ranging in thickness from 3 to 6 mm. It was dark grey externally and somewhat smooth, although it was beginning to form furrows, and was somewhat fibrous. Although the bark was so thin and fibrous, yet, it contained a fair amount of tannin, and the red constituents of the bark had hardly commenced to form in this sample, consequently the colour of the tanned hide powder was exceedingly light. The chemical reactions given with the tannin were those for *C. glauca*, so that there is little difference between the barks of these two species.

The following results were obtained with the air-dried bark:—

Moisture	10·84	per cent.
Total extract	21·09	,,
Non-tannin	8·46	,,
Tannin	12·63	,,

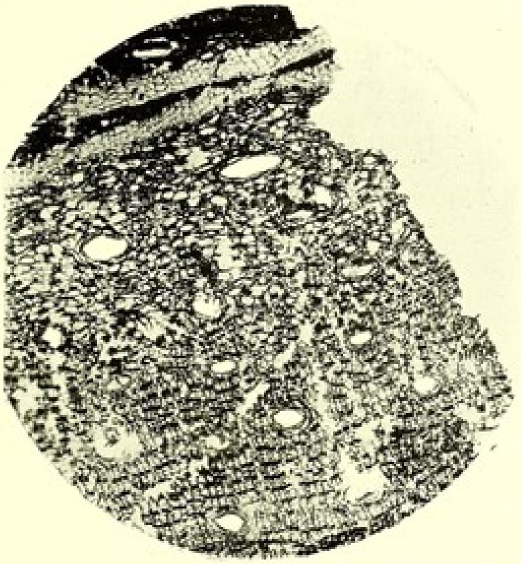


Figure 62.—Transverse section through bark. Two light-coloured bands of periderm layers are shown near the top or outer bark. The parallel, interrupted dark lines are the bast fibres, and the oval spaces oleo-resin cavities. *C. propinqua*, × 32.

Figure 63.—Transverse section through the bark. The bast cells are indicated by the black broken, parallel lines, whilst the lighter band towards the outer bark marks a periderm layer. *C. propinqua*, × 28.

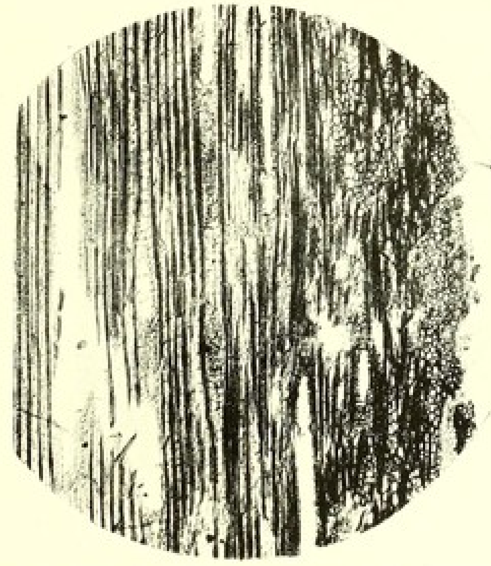


Figure 64.—Transverse section through the bark. The black lines in left of picture from top to bottom are bast fibres separated by parenchymatous cells and sieve tubes. Towards the right centre the light spaces are oleo-resin cells. The outer bark is the broken edge on the right. *C. propinqua*, × 25.

Sections of bark of Callitris propinqua, R.Br.

5. Callitris glauca,

R.Br., ex Mirb., in Mem. Mus., Par. xiii, 74.

"WHITE," "CYPRESS," OR "MURRAY RIVER PINE."

(Syn.:—*C. Preissii*, Miq. in Pl. Preiss, i, 643; *C. Huegelii*, ined.; *Frenela crassivalvis*, Miq., Stirp. Nov. Holl. Muell., i; *F. canescens*, Parlat., in DC. Prod. XVI, ii, p. 448; *F. Gulielmi*, Parlat., l.c. 449.)

Habitat.

It is perhaps quite safe to say that this species is *facile princeps* over its congeners in extent of geographical distribution, for it is found in all the States, but nearly always away from the coast.

I. HISTORICAL.

This species' name was founded by Robert Brown in 1825, and his selection was happily chosen, as the leaves partake of a glaucous character, more pronounced than in any other species of *Callitris*. It is a feature that differentiates it also in herbarium material from all its congeners, and it retains it wherever the trees grow, either in the eastern, central, or western parts of the continent, irrespective of environment. The claims of this species to specific rank were apparent to us long before seeing Brown's original specimens, and had Bentham seen Brown's species,—*C. robusta*, *C. glauca*, *C. tuberculata*, and *C. verrucosa*, in the field, he would not, we think, have synonymised them as he has done in the "Flora Australiensis," Vol. VI, p. 237, under the name *Frenela robusta*. Cunningham also regarded them as distinct, as shown by his specimens and MS. in the British Museum. Each of these species is readily characterised by the fruits alone, and even the two species *C. verrucosa* and *C. robusta*, with warted cones, cannot well be confounded.

A paper on this species was read by us before the Royal Society, N.S.W., August, 1908, Vol. XLII, portions of which are embodied here.

Herbaria Material Examined.

Kew,—

Robert Brown's specimens from Mount Brown, Iter Australiense, 1802-5. Allan Cunningham's specimen labelled by him, "Subtropical New Holland, Lieut.-Col. Sir T. L. Mitchell's expedition." Allan Cunningham's specimens from Rottnest Island, 1835. A second specimen with same label but larger fruits. A specimen from Bald Island, labelled *C. Preissii*.

Callitris glauca, R.Br. "WHITE" OR "CYPRESS PINE." Nat. size.

British Museum,—

R. Brown's specimen with note "prevailing timber in Western Interior." Specimen from Coonabarabran, New South Wales, named by Miquel *C. crassivalvis*.

Cambridge University,—

Lindley Herb., two specimens collected by Sir T. L. Mitchell, Sub-tropical New Holl., 1845. A. W. Gray's specimen.

Brussels National Herbarium,—

A specimen from Salt Lake, near Tangulla, labelled *C. Preissii*.

All the above, except where otherwise noted, are labelled *C. glauca*.

Paris National Herbarium,—

Dr. Leichhardt's specimen from Moreton Bay, 1845, probably came from further inland, for the term "Moreton Bay" would probably not be used at that time in so restricted a sense as understood to-day. It is labelled by Edward Spach and also by Brongniart as *C. Huegelii*.

II. SYSTEMATIC.

Callitris glauca is an evergreen tree, varying in height according to environment. In the far interior it is stunted in growth, whilst towards the main Dividing Ranges it attains a height of over 100 feet, with a diameter from 2 to 3 feet. The bark is hard, compact, furrowed, but lighter in colour than that of *C. calcarata*, R.Br., which forms with it the principal pines of the interior.

Leaves are at first pyramidal, then decurrent in whorls of three, glaucous, the internodes being shorter than obtain in most species; free end short, acute, the decurrent portion rounded.

Male amenta small, two to four lines long, cylindrical, oblong, or ovoid, very numerous, occurring in general, in threes at the end of the leaf series, the stamens in whorls of threes, the scale-like apex concave, cordate; anther cells two to four. Female amenta solitary or not often found in clusters, situated generally at the lower part of the branchlets.

Fruiting cones globular, rarely pointed at the top, about half an inch, exceptionally three-quarters of an inch in diameter; slightly scabrous; valves six, alternately large and small, the latter about a quarter less in size than the larger

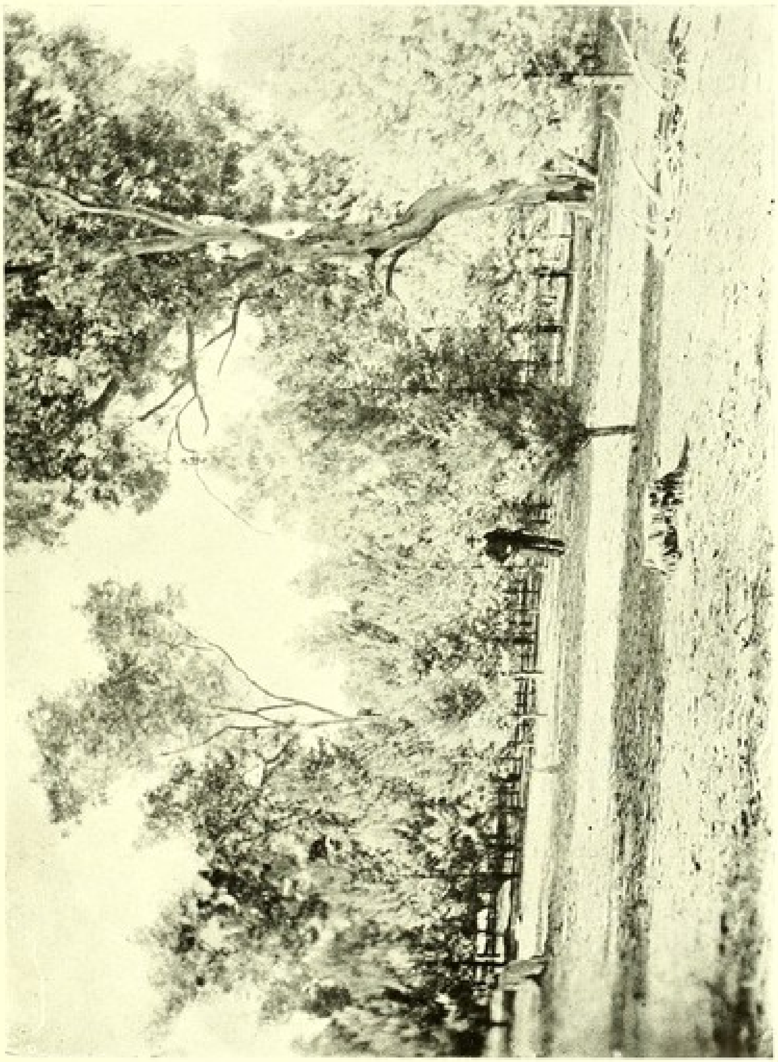


Photo. H. F. Connelly.

Callitris glauca, R.Br. "WHITE PINE."

Trees growing naturally at Cowra, N.S.W.

ones, valvate, channeled at the base; dorsal point scarcely perceptible. Seeds two to three-winged; the central columella under two lines.

All the specimens collected by us, and received from a very large number of correspondents, go to show that this is primarily an interior species, although it may occur on the coast, for Moore's specimens labelled *C. glauca*, at Kew, are recorded as collected in 1854 at Moreton Island, and Cunningham also collected it at Rottnest Island. Its coastal localities would, therefore, appear to be quite limited, or, perhaps, further investigation may prove the two latter to be *C. arenosa* and *C. intratropica* respectively. Amongst other differences from *C. robusta*, *C. tuberculata*, and *C. verrucosa*, this species may be noted by its thin cone valves and paler-coloured cones, the three, first having a black outer surface. Both *C. arenosa* and *C. intratropica* have thin cone valves, but the pronounced columns and the parallel edges of the smaller valves of the former, and the fruits as well as the timber of the latter, along with other features, differentiate *C. glauca* from both these species.

Photo. M. F. Connelly.

Callitris glauca, R.Br.

Single tree, illustrating mode of growth and general facies of tree.

III. LEAVES.

(*a*) Economics.

The presence of the oil is of course the main economic product of these organs. As a fodder plant they have little to recommend them, for it is only during the severest drought that sheep will nibble them, and then not for long.

(*b*) Anatomy.

For descriptive purposes cross sections were taken near the end of a branchlet and at various intervals along the decurrent portion of the leaves. Such sections were found satisfactory for histological work, for they included one part of each decurrent leaf as well as the portion of the branchlet which formed the central column to which the leaves were attached, the whole giving a well-defined trefoil in shape.

The free portion of the leaf was of little value in working out the anatomical structure of this part of the plant as obtains in the needles of *Pinus*, where a group of vascular bundles forms the central column around which regular leaf tissue is sustained, whilst in *Callitris* the ultimate portion of the branchlet composes the central vascular system supporting adnate leaf sections which collectively appear to form one whole, or at least that is the view here taken of this part of the tree for descriptive purposes.

The central xylem of the branchlet is succeeded by a normally orientated phloem; the relative position of these elements, therefore, is in accord with their final disposition in maturity of stem and branches. Subsidiary to these will be found near the base of each concrescent division and next the oil gland a small bundle (a primary leaf bundle, so to speak) of the true leaf, with the phloem normally orientated; these and the central bundle might perhaps be considered as corresponding to the median and secondary bundles of an ordinary bilateral leaf.

The xylem and phloem cells call for no special remark, as they conform to the usual characters of such found in the vegetable kingdom.

The phloem of the central system of the branchlet is surrounded by a mass composed of (1) parenchymatous endodermal cells; (2) transfusion tissue:—the tracheids of which in the case of this and other species of *Callitris* appear to have no uniformity of arrangement when the section is taken either through, or clear of, the oil cavities, as against the uniformity of such found in most other Conifers. When, however, oil cavities are present, the parenchymatous, or what may perhaps be regarded in this case as the endodermal cells, are found to extend round and encircle these bodies, and also to form a group or cluster between the central axis and the epidermis at the base of the cavity formed by the concave

ventral surfaces of the concrescence, in which case they are invariably filled with a substance now identified as a manganese compound. As endodermal cells they may, therefore, be said to be not regularly well defined as such in *Callitris* leaves, and in this respect there is a resemblance to those of *Sciadopitys* of Japan. The cell walls of the leaf tissue generally are irregularly circular in section, or having a slight tendency to hexagonal form, and they show no involutions or infoldings, so characteristic of Conifer leaf cells in general.

In the preparation of the sections, the protoplasmic contents of certain cells have been removed, and so they invariably appear empty, and it is thus that they are easily differentiated from the tracheids of the transfusion tissue. The mesophyll needs little comment. It consists of spongy and palisade parenchyma, and both are clearly defined in Figures 65 to 76. The latter consist of a single row having the long axis at right angles to the dorsal surface of each leaf, but cease at the ventral curve. The thick-walled hypodermal cells are, so to speak, the epidermal cell companions of these, as they also only extend as far as the epidermal and palisade cells, and gradually diminish in size and finally give out, as they approach the ventral surface. They are largest and thickest walled at the apex of the dorsal curve, and generally number about 100. The epidermal dorsal cells may be described as rectangular, and like the hypodermal ones are largest at the dorsal apex where the outer cell wall or cuticle is much thickened. They are not so numerous as the hypodermal cells, fifty being about the limit.

The cells of the ventral surface take quite a different form from those of the dorsal, for as they turn, so to speak, to curve into the ventral surface, the thick cuticle walls gradually dome until in the centre of the ventral cavity of the concrescence these walls reach their maximum height, becoming quite conical in shape—the elongated apices appearing to resemble numerous cones. They are clearly illustrated in Figure 76. This unusual structure, as far as we are aware, has only been recorded in one other instance in Conifers, *i.e.*, *Sciadopitys verticellata*, S. and Z. of Japan (C. E. Bertrand, "The Gnetaceæ et Coniferæ," pl. x, Figs. 10, 11, 12).

The function of these elongated bodies or papillose projections is probably (1) to assist the guard cells in the performance of their function or duties, (2) they also indicate the presence of the stomata, being only found along with them, (3) a protective character for the stomata by closing over them as occasion requires during adverse climatic or other conditions, and (4) eventually seed protectors, for in the transition of the terminal leaves into cone scales, these elongated cells interlock with those on the opposite leaf (sporophyll) like teeth of a cogwheel, and becoming ligneous, hold the cells together in a very firm grasp during the maturing of the seeds (Figure 17). The guard cells of the stomata call for little comment, being of the usual shape of such, relatively to the size of the air cavities, and much sunk below the cuticle.

With the exception of one or two rarely occurring on the lower dorsal surface, stomata are only to be found in depressions on the ventral concave sides of the concrescence, and where they occur in longitudinal irregular rows along the whole extent of the ventral face of the concrescence, as shown in Figure 78—the oval bodies on the left of plate. A few do, however, sometimes occur on the appressed lower part of the free portion of the leaf. Being thus placed in the channels, they have the full advantage of the whole leaf substance as a protection against solar rays, rain, or cold; and perhaps a secondary protective provision is provided, as the edges of the individual leaves have the power of closing the entrance to the cavity whenever adverse aerial conditions prevail, for the sections examined seemed to support this theory, as the apertures are sometimes found open as well as closed (*vide* Figures 65 to 75). This of course can only be verified by assiduous field observations, but nevertheless we are at present under the impression that this may be one of the physiological significances of the decurrence in Conifer leaves, *i.e.*, that the maximum amount of protection for the transpiratory surface is obtained by the minimum amount of leaf movement.

The specific name was given by Brown on account of the bloom of the leaves, as stated above, but Francis Darwin, "Journ. Linn. Soc.," Bot., vol. xxii, 1886, p. 99, states, "The position of the stomata in Conifers is very generally indicated by the existence of a glaucous bloom," but this is not so in the case of this species of *Callitris*, for the stomata-bearing surfaces are practically hidden, and cover too small an area to characterise the tree when they are exposed. In this contention of ours, *i.e.*, accounting for the concrescence in *Callitris* and the functions of the conical epidermal cells and probable movement of the ventral surface, the following quotation, we think, rather strengthens our views. In the case of *Pinus halepensis* "the leaves of this tree in warm sunny weather are fully separated, but if the sky become overcast they close partially; the sirocco produces a similar but more marked effect, but in rain the leaves collapse, giving the tree a most melancholy aspect" (Moggridge, "Journ. of Bot.," Feb. 1, 1867).

Oil Cavities.

When present these bodies are found to be situated in the upper portion of the leaf concrescence, and in the middle of the leaf substance of that part. They are obliquely fusiform in shape (Figure 77), a cross section showing a circle or an ellipse (Figures 70 to 72), whilst their limited length bars them from being classified as canals—a term used in describing oil containing bodies in most other Conifers. To be exact, they occur in the lower portion of the spongy tissue, and are not regularly distributed; sometimes one, and even two, thin-walled reservoirs will be found in each leaf, whilst often only one or two of the sections may show one. The cavities are all lined with thin-walled secretory cells, backed by a circle of thick-walled protective cells; they may be classed

as lysigenous. Under such an irregular disposition of oil cavities no assistance was rendered by these for diagnostic purposes, as obtains in other Conifers, and they cannot be used in a manner employed by Engelmann, who grouped the species of *Pinus* according to the position of their resin or oil ducts. He also lays stress on the circumstance of the resin canals being surrounded by strengthening cells or devoid of such investment. These conclusions, however, cannot be applied to *Callitris* as far as our observations go.

Figure 65 is a transverse section, showing the earliest stage of concrescence in the leaf, and where the three divisions are beginning to individualise, whilst Figures 66–67 show the concrescent portions more distinctly, also the fuller development of the ventral surfaces, and the cuticle protuberances on them. The division of the vascular bundles of the central axis into three parts by obtruding medullary pith cells, and the orientation of the phloem (indicated by the darker cells) are well brought out. In Figure 68 the section is interesting in that one or two elongated cuticle projections are seen on the lower part of the assimilating surface. No oil cavities occur in this or previous sections, where also the parenchymatous endodermal and transfusion cells are not arranged in any order. The ventral surfaces on the two leaf concrescences have edged together and so shut out any communiciation between the air and the stomata. Figures 69 and 70 illustrate the occurrence of an oil cell in the centre of the tissue of each leaf. The parenchymatous cells are here assuming some kind of order of an endodermal nature, and in Figure 70, are clustered around the oil cells, and at the base of the ventral surfaces. The bundle of each leaf is seen below each oil cavity, the dark patch being the phloem. In Figure 71 the ventral surfaces are shown exposed to the atmosphere, and three well-formed oil cells form distinct objects in each concrescence. The transfusion tissue borders laterally the leaf trace, and extends round towards the oil cavity, and is denoted by the cells with very small pits, which can be seen under a lens. Figure 72 is given to show the unusual occurrence of two oil cells in a concrescence. Figure 73 is a section through the ventral surfaces of two concrescences exposed to the atmosphere, and two air cavities, and gives the structure in this locality magnified 160 times. In Figure 74 the method of protecting the ventral surfaces from the atmosphere by the closing over of the edges of the dorsal surfaces is seen at top of the picture. Figure 75 well illustrates the leaf structure in the locality of the oil cell and leaf bundle; the transfusion tracheids are marked by the bordered pits, and are seen to be irregularly scattered amongst the other cell tissues. On the right is the phloem of the central axis, the xylem just showing, and to the left is the leaf bundle, the phloem being indicated by a black patch, and further removed from this to the left is an oil cavity.

Figure 76 gives a much finer illustration of the remarks under Figure 74. The papillose projections in the decurrent channel are well marked and form a

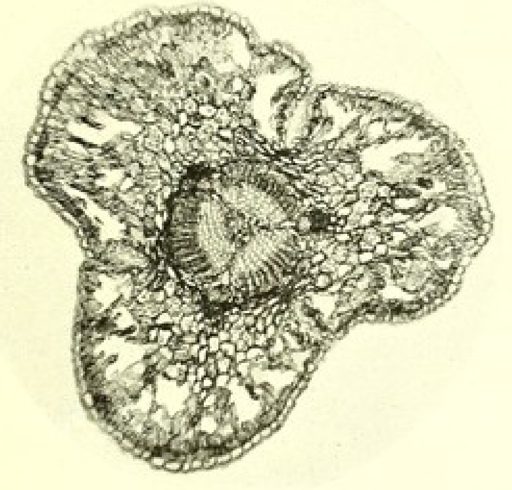


Figure 65.—Transverse section, showing a closed stage of concrescence in the leaf, and where the three divisions are beginning to individualise. *C. glauca*, × 80.

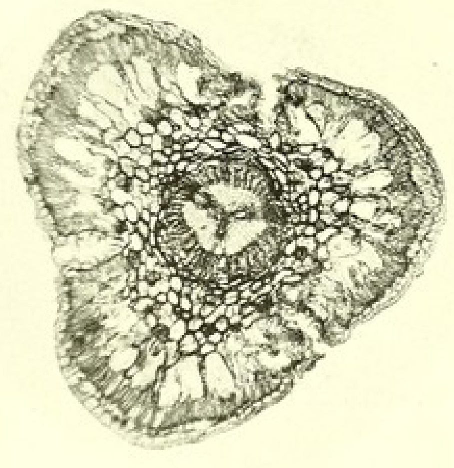


Figure 66.—This shows the concrescent portions more distinctly, also the fuller development of the ventral surfaces, and the cuticle protuberances on them. The transfusion tissue is well indicated by the pitted cells, and is seen to occupy a large proportion of the leaf tissue. The division of the median structure of the branchlet into three bundles by obtruding medullary pith cells, and the orientation of the phloem (indicated by the darker cells) are well brought out. *C. glauca*, × 80.

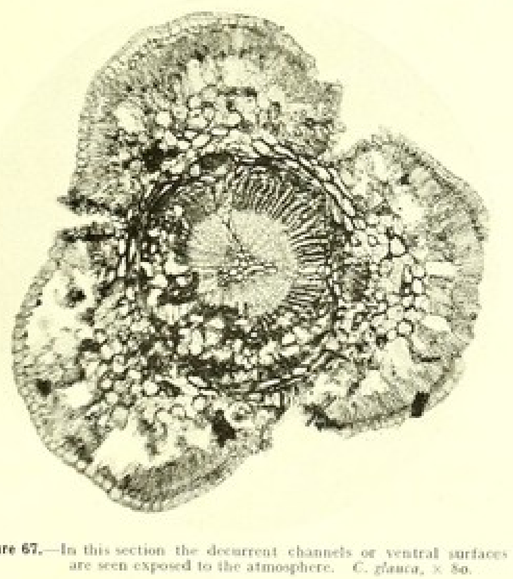


Figure 67.—In this section the decurrent channels or ventral surfaces are seen exposed to the atmosphere. *C. glauca*, × 80.

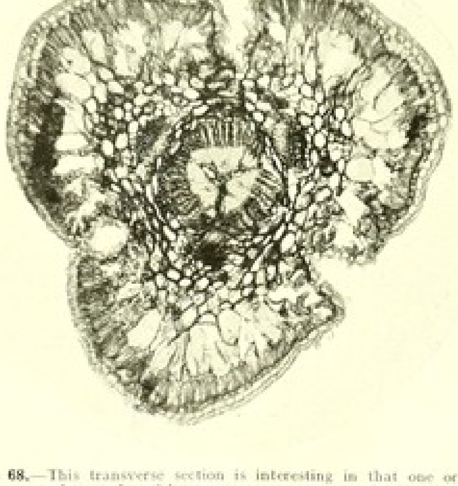


Figure 68.—This transverse section is interesting in that one or two elongated cuticle processes are seen on the lower of the assimilating surface. No oil cavities occur in this or previous sections, where also the endodermal and transfusion cells are not arranged in any order. The ventral surfaces on the two left concrescences have edged together, and so shut out any communication between the air and the stomata. *C. glauca*, × 80.

Cross sections of branchlets and decurrent leaves of Callitris glauca, R.Br.

conspicuous figure here. The transfusion tracheids can be seen at the lower left and right of the picture with their pitted cells, where also come into vision portions of phloem and xylem of the central axis. The epidermal cells are conspicuous at the top of the picture on the two portions of the convex dorsal surfaces, below which on the extreme right are four hypodermal cells just brought into the picture. In Figure 77 is given a longitudinal section through a node showing an oil cell *in situ* in the concrescence and part of the free portion of the leaf. Figure 78 is a longitudinal section through the junction of two whorls, and showing the position of stomata on the ventral surface of the lower left leaf, where they appear as oval bodies, the aperture being indicated by a white line.

(*c*) Chemistry of the Leaf Oil.

Under this species are given results derived from the investigation of a considerable amount of material, gathered in various localities widely apart, and spreading over several years.

It will be seen that there is a remarkable uniformity in the oil of this species, no matter where the trees are grown, and that in some of its characters it is distinctly different from the oil of any other species of *Callitris*, excepting that of *C. propinqua* of South Australia.

The comparative constancy of the oil from this species cannot now be questioned, and what is true of this species appears also to be true of any other well-defined species of *Callitris*.

We have worked somewhat extensively on this species because it is more largely distributed than any other, and is the common tree in the interior of New South Wales.

The distillations were continued for six hours in nearly all cases, as it was found that a fair quantity of oil came over during the fifth hour.

The main constituents of the oils of all the samples of *C. glauca* were the same, and the higher boiling fractions in all cases were highly dextro-rotatory, due to the presence of dextro-rotatory bornyl-acetate and dextro-rotatory borneol. The comparative uniformity of results with the several fractions, obtained with the five samples redistilled, can be seen from the tabulated results (Table II at end of article). The crude samples of oil were mostly slightly yellowish in tint, and only one or two were reddish in colour; this was mostly due to the material being distilled in iron vessels. When cleared by dilute aqueous solution of soda, the oil was almost colourless, being slightly yellowish in tint. When rectified by steam, or by direct distillation, it was quite colourless. In both odour and appearance the leaf oil of this species of *Callitris* compares favourably with the better "Pine-needle oils" of commerce, and the yield is also very good.

On keeping the leaf oils of *Callitris glauca* for some time a resinous substance eventually formed, and attached itself to the sides of the bottles. This was probably caused by light and oxidation, because the specific gravity of the oil had also slightly increased. The solubility of the oil in alcohol also rapidly diminished on keeping, as when freshly distilled the solubility was often as low as one volume of 90 per cent. alcohol, varying from that to ten volumes 90 per cent. alcohol, but when aged it did not form a clear solution, at ordinary temperatures, even with ten volumes absolute alcohol. The solubility test appears therefore, to be of little help in judging the value of the crude oil of this species of *Callitris*.

Equal volumes of the crude oils of each of the seven samples here investigated were mixed together, and the product analysed. It was lemon yellow in colour and retained the original odour. Although some of the samples had been distilled for a few years, yet, the alteration in any direction was not great. There was a slight increase in the specific gravity, and the increased insolubility in alcohol was marked. A very small amount of a phenol was extracted by aqueous alkali, it did not react with ferric chloride in alcoholic solution, and was, perhaps, the phenol common to the timber.

The specific gravity of the mixed oils at 16° C. = 0·8813. The rotation $a_D = +27·9$. The refractive index at 16° C. = 1·4771. The ester content by boiling was 13·82 per cent.; in the cold, with three hours contact, it was 6·26 per cent. These results compare favourably with those obtained with the Wellington sample under the same conditions. A portion was esterised with acetic anhydride in the usual way. The esterised oil had rotation $a_D + 28·1°$; and it having slightly increased with the increased ester, indicated that the alcohol was borneol. The amount of ester was 18·94 per cent., so that the amount of free alcohol as borneol was 4·63 per cent. This result closely approached that obtained with the Trangie sample.

No. 1.—This material was collected at Narrandera, New South Wales, 350 miles south-west of Sydney, 25th April, 1907. The terminal branchlets with their decurrent leaves and fruits were steam distilled for six hours in the usual way, and in a manner corresponding to what would be done commercially. The amount of oil distilling from 784 lb. of material was 70½ oz., equal to 0·562 per cent. This is a fair average yield of oil from this species.

Material was collected from one large tree and distilled separately, this was kept distinct so that the product from a single tree could be determined in comparison with that from general material. The bulk of the oil was obtained from the leaves of several trees as usual.

The yield of oil from the single tree was equal to 0·559 per cent. It gave the following results:—Specific gravity at $\frac{18}{15}$° C. = 0·8671; rotation $a_D = +21·2°$;

refractive index at 18° C. = 1·4744. The freshly-distilled oil was soluble in one volume 90 per cent. alcohol. The saponification number was 35·7, equal to 12·49 per cents. of ester as bornyl- and geranyl-acetates.

The oil obtained from the general material was taken for the full investigation. It had specific gravity at 18° C. = 0·8729; rotation $a_D = + 27·9°$; refractive index at 18° C. = 1·4747. The freshly distilled oil was scarcely soluble in ten volumes of 80 per cent. alcohol, but was not rendered turbid by excess; it was readily soluble in one volume 90 per cent. alcohol, but rapidly became less soluble on keeping. The saponification number was 47·03, equal to 16·46 per cent. of ester. In the cold with alcoholic potash, and with three hours contact, the saponification number was 24·5, equal to 8·57 per cent. of ester.

On redistilling, practically nothing came over below 156° C.; between 156° and 160,° 30 per cent. distilled; between 160° and 175° C., 45 per cent.; between 175° and 200° C., 8 per cent.; between 200° and 230° C., 12 per cent. The specific gravity of the first fraction at $\frac{21}{15}$° C. = 0·8562; of the second, 0·8571; of the third, 0·8689; of the fourth, 0·9415. The rotation of the first fraction $a_D = + 30·4$; of the second, + 27·2°; of the third, + 21·0°; of the fourth, + 32·4. The fourth fraction contained 68·2 per cent. of ester. Both borneol and acetic acid were isolated and determined; so that the high activity is largely due to the presence of dextro-rotatory bornyl-acetate, and to dextro-rotatory borneol also. The refractive index at 21° C. of the first fraction = 1·4733; of the second, 1·4736; of the third, 1·4744; of the fourth, 1·4723.

Terpenes.—The first and second fractions were mixed together and redistilled. Between 156° and 160° C. 42 per cent. distilled, and 29 per cent. between 160° and 161° C. The specific gravity of both fractions at 20° C. = 0·8549; the rotation of first fraction $a_D = + 30·8°$, or a specific rotation $[a]_D + 36·02°$ and the refractive index at 20° C. = 1·4733. The nitrosochloride was easily prepared from this fraction, and was finally purified from chloroform by precipitating with methyl alcohol. The nitrosopinene was prepared from this, and when finally purified from acetic ether it formed good crystals which melted at 132° C. The low boiling terpene in the leaf oil of this species is, therefore, dextro-rotatory pinene. The second fraction also consisted largely of this pinene. The third fraction (175°–200° C.) consisted largely of dextro-rotatory limonene together with dipentene. The presence of these terpenes in the leaf oil of this species was completely proved in the oil obtained from the material from Boppy Mountain, No. 2.

Alcohols.—That portion of the oil distilling between 200°–230° C. was taken for the determination of the alcohols and the acids of the esters. 1·091 gram of oil reg. 0·2128 gram potash, S.N. = 195·05, equal to 68·26 per cent. ester. The remainder was saponified by boiling in aqueous potash, and the oily portion separated. This oil had a marked odour of borneol. Sufficient borneol was

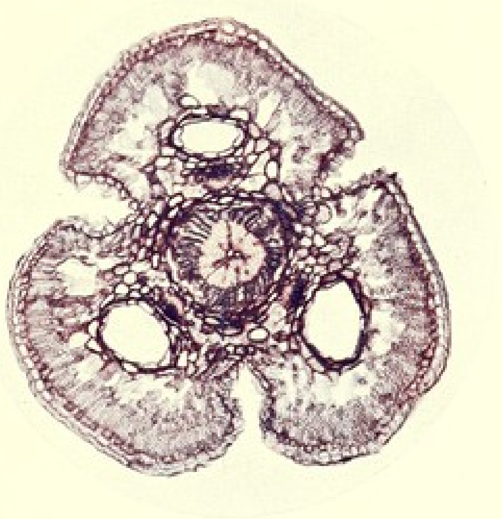


Figure 71.—Transverse section as in Figure 70. The secretory cells and strengthening walls are well shown around the oil cavities, under which are seen in two colours the leaf trace, with its normally orientated phloem, and accompanying endodermal cells and transfusion tissue. Stained with hæmatoxylin and safranin. *C. glauca*, × 80.

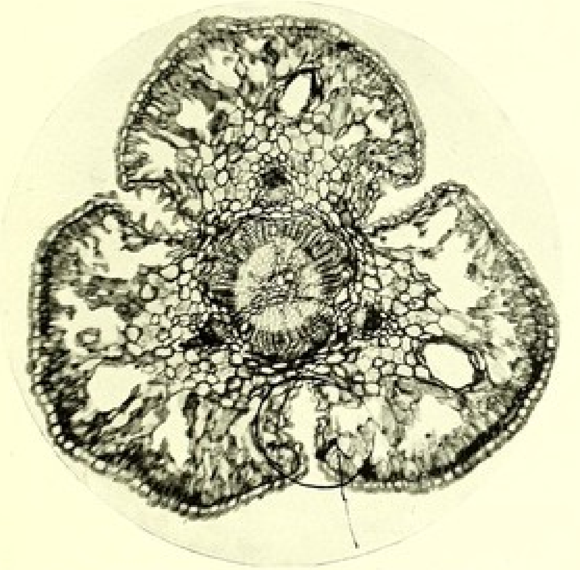


Figure 69.—Transverse section through central axis and decurrent leaves. The endodermal cells and transfusion tissue are seen massed together around the central axis and enclosing the leaf trace, and extending up to the oil cavities. *C. glauca*, × 80.

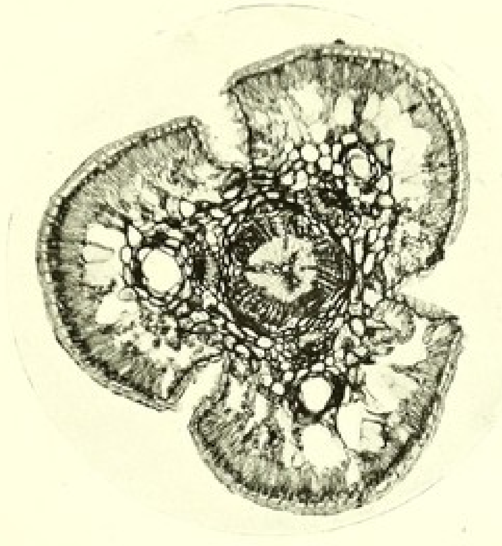


Figure 70.—Similar section to Figure 69. The decurrent channels are seen to be quite opened in contrast to those of Figure 69. *C. glauca*, × 80.

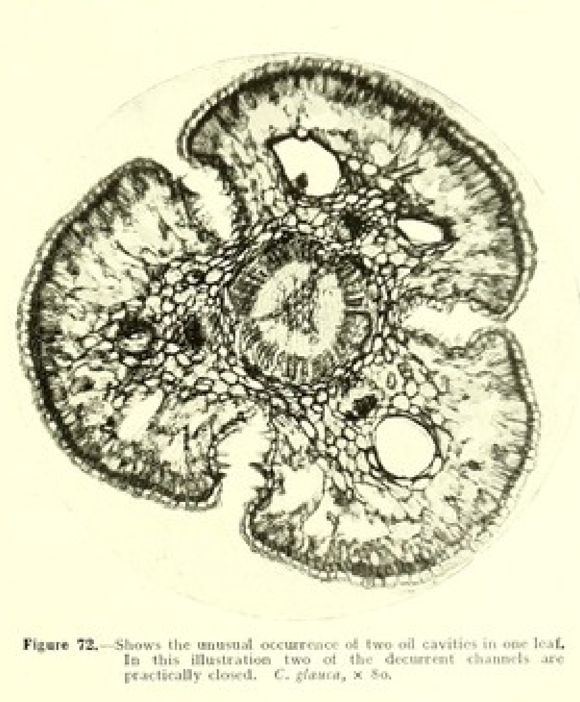


Figure 72.—Shows the unusual occurrence of two oil cavities in one leaf. In this illustration two of the decurrent channels are practically closed. *C. glauca*, × 80.

Cross sections of branchlet and leaves of C. glauca, R.Br.

present to form a semi-solid portion floating in the oil, and this was separated and purified from petroleum ether and absolute alcohol. It formed well-defined crystals, with a marked odour of borneol and melted at 202–3 °C. The appearance, odour, and melting point, together with its association, show this alcohol to be borneol.

Geraniol, which is a common constituent in the leaf oils of the *Callitris*, is also most probably present in combination with acetic acid. This is indicated by the fact that about half the total amount of esters was saponified in the cold in three hours.

Geranyl-acetate as well as bornyl-acetate may thus be considered to be present in the leaf oil of *C. glauca*, as well as in that of most species of *Callitris*. Nineteen hours contact with alcoholic potash in the cold saponified less than two-thirds of the total ester in the oil of *C. glauca*, while readily saponifying the total ester in the oil of *Callitris Tasmanica* in two hours.

Volatile Acids.—The aqueous solution separated from the saponified alcohols was evaporated down, and distilled with sulphuric acid until all the volatile acids had come over. This acid distillate was exactly neutralised with barium hydrate solution, evaporated to dryness, the barium salt prepared in the usual way, and dried at 110° C. On ignition with sulphuric acid 90·67 per cent. of barium sulphate was obtained. As the theoretical amount for barium acetate should be 91·35 per cent. it is evident that a small amount of a volatile acid of higher molecular weight was present. During the distillation and preparation of the acids, a marked odour of butyric acid was detected, so that probably it is that acid which is present with the acetic acid. The barium salts, therefore, contained 95·87 per cent. barium acetate, and 4·13 per cent. barium butyrate. The indications for butyric acid have also been obtained with the leaf oils of several of the species, particularly with *C. gracilis*, where it is most probably present in combination with terpineol.

The oil of the general material from Narrandera, 25th April, 1907, was rectified by steam distillation in the ordinary way; the greater portion of the oil readily came over. When it distilled very slowly the receiver was charged, and the distillation continued for a considerable time. A small quantity of a yellowish oil was thus obtained. The bulk oil when dried was colourless, had a very refreshing "Pine-needle-oil" odour, and was bright in appearance. The saponification number was 39·13 equal to 13·7 per cent. of ester. The rotation $a_D = +28{\cdot}2°$; the specific gravity, at $\frac{24°}{15}$ C., = 0·8682; the refractive index at 24° C. = 1·4720. It was insoluble in ten volumes of 90 per cent. alcohol. It was soluble in absolute alcohol in all proportions up to two volumes, when it becmea turbid

The smaller portion of oil was somewhat viscous, and gave saponification number 127·12, equal to 44·5 per cent. of ester by heating, and 38·81 per cent.

by cold saponification, three hours contact. The rotation $a_D = + 19{\cdot}5°$; the specific gravity at $\frac{23°}{15}$ C. = ·9524; the refractive index at 24° C. = 1·4828.

It is thus evident that the whole of the ester is not easily redistilled by steam, although the greater portion comes over in the more readily obtained distillate.

No. 2.—This material was collected at Boppy Mountain, in the Cobar district, 440 miles west of Sydney, New South Wales, 25th May, 1903. The terminal branchlets with fruit were steam distilled in the usual way. The amount of oil obtained from 472 lb. of material was 46½ oz., equal to 0·616 per cent. The rotation of the crude oil $a_D = +31{\cdot}3°$; specific gravity at $\frac{18°}{15}$ C. = 0·8665; refractive index at 19° C. = 1·4779; saponification number = 34·19, equal to 11·966 per cent. ester. Saponification in the cold, twenty hours contact, gave S.N. 22·07, equal to 7·725 per cent. ester. When freshly distilled, the oil was insoluble in ten volumes 80 per cent. alcohol, but was soluble in one volume 90 per cent. It, however, on keeping, soon became insoluble in ten volumes 90 per cent. alcohol.

On redistilling, only a few drops came over below 156° C. Between 156° and 161° C. 30 per cent. distilled; between 161° and 165° C. 22 per cent.; between 165° and 200° C. 37 per cent.; between 200° and 228° C. 6 per cent. The specific gravity of the first fraction at $\frac{18°}{15}$ C. = 0·8545; of the second, 0·8555; of the third, 0·8649; of the fourth, 0·9434.

The rotation of the first fraction $a_D = + 32{\cdot}6°$; of the second, + 32·0°; of the third, + 30·7°; of the fourth, + 33·5°. Another distillation was made with comparable results. The oil which came over below 161° C. was redistilled, and 66 per cent. came over between 155° and 157° C. The specific gravity of this at 15° C. was 0·8606; the rotation $a_D = + 34{\cdot}5°$; or a specific rotation $[a]_D = +40{\cdot}09°$; the refractive index at 20° C. = 1·4731. The nitrosochloride was also prepared from it, and this when purified melted at 107–8° C. These results show this terpene to be dextro-rotatory pinene, as in the previous sample.

To determine the limonene and dipentene, the second and third fractions were again distilled, and 16 per cent. which came over between 172° and 175° C. (uncor.) was obtained. This had specific gravity at 15° C. = 0·8535 and rotation $a_D = + 28{\cdot}6°$. The tetrabromide was readily prepared from it in some quantity, and on complete purification from acetic ether it melted at 116° C. It was recrystallised, but still gave the same result. This indicated that both dextro-rotatory limonene and dipentene were present. This high melting point of the tetrabromide was met with in all the samples of *Callitris* from which it has been prepared.

That both dextro-rotatory limonene and dipentene were present was shown also by the activity of the tetrabromide when dissolved in acetic ether; this was

strongly dextro-rotatory. It may be assumed, therefore, that both forms of limonene occur in the oil of this species, and that the dextro-rotatory form always predominates.

The fourth fraction was saponified, and from the separated oil pure borneol was prepared. The acids of the esters were not determined, as this had been done in the previous sample.

No. 3.—This material was collected at Trangie, 320 miles west of Sydney, New South Wales, 28th November, 1902. The leaves were very dry at this time, as the State was suffering from a serious drought. This dryness does not, however, seem to interfere either with the yield of oil or with its constituents, and 472 lb. of material gave 46 oz. oil, = 0·61 per cent. The rotation of the crude oil $a_D = +30{\cdot}8°$; specific gravity at $\frac{24}{15}$° C. = 0·8631; refractive index = 1·4755 at 20° C.; saponification number 36·46, equal to 12·76 per cent. ester. The freshly distilled oil was soluble in two volumes 90 per cent. alcohol. A portion of the oil was acetylated by boiling with acetic anhydride and sodium acetate in the usual way. The saponification number was then 52·09, equal to 18·23 per cent. ester. The free alcohol present was therefore 4·8 per cent. as borneol. On redistilling, 27 per cent. came over below 160° C.; 37 per cent. between 160 and 165° C.; 16 per cent. between 160–180° C.; and 12 per cent. between 180–225° C.

The specific gravity at 24° C. first fraction = 0·8477; of the second, 0·8494; of the third, 0·8561; of the fourth, 0·9256. The rotation of the first fraction $a_D = +32{\cdot}4°$; of the second, $+31{\cdot}6°$; of the third, $+30{\cdot}5°$: of the fourth, $+34{\cdot}2°$. The constituents were identical with those of the previous samples.

No. 4.—This material was collected at Wellington, 250 miles west of Sydney, New South Wales, 17th March, 1903. 583 lb. of branchlets gave $59\frac{1}{4}$ oz. of oil, equal 0·635 per cent. The rotation of the crude oil $a_D = +28{\cdot}4°$; specific gravity at $\frac{17}{15}$° C. = 0·8659; refractive index at 19° C. = 1·4774; saponification number 34·58 equal to 12·103 per cent. ester. When treated with alcoholic potash in the cold, with three hours contact, the ester value was 5·936 per cent.; with nineteen hours contact the ester value was 8·095 per cent.

On redistilling, 27 per cent. came over below 161° C.; 27 per cent. between 161°–165° C.; 31 per cent. between 165°–200° C.; 7 per cent. between 200°–225° C. The specific gravity at 20° C., first fraction = 0·8550; of the second, 0·8565; of the third, 0·8664; of the fourth, 0·9416. The rotation of the first fraction $a_D = +30{\cdot}5°$; of the second, $+29{\cdot}3°$;. of the third, $+27{\cdot}2°$; of the fourth, $+32{\cdot}0$. The constituents of this oil were identical with those of the other samples.

No. 5.—This material was collected at Bylong, 240 miles west of Sydney, New South Wales, 2nd May, 1903. 511 lb. of branchlets gave $46\frac{1}{2}$ oz. of oil

Figure 73.—Transverse section through the opened edges of a decurrent channel, showing the relative position of the papillose projections to the stomata. Two pairs of guard cells being shown. *C. glauca*, × 160.

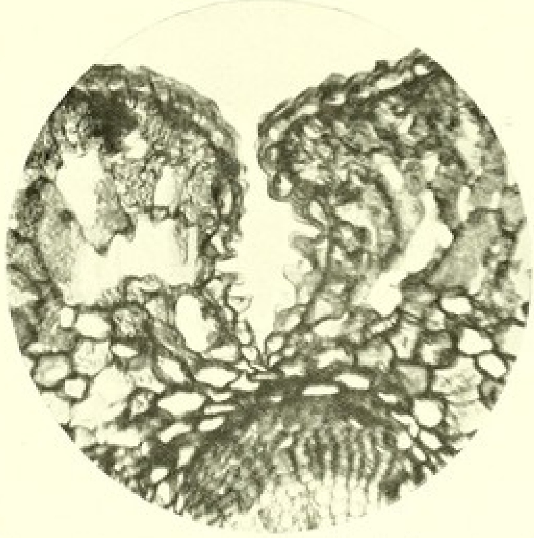


Figure 74.—Transverse section through closed edges of a decurrent channel, and showing structure in that part of the leaves. A stoma with its two guard cells is shown on the left. *C. glauca*, × 160.

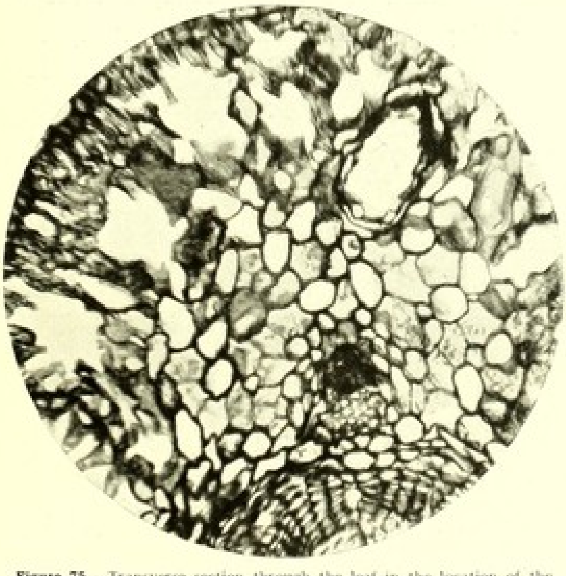


Figure 75.—Transverse section through the leaf in the location of the base of an oil cavity, with secretory cells and leaf bundle with phloem marked by the black patch. The transfusion tissue is clearly indicated by the smaller circles (bordered pits) in the individual cells. The papillose projections are shown on the lower left edge of the picture. *C. glauca*, × 160.

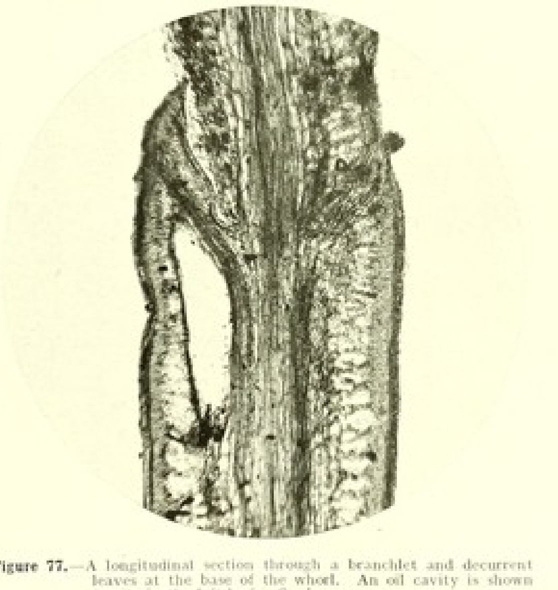


Figure 77.—A longitudinal section through a branchlet and decurrent leaves at the base of the whorl. An oil cavity is shown *in situ* in the left leaf. *C. glauca*, × 55.

Sections of different parts of leaves of C. glauca, R.Br.

= 0·569 per cent. The rotation of the crude oil $a_D = + 31·25°$; specific gravity at $\frac{19°}{15}$ C. = 0·8657; refractive index at 19° C. = 1·4749; saponification number 37·94, equal to 13·274 per cent. ester. Cold saponification, with three hours contact, gave 6·82 per cent. of ester, and with nineteen hours contact, 8·799 per cent. ester.

On redistilling, 28 per cent. came over below 160° C.; 28 per cent. between 160° and 165° C.; 32 per cent. between 165° and 200° C.; 7 per cent. between 200° and 225° C. The specific gravity at 19° C., first fraction = 0·8529; of the second, 0·8537; of the third, 0·8649; of the fourth, 0·9322. The rotation of the first fraction $a_D = + 32·2°$; of the second + 31·7; of the third + 30·6°; of the fourth + 32·5°. The constituents were identical with those in the other samples.

No. 6.—This material was collected near Tamworth, 280 miles north of Sydney, New South Wales, 3rd March, 1908. 388 lb. of branchlets, containing some fruits, gave 35 oz. of oil, equal to 0·563 per cent. The specific gravity of the crude oil at 24° C. = 0·8665; rotation $a_D = + 25·2°$; refractive index at 24° C. = 1·472; the saponification number was 40·2, equal to 14·07 per cent. ester. These results are practically identical with those obtained with the other samples, and it was thus thought unnecessary to carry the investigation further.

No. 7.—This material was collected at Nyngan, 380 miles west of Sydney, New South Wales, 29th December, 1899. 358 lb. branchlets gave 30½ oz. of oil, equal to 0·532 per cent. The distillation was continued for eight hours, but very little oil came over during the extra two hours; it was sufficient, however, to increase the specific gravity somewhat, although the ester content was but little improved. The specific gravity at 24° C. = 0·8782; rotation, $a_D = + 22·7°$; refractive index at 19° C. = 1·4774; saponification number 40·61, equal to 14·21 per cent. ester.

Table I.—Crude Oils from the Leaves of *Callitris glauca*.

No.	Locality and Date.	Specific Gravity ° C.	Rotation a_D	Refractive Index ° C.	Ester per cent.	Yield per cent.
1	Narrandera, 25/4/07...	0·8729 @ 18	+ 27·9°	1·4747 @ 18	16·46	0·562
2	Boppy Mountain, 25/5/03	0·8665 ,, 18	+ 31·3°	1·4779 ,, 19	11·96	0·616
3	Trangie, 28/11/02	0·8631 ,, 24	+ 30·8°	1·4755 ,, 20	12·76	0·610
4	Wellington, 17/3/03...	0·8659 ,, 17	+ 28·4°	1·4774 ,, 19	12·10	0·635
5	Bylong, 2/5/03	0·8657 ,, 19	+ 31·25°	1·4749 ,, 19	13·27	0·569
6	Tamworth, 3/3/08	0·8665 ,, 24	+ 25·2°	1·4720 ,, 24	14·07	0·563
7	Nyngan, 20/12/99	0·8782 ,, 24	+ 22·7°	1·4774 ,, 19	14·21	0·532

Figure 76.—Transverse section through a decurrent channel of two collateral leaves, which is marked by the papillose elongations of the cuticle of the transpiratory surface. Part of the xylem and phloem of the branchlet is seen at the bottom with endodermal and transfusion cells (pitted) on each side. Stained with hæmatoxylin. *C. glauca*, × 160.

Figure 78.—A longitudinal section through the junction of two whorls of leaves given to show the arrangement of the stomata on the ventral surfaces; they are seen on the lower left leaf as pinkish oval bodies. Stained with hæmatoxylin. *C. glauca*, × 50.

Table II.—Some redistillation results of five of the samples of Oils of *Callitris glauca*, with specific gravity and rotation results.

Numbers 1 to 5 as in Table I.

No.	1st.	2nd.	3rd	4th.	1st	2nd.	3rd.	4th.
1	156–160° 30%	160–175° 45%	175–200° 8%	200–230° 12%	·8562 +30·4	·8571 +27·2	·8689 +21·0	·9415 +32·4
2	156–161° 30%	161–165° 22%	165–200° 37%	200–228° 6%	·8545 +32·6	·8555 +32	·8649 +30·7	·9434 +33·5
3	Below 160° 27%	160–165° 37%	165–180° 16%	180–225° 12%	·8477 +32·4	·8494 +31·6	·8561 +30·5	·9256 +34·2
4	Below 161° 27%	161–165° 27%	165–200° 31%	200–225° 7%	·8550 +30·5	·8565 +29·3	·8664 +27·2	·9416 +32
5	Below 160° 28%	160–165° 28%	165–200° 32%	200–225° 7%	·8529 +32·2	·8537 +31·7	·8649 +30·6	·9322 +32·5

IV. TIMBER.

(*a*) Economics.

This is the most widely distributed species of the genus, and its timber, therefore, is more extensively used than that of any other *Callitris*. It is preferable to that of *C. calcarata*, R.Br., owing to its comparative freedom from knots and its straighter grain, and so is in general request for certain parts of house construction in the West and Central Divisions of the State. It is an easy working timber, and although usually possessing a quiet neat figure, it occasionally has some very handsome markings, which make it a valuable timber for some kinds of cabinet work, such as panelling, &c. When polished it is very attractive, and the decorative characters are well brought out in turned stands or columns for busts, statuettes, &c. Some such adorn the landings of the Technological Museum, and are a constant source of admiration to visitors.

The white-ants or termites are not particularly partial to it, and will attack it only as a *dernier ressort*, and this fact, of course, accounts for its utilisation for fence and foundation posts, in which capacity it is reputed to be very durable. The supply, unfortunately, of this most useful timber is gradually becoming less and less, and no steps are being taken for its propagation.

The following are results of transverse tests of timber specimens of *C. glauca* of standard size (38 in. by 3 in. by 3 in.).

Transverse Tests—*Callitris glauca:*—

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B. 3·02, D. 3·03	B. 2·968, D, 3·025	B. 3·005, D. 3·02
Area of cross section, sq. inches ...	9·15	8·938	9·06
Breaking load in lb. per sq. inch ...	4,850	4,290	3,050
Modulus of rupture in lb. per sq. in. ...	9,448	8,529	6,010
Modulus of elasticity in lb. per sq. in.	1,016,470	1,133,160	875,675
Rate of load in lb. per minute ...	485	451	210

Three smaller pieces, 12 in. by 1 in. by 1 in. gave the following results:—(1) broke at 900 lb., deflection ·37 in.; (2) broke at 850 lb., deflection ·28 in.; (3) broke at 690 lb., deflection ·20 in.

(*b*) Anatomy.

Very little if anything appears to have been done to investigate the anatomical structure of the timber of Australian *Callitris*, or at any rate our researches through the Conifer literature at our disposal revealed little or nothing. The data now given should, therefore, prove of interest in the future study of this genus. Phylogenetically the results are of some value, for a connecting link, so to speak, was found to exist between these living *Callitris* and the fossil pine woods of Australia and North America, in that some of the tracheids of the xylem contain a similar dark substance—its chemical identification being touched upon in another part of this work.

A transverse section of the timber viewed under a low magnification as in Figure 79, shows a more or less irregularity in the diameter and thickness of the tracheidal walls between the several medullary rays. This figure is interesting, in that there is quite an absence in the picture of any manganese compound in any of the tracheids; this is an unusual occurrence, and it simply shows that it is possible to obtain portions without this compound in the cells. The line of smaller or closely packed cells marks the autumnal growth and the point of transition from that season's wood structure to that of spring.

Under a higher magnification, as in Figures 80 and 81, a rather more uniform size of cell obtains, for although the tracheids are of varying diameters, yet the walls may be said to be of a fairly uniform thickness; in Figure 80 the black lines running from top to bottom are the parenchymatous cells of the medullary rays filled with manganese compound—the "end-on-view" of which is shown in Figures 84 and 85. In 80 and 81 are more plainly seen the autumnal tracheids with their restricted growth, and which form a darker line across the lower portion of the plate, Figure 80; these cells are slightly enlarged in Figure 81. The gradual diminution in size of the tracheids during this period is well seen, as also is the sudden change to enlarged tracheids of the spring period.

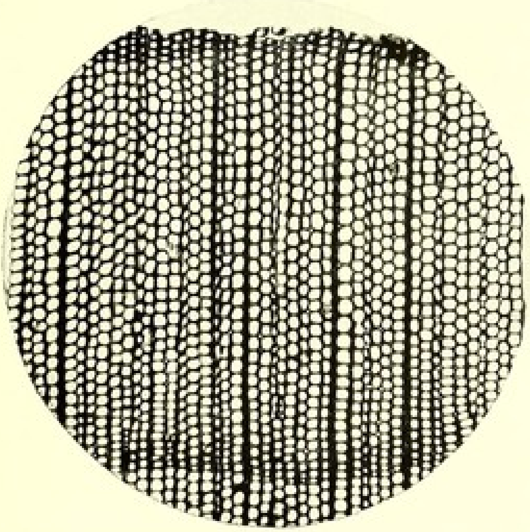


Figure 79.—Transverse section of timber through spring growth, bounded on the top and bottom by an autumnal ring of tracheids. *C. glauca*, × 50.

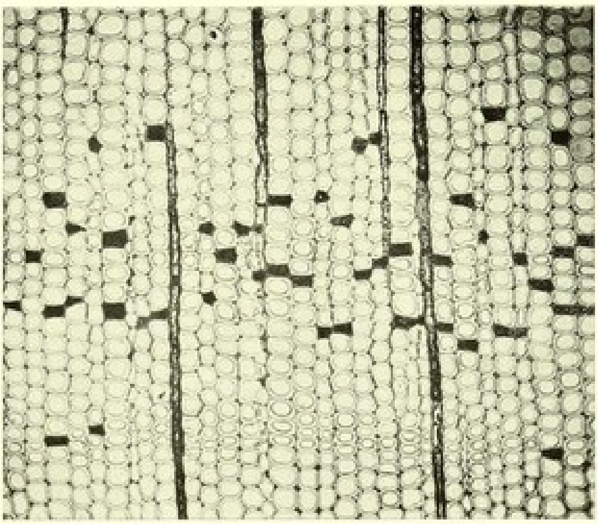


Figure 80.—Transverse section of timber. The dark lines are the medullary rays with their manganese compound contents and the rectangular dark markings the similar contents of the tracheids. *C glauca*, × 80.

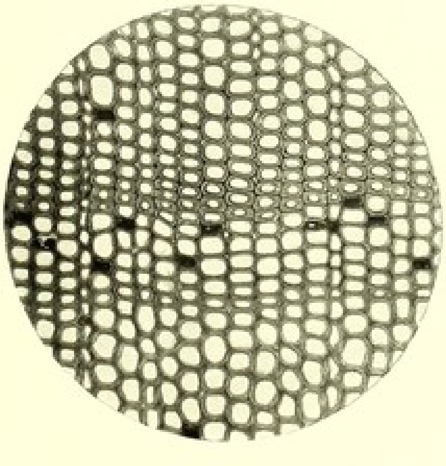


Figure 81.—Transverse section of timber at junction of spring and autumnal tracheids. *C. glauca*, × 80.

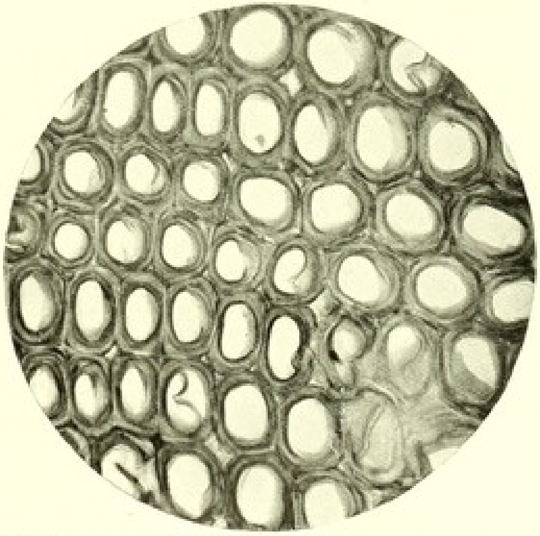


Figure 82.—Transverse section of timber showing structure of spring tracheids in greater detail than in Figure 81. *C. glauca*, × 210.

Cross sections of timber of C. glauca, R.Br.

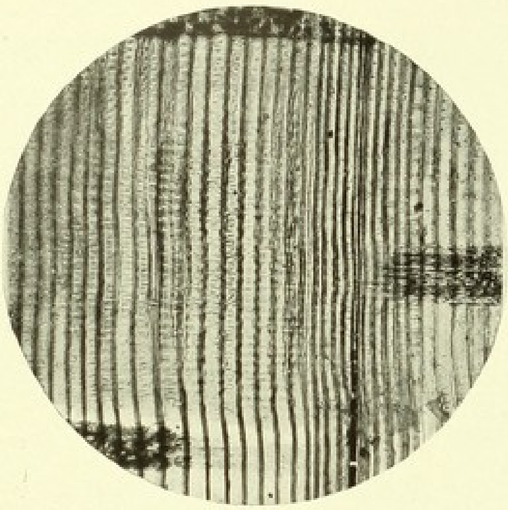


Figure 83.—Radial section of timber with autumnal tracheids towards the right centre. Portions of three rays are also seen. *C. glauca*, × 80.

Figure 84.—Tangential section of timber, showing varying heights of rays and their brown manganese compound contents. *C. glauca*, × 80.

Figure 85.—Tangential section, showing enlarged portion of Figure 84. The radial walls show the bordered pits in section. *C. glauca*, × 160.

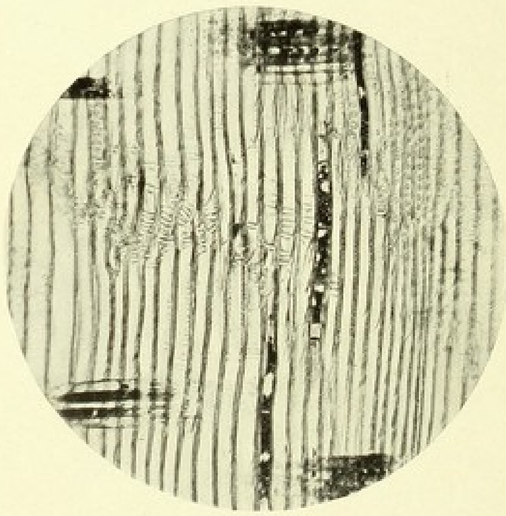


Figure 86.—Radial section of timber showing the brown manganese compound in the tracheids and ray cells. *C. glauca*, × 80.

Radial and tangential sections of timber of C. glauca, R.Br.

In Figure 81 there is a portion of a single circle (straight in the picture) of smaller tracheids, four or five cells distant from the well-defined autumnal ones, and which evidently indicates a cold " snap," or where the growth has been retarded. The manganese cavities are plainly shown, but no medullary rays are visible.

Figure 82 is portion of Figure 81 under a 210 magnification. The cells in the same rows are of almost equal diameters, and on the lower radial walls of the fifth row from the top, bordered pits in section can just be seen, and the torus is also discernible. It will be noticed in several instances, portions of the inner cell walls are detached and protrude into the cell cavity. Whether this is natural or accidental in the cutting, we could not decide. It hardly appears to be a case of tylosis.

Figure 83 is an 80 magnification of a radial section of timber. The general character of the parenchymatous cells of the medullary rays are rather obliterated by the dark contents. However, the pictures define clearly that the outer cells of the rays are of identical structure to the inner ones, and that the whole group may be classed as parenchymatous. This is a distinct difference of form or structure of the cells of medullary rays from some living non-Australian Pines. In the same figure it will be noticed that the narrow lumina of the autumnal wood are towards the right of the picture.

The numerous bordered pits are in single rows on the medullary walls of the tracheids, and are well brought out in both plates. The simple pits of the medullary rays are distinctly seen at the top right-hand corner, and the bottom of Figure 83. The diameter of the bordered pits varies according to the diameter of the lumen, and the presence of manganese compound in the tracheids is marked by the darkened content. Figure 83 has only one cell filled with manganese compound, which is low down in the right hand corner, and Figure 86 has three on the right hand centre of the field of observation, being the vertical views of the manganese cells of Figs. 80 and 81.

Medullary Rays.

In addition to what has been stated under Figure 83 it may be further remarked that these organs present novel features when compared with those of Angiosperms. In the radial and tangential sections they are found to consist entirely of narrow parenchymatous cells circular in form when viewed tangentially in the wood. Each ray is composed of a varying number of cells arranged in horizontal parallel strata only a single cell in breadth. Most of the outer and inner cells are filled with manganese compound similar to the other cells, the radial walls being marked by the presence of simple pits, and cells void of this substance are the exception. In Figures 87 and 88 they are shown radially *in situ* in the wood substance, the varying length is evidently due to the plane of cutting, the vertical diameter varying in each case according to number of cells.

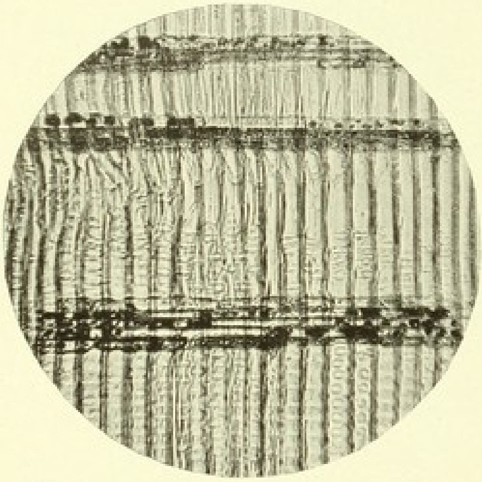


Figure 87.—Radial section of timber, showing three rays running from left to right in the picture. Numerous bordered pits are shown in the radial walls. *C. glauca*, × 80.

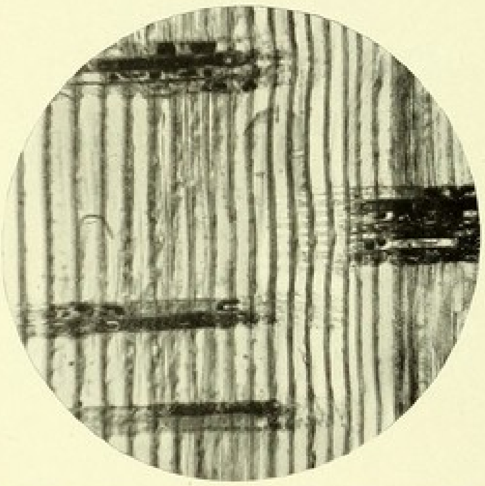


Figure 88.—Radial section of timber. Portions of four rays are shown, none of which has outer tracheidal walls. *C. glauca*, × 80.

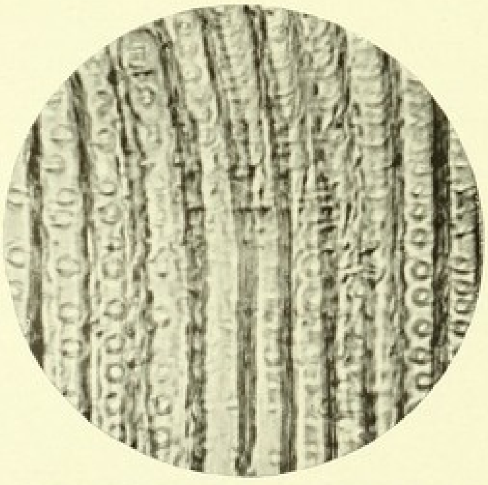


Figure 89.—Radial section, showing bordered pits *in situ* in radial wall. *C. glauca*, × 160.

Radial sections of timber of C. glauca, R.Br.

In the tangential sections, Figures 84 and 85, a good end-on view is obtained of the medullary rays. They are the dark, black-coloured fusiform bodies embedded in the radial, vertical walls of the tracheids, a single cell in breadth, and ranging in number from two to twelve in height. The black colour is due to the presence of the manganese compound.

These two sections are of further interest in that they show distinctly a run of contiguous bordered pits in some of the radial walls, and the greater magnification of Figure 85, details fairly well the torus and closing membrane. The manganese compound was found to be present in nearly all sections of timber cut, as indicated by black patches or spots scattered throughout the xylem, yet there was quite an absence of constancy in the dispositions of the cells, so that they were found to be of little value for systematic classification.

(*c*) Chemistry.

(See articles on the Phenol and the occurrence of Guaiol.)

(*d*) Forestry.

From the economics deducted in this research, beyond those already known, this tree is worthy of serious consideration for sylviculture especially for its timber, as it is naturally adapted to withstand the natural conditions of the interior of this continent, thus flourishing where many other trees would perish. Its timber is highly prized for house-building, fencing, &c., in those parts, more especially for its white-ant resisting qualities.

The pine-timber industry has been largely responsible for the opening up of some districts in New South Wales. To give one instance: Years ago what was then known as the Dubbo Bush was exploited; this forest extends back to Cobborah on the one side, and a splendid lot of timber has been obtained from this bush. Cypress Pine predominates, and this timber is one of the best for building purposes. At Balladoran a mill was established for dealing with Cypress Pine, and employed a great number of men; and other similar cases could be quoted.

It is strongly recommended as a tree suitable for South African forestry.

V. BARK.

(*a*) Economics.

Apart from its yielding resin, the presence of tannin in the bark, shown by the numerous analyses, proves it to be a tan bark of some value (see analyses appended).

(*b*) Anatomy.

The most characteristic feature of the bark is the very large number and size of the oleo-resin cells distributed throughout the entire cortex, both inner and outer. Macroscopically they appear, in a freshly transverse cut of the mass,

as so many concentric white rings, being more pronounced in the darker outer bark or cortex, and where, after the oil of the cell has been volatilised or removed, resin or sandarac, as it is called, remains as a white solid, filling the cells and giving the appearance of tangential parallel bands or rather rows. In the living bast or inner bark the cell content is in a liquid condition, and on a cut being made into fresh specimens there flows at once a liquid, which, however, indurates into beads or tears as soon as the volatile portion has evaporated or altered.

Figures 90 and 91 (longitudinal sections) show these bodies to be cavities rather than resin ducts or canals, and this is further proved by the small flow of liquid from a cut in the bark, which is quite a reverse order of things to that found occurring in the American Conifer bark and wood which yield the " naval stores " of that country, and give a continuous flow for a whole season when cut, thus proving that they are in that case canals that have been tapped. Microscopically these cells are found to be not quite so regularly arranged as appears macroscopically, but, nevertheless, their numerical strength is even then well emphasised, as shown in the transverse sections in Figures 92 and 93. The anatomical structure is interesting in that the variety of vessels is limited. The cambium is succeeded by concentric rings of cells of three distinct characters.

The most noticeable concentric row is that composed of cells of sclerenchymatous bast fibres with their much-thickened walls. These uniseriate concentric rings of bast cells are generally separated from each other by three rows of cells, a regularity that is rather unusual, as it does not appear to have been observed before in other Conifers, the general rule being consistently three or four intervening rows. The middle row of these cells, is of a parenchymatous nature, and these are often filled with manganese compound, especially in the outer cortex, and sometimes found longitudinally flattened, whilst at other times they are of a lysigenous character, for, becoming extended, they push out, or flatten as it were, the contiguous cells on each side of it and the sclerenchymatous bast cells. The intervening cells between these parenchymatous and bast ones are sieve tubes.

At irregular intervals are concentric bands of periderm or cork cells, more especially in the outer cortex.

Irregularly scattered throughout the mass, it is found some of the cells of the parenchymatous bands have tannin content determined by the usual tests. Altogether there is a regularity of successive layers of the different cells similar to that which appears to characterise some of the Conifers of the northern hemisphere (*vide* de Bary, p. 494; also " Some North American Coniferæ," E. S. Bastin and H. Trimble), but differing from some of the American Coniferæ barks figured by Bastin and Trimble. The medullary rays are not so pronounced as in the xylem, the particular feature being the numerous perforations of the communicating aperture with the lumen of the contiguous tracheids.

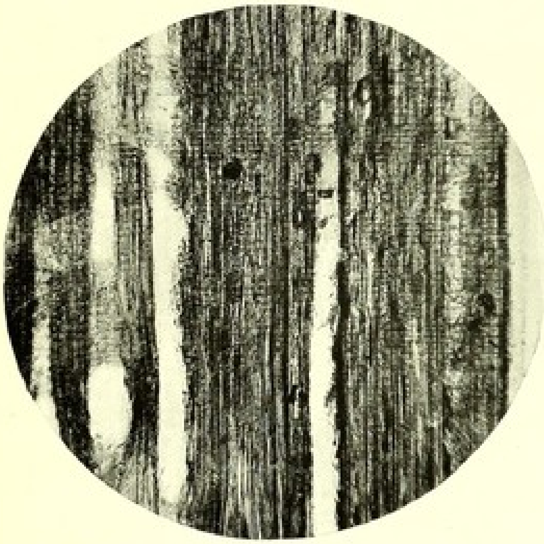


Figure 90.—Longitudinal section of inner bark. The light spaces are oleo-resin cavities. The thin parallel lines from top to bottom of the picture are the bast fibres; and rays are seen extending from left to right. *C. glauca*, × 43.

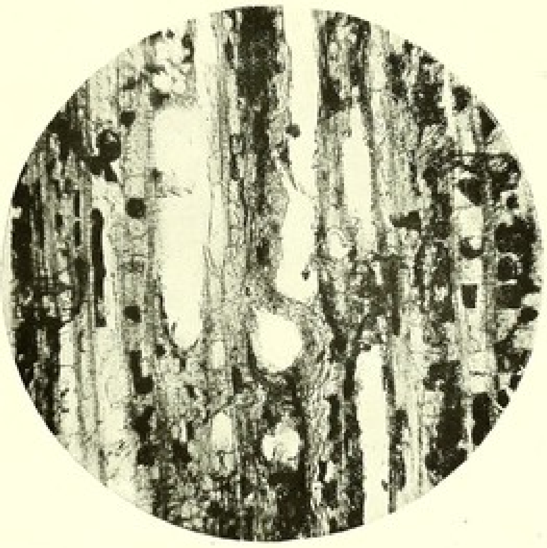


Figure 91.—Longitudinal section of outer bark. The dark patches are the brown manganese compound of the cells. *C. glauca*, × 43.

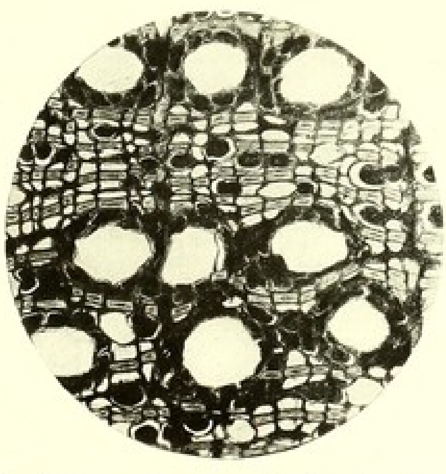


Figure 92.—Transverse section of inner bark. Nine oleo-resin cavities with their secretory cells are shown. The dark patches denote the presence of the manganese compound. *C. glauca*, × 80.

Sections of bark of C. glauca, R.Br.

(*c*) Chemistry.

The bark of this species is, macroscopically, quite distinct from those of *C. calcarata* and *C. arenosa*. It is more fibrous, and in section does not show the inner cortex so distinctly or so well defined as with those species. Externally, the bark of *C. glauca* is grey, and often somewhat light in colour; in section it has a flesh tint well marked in the thicker barks. When taken from large trees the bark is deeply furrowed, but has an interlocked fibrous appearance, which cannot be mistaken for the harder and more compact bark of *C. calcarata*.

Three samples of the bark of this species were determined:—

(*a*) Bark from small to medium size trees, collected at Narrandera, New South Wales, March, 1909. Its total thickness was from 15 to 20 mm.

The following results were obtained:—

Moisture ...	... 11·60	per cent.
Total extract	... 20·85	,,
Non-tannin	... 6·17	,,
Tannin ...	... 14·68	,,

(*b*) Bark from a large tree, 1 ft. 10 in. in diameter. The bark was very thick, ranging up to 30 mm. (nearly 1¼ inches). It was somewhat fibrous and deeply furrowed. It was collected at Narrandera, New South Wales, April, 1907.

The following results were obtained:—

Moisture ...	... 11·80	per cent.
Total extract	... 19·72	,,
Non-tannin	... 5·12	,,
Tannin ...	... 14·60	,,

The same bark was extracted entirely with cold water, with eighteen hours contact, and it then gave the following results:—

Moisture ...	... 11·80	per cent.
Total extract	... 12·70	,,
Non-tannin	... 2·45	,,
Tannin ...	... 10·25	,,

(*c*) Bark taken from a tree 5 to 6 inches in diameter. In thickness it ranged up to 12 mm. About half of this thickness consisted of the more compact portion of the bark. It was collected at Narrabri, New South Wales, June, 1909.

Figure 93.—Transverse section of a portion of bark. The bast fibres are the rectangular, yellow bodies extending in almost parallel lines, across the picture from left to right. The oval spaces are the oleo-resin cavities and the two bands of irregularly shaped, thin-walled cells are periderm. Unstained, *C. glauca*, × 100.

The following results were obtained:—

Moisture ...	...	12·50 per cent.
Total extract	...	17·49 ,,
Non-tannin	...	6·97 ,,
Tannin ...	...	10·52 ,,

To determine the value of the inner "rossed" bark of this sample, the outer portion was removed until a comparatively smooth surface was obtained, the bark had thus been reduced to about half its original thickness. This "rossed" bark gave the following results:—

Moisture ...	...	12·60 per cent.
Total extract	...	21·69 ,,
Non-tannin	...	8·90 ,,
Tannin ...	...	12·79 ,,

CALLITRIS GLAUCA, R.Br.

BOTANICAL SURVEY OF THE SPECIES IN NEW SOUTH WALES. (See also Map).

From data supplied by Public School Teachers and other correspondents.

(Where no information is given under Remarks, only herbarium specimens were received. The information is given without comment.)

Locality.	County.	Remarks.
Angledool	Finch	Taking a radius of 50 miles around here, it may be said that pines only grow on the sand ridges, or the base of other middle ridges. The pine is not very plentiful about here. I should think it does not cover more than one two-hundredth part of the above radius. *Timber.*—The average of full-grown trees is from 50 to 70 feet; diameter 12 to 18 inches, some few measure 2 feet. *Resin.*—They do not exude much resin unless wounded. Both species yield about the same quantity. Mr. R. L. Moore, Manager, Angledool Station, informs me that he has used the resin in the making of candles, and that it answers admirably. The resin is first reduced to a fine powder and then thoroughly stirred in with hot liquid fat, and the candles made in moulds. The fat, however, should not be allowed to boil. (A. Paddison.)
Attunga	Inglis	Occupies 1 to 20 acres. (Alfred Pritchard.)
Baan Baa	Pottinger ...	Covers one-third of the area of the district. (V. N. Walker.)
Ballarah, Cobbora	Lincoln ...	Grows in flat country in detached clumps, varying in extent from 1 to 20 acres. (J. Davis.)

CALLITRIS GLAUCA, R.BR.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Ballol Creek, Narrabri ...	Jamison ...	About 20,000 acres. They are very numerous in nearly all parts of this district. It is impossible to give a proper estimate without survey. (H. W. Strangways.)
Bancanya, *viâ* Milparinka ...	Evelyn	(H. H. Burns.)
Barmedman	Bland	*See* under Cootamundra.
Barringun	Culgoa	Sand ridges; 4,000 to 5,000 acres. (B. C. Hughes.)
Bendolba	Gloucester ...	Scattered on the ranges. (R. J. Fawcett.)
Berrigan	Denison... ...	The Murray Pine occurs in belts and patches, and the area of the pine country is very great, reaching from 7 to 8 miles in the north to 10 to 12 miles on the south of Berrigan. In an easterly direction I have travelled over 40 miles through pine country, and on the west I know it to reach at least 10 miles. The area given above is all pine country, but landholders have destroyed most of the timber, and a thick growth is now met with on reserves only. *Timber.*—There are very few large trees, and I think the average diameter would not exceed 9 inches, and the height 30 feet. *Resin.*—Very little resin exudes, and I have searched many trees without obtaining any whatever. I put cuts into some three weeks ago, but very little resin was produced. (H. B. C. Hughes.)
Bethungra	Clarendon ...	Scattered throughout the district. (R. F. Dale.)
Boggabri	Pottinger ...	The whole district round. *Resin.*—Exudes resin freely. (Theo. Sheehy.)
Boppy Mountain.	Robinson ...	(R. H. Cambage).
Box Ridge, Sofala	Roxburgh. ..	(R. Strong.)
Brawlin	Harden ...	The largest are about 2 feet in diameter at the base, and from 80 to 90 feet high. (Robert Black.)
Burrumbuttock	Hume	Murray Pine, from 1,000 to 2,000 acres. This area is covered with pines, but there are odd trees scattered over a large area—approximately from 80,000 to 100,000 acres. (A. T. Watson.)
Bylong...	Phillip	(H. King.)
Bynya, Narrandera	Cooper	200,000 acres. *Timber.*—70 feet high, 2 feet diameter. (A. B. Carroll.)
Canowindra	Bathurst ...	A few trees. (D. Colleton.)
Carroll	Buckland ...	Within a radius of 10 miles from here there must be at least 1,000 acres covered by the above pines. *Timber.*—Splendid grown trees were here a few years ago, but now the larger ones are all cut down, and used by our local sawmill; the majority of them now growing are not above 18 inches at the butt. *Resin.*—A fair amount of resin exudes, especially from trees that are marked or injured in the bark. (James Delmege.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Cassilis	Bligh	There are patches of considerable extent in different parts of this district covered for the most part by pine trees. They keep to the poor and sandy country. (H. W. Smith.)
Clareval, Stroud	Gloucester ...	The Cypress grows in a brush with beech and varieties of the fig, covering an area about 7 miles long by 3 wide. *Resin.*—Neither of the two varieties exude a sufficient quantity of resin to be of any commercial value. (A. McLennan.)
Clear Hills, Daysdale ...	Urana	7,000 acres; covering about two-thirds of the country side. (L. E. Fraser.)
Cocomingla, Cowra	Monteagle ...	The White or Silver Pine is not so common as the Red or Cypress Pine (*C. calcarata*) in the mountains in this district, but it is the principal sort found on the level country, both sides of the Lachlan, for hundreds of miles into the interior. (Alex. Elliott.)
Condobolin	Cunningham ...	2,500 acres. *Timber.*—Height, 40 feet; diameter, 14 to 20 inches. *Resin.*—Plentiful. (H. J. Browne.)
Coonamble	Leichhardt ...	In the district there are seventeen forest reserves, aggregating 486,700 acres, which embrace nearly one-tenth of the pine-bearing area. Not found immediately on the Castlereagh River more than say 15 miles below Coonamble, as the continuous black-soil country commences at about that distance. The supply is practically inexhaustible. The Geelmoy Scrub extends from Come-by-Chance to Coonabarabran, about 60 miles, with a width of 20 to 40 miles. The Big Monkey Scrub from Gilgandra to below Bourbah. Smaller scrubs are Nebra and Urawilkie holdings. (E. H. Taylor, F. T. Berman.)
Cootamundra	Harden ...	Out towards the flat country the White Pine is met with. A large area, embracing thousands of acres, is to be met with extending from Barmedman, Temora, and Wyalong. *Resin.*—Copious flows from both varieties in hot months of the year. (T. B. Mulligan, T. W. Henry.)
Cowra	Monteagle ...	They are to be seen all sizes and heights, from the size of a whip-handle and 2 feet high, up to trees with a diameter of 2 ft. 6 in., and height of 80 or 90 feet. *Resin.*—From every knot on the trunk, and score or crack in the bark, the resin oozes out like stalactites. When the trees have been ring-barked, the gap that has been cut round them becomes, in a short time, entirely filled up with resin. (A. Elliott.)
Cullenbone	Wellington ...	Interspersed with *C. calcarata*. (E. R. Langbridge.)
Daysdale	Hume	There is very little ground covered by pines now, as most of the land is cleared. (L. R. Brown.)
Denman	Brisbane ...	About 1,000 acres. (W. Johnson.)
Digilah...	Lincoln ...	Common pine very plentiful. (H. A. Patrick.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Dilga and Ardill	Gordon	About one-tenth of the ground. (S. E. James.)
Dubbo	Gordon	(J. Davis.)
Duesbury and Wilgas ...	Oxley	The average height is about 45 feet; average diameter, 9 to 15 inches. *Resin.*—A large quantity is sometimes found on the trees. (J. Lockart.)
Elsmore	Gough	The scrubs are in patches covering several miles in area. (J. W. Parkins.)
Enngonia	Gunderbooka ...	Scarce, occurring in small numbers on isolated places on the sand hills. (C. O'Hara.)
Eugowra, *viâ* Orange ...	Ashburnham ...	Cover the whole of this district, and are more numerous than any of the other forest trees. They extend for an indefinite distance towards the plains of the Lachlan River in the west; as far as Cudal on the east; southward and northward for many miles. *Timber.*—Specimens of timber of this species have remained sound after being in the ground for forty years (O. Blacket); grows to a height of 50 to 60 feet; average diameter, 8 to 11 inches; greatest height, 100 to 120 feet; greatest diameter, 18 to 24 inches. *Resin.*—Exudes freely. (Thos. Miller.)
Eulah Creek, Narrabri ...	Nandewar ...	Most common. The whole of the Narrabri district is pine-bearing country, and, although an immense quantity has been cut for timber, fencing, &c., and so much more ringbarked, large areas are still to be met with, and in many places the young pines are growing up as thickly as ever. (T. Abel.)
Euston	Taila	Equally distributed with *C. calcarata.* (R. Brown).
Forest Hill	Cowley	(W. J. Peacock.)
Galathara-road, *viâ* Narrabri	Nandewar ...	Hundreds of acres in and around Narrabri West, Jack's Creek (4 miles), Deep Creek, Eulah Creek, and in the scrub around Killarney. Places mentioned are within easy access of town. Pine belt from 4 to 20 miles. (J. Morrissey.)
Galway Creek, *viâ* Eugowra	Ashburnham ...	(J. L. Sim.)
Garra	Ashburnham ...	On the flats. *Timber.*—The trees in this neighbourhood are generally small, one measuring 1 foot in diameter and 20 feet high would be considered a large tree. (L. C. Young.)
Ganmain	Bourke	The greater part of the country from the Murray to the Lachlan is more or less wooded by the Murray Pine. *Timber.*—Perhaps 40 feet high and from 9 to 12 inches in diameter. The largest run 100 feet high and nearly 2 feet in diameter, but near settlement these have all been cut down. *Resin.*—They all exude resin, especially in hot weather. (W. B. Breyley.)
Gerogery	Goulburn ...	(J. Marine.)
Gilgandra	Ewenmar ...	Unlimited area; close to here is a belt of pine scrub, a mile in width and 20 miles in length. (E. H. Taylor.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Goolagong	Forbes	Black and White Pine in thousands of acres—mostly back from the river flats, in fact most of the hills are covered thickly with a small sort fit only for fishing rods. *Timber.*—60 to 70 feet high, and yield the best timbers. *Resin.*—The White yields the most. (F. L. D'Aran.)
Gralgumbone (Coonamble) ...	Leichhardt ...	(E. H. Taylor.)
Green's Gunyah (Lockhart) ...	Urana	(Alice M. Ellis.)
Gregador, Wagga Wagga ...	Wynyard ...	Thickly studded with pines for many miles. *Timber.*—20 to 30 feet in height, and 1 foot or more in diameter. *Resin.*—A fair amount is exuded in the season. (Susan McNamara.)
Grong Grong	Bourke	Small patches. (J. Bicherstaff.)
Gunbar	Nicholson ...	Extensive area to the north of this town. *Timber.*—Average height, 35 feet; average diameter, 18 to 20 inches. *Resin.*—White variety appears to exude the most. (W. C. H. Hatherly.)
Gunnedah	Pottinger ...	On the ranges and in the scrub. Thousands of acres distributed throughout the whole of the "Box" country, except the alluvial flats adjoining the river. Several sawmills have been cutting pine timber continuously for many years past, with the result that now no logs fit for the mills can be obtained within 25 or 30 miles of the town.
Guntawang	Wellington ...	On the flats, 1 acre in every 300. (T. H. West.)
Hay	Waradgery ...	(J. Guthrie.)
Hillston	Nicholson ...	The extent of ground covered is very large. Pine forests are found here and there all the way to Cudgellico, a distance of 65 miles E.N.E., and also here and there for a distance of 60 miles south from Hillston. The area covered by the three varieties of pines must be many square miles. (H. Hatherly.)
Keepit, Somerton	Darling ...	With *C. calcarata* covers an area of from 6,000 to 10,000 acres. *Timber.*—Average height, 30 or 30 feet; average diameter, 6 or 8 inches. *Resin.*—Only after being chopped or ringbarked do they exude a good deal of resin, though very little exudes through the bark in a natural manner. (E. S. Davies.)
Lake Cudgellico	Dowling ...	Hundreds of thousands of acres. *Timber.*—Full-grown trees are from 40 to 75 feet, and from 18 inches to 3 feet 4 inches thick. There are millions of saplings of all heights and sizes. *Resin.*—They exude resin in great quantities when they have been rung. (W. T. Day, W. H. Perkins.)
Lewis Ponds	Bathurst ...	About 4 miles from here there is just a small patch. About 7 miles from here is a large area measured by miles. (H. P. Mutton.)
Lockwood, Canowindra ...	Bathurst ...	Throughout the district in scattered clumps. (Maggie R. Olde.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Looby's, *viâ* Parkes ...	Ashburnham ...	The plains extending for miles are covered with the Murray Pine. *Timber.*—50 feet high, 1 ft. 6 in. in diameter. The wood is very light, splits very easily; in fact, will crack and split if hammered at all; and burns splendidly. The Murray Pine grows in some cases 70 feet high and almost 2 feet in diameter, very straight, and the branches grow near the top *Resin.*—Very freely. (A. A. Hewitt.)
Lowesdale, *viâ* Corowa ...	Hume ...	The reserves, which are not very large, are covered with pine and box; however, 20 or 30 miles out there are large tracts covered almost exclusively with pine scrub. Towards Urana and in the district of Narrandera are to be found whole forests of young pines. *Timber.*—50 feet, with a diameter of 3 feet; average height is about 20 feet and the diameter 9 inches. *Resin.*—They all exude resin, the white giving most. (C. W. Peck.)
Major's Plains, Moorwatha ...	Hume ...	After leaving this locality and going W. or N.W. you will find pines for hundreds of miles, but none E. or N.E. (Murray Pine). (A. J. Pittock.)
Manilla	Darling ...	Only a few trees. More or less all over the district. *Timber.*—Pines have a quick growth, and forests could be readily grown. (C. M. Brophy.)
Mathoura	Cadell ...	In patches in all directions. (S. Smith.)
Menindee	Menindee ...	On all the ridges. (W. J. Ross.)
Meranburn	Ashburnham ...	(J. Anderson.)
Milburn Creek, Woodstock ...	Bathurst ...	(J. Sullivan.)
Minore, Dubbo	Narromine ...	Red and White Pine extend from, or nearly all the way from, Dubbo to Trangie, 50 miles. (Gertrude A. Harrison.)
Mitta Mitta, Bethungra ...	Clarendon ...	Once covered hundreds of thousands of acres in this district. (Miss J. E. Macdowell.)
Mitten's Creek, Brundah ...	Monteagle ...	Most of them destroyed now, only a few remaining. (J. W. Bell.)
Monteagle	Monteagle ...	Hundreds of acres. Many thousands of acres. (J. B. Daly.)
Moor Creek, Tamworth ...	Inglis ...	The pines grow in belts of from a few acres to, say, 2 or 3 square miles. They grow very quickly on the ridges. Within a radius of 10 miles from here, they would cover an area of about 7 square miles. *Timber.*—About 30 feet. Those cut for timber reach to from 40 to 70 feet; diameter 1 ft 6 in. to 2 feet. (B. E. Sampson.)
Mossgiel	Mossgiel ...	In scattered clumps in the eastern part of the district. (H. W. Smith, B.A.)
Mount Arrowsmith, *viâ* Milparinka. ...	Evelyn ...	(H. H. Burns.)
Mulwala	Denison... ...	Murray Pine grows for miles back from both banks of the river, covering, I believe, the larger part of the country included between the banks of the Murray and Murrumbidgee Rivers. (John Dennis.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Mungindi, *viâ* Moree ...	Courallie ...	About one-sixteenth of this district. (A. W. Greville.)
Muswellbrook	Durham ...	1,000 acres. (J. W. Hazelwood.)
Narrandera	Cooper	There must be thousands of acres, known as Murrumbidgee Pine. (W. G. Heath.)
Narromine	Narromine ...	Both Black and White Pine. The greater part of this locality in its natural state is almost covered with these pines, and growing so thickly that it is impossible to ride through the scrub. *Timber.*—Varies much in height, from 30 to 80 feet. *Resin.*—Both (White and Black) give resin. The White gives most. (F. J. Grainger.)
Nevertire (Wilgas).	Oxley	In patches, from 1 to 10 acres. (J. McLennan.)
Nurramundi	....	Nearly all scrub land on sides and tops of ranges. Sparsely in some parts, but dense in patches.
Nullamanna	Arrawatta ...	*Resin.*—The trees exude very small quantities of resin. (P. Head.)
Nyngan	Oxley	(R. T. Baker.)
Oakey Creek, Woodburn. (Warialda.)	Burnett ...	In patches throughout the district into Queensland. (S. T. Fitzpatrick.)
Parkesborough	Ashburnham ...	Only a small quantity left. (A. J. Bourke.)
Piallaway	Buckland ...	On all the low country. See also under *C. calcarata*. (W. A. Kennelly.)
Pine Ridge, Quirindi ...	Buckland ...	Not less than 100,000 acres. (E. W. McMahon.)
Pleasant Hills, *viâ* Henty ...	Mitchell... ...	Murray Pine. From the Murray River to the Lachlan and still further out, say,—Billabong Creek on the south, Urana on the west, and the Great Southern Railway from Wagga to Culcairn on the east. *Timber.*—. A soft wood, somewhat tough when green, very brittle when dry. Highly inflammable. As a building timber it is easily worked, well adapted for flooring and lining boards. Is not so liable to warp as other timber. Is well adapted for ground plates and joists on account of its white-ant resisting properties. Is more durable in the ground than the general run of hardwoods. The ash from this timber is frequently used in the bush for white-washing fire-places. *Resin.*—The tree yields resin of an excellent quality. Simply boiled I have found it equal to the best French preparation for violin bows, and as good as any other resin for other purposes. *Leaves as a fodder.*—It is said sheep will live on the foliage in the absence of other fodder, but I doubt it. I have seen it tried, but great losses of stock resulted when it was depended on. Sheep, if very hungry, will nibble the leaves of a fresh-cut tree, but soon leave it.

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Pleasant Hills, *via* Henty ...	Mitchell... ...	*General Economic Note.*—Nothing has been done on the part of the settlers to provide for a future growth of the timber, while at the same time they admit its value; but it has to make way for the wheat-fields, the duration of which latter, considering the light nature of the soil, and the wearing-out system persevered in by our up-country farmer, is problematical; and it is an open question, in view of the large demand for Cypress Pine, whether it would not be to the best interests of the community generally if some steps were taken for the propagation of this pine in a district which is its home, and where it will grow to perfection. (C. Ledwidge.)
Quandong	Monteagle ...	About half of the district. *Timber.*—Extensively used for building purposes. *Resin.* Exudes very little resin. (Samuel Lewis.)
Scone	Brisbane ...	Isolated patches on gravelly ridges, not extensive. A useful timber. (A. Moore.)
Spring Ridge, Quirindi ...	Buckland ...	About 60,000 acres. (May Burns.)
Staggy Creek, Gum Flat ...	Murchison ...	Cover a great area of country—not less than 50 or 60 square miles—but chiefly in ridges along the Gwydir River. *Resin.*—Trees about 12 inches in diameter seem to exude the most. If these trees are ring-barked, or incisions made through the bark with an axe, the resin flows in greater quantities. (J. S. Cormack.) *General Economic Note.*—The pines are easily propagated from the seeds, and they grow very quickly in any soil. (E. V. Campbell.)
Stockinbingal	Bland	Percentage of pines now is very small. *General Economic Note.*—The wholesale destruction of various kinds in this district is lamentable, and is carried on with no apparent forethought. (A. E. Kendall.)
Stonefield, Warialda	Burnett ...	Grows in small scrubs, has been cut down for timber during late years. (F. Campbell.)
Suntop	Gordon	About 4 square miles with *C. calcarata.* (R. T. Baker).
Swamp Oak, Moonbi ...	Inglis ...	Some hundreds of acres. Most of the ridges are covered with pines. (Christina McClelland.)
Tambar Springs, *viâ* Gunnedah.	Pottinger ...	This district (Liverpool Plains) is pretty thickly timbered with pines; they grow in clumps of 50 to 100 or 200 acres. *Timber.*—Both the White and Black Pines furnish splendid timber for house-building purposes, and for furniture. This timber is in great request by builders. *Resin.*—The most resin is obtained from the White Pine. *General Economic Note.*—At present, owing to the manner in which these trees grow, they cannot attain to any very great size or height, being too crowded. The pine forests require thinning out very much for the trees to do any good. (S. B. Sargeant.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Tamworth	Parry	20,000 acres, chiefly on the top of the Peel Ranges. *Resin.*—The exudation of resin is plentiful. (B. E. Sampson.)
Tareena	Tara	(G. A. Blumer, M.A.)
Tataila, Moama	Cadell	Murray Pine. Confined now to the sand ridges. (S. F. Johnstone.)
Terra Bella	Gordon	Cover about two-thirds of the land. (Annie I. Slack.)
The Welcome, Parkes ...	Ashburnham ...	Distributed throughout the whole of the forests of this district, in many places miles in extent. (E. A. Grant.)
Tocumwal	Denison... ...	The whole of the district, except where cleared off. (John Richards.)
Trangie	Narromine ...	Country from the Macquarie to the Bogan and beyond consists of alternate stretches of pine scrub. *Timber.*—Average height, 50 feet; average diameter, 15 to 18 inches. (J. McLennan.)
Trelowarren, Parkes	Ashburnham ..	Almost the whole of the Lachlan Valley contains clumps of this kind of pine. *Timber.*—The timber is certainly very peculiar, being very heavy, and yet almost brittle. It is capable of taking a very high polish and for lining floors, &c., it is commonly used in this district. The school is built of local pine, and though ten years have elapsed since the erection of parts of the building the timber (of course well painted) shows no sign of decay. The timber is proof against the ravages of white ants, owing perhaps to the peculiar scent. I have noticed that when buried in the earth the timber quickly decays. (P. F. Newman.)
Ulan, *viâ* Mudgee	Bligh	A very considerable area is covered by pines, not less than 50 or 60 square miles. In some places they form dense scrubs, in others they are very scattered, and again they may be found evenly distributed amongst the other forest trees. *Timber.*—Very large quantities of this timber have been used by the sawyers round. *Resin.*—The pines exude a considerable quantity of resin. Before solidifying, the resin is quite clear and colourless. In some cases it is of a dark or reddish colour, but this, I think, is due to the presence of foreign substances. (J. S. Harding.)
Upper Colo	Cook	A few trees. (G. E. Cummings.)
Uranquinty	Mitchell... ...	Not less than 15,000 acres. (H. C. Brettell.)
Walhallow, Quirindi	Buckland ...	Same as Quirindi. (William Hagon.)
Warge Rock	Kennedy ...	Plentiful (*see* Looby's).
Warialda	Burnett ...	20 square miles. (P. F. Hall.)
Watergumben, *viâ* Cowra ...	Forbes	Within a radius of about 3 miles there are probably about 700 acres. (J. A. Byrne.)

CALLITRIS GLAUCA, R.Br.—Botanical Survey of Species (*continued*).

Locality.	County.	Remarks.
Weetalabar, Tambar Springs, *viâ* Gunnedah.	Pottinger ...	In Trunkey Scrub, about 2 or 3 miles from here, must be more than 10 or 12 miles of these trees quite close together; so thick is the scrub, it is difficult to ride through it. *Timber.*—This timber makes good flooring boards and sawn slabs. There must be thousands of pounds worth of good timber, which could be sold yearly in large quantities if taken to Sydney or other large towns. It is used here for firewood. No pine is any good for putting in the ground, as it decays very quickly about here. (W. A. Griffith.)
West Narrabri	White	Wherever there are sand ridges, there the pine-trees grow to a greater or less extent. It is impossible to exactly determine the area. *Timber.*—There has been a constant supply for several saw-mills for years past, and the logs now brought in appear to be as good as those brought in a dozen years ago. The large amount of resin is a sure preventative against the ravages of the white ant. I have never seen the local pines interfered with by that pest. (Morgan Dunne.)
Willandra, Dubbo	Narromine ...	All the country between the Mountains and the Western Plains is interspersed with belts of pine. *Timber.*—Steps are now being taken in all cases to preserve all promising trees, and in a few years a good supply of timber trees will be found in all parts of the West. Full-grown specimens of White Pine in this district cut, on an average, from 1,200 feet to 1,800 feet of boards, but they are getting scarce near the towns owing to the great demand for this timber, and the thoughtless destruction of young trees. (R. W. Fitzell.)
Yallaroi	Burnett ...	10,000 acres. (E. C. Court.)
Yetman	Arrawatta ..	(H. Tresher.)
Young	Monteagle	A belt of White Pines runs between this town and Grenfell. (C. F. Laseron.)

6. Callitris arenosa,

A. Cunn., Herb et Ms.

A "CYPRESS PINE."

(Syn.:—*Frenela robusta*, A. Cunn., var. *microcarpa*, Bentham, B. Fl. VI, 237; *F. Moorei*, Parlat. in DC. Prod. XVI, ii, 449; *F. arenosa*, A. Cunn.; *F. microcarpa*, A. Cunn., Herb. (*vide* Historical, infra); *F. columellaris*, F.v. M., Frag. V, 198; Parlat. in DC. Prod. XVI, ii, 451.)

Habitat.

This is the Richmond and Clarence Rivers Pine of New South Wales, and of the Southern Coast of Queensland.

I. HISTORICAL.

Like most of the species of this genus, this Conifer has been very much synonymised. It was first collected by A. Cunningham at Moreton Bay, 1825, and labelled by him *C. arenosa*—specimens with his autograph being extant to-day at the British Museum. It was also collected in the same neighbourhood—Stradbroke Island—by Fraser, in 1829. In the Lindley Herbarium at Cambridge University there is a specimen labelled "*C. arenosa*, Moreton Bay, New Holland, Hooker, 1835"; Parlatore later named it *F. Moorei* in De Candolle's Prodromus (l.c.), and Mueller in 1865–6 called it *F. columellaris*.

Bentham in his "Flora Australiensis," Vol. VI, p. 237, places A. Cunningham's *F. microcarpa* with this species, but from our examination of this specimen (no fruits) we think this particular variety requires further investigation, especially as it comes from York Sound on the N.W. Coast, and it would be exceptional to find a species extending half round the coast, in view of the fact that the Port Darwin *Callitris* is now shown to be distinct from the Richmond River under the name of *C. intratropica*, F.v.M.

Herbaria Material Examined:—

Kew,—
Fraser's material from Stradbroke Island, Moreton Bay, 1829.

British Museum,—
A. Cunningham's specimen from Moreton Bay, 1825.

Cambridge University,—
Hooker's specimens from Moreton Bay, 1835 (Lind. Herb.).

Melbourne,—
Mueller's and other specimens from the Richmond River.

Frank H. Taylor, Photo.

Callitris arenosa, A.CUNN, "CYPRESS PINE."

[Cones unopened.]

Nat. Size.

II. SYSTEMATIC.

This is a shapely tree attaining a height from 40 to 60 feet, with a dark compact rough bark. Branchlets in thick clusters; leaves, terete or with obtuse angles, greenish-blue in colour, internodes exceedingly short, free portion acute, incurved. Male amenta cylindrical, about a line long, terminal in clusters of two, three, or four in spikes. Female amenta at the lower portions of the branchlets.

Fruit cones globose, flattened at the base and a little at the top, slightly rough on the outside, 6 lines in diameter before expanding, solitary or in clusters; valves thin, valvate, alternately large and small, the latter, linear lanceolate, the former broadest in the middle, channelled at the base, dorsal point not prominent. The central columella from 3 to 4 lines in height. Seeds nearly all two-winged.

The pronounced columella is characteristic, but for systematic purposes the three smaller valves of the cones differentiate, more especially the species. They are narrow, with parallel sides, whilst in all other species are convergent to the apex. The timber and chemistry also differentiate it from *C. intratropica*.

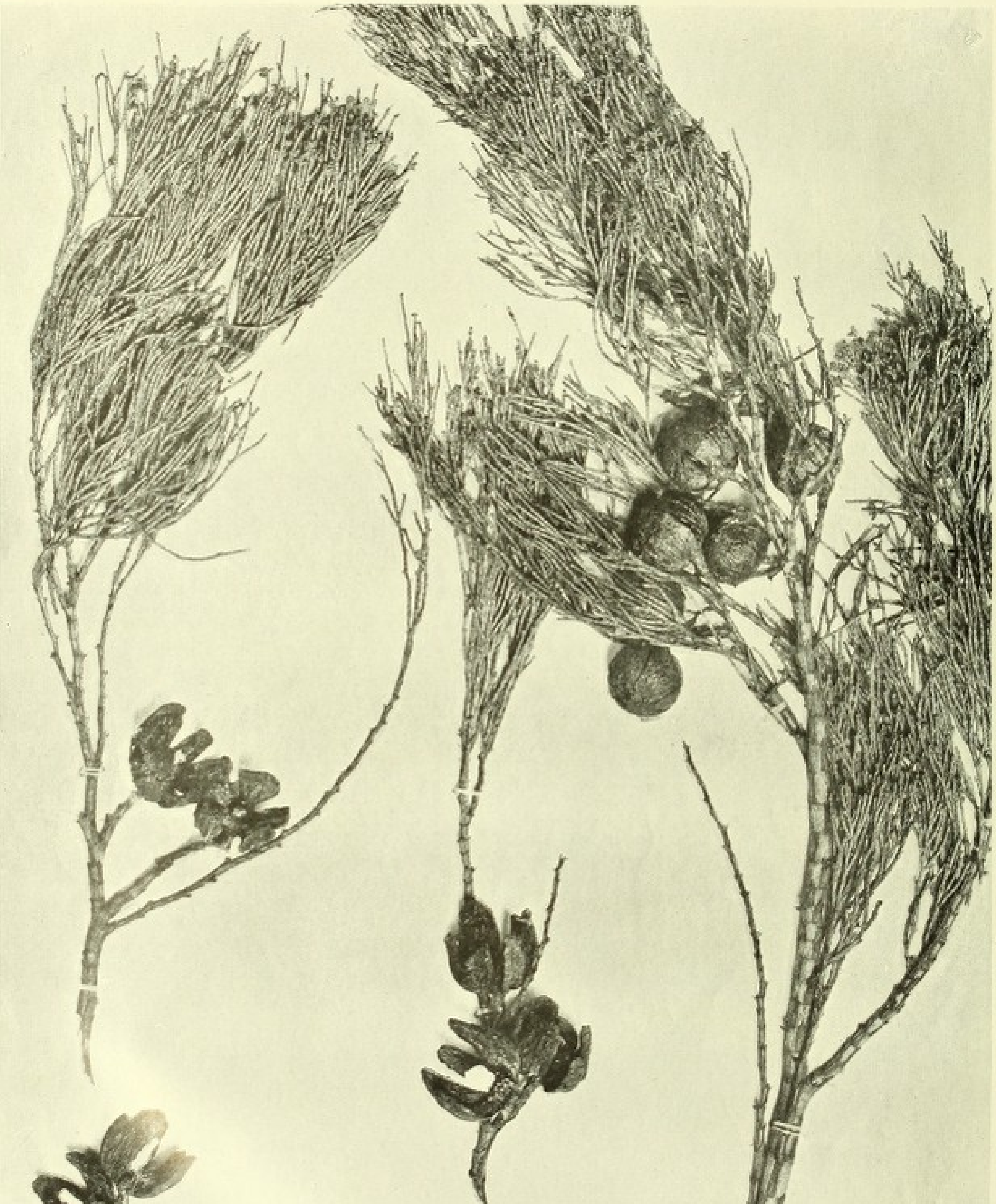
This species is found in patches along the southern Queensland coast and N.E. corner of New South Wales. It is found almost on the sea shore, in the slight hollows behind the sea beach. It does not attain a large size; some trees of 1 foot in diameter and 30 feet high were noticed on private property. As a rule it occurs as a shrub up to 12 feet high and densely tangled with other vegetation (Casuarina, &c.). It is very irregular and straggly in growth even when in tree form, lacking the regular branches of *C. glauca*, or the stately, narrow appearance of *C. rhomboidea*. (C. F. Laseron.)

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

The general outline of a cross section through the leaves of the genus may be described as a trefoil; but in this instance the dorsal surface is a little more flattened than in that of other *Callitris*, as seen in a section when taken through the top of the oil cavities as in Figures 96 and 97. The individual leaf section is not at all unlike an umbrella, for the cells of the spongy mesophyll corresponding to the ribs, the cells of this tissue being elongated, appear to radiate from the central cylinder of the branchlet, and this angle of radiation is also obvious in the long axils of the palisade parenchyma; but when taken lower down, as in Figures 94 and 95, the resemblance more closely approaches its congeners.



Callitris arenosa, A.CUNN., "CYPRESS PINE."
[Cones opened.]

Nat. Size.

Leaney, Photo.

Callitris arenosa, A.CUNN.
BRUNSWICK HEAD, N.E. NEW SOUTH WALES.

Uniseriate epidermal and hypodermal cells bound the palisade parenchyma.

The parenchymatous empty cells and those staining a dark brown colour,—the manganese compound, form a band enclosing the bundles of the stele, and do not always extend around the oil cavities, which have very distinct elongated guard and secretory cells.

The bundle of the leaf has the usual complement of transfusion tissue, but no sclerenchymatous cells were seen.

The transpiratory surface is quite ventral, the stomata having the usual elongated cuticle cells, described under *C. glauca* and other species.

Figure 96 is a transverse section through mid-distance of the two nodes of a branchlet showing the axil bundles and dissected decurrent leaves. Although the section was, perhaps, a little too thick to determine the outer details distinctly, yet the darker staining brings out the palisade parenchyma, backed by a single row of hypodermal cells, which in turn are supported by those of the epidermis, the whole showing an assimilatory dorsal wall out of all proportion to that of the transpiratory one, which in this illustration shows the elongated cuticle cells or projections. The remaining features are described above. Figure 97 whilst illustrating three oil cavities—one in each leaf—determines also the position from which the section is taken, *i.e.*, near the diverging of the free ends of the leaves. The cell formation of the mesophyll surrounding the oil reservoirs is well characterised here and is quite specific. The leaf trace next to each oil cavity is distinctly seen as well as the character of the surrounding cells. Figure 98.—This enlargement (190) brings out fairly well the detail structure of the central axis of the branchlets with its three bundles, each with its xylem and phloem and the pith or vessels with their three medullary branches. The bundle of each individual leaf is well seen just below an oil reservoir—the circular spaces being not quite wholly shown in the picture. This plate also shows the normal orientation of all these vascular bundles. The three wedged-shaped spaces are the lower parts of the ventral surfaces of the leaf, and show where the decurrent leaves join, and with the central axis form one whole living portion of the tree. The coloured and empty parenchymatous cells form a distinguishing feature, whilst on each side of the leaf bundle can be seen the transfusion cells—marked by the small circles (bordered pits) in them—arranged crescent shape, concentric with the lower curve of the oil cavities. Figure 99 gives a longitudinal section through the base and top of two leaves, showing in the case of the latter their free portions, and also how these particular parts form only a small fraction of these organs. The leaf on the lower left side has an oil reservoir, to the right of which is seen the bundle of that leaf—the light shaded portion, curved at the top to the left. Figure 100 shows the structure surrounding this oil cavity further magnified to 160 diameters, the right half of the picture giving a portion of the leaf bundle and central axis. The

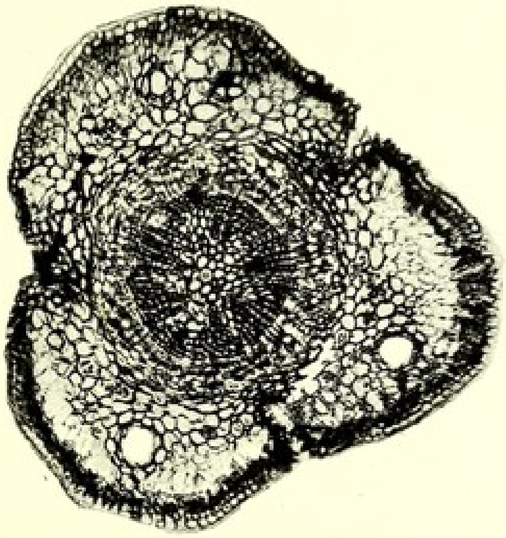


Figure 94.—Transverse section through branchlet and decurrent leaves, showing various diameters of oil cavities at the point of section. *C. arenosa*, × 80.

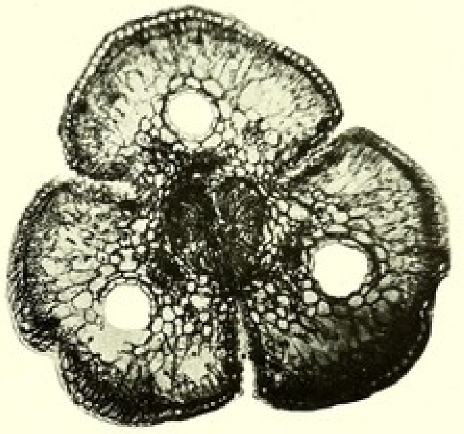


Figure 95.—Transverse section through branchlet and three decurrent leaves, with an oil cavity in each of the latter sections, just about the middle. *C. arenosa*, × 80.

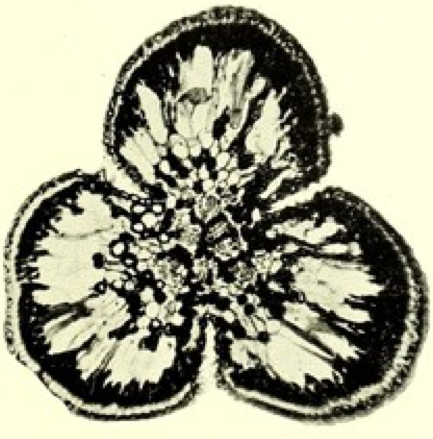


Figure 96.—Transverse section through branchlet and leaves, clear of oil cavity in the latter. The dark patches in and around the centre are the brown manganese content in the cells. *C. arenosa*, × 80.

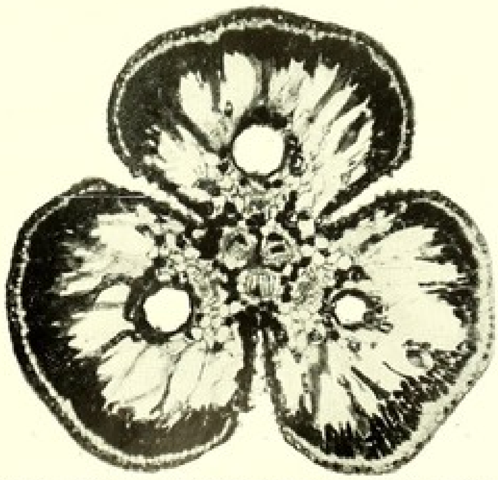


Figure 97.—Transverse section through branchlet and leaves, with oil cavity in each of the latter. *C. arenosa*, × 80.

Cross sections of branchlet and leaves of C. arenosa. A. Cunn.

cells with the bordered pits are the tracheids of the transfusion tissue, and a good view is obtained of the empty and filled parenchymatous endodermal cells. The oil reservoir is in the left top centre of the picture. Figure 101 illustrates a longitudinal section through the upper part of two leaves clear of the main axis, and through two oil cavities. The empty parenchymatous endodermal cells are well defined in the centre of the picture, the filled ones making the dark-coloured lines down the centre of the picture, and almost midway between them and the right oil cavity are the rows of transfusion cells of the leaf bundle and marked by the small circles (bordered pits) in their lumina. The oil cavities are seen, one on the right and one on the top left-hand side, so that the cavity form of

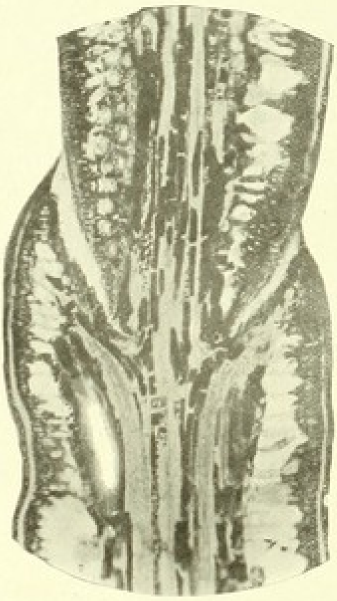


Figure 99.—Longitudinal section through junction of a whorl of leaves of *C. arenosa*, × 65.

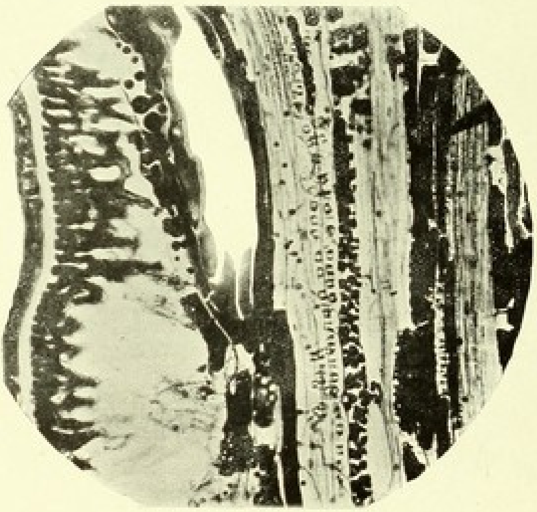


Figure 100.—Longitudinal section through part of central axis, oil cavity and part of leaf surrounding it; taken from Figure 99. The bordered pits of the transfusion tracheids are clearly seen. The oil cavity is in the top left centre backed by the mesophyll of the leaf. *C. arenosa*, × 160.

these bodies prevails in this species as throughout the *Callitris*. The amygdaloidal bodies at the base of the left oil cavity show peculiar depressed markings on the brown manganese compound cell contents, when in direct contact with the oil in the cavity. The space at the top is where the succeeding whorls of leaves have been removed.

(c) Chemistry of the Leaf Oil.

The leaf oil of this species was distilled from material collected at Ballina, New South Wales, 340 miles north of Sydney, on 2nd September, 1904, and also at Corrumbian Creek, in the Murwillumbah District, on the borders of New South Wales and Queensland, 410 miles north of Sydney, on the 13th January, 1908.

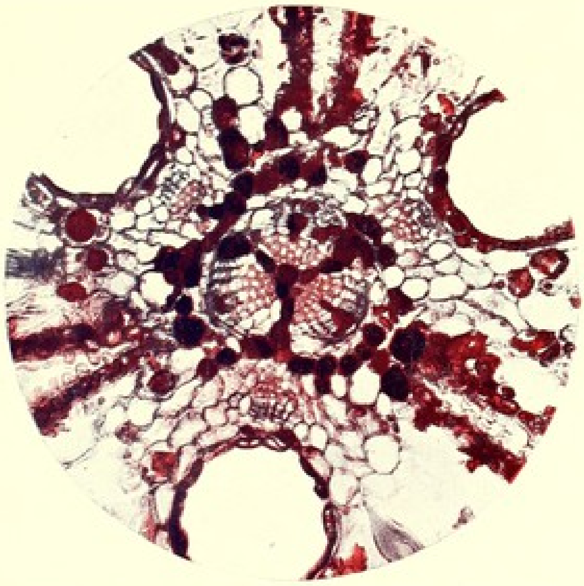


Figure 98.—Transverse section through branchlet and attached portions of decurrent leaves. The three circular spaces are the oil cavities, one in each leaf, below which is a bundle with its red-coloured xylem and purple phloem. The transfusion tissue shows bordered pits in the cells, whilst the dark brown colours are manganese compound contents in some of the endodermal cells. The three wedge-shaped figures are the lower portions of the decurrent channels. Stained with hæmatoxylin and safranin. *C. arenosa*, x 190.

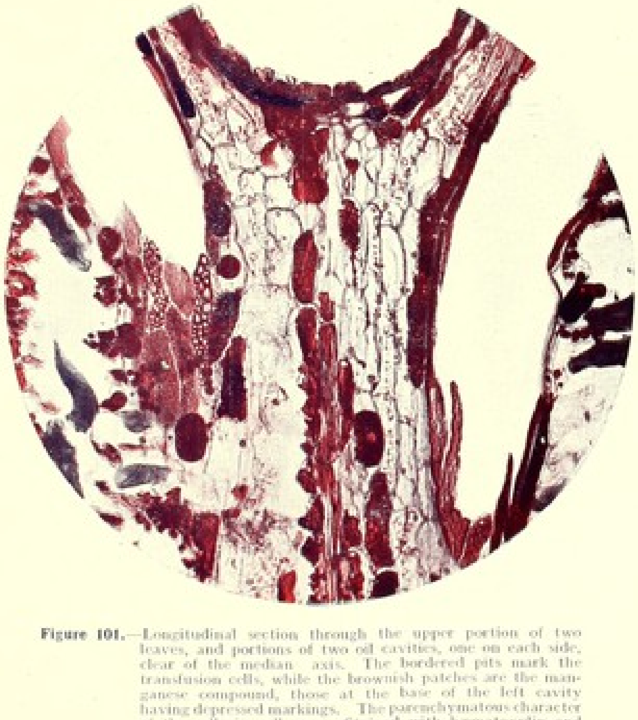


Figure 101.—Longitudinal section through the upper portion of two leaves, and portions of two oil cavities, one on each side, clear of the median axis. The bordered pits mark the transfusion cells, while the brownish patches are the manganese compound, those at the base of the left cavity having depressed markings. The parenchymatous character of the cells is well seen. Stained with hæmatoxylin and safranin. *C. arenosa*, x 190.

The distillations, in both cases, were continued for six hours. Although over three years had elapsed between the two periods, yet, the oils were found to be practically identical, consisting very largely of dextro-rotatory limonene and dipentene. In the leaf oil of this species of *Callitris*, the limonenes appear to have reached their maximum, largely to the exclusion of the pinene. From the results, certainly not less than 85 per cent. of the oil from this species belonged to the limonenes, mostly as dipentene. The predominant limonene was the dextro-rotatory form, and in the oil of the January sample had the rotation a little less to the right than had the other. This result indicated that at a certain time of the year (midsummer) the larger amount of the lævo-rotatory form is present, and, consequently, the oil has a less rotation to the right at this time than at other periods of the year. This peculiarity has been noticed with the oils of other species of *Callitris*. The chemical characters peculiar to the oil of this species, show it to be distinct from that of any other *Callitris*. The one nearest to it is *C. intra-tropica*, but in the oil of that species the predominant limonene was found to be lævo-rotatory, and is the species in which the lævo-rotatory form appears to reach a maximum. The limonenes were so pronounced in the oil of *C. arenosa*, that the tetrabromide could be formed in abundance from the crude oil alone, without the oil undergoing any preparation whatever. The physical results also indicated that limonene was mostly present in the oil. The tetrabromide was fractionally crystallised from acetic ether, with the result that the fractions melted at different temperatures, and that the one which separated first had the highest melting point. When dissolved in cold acetic ether, the tetrabromide was found to be dextro-rotatory. It is thus evident that both dextro-rotatory limonene and dipentene, or in other words, both forms of limonene, occur in the oil of this species, as with those of the *Callitris* generally, and that the dextro-rotatory form here predominates. The amount of ester was small, but it appeared to consist of the acetates of both borneol and geraniol, thus resembling the esters from most species of *Callitris*.

No. 1.—This material was collected at Ballina. It consisted of the extreme terminal branchlets with very few fruits. 592 lb. gave 38½ oz. of oil, equal to 0·402 per cent. The crude oil was light lemon-coloured, and had an odour slightly resembling the ordinary "Pine-needle oils," but with a marked lemon-like odour. It was insoluble in ten volumes of 90 per cent. alcohol. The specific gravity of the crude oil at $\frac{23°}{15}$ C. = 0·8491; rotation $a_D = +35·8°$; refractive index at 23° C. = 1·4760. The saponification number was 14·77, equal to 5·17 per cent. ester. On redistilling, only 1 per cent. came over below 167° C. Between 167° and 172°, 36 per cent. distilled; between 172° and 177°, 44 per cent.; between 177° and 180°, 10 per cent. As this represents 91 per cent. of the total oil, and as 5 per cent. of the esters were present, it is evident that the high boiling constituents, as the sesquiterpenes, &c., could only be present in a very small amount.

The specific gravity of the first fraction at 23° C. = 0·8404; of the second = 0·8413; of the third = 0·8515. The rotation of the first fraction a_D = + 35·7°; of the second + 37·2°; of the third + 38·7°. The refractive index of the first fraction at 23° = 1·4741; of the second = 1·4752; of the third = 1·4757. It is remarkable how closely the three fractions agree in the above results.

It is apparent that pinene could only have been present in small amount, because the specific gravity and refractive indices differ but little from those of pure limonene.

The above results show the oil to differ entirely from that of *C. glauca*, a species to which *C. arenosa* has, by some, been thought to belong.

Neither sylvestrene nor phellandrene could be detected.

The tetrabromide was prepared with the second fraction in the usual way, and this, when crystallised from acetic ether, melted at 117°–118° .C. When dissolved in cold acetic ether it was dextro-rotatory. It was fractionally precipitated from acetic ether, when the first portion which separated on cooling melted at 122° C.; the next at 119°, and the third at 117°. Better results were even obtained by fractional precipitation from ether, the first portion melting at 121°–122° C., and the latter portion at 115°–116° C.

The tetrabromide was readily prepared with the crude oil, and this (after removing a very small amount insoluble in acetic ether) was identical with that obtained with the second fraction; it gave similar fractions by crystallisation, which melted practically at the same temperatures, and were dextro-rotatory also.

It thus appears that the oil of this species consists largely of dextro-rotatory and lævo-rotatory limonenes, the former being in excess, and that these when occurring together in the plant behave similarly to a mixed solution of the two limonenes.

No. 2.—Material was collected at Corrumbian Creek, and 414 lb. of terminal branchlets with fruits gave 19½ oz. of oil, equal to 0·294 per cent. The crude oil was insoluble in ten volumes of 90 per cent. alcohol. It was practically identical with the previous sample, and contained the same constituents in about the same amount. The specific gravity of the crude oil at 26° C. = 0·8452; rotation a_D = + 18·9°; refractive index at 26° C. = 1·4764. The saponification number was 10·2, equal to 3·57 per cent.

The tetrabromide was prepared from the crude oil similarily with the previous sample, and when purified from acetic ether it melted at 118°–119° C.

As the above results show that this oil was distilled from the same species as that from Ballina, no further work was done upon it.

Crude Oil from the Leaves of *Callitris arenosa*:—

No.	Locality and Date.	Specific Gravity, ° C.	Rotation, α_D.	Refractive Index ° C	Ester per cent.	Yield per cent
1.	Ballina, 2/9/04.	0·8491 @ 23°	+ 35·8°	1·4760 @ 23	5·17	0·402
2.	Corrumbian Creek, 13/1/08	0·8452 @ 26°	+ 18·9°	1.4764 @ 26	3·57	0·294

IV. TIMBER.

(*a*) Economic.

This is a pale, chocolate-coloured, easy-working, free timber. It has a straight grain, but, nevertheless, the figure is rather attractive, although wanting in the more elaborate flower often present with the timber of *C. calcarata*.

It could be used for various forms of cabinet-making, as it takes a high polish; but as other timbers are plentiful in the locality where it occurs, it is little used for house-building.

It is highly aromatic, and contains the phenol, callitrol, in some quantity.

(*b*) Anatomy.

The most characteristic feature is the small number of cells containing the manganese compound substance in the xylem, but this material occurs in most of the cells of the medullary rays.

The bordered pits are very numerous on the radial walls, being well brought out in Figure 103—a radial section, and which is an exceptional field for observation, showing, as it does, (1) two rows of pits in some of the lumina of the tracheidal cells, an exception to the rule obtaining in other species of the genus, *i.e.*, single rows, and also (2) the diameter of each pitted cell extending from wall to wall.

The manganese compound occurs in almost all the cells of the rays, but sparsely in the tracheids, and when it is present in the xylem cells it is found to be distributed irregularly in the autumnal and spring wood.

In Figure 102 is given a tangential section of the timber showing the fusiform shape of the medullary rays in this plane, the irregular number of horizontal cells in each, and the presence of the manganese compound in some of them.

Figure 103 gives a radial section showing two autumnal periods of growth at the sides, and one vernal period in the centre of the section. The single pits of the rays are conspicuous in the centre, whilst a double row of bordered pits in some of the tracheidal cells to the right centre is, as stated above, unusual in *Callitris*.

Figure 104 shows a transverse section through the xylem, cambium, and one resin cavity in the inner cortex, and also the regular parallel arrangement (concentric) of the bast fibres.

(*c*) Chemistry.

(See articles on the Phenol and the occurrence of Guaiol, &c.)

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

Practically this bark is identical in structure to that of the genus in general; the walls, however, of the various cells have perhaps a more distinct definition, especially in the periderm bands (Figure 105), in fact, more so than in any other species; whilst the parenchymatous, concentric cells appear under a low magnification to occupy almost the entire space between the uniseriate ring of hard bast fibres, and so a higher magnification is required to detect the sieve tubes intervening between them and these sclerenchymatous tissue.

The bands of cork layers and oleo-resin cells are more numerous in this species than probably any others.

Figure 105 is a transverse section through a junction of the outer and inner cortex, the boundary between the two being marked by a broad band of periderm layers. The bast fibres are seen to be in regular rows, and the parenchymatous cells empty in the inner and filled with the manganese compound in the outer bark. Figure 106 is a perpendicular section through the inner cortex, and illustrates particularly well the parenchymatous nature of the cells between the sieve tubes surrounding the bast fibres, two of which are seen extending in continuous lines from the top to the bottom of the plate. The form of crystals composing the bast fibres is given in the article on bark under *Araucaria Bidwilli*.

(*c*) Chemistry.

The bark of this species was received at the Museum from Mr. Sharpe of North Creek, Ballina, and it was taken from a tree about 1 foot in diameter. In appearance it more closely resembled the bark of *C. calcarata* than that of *C. glauca*, and in section the outer corky layer was very pronounced. It thus differed both in

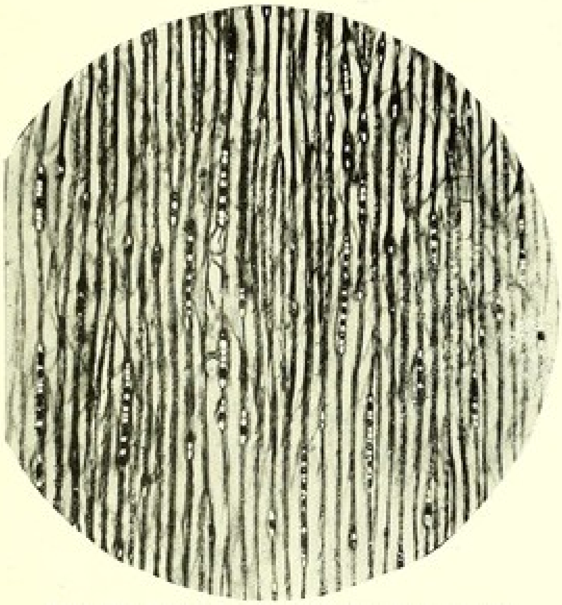


Figure 102.—Tangential section of timber of *C. arenosa*, × 50.

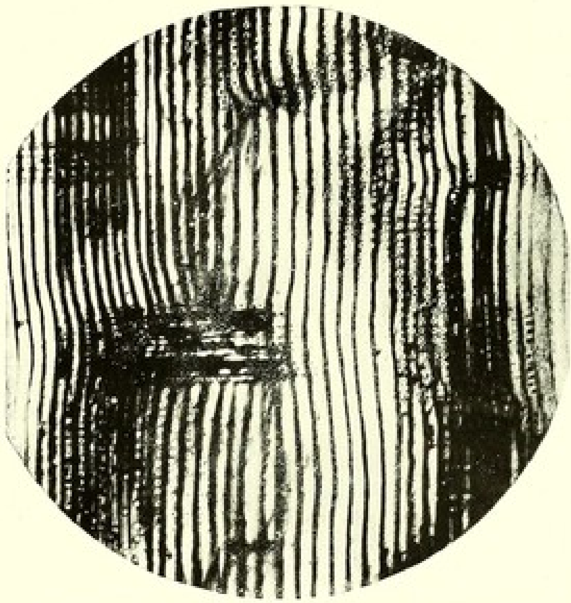


Figure 103.—Radial section through timber of *C. arenosa*, × 50.

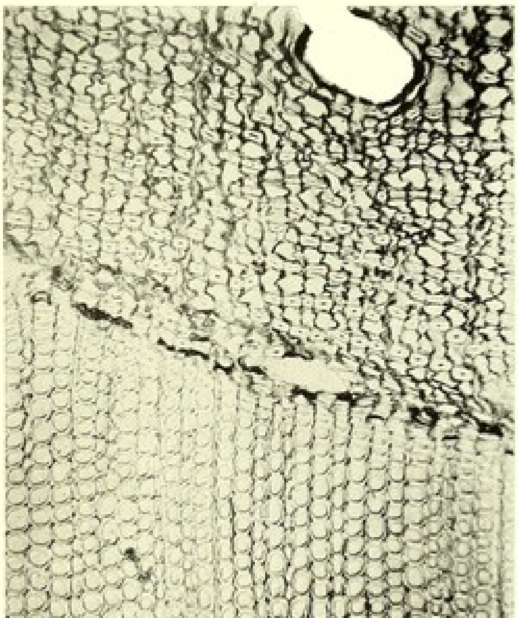


Figure 104.—Transverse section through cambium with bark and timber on each side. The parallel rows of bast fibres are distinctly focussed, and two oil cavities, one near the cambium, are seen. *C. arenosa*, × 50.

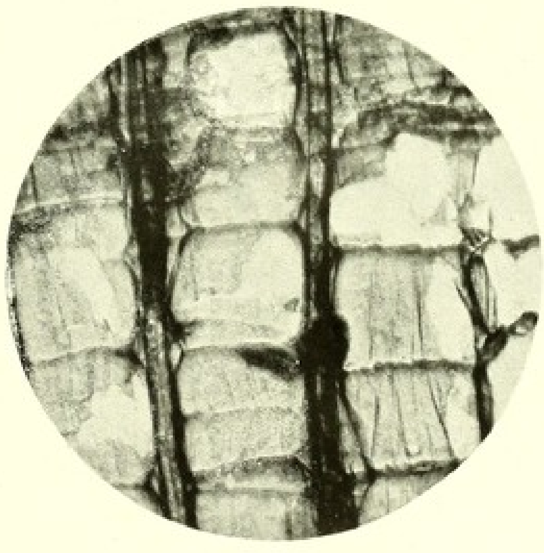


Figure 106.—A longitudinal section through the bark shewing parenchymatous cells (almost square), with two bast fibres extending from top to bottom between the sieve tubes. For crystals composing these fibres see Figures under bark of *Araucaria Bidwilli*. *C. arenosa*, × 175.

Sections of Timber and Bark of C. arenosa, R.Br.

texture and appearance, from the more interlocked and fibrous bark of *C. glauca*. In the green state it differed from *C. calcarata* by showing a more red, almost crimson layer where the outer portion is separated from the inner or more compact bark. The red colour of this layer faded as the bark dried, and did not appear to be at all objectionable.

Externally, the bark was of a dark dirty-brown colour, somewhat blackish in places, and seldom grey. It was deeply furrowed. The total thickness was 20 to 30 mm. (almost 1¼ inches). The portion without the corky layer was 7 to 8 mm. The air-dried bark powdered fairly well, giving a light-coloured powder. The tannin content was very considerable for barks belonging to the Coniferæ, and compares very favourably in this respect with most tan-barks. The greater portion of the tannin was readily extracted with cold water, and the amount of non-tannin in the extract was found to be very small indeed. Three analyses were made with the bark, in all cases air-dried:—

(*a*) A fair section through the whole bark.

(*b*) The "rossed" bark in which the outer cortex was removed, until practically a smooth surface had been obtained, and

(*c*) A determination of the tannin in the "rossed" bark, extracted entirely by cold water after eighteen hours' contact.

The following results were obtained with the whole bark:—

Moisture	13·3 per cent.
Total extract ...	29·3 ,,
Non-tannin ...	4·2 ,,
Tannin	25·1 ,,

The results with the inner "rossed" bark were:—

Moisture	13·50 per cent.
Total extract ...	40·14 ,,
Non-tannin ...	5·37 ,,
Tannin	34·77 ,,

The results with the inner "rossed" bark by cold-water extraction alone were:—

Moisture	13·50 per cent.
Total extract ...	31·74 ,,
Non-tannin ...	3·24 ,,
Tannin	28·50 ,,

Although the bark was so rich in tannin, yet, the extract (25 grams per litre) became but little turbid when cold, and the liquor obtained by the cold extraction was excellent in this respect. See also article, "The Tanning Value of *Callitris* Barks."

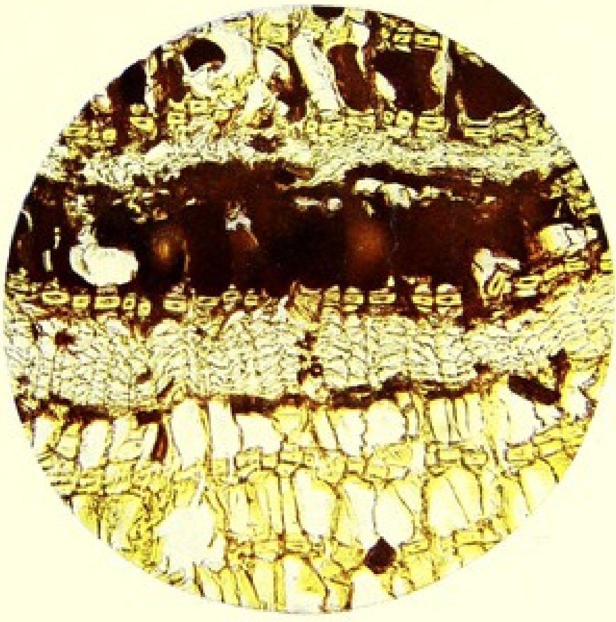


Figure 105.—A transverse section at the junction of the inner and outer cortex,—the latter at the top half of the plate. The bast fibres are the rectangular figures extending in lines from left to right, whilst the parenchymatous cells between these, seen clearly in the lower half, have their radial walls lengthened. The band of thin-walled, compressed cells running through the centre of plate from left to right is a layer of periderm. The dark brown band shows the contents of the outer cortex parenchymatous cells. Unstained. *C. arenosa*, × 100.

CALLITRIS ARENOSA, A. Cunn.

BOTANICAL SURVEY OF THE SPECIES IN NEW SOUTH WALES. (*See* also map.)

From data supplied by Public School Teachers and other correspondents.

(Where no information is given under Remarks only herbarium specimens were received. The information is given without comment.)

Locality.	County.	Remarks
Boggumbil, Lismore	Rous	Dispersed throughout the district. *Resin.*—Exudes resin in abundance. (Helen C. Crowley.)
Bonville, Coff's Harbor ...	Raleigh	Grey. (J. J. Farrell.)
Byron Bay	Rous	Several thousand acres. Timber.—80 to 120 feet high, 3 feet diameter. (H. McLennan.)
Coorabell Creek	Rous	Scattered through the scrub at intervals, numerous other kinds of trees growing in between. Patches of scrub in some places not yet touched by the timber-getter, may contain twelve to twenty pine trees to the acre. *Timber.*—Height, 100 to 120 feet; diameter, about 3 feet or 3 ft. 6 in. *Resin.*—No great quantity of resin exudes from the trees until an incision is made. (E. J. Blanch.)
Mullumbimby	Rous	Grows on sandy ridges near the coast. *Timber.*—70 feet in height, and 26 inches in diameter. (Henry R. Anstey.)
New Italy	Richmond ...	On the pine ridges. (T. J. Morgan.)
Point Danger	Clarence ...	(M. J. Schaefer.)
Tintenbar	Rous	(L. C. Shaw.)
Tumbulgum	Rous	Occurs here in the scrubs. (J. Cameron.)
Tweed Heads	Rous	Scattered over an area of 10 square miles. (C. F. Laseron.)
Wardell	Rous	Grows on a few sandy ridges near the coast, about 1 square mile. (A. Cousins.)
Wyrallah	Rous	(J. Jacobs.)

Forms vast tracts along the coast of Queensland. (M. Hill.)

7. Callitris intratropica,

Benth. et Hook, f. Gen. Pl. Vol. III.

"CYPRESS PINE."

(Syn.:—*Frenela intratropica*, F.v.Muell, Herb.; *F. robusta*, A. Cunn., var. *microcarpa*, Benth., B. Fl., VI, 237.)

Habitat.

As far as can be ascertained this species appears to be confined to the northern part of the Northern Territory and the north-west coast of Western Australia. This part of Australia, however, being so little settled, it is difficult to give anything approaching its true geographical distribution. It occurs plentifully at Port Darwin, according to Mr. Nicholas Holtze, to whom we are indebted for splendid material upon which our botanical and chemical researches were made.

Mueller's specimen from Arnhem's Land is the same as that from Port Darwin.

I. HISTORICAL.

Like Bentham, Mueller, Maiden, and others, we were at first inclined to regard this species as identical with *C. arenosa*, A. Cunn. (*F. columellaris*, F.v.M.), and it was not till after examining herbaria material in Europe, as well as in Australia, that the morphological and histological differences were found to be well marked, and these differences were further supported by chemistry.

The shape of the smaller valves of the cones, the small column, timber, and chemistry, differentiate the species from *C.arenosa*, A. Cunn., otherwise the fruits resemble somewhat those of *C. glauca*.

Whether A. Cunningham's specimen from York Sound, N.W. Coast, and labelled by him as *C. microcarpa*, is identical with this, there is not sufficient data available to enable us to speak with confidence, but we are inclined to think that the two will be found to be the same species. Cunningham's specimen is not in fruit.

Herbaria Material Examined.

Kew,—

Mueller's specimen from Arnhem's Land.

Melbourne,—

These are duplicate specimens of those at Kew.

II. SYSTEMATIC.

An average, foliaceous *Callitris* tree, attaining generally 50 to 60 feet in height. The leaves are glaucous and not dorsally ridged, the free portion more or less spreading, acute, and proportionately long. Male amenta ovoid, terminal in twos or threes. Female amenta below the ultimate branchlets.

Fruit cones spherical, wrinkled, under ½ inch in diameter, valves alternately large and small, comparatively thin, dorsal point fairly prominent, the central columella very short, rarely lengthened. Seeds one-, two-, and three-winged.

The main points of differentiation of this species from *C. arenosa* are the timber, bark, and the chemistry of its several parts.

III. LEAVES.

(*a*) Economic (*vide* Chemistry, *infra*).

(*b*) Anatomy.

These sections are characterised on the dorsal side by (1) the flattened or oblong epidermal cells with specially thickened walls, (2) the double row of hypodermal cells, (3) the packed palisade tissue, and (4) the preponderance of loose, spongy mesophyll.

To these might be added the comparatively small number of parenchymatous, endodermal cells and tracheids of the transfusion tissue in the vicinity of the central axis of the branchlet. The stomata are found in the ventral channel formed by the leaves, on the inner side of the free portion of the leaves, as well as at the base of the decurrent portion immediately facing it. The usual elongated projections of the cuticle also occur here.

Figures 107 and 108 are cut just below the oil cavities in the upper part of the leaves, and well illustrate the predominance of spongy mesophyll in the leaf substance, and the small proportion of parenchymatous endodermal cells; the transfusion tissue is well indicated by the pitted cells, and these latter details are more clearly shown in Figure 109—a 200-magnification. Figure 110 illustrates a cross-section cut through the three oil cavities.

The salient feature in the anatomy of the leaves of this species, is the delicate structure of the spongy tissue, and in cutting, it is very difficult to obtain sections whole, the central axis and its adnate cells generally tearing away from the fundamental leaf tissue, which is traceable by delicate lines in the figures here given.

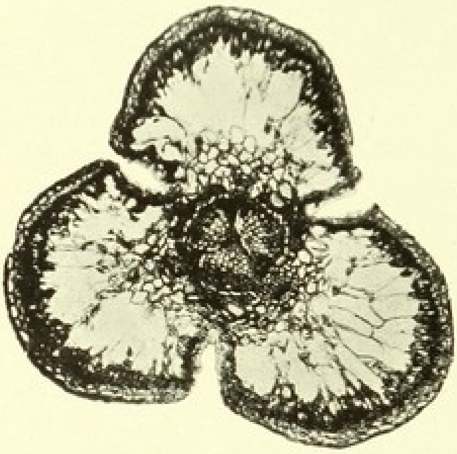


Figure 107.—Transverse section through branchlet and decurrent leaves, free of oil cavities. The spongy tissue of the mesophyll is proportionately large, and the hypodermal cells of the assimilatory surface are doubly packed. *C. intratropica*, × 80.

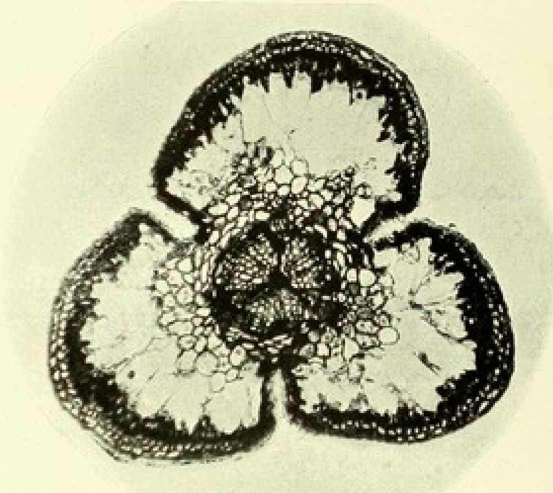


Figure 108.—Transverse section through branchlet and decurrent leaves, free of oil cavities. The pith and medullary rays of the central axis and a few cells round the phloem are darkened by the presence of the manganese compound; amongst the endodermal cells are the transfusion cells denoted by the minute circles in them. *C. intratropica*, × 90.

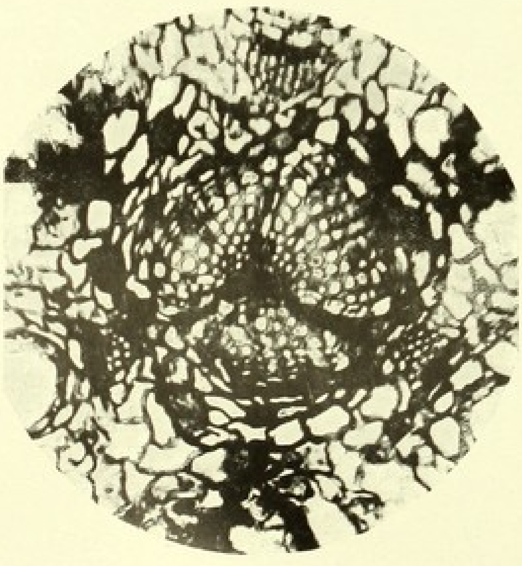


Figure 109.—Transverse section through central axis of Figure 108. Three-leaf bundles are also included, one at the top and one at the lower left and right hand sides of the central bundles. The brown manganese compound is indicated by the black patches. *C. intratropica*, × 200.

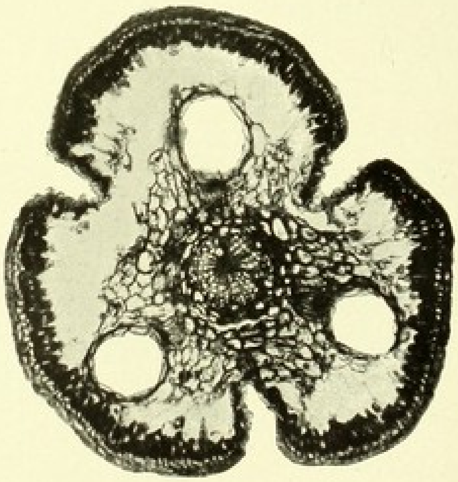


Figure 110.—Transverse section through branchlet and decurrent leaves, with an oil cavity in each leaf. *C. intratropica*, × 90.

(c) Chemistry of the Leaf Oil.

This material was forwarded to us from Port Darwin by Mr. Nicholas Holtze, the Curator of the Botanic Gardens at that place. It was received on the 2nd November, 1904. The leaves and branchlets had been packed with very few twigs, and fruits were absent.

The crude oil was amber coloured, very mobile, and had an odour somewhat resembling the leaf oil of the *Callitris* species generally, but with a distinct lemon-like odour. The distillation was continued for six hours, and 169 lb. of material gave 3 oz. of oil, equal to 0·11 per cent.

The crude oil was insoluble in ten volumes of 90 per cent. alcohol. It was practically a terpene oil, consisting largely of lævo-rotatory limonene, dipentene, and pinene. The ester content was very small in amount, but it consisted of both borneol and geraniol, probably in combination with acetic acid. The specific gravity of the crude oil at $\frac{22}{15}$° C. = 0·8481; rotation $a_D = -21·6°$; refractive index at 22° C. = 1·4768. The saponification number was 10·9, equal to 3·81 per cent. esters. Only 25 c.c. of oil could be spared for redistillation, and this commenced to distil at 156° C. Between 156° and 165,° 36 per cent. distilled; between 165° and 175° 40 per cent.; above 175° (left in still), 24 per cent.

The specific gravity of the first fraction at 20° C. = 0·8457; of the second, 0·8435; of the residue, 0·8782. The rotation of the first fraction $a_D = -7·5°$; of the second $-25·4°$. The rotation of the residue could not be taken, but it must have been highly lævo-rotatory. The refractive index at 20° C. of the first fraction was 1·4749; of the second, 1·4752; of the residue, 1·4889. The residue was saponified and the oil separated, when both borneol and geraniol were detected. The volatile acids gave marked reactions for acetic acid, so that the esters were probably those of acetic acid.

From the above results it is seen that this species has no marked agreement with any other species of *Callitris*, so far as characteristic properties influence the determination. It is more nearly in agreement with *C. arenosa* than with any other, but differs from that species by the predominant limonene being lævo-rotatory, while that of *C. arenosa* is dextro-rotatory. It did not deposit a resin on the bottle on keeping, thus differing from the leaf oils of *C. glauca* and like species.

We had previously received on 29th December, 1903, a small quantity of material of this species from Port Darwin, but it only weighed 36 lb., and was altogether inadequate for our purpose. It was thought desirable, however, to distil it, and the following results were obtained. It will be seen that for such a small amount of oil there is a marked resemblance to that of the other sample. Only about 3 grams of oil could be collected, the specific gravity of which at

$\frac{23°}{15}$ C. = 0·8563, and the refractive index at 19° C. = 1·4755. The saponification number was 13·57, equal to 4·75 per cent. of ester. It was evidently a terpene oil, and was but little soluble in alcohol.

Crude Oil from the Leaves of *Callitris intratropica*.

No.	Locality and Date	Specific Gravity ° C	Rotation a_D	Refractive Index ° C	Ester per cent	Yield per cent.
1.	Port Darwin, 2/11/04	0.8481 @ 22	− 21·6	1·4768 @ 22	3·81	0·11
2.	Port Darwin, 29/12/03	0.8563 @ 23	......	1·4755 @ 19	4·75	......

III. TIMBER.

(*a*) Economic.

This timber is the darkest coloured of all the *Callitris*, a character due to the presence of the manganese compound, as well as a large percentage of oil and a phenol—a circumstance that, no doubt, makes it one of the best white-ant-resisting species of the whole genus, but at the same time would materially bar it from use for furniture and other like purposes to which the timbers of its congeners are put. This one feature alone should make it worth while cultivating in forest lands, as in time its timber would be invaluable for railway sleepers in ant-infested districts.

It is in great request in the Port Darwin district, and the authorities of that Territory despatch from time to time search parties to locate it, with a result that a large area carrying this valuable pine in sparse quantities, has been discovered in the vicinity of Cape Shields, and it is now thought that ample timber for many years to come may be had by systematic operations.

(*b*) Anatomy.

In the various sections examined, the salient features of distinction from other species, were the slender walls of the tracheids, and those of the parenchymatous cells of the medullary rays, and also the height of these, which sometimes contain as many as fifty rows.

The tracheids of the autumnal wood are compressed concentrically, the outer ones especially so, and show no gradation of size into the spring wood, the larger cells of the latter commencing immediately after the former.

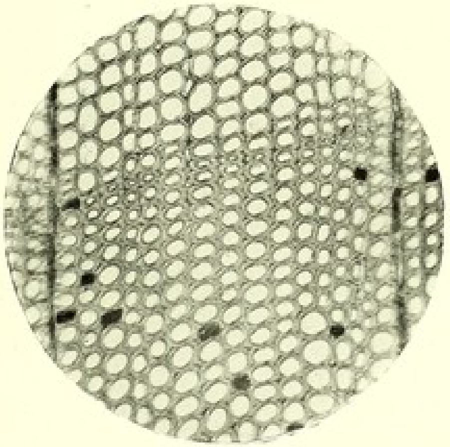


Figure 111.—Transverse section mainly through autumnal growth of timber, the larger cell sections denoting the spring area. *C. intratropica*, × 80.

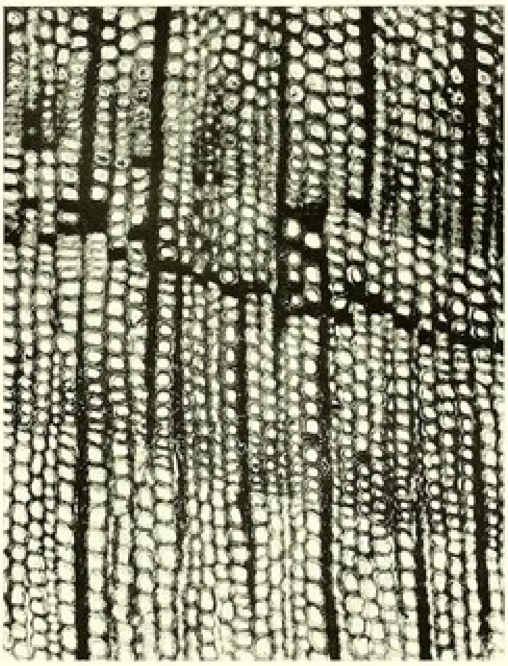


Figure 112.—Transverse section through timber, the tracheids of the autumn wood being distinguished by their narrow lumina in two bands across the picture. The presence of the brown manganese is strongly marked by the black bands in the rays and black spots in the tracheids. *C. intratropica*, × 100.

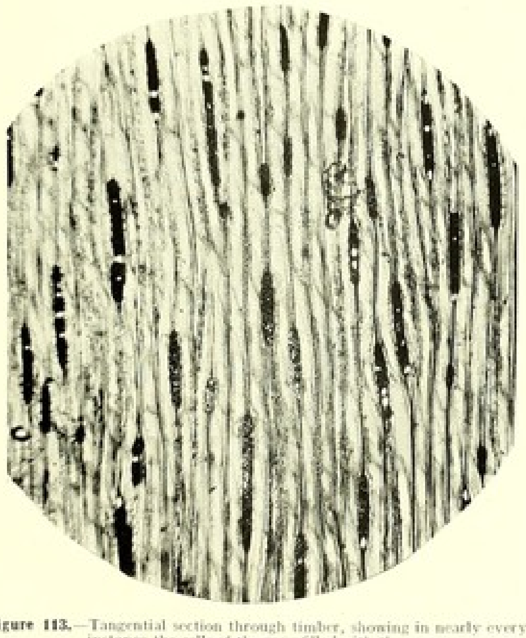


Figure 113.—Tangential section through timber, showing in nearly every instance the cells of the rays filled with the manganese compound. *C. intratropica*, × 84.

Figure 114.—Tangential section through timber, showing unusual height of the rays, most of which are filled with the manganese compound, which can also be seen in the walls of the tracheids. *C. intratropica*, × 80.

Sections of timber of C. intratropica, F.v.M.

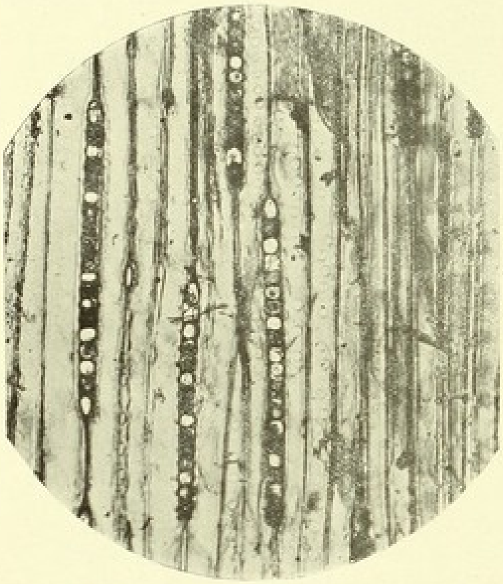


Figure 115.—Tangential section through timber, showing the dark manganese compound substance in most of the ray cells, and the linear shape of the rays. Pitted cells can be detected on both radial and tangential walls. *C. intratropica*, × 120.

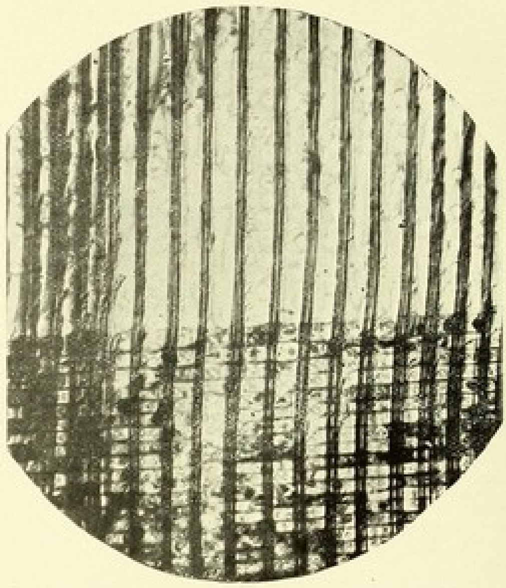


Figure 116.—Radial section through timber. The horizontal parallel lines are the walls of a ray, and the vertical ones those of the tracheids. *C. intratropica*, × 120.

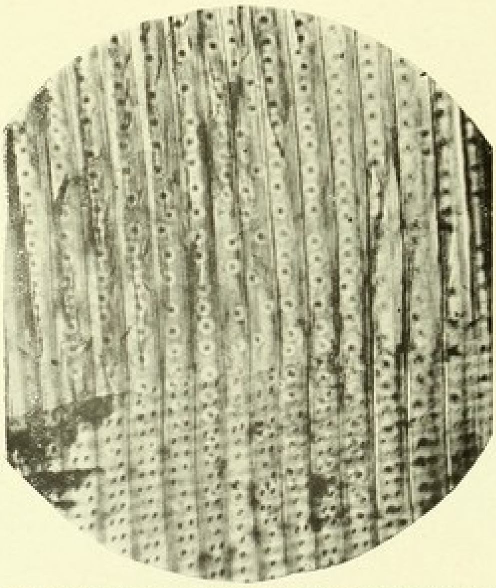


Figure 117.—Radial section through timber, showing the bordered pits of the tracheids, and simple pits of the rays (lower half of picture). *C. intratropica*, × 120.

Sections of timber of C. intratropica, F.v.M.

The simple pits vary from two to five in each lumen of the section and have oblique perforations, which are seen in Figures 116 and 117, at the bottom of both plates. The bordered pits are a conspicuous object on the radial walls, and exceptionally show a likeness in disposition to those of the *Araucarias*, being sometimes found in double rows.

In Figure 111 the autumnal wood running from left to right just above the middle of the picture, is marked by the cells having restricted lumina. The two dark lines on the right and left of the plate locate the medullary rays, and the dark spots the manganese compound content of a few of the tracheids. Figure 112 takes in a much larger field in a transverse section, the black lines marking the medullary rays. Figure 113 is a tangential section showing the fusiform shape of the rays, cut end-on, which are well outlined owing to the dark contents of the cells. Figure 114 is a similar section to Figure 113, but produced to show the extraordinary height of some of the rays, and it also shows the bordered pits in section on the radial walls. Figure 115 is a larger magnification of Figure 114, but is specially interesting, as it shows bordered pits on the tangential walls, a very rare feature in *Callitris;* sections of bordered pits on the radial walls are seen towards the left.

(*c*) Chemistry.

(See articles on the Phenol and the occurrence of Guaiol.)

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

The parenchymatous cells are particularly well developed in this bark, and can be well seen in Figures 118, 119, 120. In Figure 118 they are the distinctly marked, empty spaces between the regular rows of bast fibres, in which Figure are also well defined the medullary rays running from top to bottom of the plate; whilst the larger empty spaces are the oleo-resin cavities, one of which occurs in the centre of Figure 119, where also are numerous parenchymatous cells filled with the manganese compound. Figure 120 is given in order to show what a great proportion of the bark substance is composed of sieve tubes and parenchymatous cells (top half of picture) in comparison to that of the bast fibres,—which can just be detected as small rectangular bodies, with a line in the centre indicating the locality of the central channel. In the middle of Figure 120 is a band of periderm running through the centre of the picture from left to right, and below this towards the bottom of the plate are three large empty oleo-resin cavities. Sieve tubes, although very numerous, are exceedingly small in this bark.

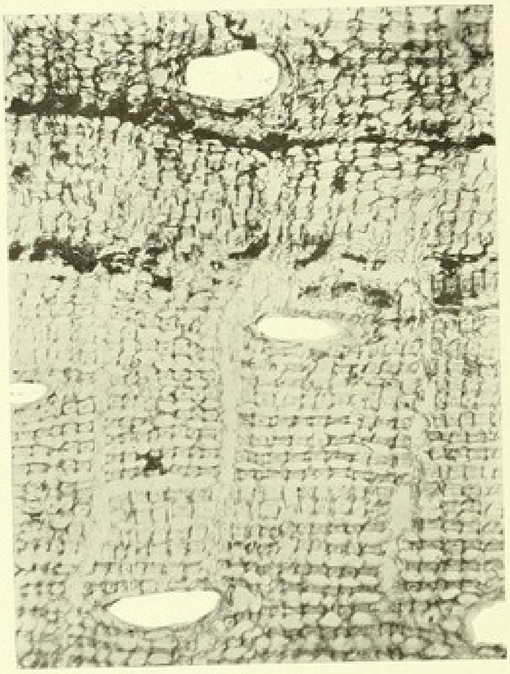


Figure 118.—Transverse section through a junction of the inner and outer bark. The dark blotches mark the presence of the manganese compound. The bast fibres are in regular chains of rectangular shape. Three medullary rays are shown as faint markings from top to bottom of picture. The empty spaces are oleo-resin cavities. *C. intratropica*, × 80

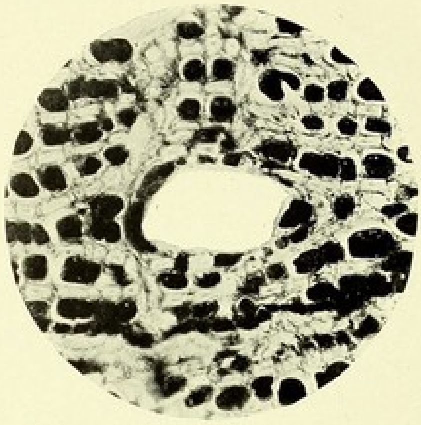


Figure 119.—Transverse section of oleo-resin cavity of inner bark. The black content of the parenchymatous cells is brown manganese compound. The rectangular bodies are the bast fibres. *C. intratropica*, × 80.

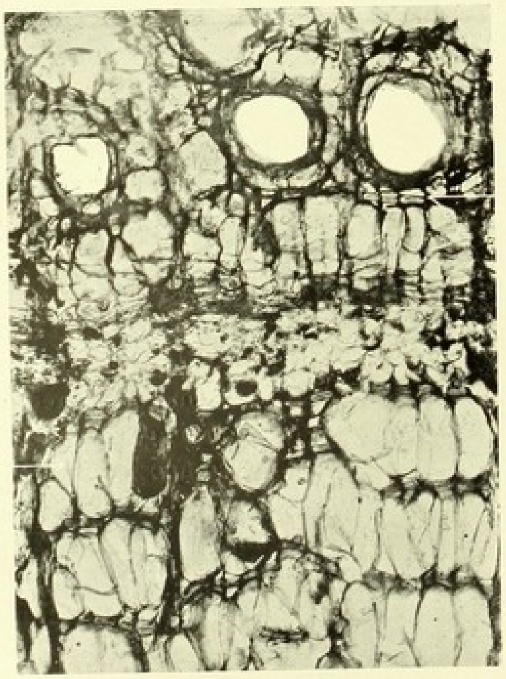


Figure 120.—Transverse section of bark at junction of inner and outer cortex, the latter indicated by three large oleo-resin cavities The light area of irregular cells running through the centre of the field from left to right is a periderm band, followed outwards by exceedingly small sieve tubes, then large parenchymatous cells, sieve tubes and bast fibres. *C. intratropica*, × 100.

(*c*) CHEMISTRY.

This sample of bark was taken from a log sent to the Museum from Port Darwin by Mr. N. Holtze, Curator of the Botanic Gardens there.

The log was 7 inches in diameter, and the bark was somewhat hard and compact, dark grey externally, deeply furrowed and fibrous. In thickness it ranged from 7 to 10 mm.

The following results were obtained with the air-dried bark:—

Moisture	11·14 per cent.
Total extract ...	16·18 ,,
Non-tannin ...	5·46 ,,
Tannin	10·72 ,,

8. Callitris gracilis.

R. T. Baker, Proc. Linn. Soc., N.S.W., 1903, p. 39.

"CYPRESS" OR "MOUNTAIN PINE."

HABITAT.

Tal Tal Mountain and Gowie Range, Bylong, Rylstone. J. Dawson, L.S., and R. T. Baker.

I. HISTORICAL.

This pine was discovered in 1893 by J. Dawson, L.S. In the same district are also found *C. calcarata*, R.Br., *C. glauca*, R.Br., *C. Tasmanica*, Nobis, *C. Muelleri*, Benth. and Hook. In the fineness of the branchlets it approaches *C. rhomboidea*, R.Br., and *C. arenosa*.

It is always found at higher elevations than any of its local congeners, as it occurs on ridges or rocky mountains in company with (although in the higher ridges) *C. calcarata*, R.Br., which species, however, extends on both sides of the Coast Range and well into the interior, whilst this Pine, so far, has only been found on the Western slopes. The fruits show a remarkable likeness to those of *C. Muelleri*, but the branchlets with the decurrent leaves show no resemblance to that species. The long, fine, drooping branchlets occasionally, give it a willow-like appearance, and in addition to other differences the chemical constituents are distinct from those of this latter species.

Callitris gracilis, R.T.B., TAL TAL MOUNTAIN, BYLONG, N.S.W.

This *Callitris* so far appears to be very local, for after a rather exhaustive survey of the pines it does not appear to occur elsewhere, and there is no indication, at present of any forms really transitional between it and any of the above-mentioned species, whilst it is distinct from any Western Australian *Callitris*. Mr. J. H. Maiden ("Forest Flora, N.S.W.," Vol. II, p. 2, p. 55,) expresses an opinion that this species is *C. propinqua;* the results of this investigation, however, show it to be distinct from that species.

Herbarium Material Examined.

Kew,—

A specimen, labelled Port Phillip, and named by Mueller as *C. robusta*, has a resemblance to this species.

II. SYSTEMATIC.

This is a tree attaining a height of over 50 feet, with a diameter from 1 to 2 feet, and having a hard, compact bark similar to that of other species of *Callitris*. The branchlets are numerous and slender, with decurrent leaves, having a bright green colour; internodes terete, or with very obtuse angles, the free ends of the leaves being small and acute.

Male amenta terminal, seldom axillary, solitary, or only occasionally two together, 3 lines long and slightly exceeding the branchlets in diameter, cylindrical, oblong. Stamens in whorls of three, imbricate in six vertical rows; apex, scale-like, ovate or orbicular, concave, with two anthers (two-celled) at the base. Female amentum about 1 line in diameter, having six scales, solitary or two or three together, fairly numerous below the terminal drooping branchlets.

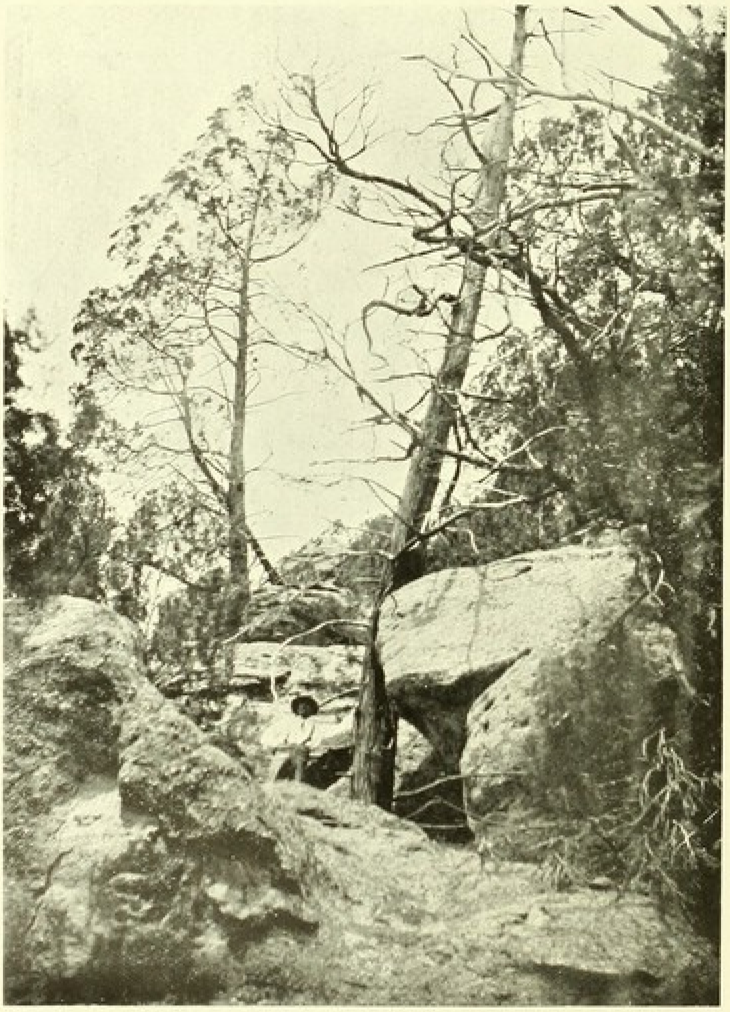
Fruit-cones large, solitary, globular, or compressed globular, from 1 inch to 1¼ in. diameter, or even larger; valves six, very thick, smooth or slightly rugose, furrowed at the junctions, the three larger ones broadest at the middle and then tapering upwards, and very thick from the base to the middle, the smaller ones about one-half as wide as the larger and shorter in length; the dorsal point minute and close to the apex. Seeds dark-coloured, the wings varying in size and shape.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

One of the chief features of these leaves, is the large epidermal cells of the dorsal surface; in the ventral channel of the collateral leaves, they take the same form generally observed in the genus—the cuticle developing into elongated



Callitris gracilis, R.T.B., TAL TAL MOUNTAIN, BYLONG, N.S.W.
[The largest trunk seen.]

conical projections, at the base of which are found the stomata, as well as on the inner surface of the free portion of the leaf, and on the opposite dorsal surface of the decurrent leaf, but only on that portion of it immediately covered by the free end. On the dorsal side, the epidermal cells are backed by a single row of hypodermal cells and again by palisade parenchyma; the spongy mesophyll occupying the bulk of the leaf substance.

The endodermal parenchymatous cells are not much in evidence, there being an unusual number of transfusion tracheids around and between the leaf bundle and the central bundles of the branchlet; one or two sclerenchymatous cells were detected just on the outside of the phloem of the leaf bundle.

The oil cavities are fairly numerous and large, and are surrounded by strengthening and secretory cells.

A cross section through the decurrent leaves shows distinctive characters that aid in establishing the specific rank of this *Callitris*, *vide* Figures 121, 122.

The central cylinder of the branchlet is composed of bundles (generally three) having very thick-walled cells in the xylem and a phloem also unusually thick, these being separated medullary by the usual pith tissue of the central column, which latter is not surrounded by the usual parenchymatous cells, whilst the transfusion tissue is well developed, *vide* Figure 123.

A small bundle occurs as usual along the inner side of each leaf (and between the base and the oil cavity, if the latter be present) in the section, and surrounded by the fundamental tissue.

The oil cavities have exceptionally large diameters, and have strengthening cells, as well as secretory ones, as shown in Figures 121 and 122.

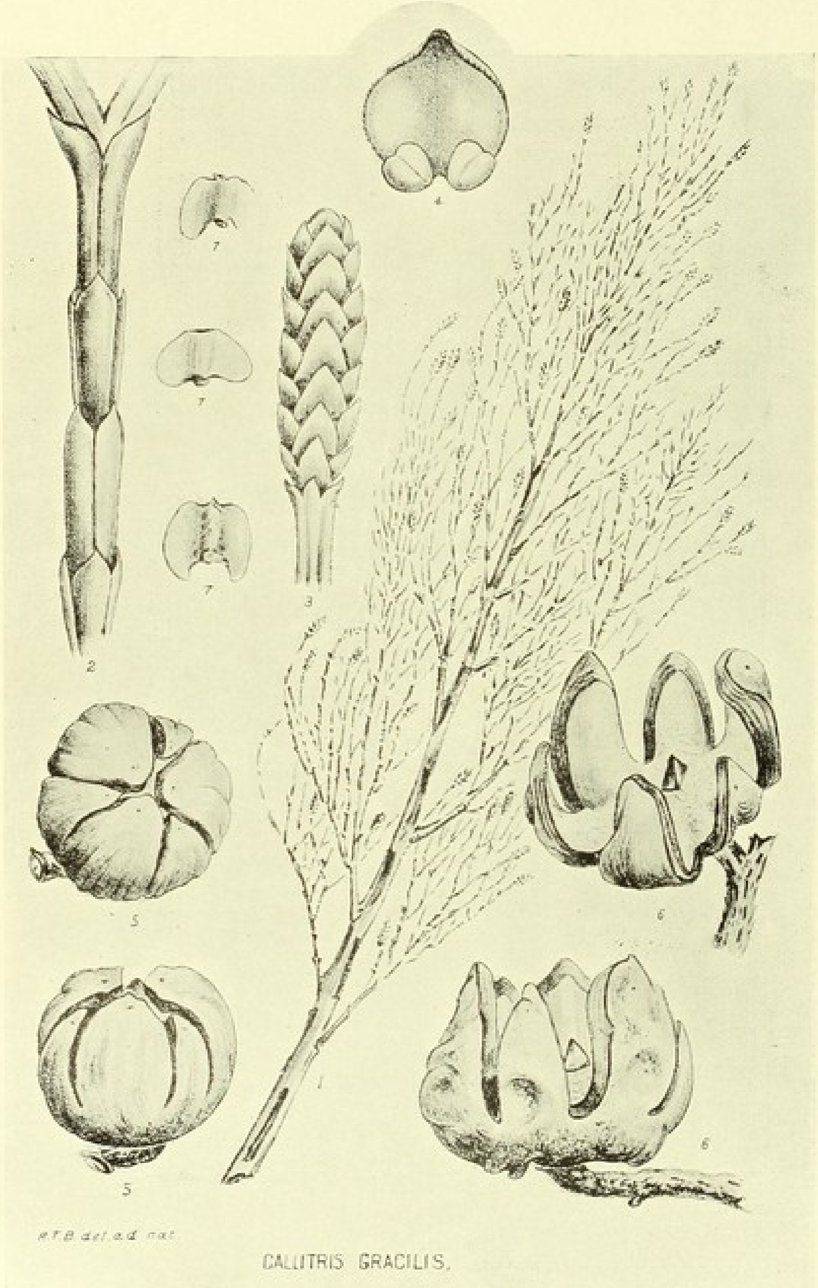
The assimilatory surface is on the superior side, and the transpiratory on the inferior.

The epidermal cells are in a single row below the former, and this is subtended by a single row of hypodermal cells which, if anything, are larger individually than epidermal cells.

The two Figures 123 and 124 illustrate the features above recorded.

(*c*) Chemistry of the Leaf Oil.

Material of this species was collected at Tal Tal Mountain, near Bylong, New South Wales, 240 miles from Sydney, on the 22nd March, 1905. The terminal branchlets with fruit were distilled for six hours, and the yield was somewhat large; 480 lb. of material gave 55½ oz. of oil, equal to 0·723 per cent., which is the greatest yield obtained with the leaf oil of any species of *Callitris*. The crude oil was but slightly lemon-coloured, and had the usual odour, although



Callitris gracilis, R.T.B., "CYPRESS PINE."

this was less marked than with the oil of *C. glauca*. It was largely a terpene oil, and, consequently, was not readily soluble in alcohol. Eventually it was soluble in 10 volumes of 90 per cent. alcohol. A small amount of resin deposited on the sides of the bottle on keeping, although this deposit was in less amount than with *C. glauca*. The oil contained about 12 per cent. of esters, of which half was saponified in the cold with three hours contact. The alcohols present were dextro-rotatory borneol and terpineol, and most probably geraniol. The alcohols were present mostly in the form of esters. The acids separated from the esters were acetic and butyric, the latter being most probably in combination with the terpineol. Of all the species of *Callitris* investigated, this is the only one in which terpineol was present in the oil in sufficient amount to be indicated with reasonable certainty, and butyric acid was also present in greater quantity than in the oil of any other species. The presence of a small amount of butyric acid has been detected in the esters of several other species, and it may, therefore be, that terpinyl-butyrate occurs in most of the oils of the *Callitris* in small amount, reaching a maximum in the oil of this species. The results indicated that the predominant limonene was the lævo-rotatory form, but the limonenes do not occur in this oil in large amount; the higher boiling fraction, being dextro-rotatory, indicated the presence of the bornyl-acetate, which constituent is common to nearly all *Callitris* species. The pinene fraction, was not so highly dextro-rotatory as with some other species, thus indicating that the pinenes were present in these species in the isomeric forms. A very small amount of a phenolic body was separated but its distinctive characters was not determined, as sufficient material could not be spared for the purpose. It may, perhaps, be allied to the phenol, callitrol, isolated from *Callitris* timber, as in some directions it gave similar reactions.

The specific gravity of the crude oil at $\frac{20°}{15}$ C. = 0·8683; rotation, a_D = + 8·7°; refractive index at 20° C. = 1·4752. The saponification number was 34·64, equal to 12·1 per cent. ester. In the cold, with three hours contact, the saponification number was 17·85, equal to 6·25 per cent. ester.

On redistilling, practically nothing came over below 155° C. Between 155° and 167°, 54 per cent. distilled; between 167° and 174°, 20 per cent.; between 174° and 200°, 10 per cent.; between 200° and 230°, 9 per cent. There was slight decomposition of the esters at the higher temperatures. The specific gravity of the first fraction at 20° C. = 0·8545; of the second 0·8534; of the third, 0·8674; and of the fourth, 0·9422. The rotation of the first fraction a_D = + 12·1°; of the second, + 4·8°; of the third, — 2·5°; of the fourth, + 12·8°. The refractive index of the first fraction at 20° C. = 1·4741. It had all the characteristics of pinene. The nitrosochloride was readily prepared from it, and, when purified from chloroform and methyl alcohol, melted at 107–108° C. The nitrosopinene prepared from this, melted at 131–132° C. The saponification of the fourth fraction was 173·9, equal to 60·9 per cent. ester. The separated oil contained a considerable

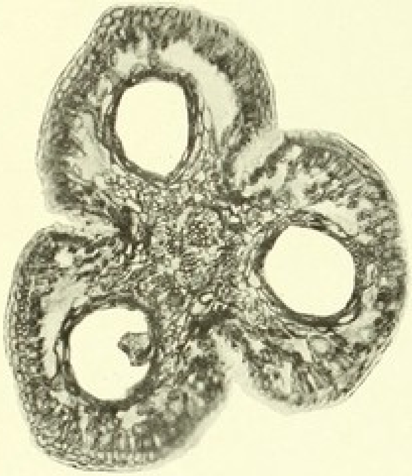


Figure 121.—Transverse section through branchlet and decurrent leaves, showing oil cavity in each leaf. One contains a specimen of resin. *C. gracilis*, × 105.

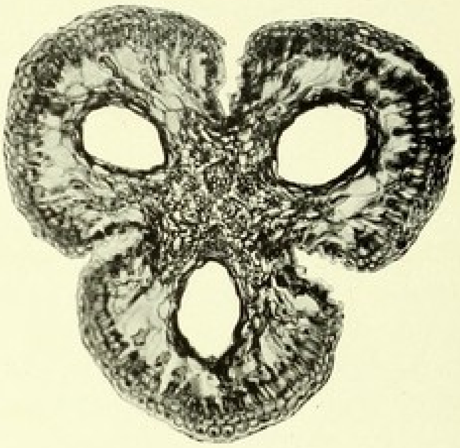


Figure 122.—Transverse section through leaves and median axis of branchlet, showing oil cavity in each leaf. *C. gracilis*, × 105.

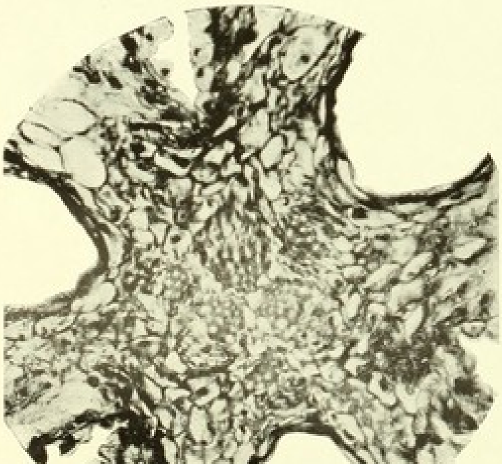


Figure 123.—Transverse section through branchlet showing the number of bundles composing the axis. The inner side of three oil cavities obtrude in the picture, as well as the bottom of three decurrent channels. *C. gracilis*, × 250.

Figure 124.—Transverse section through decurrent channel formed by the decurrent leaves, given to show the conical prolongations of the cuticle over the stomata. *C. gracilis*, × 250.

Cross sections of branchlets and leaves of C. gracilis, R.T.B.

amount of borneol, which was separated and determined as in the case of *C. glauca*. The liquid portion gave a marked secondary odour of terpineol, which was most persistent. Geraniol was not strongly marked. When agitated with hydriodic acid a heavy oil was formed, from which a small amount of crystallised substance was eventually obtained. This melted at about 78° C. and was most probably dipentene dihydriodide $C_{10}H_{18}I_2$, thus confirming the presence of terpineol.

The free acids were determined by evaporating the alcohol from the aqueous portion, and distilling with sulphuric acid, until all the free acids had come over. The barium salt was prepared in the usual way, and 0·5642 gram gave 0·5012 gram, $BaSO_4$ = 88·83 per cent. A second determination gave identical results. The presence of butyric acid was most marked when distilling, and the characteristic odour of its ethyl ester was easily obtained. If only butyric and acetic acids were present, then the salt contained 84·71 per cent. of barium acetate and 15·29 per cent. of barium butyrate.

It is thus seen that the oil of this species has several distinctive characters from those of any other species of *Callitris*.

Crude Oil from the Leaves of *Callitris gracilis*.

Locality and Date.	Specific Gravity ° C.	Rotation a_D.	Refractive Index ° C.	Ester per cent	Yield per cent.
Tal Tal Mountain, 22/3/05	0·8683 @ 20	+ 8·7	1·4752 @ 20	12·1	0·723

IV. TIMBER.

(*a*) Economic.

This pine grows to the average height of a *Callitris*, *i.e.*, 60 feet. The timber is slightly heavier than that of *C. rhomboidea;* it is straight in the grain, and possesses a rather pleasing figure, produced by small medullary rays.

It could be used for indoor carpentry and panelling, and takes a good polish.

As its habitat is the rocky sides of ridges it should be a splendid timber for afforesting these barren places, with some hopes of monetary returns.

(*b*) Anatomy.

Figure 125 is taken from a two-years old growth, and is interesting, as it shows a large number of cells containing the manganese compound in the tracheids, at this period of the tree's life history.

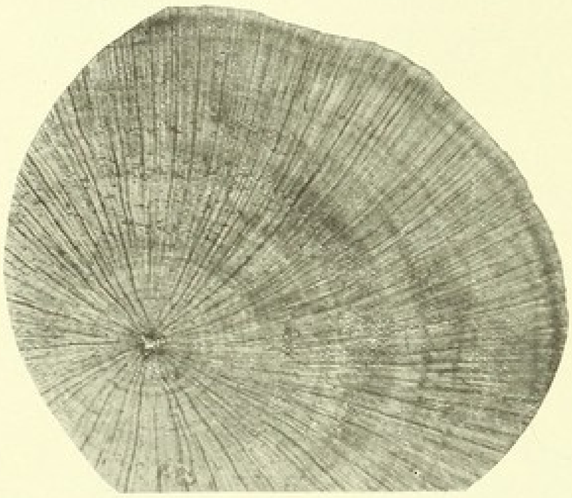


Figure 125.—Transverse section through young timber showing dark substance in tracheids at this early stage of growth. *C. gracilis*, × 10.

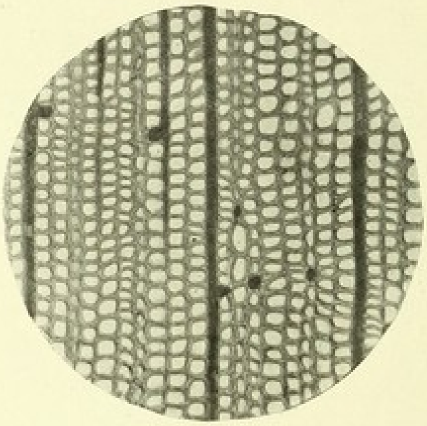


Figure 126.—Transverse section through vernal growth of timber, the three dark bands are rays with dark substance in cells. *C. gracilis*, × 80.

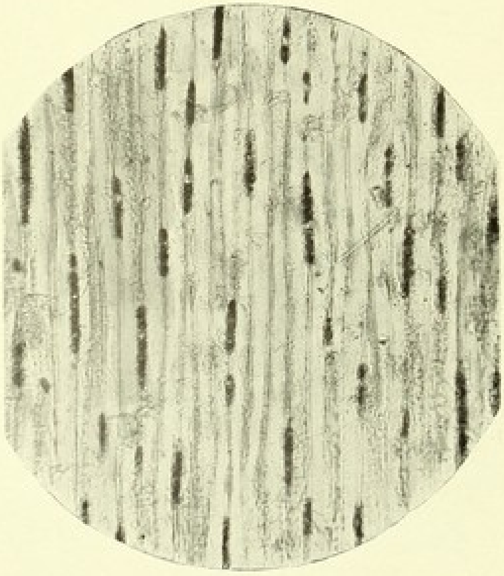


Figure 127.—Tangential section of timber, showing how numerous the manganese compound is in the cells of the rays. *C. gracilis*, × 80.

Sections of timber of C. gracilis, R.T.B.

One of the most important differential characters found in the various mature sections examined, was the uniformly small number of single vertically imposed cells of the medullary rays, as seen in a tangential section. The rays are quite numerous and considerably more lengthened than in other species, whilst every cell is filled with a brown substance,—the manganese compound.

In Figure 126 these cells appear as thick black lines right through the picture from top to bottom of the field.

The cells of the tracheids containing the manganese compound, are fairly distributed throughout the xylem, but favour perhaps the locality of the autumnal growth. Figure 126 shows a few of these cells.

The pitted cells are all disposed on the radial walls of the tracheids. They are faintly shown in section in Figure 127, a tangential section of the timber.

The perforations are circular and single in each lumen.

V. BARK.

(*a*) Economic (see Chemistry).

Chemistry.

The bark of this species is somewhat hard and compact. Externally it is of a dark grey to brown colour and deeply furrowed. The specimen determined was from 10 to 12 mm. in thickness. The colour of the powdered bark was darker than that of any of the other species, and the extract was very dark coloured also. Although this shows a defect for tanning purposes, yet, this may not be characteristic of this bark always, as the specimen had been in the Museum for a considerable time.

The following results were obtained with the air-dried bark:—

Moisture ...	...	9·94	per cent.
Total extract	...	20·08	,,
Non-tannin	...	7·79	,,
Tannin ...	...	12·29	,,

EXPLANATION OF PLATE (Page 186).

Fig. 1.—Twig with branchlets and male amenta.
*Fig. 2.—Individual branchlets.
*Fig. 3.—Male amentum.
*Fig. 4.—Stamen with anthers.
Fig. 5.—Cones unexpanded (natural size).
Fig. 6.—Cones expanded.
Fig. 7.—Seeds (natural size).

* Enlarged.

9. Callitris calcarata.

R. Br., ex Mirb. in Mem., Mus., Par. xiii (1875), 74.

"BLACK," "RED," OR "MOUNTAIN PINE."

(Syn.:—*C. spæroidalis*, Slotsky; *C. fruticosa*, R.Br., MS. ex Rich. Conif., 49; *Frenela calcarata*, A. Cunn., MS.; *F. Endlicheri*, Parlat. in DC. Prod., XVI, ii, 449; *F. fruticosa*, Endl., syn. Conif., 36 [Parlatore]; *F. pyramidalis*, A. Cunn., Sweet, Hort. Brit., ed. ii, 473; *F. ericoides*, Hort. ex Endl., syn. Conif., 38 [Gord. Pin., p. 117]; *F. australis*, Endl., syn. Conif., 37 [Gord. Pin., p. 119]; *Cupressus australis*, Persoon, syn. 2, p. 589 [Gord. Pin., p. 119]; *Juniperus ericoides*, Noisette ex Desf. Hort., Paris, edit. 3, p. 355 [Gordon Pin., p. 117].)

HABITAT.

This is a widely distributed species throughout the Eastern States, occurring almost invariably on hills and ridges.

It appears to favour rising ground, and is the pine which has given rise to the term "Pine ridge"—so commonly applied to hills in New South Wales.

I. HISTORICAL.

This species, as the above list of synonymy shows, has had a rather checkered systematic career, and yet it is one of the best naturally defined species of the genus and not easily confounded with any other Conifer. Good specimens of it were collected very early in the beginning of last century, and these are extant to-day in European herbaria, so that it is difficult to understand why so much confusion has surrounded its differentiation.

It is essentially a ridge or mountain pine, and hence is known in many parts as "Mountain Pine," but it is also found near the coast at Wide Bay, Queensland, and near Stroud and at Longreach, Shoalhaven, New South Wales.

The name "Black Pine" alludes to the colour of the bark, and also to the dark shade of the foliage, whilst it is called "Red" owing to some of the trees having a red-tinted timber.

In general appearance this tree is perhaps more rigid than *C. glauca*, R.Br., and the branchlets less drooping, and from which species it is amongst other characters distinguished by its non-glaucous and angular, decurrent leaves. The

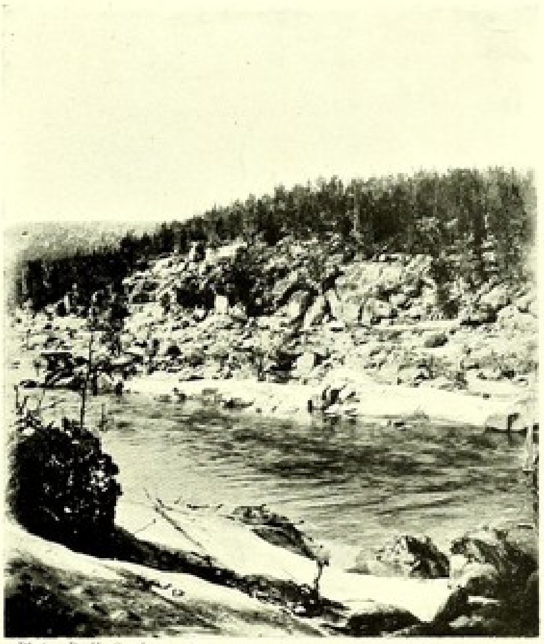


Photo., R. H. Cambage.

Callitris calcarata, R.Br. A PINE RIDGE, LACHLAN RIVER, ABOVE COWRA, N.S.W.

Callitris calcarata, R.Br. TREES LEFT FOR SHADE AND ORNAMENTAL PURPOSES IN A HOME PADDOCK, BYLONG, N.S.W.

fruits are characteristic, and differ from those of *C. Muelleri* only in size, which are twice as large as those of this species, the outer surface being black and smooth in both cases.

The specific name is not well chosen, as a spur or dorsal point is a common character of all the species, and is perhaps not more prominent in this than in several other *Callitris*. The origin of this feature is fully explained in the article on the origin of the " spur " in *Callitris* cones.

Herbaria Material Examined.

Kew,—

A. Cunningham's specimens from Liverpool Plains, New South Wales, 1825, and from Bathurst.

Bidwell's specimens from Wide Bay.

Fraser's specimens (no locality).

Mueller's specimens from Rocky Ranges near Bathurst.

Fulter's Range and Grampians, labelled *F. pyramidalis*, Sweet.

British Museum,—

A. Cunningham's specimen, Oxley's Mt. and Second Expedition.

A. Cunningham's specimens, First Voyage of the " Mermaid," 1810 (no locality).

A. Cunningham's specimen from the vicinity of Bathurst, "A tree . . . . clothing every range."

G. R. Bennett's specimens, Murrumbidgee, 1831.

Cambridge University Herbarium,—

Bidwell's specimen from Wide Bay.

Slotsky's specimens from Menaro. (*C. sphæroidalis.*)

Paris,—

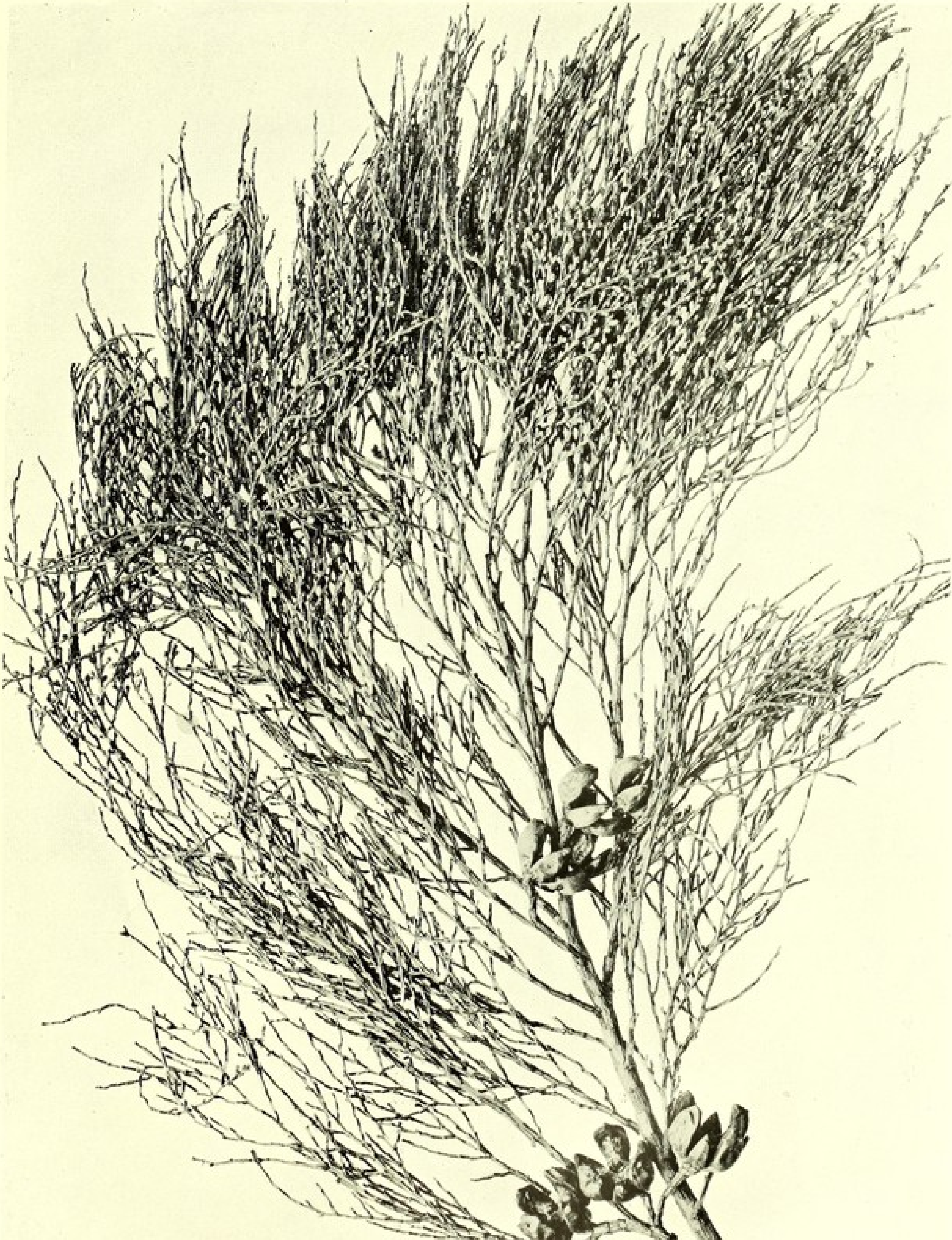
D'Urville's specimen, labelled " from Port Jackson."

Berlin,—

D'Urville's specimen from New Holland, 1815, labelled "*Actinostrobus pyramidalis*."

II. SYSTEMATIC.

It is an evergreen tree attaining a height of 60 to 80 feet with a dark, hard, compact, deeply furrowed bark. The leaves are not glaucous, and occur in whorls of threes, decurrent, sharply convex on the back, free end obtuse or acute with almost scarious edges; in the very young plants the internodes are very short and the ridges flattened. Male amentum mostly solitary and axillary, and when terminal in twos or threes, 1½ lines long, compact, rather paler in colour than those of other species. Anthers two or three, rarely four. Female amentum as in other species.



Callitris calcarata, R.Br., "Black Pine."

Nat. Size.

The cones are in clusters or solitary, smooth, sometimes rugose, globose, or oval, obtuse, 9 lines long and about 6 lines in diameter, the three larger valves being slightly dilated upwards; the dorsal point not far removed from the apex of the valves; valves valvate before opening, but the edges rounded afterwards, central columella short, with three narrow sides. Seeds black, wings varying in size up to 6 lines.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

The leaves in this species differ from those of its congeners, in having a high and often sharp dorsal ridge in the decurrent portion, as seen in a cross section taken anywhere in the internodes. This contour of the leaves is characteristic and might be classed as almost specific amongst eastern species as evidenced by a comparison with other specific sections reproduced in this work.

The general structure conforms to that of *C. glauca,* which may be taken as characteristic of the type of the genus.

The mesophyll and the parenchymatous cells, together with conjunctive tissue, may be said to form the fundamental structure, the two latter being well packed around the leaf trace and phloem of the central column—composed of the xylem and phloem of the branchlet to which the leaves are attached. The transfusion cells are more numerous than those in *C. glauca;* they are generally clustered on each side of the leaf bundle and on the inner side of the oil cavity. The palisade and spongy tissue are normally situated, the former being faced by uniseriate hypodermal and epidermal cells.

The oil cavity is situated in the upper part of the leaf and near the free end, and between it and the stem runs a bundle with the phloem normally orientated, and exceptions to this have rarely been found.

Immediately between the oil cavity and the phloem of the leaf bundle, and exterior to the phloem of the central stem of the branchlet, are found a few sclerenchymatous cells, a specific difference from *C. glauca.*

A noteworthy distinctive feature is the scarcity of stomata, and even these few are not surrounded with such well emphasised papillose projections as in the leaves of *C. glauca.* The stomata occur in the cavities of the ventral leaves as in *C. glauca,* but also on the concave surfaces of the dorsal cuticle of the leaf, although few in number.

This being a mountain species, perhaps the habitat may account for the different disposition of the stomata.

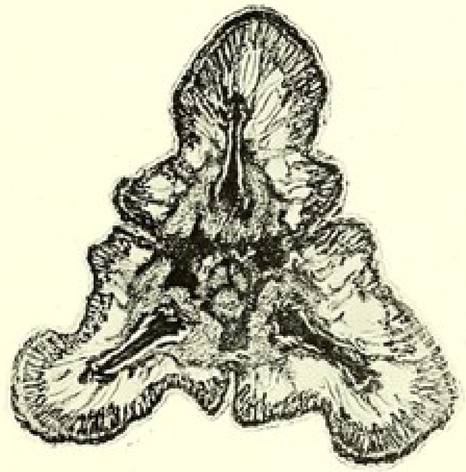


Figure 128.—Transverse section through branchlet and decurrent leaves, cut after being dried, with the consequence that the oleo-resin has indurated, and appears as a dark ligulate body in the contracted cells. *C. calcarata*, × 50.

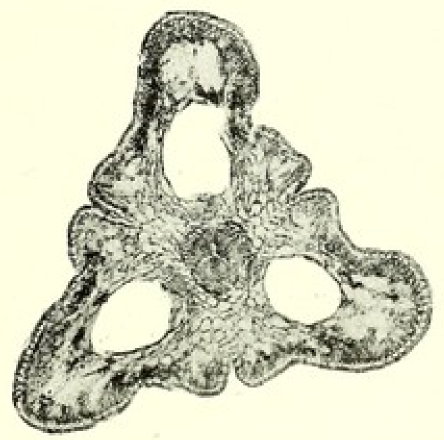


Figure 129.—Transverse section through branchlet and three decurrent leaves, showing oil cavity in each leaf. *C. calcarata*, × 50.

Cross sections of branchlet and leaves, C. calcarata, R.Br.

Figure 128 is interesting as it shows the effect of cutting a section from a dried specimen, the shrinking in this case being indicated by the pinched sides below the dorsal ridge.

The effect of the lateral shrinkage is to compress the oil cavity, and the volatile constituent of the oil having departed, the resinous portion remains and almost fills the compressed cavity as a dark spathulate body, in fact, not unlike the ligule figured in some illustrations of *Lepidodendron* leaves, but, of course, it is not a similar body. If found in a fossil condition, this is most probably what a section would represent.

This is also interesting as showing how, in this instance, the transfusion tissue has massed itself around the inner side of the oil cavity. In Figure 129 is seen a transverse section through the upper portion of the three leaves below the free ends, but prepared in a fresh condition in alcohol; three oil reservoirs have been cut through, which are marked by the oval, blank spaces in each leaf, such as would have appeared in Figure 128 if the specimen had not been dried. In Figure 130 the edges of the section are not perfect, but it is given, as the whole median tissue is so clearly defined, and gives one a good idea of the evident unity of the physiological functions in the organs of the collaterally placed leaves and median axis, for they must all here act in unison for the plant's welfare, and might be regarded in this respect as one whole leaf. The three dark oval bodies towards the base of the leaves are sclerenchymatous cells, and between these and the phloem of the axis of the branchlet is the leaf bundle, and surrounding these are parenchymatous cells (all empty) and transfusion tissue. Figure 131 well illustrates how the parenchymatous endodermal cells dispose themselves when oil reservoirs are present, and they are here well defined surrounding the central axis and extending nearly to the top of the oil cavities, the secretory cells of which are also well defined in this section. Figure 132 is a 150-magnification of the central axis and the surrounding tissue, and is given to show more clearly the disposition of the organs, which go to make up the latter substance, and which from the previous remarks given under Figures 129–131 should not be difficult to follow. The clusters of sclerenchymatous cells abutting on the phloem of the leaf bundles are well emphasised, and one or two can also be detected in the neighbourhood of the phloem of the main axis. The transfusion cells, marked by single circles (bordered pits) in each, are irregularly scattered amongst the empty parenchymatous cells. The three V-shaped dark figures just coming into the picture are the bases of the decurrent channels. From the above remarks it should not be difficult to follow the structure in Figure 133, which is a 175-enlargement taken in the neighbourhood of the decurrent channel in the top of Figure 131. Figure 134 gives a view of a longitudinal section through a node showing the free end of one leaf on the right and an oil cavity in the leaf on the left.

Figure 130.—Transverse section through branchlet and decurrent leaves, well below the oil cavities. The endodermal and transfusion tissues, connected with the palisade parenchyma by the spongy tissue, are massed in the lower half of each leaf and surround a leaf bundle and the median axis. Stained with hæmatoxylin and safranin. *C. calcarata*, × 73.

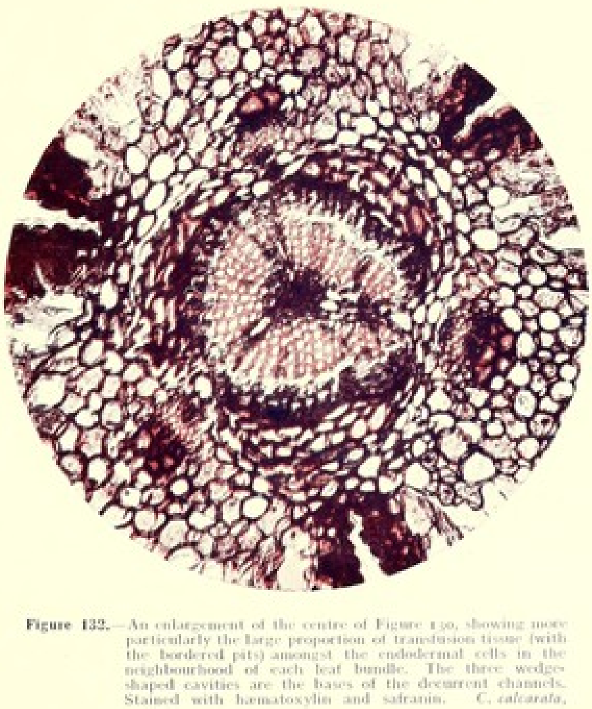


Figure 132.—An enlargement of the centre of Figure 130, showing more particularly the large proportion of transfusion tissue (with the bordered pits) amongst the endodermal cells in the neighbourhood of each leaf bundle. The three wedge-shaped cavities are the bases of the decurrent channels. Stained with hæmatoxylin and safranin. *C. calcarata*, × 150.

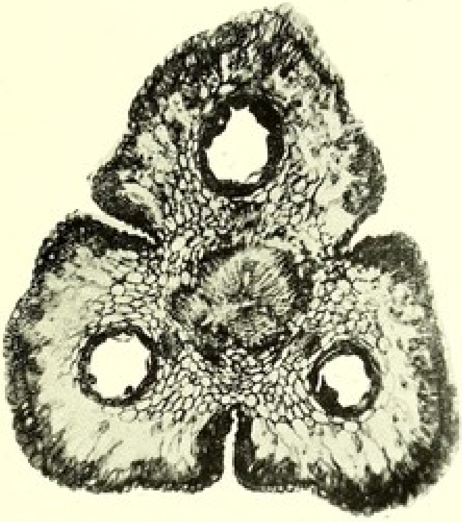


Figure 131.—Transverse section through branchlet with decurrent leaves, showing oil cavity in each of the latter, supported by pronounced secretory cells. *C. calcarata*, × 70.

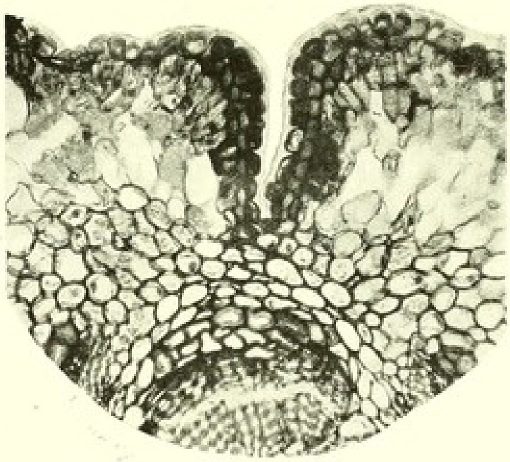


Figure 133.—Transverse section through a decurrent channel of two leaves and on to central axis. Two leaf bundles are just seen at the lower left and right hand of the picture, indicated by clusters of three or four dark sclerenchymatous cells. From those with small pits can be traced lighter-coloured cells, which form the transfusion tissue; the masses of these are separated by empty parenchymatous cells. *C. calcarata*, × 175.

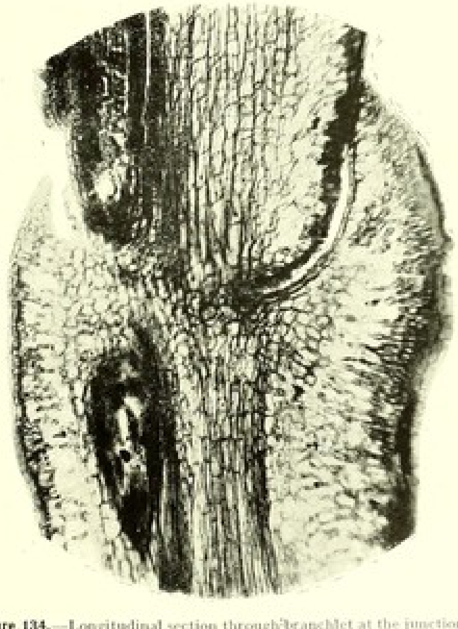


Figure 134.—Longitudinal section through branchlet at the junction of two whorls, and free portions of two decurrent leaves. The oil cavity is marked by a dark pyriform figure in the lower left-hand leaf. *C. calcarata*, × 63.

Sections of branchlets and leaves of C. calcarata, R.Br.

(c) Chemistry of the Leaf Oil.

The yield of oil from the leaves of this species, although practically constant, is considerably less in amount than is always obtained from similar material of *C. glauca*. The ester content, however, is nearly three times as great as that occurring in the oil of the latter species, and the acetic acid ester of geraniol is present in large amount also. The lævo-rotatory limonene, too, is more pronounced in the oil of *C. calcarata* than in that of *C. glauca*, in which species the predominant limonene is found to be always dextro-rotatory. From the results given by the Shuttleton sample, the lævo-rotatory limonene appears to predominate in *C. calcarata* during the summer months. The alteration in rotation is thus mostly with the members of the limonene group, as the ester content and the pinene appear to differ but slightly in amount. The melting point of the tetrabromide formed with the limonene is always high, and this indicates the presence of dipentene also, as well as the active form of limonene. It may be assumed, therefore, that both the dextro- and lævo-rotatory limonenes occur together in the leaf oil of this species, as well as in the leaf oils of most other species of this genus. The specific gravity, boiling point, and other characteristics of this terpene, show it to be limonene. From the chemical results obtained with *C. calcarata* and *C. glauca*, it is readily seen that they have marked distinctive properties, and could never be confounded one with the other. The free acids of the esters were found to consist almost entirely of acetic acid, and only a small amount of an acid of a higher molecular weight was present; this acid is most probably butyric, as with the esters of *C. glauca*. The borneol occurring in the oil of *C. calcarata* is dextro-rotatory, and its acetate also rotates to the right. The lower boiling terpene is dextro-rotatory pinene; and this was proved by the formation of its characteristic compounds.

Sylvestrene could not be detected, nor does it appear to occur in the oils of any species of *Callitris*.

No. 1.—This material was collected at Wellington, New South Wales, 250 miles west of Sydney, on the 9th March, 1903. The terminal branchlets, which were almost entirely free from fruits, were used, and these were distilled for six hours. The weight of the material was 519 lb. and this gave 14 oz. of oil, equal to 0·168 per cent. The crude oil was of a light lemon colour, and had a somewhat distinctive aromatic odour, due to the large amount of geranyl-acetate present. The oil was quite distinct from that of *C. glauca*, and was also less volatile than the oil of that species, and for a similar reason. The specific gravity of the crude oil at $\frac{17}{15}$° C. = 0·8949; rotation, $a_D = +11·7°$; and the refractive index at 19° C. = 1·4747. When freshly distilled it was somewhat readily soluble in alcohol, but on keeping, it became less soluble. After some considerable time had elapsed the crude oil was still soluble in one volume 80 per cent. alcohol, but became turbid with two volumes; it thus differs in solubility in alcohol from the oil of *C. glauca*. There was also no deposition of resin on the sides of the bottle, as was the case

with all our samples of oil from *C. glauca*. The saponification number was 133·1, equal to 46·8 per cent. of ester, as bornyl- and geranyl-acetates. In the cold, with two hours' contact, the saponification number was 112·6, equal to 39·4 per cent. of ester. This result indicates the presence of a large percentage of geranyl-acetate. When redistilled, practically nothing came over below 156° C.; between 156° and 170°, 19 per cent. distilled; between 170° and 180°, 16 per cent.; between 180° and 200°, 11 per cent.; between 200° and 240°, 47 per cent. The specific gravity of the first fraction at $\frac{18}{15}$° C. = 0·8514; of the second, 0·8566; of the third, 0·8662; of the fourth, 0·9249. The rotation of the first fraction a_D = + 13·8°; of the second, + 8·7°; of the third, + 3·9°; of the fourth, + 13·6°. As both borneol and acetic acid were isolated and determined, it may be assumed that the higher rotation of the fourth fraction was mostly due to the presence of the dextro-rotatory bornyl-acetate, which is so pronounced a constituent in the oil of *C. glauca*. The principal ester in the oil of *C. calcarata* is, however, geranyl-acetate.

The volatile acids of the esters were separated by boiling the oil with aqueous soda until the saponification was complete, separating the aqueous portion, distilling over the acids, acidifying with sulphuric acid, forming their barium salts, and determining these, by ignition with sulphuric acid. The mean of three determinations gave 90·92 per cent. barium sulphate. It is probable that butyric acid was present in small amount, as this acid was indicated, so that the salt contained 97·39 per cent. barium acetate, and 2·61 per cent. barium butyrate.

Both borneol and geraniol were separated from the product of saponification, and their identity determined. The geraniol was oxidised to citral, and this, after being isolated, was determined by Doebner's method.

No. 2.—This material was collected at Bylong, New South Wales, 240 miles west of Sydney, on the 29th April, 1903. The terminal branchlets with fruits were steam distilled for six hours in the usual way. The amount of oil obtained from 560 lb. of material was 14½ oz., equal to 0·162 per cent. The crude oil was identical in colour and odour with that distilled from the Wellington sample. The rotation of the crude oil was a_D = + 14·1°; specific gravity at 19° C. = 0·8861; refractive index at 19° C. = 1·4760; saponification number was 118·09, equal to 41·33 per cent. ester. Saponification in the cold, with two hours' contact, gave S.N. 77·38, equal to 27·08 per cent. ester; with eighteen hours' contact the S.N. 109·9, equal to 38·46 per cent. After keeping the oil for some time the solubility in alcohol had diminished somewhat, but in this respect it was identical with the Wellington sample, as it was soluble in an equal volume of 80 per cent. alcohol, but became turbid with two volumes. There was no deposition of resin on the bottle on keeping, as takes place with the oils of some other species of *Callitris*. When redistilled, nothing came over below 156° C.; between 156° and 170°, 24 per cent. distilled; between 170° and 180°, 23 per cent.; between 180° and 200°, 7 per cent. between 200° and 225°, 37 per cent. The specific gravity of the first fraction at

$\frac{20}{15}$° C. = 0·8508; of the second, = 0·8555; of the third, = 0·8753; of the fourth, = 0·9293. The rotation of the first fraction a_D = + 16·9°; of the second, + 11·9°; of the third, + 8·6°; of the fourth, + 15·3°. Borneol, geraniol, and acetic acid were all isolated from this oil, and determined. The higher rotation of the fourth fraction is evidently due to the dextro-rotatory bornyl-acetate. There is but little difference between the characters of this oil and those of the Wellington sample, although a slightly larger amount of bornyl-acetate was indicated, and, consequently, a little less of the geranyl-acetate. This is shown by the higher rotation of the fourth fraction, and the less amount saponified in the cold in two hours. The determination of the volatile acids gave 91·03 per cent. barium sulphate, so that the greater portion of the acids of the esters was acetic acid, and the barium salt only containing 1·95 per cent. barium butyrate. A slightly larger amount of the lower-boiling terpenes were present in this oil, as shown by the quantity distilling, and by the increased rotation, but the differences were not great. The results of the fractions were in agreement with those of the Wellington sample.

No. 3.—This material was collected at Shuttleton, New South Wales, 512 miles west of Sydney, on the 7th December, 1903. The terminal branchlets, with fruits, were distilled for six hours, and 13 oz. of oil obtained from 496 lb. of material, equal to 0·164 per cent. The crude oil was slightly darker in colour than the other two samples, but was identical in odour.

The specific gravity of the crude oil at $\frac{23}{15}$° C. = 0·8803; rotation, a_D = — 4·5°; refractive index at 19° C. = 1·4752; saponification number 110·38, equal to 38·6 per cent. ester. The solubility in alcohol was similar to that of the other samples, and no resin was deposited on the sides of the bottle on keeping. When redistilled, 16 per cent. came over below 170°; between 170° and 180°, 27 per cent.; between 180° and 200°, 11 per cent.; between 200° and 228°, 37 per cent. Slight decomposition of the esters took place at the higher temperatures. The specific gravity of the first fraction at $\frac{24}{15}$° C. = 0·850; of the second, = 0·851; of the third, = 0·8588; of the fourth, = 0·9124. The rotation of the first fraction a_D = + 0·8°; of the second, — 12°; of the third, — 27·8°; of the fourth, + 2·7°. Borneol, geraniol, and acetic acid were all isolated from this oil as with the previous samples, so that the dextro-rotation of the fourth fraction is due to the presence of the bornyl-acetate. The rotations of the several fractions are more to the left than with the previous samples, although the general characters of the oils are the same. This difference in rotation is due to the presence of an increased amount of lævo-rotatory limonene in the oil at this time of the year. To prove the presence of the limonenes the tetrabromide was prepared, the portion of oil distilling between 170–180° C. being utilised for the purpose. The tetrabromide was readily formed, but it melted at 118° C., thus indicating that dipentine was present in some quantity.

The Oil of the Fruits.

The oil was distilled from the fruits alone of this species, so as to determine whether it differed in its characters from the leaf oil, as is the case with some other species of *Callitris*. The results show, however, that the oil distilled from the fruits of *C. calcarata* is practically identical with that obtained from the leaves, and the only difference noticeable was a slightly larger yield. The fruits were collected at Shuttleton, New South Wales, on the 10th December, 1903, and they were distilled for six hours; 68 lb. gave 2½ oz. of oil, equal to 0·229 per cent. The crude oil was somewhat dark in colour, but had a pleasant aromatic odour. The specific gravity of the crude oil at $\frac{23}{15}$° C. = 0·8797; refractive index at 23° C. = 1·4744; rotation α_D + 2·15°; saponification number was 95·35, equal to 33·37 per cent. of esters as bornyl-acetate and geranyl-acetate. In the cold, with two hours' contact, the saponification number was 89·1, equal to 31·18 per cent. ester. The separated oil after saponification, had a marked odour of geraniol, and was readily oxidised to citral. The amount of borneol present in the oil of the fruits of this species is very small.

Crude Oils from the Leaves of *Callitris calcarata*.

No.	Locality and Date.	Specific Gravity °C	Rotation α_D	Refractive Index °C.	Ester per cent by boiling.	Ester per cent. in cold.	Yield per cent
1.	Wellington, 9/3/03	0·8949 @ 17	+ 11.7	1·4747 @ 19	46.58	39·4	0·168
2.	Bylong, 29/4/03	0·8861 @ 19	+ 14·1	1.4760 @ 19	41·33	27·08	0·162
3.	Shuttleton, 7/12/03	0·8803 @ 23	− 4·5	1.4752 @ 19	38·6	.....	0·164

Crude Oil from the fruits of *C. calcarata*.

	Shuttleton, 10/12/03	0·8797 @ 23	+ 2.15	1.4744 @ 23	33·37	31·18	0·229

IV. TIMBER.

(*a*) Economic.

This timber has sometimes a duramen almost as dark as that of *C. intratropica*, but with a far more ornamental figure, and so is in much request for inside boards, for lining houses, wainscoting, panelling, &c.

The timber, however, is seen to best advantage along with other and quieter-looking woods, for when used alone the figure is perhaps too pronounced.

For general purposes, such as those in which our eastern coast pine timbers are employed, it is not recommended, being too short in the grain and too thickly studded with knots. But in the interior districts it is invaluable, being used for building, fencing, post and rails—lasting in the ground, according to some correspondents, twenty-five years or more. Others say it is not so durable.

For turning into columns for halls and statuary it is particularly well adapted—the numerous knots and wavy "flower" producing a very effective natural decoration. It takes a high polish.

Like its congener (*C. glauca*) it has a reputation for immunity from termites, and on this account is highly valued for house-building in the interior of the country.

It often contains a good quantity of guaiol which crystallises out on the surface of the freshly-cut timber.

Transverse Tests of Timber—*Callitris calcarata*.

(The following were made upon selected timber of standard size, 38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 2·98; D 3·00	B 3·00; D 3·00	B 2·95; D 2·96
Area of cross section, square inches	8·94	9·00	8·73
Breaking load	1,200	2,660	2,540
Modulus of rupture in lb. per square inch ...	2,416	5,320	5,341
,, elasticity ,, ,, ...	1,028,571	1,309,090	1,458,000
Rate of load in lb. per minute	109	380	423

(*b*) Anatomy.

Structure of the axis.—Two parts of the tree were taken for examination, *i.e.*, early and mature growth.

A transverse section of a stem of a twelve months old plant is seen in Figure 135. It was grown from seed in a flower-pot and kept under observation, and was found to be in general structure almost similar to that of a mature tree.

The dark cell substance,—the manganese compound, is conspicuous and present in both the wood prosenchyma and medullary parenchyma, but these cells are, however, in the former more regularly arranged in single-cell concentric rings than in the mature wood.

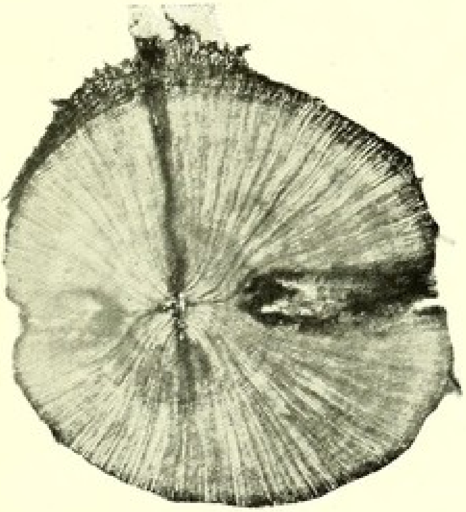


Figure 135.—Transverse section through a stem of a very young plant of *C. calcarata*, × 30.

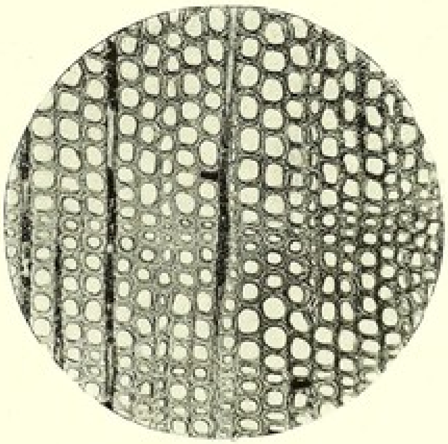


Figure 136.—Transverse section of timber through part of two seasons' growth. The rays are seen to contain the manganese compound substance in some of the cells. *C. calcarata*, × 80.

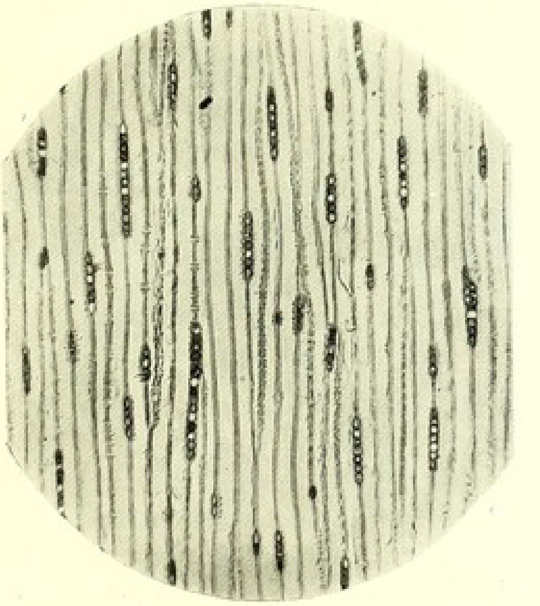


Figure 137.—Tangential section of timber. This shows the varying heights of the rays and also the numerous bordered pits, cut in section in the tracheidal radial walls. *C. calcarata*, × 80.

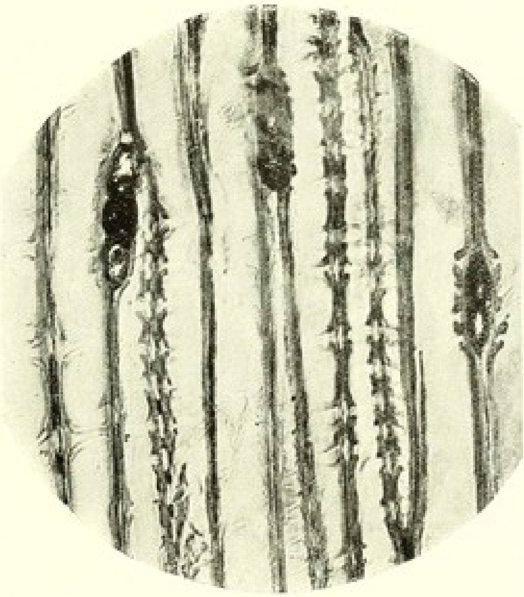


Figure 138.—Tangential section with a much higher magnification than Figure 137, being 210 diameters. Three rays are shown as well as numerous bordered pits cut in section on the radial walls. *C. calcarata*, × 210.

Sections of timber of C. calcarata. R.Br.

The medulla in the specimen is tetrarchous, a circumstance probably marking the close of the individual stage of each bundle.

In this early period of plant life the secondary tracheids of the xylem have fully developed bordered pits in their radial walls, the lamellæ with their tori being distinctly seen under a medium power objective.

In the phloem the structure is precisely a forerunner of what is found in the bark of mature trees, for under a 70- and, more especially a 325-magnification it is found that the uniseriate concentric rings of hard bast cells alternate with three rings made up of a uniseriate parenchyma, separating sieve tubes of a uniseriate ring. The similar staining and general resemblance of the former appear to indicate a xylemic origin, or at least a close affinity to that structure.

The oleo-resin cells of the bark are just beginning to evolve even at this early period of that formation, and are easily seen in the phloem substance.

When dealing with the mature wood, a number of transverse sections were cut, the prominent feature upon examination being the irregular manner in which the cells, containing the manganese compound, are scattered throughout the tracheids. Sometimes they occur closely packed on either side of the autumnal wood, whilst in other instances they are sparsely scattered throughout the vernal growth, or again, in an area of three consecutive years of autumnal and spring growth, they are not found. These features are well shown in the Figures 136 to 139.

The whole of the secondary wood in these sections consists of prosenchymatous cells of strongly thickened walls, almost uniformly hexagonal on the outer walls and circular on the inner. Those of the autumnal series are thicker than the others, all being arranged in radial rows with cells of varying diameters.

A radial section shows that the parenchymatous cells of the medullary rays are fewer in number than those of *C. glauca*, averaging say from five to twelve cells high, and are narrower than obtains in that species, and also that the outer cells, as in that species, are of similar structure to the inner, and not tracheidal in nature.

In a tangential section (Figure 137) it will be noted that the parenchymatous cells of the medullary rays are apparently rather freer of cell contents than obtains in most species of *Callitris*, which fact may be thought to be a slight specific difference, but this is not reliable enough for systematic classification, for sections taken in other parts, such as in Figure 138, show quite the reverse of this feature, for all the ray cells appear to be filled with the brown-coloured substance,—manganese compound.

These parenchymatous rays are from one to twelve cells high, and linear or fusiform in shape in the tangential view. (Figure 137.)

In Figure 139, a longitudinal, radial section, the bordered pits are seen to be on the radial walls of the tracheids, their diameter filling up the whole of the lumina. Only one row was found to occur in each tracheid. A portion of a medullary ray is also shown, running across the figure from left to right.

When working over the longitudinal sections an interesting feature in connection with the dark substance present in some of the prosenchymatous cells, was noted, namely that in such cells the walls differed in no way from those of the contiguous or empty ones, having bordered pits just as equally distributed on their radial walls as those where no substance occurred.

The substance itself was found not to be restricted to any particular portion of the cells, but at certain intervals, was broken into parts, each bounded by a septum composed of this material at right angles to the walls of the tracheids. Now, if these cells are followed along in the opposite directions to the cell substance they will be found to have acute, angular terminations at the other end, showing their prosenchymatous nature. Our observations on these particular cells lead to the conclusion that there is probably some functional agreement between the lumina content of the prosenchyma with that of the parenchymatous cells of the medullary rays; the simple slits or pits of the latter being perhaps the avenue of exchange or supply of cell contents between these two organs.

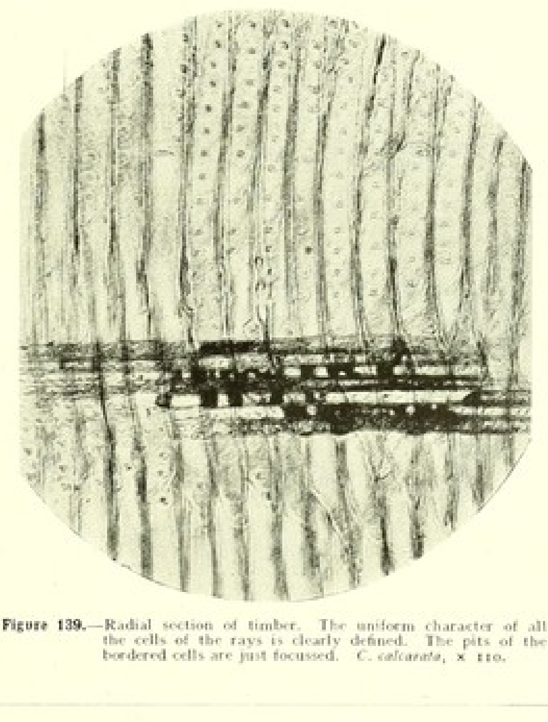


Figure 139.—Radial section of timber. The uniform character of all the cells of the rays is clearly defined. The pits of the bordered cells are just focussed. *C. calcarata*, × 110.

The mural pits are of two kinds—bordered and simple, the former occurring as a rule on the radial walls, although they do occasionally occur in the tangential walls of the prosenchymatous cells, whilst the latter are found on the radial walls of the parenchymatous cells of the rays.

The aperture of the simple cells is a narrow, ovate, oblique slit between the walls of the lumina, and these means of communication vary in number from one to four, but mostly two to four. The bordered pits are well shown in section on the radial walls in Figure 138.

(*c*) Chemistry.

(See articles on the Phenol and the occurrence of Guaiol.)

(*d*) Forestry.

As a suitable tree for stony and barren ridges of the coast ranges and interior it has few compeers, and as the timber is highly valued on account of its ornamental character and comparative immunity from the attacks of termites, it is worthy of every consideration for forest culture.

The exceeding value of its bark as a tanning material causes this tree to be of special interest, and from its natural growth and location no great care would be needed to preserve for all time natural plantations of this valuable tree, so as to supply the needs of the builder and of the tanner, to say nothing of the value of its resin.

From data supplied by correspondents it will be seen how extensively this species is distributed on the hills and ranges, and how readily plantations of any extent could be propagated with ordinary care and attention.

V. BARK.

(*a*) Economic.

The same remarks in this connection apply as those given above under Forestry. (*Vide* also Chemistry.)

(*b*) Anatomy.

This bark is outwardly darker in colour and more compact than that of *C. glauca*, with which species it is so closely associated in the field.

Macroscopically this part of the tree may be divided in a cross section into two parts, the inner and outer cortex, being dark and light coloured respectively.

The reddish appearance of the inner cortex is where the live tannin cells predominate, whilst the colour of the outer appears to be due to the blocking up of the parenchymatous cells with dead matter, principally manganese compound and tannin.

The structure follows in a measure the general and regular rule of the genus, consisting of alternate, uniseriate, concentric rings of sieve tubes, parenchymatous cells, bast fibres, and bands of periderm at varying intervals.

Although a conformity exists between this bark and that of *C. glauca* in the presence of similar cells and tissue, yet when microscopically examined a

marked distinction is noticed between the two barks, caused by an irregularity in the disposition and shape of these organs of structure. Thus in this bark the conspicuous feature is the proportionately large area taken up by the parenchymatous and tannin cells, the former being much flattened radially, and so widely separating the bast fibres, which in this case are quite small bodies (hence its less fibrous character comparatively with *C. glauca*), and occur in broken concentric rings, whilst the companion sieve tubes are also much restricted in size. The oleo-resin cavities, although more abundant than in *C. glauca*, yet are smaller in size, and the bands of periderm are narrower and very much fewer in number than in *C. glauca*.

Figure 140 is a cross section through the junction of the inner and outer bark (one third of the picture from the top) and gives a general idea of the difference between it and *C. glauca*. The light irregular bands stretching from left to right are the parenchymatous cells showing their radially flattened cell walls. The bast fibres can be traced by the zig-zag, broken black lines extending from left to right, but being so small their individual outline cannot be well traced.

Figure 140.—Transverse section through inner and outer bark, the latter towards the top. The bast cells are not all regularly concentric, as obtains in some other species of *Callitris*, and form irregular narrow broken lines from left to right. These are separated by very small sieve tubes and unusually large parenchymatous cells. A few oleo-resin cavities are seen in both barks. *C. calcarata*, × 70.

The oleo-resin cavities are seen to be smaller than in most species. The black patches in the outer cortex are the manganese compound contents of the parenchymatous cells.

Figure 141 is a cross section taken near the external edge of the outer cortex, and is given to illustrate a band of periderm, a rather inconspicuous feature in this bark.

(*c*) Chemistry.

The bark of this species appears, chemically, to be distinct in some respects from the other *Callitris* barks, with the exception, perhaps, of *C. arenosa*. It is of a darker colour than that of *C. glauca*, and in the larger trees is more compact and "corky" externally; in section it is a light brown colour in the

outer portion. It powders fairly well, and is more brittle and less fibrous than the bark of *C. glauca*. It is very much richer in tannin than any other *Callitris* bark, with the exception of *C. arenosa*, and although a thicker and darker coloured bark than *C. glauca*, yet the extract was not comparatively more deeply coloured, considering the increased amount of tannin. (See also article on the tanning value of *Callitris* barks in this work.)

Five samples of the bark of this species were determined:—

I. This bark was collected from a tree 3 to 4 inches in diameter, at Warialda, New South Wales, June, 1909. The bark was beginning to thicken even at this stage, and was somewhat deeply furrowed. Its greatest thickness was 12 mm. It was blackish-grey externally, hard and compact, and commencing to become corky in appearance, while in section the two layers were well defined, the interior layer being yellowish in colour. Two determinations were made with this sample, one with the whole bark, the other with the "rossed" bark.

The following results were obtained with the whole bark:—

Moisture ...	... 12·70	per cent.
Total extract	... 37·03	,,
Non-tannin	... 6·10	,,
Tannin ...	... 30·93	,,

The results with the inner "rossed" bark were:—

Moisture ...	... 12·6	per cent.
Total extract	... 42·9	,,
Non-tannin	... 6·8	,,
Tannin ...	... 36·1	,,

The information gained from the above determination indicates that the larger amount of tannin is contained in the living portion of the bark; so that trees of medium size may be expected generally to contain the greatest amount of tannin in their barks.

II. This bark was taken from a tree 12 inches in diameter, collected at Woodstock, New South Wales, in May, 1907. The exterior was blackish-grey in colour, deeply furrowed, hard and compact, and the corky layer well defined. Its greatest thickness was 30 mm. It was somewhat brittle, and thus powdered fairly well. Two determinations were made with this sample, in one of which the extraction was completed with hot water, while in the other it was carried out with cold water alone, eighteen hours being allowed for extraction.

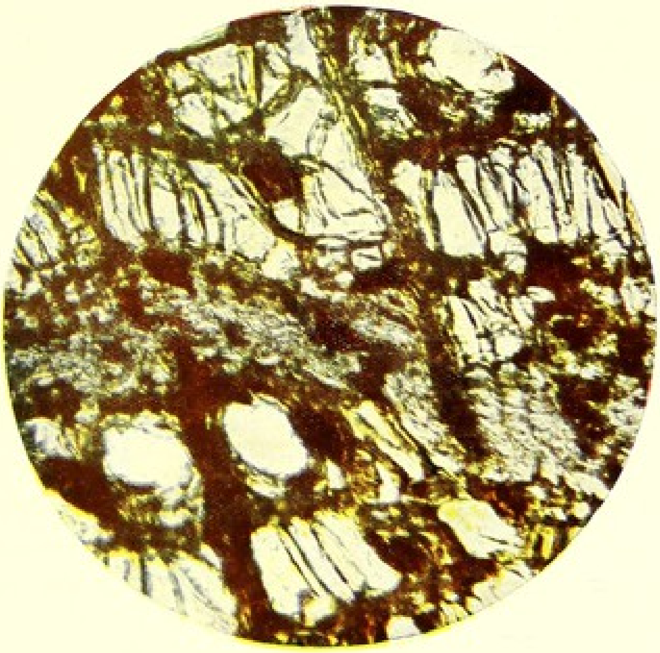


Figure 141.—Transverse section through outer bark. The periderm is marked by an oblique band of thin-walled compressed cells across the picture; two oleo-resin cavities occur just below it on the left. The bast fibres are in lines across the picture from left to right, the parenchymatous cells having their long axes parallel to the medullary rays—two of which extend from top to bottom of the section. Unstained. *C. calcarata*, × 100.

The following results were obtained by the first method:—

Moisture ...	...	13·50 per cent.
Total extract	...	37·33 ,,
Non-tannin	...	6·16 ,,
Tannin ...	...	31·17 ,,

By the cold water extraction alone the results were:—

Moisture ...	...	13·49 per cent.
Total extract	...	31·47 ,,
Non-tannin	...	3·66 ,,
Tannin ...	...	27·81 ,,

III. This bark was taken from trees growing at Grenfell, New South Wales, March, 1909. The trees were only of medium size, and the bark ranged in thickness from 10 to 15 mm. In appearance it resembled the barks of this species collected at other localities and gave the following results:

Moisture ...	...	12·80 per cent.
Total extract	...	26·80 ,,
Non-tannin	...	7·82 ,,
Tannin ...	...	18·98 ,,

IV. This bark was stripped from a log in the Museum, which had been collected at Wellington, New South Wales, September, 1903, and having a diameter of 11 inches. In appearance the bark resembled that of this species from other localities, but it was less rich in tannin; perhaps this was partly due to the length of time that the tree had been felled. The greatest thickness of the bark was 28 mm. It powdered fairly well, but was somewhat more fibrous than the thick bark from Woodstock. The following results were obtained with it:—

Moisture ...	...	13·50 per cent.
Total extract	...	18·39 ,,
Non-tannin	...	4·28 ,,
Tannin ...	...	14·11 ,,

V. This specimen was collected in July, 1909, at Wyalong, New South Wales. It was from a small, very young tree 7 feet high, and 1 inch in diameter, the bark being taken from a portion 25 mm. (under 1 inch) in diameter, and 1 to 3 feet from the ground.

The bark stripped very readily. It was mostly smooth, but beginning to crack externally, and to show the commencement of the deeply-furrowed outer

bark of the older trees. The thickness of the bark was 2 to 3 mm. (about $\frac{1}{8}$ inch). Externally it was dark grey and internally light yellowish in colour, and when quite air-dried it powdered very well. The extract was excellent in its colour, and was rapid in its action on hide powder, which was but little coloured by the tannin. The amount of non-tannin was somewhat high for the bark of this species, but this was to be expected from such young material. The comparatively large amount of 25 per cent. of tannin from air-dried bark stripped from saplings 1 inch in diameter, together with the excellence in colour of the extract, illustrates again the value of the bark of *Callitris calcarata* for tanning purposes. It also shows that the material removed when thinning out for plantation purposes has a considerable tanning value, which should not be neglected.

The reactions given with the extract (25 grams per litre) were identical with those given by the bark of this tree in all stages. The following results were obtained with the air-dried bark:—

Moisture ...	... 13·70	per cent.
Total extract	... 33·47	,,
Non-tannin	... 8·28	,,
Tannin ...	... 25·19	,,

The total extract from the air-dried powdered bark, by cold water alone during twenty hours' contact, was 24·5 per cent., and the non-tannins extracted were considerably less in amount than when the bark was finally extracted with hot water.

Trees of this species about 3 to 4 inches in diameter seem to be in about the best condition for stripping, as the bark then contains a maximum amount of tannin, a comparatively small amount of non-tannin, and only a small quantity of the external corky layer containing constituents of a dark colour.

When a portion of the dried tannin was heated with glycerol to 210° C. in the usual way, and extracted with ether, the aqueous solution of the ether extract gave reactions as follows:—

Ferric chloride, an olive-green colour.

Lime water, red colour.

Pine chip and hydrochloric acid, slight violet colour.

It is thus evident that although somewhat intermediate in character, the tannin of *C. calcarata* belongs to the catechol group.

CALLITRIS CALCARATA, R.Br.—"RED," "BLACK," OR "MOUNTAIN PINE."

Botanical survey of the species in New South Wales. See also map.
From data supplied by Public School Teachers and other correspondents.

(Where no information is given under Remarks, only herbarium specimens were received. The information is given without comment.)

Locality.	County.	Remarks.
Amaroo	Ashburnham	The area covered is said to be about 10 acres (W. Manson.)
Baker's Swamp, Dripstone	Wellington	There are two belts of country, which are studded with these pines, both commencing from the Cundumbil Mountains, which are 20 miles from Molong and about the same distance from Wellington, or about 5 miles from Baker's Swamp, on the main road Wellington to Molong. These mountains form a continuous chain of hills all the way to Wellington, and are, with the exception of a few intervening patches of box, studded with Black Pine, this belt of pine country is about a mile in width; the other belt follows the course of the Bell River for a distance of about 5 or 6 miles. *Resin.*—Black Pine exudes large quantities of resin, especially in the spring, when, by making an incision in the tree, the resin oozes out, forming what might be called icicles, very often as long as 18 inches. (Chas. Varcoe.)
Ballarah, Cobbora	Lincoln	Generally grows upon hillsides and "Ironbark" country. (J. Davis.)
Baerami, Denman	Brisbane	Covers the ground to the extent of about 1 acre to every 100 acres. In odd places there are pine scrubs, which cover a large extent of ground. (W. F. Wedlock.)
Berrigal Creek, Narrabri	Jamison	From Quirindi to Moree, distance about 200 miles, there are extensive forests of pines, generally close to the ranges to the east of the plains. In many instances these forests advance right on to the plains. From Boggabri to some distance below Pilliga along the left bank of the Namoi River there are very large pine forests all the way. This forest extends to Coonabarabran on the Castlereagh River, and, I believe, continues on to the Macquarie and Bogan Rivers. In this district, Berrigal Creek, there are pine scrubs to Narrabri, 50 miles. (Francis Squire.)
Berrima	Camden	Only a few trees growing on the banks of the river. (William Gambell.)
Bethungra	Clarendon	Mountain Pine grows on the ranges in this neighbourhood. (B. F. Dale.)

CALLITRIS CALCARATA, R.Br.—Botanical Survey of the Species (*continued*).

Locality.	County.	Remarks
Bigga, Binda	Georgiana ...	The Bigga district is between the Lachlan and Abercrombie Rivers. The country along these rivers is very rough, the hills being in many cases covered with pine. Approximate area of ground covered by pine, 10,000 acres. *Timber.*—30 feet height; diameter, 9 to 12 inches—a few trees from 1 to 2 feet, these are rare. *Resin.*—Very little exuded, except the tree has received some cut or knock. Where the trees have been ringbarked, the resin is exuded freely. On the Burrowa River, persons have been known to gather from 12 to 14 lb. per day. (C. S. Chudleigh.)
Boggabri	Pottinger ...	The whole district round. *Resin.*—Exudes resin freely. (Thos. Sheehy.)
Booroomba, Queanbeyan ...	Murray	(G. H. Barker,)
Boree Cabonne	Ashburnham ...	(J. P. Lynch.)
Box Ridge, Sofala	Wellington ...	(R. Strong.)
Brawlin	Harden ...	They extend in patches from the southern edge of the district to Junee, and thence to Hay and out West. (Robert Black.)
Brodie's Plains, Inverell ...	Gough	In patches forming dense pine scrubs. *Timber.*—In the scrub, about 30 to 40 feet; diameter, 3 to 4 inches. If isolated, 60 to 80 feet high; 12 to 18 inches in diameter. *Resin.*—In some cases the bark is completely covered. The resin exudes where the bark is injured or when a branch is broken. (F. V. Holtsbaum.)
Brogan's Creek, Rylstone ...	Roxburgh ...	Scattered over the ranges. (Joseph Rigg.)
Bumbaldry	Monteagle ...	Very abundant. (C. F. Laseron.)
Burrowa	King	Is fairly common between this town and Cowra. (C. F. Laseron.)
Bylong...	Phillip	About 150 acres. Trees from 50 to 80 feet high, and 15 to 20 inches in diameter. (A. N. Tindale.)
Canowindra	Bathurst ...	A few trees. (D. Colleton.)
Cassilis	Bligh	There are patches of considerable extent in different parts of this district, covered for the most part by pine trees. They keep to the poor and sandy country. *Timber.*—30 feet to 50 feet high, and 9 to 12 inches in diameter. *Resin.*—In a natural state they do not exude much resin, but when the bark is wounded there is a greater exudation. Old trees give out much more resin than young ones. (H. W. Smith.)
Chaucer, *viâ* Walli	Bathurst ...	Red Pine grows in detached groups. In a radius of about 10 miles there are only about 40 acres. (Alfred Carroll.)

CALLITRIS CALCARATA, R.Br.—Botanical Survey of the Species (*continued*).

Locality.	County.	Remarks.
Clareval, *viâ* Stroud	Gloucester ...	Although the Black Pine is found throughout the district, if all the trees were put together they would not cover 10 acres. (A. McLennan.)
Cocomingla, Cowra	Monteagle ...	The Cypress Pine grows on a large tract of country in this locality and is, on some of the ranges, the principal tree. In extent, it covers an area of about 30 to 35 miles. It is chiefly found on the south side of the Lachlan River, from the junction of the Burrowa River up the Lachlan. (Alex. Elliott.)
Coffey Hill, Orange	Ashburnham ...	As they grow in patches, it is impossible to give an estimate. They are from the Canoblas south and west on all the ridges, getting larger and more plentiful approaching the Lachlan, but, being abundant in the hills around Eugowra. *Timber.*—If full grown the majority are about 75 feet in height, and 1 foot 6 inches in diameter. *Resin.*—They exude considerable quantities, but much seems to depend on treatment of the tree, for two trees of the same sort growing in the same locality differ very much in the quantity given out. (J. V. Curry.)
Connorton, Wagga	Wynyard ...	About 1,000 acres. (H. C. Brettell).
Coolac	Harden ...	About 8 or 9 miles due west from Coolac in the vicinity of a place called Nongongolong there is a considerable belt of pine scrub. *Timber.*—It has been ascertained that a tree under observation for ten years had grown 30 feet high. (B. G. N. Freeman.)
Coolah	Napier	The Black Pine forms patches of thick scrub covering on an average 50 or 60 acres in extent, and these patches are 5 or 10 miles apart. The pines are scarce in this district, the nearest patch is three miles distant from the town. *Resin.*—They exude a great quantity of resin, the smell of the resin is very marked in summer time, the resin can be seen oozing out in different parts of the tree and in places patches on the ground may be seen. (John Aston.)
Cooma	Beresford ...	About 40 square miles around Cooma. (Henry Thomas.)
Cootamundra	Harden ...	Grows luxuriantly on the ranges, at any rate within a radius of 15 miles from the town—thousands of acres. The Cootamundra district producing Red Pine only. *Timber.*—On some of the ranges the timber is so close together that the stems are mere whip-handles. In less dense belts their diameter ranges up to 1 foot. *Resin.*—See under *C. robusta.* (T. W. Henry, T. B. Mulligan.)
Crow Mountain (Upper Manilla)	Darling	200 acres. (Cecilia Kealy.)
Cullenbone	Wellington ...	Most common. From ¼ to 20 acres in many parts, there are many patches, no extensive belts. (E. R. Langbridge.)

CALLITRIS CALCARATA, R.Br.—Botanical Survey of the Species (*continued*).

Locality.	County.	Remarks.
Denman	Brisbane ...	About 1,000 acres. *Resin.*—The pine trees are exuding an abundance of resin at the present time (October), and several parties have been out collecting it in the district, however it is only for the best quality that a payable price is obtained. (W. Johnson.)*
Digilah, *via* Merrygoen ...	Lincoln	Black Pine very plentiful. (G. A. Patrick.)
Dilga and Ardell, *viâ* Cumnock.	Gordon	Most common. Covers about one-third of the surface of the ground. (S. E. James.)
Dubbo	Gordon	(J. H. Smith.)
Elsmore	Gough	(J. W. Parkins.)
Emmaville	Gough	(S. R. Baker.)
Enngonia	Culgoa	Scarce. (C. O'Hara.)
Eugowra, *viâ* Orange ...	Ashburnham ...	(T. Miller.)
Eulah Creek, Narrabri ...	Nandewar ...	The Red Pine is found only on the ridges, and not in such large areas as the Cypress Pine, *C. glauca*. (T. Abell.)
Euston	Taila	Equally distributed with *C. glauca*, 15,000 acres.
Farnham	Wellington ...	(E. Langbridge.)
Furill, *viâ* Mudgee	Wellington ...	Not less than 500 acres. *Timber.*—The trees in this district are used to a great extent for building purposes. *Resin.*—The Black Pine yields about 1 lb. at every exudation, which takes place immediately after a fall of rain. Several families in this district make a livelihood by collecting the resin, which they dispose of at Gulgong or Mudgee at from 2d. to 3½d. per lb. according to quality—the white kind realises the highest price. (W. H. Capon.)*
Galway Creek, *viâ* Eugowra	Ashburnham ...	The whole of the ranges in this district are covered with pine. (L. J. Sim.)
Garra	Ashburnham ...	On the ridges. *Timber.*—See under *C. glauca*. *Resin.*—The Red Pine yields the most. The resin was collected here last season in considerable quantities and brought 2½d. to 3d. per lb. in Molong. (L. C. Young.)*
Gerogery	Goulburn ...	(A. Maune.)
Giants Creek	Brisbane ...	Most plentiful, 20,000 acres. *Resin.*—Black Pine yields the most. (W. F. Wedlock).
Golspie...	Georgiana ...	A few trees. (G. C. O'Brien.)
Goolagong	Forbes	(F. L. D'Aran.)
Grenfell	Monteagle ...	Abundant on granite hills near the town. (C. F. Laseron.)
Gunning's Gap	Forbes	14 miles from Forbes. (T. Miller)
Guntawang	Wellington ...	On the ridges 1 acre in every 300. (T. H. West.)
Jennings	Clive	About 5 square miles western slope of the Macpherson Ranges. (W. A. Dalton.)

* A few years have elapsed since this information was collected. At the present time (1910) but little resin is being collected.

CALLITRIS CALCARATA, R.BR.—Botanical Survey of the Species (*continued*).

Locality.	County	Remarks.
Keepit, Somerton	Darling ...	Within a radius of 10 miles from Keepit this species occurs on all the ranges, covering with *C. glauca* an area of from 6 to 10,000 acres. (E. S. Davies.)
Little Narrawa	King	A few scattered clumps. (F. K. Tutland.)
Lockwood, Canowindra ...	Bathurst ...	Confined to the ranges, which cover one-fourth of the district. (Maggie R. Olde.)
Longreach, Shoalhaven River	Camden... ...	Very scarce; grows at sea-level on banks of the river, about 15 miles from the sea. (C. F. Laseron.)
Looby's	Ashburnham ...	The whole of the ridges extending for miles in this district are covered with these pines. *Timber.*—25 feet high to 1 foot diameter. This species is only found growing on the ridges in this district, but is very scarce in comparison to the Murray Pine, *C. glauca*. *Resin.*—Very freely. Resin gatherers prefer it to the other species, because the resin is more abundant, in fact, some hold that a Black Pine yields twice as much resin as a White Pine of the same size. (A. A. Hewitt.)
Manildra	Ashburnham ...	(C. F. Laseron.)
Manilla	Darling	On the steep rocky ground. (H. Rudd.)
Marengo	Monteagle ...	All along the ridges of the Black and Dananbilla Ranges, north-west spurs of the Mundoonan. *Timber.*—Height varies from 15 to 40 feet, the diameter rarely exceeding a foot, the timber is not much used, being small and not easily got at. (A. Tonking.)
Marlow, Braidwood	St. Vincent ...	They grow in clumps along the Shoalhaven Rive , the largest extent is, perhaps, 3 miles long and nearly ½ mile wide. *Resin.*—There is not sufficient to be of any commercial value. (S. G. Tate.)
Menindie	Menindie ...	On all the ridges. (W. J. Ross.)
Meranburn	Ashburnham ...	In the parish of Manildra, 3,000 or 4,000 acres. In the parish of Dulladerry a similar area. In the parish of Mandagery a larger area. *Resin.*—The Black Pine is best. (James Anderson.)
Michelago	Murray	Covering ridges in the gorge of the Murrumbidgee River. (C. F. Laseron.)
Milburn Creek, Woodstock ...	Bathurst ...	The pines cover a large area. (J. Sullivan.)
Millfield	Northumberland	Scarce. (C. F. Laseron.)
Minore, Dubbo	Narromine ...	Intermixed with *C. glauca*; (see under that species.) (Gertrude A. Harrison.)
Mittens Creek, Brundah ...	Monteagle ...	Many hundreds of acres on the ranges. (J. W. Bell.)
Molong...	Wellington ...	Grows abundantly on the hills. (R. T. Baker.)
Monkerai	Gloucester ...	Many thousands of acres. *Timber.*—About 50 feet high; diameter, 15 inches. *Resin.*—The black yields a good deal of resin. (J. B. Daly.)

CALLITRIS CALCARATA, R.Br.—Botanical Survey of the Species (*continued*).

Locality.	County.	Remarks.
Morungulan, Dripstone ...	Wellington ...	Apparently there are thousands of acres of stony barren ridges covered with stunted pine interspersed with box. *Timber.*—40 to 50 feet in height, and from 2 to 2½ feet in diameter. *Resin.*—Resin is exuded plentifully by the Black Pine. (A. McInnes.)
Mount Aubery, Parkes ...	Gordon	Patches interspersed along the Harvey Range for several miles. (A. J. Bourke.)
Mount McDonald	Bathurst ..	Two and a half per cent., or perhaps less. *Timber.*—Timber brittle, not much good. *Resin.*—Gives more resin than the White Pine, *C. glauca.* (J. Sullivan.)
Murrurundi	Brisbane ...	(W. S. Goard.)
Narrandera	Cooper	(W. G. Heath.)
Newbridge	Bathurst ...	*Timber.*—The tree is too knotty to be of any commercial value. *Resin.*—If cut or bruised, the resin will exude by the gallon. If it is of any use, there is plenty of it. (J. Hadley.)
Nine Mile, Deepwater ..	Gough	About 100 acres. (John Surtee.)
Nullamanna	Arrawatta ...	2,000 acres. (P. Herd.)
Oakey Creek, Warialda ...	Burnett ..	Scarce; and as a rule does not grow to a large tree. (J. T. Fitzpatrick.)
Piallaway	Buckland ..	On all the ranges two-thirds of the country within 10 miles of this place appear to be covered by these trees. (W. A. Kennelly.)
Pine Ridge, *viâ* Quirindi ...	Buckland ...	Interspersed with *C. glauca*, 100,000 acres. (E. W. McMahon.)
Pokolbin	Northumberland	Fairly common on the hills. (C. F. Laseron.)
Quandong, Grenfell	Monteagle ...	About one-third of the district. *Timber.*—Useless as a timber or fuel. *Resin.*—Exudes the greatest quantity. (Samuel Lewis.)
Quirindi	Buckland ...	Very common, hundreds of acres. (Sydney C. Byrnes.)
Round Mount, Inverell ...	Hardinge ...	Not extensive; very patchy; growing on the hills. (A. A. McWhirter.)
Rutherfield, Quirindi... ...	Buckland ...	See under Pine Ridge and Spring Ridge. (H. E. Baker.)
Rylstone	Roxburgh ...	Near the town. (H. King.)
Salisbury Plains, Uralla ...	Sandon	On all the ranges. (G. McD. Adamson.)
Sapphire, Inverell	Gough	1,200 acres. *Resin.*—Appears to yield most resin after they have been cut with an axe or ringbarked. (C. H. Chawner.)
South Forbes	Forbes	Within a 5-mile radius there is about 3,000 acres of pine, *C. glauca* and *C. calcarata.* (Alex. Aikman.)
Spicer's Creek	Lincoln ...	Within a radius of 4 miles there are only five patches of pines, each being of small extent. The largest is not more than about 2 acres. (Chas. Readford.)

CALLITRIS CALCARATA, R.Br.—Botanical Survey of the Species (*continued*).

Locality.	County.	Remarks.
Stroud	Gloucester ...	Mountain brushes throughout the whole district; probably not more than 20 acres. (E. V. Mitchell.)
Suntop, Wellington	Gordon	About 4 square miles with *C. glauca*. (R. T. Baker.)
Tal Tal Mountain, Rylstone...	Roxburgh ...	(H. King.)
Tambar Springs, *viâ* Gunnedah.	Pottinger ...	(S. B. Sargeant.)
The Welcome, Parkes ...	Ashburnham ...	Is confined to stony ridges, and not so abundant as *C. glauca*. (E. A. Grant.)
Tollbar and Clifford, Cooma	Beresford ...	About 1 acre in 1,000. They grow in certain ridges, and even do not grow thickly but are considerably scattered. (William Fairley.)
Tuena	Georgiana ...	About 20 acres. (J. J. Hook.)
Ulan, *viâ* Mudgee	Bligh	(J. S. Harding.)
Upper Colo	Cook	A few trees. (G. E. Cumming.)
Uralla	Sandon	(A. Adamson.)
Uranquinty	Mitchell... ...	(H. C. Brettell.)
Vere	Northumberland	(W. H. Bates.)
Wagga Wagga	Clarendon ...	(J. S. Middenway.)
Walhallow	Buckland ...	Same as Quirindi. (Wm. Hagan.)
Wallangra, *viâ* Inverell ...	Arrawatta	More or less dotted with pine scrub, from McIntyre River to Severn River. (H. Thresher.)
Wallaya	Camden... ...	(H. Thresher.)
Warkworth	Northumberland	Top of Wombo Mountains, a continuation of the Bulga Mountains and extending beyond Jerry's Plains, a distance of 6 or 7 miles. (Henry Atkinson.)
Warrangunyah, Ilford ...	Roxburgh ...	About 5 acres on the tops of the ranges. (Sarah Hickey.)
Weddin, *viâ* Young	Monteagle ...	About 100 acres. (H. V. Wigg.)
Weetalabar, Tamban Springs, *viâ* Gunnedah.	Pottinger ...	*Timber.*—The Black Pine is quite useless for anything. (W. A. Griffiths.)
Wellington	Lincoln	(R. T. Baker.)
Wheeo	King	Only a few trees. (Geo. Boulton.)
Willandra, Dubbo	Narromine ...	Confined to very loose, red sand ridges—rather poor soil. *Timber.*—The most copious supply is afforded by the Black Pine, which is a very resinous tree. (R. W. Fitzell.)
Windeyer, *viâ* Mudgee ...	Wellington ...	Only a few trees. (T. E. Cambower.)
Woodstock	Bathurst ...	Common on ranges 10 miles east of township. (C. F. Laseron.)
Yarralumla, Queanbeyan ...	Murray	A few on the ridges.
Yarrowyck, *viâ* Armidale ...	Hardinge ...	Not many in this locality. (Joseph Hanify.)
Yetman	Arrawatta ...	(H. Thresher.)

10. Callitris rhomboidea.

R.Br. in Rich. Conif. 47 t. 18 (1826).

"CYPRESS PINE."

(Syn.:—*C. ?cupressiformis*, Vent. Nov., Gen. Dec., 10; *C. arenosa*, Sweet, Hort. Brit., 473; *Frenela rhomboidea*, End., syn. Conif., 36; *F. Ventenatii*, Mirb. in Mem. Mus. Par., XIII, 74; *F. arenosa*, A. Cunn., Endl., syn. Conif., 38, Parlat. in DC. Prod., XVI, ii, 451; *F. triquetra*, Spach. Suit. Baff., XI, 345, Endl., syn. Conif., 36; *F. attenuata*, A. Cunn., Hort.; *Cupressus australis*, Desf. Cat. Hort., Par. ed., 3, 355 not of Persoon; *Thuja australis*, Poir. Dict. Suppl., V, 302; *T. articulata*, Tenore.)

Habitat.

This species, as understood in this research, has not an extensive range in the Eastern Coast District of the Continent, and occurs only in certain parts of Queensland, and New South Wales in the neighbourhood of Sydney, as for instance, Middle Harbour, Mosman, St. Albans, Woniora River (Como).

I. HISTORICAL.

The inordinate list of synonyms associated with this species is probably due to its being one of, if not the first described *Callitris*, and its seed being widely distributed, for plants were early cultivated in European nurseries.

As there is no evidence to show that this was the particular species upon which Ventenat founded his genus, we thought it better to employ Robert Brown's designation for this pine, and thus remove all doubt, for his specimens seen by us are unmistakably identical with those of the other authors *l.c.*, and as understood by Bentham in his "Flora Australiensis." Ventenat, when founding the genus *Callitris* upon an Australian pine, mentions no species; so that there is no justification for crediting him as the author of *C. cupressiformis*.

Material purporting to be this species is more widely distributed in the world's herbaria than that of any other *Callitris*, and some so named are difficult of identification or rather determination, as in many instances they are often incomplete, and there is thus great confusion in its nomenclature. At the Paris Herbarium all the specimens of M. Verreaux from New Holland, 1846, named *C. australis*, are *C. rhomboidea* with immature fruits.

Frank H. Taylor,

Callitris rhomboidea, R.BR.—SHOWING FASTIGIATE GROWTH OF BRANCHES.
MOSMAN, SYDNEY, N.S.W.

Cunningham's specimen of "*F. arenosa*," at Kew, is not in fruit, so that probably this synonym, and that of Sweet's should not stand, as the specimens are most probably those of his true *F. arenosa* from Moreton Bay, the branchlets of the two being quite similar, and Cunningham would hardly have confounded *C. rhomboidea* with *C. arenosa*. The specimen in the Brussels Herbarium labelled *F. Ventenatii* is probably *C. calcarata*, but has no fruits.

Bentham in his "Flora Australiensis," Vol. VI, p. 238, places Gunn's specimen, which is labelled "Oyster Bay Pine" in the British Museum, as the variety *Tasmanica* of the species, but the differences mentioned are, we think, more than sufficient to warrant varietal rank for the Tasmanian plant and the specific name of *C. Tasmanica* is now proposed for it.

At Kew Herbarium there is a specimen labelled by A. Cunningham, *C. attenuata*, and another of the same at the British Museum, but these have no fruits.

Herbaria Material Examined.

Kew,—

- Robert Brown's specimen, 1802–5, this is labelled "*C. Ventenatii*," R.Br.
- A. Cunningham's specimen from Moreton Bay, labelled "*C. calcarata*."
- A. Cunningham's specimen from Moreton Bay, Hook. Herb., labelled "*C. arenosa*."
- A. Cunningham's specimens from Elizabeth Bay, Sydney, "a small drooping tree," Port Jackson, both the above two are labelled "*C. attenuata*, A. Cunn."; the former in pencil and the latter in ink.
- Fraser's specimen from N.W. Coast, 1829.
- Hooker's specimen labelled "Sydney."
- W. Macarthur's specimen, "Sydney Woods, Paris Exhibition, 1854."
- Specimen labelled "London Exhibition, 1862."
- A specimen labelled by Bentham as var. *mucronata*.
- Mueller's specimen labelled "*C. pyramidalis*," fruits immature.
- Specimens from Botanic Gardens, Naples.
- Specimen from St. Helena, with name by Sir J. D. Hooker.

  Neither of these last two shows variation from the Australian specimens, although cultivated so far from its native habitat.

British Museum,—

- Robert Brown's specimen from Port Jackson, 1804–5, labelled "*C. Ventenatii*."
- A. Cunningham's specimens, 1825, labelled "*C. attenuata*," without fruits.
- A. Cunningham's specimen from Stradbroke Island, Moreton Bay.
- Flinders' specimens, no loc.
- G. Caley's specimens, no loc.
- Backhouse's specimens, no loc.

Callitris rhomboidea, R.BR., "CYPRESS PINE."

Berlin National Herbarium,—

Specimen labelled "*Frenela rhomboidea*, Endr. Parl. Nov. Hollandia ex Museo, Paris, 1819."

Specimen labelled "*Frenela rhomboidea*, Port Jackson, Lesson, 1815."

Brussels National Herbarium,—

Specimen from Paris Herbarium of Decaisne, no loc., fruits immature.

II. SYSTEMATIC.

This is rather a small tree, attaining sometimes, however, a height of 50 or 60 feet in favourable situations, such as water courses; it has a hard, compact, furrowed bark. The branches and branchlets slender and angular, owing to the shape of the decurrent green leaves, the internodes short, the free portion of leaf perhaps a little more acute than *C. gracilis*, which has similar angular internodes. Male amenta, mostly solitary, terminal, and small. Female amenta in panicles at the base of the branchlets.

Fruit cones not densely clustered on scarcely thickened branches, mostly solitary, under ½ inch in diameter, globular; valves six, alternately smaller, the larger ones dilated upwards into a wedge-shaped apex, the sporophyll producing a pronounced dorsal spur, at first smooth but becoming rugose with age, the smaller valves about half the width of the others, and tapering upwards, but otherwise similar, distinctly channelled at the edges. Seeds two-winged.

The tree is easily determined in the field by its fastigiate growth, and in herbarium material by its characteristic slender branchlets, and fruits, the larger valves of which have a broadly rhomboidal apex, a feature that distinguishes the species from all others, except *C. Tasmanica*.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

A cross section through the three decurrent leaves gives an outline fairly distinct from a corresponding section of any other species of *Callitris*, as shown in the several plates.

The various tissues or organs of the leaves are found to occupy a relatively similar position to those described more fully under such species as *C. glauca*, *C. calcarata*, and *C. robusta*, and so are not so fully particularised here, as the illustrations define their situations.

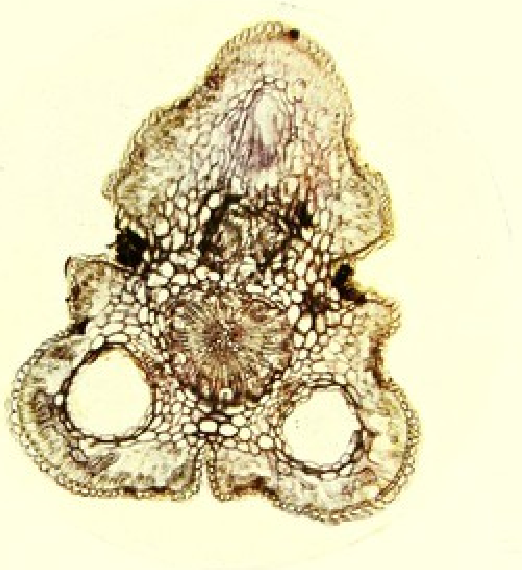


Figure 145.—A transverse section through a main branchlet and decurrent leaves, showing an oil cavity in the two lower, and just the base of one in the third leaf. Between this and the central axis are sectioned two bundles of a minor branchlet. The endodermal cells preserve some order, and in the mesophyll of the two lower leaves can be seen some stone cells,—the darker shaded bodies. Stained with hæmatoxylin. *C. rhomboidea*, × 25.

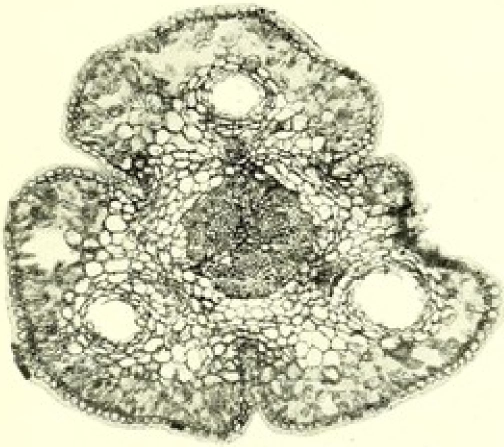


Figure 142.—Transverse section through branchlet with decurrent leaves and oil cavity in each leaf. *C. rhomboidea*, × 25.

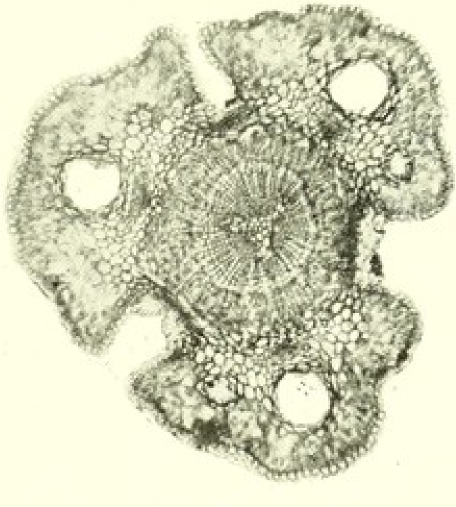


Figure 143.—Transverse section through branchlet and decurrent leaves. *C. rhomboidea*, × 25.

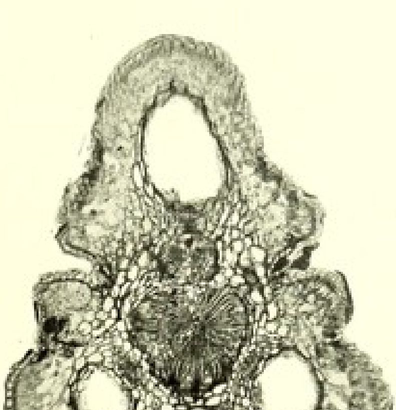


Figure 144.—Transverse,section through branchlet and decurrent leaves, showing a minor branchlet between the median one and the leaf bundle below the top oil cavity. *C. rhomboidea*, × 25.

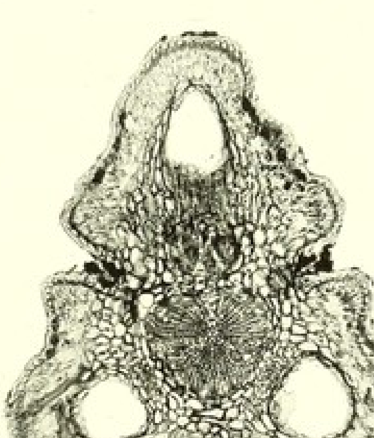


Figure 146.—Transverse section through branchlet and decurrent leaves, with an oil cavity in each of the latter. The darker patches in the mesophyll in the two lower leaves are sclerenchymatous cells. *C. rhomboidea*, × 25.

Sections of branchlets and decurrent leaves of C. rhomboidea, R.Br.

The most important features of difference in the leaf structure, from those of its congeners, are (1) the presence of many sclerenchymatous cells in the spongy parenchyma of the mesophyll; (2) the absence almost of a well-defined mass of transfusion tissue, as obtains in *C. calcarata* and *C. robusta*, and (3) the absence of the manganese compound in the parenchymatous endodermal cells.

The dorsal surface may be said to be concavo-convex, and it is in the concave portion the stomata occur, such as is also found occasionally in *C. calcarata*.

The epidermal cells are larger proportionately than those of its congeners.

Figure 142 illustrates a section taken just below the free ends of the leaves, and shows, as in other species, how the three decurrent leaves form, along with the central axis of the branchlet, one whole. The palisade cells are poorly developed in these leaves and even the spongy tissue of the mesophyll is less than that of other species, their place being taken by an unusual proportion of parenchymatous endodermal tissue, the cells of which can be seen to be empty and closely packed around the central axis and oil cavities, filling the base of the leaves and also enclosing the leaf bundles. The transfusion tissue is only fairly well developed as compared with other species of *Callitris*. One marked characteristic feature of *C. rhomboidea* leaves, is the unusual number of sclerenchymatous cells in the spongy tissue of the leaves, although not so well seen in this Figure as in Figures 144–6 where they can be traced as dark irregular bodies in the mesophyll.

Figure 143 gives the contour in section of the three leaves when the branchlet is fully formed, and they are beginning to be thrust apart. It will be observed in this illustration that the phloem of the branchlet forms a complete circle enclosing the xylem together with its median pith cells; the decurrent channel has gradually widened, and the dorsal surface is convex in the centre and concave at the sides, where are situated the stomata, a feature which marks this as a coastal species, and in which respect, therefore, it differs from the *Callitris* of the interior. Figure 144 is reproduced as it shows the effects in the contour of a leaf when a branch trace begins, as in the base of the upper leaf. The depressions on the dorsal surfaces locate the stomata. Note the sclerenchymatous cells in the lower leaves. Figures 145–6 are different sections taken in the neighbourhood of the oil cavities in the upper portion of the leaves.

(c) Chemistry of the Leaf Oil.

This material was collected at the Spit, near Sydney, New South Wales, on the 25th January, 1907.

The terminal branchlets alone were used, and although a few fruits were present, they contained no oil. The distillation was continued for six hours, but the yield was very small—616 lb. only giving 3¼ oz. of oil, equal to ·0335 per cent.

The crude oil was somewhat dark coloured, but the colour was easily removed when the oil was agitated with a very dilute soda solution; it was then a light lemon colour. It was soluble in 7 volumes 80 per cent. alcohol. The odour was more aromatic than with the oils of the *Callitris* generally, except *C. Tasmanica*, and resembled less the ordinary leaf oils of this genus. This was due to the fact that there was an almost entire absence of borneol and its ester; the somewhat large amount of ester being almost entirely geranyl-acetate. This was shown by the ease with which it was saponified in the cold, and the alcohol when separated from the ester determinations was found to be geraniol; it had the odour of geraniol and was readily oxidised to citral. The acid of the ester was acetic. The terpenes were probably pinene, lævo-limonene, and dipentene. The yield of oil being so small, the amount at our disposal did not allow of complete separation of its constituents, but a full investigation was made with the oil of *C. Tasmanica*, a somewhat closely agreeing *Callitris* obtained from Glen Regis and from Tasmania.

The specific gravity of the crude oil at $\frac{22}{15}$° C. = 0·8826; rotation a_D — 19·2; refractive index at 25° C. = 1·4747. The saponification number of the uncleared oil was 87·8, equal to 30·73 per cent geranyl-acetate; and that of the cleared oil 86·86, equal to 30·43 per cent. In the cold, with four hours' contact, the saponification number was 85·08, equal to 29·78 per cent. of ester. The saponification number for the free acids was, therefore, 0·94.

The optical activity shows the presence of lævo-rotatory terpenes, the principal one being, most probably, lævo-rotatory limonene, similar to that in the oil of *C. Tasmanica*. The results of the above determination show this species to be more closely allied with the group to which *C. calcarata* belongs, than to that which includes *C. glauca*. Although the *Callitris* species from Glen Regis and Tasmania are closely related, yet those trees are not identical with the Sydney trees.

Crude Oil from the Leaves of *Callitris rhomboidea*.

Locality and Date	Specific Gravity ° C.	Rotation a_D	Refractive Index ° C.	Ester per cent, by boiling	Ester per cent, in the cold.	Yield per cent
The Spit, near Sydney, 25/1/'07.	0·8826 @ 22	− 19·2	1·4747 @ 25	30·43	29·78	0·0335

IV. TIMBER.

(*a*) Economic.

Occasionally a fair-sized (60 feet) *Callitris*, but its timber is not much used, as the tree only occurs sparsely in the bush.

The timber is light in weight, as well as in colour, and is suitable for indoor work, the grain being straight and the figure plain.

(*b*) Anatomy.

The most notable feature in the transverse sections of secondary wood is the unusually large number of manganese compound containing cells, which cells throughout are probably larger in diameter than those of other species, as illustrated in Figure 147.

The radial sections produced some interesting features, almost specific, *i.e.*, the walls of the prosenchymatous cells of the tracheids being covered with bordered pits always in single rows, *vide* Figures 149, 150, the former giving the pits in focus, the centres of which in this case have taken the stain, probably marking the torus of the organ. Another character is also represented in Figure 149, *i.e.*, the simple pits of the medullary rays, which in this case have a circular orifice, and number mostly four between the walls of each lumen, as distinct from the oblique slit of *C. calcarata*.

The medullary rays have comparatively very long cells and present a compact body, the walls of the upper and lower layers being as well defined as those of the inner. They stain indigo with hæmatoxylin, and have, perhaps, the most strongly defined walls of all the *Callitris*, are one cell in breadth, and two to six or more high.

It was thought that this species was in a measure related to *C. calcarata*, but there are certain anatomical characters such as the circular orifice of the simple pit, &c., that give, at least, one feature of differentiation in secondary wood characters.

Figure 147 is a view of a cross section of the timber multiplied eighty times, taken with the autumnal growth in the centre running from left to right and indicated by the narrow lumina of the tracheids, which, in this case, are found to contain the manganese compound in both that period and also the vernal time, as evidenced by the black spots in the picture. The black lines running from top to bottom mark the cells of the medullary rays, also containing this substance. Figure 148 is a tangential section of the timber but, unfortunately, not a clear one, but, nevertheless, is reproduced to show that it is possible to obtain a number of rays in which the manganese compound is not found. In the radial section, Figure 149, the pits of the bordered cells are focussed, and the rays show that all the cells are uniform in character and have no marginal tracheidal cells, whilst in Figure 150 the borders of the pits are focussed, and some good samples of medullary rays are also illustrated.

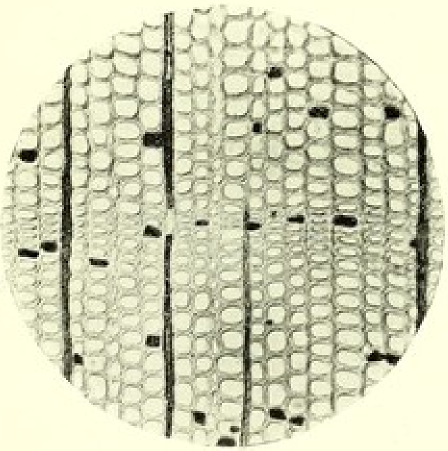


Figure 147.—Transverse section through timber, with autumnal tracheids running through the centre of section. The continuous dark lines indicate the rays and the scattered rectangular markings are the brown manganese contents of the tracheids. *C. rhomboidea*, × 80.

Figure 148.—Tangential section of timber of *C. rhomboidea*, × 100.

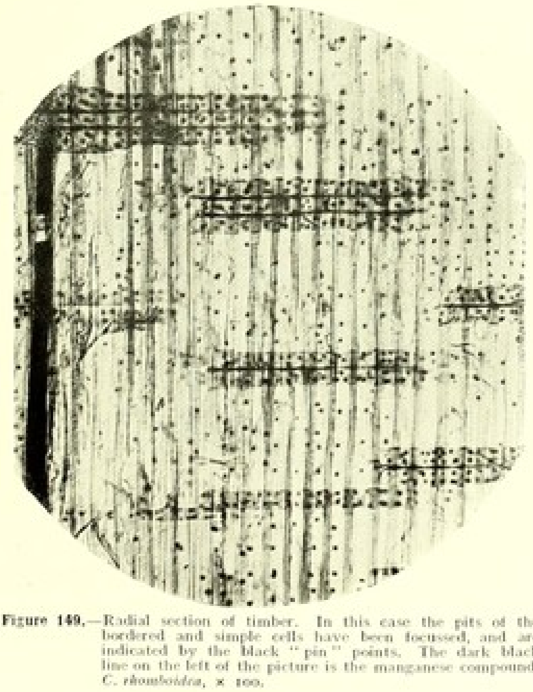


Figure 149.—Radial section of timber. In this case the pits of the bordered and simple cells have been focussed, and are indicated by the black "pin" points. The dark black line on the left of the picture is the manganese compound. *C. rhomboidea*, × 100.

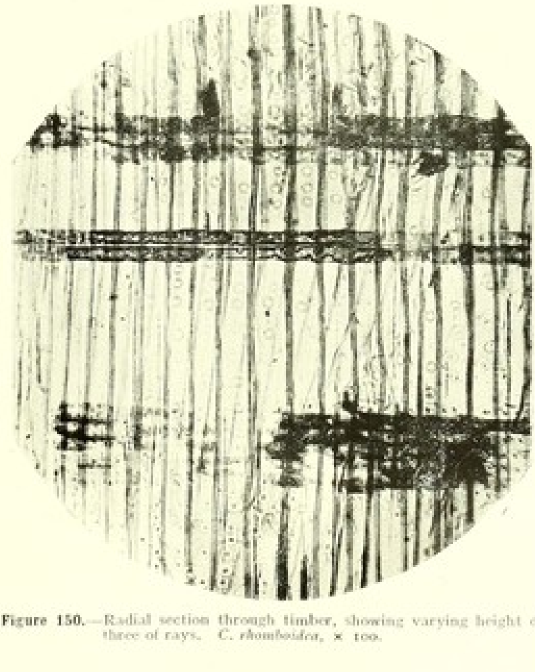


Figure 150.—Radial section through timber, showing varying height of three of rays. *C. rhomboidea*, × 100.

Sections of timber of C. rhomboidea, R.Br.

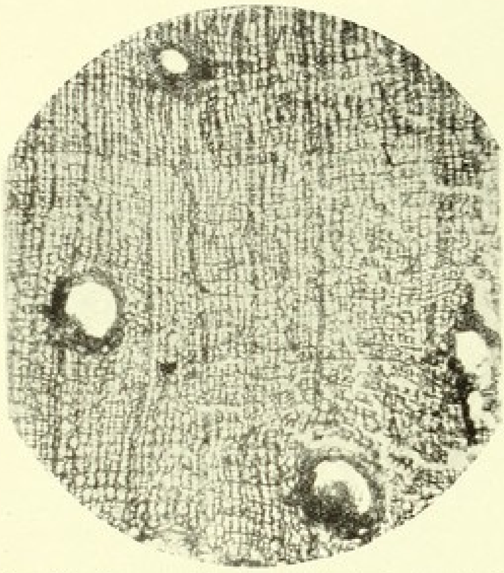


Figure 151.—Transverse section through bark, showing four oleo-resin cavities. *C. rhomboidea*, × 30.

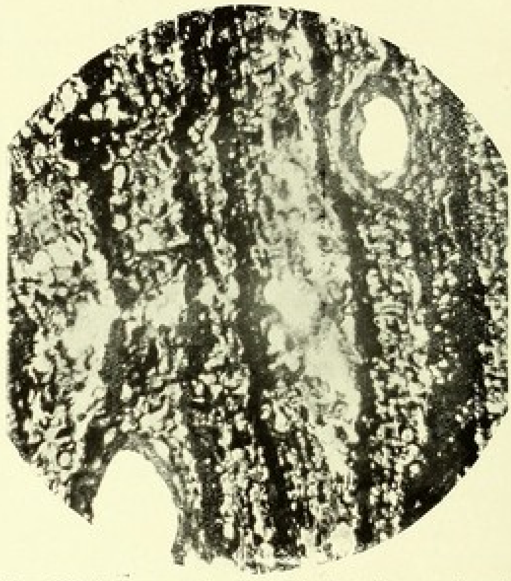


Figure 152.—Transverse section through bark, showing two oleo-resin cavities. The dark bands through the picture denote the manganese compound in the cells. *C. rhomboidea*, × 60.

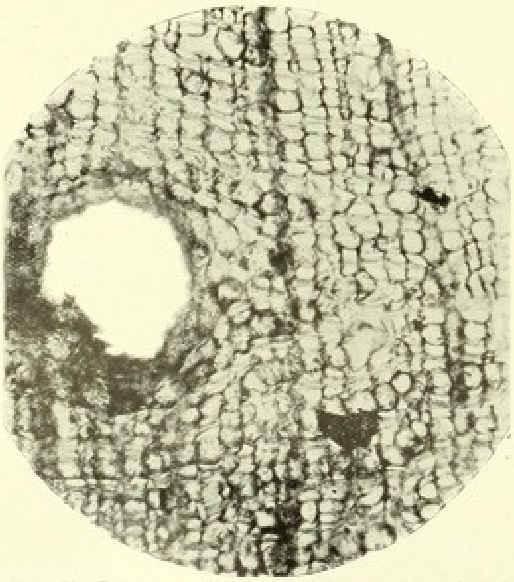


Figure 153.—Transverse section of inner bark, through one oleo-resin cavity, showing its lysigenous nature. *C. rhomboidea*, × 100.

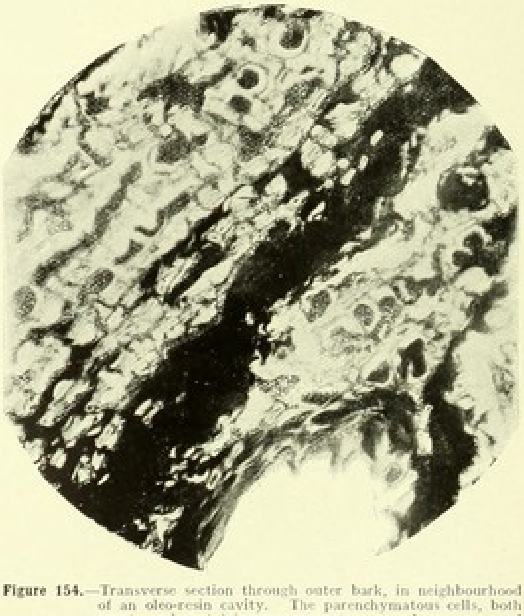


Figure 154.—Transverse section through outer bark, in neighbourhood of an oleo-resin cavity. The parenchymatous cells, both empty and containing manganese compound, are seen, and bast fibres are fairly distinct. The dark band is a periderm layer. *C. rhomboidea*, × 100.

Sections of bark of C. rhomboidea, R.Br.

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

A fairly comprehensive series of sections of this bark is given. The cross-sections show a structure similar to that of its congeners, the layers of periderm being restricted to the outer cortex, and in Figure 152 are shown as dark parallel bands running from top to bottom of the picture, the dark colour probably being due to the manganese compound and tannin contents, whilst Figure 154 shows one periderm band passing diagonally through the picture, where the black manganese contents of the parenchymatous cells are also well defined. Medullary strands are illustrated in Figures 151–153, and in the latter the lysigenous nature of oleo-resin cavities is clearly shown.

Two longitudinal sections are given under Figures 155 and 156. The former is interesting as showing the parenchymatous nature of the medullary cells, and more especially is this feature seen in the concentric cells between the sieve tubes. The dark cell contents to the left mark the presence of the manganese compound.

The pale coloured structure composed of thin-walled cells running through the centre of the picture, Figure 155, from top to bottom, marks the band of periderm, and in this case forms the median material between the inner, on the left, and the outer bast. Figure 156 illustrates a longitudinal section of bark, and shows the sieve plates of the tubes, as well as the latter's position in the bark structure. A parenchymatous cell runs through the centre of the picture from top to bottom ; this is bounded on both sides by sieve tubes, that on the right showing the plates particularly well. Each of these tubes is in turn in juxtaposition to a bast fibre.

(*c*) Chemistry.

The log from which this bark was taken was obtained near Sydney. Its diameter was 8 inches. The bark was thin and somewhat fibrous, and its thickness was from 6 to 10 mm. It was externally of a dark-brown colour, and was comparatively deeply furrowed. From the results obtained with this specimen it has little value for tanning purposes.

The following results were obtained with the air-dried bark :—

Moisture ...	...	14·5 per cent.
Total extract	...	7·8 ,,
Non-tannin	...	3·8 ,,
Tannin ...	...	4·0 ,,

Figure 155.—Longitudinal section through bark. The narrow parallel bands running from top to bottom of picture are the bast fibres separated by wide parenchymatous cells and very narrow sieve tubes. A few of the sieve plates can just be seen. The dark patches mark the manganese in the cells. The light area in the middle is a periderm layer. *C. rhomboidea*, × 100.

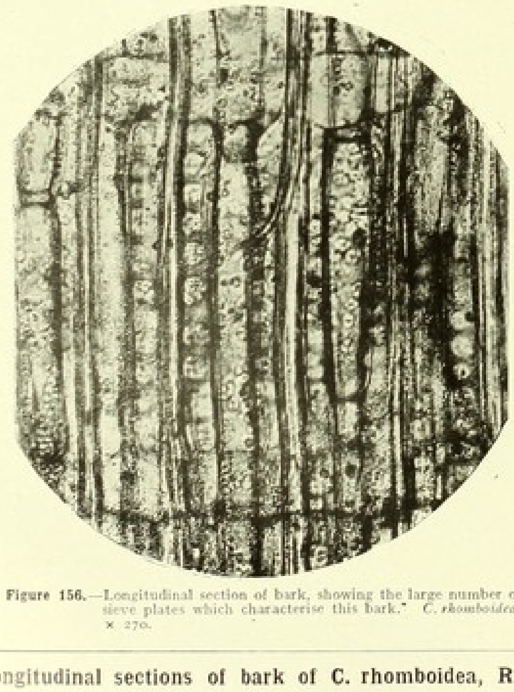


Figure 156.—Longitudinal section of bark, showing the large number of sieve plates which characterise this bark. *C. rhomboidea*, × 270.

Longitudinal sections of bark of C. rhomboidea, R.Br.

11. Callitris Tasmanica,

Nobis.

"CYPRESS PINE," NEW SOUTH WALES.
"OYSTER BAY PINE," TASMANIA.

(Syn.:—*Frenela rhomboidea*, R.Br., var. *Tasmanica*, Benth., " Flora Australiensis," Vol. VI, p. 238.)

Habitat.

The Grampians (Mueller), Victoria. Glen Regis, Rylstone, (R. T. Baker); Lochiel, Pambula, (W. J. Davis), New South Wales. Oyster Bay, near Launceston, Tasmania.

I. HISTORICAL.

This *Callitris* appears to have been first discovered by Gunn at Oyster Bay, Tasmania, in 1840, and was placed by Bentham, " Flora Australiensis," Vol. VI, p. 238, as *Frenela rhomboidea*, variety *Tasmanica*, but our investigations seem to point to a specific pine, and it is here given such rank, under the name of *C. Tasmanica*.

Mueller's specimens collected at the Grampians, Victoria, and placed by Bentham as variety *mucronata* of *F. rhomboidea*, *l.c.*, were seen at Kew, and in our opinion are this species.

Herbaria Material Examined.

Kew,—

R. Gunn's specimens from Oyster Bay, Tasmania. (This is Bentham's *C. rhomboidea*, var. *Tasmanica*, *loc. cit.*)

Archer's specimens from Tasmania.

F. Mueller's specimens from the Grampians, Victoria. (This is Bentham's *F. rhomboidea*, var. *mucronata*.)

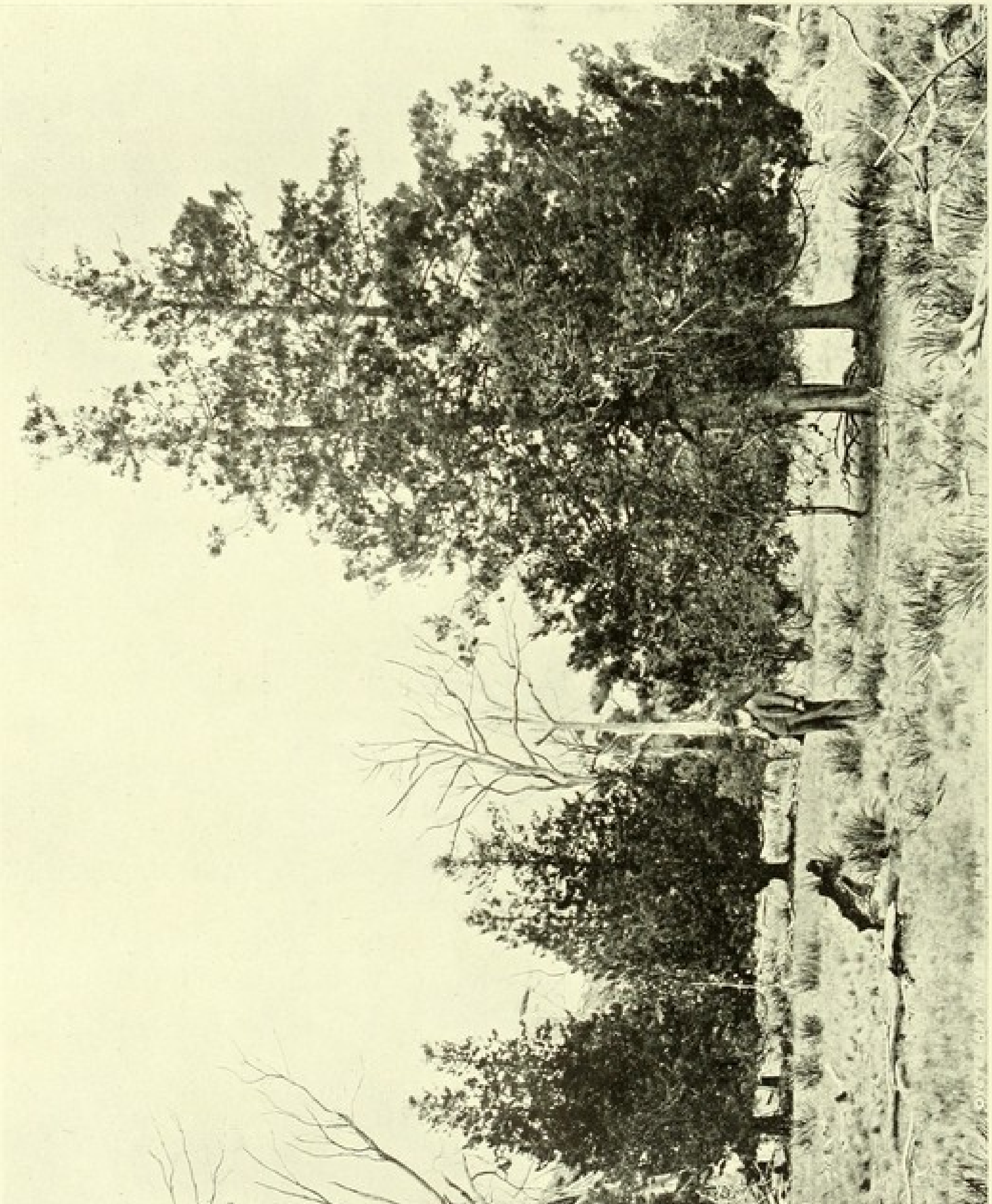
British Museum,—

R. Gunn's specimens, dated 3rd April, 1840, from Oyster Bay, Launceston, Tasmania.

Cambridge University,—

R. Gunn's specimen, labelled " Oyster Bay, Van Dieman's Land, 1843, *C. australis*, R.Br."

Herb. Lindley, Ph.D., a specimen labelled—" This was Tenores' *Thuya articulata* in 1832. It is *T. australis* in 1838."



Callitris Tasmanica, NOBIS. TREES GROWING AT OYSTER BAY, TASMANIA.

Nat. size.

Callitris Tasmanica, NOBIS. "CYPRESS PINE," GLEN REGIS, RYLSTONE, N.S.W.

Nat. size.

Callitris Tasmanica, nobis. "Oyster Bay Pine," Tasmania. "Cypress Pine," N.S.W.

Paris Herbarium,—

Herb. Lindley's specimen labelled "*Thuya australis*," no locality.

Specimen labelled "*F. triquetra*," no locality.

Specimen labelled "*Cupressus australis*, Pers. *C. rhomboidea*, Rich., Nov. Holl., 1832."

Specimen labelled "Ex. Herb. Hook., *F. australis*, R.Br., Hab. Tas., Coll. R. C. Gunn."

Brussels National Herbarium,—

Specimen labelled "from Tasmania," but the fruits are immature.

Melbourne,—

A specimen labelled "Oyster Bay Pine, Tasmania," is named *C. rhomboidea* by Mueller and Parlatore; the fruits are too small for correct determination, but the branchlets and localities leave little doubt of its systematic position.

II. SYSTEMATIC.

This is a small, medium-sized tree, occasionally 40 feet high and over, attaining its largest size in fairly flat situations, and near water, as at Glen Regis, Rylstone. Branches spreading, horizontal or drooping, rarely if *ever fastigiate*. Branchlets with the decurrent leaves stouter than in *C. rhomboidea*, and almost matching those of *C. calcarata*. Male amenta small, terminal, almost globular, of a lighter colour than the leaves. Female amenta in panicles at the base of the branchlets.

Fruit cones densely clustered on short, very stout, much-thickened branches, in this feature resembling *C. robusta*, R.Br., over ½ inch diameter, globular, valves six, alternately smaller, the larger ones thick and dilated upwards into a wedge-shaped apex.

Remarks.

One great distinctive difference between this species and *C. rhomboidea* will be found in its field appearance, for while *C. rhomboidea* is quite fastigiate in its growth, *C. Tasmanica* has distinctly spreading, low, horizontal branches, which occasionally droop, whilst they are never fastigiate, and this feature characterises the tree both in New South Wales and Tasmania.

The glaucous feature of the leaves and the almost sessile clustered fruits with their thickened valves also differentiate the species from *C. rhomboidea*. The very slender branchlets with the decurrent leaves of *C. rhomboidea* is also a distinguishing character from *C. Tasmanica*.

It is this comparative constancy of characteristics as well as that of the chemical constituents that prompted us more especially to give it specific rank. Very probably the locality—New England (Stuart)—given by Bentham, *loc. cit.*, for *C. rhomboidea* refers to this species.

It is specially worthy of note that it should occur at places so far removed as Tasmania, and Rylstone on the mainland, whilst there are only two records of its occurrence (Grampians, Victoria and New South Wales), in the intervening distance, and yet preserves intact the botanical characters as well as its chemical constituents.

Callitris Tasmanica, Glen Regis, Rylstone, N.S.W.

Mr. C. F. Laseron states—"That on rocky, basaltic hills near the coast it is rarely more than 20 feet high, while on sand dunes, which lie behind the open beaches it lives as a dense shrub, sometimes only 2 or 3 feet high. The branches are very low and irregular, though usually drooping, and so dense that it is difficult to approach the base of the tree. The spread of branches is very wide near the base, giving a peculiar shape to the tree. It occurs in patches on the East Coast of Tasmania from Otford to Swansea, and probably still further north, and was noticed in steep rocky gullies 16 miles inland from Swansea. Young plants are greedily eaten by stock.

The habit of this tree is very different from the Sydney *C. rhomboidea*, lacking the stately grace and symmetry, and the almost parallel and perpendicular branches of that tree."

III. LEAVES.

(*a*) Economic.

It is stated that the young plants are sometimes eaten by stock. (*Vide* Chemistry also.)

(*b*) Anatomy.

Transverse sections show a configuration quite distinct, not only from its congener *C. rhomboidea*, but from all the *Callitris* and, in fact, unlike that of any other Australian pines. Some, however, resemble the cross sections figured by Dr. Masters ("Linn. Soc. Journ.," Bot., Vol. XXXV) of the leaves of *Pinus*

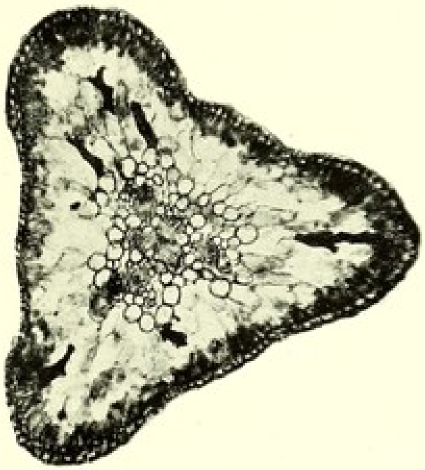


Figure 157.—Transverse section through the central stem and three adnate leaves. The transpiratory surfaces are the level areas between the curved dorsal apices. Three bundles are seen corresponding to each leaf. *C. Tasmanica*, × 50.

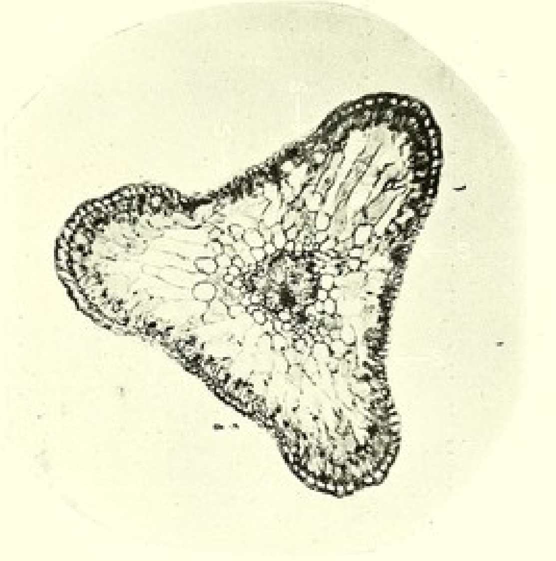


Figure 158.—Transverse section through branchlet and decurrent leaves clear of oil cavities. The transpiratory surfaces are marked by the letter S. *C. Tasmanica*. × 50.

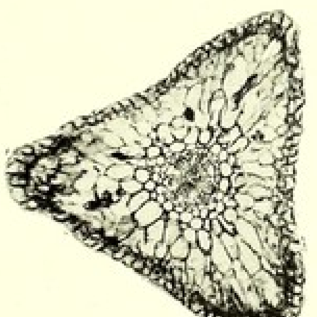


Figure 159.—Transverse section through branchlet and adnate leaves. No leaf bundles are seen, but endodermal cells and spongy mesophyll are well defined. This is quite an unusual form for *Callitris* leaves *C. Tasmanica*, × 35.

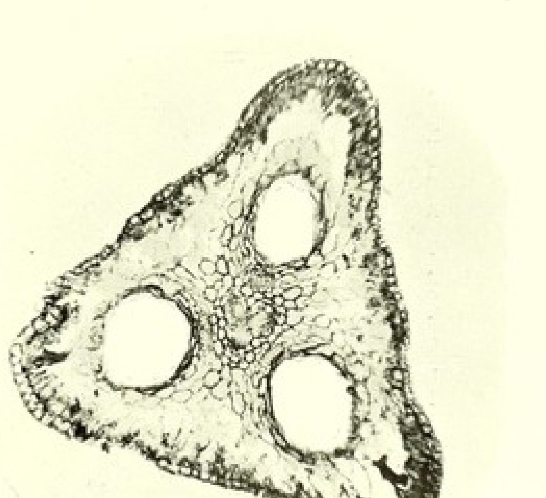


Figure 160.—Transverse section through branchlet and decurrent adnate leaves, with an oil cavity in each leaf. The transpiratory surfaces are marked by the letter S. *C. Tasmanica*, × 50.

Transverse sections of branchlets and leaves of C. Tasmanica, nobis.

cembra, P. filifolia, for in this instance the decurrent leaves are more adnate to each other and sometimes form as it were one complete triangular section of a pyramidal leaf substance, similar to those quoted above.

The central cylinder of the branchlet in this case occupies a small area of the whole, and is surrounded by the irregularly disposed parenchymatous cells of the mesophyll, and only traces of bundles are found in the lower portion of each decurrent section near to the phloem of the midrib. The endodermal cells were not found to extend around the outer surfaces of the oil cavities. When the section is taken clear of the oil cavities, the spongy tissue of the mesophyll, forms the bulk of the leaf substance. There is, also in this case, no ventral surface, corresponding to that of the leaves of other species, for the transpiratory organs occupy the three flat sides of the leaf-branchlet, the stomata thus not being arranged all round as in *Pinus.* The assimilatory surfaces are situated at the dorsal ridges or angles of the leaf-branchlets, which is backed by epidermal, hypodermal, and palisade cells.

The spongy tissue forms a good proportion of the leaf substance throughout.

In other instances, the anatomy of the leaves taken from Tasmania, and Glen Regis, Rylstone, when examined was practically identical. Both, however, have a tendency to develop the dorsal surface at the expense of the ventral, and in some instances in Tasmania no decurrent channel exists, as in Figs. 157–160, where it is seen that there is no demarcation between the decurrent leaves, but which form one whole, regular body around the central axis. In these four figures the curved apices of the sectioned triangle correspond to the dorsal ridge of the leaf or the assimilatory surface, whilst the surface joining these is transpiratory. Figures 157–159 show how irregularly arranged around the median bundles are the parenchymatous cells and amongst which are a few transfusion tracheids. The palisade parenchyma is poorly developed, whilst the spongy tissue is very much so. Figure 160 has been cut through three oil cavities. Figures 161–2 are cross-sections through the normal leaflets, and call for no special explanation except that all the parenchymatous cells are empty. Figures 163–4 are longitudinal sections cut through the nodes, and showing that the oil reservoirs are not canals.

(c) Chemistry of the Leaf Oil.

The results of the analyses of the oil of this form of *Callitris,* found growing in Tasmania, and also that of similar trees of the Rylstone district of New South Wales, show them to be practically identical in composition, and it is evident that the oils must have been distilled from the same species. The botanical differences which had previously been supposed to exist between *C. rhomboidea* of the eastern coast of New South Wales and the Tasmanian form are by this

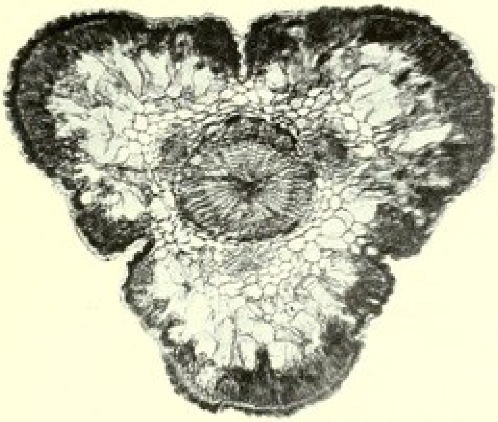


Figure 161.—Transverse section through branchlet and decurrent leaves, cut below the oil cavities shown in Figure 162. The individual bundle for each leaf is seen surrounded by endodermal cells, which also enclose the central axis. *C. Tasmanica*, × 70.

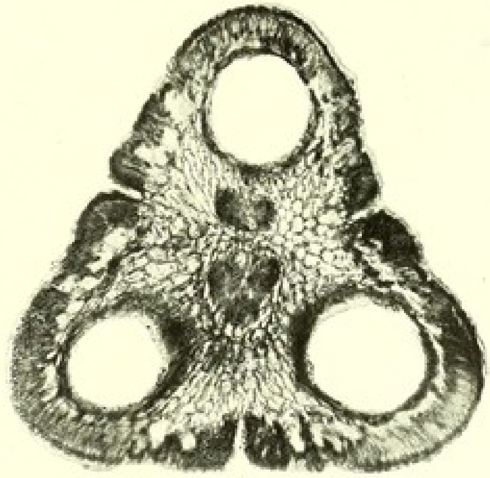


Figure 162.—Transverse section through branchlet and oil cavities of each leaf, which in this instance are of unusual size. A branchlet trace is seen between the main axis and oil cavity of the top leaf. *C. Tasmanica*, × 70.

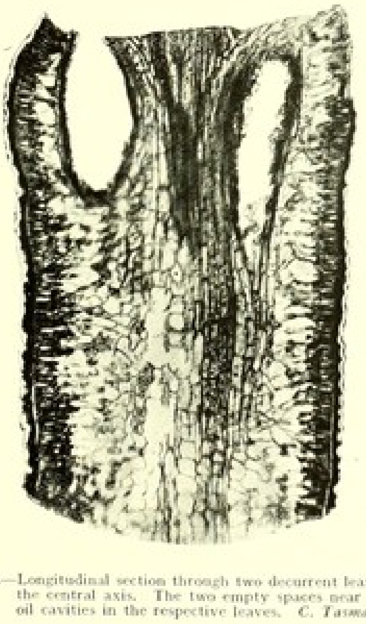


Figure 163.—Longitudinal section through two decurrent leaves, clear of the central axis. The two empty spaces near the top are oil cavities in the respective leaves. *C. Tasmanica*, × 54.

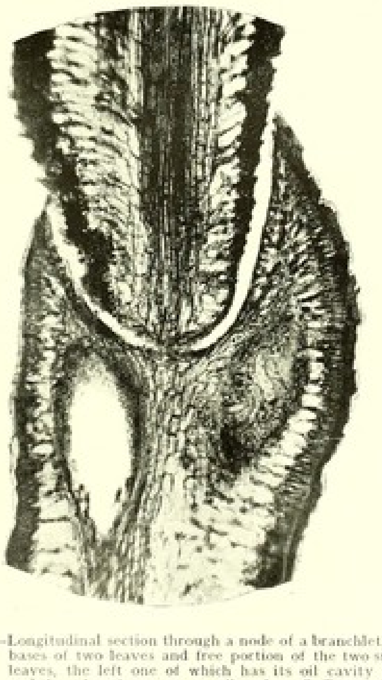


Figure 164.—Longitudinal section through a node of a branchlet, showing bases of two leaves and free portion of the two succeeding leaves, the left one of which has its oil cavity sectioned and the other the secretory cells only. *C. Tasmanica*, × 54.

Sections of branchlets and leaves of C. Tasmanica, nobis.

investigation shown to be substantial. It is remarkable, however, to find this Tasmanian Pine existing so far north as the Rylstone district, New South Wales, and the evidence thus appears conclusive that this form, although somewhat related to the Sydney tree (*C. rhomboidea*), must have been entirely distinct before Tasmania became separated from Australia.

The presence of such a large amount of geranyl-acetate in the oil of this species of *Callitris* is particularly interesting, and it is here that the geraniol—which appears to occur in the oils of most species of *Callitris*—has reached its maximum. The free alcohol was found to be almost entirely geraniol, and this was proved by the results of the cold saponification of the acetylated oil. It has been determined, particularly with the oil of this tree, that two hours' contact in the cold is sufficient to entirely saponify the geranyl-acetate, and identical results were obtained when the oil had been in contact with the alcoholic potash for either two or four hours. Borneol seems to have been almost entirely eliminated from the oil of this species, and terpineol is probably absent also, as no butyric acid was detected in the volatile acids of the esters. The terpenes present were pinene,—of which the dextro-rotatory form was slightly in excess—and limonene, of which the predominant form was the lævo-rotatory modification. The tetra-bromide prepared from the limonenes melted at 118° C., thus agreeing with that obtained with the corresponding terpenes of *C. calcarata*.

A small amount of a phenolic body was detected in the oil of this tree, which was probably identical with a similar substance occurring in the oil of *C. gracilis*. Sufficient material could not, however, be spared to enable it to be isolated in sufficient quantity to be determined. It may possibly occur also in other species, although it has not so far been detected. The odour of the oil has a strong resemblance to that of geranyl-acetate, due to the presence of such a large amount of that substance. Unfortunately the yield of oil from the leaves of this species is small, so that the commercial value in this respect is somewhat restricted. We have previously shown that large quantities of geranyl-acetate occur in the oils of two Australian trees, viz.:—*Eucalyptus Macarthuri* (" Research on the Eucalypts "), and *Darwinia fascicularis* (Roy. Soc., N.S.W., Dec., 1899). Scientifically, however, its occurrence in the oils of the *Callitris* is of great interest, and has assisted greatly in the study of the several members of the genus.

No. 1.—This material was collected at Glen Regis, near Rylstone, New South Wales, 180 miles west of Sydney, 27th March, 1905. The terminal branchlets with their decurrent leaves were used. Although some fruits were present, these had no influence, because oil could not be obtained from the fruits of this species by steam distillation when treated alone. This was proved with the fruits of the Tasmanian sample, and although the distillation was continued for six hours not a drop of oil was obtained. The yield of oil was small, and 403 lb. of branchlets

only gave 9 oz. of oil, equal to 0·14 per cent. The crude oil was amber coloured, had an odour resembling that of geranyl-acetate, and was distinct from the oil of any other *Callitris*, with the exception, perhaps, of *C. rhomboidea*. The crude oil was insoluble in 10 volumes of 70 per cent. alcohol, but was soluble in 1 volume of 80 per cent. alcohol, and in all proportions after.

The specific gravity of the crude oil at $\frac{23}{15}$° C. = 0·9036; rotation a_D = + 1·0°; refractive index at 25° C. = 1·4738. The saponification number, after boiling for half an hour, was 171·3, equal to 59·95 per cent. ester, or 47·11 per cent. alcohol of the formula $C_{10}H_{18}O$. In the cold, with two hours' contact, the saponification number was 171·18, equal to 59·91 per cent. of ester, or 47·1 per cent. alcohol. The whole of the ester was thus shown to consist of geranyl-acetate. The crude oil was acetylated by boiling with acetic anhydride and sodium acetate in the usual way. The saponification number had then increased to 190·8, representing 61·2 per cent. of total alcohol in the oil, so that it contained 14 per cent. free geraniol.

On redistilling 100 c.c. of the crude oil, practically nothing came over below 155° C. Between 155° and 172°, 14 per cent. distilled; between 172° and 188°, 13 per cent.; between 188° and 225°, 57 per cent., of which no less than 52 per cent. distilled between 214° and 228° C.

The first fraction was again distilled and that portion which came over between 155° and 157° separated. This was a colourless mobile liquid, and had the odour and appearance of pinene. The nitrosochloride was prepared with it, and this melted at 107–108° C. It was then converted into the nitrolbenzylamine compound, which melted at 122–123° C. The rotation of the pinene as thus prepared was a_D + 9·9°; the specific gravity at $\frac{23}{15}$° C. = 0·857; and the refractive index at 24° = 1·4706. It was evidently a mixture of both forms of pinene, of which the dextro-rotatory one predominated.

The second fraction, which was lævo-rotatory, was again distilled, and the oil which came over between 174° and 176° C. separated. This oil had all the characteristics of limonene, and the rotation was a_D — 9·1°. The tetrabromide was prepared with it, and this melted at 118° C., showing that dipentene was also present, and that the lævo-rotatory limonene was in excess. This is in agreement with the results from *C. calcarata* and other allied species.

The third fraction, which was slightly lævo-rotatory, due to the small amount of lævo-rotatory limonene which still remained, had specific gravity at $\frac{23}{15}$° C. = 0·901 ; and refractive index 1·4685 at 23° C. The saponification number was 235·34, equal to 82·369 per cent. of unaltered ester. The remainder was then wholly saponified, the alcohols separated, and the volatile acids determined in the aqueous portions in the usual way. 0·5546 gram of the barium salt gave 0·5066 gram $BaSO_4$, equal to 91·34 per cent. As the theoretical amount required

for acetic acid is 91·35 per cent., this result shows that no other volatile acid than acetic was present.

The separated oil containing the alcohols was redistilled, when the greater portion came over between 217° and 229° C. This had the marked rose odour of geraniol, was inactive to light, and had specific gravity at 18° C. = 0·8818. These results alone were strong evidence for geraniol, and it was not even necessary to separate the alcohol in a perfectly pure condition by means of its calcium chloride compound. When treated in the cold with the usual potassium bichromate oxidising mixture, the marked odour of citral was obtained. A quantity was then carefully oxidised with the more dilute oxidising mixture, and the citral which formed extracted and purified. The oil which remained on the removal of the ether had the marked odour of citral, and when treated with pyroracemic acid and β-naphthylamine, as suggested by Doebner, gave citryl—β-naphtho-cinchoninic acid, which melted at 197–198° C. The principal constituents in the oil of this *Callitris* are thus shown to be geranyl-acetate and free geraniol. In the oil of no other species of *Callitris* has such a large amount of geraniol been found.

No. 2.—This material was collected at Swansea, Tasmania, 3rd June, 1908. The leaves and terminal branchlets alone were used, the fruits having been removed before distillation, and these treated separately. 600 lb. of branchlets gave 20 oz. of oil, equal to 0·208 per cent.

Although the fruits were distilled for six hours, yet not sufficient oil was obtained to separate. The general appearance, too, of the fruits is not at all promising for oil.

The leaf oil was amber coloured and had an odour strongly indicating that of geranyl-acetate. It was insoluble in ten volumes of 70 per cent. alcohol, but was soluble in one volume of 80 per cent. alcohol, and in all proportions after.

The specific gravity of the crude oil at 15° C. = 0·8976; rotation $a_D = -5·8°$; refractive index at 15° = 1·4739. The saponification number after boiling was 179·3, equal to 62·75 per cent. of ester. In the cold, with two hours' contact, the saponification number was 177·7, equal to 62·2 per cent. ester, or 48·9 per cent. of alcohol; an identical result was obtained with four hours' contact. This result shows that the whole ester was geranyl-acetate. A portion of the oil was acetylated in the usual way, when it had a rotation a_D = — 5·4° C. The saponification number after boiling was 195·1, representing 62·9 per cent. total alcohol in the oil. In the cold, with two hours' contact, it was 192·9, representing 62 per cent. total alcohol, so that practically the whole of the alcohol in the oil of this species is geraniol, and 14 per cent. of free geraniol was present in this sample.

The results of these analyses show that over 70 per cent. of the oil of *C. Tasmanica* consists of geranyl-acetate and free geraniol.

The lævo-rotation of the crude oil is evidently due to a slightly increased amount of the lævo-rotatory limonene over that of the Rylstone sample.

Crude Oil from the Leaves of *Callitris Tasmanica*.

No.	Locality and Date.	Specific Gravity ° C.	Rotation α_D.	Refractive Index ° C.	Ester by boiling per cent.	Ester in cold per cent.	Yield per cent.
1	Glen Regis, N.S.W., 27 3 05	0·9036 @ 22°	+ 1·0°	1·4738 @ 25°	59·95	59·91	0·14
2	Swansea, Tasmania, 3 6 08	0·8976 @ 15°	- 5·8°	1·4739 @ 15°	62·75	62·2	0·208

IV. TIMBER.

(*a*) Economic.

The timber is yellowish-brown, not unlike that of *C. gracilis*.

Transverse Tests of the Timber of *Callitris Tasmanica*, of standard size. (38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 3·00 ; D 3·00	B 2·94 ; D 2·95	B 3·00 ; D 3·00
Area of cross-section, square inches	9·00	8·67	9·00
Breaking load, in lb.	5,690	4,200	4,000
Modulus of rupture in lb. per square inch ...	11,380	9,257	8,000
,, elasticity ,, ...	1,515,789	2,120,727	1,440,000
Rate of load in lb. per minute	711	600	500

(*b*) Anatomy.

The medullary rays are specially numerous in this timber, and range in height from two to twenty cells or even more; they are all of a parenchymatous character and mostly devoid of the brown manganese compound contents—a substance that is, however, fairly well scattered throughout the prosenchymatous tracheids of the xylem.

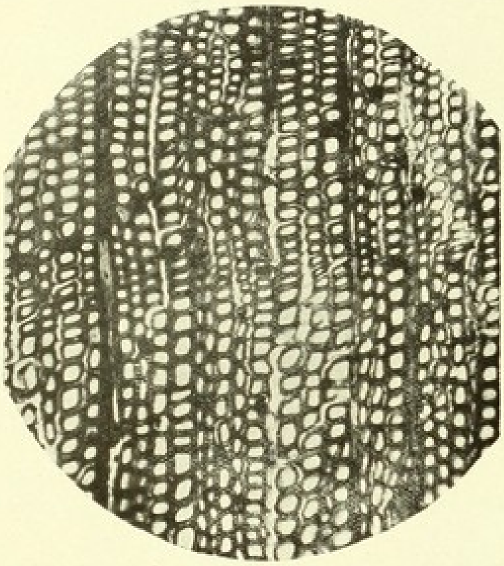


Figure 165.—Transverse section of timber. The autumnal tracheids run across the picture from left to right. *C. Tasmanica*, × 100.

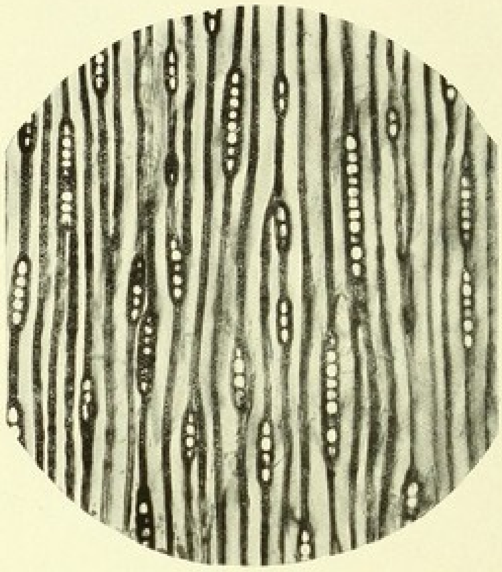


Figure 166.—Tangential section through timber. Here few of the ray cells contain manganese compound. *C. Tasmanica*, × 100.

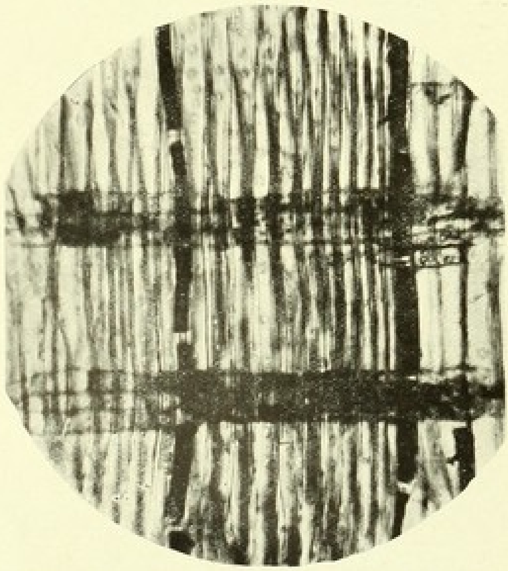


Figure 167.—Radial section through timber through two rays. The two black interrupted lines from top to bottom of picture are manganese compound. The left one is interesting as the substance has come away from the cell. *C. Tasmanica*, × 110.

Sections of timber of C. Tasmanica, nobis.

The simple cells of the rays are comparatively large, as also are the oblique perforations leading into the lumina of the tracheids.

The pitted cells are numerous on the radial walls, and occasionally occur in double rows—a rare occurrence in species of the *Callitris* genus.

Vide Figures 165-6-7.

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

The structure of this part of the tree conforms to the general rule of *Callitris* barks fully described under *C. glauca* and other species.

The most distinctive feature is, perhaps, the strongly-developed sieve tubes, the plates being very numerous and clearly seen in a longitudinal section even under the low magnification of Figure 168, whilst in Figure 169, with a 350-enlargement, they are very conspicuous objects.

(*c*) Chemistry.

This specimen of bark was taken from a log 12 inches in diameter, sent from Tasmania. The bark was somewhat thin for a tree of this size, and it does not seem to thicken to the extent shown in that of some species. The total thickness was 7 to 10 mm.

The colour externally was a dark grey to brown, somewhat deeply furrowed and fibrous. It is a fair bark for tanning purposes, more especially for the preparation of tanning extracts.

The following results were obtained with the air-dried bark:—

Moisture ...	...	13·6 per cent.
Total extract	...	22·8 ,,
Non-tannin	...	5·4 ,,
Tannin ...	...	17·35 ,,

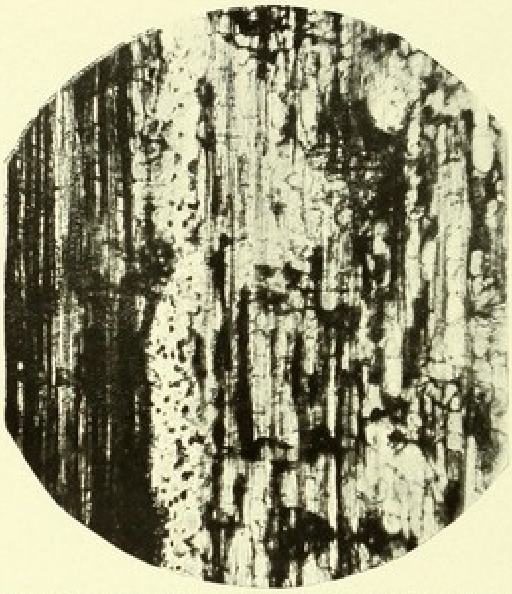


Figure 168.—Radial section at junction of inner and outer bark. The lighter structure in left centre from top to bottom of picture is a periderm band. The bast fibres are the narrow dark lines in the left or inner bark. They are more irregularly scattered through the outer bark, when the parenchymatous cells can be plainly seen as well as the sieve tubes, by the aid of a lens. *C. Tasmanica*, × 54.

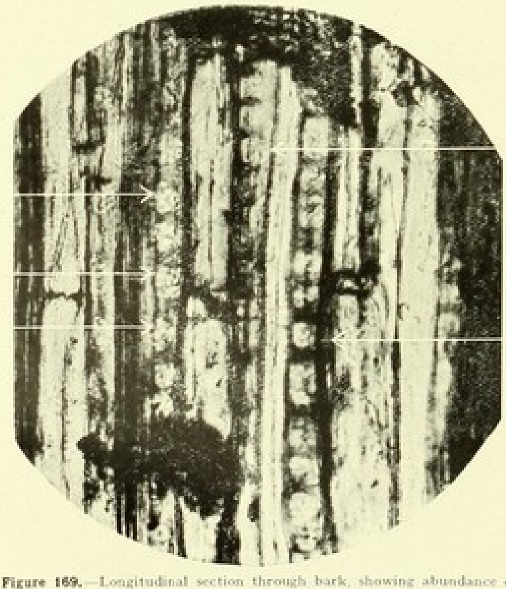


Figure 169.—Longitudinal section through bark, showing abundance of sieve plates in the tubes separated by parenchymatous cells. *C. Tasmanica*, × 350.

Sections of bark of C. Tasmanica, nobis.

Callitris sp.

"WEEPING PINE."

Habitat.

Little Swanport, East Coast, Tasmania.

Remarks.

There is a plant in Tasmania passing under this vernacular, but as sufficient material was not available for full investigation, only attention can here be drawn to its existence.

It was discovered by Mr. C. F. Laseron of this Museum, who states:—

> This small conifer is found in only one spot on the main road, 5 miles from Triabunna (Spring Bay), and 8 miles from Little Swanport, Tasmania (East Coast). Here there are only some half-a-dozen plants. In habit it is a small, erect shrub up to 5 feet high, growing amongst young plants of Oyster Bay Pine. It is very like young Casuarina in appearance. The branchlets or needles are long and drooping, and spring from the main stems in rings about 12 to 18 inches apart, hence the name. Two distinct types of leaves were obtained. Though careful search was made, no fruits were found. One or two small plants were noticed cropped very close to the ground by stock.

These may probably be young plants of *C. Tasmanica*, but further investigation is necessary. The special feature about the plant that is worthy of note is the very long leaves in the decurrent form, in fact they are the longest of any *Callitris* known to us in this respect. If new, the species might be dedicated to its discoverer.

Figures 170–173 are taken through the branchlet and the three decurrent leaves, which have a form quite distinct from any other *Callitris*, and what is still more characteristic, is that each leaf has three oil cavities, and it is to prove these latter are not canals that the four figures are given. Figures 174–5 are longitudinal leaf sections of different magnifications.

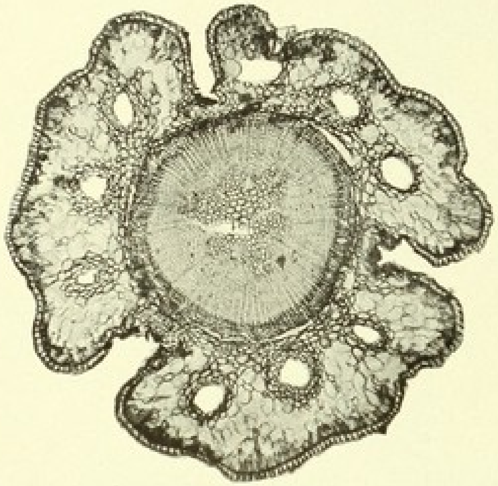


Figure 170.—Transverse section through branchlet and three decurrent leaves of "Weeping Pine." The shape of the leaves with their three oil cavities is unique amongst the genus. *Callitris* sp., × 40.

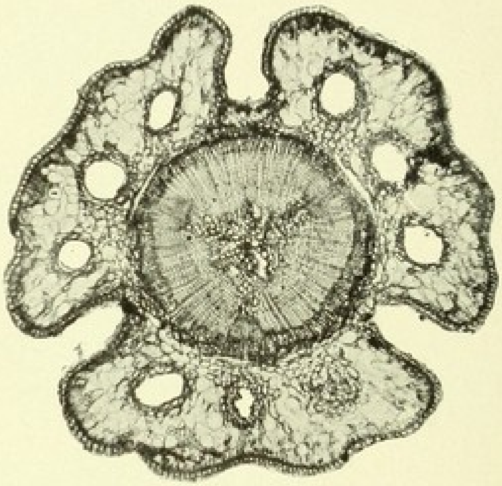


Figure 171.—Transverse section through branchlet and decurrent leaves showing the unusual occurrence of three oil cavities in each leaf. "Weeping Pine," Tasmania, *Callitris* sp., × 40.

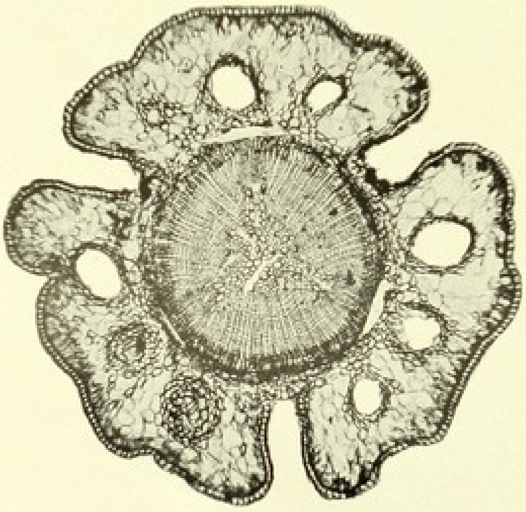


Figure 172.—Transverse section, same as Figure 171, but showing that three of the oil cavities have just cleared the knife, hence these organs are not canals. *Callitris* sp., × 40.

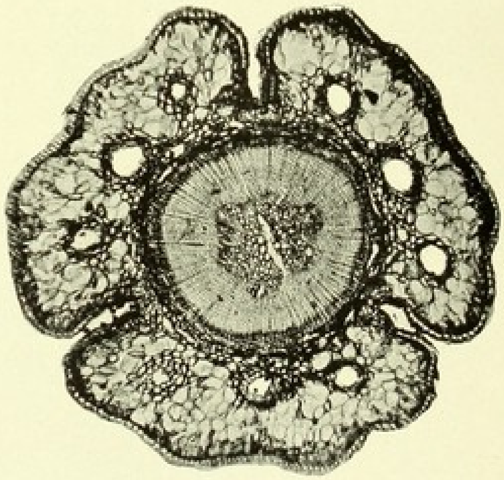


Figure 173.—Transverse section same as Figure 171. *Callitris sp.*, × 40.

Transverse sections through branchlet and decurrent leaves of Callitris sp.

Figure 174.—Longitudinal section through a decurrent leaf. The parenchymatous nature of the endodermal cells is well shown. Coming in from the top right centre is a bundle, and to the right of which is some transfusion tissue. On the left is another bundle with a thread-like bast fibre at the top marking the phloem. The lacunæ are oil cavities. "Weeping Pine," *Callitris* sp., × 50.

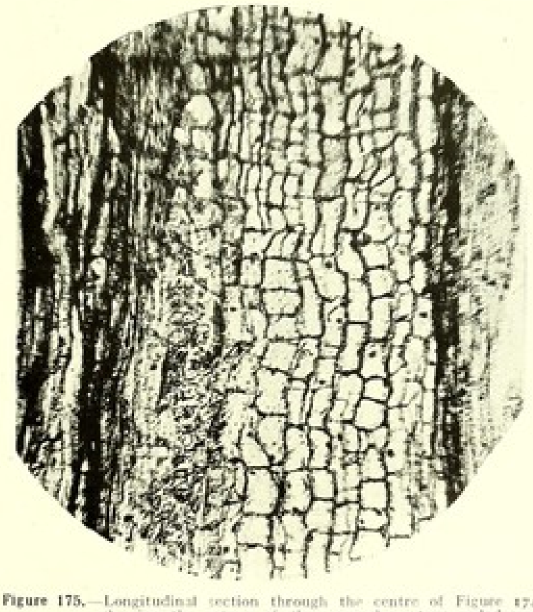


Figure 175.—Longitudinal section through the centre of Figure 174, showing the nature of the parenchymatous endodermal cells in greater detail. *Callitris* sp., × 120.

Longitudinal sections of a leaf of Callitris sp.

Nat. size.

Callitris Drummondii, BENTH. ET HOOK. F. "CYPRESS PINE," WESTERN AUSTRALIA.

12. Callitris Drummondii.

Benth. et Hook. fil., Gen. Plant., III., 424.

A "CYPRESS PINE."

(Syn.:—*Frenela Drummondii*, Parlat. in DC. Prod. XVI, ii, 448.)

Habitat.

Western Australia. It occurs on the Coast from Esperance Bay (Maxwell), to Cape Riche. (Drummond.)

I. HISTORICAL.

This Conifer is in the happy position of having only one synonym, so that its specific rank remains, so far, unquestioned.

Herbarium Material Examined.

Kew,—

Oldfield's specimen collected at Esperance Bay.
Drummond's specimens from Swan River.

We are indebted to the Western Australian Government for the material of this species, upon which the researches were carried out.

II. SYSTEMATIC.

A shrub or tree attaining a height of 50 feet or more, with a hard, compact, furrowed bark. Branchlets with the decurrent leaves, rigid, coarse, the latter drying a fresh green in the herbarium specimens, and are more robust than in any other species of *Callitris* except *C. Roei*. Free ends of leaves appressed, margins scarious, obtuse, the decurrent portion of the leaf forming an acute angle, the three producing an equilateral triangular prism—the angles being more acute than in *C. calcarata*, and the internodes sometimes measuring 6 lines in length. Male amenta terminal, mostly solitary. Female amenta not seen.

Fruit cones somewhat globose, but in the middle stage when half-grown and on to maturity they are quite top-shaped and glaucous, mostly solitary, yet numerous at the base of the older branchlets, drying a light-brown colour, scabrous when young, smooth or slightly rugose in advanced age, under 8 lines in diameter; the valves are stout, alternately rather shorter and more acute, valvate, the dorsal point not very distinct.

It is differentiated from cognate species by—

1. Its fruits which have almost equal valves and which are thicker than those of other fruits of equal size, and the base of the cone also tapers into the peduncle.

2. Its comparatively large decurrent leaves, which give herbarium material a coarser appearance than the others.

3. Its anatomical characters.

4. Its chemical constituents.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

These leaves are characterised by their angularity and a cross-section through a branchlet and the three decurrent leaves form a very fair equilateral triangle, whilst an examination of the leaf tissue reveals a certain specific structure, as, for instance, the occurrence of hypodermal cells at the ventral surfaces of the leaves—a feature found not to occur in any other species. The occurrence of a comparatively large number of branched sclerenchymatous cells in the fundamental tissue is only paralleled in the leaves of *C. rhomboidea*, whilst the disposition of the transpiratory surfaces is identical with those of the Tasmanian species, which circumstance calls for investigation into the environment of these two species, *C. Drummondii* and *C. Tasmanica*.

In Figure 176 the oil cavities of each individual leaf form a conspicuous object, whilst at the most acute angle of the triangle the double row of hypodermal cells can be seen, and at the base or ventral surface can just be made out similar cells, with their long axis running obliquely to the surface; this is more distinctly shown in all the other figures given under this species. The branched sclerenchymatous cells in the mesophyll are shown cut at different angles, whilst the number of parenchymatous cells and transfusion tissue is very limited in this species; some of the former are, however, occasionally found filled with the brown content,—the manganese compound. The assimilatory surfaces of the leaf are at the apex and free base portion, the transpiratory area lying between these two, so that the palisade parenchyma does not present so solid a phalanx as generally obtains in *Callitris* leaves. Figure 177 shows two of the three leaves with oil cavities, but generally each possesses an oil reservoir; the sclerenchymatous cells show out prominently. Figure 179 being cut well below the node has no oil cavities in the leaves.

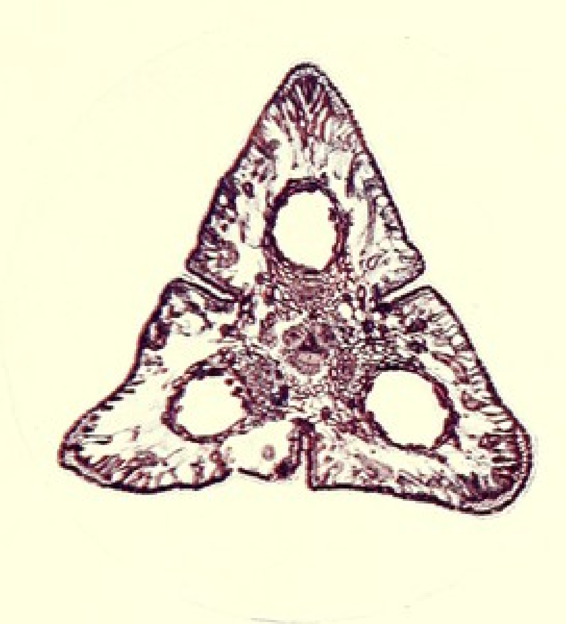


Figure 176.—Transverse section through a branchlet and three decurrent leaves, illustrating the sharp angle formed by the dorsal ridge in this species in each leaf, and where the hypodermal cells are seen to be well pronounced. The endodermal cells are not numerous around the three oil cavities and median tissue. On the underside of each oil cavity is a bundle. Sclerenchymatous cells occur throughout the parenchyma. Stained with hæmatoxylin. *C. Drummondii*, x 40.

(*c*) Chemistry of the Leaf Oil.

The material for this investigation was forwarded to us by the Government of Western Australia, and was received the 26th June, 1903. As there were numerous fruits upon the branchlets, it was thought desirable to distil them separately, and none was left upon the branchlets, so that this oil was distilled entirely from the leaves and terminal branchlets. The distillation was continued for seven hours, and 354 lb. of material gave 31 oz. of oil, equal to 0·547 per cent. The crude oil was of a light amber colour and had a slight "pine-needle oil" odour, but inclining more to that of turpentine, and was but little soluble in alcohol. Over 90 per cent. of the oil consisted of dextro-rotatory pinene, and this had a very high specific rotation. The amount of esters was very small, and this was found to consist of the esters of borneol and geraniol, most probably in combination with acetic acid alone, as the indications for that acid were most marked. Limonene and dipentene do occur, but only in very small amounts, because in one distillation less than 2 per cent. was obtained distilling between 173° and 200° C. The presence of dextro-rotatory limonene was indicated by the specific gravity and rotations of the two larger fractions, and by the slightly less rotation of the pinene fraction.

The specific gravity of the crude oil at $\frac{15}{15}$° C. = 0·8591; rotation a_D = + 42·2°; refractive index at 19° C. = 1·4739. The saponification number (mean of three determinations) was 5·29, equal to 1·85 per cent. of ester as bornyl and geranyl acetates. In the cold, with two hours' contact, the saponification number was 3·71, equal to 1·3 per cent. of ester, thus indicating the presence of geranyl-acetate.

On redistilling, practically nothing came over below 155° C. Between 155° and 160°, 75 per cent distilled; between 160° and 165°, 11 per cent.; between 165° and 200°, 6 per cent.; between 200° and 250°, 3 per cent. Although separated into the above fractions, yet only about 1 per cent. was obtained between 180° and 230° C.

The specific gravity of the first fraction at $\frac{15}{15}$° C. = 0·8551; of the second, 0·856; of the third, 0·8565; of the fourth, 0·9099. The rotation of the first fraction a_D = + 43·6; of the second, + 47·2°; of the third, + 52·8°. This indicates that the predominant limonene is the dextro-rotatory form. The ester in the fourth fraction was determined, the saponification number being 69·78, equal to 24·4 per cent. Both borneol and geraniol were present as mixed esters, thus being in agreement in this respect with most species of *Callitris*.

To prepare the pinene, 100 c.c. of the oil boiling below 160° was again distilled, and 51 c.c. obtained between 155–156° C. This had a specific gravity at 15° C. = 0·8579; rotation a_D = + 42·7°, or specific rotation $[a]_D$ = + 49·77; refractive index, 1·4714 at 24° C. The nitrosochloride, which melted at 108° C., and the nitrosopinene melting at 132° C. were prepared, thus giving results conforming

to the requirements for pinene. The dextro-rotatory pinene occurring in the leaf oils of the *Callitris* has reached a maximum in the oil of this species.

The Oil of the Fruits.

This material consisted of the fruits alone, the leaves having been entirely removed, and 56 lb. of fruits gave 2½ oz. oil, equal to 0·3 per cent. The crude oil was light coloured, very mobile, and in odour and appearance strongly resembled the oil from the leaves. The constituents of the fruit oil were also in agreement with those of the leaf oil. The specific gravity of the crude oil at 15° C. = 0·8663; rotation a_D = + 45·1°; refractive index at 19° C. = 1·4798; saponification number 6·86, equal to 2·4 per cent. ester. From these results it is seen that the oil obtained from the fruits of this species of *Callitris* is practically identical with that obtained from the leaves. The tabulated results will show this more clearly:—

Crude Oil from the Leaves of *Callitris Drummondii*.

Locality and Date.	Specific Gravity ° C.	Rotation a_D.	Refractive Index ° C.	Ester per cent.	Yield per cent.
West Australia, 26/6/03	0·8591 @ 17	+ 42·2	1·4739 @ 19	1·85	0·547

Crude Oil from the Fruits of *Callitris Drummondii*.

Do.	0·8663 @ 15	+ 45·1	1·4798 @ 19	2·4	0·3

IV. TIMBER.

(*a*) Economic.

Very little appears to be known in regard to the uses of this tree.

(*b*) Anatomy.

The distinguishing characteristics of this timber are the medullary rays which are generally only a few cells in height, and which are mostly empty of the brown manganese content, this substance, however, occurs scattered throughout the prosenchymatous tracheids of the xylem in the autumnal and spring woods, and can be well seen in a transverse section. The pitted cells are numerous on the radial walls of the tracheids.

V. BARK.

Only young bark was at our disposal for examination, and this called for no special remarks, as its structure corresponded relatively to that of the mature cortex of its congeners.

Nat. size.
Callitris Morrisoni, R.T.B. "CYPRESS PINE," WESTERN AUSTRALIA.
(Cones closed.)

Callitris Morrisoni, R.T.B. "CYPRESS PINE," WESTERN AUSTRALIA. Nat. size.
(Cones opened.)

the decurrent portion being quite short and flattened. Male amenta terminal, mostly single, with few whorls of stamens. Female amenta unknown.

Fruit cones globular, axillary, solitary, or in clusters, about 8 lines in diameter when opened, smooth or wrinkled when aged, ash-grey in colour, in early fruit tapering towards the pedicel or branchlets, as in *C. Drummondii*, Benth. and Hook.f., but rather intruded at the base in the mature stage. Valves six, thick, at first valvate, then channelled, the larger one with parallel edges, the smaller ones triangular.

Seeds usually two-winged, the central columella three-branched ; about 2 lines long.

15. Callitris Muelleri,

Benth. et Hook. fil., Gen. Plant., III., 424.

" ILLAWARRA PINE."

(Syn.:—*Frenela fruticosa*, A. Cunn. Herb.; *F. Muelleri*, Parlat. in DC. Prod. XVI, ii, 450.)

Habitat.

This species is apparently confined to a few localities in New South Wales. It is found on the north shore of Port Jackson, Middle Harbour, especially at Mosman, and on the sandstone ridges surrounding the Spit. It is also found in the Illawarra District, and on the Blue Mountains, as well as the Curricudgery Ranges. It has been announced as also occurring at the following places in this State:—Berrima, Blackheath, National Park, Eden, King's Tableland, Mount Wilson, Nowra, Rylstone, St. Albans, Wentworth Falls, and Woy Woy.

I. HISTORICAL.

There is a specimen of Fraser's in the Kew Herbarium labelled from Moreton Bay, Queensland.

The original specimen of *F. fruticosa* of Cunningham, mentioned by Bentham, Flora Aus. vi, p. 237, we could not trace, but both at Kew and the British Museum there are specimens of this species, named by Cunningham as *F. attenuata*. These apparently were overlooked by Bentham when compiling his classical work.

M. F. Connelly, Photo.

C. Muelleri, BENTH. ET HOOK. F. "CYPRESS PINE," CLONTARF, SYDNEY, N.S.W.

Callitris Muelleri, BENTH. ET HOOK. F. "CYPRESS PINE." *Nat. Size.*

Herbaria Material Examined.

Kew,—

Parlatore's specimen from Port Jackson.

A. Cunningham's specimens—(1) from the Blue Mountains; (2) no locality, but marked "*C. attenuata*."

Fraser's specimen from Moreton Bay.

British Museum,—

Mr. Heward's specimen from New Holland, named *C. pyramidalis*.

A specimen in R. Brown's herbarium from New Holland.

Berlin National Herbarium,—

Sieber's specimen No. 137 from New Holland is labelled "*Exocarpus stricta*, R.Br.," an obvious slip of the pen.

II. SYSTEMATIC.

A handsome, shapely Conifer under 50 feet high, with a dense head of dark green foliage. Bark—hard, black, compact. Branchlets appearing angular from the decurrent leaves, making the angles rather acute; the internodes lengthening to half an inch towards the branches. Free ends of the leaves appressed, and not quite so acute as in other species, the decurrent portion slender and raised from the base, giving the branchlets an acute angular appearance. Leaves in whorls of three, sometimes reaching five lines in length. Male amenta terminal, in twos or threes, ovoid, cylindrical, under two lines in length, about six whorls of stamens; anthers, generally three at the base of the orbicular stamens. Female amentum solitary, at the lower portion of base of the branchlets, about two lines in diameter, sporophylls glaucous on the inner side.

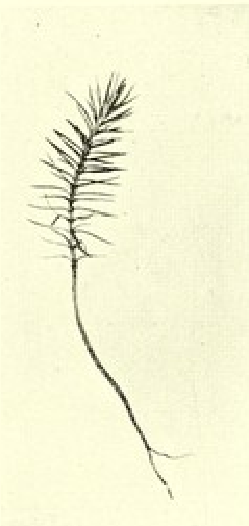


Figure 180.—Seedling of *C. Muelleri*, Nat. size.

Fruit cones solitary, or sometimes numerous, on the second year's branchlets, subglobose, about nine lines in diameter before dehiscing, and over an inch when the valves are fully expanded. Valves six, alternately large and small, smooth on the back, the larger ones are oblong and rather obtusely pointed, the three smaller ones triangular, valvate. Columella, very short, three-branched, flat. Seeds, oblong, two, rarely three-winged, about two lines long.

This is one of the most ornamental of the smaller *Callitris*, being a very compact, shapely tree with olive-green branchlets.

Systematically it comes nearest to *C. calcarata*, R.Br., but differs from it in its larger fruits and longer internodes, although in this latter character it differs with one exception from all other *Callitris*, and can be classified from this feature alone. Like *C. Macleayana* the acicular leaves are often to be found at the base of the branchlets.

On a carpological classification it would be placed with *C. gracilis*, R.T.B., these two having the fruit cones of equal dimensions, the latter occasionally being tuberculate, but again in *C. Muelleri* the fruits might also be described, perhaps, as an enlarged form of *C. calcarata*.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

(*a*) *Primordial leaves.*—In Figure 181 is shown a cross section of a leaf that this species appears to be more prone to produce than its congeners, excepting *C. Macleayana*, and such can be found almost invariably on every individual tree.

In cross-section they may be described—first, as roughly triangular in shape; and, secondly, with channels on two sides which generally form the transpiratory surfaces. Epidermal cells are larger than the hypodermal—the usual order of things obtaining in the decurrent leaf; the spongy mesophyll is unduly out of proportion to the palisade layer, and carries in the centre an oil cavity and a single bundle with its attendant transfusion tissue.

(*b*) *Decurrent leaves.*—These divide themselves morphologically into two kinds, *i.e.*, those which sectionally may be described as dumb-bell shaped, and those which sectionally are roughly triangular in outline. The former occur near the ends of the branchlets, especially on what was known as *C. Parlatorei*, and, therefore, in a measure represent, probably, the transition state between the acicular and the decurrent forms. In Figure 182 is given a cross-section through a branchlet showing the attachment of three of the former to the central axis, and morphologically are unlike any other conifer. The three knobs of the leaves are the assimilatory surfaces of the epidermal cells backed by a double row of hypodermal cells. The transpiratory organs are on the concave surfaces, which are followed by another small area of assimilatory surface at the foot of the leaf near the adnate portion. The spongy mesophyll consists of elongated cells joining the palisade parenchyma with oil cells not shown in the picture, and below which is the leaf bundle with a fair amount of conjunctive tissue. Parenchymatous endodermal cells appear to be quite absent.

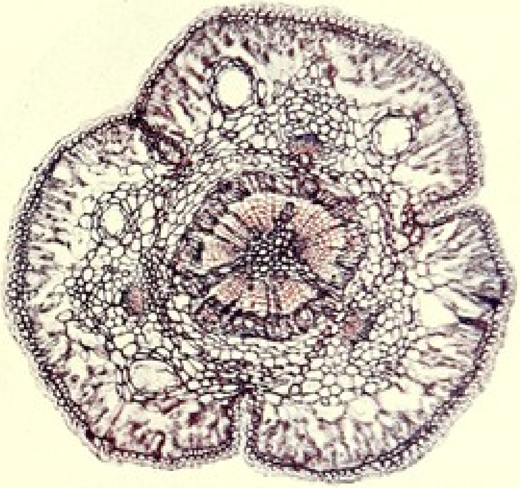


Figure 184.—Transverse section through branchlet and decurrent leaves, showing two oil glands in two of the leaves. The endodermal cells are specially abundant and in the centre of which in each leaf is a bundle with its red-stained xylem and purple phloem. Stained with hæmatoxylin and safranin. *C. Muelleri*, × 25.

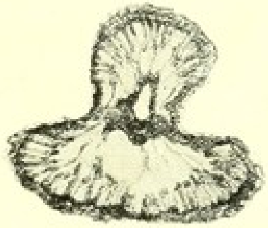


Figure 181.—Transverse section of primordial leaves of *C. Muelleri*, × 35.

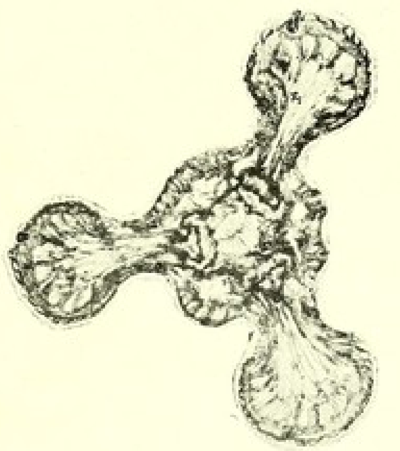


Figure 182.—Transverse section through central stem and decurrent leaves of an unusual shape. *C. Muelleri*, × 70.

Figure 183.—Transverse section through branchlet, showing attachment of tissue of decurrent leaves to central axis—these forming practically one whole. *C. Muelleri*, × 50.

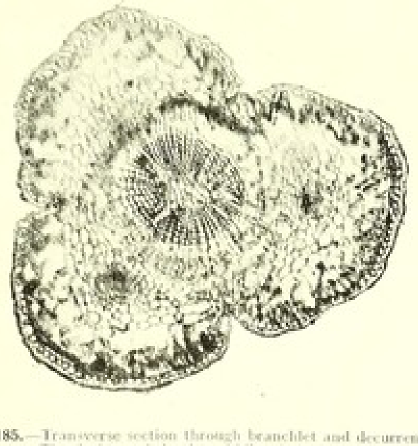


Figure 185.—Transverse section through branchlet and decurrent leaves. The dark patch in the middle of each leaf is a leaf bundle. *C. Muelleri*, × 50.

Sections of branchlets and decurrent leaves of C. Muelleri, Benth. et Hook. f.

Figure 183 well illustrates that the transverse sections of the normal leaves present some interesting samples of structure, for whilst conforming in a general way to the usual anatomy of this part of the *Callitris*, yet there are specific differences that may be worthy of notice, viz.:—A narrow ring, two or three cells wide, of empty parenchymatous vessels enclosing the bundles of the central cylinder or column of the branchlet, and occasionally connected by medullary rays with the pith cells. This is the only species in which the parenchymatous cells partake more of a true endodermal character (Figures 183–5), for not only are they arranged in a circle around all the bundles, but also around the oil cavities, the transfusion tissue in a compact mass on either side of the leaf bundle, and partly around the base of the oil cavity, and not irregularly scattered, as holds in some other species. The manganese compound containing parenchymatous cells, are not so clearly defined, but, nevertheless, can be traced in Figure 185, as a narrow band around, but distant from the central axis or phloem, and also at the base of the decurrent channels. At this early stage of growth it may be noted (Figure 184) that the bast cells of the phloem are beginning to form, and if staining is any guide to origin, the evidence is in favour of a xylemic one, or at least they are closely allied to, or have affinity with that material. No sclerenchymatous cells were detected corresponding to those of *C. rhomboidea* or *C. calcarata*. It is to be noticed how relatively small are the many oil cavities to those of other species, and also that two sometimes occur in each leaf (Figures 183–4). The hypodermal cells occur at the dorsal side and at the edge of the leaf as it turns into the decurrent channel, where are found the stomata.

(*c*) Chemistry of the Leaf Oil.

This material was collected at the Spit, near Sydney, New South Wales, 20th September, 1907. The leaves and terminal branchlets alone were used. The whole of the fruits were removed before distillation, and these distilled separately. The distillation was continued for six hours, and 212 lb. of terminal branchlets gave 3½ oz. of oil, equal to 0·103 per cent. The crude oil was slightly lemon coloured, very mobile, and had the "pine-needle oil" odour much less distinctly marked than with most species, resembling that of turpentine more strongly. It was practically a terpene oil, and, consequently, was indifferently soluble, being insoluble with ten volumes of 90 per cent. alcohol. The principal constituent was pinene, both forms being present, the dextro-rotatory pinene only slightly predominating. The limonenes were also present, the one in excess being the lævo-rotatory form. The esters were very small in amount, but there is no reason to suppose that they differ in composition from those of the *Callitris* generally, and the amount of oil at our disposal was too small to allow the constituents to be isolated for specific determination.

The specific gravity of the crude oil at $\frac{24}{15}$° C. = 0·8582; rotation a_D = — 4·7°; refractive index at 20° C. = 1·4749. The saponification number was 7·88, equal to 2·76 per cent. of ester.

On redistilling, practically nothing came over below 155° C. Between 155° and 157°, 50 per cent. distilled; between 157° and 170°, 33 per cent.; between 170° and 180°, 10 per cent.

The specific gravity of the first fraction at $\frac{24}{15}$° C. = 0·8512; of the second, 0·8502; of the third, 0·8482. The rotation of the first fraction a_D = + 6·6°; of the second, — 4·5°; of the third, — 22·1°. The chemical products were readily prepared with the first fraction, proving it to consist mostly of pinene. That limonene was present in the oil is also indicated by the above results. There was an almost entire absence of the higher boiling constituents, and no indication of a sesquiterpene corresponding to cadinene was detected.

The oil of this species is distinct from that of any other *Callitris*, thus supporting botanical and other characteristics.

The fruits of this species are apparently devoid of oily constituents, and 26 lb. removed from the green branchlets, although distilled for five hours, did not give a single drop of oil.

Crude Oil from the Leaves of *Callitris Muelleri*:—

Locality and Date.	Specific Gravity ° C.	Rotation a_D.	Refractive Index ° C.	Ester per cent.	Yield, per cent.
The Spit, Sydney, 20/9/07	0·8582 @ 24	— 4·7	1·4749 @ 20	2·76	0·103

IV. TIMBER.

(*a*) Economic.

This is a pale-coloured timber, but as the tree is so sparsely scattered and attains only a small diameter it is necessarily not found in commerce, and so is never likely to be of any commercial value, unless cultivated.

(*b*) Anatomy.

The main features of this timber show some specific characteristics, as, for instance, the medullary rays are almost uniformly fewer-celled in height than, perhaps, other species, and there appears to be less manganese compound content, so pronounced in corresponding cells of other species, and thus this substance is not by any means a prominent feature of the tracheids.

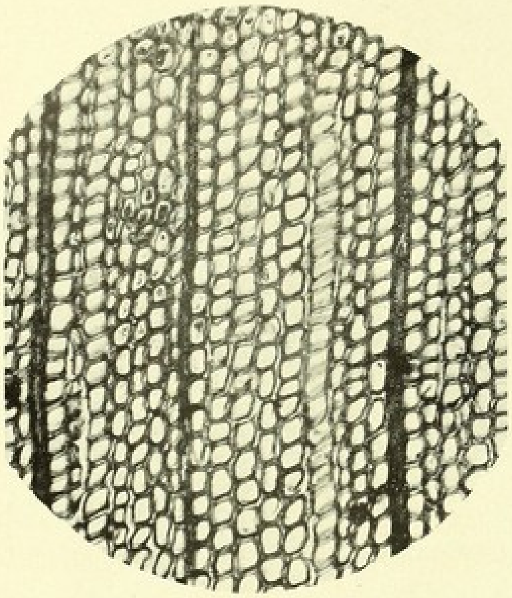


Figure 186.—Transverse section through vernal timber. The three parallel black bands extending from top to bottom of picture mark three medullary rays—the black colour being due to the brown manganese compound. *C. Muelleri*, × 120.

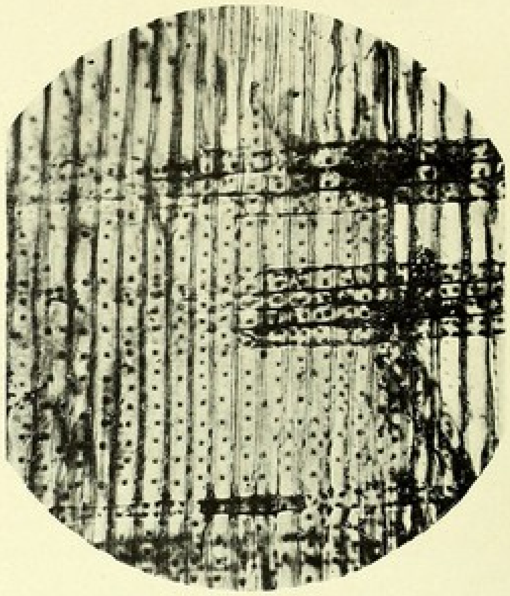


Figure 187.—Radial section through timber. The bordered pits are very numerous on the radial tracheidal walls, and the simple pits of the rays are equally well shown. The cells of the rays are all parenchymatous. *C. Muelleri*, × 120.

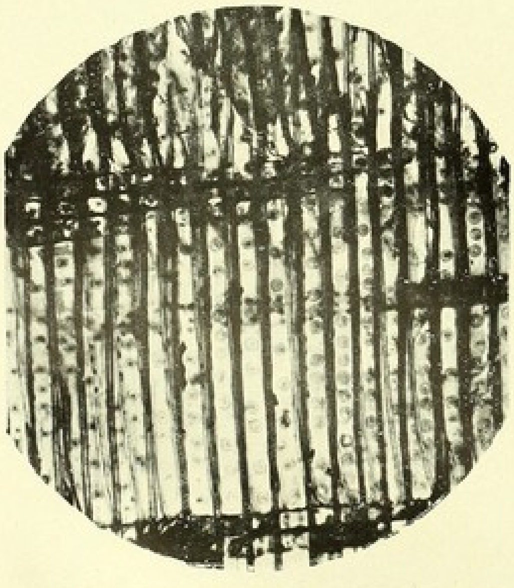


Figure 188.—Radial section through timber. Numerous pitted cells are shown on radial walls of tracheids. Portions of three rays are shown. *C. Muelleri*, × 150.

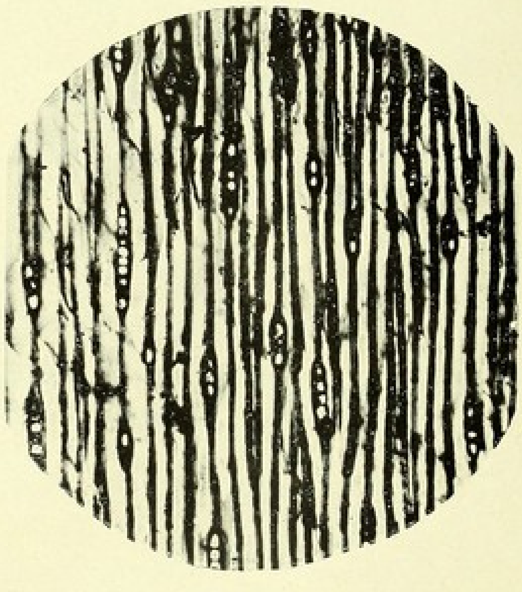


Figure 189.—Tangential section through timber of *C. Muelleri*, × 90.

Sections of timber of C. Muelleri, Benth. et Hook. fil.

All the cells of the medullary rays are parenchymatous, both the inner and outer. In Figure 186 the three black lines mark the medullary rays by the presence of a manganese compound. Pitted cells are numerous on the radial walls of the tracheids, whilst the perforations of the ray cells are circular, with about two apertures between each wall of the tracheids. Figures 187–8.

V. BARK.

Chemistry.

The sample of bark was taken from a tree 3 to 4 inches in diameter growing near Sydney. The bark was grey to brown externally, furrowed, soft, and fibrous. The greatest thickness was 10 mm.

The following results were obtained with the air-dried sample:—

Moisture ...	... 12·1	per cent.
Total extract	.. 16·8	,,
Non-tannin	... 4·9	,,
Tannin ...	... 11·9	,,

---

16. Callitris oblonga.

Rich., Conif., 49 T., 18 F., 2 (1826).

(Syn.:—*C. Gunnii*, Hook. f. in Hook. Lond. Journ., IV, 147; *Frenela australis*, R.Br.; Mirb. in Mem. Mus. Par. XIII, 74, not of End.; Hook. f. Fl. Tasm. I, 352 t. 97; *F. Gunnii*, Endl. Syn. Conif., 38; Parlat. in DC. Prod. XVI, ii, 450; also according to Parlatore; *F. variabilis*, Carr. and *F. macrostachya*, Gord.)

Habitat.

This species is quite endemic to Tasmania, where it was collected by Robert Brown at Port Dalrymple, and on the gravelly banks of the South Esk River, near Launceston.

I. HISTORICAL.

From the above list of synonyms it will be seen that this *Callitris* has received no little attention at the hands of systematists. It was first collected by Robert Brown, as stated above, and afterwards in the same locality by several distinguished botanists, and Sir Joseph D. Hooker, in his "Flora Tasmanica," gives a splendid illustration of the species.

Callitris oblonga, RICH. "CYPRESS PINE," TASMANIA. *Nat. Size.*

Herbaria Material Examined.

Kew,—

Sir J. D. Hooker's specimens collected on the bank of the Esk River, with notes and sketches for plates in his "Flora Tasmanica."

R. Gunn's specimens, labelled "*C. Gunnii*" by Hook. f.

A specimen from Launceston, no collector's name given.

A specimen grown in the open air since 1893 by Mr. W. J. Ross, Rosstrevor, Ireland—shows no variation.

British Museum,—

R. Gunn's specimen from South Esk Bank, 25–5–43.

Caley's specimen, labelled *F. Gunnii*, no loc.

Paris Herbarium,—

Gunn's specimen ; information, Kew and British Museum.

Cambridge University Herbarium,—

Gunn's specimen ; information, Kew and British Museum.

Brussels Herbarium,—

Verreaux's specimen from Paris Herbarium, labelled "*Frenela australis*, R.Br. 1844–46," not in fruit.

II. SYSTEMATIC.

A shapely bush or small tree rarely attaining a height of 25 feet, with a hard, compact bark, and very numerous branchlets. Free ends of leaf small, acute, closely appressed at the base of each joint, the three decurrent portions forming angles on the branchlets resembling those of *C. Muelleri ;* the internodes are comparatively rather long, ranging from 2 to 3 lines. Male amentum terminal or towards the ends of the branchlets, very short, just over a line long, the whorls of stamens few, anther cells a little larger than in other species. Female amentum not seen.

Fruit cones somewhat conical, about an inch long and ¾ inch in diameter towards the base, solitary, on short peduncles or in clusters, and sessile at the base of the younger branches. Valves six, obtuse at the apex, rather thick, the alternate ones about half the size of the others,—which are sometimes convex longitudinally at the lower half and concave at the upper, smooth on the back, the dorsal point very prominent on the outer edge at the top; the central columella short, three-partite. Seeds, broad, equally or unequally winged.

On a carpological classification the species has greatest affinity with *C. rhomboidea*, R.Br., as both have a well-developed "spur."

This is one of the smallest trees of the genus, and is usually found on the gravelly banks at the mouth of the Esk River. It is characterised by the very prominent development of the dorsal point of the valves, which distinguishes the fruit cones from all the other species.

Known locally as " Native Cypress." This is a very small species of *Callitris*, usually not more than 5 or 6 feet high, and rarely up to 10 feet. It is rarely above 2 or 3 inches in diameter. It is fairly common on the extreme edge of river flats on the South Esk River, also St. Anne's River, near Avoca, Tasmania. It is never seen far from the edge of the river. It is erect in habit, usually consisting of several branches rising from the ground. The foliage is dense, and, as the outline is very symmetrical, it forms a handsome and prominent little shrub. (C. F. Laseron.)

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

Like most Tasmanian species the contour of a cross-section of the decurrent leaves together with the branchlet is almost triangular, the decurrent channel being hardly perceptible in many instances, while the fundamental tissues of the three leaves have no regular line of demarcation, and so, together with the central cylinder of the branchlet, form, as it were, one whole structure, somewhat similar to certain leaves of *Pinus*.

The dorsal angles are the assimilatory surfaces; a row of hypodermal cells intervenes between the epidermal and the palisade layer of cells, both of which are uniseriate.

The central column is surrounded by an irregular circle of parenchymatous endodermal cells, which enclose the small leaf bundle and extend around the oil cavity when it is present.

Only a limited number of sclerenchyma and transfusion cells were detected.

The spongy tissue of the mesophyll forms a loose structure and occupies a fair proportion of the leaf. Stomata are not numerous, and when present were found to occur on the straight, lateral surfaces of the combined three leaves, as obtains in others assuming this shape; there may possibly be some in the traces of decurrent channels, where also were found a few conical-shaped cuticle cells, and which are fully dealt with under *C. glauca*.

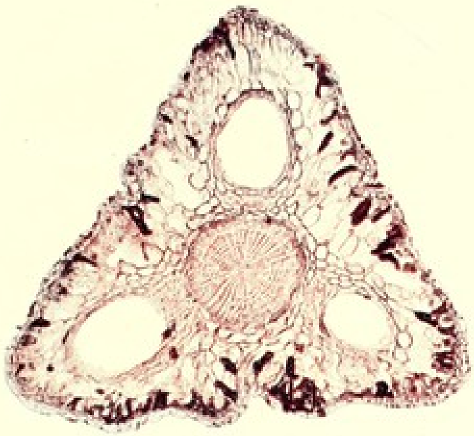


Figure 192.—Transverse section through branchlet, and decurrent, adnate leaves, with an oil gland in each of the latter. Stained with safranin. *C. oblonga*, × 55.

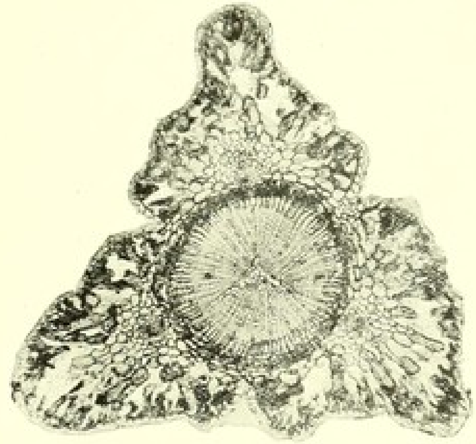


Figure 190.—Transverse section through branchlet and decurrent leaves free from oil cavities. The dark irregular shapes in the mesophyll are sclerenchymatous bodies. *C. oblonga*, × 55.

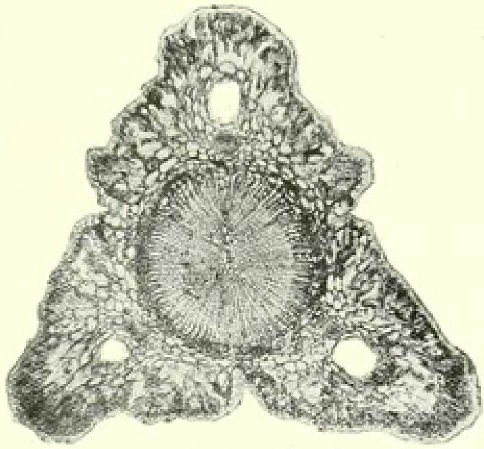


Figure 191.—Transverse section through branchlet and three decurrent leaves, showing an empty oil cavity in each of the latter. *C. oblonga*, × 55.

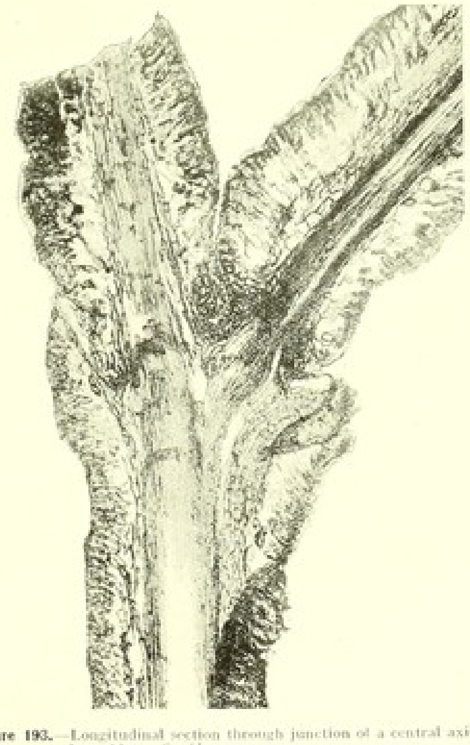


Figure 193.—Longitudinal section through junction of a central axis and branchlet. *C. oblonga*, × 35.

Sections through branchlets and decurrent leaves of C. oblonga, Rich.

The position of the stomata is worthy of notice in this case, as well as the general absence of decurrent channels—a condition of circumstances probably due to natural selection or adaptation to environment and, perhaps, produced by the climatic conditions of the island home of this species, for the West Coast of Tasmania is notorious for its great rainfall. This disposition of transpiratory organs is in marked contrast to what realises with the *Callitris* of the arid interior of the continent, where all have marked decurrent channels into which the stomata communicate, and by which they are well protected from the heat, and other adverse climatic conditions. Figure 190 illustrates a section cut well down the internode of a branchlet, and showing no oil reservoirs. Figure 191 is a cross-cut higher up than Figure 190, and takes in the lower extremities of the oil cavity in each leaf, whilst in Figure 192 the triangular shape of this section is complete, and being cut through the middle of the oil cavities shows the varying diameter of these bodies compared with those given under Figure 191. The parenchymatous cells are arranged in a fairly regular manner around the central axis and oil reservoirs, and may almost be called quite endodermal in this instance. It will be noticed that they are all empty. The leaf trace can be seen but not the transfusion tissue, which, in this species, is only developed to a limited degree. Figure 193 is a longitudinal section cut through the centre of a branchlet and offshoot.

(*c*) Chemistry of the Leaf Oil.

This material was collected at Avoca, Tasmania, 25th June, 1908. The leaves and branchlets, containing some fruits, were taken for distillation, and this was continued for six hours, but the yield of oil was very small, as 526 lb. of branchlets only gave $4\frac{1}{2}$ oz. of oil, equal to 0·054 per cent. The crude oil was somewhat dark coloured, but after agitation with a dilute solution of soda it became of a light-lemon colour. It was very mobile, and had an odour somewhat resembling *Callitris* oils generally, but, perhaps, more aromatic than those of the *C. glauca* group. The esters were in somewhat small amount, and appeared to consist mostly of geranyl-acetate, as only a small amount of bornyl-acetate could be detected. In this respect the oil belongs more to the group to which *C. calcarata* is a representative than to that including *C. glauca*. The principal terpene present in the oil of this species is pinene, the dextro-rotatory form being the most pronounced, and no less than 80 per cent. of the crude oil distilled below 170° C. The limonenes were present, but only in a very small amount. There was also detected a small proportion of a high boiling constituent other than the esters, and which was most probably a sesquiterpene or similar body. This was indicated by the distillation results, the refractive index, and the specific gravity of the crude oil. The oil, consisting mostly of pinene, was naturally somewhat insoluble, and it did not form a clear solution with 10 volumes of

90 per cent. alcohol. The specific gravity of the crude oil at 16° C. = 0·8735; rotation a_D = + 38·1°; refractive index at 16° C. = 1·4783. The saponification number, after boiling, was 17·3, equal to 6·05 per cent. esters. In the cold, with two hours' contact, the saponification number was 15·9, equal to 5·6 per cent. It was thus seen that the greater portion of the esters was saponified in the cold, and the separated oil had a secondary odour of geraniol. Only 40 c.c. of the oil could be spared for redistillation. Between 154° and 160°, 67 per cent. distilled; between 160° and 170°, 13 per cent.; between 170° and 200°, 7 per cent; between 200° and 250°, 8 per cent. The specific gravity of the first fraction at $\frac{20}{15}$° C. = 0·8583; of the second, 0·8583; of the third, 0·8656; of the fourth, 0·916. The rotation of the first fraction a_D = + 40·7°, or a specific rotation $[a]_D$ = + 47·42°, which is nearly as high as the specific rotation of the pinene of *C. Drummondii*. The rotation of the second fraction a_D = + 38·5°; of the third, + 33·1°; of the fourth, + 19·9°. The refractive indices of the first three fractions at 20° C. also closely agreed—the first = 1·4733; the second = 1·4736; the third = 1·4751.

The above results show that the oil consisted largely of dextro-rotatory pinene, and that the indications for limonene were not strongly marked. The first fraction was again distilled, and that portion which came over between 155–156° C. was separated. The nitrosochloride was prepared from this in the usual way. The oil of this species shows distinctive characters from those of any other species of *Callitris*, and although having resemblances in composition in some respects to the oil of *C. Muelleri*, yet, it can be seen that the two oils are distinct.

Crude Oil from the Leaves of *Callitris oblonga*.

Locality and Date.	Specific Gravity ° C.	Rotation a_D.	Refractive Index ° C	Ester by boiling, per cent	Ester in the cold, per cent.	Yield, per cent.
Avoca, Tasmania. 26/6/08	0·8735 @ 16	+ 38·1	1·4783 @ 16	6·05	5·6	0·054

IV. TIMBER.

(*a*) Economic.

The economics of the timber are quite limited owing to its small size.

17. Callitris Macleayana.

F. v. M. in Rep. Burdek. Exped. 17, 1860.

"STRINGYBARK" OR "PORT MACQUARIE PINE."

(Syn.:—*C. Parlatorei*, F.v.M., Fragm. V, 186; *Frenela Macleayana*, Parlat., in DC. Prod. XVI, ii, p. 446; *Octoclinis Macleayana*, F.v.M., in Trans. Phil. Inst., Vict., ii, t.; *Leichhardtia Macleayana*, Shep. Cat. Pl. cult. Sydney, 1851, p. 15.)

HABITAT.

The geographical range of this species is rather limited, being confined to the Coast district from Coolongolook, north of Newcastle, New South Wales, to Queensland.

It occurs at Alstonville, Booral, Coolongolook, Coopernook, Dorrigo, Hastings River, Kempsey, Killabakh, Port Macquarie, Tumbulgum, Woodford Dale, and Yarrahappini, all in New South Wales.

I. HISTORICAL.

C. Macleayana and *C. Parlatorei* were for many years regarded as distinct species, and Bentham in his "Flora Australiensis" and Mueller in his last "Census" give them specific rank.

The reason for this classification is not far to seek, *C. Macleayana* was founded on that form of the tree, or rather material, which has mostly acicular leaves and eight-valved cones; and *C. Parlatorei* on that with six-valved fruits and an absence of acicular leaves, as shown by herbaria specimens extant to-day at Kew, Paris, and Melbourne. Thozet's specimens (*loc. infra*) have acicular leaves and eight-valved cones, as also have Mueller's specimens at Paris and Melbourne, whilst Thozet's specimens referred to by Bentham have six-fruited valves and no acicular leaves; thus showing how imperfect collecting in the field has misled the able botanists above mentioned. We long suspected that the two names referred to one species, and were further convinced in our views after visiting the Hobart Botanic Gardens, Tasmania, where the features which were supposed to characterise the two species are to be found occurring on the same tree.

HERBARIA MATERIAL EXAMINED.

Kew,—

Thozet's specimen from Hastings River, New South Wales.
Hill's specimen from Darlington Range, Queensland.

Callitris Macleayana, F.v.M. "Stringy Bark" or "Port Macquarie Pine."   Nat. Size.

Paris,—

Mueller's specimen from Hastings River, labelled "*C. Macleayana*."
A. Rudder's specimens from Macquarie Harbour.

II. SYSTEMATIC.

This tree is said to attain a height of 150 feet, with a diameter of 2 to 4 feet, and has a red, stringy bark.

The branchlets appear angular from the shape of the decurrent leaves, which are short (1 to 2 lines long), similar to those of *C. calcarata ;* acicular leaves variable in length, are sometimes 4 to 5 lines long, rigid, and pungent pointed, and shortly decurrent in whorls of three.

Cones large, pyramidal-ovoid, acuminate, over an inch long, on thick recurved pedicels, rather less than an inch long; valves six to eight, almost of equal size, and lanceolate in shape, valvate, channelled on the back, the dorsal point at the apex being reflexed, occasionally slightly reflexed at the tips. Fertile seeds with only one wing developed.

The vernacular name well describes the nature of the bark, which is entirely different to that of any other species of the genus. It appears to be a parallel case to *Casuarina inophloia*, F.v.M. et F.M.B., the only "Stringybark" of that similarly unique genus.

It is also distinguishable from its congeners by its pyramidal angular fruits and its pale-coloured timber which has not a dark duramen, although possessing in a slight degree the same aromatic odour. This lighter colour is probably due to a smaller amount of the characteristic chemical substances.

The tree is ornamental, and is recommended for cultivation in botanical gardens, and especially for forestry. Trees growing to the height of 150 feet are stated to occur at Coolongolook, New South Wales.

III. LEAVES.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

The distinguishing characteristics in the leaf anatomy of this species are the minimised development of hypodermal cells below those of the epidermal, the dorsal surface, and the environment of the central axis by sclerenchymatous cells—a feature not found by us in the other species. Sclerenchymatous cells are also found in the spongy mesophyll, which latter forms an unusually large proportion of the leaf substance as shown in the sections, whilst transfusion tracheids and

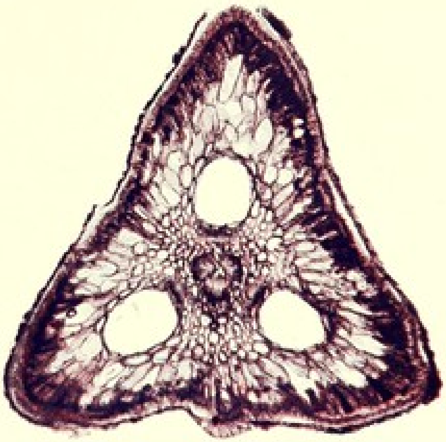


Figure 195.—Transverse section through branchlet and middle of oil cavity in each decurrent, adnate leaf. Hypodermal cells are only below the dorsal ridge (assimilatory surface); the transpiratory surfaces are on the middle of the sides of the triangle. Stained with hæmatoxylin. *C. Macleayana*, × 70.

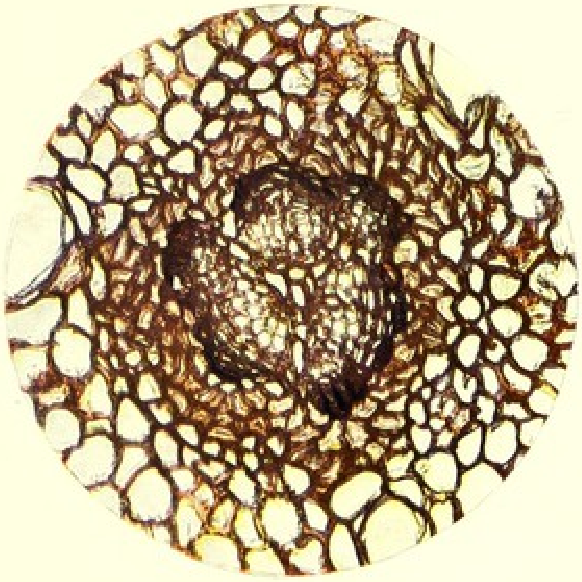


Figure 196.—Transverse section through a branchlet and surrounding leaf tissue. A band of sclerenchymatous cells (light brown) surround the phloem of the median bundles. Transfusion cells are seen more clearly towards the top, and denoted by the pitted cells. The lower portions of two oil glands are seen on the left and right towards the top. Stained with hæmatoxylin and safranin. *C. Macleayana*, × 280.

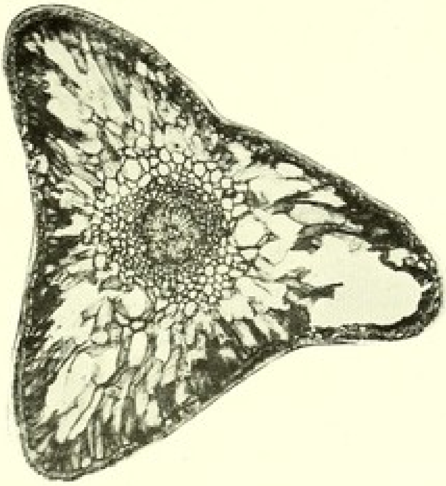


Figure 194.—Transverse section through branchlet and the three adnate decurrent leaves. Three small oil cavities are sectioned near the outer parenchymatous endodermal cells, surrounding the sclerenchymatous cells enlarged in Figure 196 *C. Macleayana*, × 70.

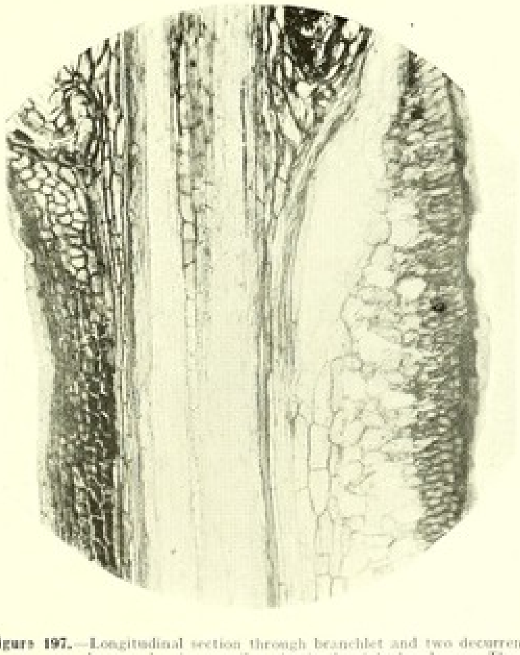


Figure 197.—Longitudinal section through branchlet and two decurrent leaves, showing an oil cavity in the right-hand one. There is one row of parenchymatous pith vessels running through the picture from top to bottom. *C. Macleayana*, × 70.

Sections of leaves of C. Macleayana, F.v.M.

parenchymatous endodermal cells occur in about even proportions. The transpiratory surface occupies the mid-distance between the dorsal apices, there being no decurrent channel in this species and, consequently, no ventral surfaces so to speak. Figure 194 has been cut near the bottom of the three oil cavities, which can be seen on the outer edge of the whole median structure, and this is reproduced in Figure 196. Other structures can also be traced from the remarks given under previous species. Figure 195 is a section through the middle of the oil cavities of the leaves. Figure 196 is given to illustrate the sclerenchymatous cells enclosing the bundles of the axis of the branchlet, and are well-defined objects in the plate. At the top right-hand corner is focussed an isolated transfusion cell, the other empty cells are of a parenchymatous nature. Figure 197 is a longitudinal section of a branchlet and leaves, just cutting an oil cavity in the upper half of the leaf.

(*c*) Chemistry of the Leaf Oil.

This material, which consisted of both forms of the leaves with terminal branchlets, was collected at Coolongolook, New South Wales, 180 miles north of Sydney, on the 11th October, 1907. It contained many fruits, but all of them were removed before distilling, so that the oil is that of the leaves only, together with their accompanying branchlets. This procedure was, however, found to be unnecessary, because the fruits only contained traces of oil, and 331 lb. when steam distilled for six hours did not give sufficient oil to enable it to be collected. The yield of oil from the leaves was not large, and 290 lb. only gave 8 oz., equal to 0·172 per cent.

The crude oil was but little coloured, and had somewhat of a turpentine odour with but slight resemblance to that of the leaf oils of the *Callitris* generally; it was insoluble in 10 volumes of 90 per cent. alcohol.

The oil of this species, although in most respects agreeing with those of the *Callitris* leaf oils, yet contained a constituent in some quantity which has not been detected in the oil of any other species of *Callitris*, although, perhaps, occurring in traces in some of them. This constituent appears to be dextro-rotatory menthene or some member of the menthene group, and when isolated by fractional distillation, in as pure a condition as possible, it had a marked odour of menthene, and altogether strongly resembled that substance. It was not possible, of course, to separate it in a pure condition by distillation, nor was the amount of material at our disposal sufficient for the purpose, but from the results obtained there appears little doubt but that a member of the $C_{10}H_{18}$ series does occur in the leaf oil of this species, as indications for an undetected terpene were not given. The only Conifer from which we have succeeded in isolating hydrocarbons belonging to the $C_{10}H_{18}$ or $C_{10}H_{20}$ series is *Araucaria Cunninghami*, and in this tree only from the latex of the plant.

The other constituents of the leaf oil of *C. Macleayana* were dextro-rotatory pinene, highly dextro-rotatory limonene with some dipentene, a small amount of ester, and a sesquiterpene which indicated cadinene strongly, although it was not lævo-rotatory.

The specific gravity of the crude oil at $\frac{20}{15}$° C. = 0·8484; rotation a_D + 42·5°; and refractive index at 20° C. = 1·4791. The saponification number, after boiling, was 9·9, equal to 3·5 per cent. of esters. In the cold, with three hours' contact, the saponification number was 9·2, equal to 3·2 per cent. of esters, thus indicating that geranyl-acetate was the principal ester, and although the identity of the alcohol was not determined with certainty, yet it had the geraniol odour strongly marked.

On redistilling 100 c.c. of the oil, but little was obtained boiling below 160° C. Between 160° and 170°, 50 per cent. distilled; between 170° and 180°, 26 per cent.; between 180° and 240°, 8 per cent.; between 240° and 270°, 11 per cent.

The specific gravity of the first fraction at 22° C. = 0·8372; of the second, 0·8379; of the third, 0·862; of the fourth, 0·9167. The rotation of the first fraction, a_D= + 46·2°; of the second, + 56·0°; of the third, + 57·3°; of the fourth, + 16·6°.

The first fraction was again distilled, when 19 c.c. was obtained boiling below 160° C., and 18 c.c. between 160° and 168° C. The specific gravity at 22° C. of the first fraction was 0·8413; of the second, 0·837. The rotation of the first fraction, a_D= + 42·3°; of the second, + 52·6°.

The Pinene.—The portion which came over below 160° was again distilled, and 7 c.c. collected, boiling between 155° and 157° C. This was largely pinene. It had a specific gravity at 22° C. = 0·8443; rotation, a_D= + 37·4°; and refractive index, = 1·4733. A small amount of the nitrosochloride was obtained with it, which, when finally purified, melted at 107–108° C.

The Menthene Fraction.—The oil boiling between 160–168° was added to the remainder in the flask, and the distillation continued, when the oil which came over below 162° C. was separated; 10 c.c. was thus obtained, boiling between 162° and 165°. This had specific gravity at 22° C. = 0·837; rotation, a_D= + 58·7°; and refractive index at 22° C. = 1·4703. It probably contained some limonene, but had a very marked odour of menthene; and this, together with the low specific gravity and the low refractive index, indicated the presence of a member of this group. Although the results do not correspond closely to those of the known menthenes, yet, even among the comparatively pure members considerable differences occur, as, for instance, between menthene and carvo-menthene. It was not possible, with the amount of material at our disposal, to carry the separation and purification further, and the complete identity of this hydrocarbon thus remains in abeyance.

The Limonene.—The second fraction of the first distillation was again distilled, and 12 c.c. obtained boiling between 170° and 177° C. This had specific gravity at 22° C. = 0·8381; rotation, a_D = + 63·6°; and a refractive index at 20° C. = 1·476. It consisted mostly of limonene, as it gave the characteristic bromide for that substance; but as this melted at 117–118° C. evidently some dipentene was present; it thus agrees with the oils of the *Callitris* generally. The fourth fraction of the first distillation was again distilled, and 5 c.c. boiling between 270° and 280° C. separated. This had specific gravity at 22° C. = 0·9203, and refractive index at the same temperature = 1·5052. It gave the colour reaction for cadinene when dissolved in chloroform and treated with sulphuric acid, and the physical properties appear to indicate that sesquiterpene, but we were not successful in preparing the crystallised dihydrochloride with it.

Crude Oil from the Leaves of *Callitris Macleayana*.

Locality and Date	Specific Gravity ° C.	Rotation a_D	Refractive index ° C	Ester per cent. by boiling.	Ester per cent. in the cold.	Yield per cent.
Coolongolook. 11/10/07	0·8484@20	+42·5°	1·4791	3·5	3·2	0·172

IV. TIMBER.

(*a*) Economic.

This tree is found on level ground in rich scrub soil as well as on steep sides of ridges. It attains a general height of from 60 to 80 feet, and a diameter of about 2 feet; the trunk being for a great length without any branches, makes the tree appear different from the usual aspect of *Callitris*. The bark is very thick and fibrous, and a rich reddish-brown colour, differing in these respects from those of *C. glauca* and other *Callitris*.

The timber may be said to be entirely free from figure, the grain being quite straight, but, nevertheless, when planed it has a nice pale colour. Unfortunately it is a rare tree, occurring only in patches in the northern coast district, and, so far as known, only in a comparatively few localities in New South Wales (*supra*). It has a very light brown-coloured duramen and is fissile, easily worked, and much resembling the "Brown or Damson Pine," *Podocarpus elata*, R.Br., in texture and colour, and could be used for cabinet work, panelling, &c. It is only slightly aromatic compared to those of its cognate species of *Callitris*. Concerning its ant-resistant properties there are no data available, but it probably possesses some of these qualities, for Mr. A. B. Barlow of Yarrahappini has forwarded to us a specimen which has lain on the ground for nineteen years and is still in a good state of preservation—a rather good record of durability.

Tests,—

Three pieces 1 foot by 1 inch in a transverse stress gave the following results :—

1. Broke at 550 lb., deflection ·29 inch.
2. Broke at 530 lb., deflection ·36 inch.
3. Broke at 500 lb., deflection ·25 inch.

(*b*) Anatomy.

Viewed microscopically the various sections of the xylem present differences from some of its congeners. The medullary rays run along the field of view in distinct broad bands with well-defined end and lateral walls, as well as distinct simple pits, which give it the appearance of a number of bolted iron plates (Figure 202); these parenchymatous cells are narrower than in the other species. There is also a distinguishing scarcity of the brown manganese compound in the cells of the tracheids, those found being distantly scattered throughout the two seasons' growths.

The bordered pits occur on the radial walls and in a tangential section are less prominent (in section) than in other species. The free edges scarcely protruding into the lumina of the tracheids. In examining these bordered pits under a DD objective (Zeiss), the limiting lamella (torus) is seen to be more enlarged on both sides than in any other species examined, whilst in almost every case there appears to be only one opening into the tracheid instead of two, such as obtains in other species, the opposing wall of the tracheid being quite entire.

In a transverse section the walls of the autumnal growth are, perhaps, thicker than the others, and the cells are flatter, giving the annual ring a rather pronounced appearance, the transition from the spring growth showing little or no gradation, as shown in Figure 198, which section depicts a narrow band of autumnal tracheids, such as obtains in this species, across the plate from left to right just above the middle. There are two medullary rays in the left of this figure, the longer and darker is towards the middle. Only a very few tracheids have brown manganese compound contents, and there is none in the rays. Figure 199 is a portion of Figure 198 more restricted, while Figure 200, a tangential section, shows the prosenchymatous nature of the tracheids along with other characters specified under these plates. Figure 201 is a radial section showing a single row of pitted cells on the walls of the tracheid, and Figure 202 gives a radial section with two rays, and also shows a double row of pitted cells in the tracheids, a rare occurrence in *Callitris*. Figure 203 is a higher magnification of a portion of Figure 202, and the double rows of pitted cells are more plainly visible, whilst the parenchymatous nature of the whole of the ray cells is well depicted.

(*c*) Chemistry.

(*Vide* Chemistry of products of this wood, page 62.)

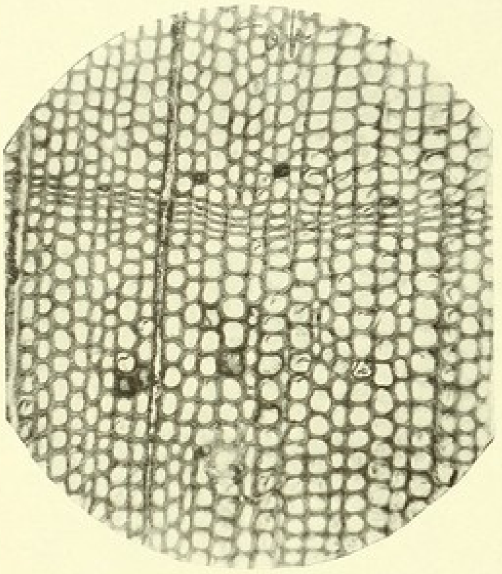


Figure 198.—Transverse section of timber. The narrow band of tracheids marks an autumnal growth. *C. Macleayana*, × 80.

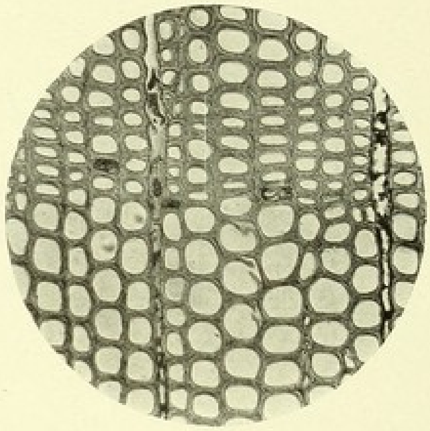


Figure 199.—Transverse section through timber. The narrow band of tracheids marks an autumnal growth. The manganese compound is only sparsely distributed in this timber. The upper half is the autumnal growth. *C. Macleayana*, × 100.

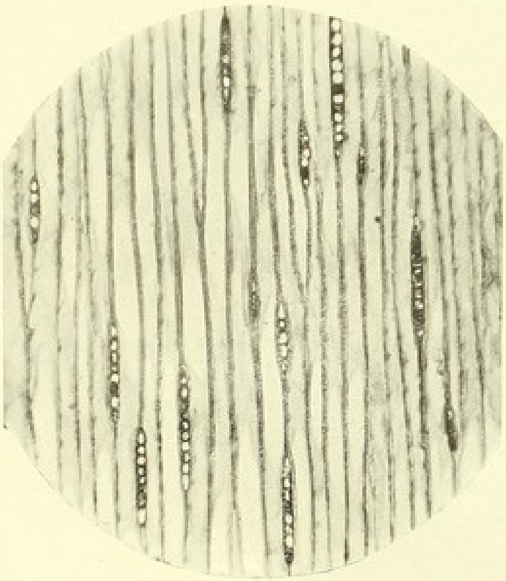


Figure 200.—Tangential section through timber of *C. Macleayana*, × 80.

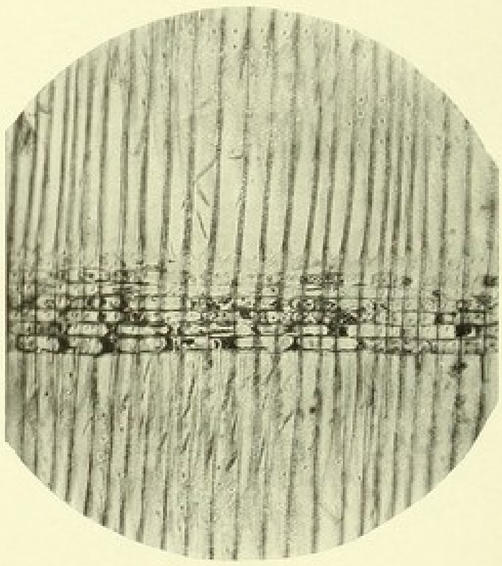


Figure 201.—Radial section through timber, showing a single ray across the field of vision. *C. Macleayana*, × 80.

Sections of timber of C. Macleayana, F.v.M.

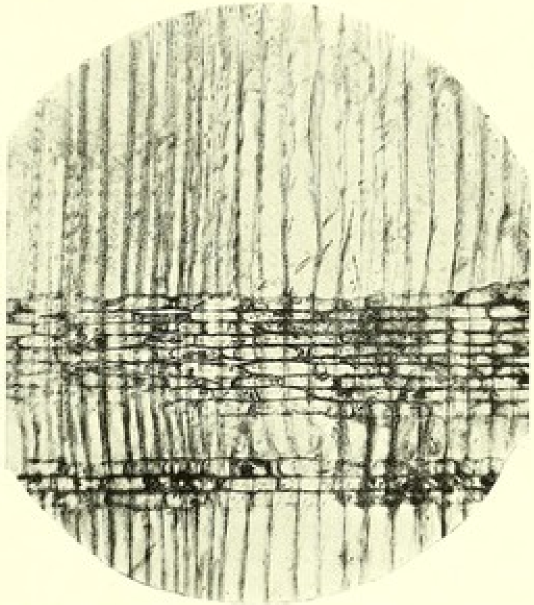


Figure 202.—Radial section of timber showing portions of two rays of different heights. The left tracheids are autumnal, and the right vernal, which in some instances show two rows of pitted cells. No other *Callitris* has this feature. *C. Macleayana*, × 80.

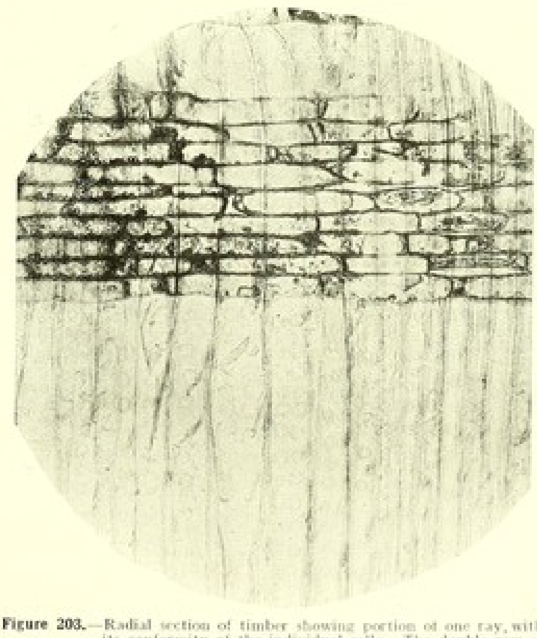


Figure 203.—Radial section of timber showing portion of one ray, with its conformity of the individual cells. The double row of bordered pits in the central tracheids is quite unusual amongst *Callitris*. *C. Macleayana*, × 110.

Sections of timber of C. Macleayana, F.v.M.

V. BARK.

Anatomy.

The characteristic feature is the predominance and concentric regularity of the bast fibres, the parenchymatous and sieve tubes being quite restricted. The bast fibres in a cross-section alter from a rhomboidal shape near the cambium to a square as they recede to the outer cortex as seen in Figure 204, which also shows some young desmogen cells in process of differentiation into young xylem tracheids below the cambium; these are succeeded by alternate rows of bast cells, sieve tubes, and parenchymatous cells filled with dark-brown manganese compound.

The outer bark consists almost entirely of a mass of fibre, and the indications for tannin gave such little promise that an analysis for tannin was not undertaken.

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18. Callitris sp.

Habitat—Mount Lindsay.

Remarks.

This species is suggested from material at Kew Herbarium, and labelled "*Callitris, sp.*, Mount Lindsay, New Holland, 1829, 186," and a note in pencil "*C. robusta*, var."

Its branchlets have the angular character of those of *C. calcarata*, whilst the fruit cones in outward appearance might easily be mistaken for those of *C. Muelleri*, but the central columella is the largest of any known species.

Such characters as these are, perhaps, hardly sufficient to warrant the making of a new species, but we make the reference so as to place on record our opinion on the matter.

Mount Lindsay is rather indefinite as regards locality, especially as no collector's name is given, and when full material is acquired its specific identity will be easily determined.

The name "*intermedia*" might be given it.

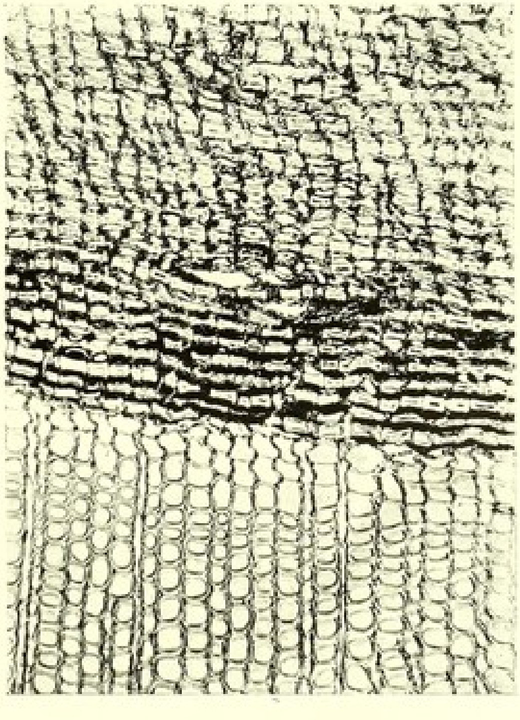

Figure 204.—Transverse section at junction of timber and bark, showing the cambium, in the neighbourhood of which the parenchymatous cells contain the manganeie compound, and forming a distinct line between the bast fibres. It also shows the gradual increase in size of the tracheids as they recede from the cambium in their early growth. *C. Macleayana*, × 100.

Actinostrobus pyramidalis, MIQ. WESTERN AUSTRALIA.

Nat. Size

THE GENUS ACTINOSTROBUS.

I. HISTORICAL.

Miquel founded this Genus in Lehmann's "Plantæ Preissianæ" in 1848, on a densely branched shrub occurring in Western Australia. Since then another species has been recorded, but both are endemic to that part of the Continent. Although closely allied to *Callitris*, yet its imbricate bracts on the cone scale as well as physical and other features, mark it as distinct from that genus.

II. SYSTEMATIC.

The leaves are homomorphic, in alternate ternary whorls of three, very short, thick, rigid, acute, and like those of *Callitris* are characterised by a concrescent or decurrent portion. Flowers monœcious. Male amenta oblong; microsporophylls in whorls of three, and in six vertical columns; microsporangia 2–4. Female amentum solitary, globular or acuminate; macrosporophylls imbricate in whorls of three, closely appressed, the innermost, bearing one or two macrosporangia at the base.

Fruit cones on the end of short, thick, woody stalks, the innermost thickened and subtended by closely appressed sterile scales. Seeds, three-winged, central column mostly present. *Vide* Lubbock's "Seedlings," Vol. II, p. 549 (1892), where it is stated this genus has three subulate cotyledons.

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1. Actinostrobus pyramidalis.

Miq. in Pl. Preiss. i. 644.

(Syn.:—*Callitris actinostrobus*, F.v.M., Rep. Burdek. Exp., 19.)

Habitat.

Western Australia, King George's Sound, Baxter to Swan River (Preiss), Murchison River (Oldfield).

I. HISTORICAL.

(*Vide supra.*)

II. SYSTEMATIC.

A shrub with fastigiate branches, having closely packed, glabrous, rigid branchlets. Leaves varying in size according to the age of the dependent branch, graduating from the acicular form of primordial leaf to a comparatively long decurrent one on the smaller uppermost branchlets, the free ends spreading.

Male amentum short, about 4 mm. long ; microsporangia orbicular, obtuse. Female amentum at first consists of a series of scales (five or six) in whorls of three each, all imbricate ; as these develop the two uppermost whorls of scales become sporophylls and by a process of adnation at the base form the cone, which is then composed of six equal, valvate valves, with one or two seeds at the base of each, and several imbricate scales on the back. The shape of the cone is rather inclined to elongation from a sphere, or say conical, measuring ½ inch in diameter ; the whole being permeated with oil cavities.

III. LEAVES.

(*a*) Economic.

(None known, except chemical constituents.)

(*b*) Anatomy.

A cross-section through the three decurrent leaves gives a distinctive outline from that obtained from a corresponding section in the *Callitris*, the dorsal surface is marked by a pronounced ridge, at the base of which are situated the stomata in longitudinal lines, the collateral ventral surfaces of the leaves only appearing in this case to be transpiratory at the very base of the ventral canal, so that there are no well-defined transpiratory and assimilatory surfaces. The epidermal cells are uniseriate, with rectangular or conical cavities, the hypodermal cells extending round each leaf to the base of the ventral canal of the collateral leaves, where the cuticle is marked by elongated processes as in *Callitris*. Here also the palisade parenchyma is much more closely packed than on the dorsal side, the material of the spongy tissue being particularly loosely distributed or attenuated, and connecting the former with the sparsely scattered parenchymatous cells, as well as the strengthening walls of the oil cavities. The central cylinder of bundles of the branchlet is surrounded by transfusion tissue more marked than in the *Callitris* ; each leaf has an individual bundle normally orientated, backed on the outer side witn parenchymatous endodermal cells. (Figures 205–206.)

(*c*) Chemistry of the Leaf Oil.

This material was received from the Government of Western Australia' and was distilled 6th July, 1903. It consisted of the leaves with terminal branchlets

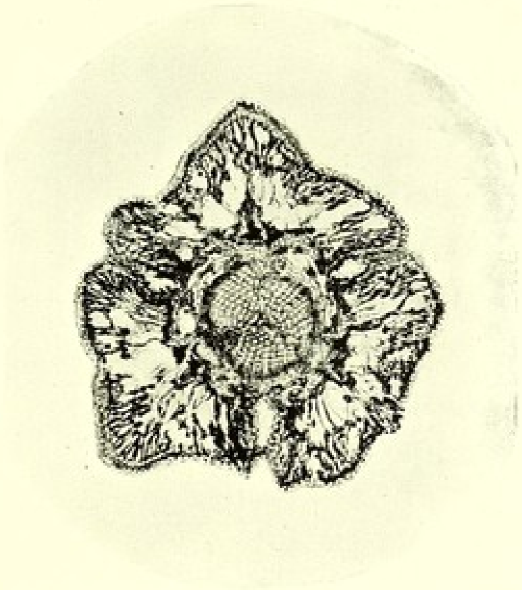

Figure 205.—Transverse section through branchlet and decurrent leaves. The black patches in the lower portions of the spongy mesophyll are manganese. *Actinostrobus pyramidalis*, × 50.

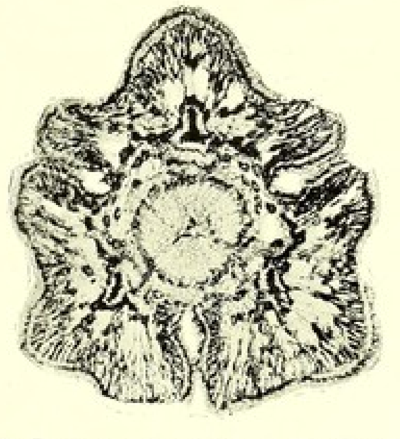

Figure 206.—Transverse section through branchlet with attached decurrent leaves, showing decurrent channels more distinctly than Figure 205. *A. pyramidalis*, × 70.

Transverse sections of branchlets and decurrent leaves, Actinostrobus pyramidalis, Miq.

only, and 207 lb. of these, when steam-distilled for six hours, gave 8½ oz. of oil, equal to 0·256 per cent.

The crude oil was of a light-amber colour, and had an odour only slightly resembling "pine-needle oils" generally, and a secondary one which was distinctly aromatic. It was soluble in 4 volumes of 90 per cent. alcohol. The principal constituent in the oil was dextro-rotatory pinene, and there appeared to be an entire absence of limonene, a fact which shows a distinctive difference between this genus and *Callitris*. No less than 87 per cent. of the total oil distilled below 170° C., and less than 2 per cent. came over between 170° and 200° C.

The ester was not completely identified because the small amount of material at our disposal did not permit of this being done, but the odour of the saponified oil was distinctly that of geraniol, and borneol was not indicated. The result with cold saponification also confirmed the presence of geranyl-acetate.

The specific gravity of the crude oil at 15° C. = 0·8726; rotation $a_D = +40·9°$; refractive index at 19° C. = 1·4736. The saponification number was 21·6, equal to 7·6 per cent. of ester, as geranyl-acetate. In the cold, with two hours' contact, the saponification number was 19·81, equal to 6·93 per cent. ester.

On redistilling, only a small amount came over below 154° C. Between 154° and 160°, 76 per cent. distilled; between 160° and 170°, 10 per cent. The thermometer then quickly rose to 215°, and only 2 per cent. had been obtained between 170° and 215°; between 215° and 230°, 8 per cent. distilled.

The specific gravity of the first fraction at 15° C. = 0·8616; of the second, 0·8621; of the fourth, 0·9140. The rotation of the first fraction, $a_D = +44·5°$, or a specific rotation $[a]_D + 51·64°$; of the second, $+42·9°$. The refractive index of the first fraction at 20° C. was 1·4724. The characteristic pinene reactions were obtained with the oil of the first fraction, thus showing it to be that terpene.

The saponification number of the fourth fraction was 127·4, equal to 44·7 per cent. ester. The saponified oil of this fraction had a marked geraniol odour, and when oxidised the odour of citral was readily obtained. There was no deposition of resin on the sides of the bottle on keeping, as often occurs with many of the oils of *Callitris*.

IV. TIMBER.

(*a*) Economic.

The timber being small, is of little economic value.

(*b*) Anatomy.

In a tangential section of the secondary wood (Figure 209) are conspicuously seen numerous instances of end-on views of the medullary rays, and the radial walls

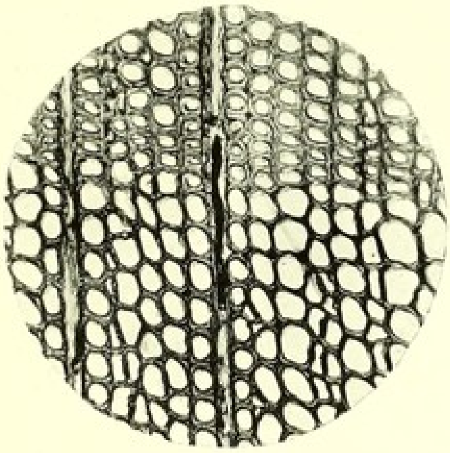

Figure 207.—Transverse section through timber. The trachrids with smaller lumina towards the top mark the autumn growth. Two rays are included running from top to bottom of picture, the centre one containing some manganese compound. *A. pyramidalis*. × 80.

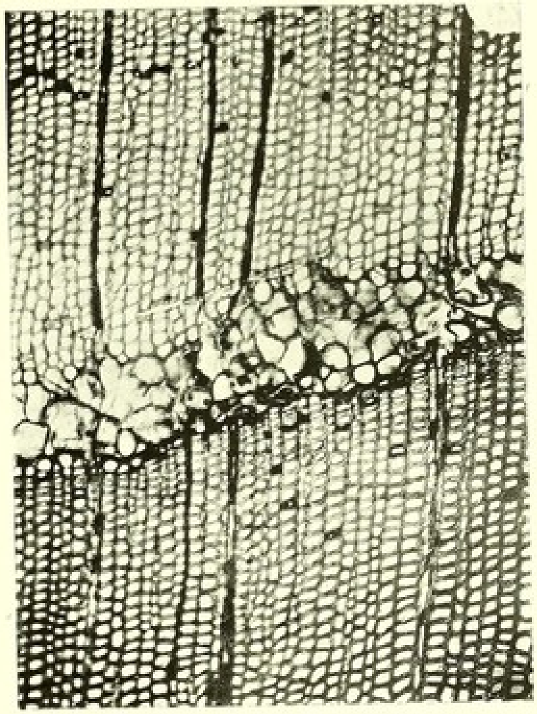

Figure 208—Transverse section through timber. Traumatic resin mass running obliquely through the centre. The rays are located by the black lines running from top to bottom, the colour being due to manganese compound. A small quantity of this substance is also seen amongst the tracheids. *A. pyramidalis*, × 100.

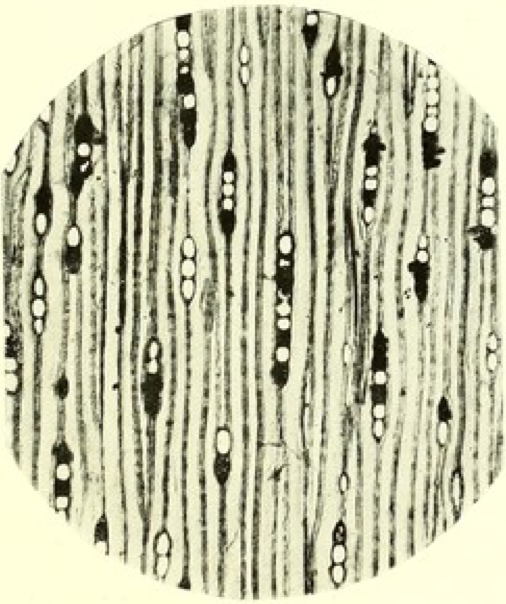

Figure 209.—Tangential section through timber. *A. pyramidalis*, × 120.

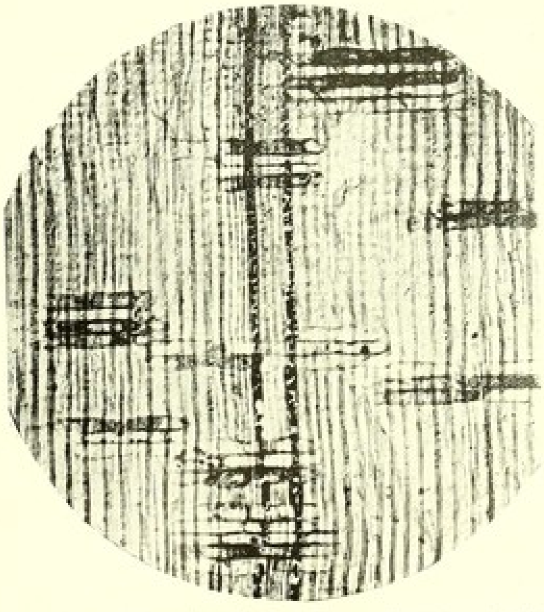

Figure 210—Radial section of timber. The parenchymatous character of the outer cells of the rays are distinctly seen in the lower medullary of the section. *A. pyramidalis*, × 100.

Sections of timber of Actinostrobus pyramidalis, Miq.

of the tracheids with pitted cells in section. The rays are fairly numerous, and scattered irregularly throughout the xylem; the cells which are parenchymatous being, perhaps, fewer in height than obtains in most species of the cognate genus *Callitris*, but resembling these in being only a cell in breadth, at the same time they are relatively wider. About 50 per cent. of the ray cells were found to be filled with the manganese compound. The radial walls of the tracheids appear to be covered almost entirely with bordered pits (Figure 210), a somewhat characteristic difference from *Callitris* species. A radial section taken also from the duramen, indicated in this species by a darker colour than the sapwood, also shows the rays to be fairly numerous, the simple pits of the rays varying in number from two to four in each lumen.

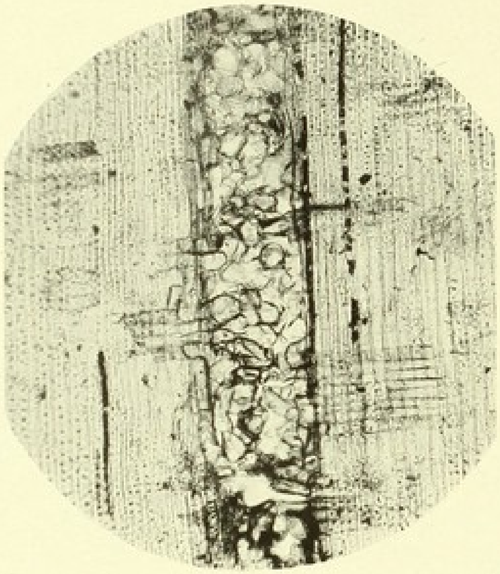

Figure 211.—Radial section through timber. Rays are only faintly indicated. A broad band of traumatic resin mass runs through the centre of the picture from top to bottom—a very rare occurrence in Australian Coniferæ. The black interrupted lines are the manganese compound in the tracheids, the walls of which are quite covered with bordered pits. *A. pyramidalis*, × 80.

Figures 208 and 211 show a transverse and longitudinal section respectively of a comparatively broad and what we regard as a traumatic resin reservoir.

It may be noted that only one pitted cell occupies the diameter of a tracheid, the walls of which are, as above stated, simply covered with them.

In the secondary xylem the cells containing the brown manganese compound are in peripheral zones, mostly close to the autumnal wood.

A transverse section shows the tracheid walls to be rather more irregular in shape than those of the *Callitris*. (Figures 207–208.)

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

Anatomically the bark presents a somewhat similar structure with that of the closely allied genus *Callitris*. The sclerenchymatous cells form concentric rings regularly alternating with three rows composed of one central

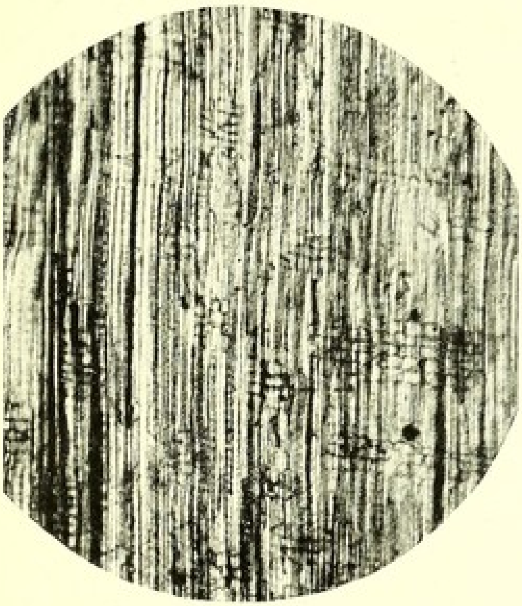

Figure 212.—Radial section through bark. Although a low magnification the sieve tubes with the accompanying sieve plates can fairly well be seen with the empty parencyhmatous vessels between each. *A. pyramidalis*, × 76.

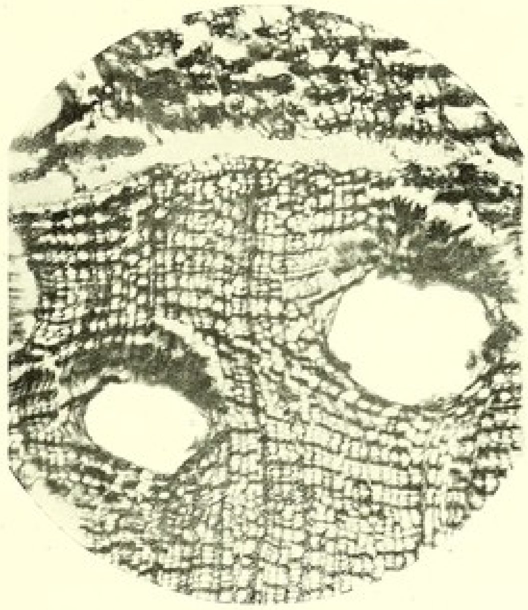

Figure 213.—Transverse section through the outer bark: two oleo-resin cavities are in the field of vision, the displacement of the contiguous cells showing the lysigenous channel of these. The broken parallel lines are the bast fibres, whilst the light streak across the picture is a periderme layer. *A. pyramidalis*, × 60.

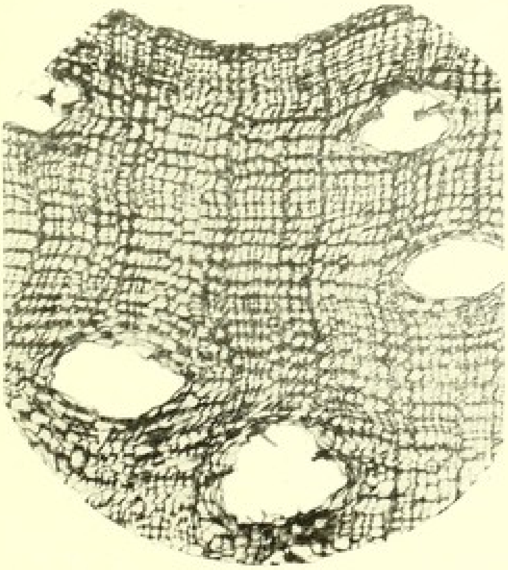

Figure 214.—Transverse section showing greater field of vision than Figure 213. *A. pyramidalis*, × 60.

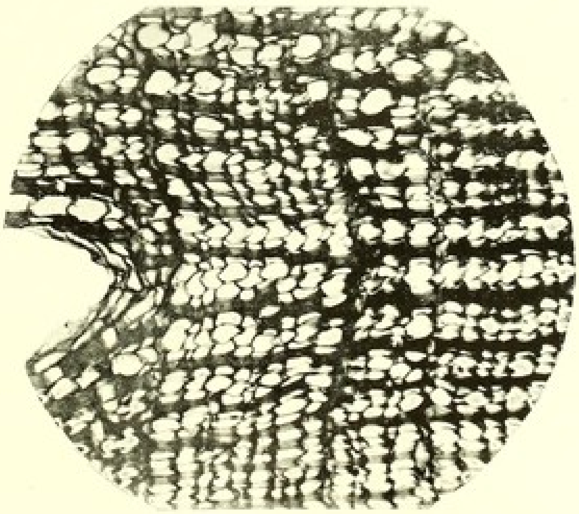

Figure 215.—A higher magnification of the inner bark than shown in Figure 213. The concentric bands of bast fibres run across the figure from left to right in dark lines. The lacuna on left of the picture is part of an oleo-resin cavity. *A. pyramidalis*, × 160.

Sections of bark of Actinostrobus pyramidalis, Miq.

parenchymatous ring between two of sieve tubes, and certainly very closely resembling in structure the bark of *Callitris propinqua*. (Figures 212–215.)

Sieve tubes with their accompanying plates are illustrated in Figure 212.

Oleo-resin cavities are very numerous throughout the whole bark substance. (Figures 213–215.)

In the primary cortex these cells are exceedingly numerous, and a freshly-cut section of the bark in this locality will soon be followed by numerous beads of resin, exposure to the sun of the newly-cut surface greatly facilitating the flow.

The beads seldom have a greater size than a small pea, nor does the resin flow in a stream. This is further evidence that they are resin cavities or cells and not ducts or canals. Upon a fresh cut other beads will exude, and so the process can be continued, but a continuous flow for a long period cannot be obtained.

(*c*) Chemistry.

Only a small amount of the resin of this tree was procured from the material received from Western Australia; it was collected at the junction of the wood and the bark, and was freshly exuded in small, orange-red, transparent beads.

It melted at a low temperature, and on heating gave an odour resembling somewhat that of shellac. Neither in appearance, nor in other characters, had it any resemblance to the sandarac resins of the *Callitris*. It was very readily soluble in alcohol to a yellowish-red solution, which became deep red on the addition of potash, and changing to yellow when treated with nitric acid.

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2. Actinostrobus acuminatus.

Parlat. Enum. Sem. Hort. Flor., 1862, 25 and DC. Prod., XVI, ii, 445.

Habitat.

Western Australia, between Moore and Murchison River, (Drummond).

SYSTEMATIC.

A rather smaller shrub than *A. pyramidalis*, but with similar branches and leaves, the specific difference being in the shape of—(1) the stamen which has a dorsal ridge and acuminating point, (2) the cone which has the " top contracted into a neck, and each valve terminating in a short spreading point." (Bentham.)

THE GENUS DISELMA.

I. HISTORICAL.

This genus was founded by Sir J. D. Hooker in his "Flora Tasmanica," I, p. 853, t. 98, in 1859. Bentham and Hooker, however, Gen. Pl. III, 426, 1880, place it under *Fitzroya*, a genus established by Sir Joseph D. Hooker in 1852 upon an evergreen tree—a native of Chili and Patagonia. As we have not been able to procure specimens of the latter for comparison we retain Hooker's original name for the same reason as *Callitris* is now the restricted name for Australian trees in opposition to *Widdingtonia* and *Tetraclinis*, of South and North Africa respectively, and so preferring in this case the original classification of Sir J. D. Hooker, until such time as the matter has been worked out on lines similar to those laid down in this research.

II. SYSTEMATIC.

The only Australian species recorded is endemic in Tasmania. It is an erect shrub with, as far as known, homomorphic, small, opposite, closely appressed leaves in alternating ternary whorls. Flowers diœcious. Male amentum terminal, ovoid or oblong; microsphorophylls opposite, in three or four pairs, filaments short, the terminal leaf expansive, triangular and coriaceous, bearing two sporangia; pollen cells globose. Female amentum solitary, terminal, the leaves passing abruptly into the scales of the cones, the two uppermost and opposite pairs forming the macrosporophylls, with erect sporangia at the base of the inner ones. Fruit cones small. Seeds, three-winged.

Diselma Archeri.

Hook. f., Fl. Tasm., I, 353, t. 98.

Habitat.

Tasmania—Western Coast Ranges, and Lake St. Clair.

I. HISTORICAL.

(*Vide supra.*)

II. SYSTEMATIC.

An erect, compact tree under 20 feet in height. Leaves exceedingly short, ½ line long, closely packed and imbricate, opposite, decussate or verticillate, obtuse,

keeled. Male amentum terminal, rarely axillary, erect, narrow, solitary, about the same diameter as the branchlets with their leaves. Female amentum globular, solitary, terminal under 2 lines long. Seeds, two or three-winged, under 1 line long.

Remarks.

This small Conifer was not noticed anywhere under 3,000 feet. It is fairly common in small gullies almost on the summit of Mount Read, near Williamsford, Tasmania. It grows to a height of 5 or 6 feet, and is very straggly in habit, being more or less entangled with other vegetation. (C. F. Laseron).

III. LEAVES.

Anatomy.

These leaves are attached by a comparatively broad rhomboidal base to the branchlet, and overlap each other in their phyllotaxy; consequently it was found more advantageous to take a cross section through one whole group of decussate leaves, and such a section is shown in Figure 216.

As in *Callitris* the adnate portions form one whole with the branchlet, which is medullated in several bundles, the whole surrounded by parenchymatous cells which are succeeded by the spongy tissue of the mesophyll which forms the bulk of the leaf substance in these parts. Here also is generally found an oil cavity surrounded by strengthening and secretory cells and subtended by a bundle.

The dorsal surface has one row of epidermal cells superimposed upon one, often two or three, hypodermal sclerenchymatous cells, but the palisade parenchyma is not at all pronounced or well defined.

The stomata are found on the lower dorsal and ventral surfaces, but always protected by the free portion of the subtending imbricate leaf.

The free portion of the leaf has epidermal and hypodermal cells only on the dorsal side, and has no oil cell but often a bundle trace, the rest of the leaf substance being composed of the usual two kinds of mesophyll, the inner surface carrying the stomata in this case.

The sections were of interest as they cut through leaves at various stages of growth, and so brought out the detail in each case.

Only a few transfusion cells were seen, and these were comparatively large, being reticulate and not unlike sieve-plates; they are coloured pale blue in the section. (Figure 216.) Most of the cells which make up the leaf-tissue are nucleated.

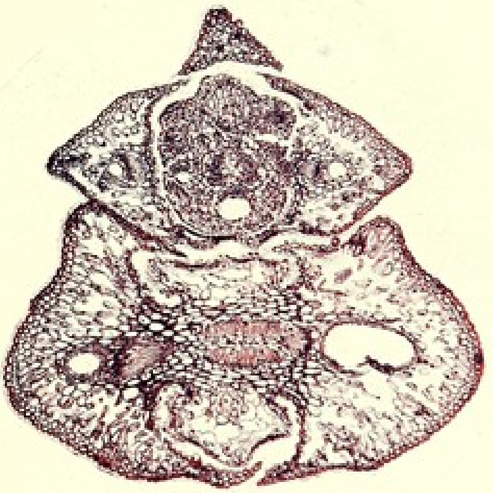

Figure 216.—Transverse section through a branchlet and two clusters of imbricate leaves. In the lower the central axis is seen to be oval in shape with its bundles composed of xylem (red) and narrow phloem (blue), the whole surrounded by endodermal cells which also run into the two adnate leaves—with an oil cavity in each. A bundle cut obliquely is seen on the inner side of the left oil cavity. The nucleated character of the cells is a feature of the leaves. The top half is a cluster of younger leaves. Stained with hæmatoxylin and safranin. *Diselma Archeri*, x 30.

THE GENUS MICROCACHRYS.

I. HISTORICAL.

A single species genus established by Sir Joseph Hooker in 1845 upon an endemic pine in Tasmania, and who gives a beautiful plate of it in his "Flora Tasmanica."

II. SYSTEMATIC.

It is a little shrub with small, decussate leaves. Flowers diœcious, the males in terminal spikes. Male amentum ovoid, microsphorophyll shortly stipitate, with an incurved scale-like connective. Pollen grains three-cornered or somewhat globose. Female amentum terminal, macrosphorangia spirally imbricate, with an incurved ovule to each, ultimately becoming succulent in the small ovoid fruit cone. Seeds nearly erect, three-sided, and not winged.

It has been confounded with the cognate genera, *Diselma*, *Pherosphæra*, and *Dacrydium*, owing to its various organs being identical with those of these genera; for instance, the leaves morphologically resemble those of *Diselma*, whilst the fruits or cones are not unlike those of the two latter genera.

It differs from *Podocarpus* mainly in the form of the pollen grains, the aggregate fruits, and the woody axis of the spike.

Microcachrys tetragona.

Hook. f. in Lond. Journ. Bot., vol. IV, p. 150 and Fl. Tas., p. 358, t. 100.

Habitat.

Summits of Western Mountain Range, Tasmania.

I. HISTORICAL.

(*Vide supra.*)

II. SYSTEMATIC.

A low rambling bush, with tough straggling fore-angled branches and branchlets so formed by the leaves. Leaves about $\frac{3}{4}$ line long, closely imbricate, ovate, rhomboid, obtuse, convex at the back. Male amentum terminal, solitary,

ovoid, of 20 to 30 triangular, scarious microsphorophylls. Female amentum also terminal, ovoid or globular, about 4-6 lines long, fleshy, bright red and translucent.

Remarks.

Sir Joseph D. Hooker states concerning this plant that:—" This is surely one of the most remarkable of Conifers, and is in other respects one of the most interesting, being extremely rare in its native country, and presenting the unique character in the order of bearing a fleshy brilliant-coloured cone. It is true that we have in the Yew, and in various species of *Podocarpus*, &c., fleshy, highly-coloured fruits, but a Conifer with the scales themselves of the young cones assuming a pulpy texture, semi-transparent consistence, and bright colour, is, as far as I know, unique in the Order; whether these characters persist in the ripe fruit I am unable to say."

THE GENUS ATHROTAXIS.

I. HISTORICAL.

This genus was established by D. Don in 1839. The orthography of the name has varied under different botanists, *Arthrotaxis* being used by some; the original spelling of Don is, however, retained here, being taken from ἀθρὀος,—crowded. The known species, numbering three, are small trees reaching a maximum height of 100 feet, and are all indigenous to Tasmania.

According to Masters some closely allied fossil forms have been recorded from the Upper Oolite, Solenhofen (Renault); also at Stonefield and Scarborough.

II. SYSTEMATIC.

Leaves small, homomorphic, decussate or in close spires, appressed or spreading. Male amentum terminal, catkin-like; microsporophylls spirally arranged, imbricate, shortly attached, scale or leaf-like expansion, oblong, sagittate and peltate, bearing two-celled sporangia; the pollen cells are globose or three-sided, with two or three bands. Female amentum is composed of spirally arranged imbricate macrosporophylls, bearing from three to six pendulous ovules.

Fruit cones terminal, sessile, small, globular, composed of woody scales wedge-shaped at the base, thickened upwards, dilated at the apex, below which is a dorsal point. Seeds few under each scale, ovate, compressed, with a transverse hilum and two longitudinal wings, the integument being crustaceous. The cotyledons number two.

The following are given as separate species, being generally so regarded, but as the differences are mostly in the size and disposition of the leaves, we are of opinion that they may be one species, the variability being perhaps due to environment and climatic conditions. The timbers are practically identical.

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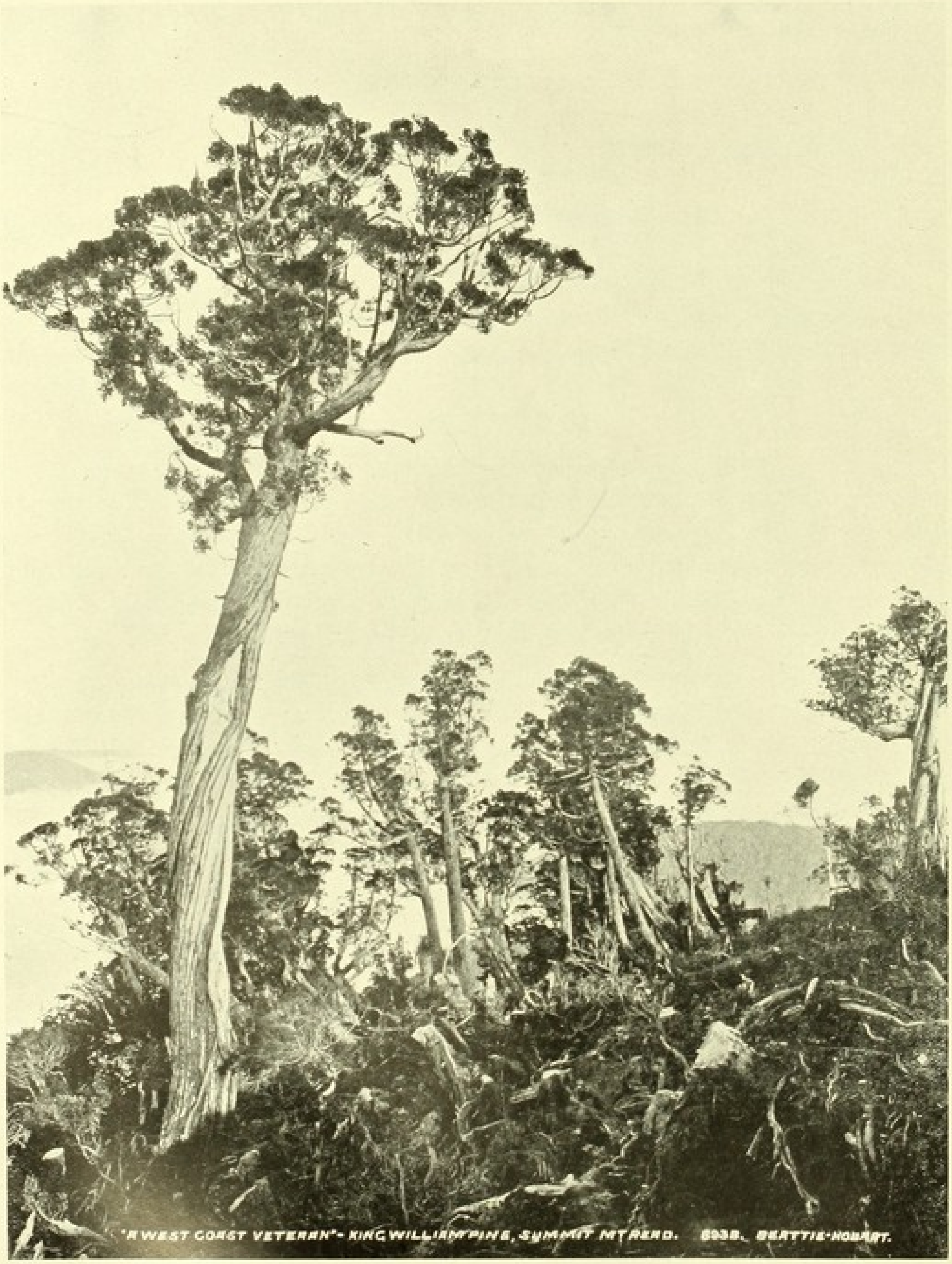
1. Athrotaxis selaginoides.

Don in Trans. Linn. Soc. XVIII, 172, t. 14; also figured in Hook. Ic. Pl. t. 574.

"KING WILLIAM PINE."

Habitat.

This tree is found in the neighbourhood of Williamsford, Tasmania.



Athrotaxis selaginoides, DON. "KING WILLIAM PINE," TASMANIA.

Nat. size.

Athrotaxis selaginoides, DON. "KING WILLIAM PINE," TASMANIA.

I. HISTORICAL.

(*Vide* above.)

II. SYSTEMATIC.

It is a larger tree than either of its congeners, and has loosely spreading, slightly imbricate leaves, measuring about 4 lines long. Cones about ¾ inch in diameter.

REMARKS.

This is a medium size tree, up to 100 feet high and 3 feet diameter, and is common in the immediate neighbourhood of Williamsford, Tasmania, about 1,000 feet above sea-level. It is a prominent member of the dense scrub which covers this locality, being associated with "Celery-top Pine," "Sassafras," "Myrtle," &c. It is not a handsome tree, having a small and irregular, though very dense, crown of branches, and generally unbranched for about three quarters of its height. The bark is slightly furrowed and fibrous, but not very rough.

The leaves of fallen trees keep green for upwards of eighteen months. A peculiar feature of the branches is the way the tops are bunched, each branch terminating in a dense crown of foliage.

The vertical range of this species is about 2,000 feet, as it occurs on the summit of Mount Read and other mountains, usually in a much dwarfed and stunted form. (C. F. Laseron.)

III. LEAVES.

(*a*) ECONOMIC (*vide* Chemistry).

(*b*) ANATOMY.

In the transverse sections of the leaves given here (Figures 217 to 223), and taken from various parts of the tree, a good idea of the general form of the leaf can be obtained, as they show that the leaf varies in shape in different parts of its length, being mostly two-sided with convex dorsal and concave ventral surfaces, and from these illustrations can be traced the structure throughout the whole leaf material.

The main feature in the substance of the leaf is the large proportion of the spongy parenchyma of the mesophyll, and the comparatively small amount of palisade layers in some of the sections; the disposition of each leaf conforming to the general law in leaf life, *i.e.*—the sclerenchymatous cells and palisade parenchyma being far more strongly developed towards the assimilating surface than on the transpiratory side, and this feature whilst traceable in lower magnifications (Figures 217 and 218) is more distinctly seen in the higher ones, such as Figures 223–225.

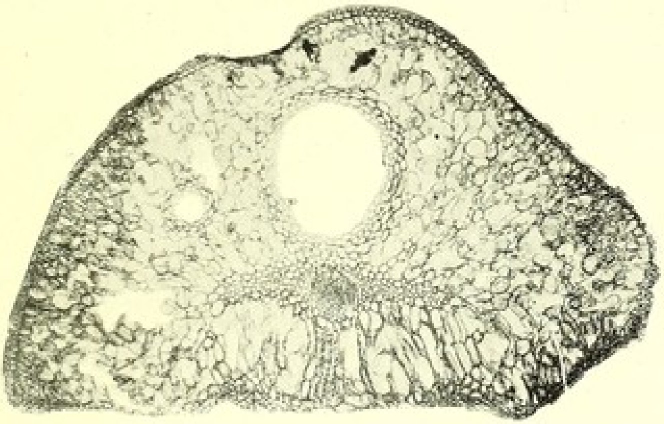


Figure 217.—Transverse section of leaf through attached portion to branchlet. One comparatively large and one small oil cavity are sectioned. Below the larger cavity is the leaf bundle, with its lateral transfusion tissue and endodermal cells. *Athrotaxis selaginoides*, × 30.

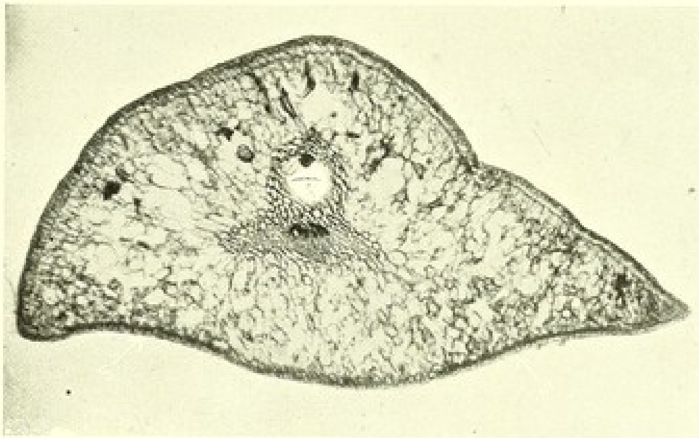


Figure 218.—Transverse section through free portion of leaf. Assimilatory or inner surface denoted by letter S. *A. selaginoides*, × 30.

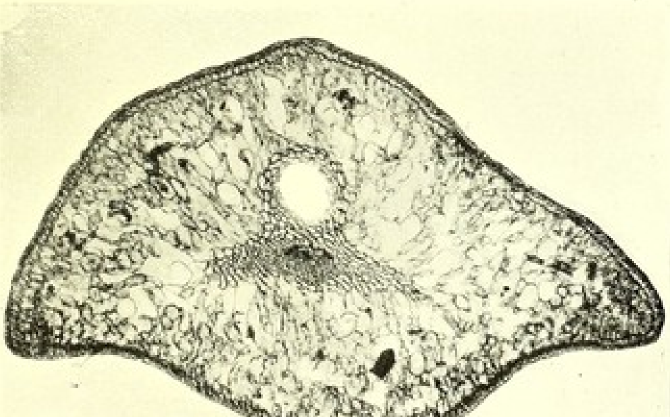


Figure 219.—Similar to Figure 218. Among the dorsal spongy mesophyll are some sclerenchymatous cells cut longitudinally. *A selaginoides*, × 30.

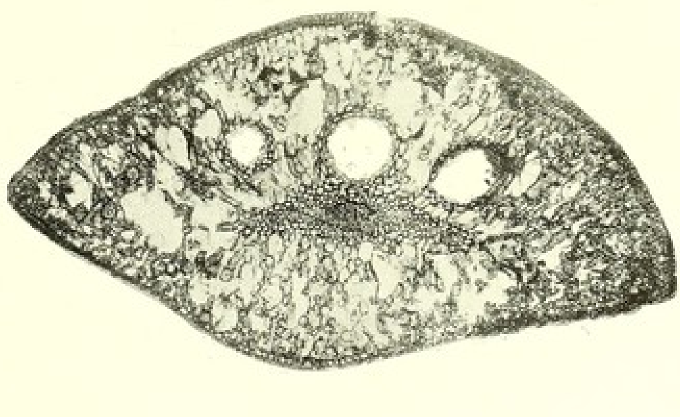


Figure 220.—Transverse section through leaf showing three oil cavities between the dorsal or assimilatory surface and the bundle with its accompanying laterally-extending transfusion tissue. *A. selaginoides*, × 30.

Sections of leaves of Athrotaxis selaginoides, Don.

The walls of the mesophyll are not plicate. All systematists of the genus have described the leaves as incurved, and the reason is now advanced for this incurving to the presence of the stomata on the inner (upper) surface, which occupy the two slightly concave longitudinal portions of that part, and the protection of such from adverse climatic conditions—the two transpiratory areas being separated by the umbo of the dorsal surface over the central vascular bundle. The guard cells are exceedingly small, and only detected by a high-power objective.

Both epidermal and hypodermal cells, mostly in single rows except at the edges, characterise the sub-cuticle substance where stomata do not occur, whilst at the angle formed by the dorsal and ventral surfaces the hypodermal cells are found to be more numerously packed (Figures 223 and 224), although a few secondary isolated ones are occasionally found on the inner sides of the hypodermal chain of cells (Figures 223 and 224), and much resembling these cells in structure are found stone cells scattered throughout the mesophyll as shown in Figures 223, 224, and 225. Bertrand classifies similar bodies occurring in *Araucaria Cunninghamii* as " fibres hypodermic."

The meristele is elliptical, with an unbranched fibro-vascular bundle which is surrounded with a fairly regular single or double row of parenchymatous endodermal cells which, occasionally, encloses an oil cavity as in Figure 225; they include not only the bundle but also some transfusion tissue composed of reticulate cells.

The unbranched vascular bundle has a normally orientated phloem which generally has an oil cavity between it and the assimilating surface, probably to serve as an auxiliary protection to the protoxylem.

The oil vessels are not ducts or canals but cavities, as the various sections show no continuity of channel, and these bodies occur, except in the above instance, irregularly in the leaf substance, *vide* Figures 217–225, and are surrounded by well defined yet thinner-walled stereome cells than those of the endodermis.

Reticulated cells extending laterally from the central bundle compose the transfusion tissue (Figures 218, 219, 225), which latter also has in its neighbourhood a few sclerenchymatous cells in the lower left portions of the section, and these features can also be traced in nearly all the other plates given of this species.

(*c*) Chemistry of the Leaf Oil.

This material, collected at Williamsford, Tasmania, was distilled on the 28th July, 1908. The leaves with terminal branchlets were used, and the distillations were continued for six hours, but the yield of oil was very small, and 538 lb. of terminal branchlets gave only 6½ oz. of oil, equal to 0·076 per cent.

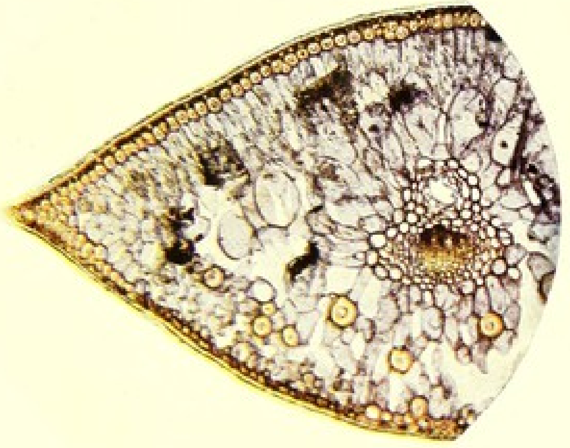


Figure 224.—A cross section taken through a little more than half a leaf, the top being the dorsal surface, where it can be seen the hypodermal cells are a distinct feature, and which are packed at the edge of the leaf. In the transpiratory surface (lower portion) they are quite wanting, but a few large ones can be detected scattered in the lower spongy parenchyma. The palisade layers, whilst a feature of the assimilatory surface, do not occur on the ventral side. The median bundle is normally orientated, the phloem staining a darker colour than the xylem. The endodermal cells surround an oil cavity as well as the bundle. Stained with hæmatoxylin and safranin. *Athrotaxis selaginoides*, × 62.

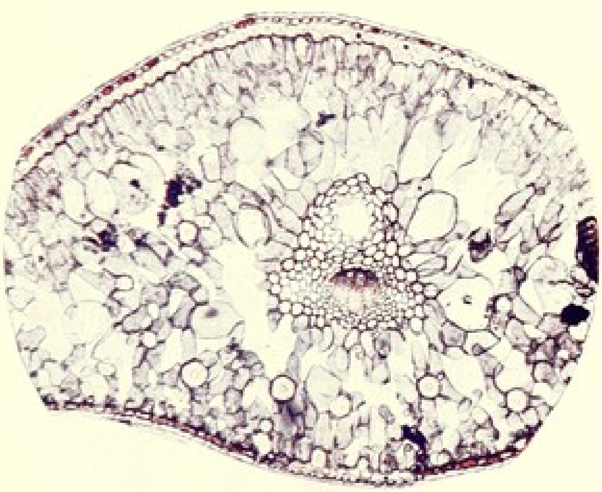


Figure 225.—A cross section through the median area of a leaf, showing in this part of the foliar structure the characters and organs as detailed above in Fig. 224. The endodermal cells, as well as the phloem and xylem of the central bundle, are very clearly defined. Stained with hæmatoxylin and safranin *Athrotaxis selaginoides*, × 60.

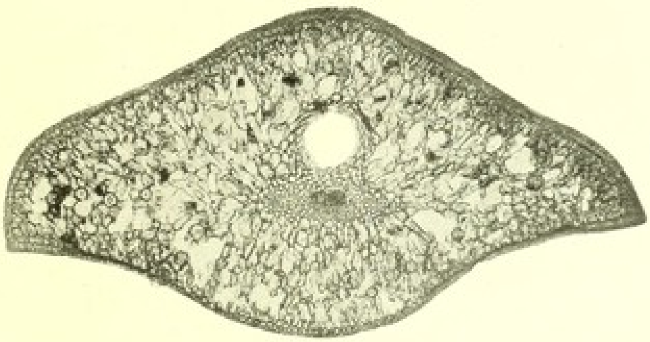


Figure 221.—Transverse section through a leaf. The concave areas mark the transpiratory or the inner surface of the leaves. *A. selaginoides*, × 30.

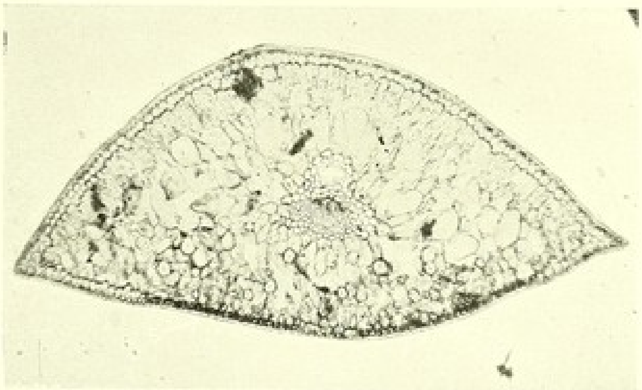


Figure 222.—Similar to Figure 221, but cut nearer the apex. Transpiratory area marked by letter S. In the ventral mesophyll are seen some stone cells cut transversely. The endodermal cells are clearly seen surrounding the bundle and oil cavity. *A. selaginoides*, × 40.

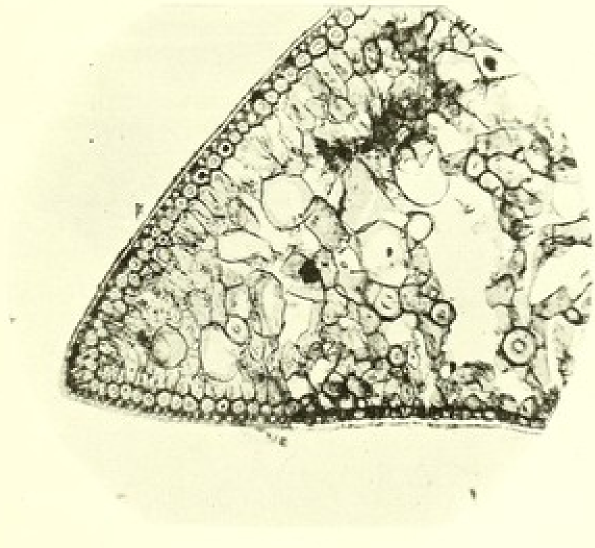


Figure 223.—Transverse section through the edge of a leaf. A portion of the transpiratory surface extends half across the bottom edge. The transpiratory surface extends around the edge and onwards, and is backed by a regular row of hypodermal cells. Cross sections of sclerenchymatous cells are seen amongst the spongy mesophyll. *A. selaginoides*, × 75.

Sections of leaves of Athrotaxis selaginoides, Don.

The crude oil was of a light amber colour, was somewhat mobile, and had a secondary lemon-like odour not well defined. The oil was a terpene one, and consisted very largely of dextro-rotatory limonene, which had the very high specific rotation $[\alpha]_D = + 112 \cdot 2°$. The oil was somewhat insoluble in alcohol, but it formed a clear solution with absolute alcohol in all proportions. Pinene was probably present, but in traces only. A small amount of an ester was found, but sufficient material was not available to enable either the alcohol or the acid to be identified.

The oil contained a fair amount of a constituent boiling above 270° C.—evidently a sesquiterpene or similar body. The reactions for cadinene were not satisfactorily obtained, although some of the results would seem to indicate the presence of that sesquiterpene.

The specific gravity of the crude oil at $\frac{16°}{15}$ C. = 0·8765; rotation $\alpha_D = + 74 \cdot 8°$; the refractive index at 16° C. = 1·4905. The saponification number for the esters was 8·6, equal to 3 per cent. of ester as bornyl-acetate.

Only a small quantity of the oil could be spared for analysis, but this on redistillation gave a very small amount boiling below 174° C. Between 174° and 177° C., 47 per cent. distilled; between 177° and 200°, 23 per cent. distilled; the temperature then quickly rose to 275°, and between that and 295° C. 12 per cent. distilled.

The specific gravity of the first fraction at $\frac{18°}{15}$ C. = 0·8446; of the second, = 0·8494; of the third, 0·9373. The rotation of the first fraction, $\alpha_D = + 90 \cdot 2°$; of the second, $+ 91 \cdot 8°$; of the third, $+ 29 \cdot 6°$.

On again distilling the first two fractions, 28 per cent. of the total oil came over between 174–175° C., and 18 per cent. between 175–176° C. (cor.). The specific gravity of the first fraction at 19° C. = 0·8427; and of the second, 0·8425.

The rotation of the first fraction $\alpha_D = + 91 \cdot 4°$, or specific rotation $[\alpha]_D = + 108 \cdot 5°$; of the second, $+ 94 \cdot 5°$, or specific rotation $[\alpha]_D = + 112 \cdot 2°$. The refractive index of the first fraction at 20° C. = 1·4783; of the second, 1·4785.

The tetrabromide was readily prepared with both fractions, and this melted at 104° C.

From the above it is ev.dent that the larger portion of the lower boiling constituents of the oil of this tree is dextro-rotatory limonene. Dipentene does not occur. From the slightly less rotation and boiling point of the first fraction, it is probable that a small amount of pinene was present, but it can only occur in traces. A trace of the sesquiterpene evidently still remained with the oil, as indicated by the refractive index, although the results, taken as a whole, are very close to those required for pure limonene. The specific rotations of the limonenes are usually stated to be 105° to 106°, yet, besides the limonene in this oil, others

with higher specific rotations have been isolated, and Kraemer (Amer. Chem. Journ., 17, 692) records a freshly distilled limonene which had a specific rotation 121·3°.

A small amount of a phenolic body was isolated from the higher boiling portion of the oil, and this gave strong indications for carvacrol, but it could not be separated in sufficient quantity to determine it with accuracy.

IV. TIMBER.

(*a*) Economic.

The wood when freshly cut is pale reddish in colour, but becomes lighter on exposure. It is open and straight in the grain, light in weight, easy to work, and is not unlike the American "Redwood" (*Sequoia sempervirens*), both in general characters and texture.

It is in good repute for durability in Tasmania and is suitable for cabinet work, coachbuilding, and many other purposes, and possesses far more toughness and strength than its lightness would lead one to suppose. It is, according to A. O. Green, used for making sculls and oars.

Transverse Tests of Timber, *Athrotaxis selaginoides*.

(Standard size, 38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 2·96; D 2·96	B 3·00; D 3·00	B 2·95; D 2·98
Area of cross section, square inches	8·76	9·00	8·79
Breaking load, lb. per square inch	2,620	2,580	3,000
Modulus of rupture in lb. per square inch ...	5,458	5,160	6,230
,, elasticity ,, ,, ...	810,000	822,857	845,217
Rate of load in lb. per minute	238	215	375

(*b*) Anatomy.

The characteristic feature in this direction for this Conifer is the almost entire absence of the manganese compound in any of the tracheids that go to make up the wood substance, and in a radial section the medullary cells are seen to be quite devoid of such product, and it is only now and again that a trace is found in a lumen of the xylem, as in Figure 227.

The pitted cells are almost rudimentary and not easily detected, while the simple pits of the medullary rays are both numerous and well defined, there being generally two or three between the rays and the tracheids. The autumn tracheids have very narrow lumina, and only a few cells wide in the circle (Figures 226–228).

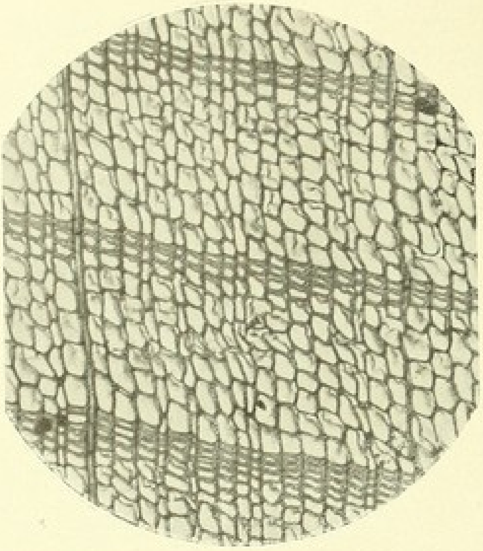


Figure 226.—Transverse section showing positions of annular rings, the autumnal tracheids being more closely packed. *A. selaginoides*, × 100.

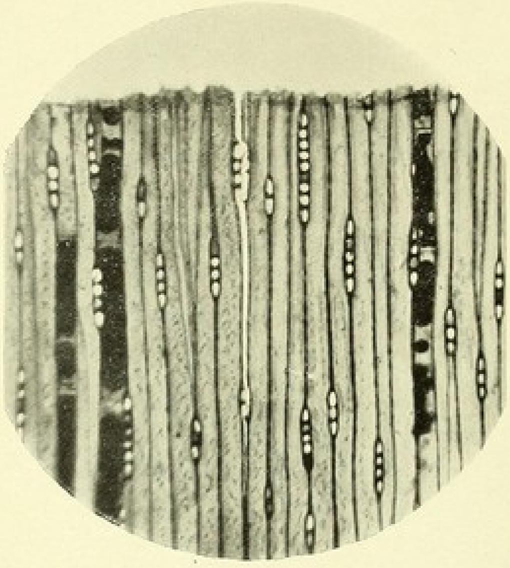


Figure 227.—Tangential section through timber. Bordered pits can just faintly be seen on the tangential walls of the tracheids. The three broad dark bands are manganese compound in the tracheids. *A. selaginoides*, × 90.

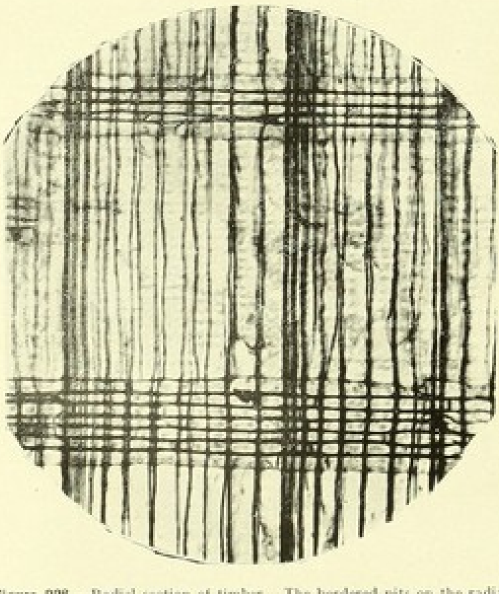


Figure 228.—Radial section of timber. The bordered pits on the radial walls of the tracheids and the simple pits of the rays are traceable. Two complete annular rings are sectioned, *A. selaginoides*, × 100.

Sections of timber of Athrotaxis selaginoides, Don.

2. Athrotaxis cupressoides.

Don in Trans. Linn. Soc. XVIII, 173 t. 13, f. 2; also figured in Hooker's Ic. Pl., t. 559.

"PINE."

HABITAT.

Western Ranges and Lake St. Clair, Tasmania.

SYSTEMATIC.

A small tree with an erect habit and having fastigiate branches, and a height about 50 feet. Leaves closely appressed to the stem and obtuse, and measuring 1 to 2 lines in length, thick and keeled. Fruit cones ½ inch diameter, spherical, scales with the usual point produced from the original free end of the sporophyll.

TIMBER.

Similar in character and texture to that of *A. selaginoides*, which is fully described under that species.

---

3. Athrotaxis laxifolia.

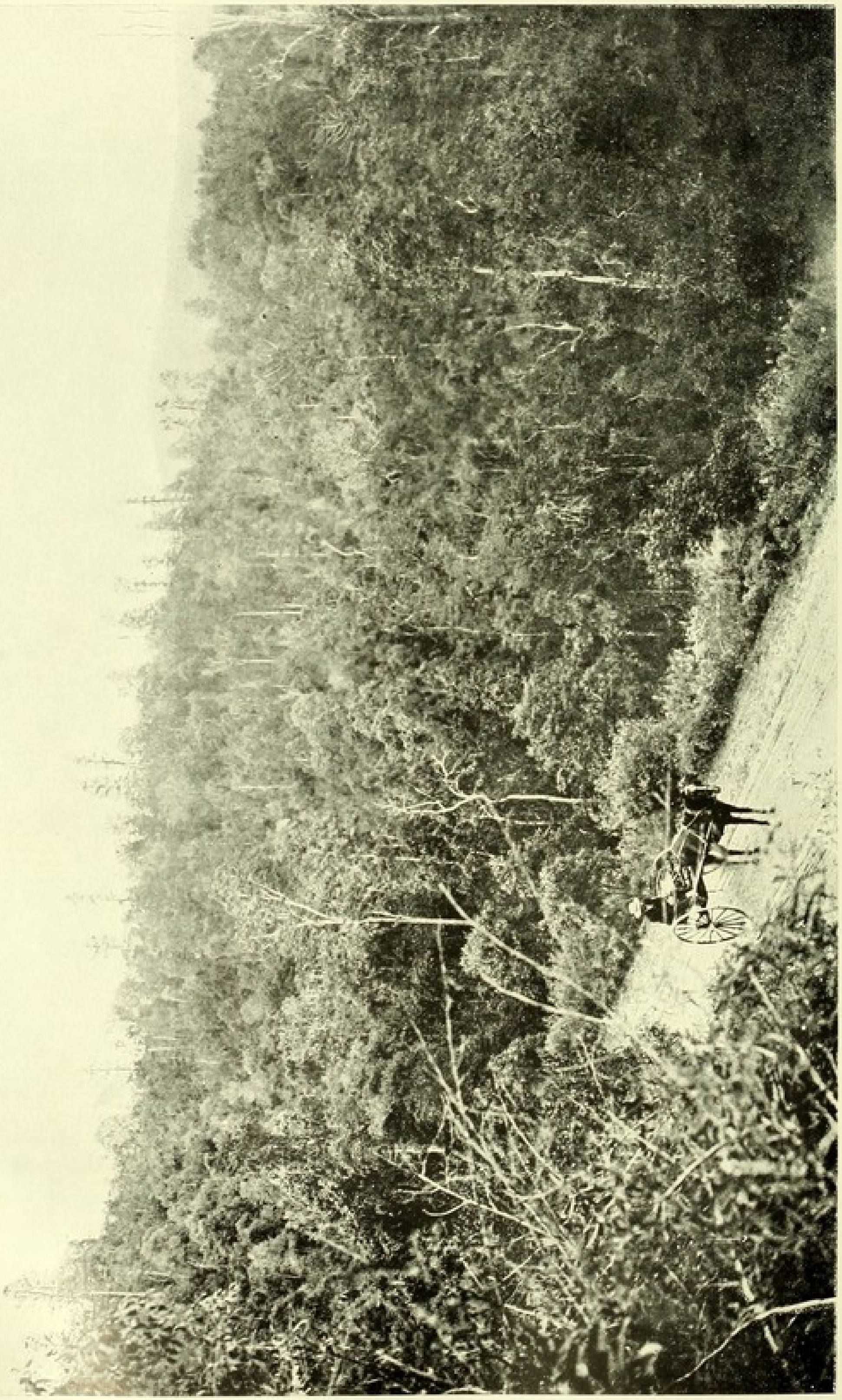
Hook., Ic. Pl., t. 573.

HABITAT.

Western Mountain Summits, Tasmania.

SYSTEMATIC.

A rather smaller tree than *A. cupressoides*, but with the general facies of that species, the main difference being the looser, acute, less appressed leaves, and a slightly larger cone.



Frank H. Taylor, Photo.

Araucaria Cunninghamii, Ait. Growing on the Ranges at Sandilands, North Coast, N.S.W.

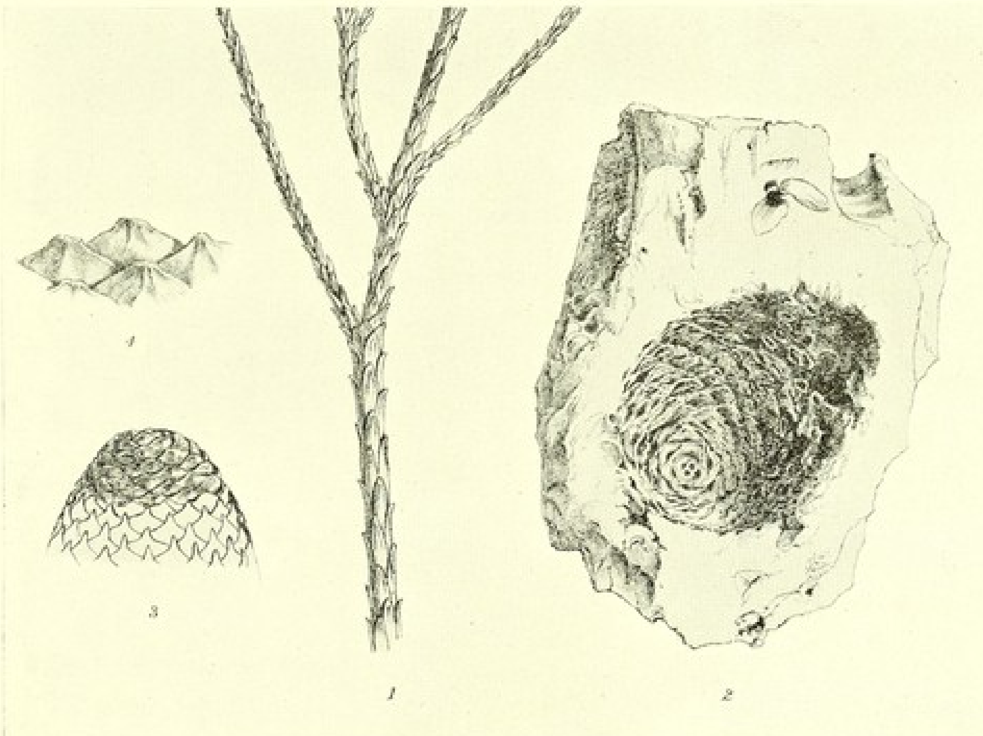
THE GENUS ARAUCARIA.

A. L. de Jussieu, Gen. Plant. 413 (1789).

I. HISTORICAL.

This genus was established by Jussieu in 1789, and its original name has found general acceptance with systematists from that time.

It has a fairly extensive geographical range, extending as it does over extra-tropical and subtropical South America, the South Sea Islands, New Zealand, and North-eastern Australia, from which latter locality only two species have been recorded.



Fossil Araucaria, A. Johnstonii, F.v.M.
[Rep. Min. Surv. and Reg. Victoria, 1879.]

Close connection with existing trees has been established by fossil forms occurring in Australia in the Pliocene period, as recorded by Baron von Mueller in Rep. Mining Surv. and Registrars, September, 1879, under the name of *A.*

Johnstonii; and according to Masters in the Carboniferous, Oolitic, and Miocene times; also in the Tertiary of the Arctic regions, in the English Eocene, and American Cretaceous (Nicholson and Lydekker, Man. Pal. II, 1533.)

The alternate rows of pitted cells on the walls of the tracheids of the fossil and living timber indicate a phylogenetic relationship between the species past and present of this genus, and perhaps *Agathis*; for these two genera—*Araucaria* and *Agathis*—appear to be closely allied by certain affinities, such as anatomical structures of the timber, chemical constituents of their various parts, deciduous cone scales, and integumented seeds, whilst both are probably of comparatively recent geological age.

II. SYSTEMATIC.

The two Australian species are large characteristic trees of the Northern Coast brushes, and have distinct forms of leaves. Flowers diœcious, terminal. Male amenta, catkin-like, solitary or in bundles. Microsporophylls numerous, spirally imbricate, contracted at the base, having a lanceolate connective from which are suspended the microsporangia in two rows.

The macrosporophylls are spirally placed in a continuous series with the leaves, containing a single pendulous macrosporangium.

The fruit cones vary in size, are ovoid in shape in the Australian species, with numerous closely-packed scales, having (1) a thickened and hardened apex, with winged margins at the base, and (2) the dorsal spur well developed (*vide* article under origin of this feature in the *Callitris*).

The seed is similar in shape to the almond nut, and has a free apex. The germination of the seeds of *A. Bidwilli* has been described by Heckel in Compt. Rend., Dec. 7, 1891.

Under the two Australian species are respectively described (*infra*) the foliation, phyllotaxy, histology, and movements of leaves.

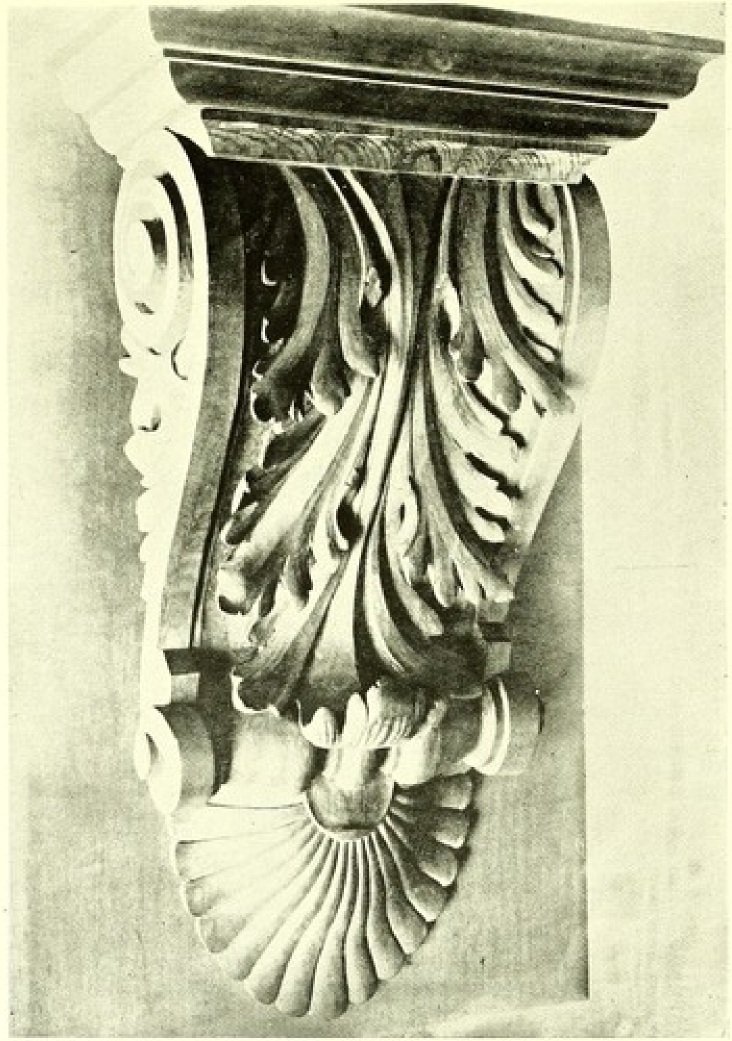
IV. TIMBERS (Forestry).

As timber trees, too much cannot be said concerning their value, for one desideratum of our local builders is softwoods, and as these trees are endemic and flourish abundantly, every effort should be made to at once carry out extensive replanting of the denuded areas where these pines once flourished.

In Queensland, *A. Bidwilli* is still standing in some quantity awaiting the saw-miller, but in New South Wales, *A. Cunninghamii* is almost a tree of the past.

Frank H. Taylor, Photo.

Araucaria Cunninghamii. CULT. BOTANIC GARDENS, SYDNEY.



Frank H. Taylor, Photo.

CARVED BRACKET OF "HOOP PINE," *Araucaria Cunninghamii.*

Mr. Jasper Morgan of New Italy, writing on the "Moreton Bay Pine," *Araucaria Cunninghamii*, states:—"I am informed that forty years ago the ridges on the Lower Richmond were covered with what appeared to be an inexhaustible supply of this variety. A saw-mill to cut up the pine was started at Lismore about 1856; followed by several others at different parts of the river, with the result that untold millions of feet were used or shipped away since that time; while in addition great quantities were destroyed in clearing the ground. Specimens were often cut, which girthed 22 or 23 feet. As a natural consequence, at the present time, this pine is rapidly becoming a tree of the past on the Lower Richmond. This timber is now procured from the Big Scrub, being brought into Lismore by rail and rafting it down the river. This shows the scarcity of the timber in this part. But on the ranges at the head of the Richmond, miles above Casino, there is a vast supply, which one would think inexhaustible. Looking, however, at the way it has disappeared on the Lower Richmond, it appears to be only a matter of time for these forests of pine to disappear also."

Dr. Schlich, in a recent able paper read before the Imperial Institute, has shown how the pine-timber supplies of the world are reaching a visible termination.

A warning note such as this should be sufficient to induce, not merely this State, but the whole of Australia, to now take up the question of pine conservation, for it seems certain that Hoop Pine, Brown Pine, Bunya Bunya, Port Macquarie Pine, White Pine, and Queensland Kauri, properly grown in close plantation (and this is a very important and imperative proviso), would soon supply the greater part of any future demand for pine wood. At present we have the pick of the pine forests of the world at prices so low that they cannot last long. Locally there is a certain market for our Colonial pine woods, as our light timbers are excellent substitutes for American and Baltic timbers, whilst the white-ant-resisting qualities of our interior species of *Callitris* will always enhance the value of that timber above others for house-building, &c., in certain parts of Australia.

It has been computed that nine-tenths of all the wood used in the world is pine, or wood of that class.

1. Araucaria Cunninghamii.

Ait. in Sweet, Hort. Brit. 475.

"HOOP," "COLONIAL," OR "MORETON BAY PINE."

Habitat.

North Coast District, New South Wales, and Southern Coast District, Queensland.

Frank H. Taylor, Photo.

Araucaria Cunninghamii, Ait. "Hoop Pine," Sandilands Range, N.S.W.
Centre tree, height 150 ft., girth 12 ft. 6 in.

II. SYSTEMATIC.

This is one of the largest of Australian pines, attaining sometimes a height of 200 feet. The bark is characteristic, having the appearance of horizontal bands (hence the name Hoop Pine), and is hard, compact, and permeated with oleo-resin cells. Leaves are dimorphic, being crowded, spirally arranged, imbricate, incurved, 3 to 4 lines long, ribbed, pungent pointed, in one case, and on the lower branches spreading, straight, vertical, decurrent, and sometimes over an inch long. Male amentum sessile, cylindrical, compact, 2 to 3 inches long, about 4 lines in diameter; the scale-like apices of the stamens are ovate-rhomboidal and acute.

Fruit cones ovoid, about 4 inches long and 3 inches in diameter, the scales broadly cuneate, the original sporophyll apex developing into a recurved, rigid, acute point.

III. LEAVES.

(*a*) ECONOMIC (none appears to be known).

(*b*) ANATOMY.

These are of a dimorphic character, both forms of leaves being inserted on the branchlets in a spiral arrangement.

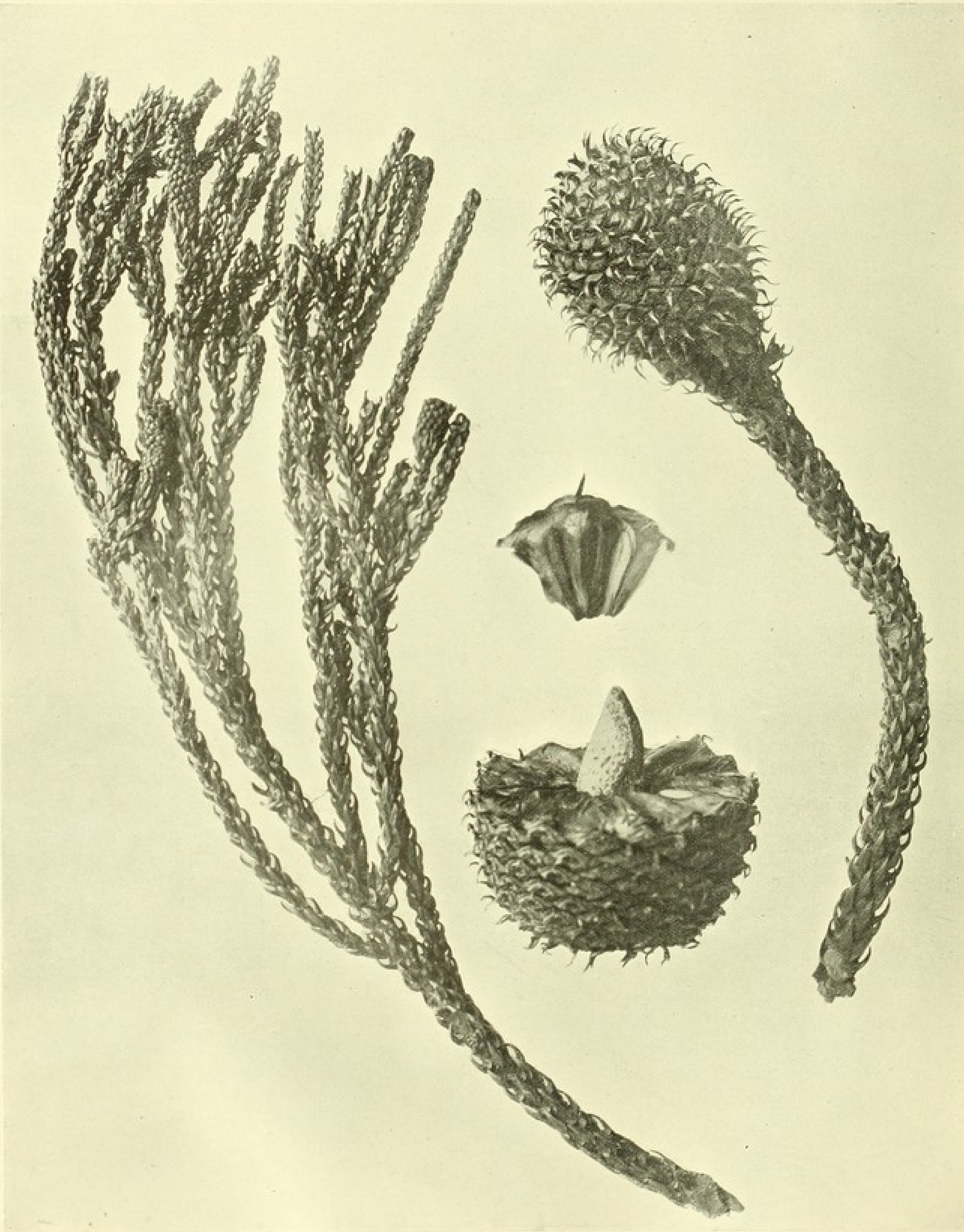
The vertically flattened form of leaf is generally found on branchlets growing from the main stem, and in the shade of the whole tree foliage. It is spreading, slightly oblique, pungent pointed, and gradually widening all the way to the base, which is attached vertically to the branchlet, slightly decurrent, and measures under an inch long. Most probably the disposition of this leaf accounts for its morphological difference from the normal one.

A cross section (Figure 229), which is rhomboidal in shape with the two shorter sides on the upper surface, shows perhaps a greater uniformity of leaf structure than holds in the *Callitris*, for a single row of epidermal cells extends around the whole, and these are subtended by a single row of hypodermal cells, which in turn are superimposed upon a single layer of palisade parenchyma, which cells perhaps are more numerous towards the upper surface. The fundamental tissue—the spongy mesophyll, forms a very large proportion of the leaf substance, and is composed of exceedingly thin-walled, elongated, irregularly-shaped cells, much differentiated from the palisade parenchyma and very little resembling the spongy tissue of ordinary mesophyll.

There is only one bundle, which is normally orientated, and situated in the centre of the leaf substance, with a protective sheath of endodermal parenchymatous cells. A few sclerenchymatous fibres are found on the outer edge of the phloem (Figure 230).

Frank H. Taylor, Photo. Nat. size.

Araucaria Cunninghamii, AIT. PRIMORDIAL OR ABNORMAL LEAVES.



Frank H. Taylor, Photo. *Araucaria Cunninghamii*, AIT. Nat. Size.

1. MALE AMENTA TO THE LEFT. 2. FEMALE AMENTUM TO THE RIGHT. 3. LOWER HALF RIPE CONE. 4. SCALE WITH SEED.

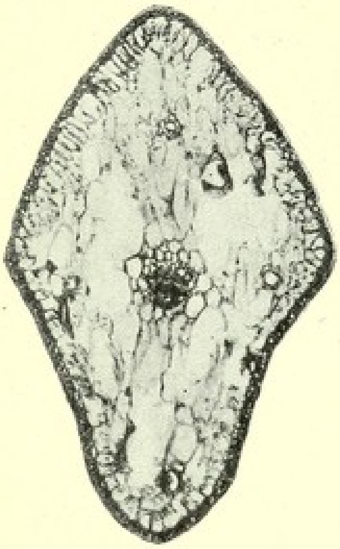


Figure 229.—Transverse section through abnormal leaf. The concave surfaces are transpiratory, and the convex dorsal, assimilatory. Four oil cavities are shown. *A. Cunninghamii*, × 50.

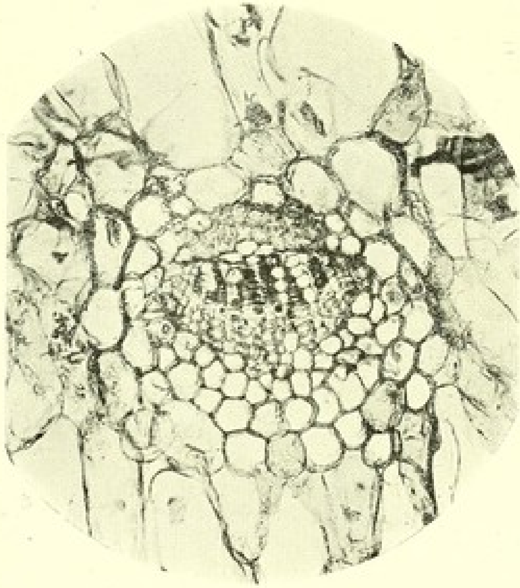


Figure 230.—Transverse section through bundle of normal leaf, showing the crescent shape of the xylem portion and individual masses of phloem separated by medullary cells. Endodermal cells are well defined, but no transfusion tissue is seen. *A. Cunninghamii*, × 190.

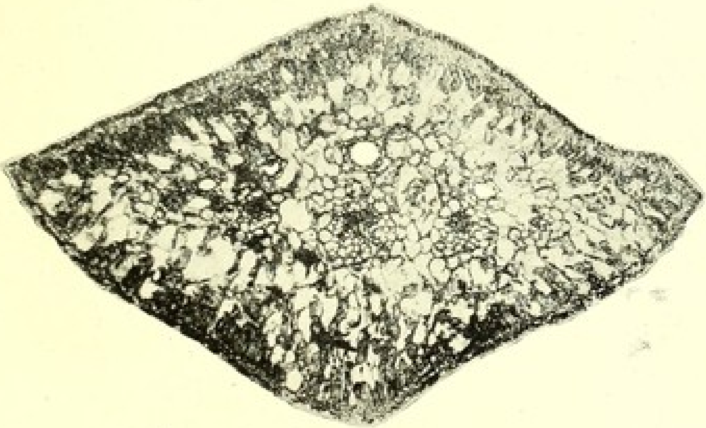


Figure 231—Transverse section of normal leaf showing the packed hypodermal cells marking the assimilatory outer surface and (at top) several oil glands with the usual secretory cells, the three central ones being subtended by a bundle. *A. Cunninghamii*, × 47.

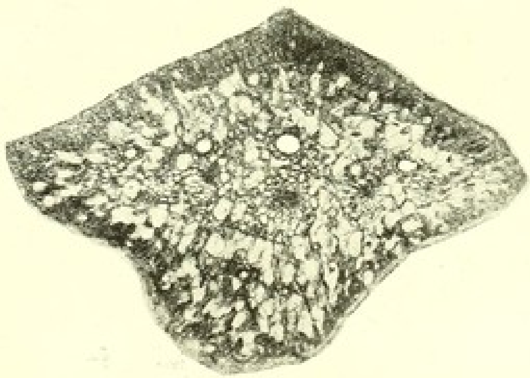


Figure 232.—Similar section to but higher up than Figure 231, and showing the contour of the cross section at this part. *A. Cunninghamii*, × 40.

Sections of leaves of Araucaria Cunninghamii, Ait.

An oil cavity occurs in the fundamental tissue at each angle of the leaf and is surrounded by a protective circle of secretory cells. Stomata occur on both the upper and lower surfaces, the guard cells being situated at the bottom of a depression in the cuticle.

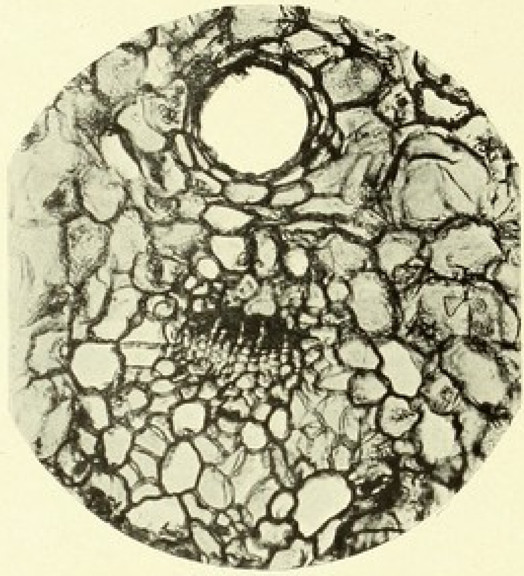


Figure 233.—Transverse section through median portion of a normal leaf, showing an oil cavity and the normally orientated bundle below it, together with the leaf structure in this part. *A. Cunninghamii*, × 190.

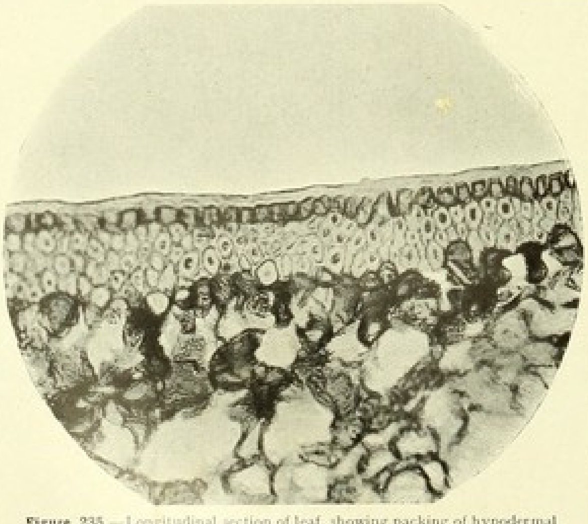


Figure 235.—Longitudinal section of leaf, showing packing of hypodermal cells below the assimilatory surface. *A. Cunninghamii*, × 180.

The normal leaves, like the abnormal ones, are spirally arranged and occur on the thickest branchlets right down to the attachment with the branches. They measure under half an inch long, are imbricate and incurved,—the physiological significance of the latter feature is no doubt a protection to the transpiration surface, and if studied in the field would probably be found to be spreading during favourable climatic conditions.

A cross-section, taken above the middle, shows a rhomboidal figure, but below this the geometrical shape is not so clearly defined, the inner surface being more embonpoint (Figure 232).

The epidermal cells extend around both surfaces, the inner containing the stomata (Figure 236), the outer or dorsal is, therefore, the assimilatory one. The hypodermal cells are very thick-walled and closely packed in several rows below the dorsal epidermis (Figures 231 and 235), but are fewer on the ventral side where also the palisade parenchyma is less developed. The fundamental tissue partakes

Figure 234.—Transverse section through a median portion of a leaf with one oil gland towards the top, and the middle bundle a little distance below surrounded by endodermal cells. A small cluster of sclerenchymatous cells occurs on the outer edge of the phloem (dark brown). Two comparatively large transfusion cells (stained purple) are sectioned on each side of the oil cavity. Stained with hæmatoxylin and safranin. *Araucaria Cunninghamii*, × 110.

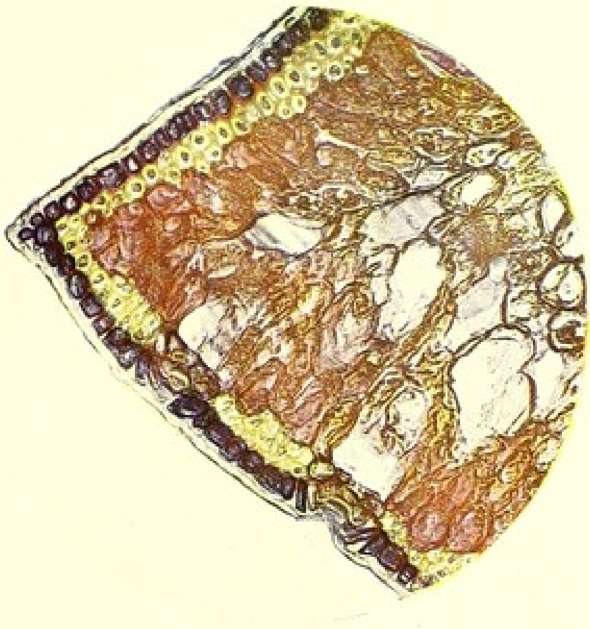


Figure 236.—A transverse section through an edge of a leaf, showing the cell structure at that particular part. The epidermal cells are in a single row on both surfaces, whilst the hypodermal cells (yellow) are larger and more numerous on the dorsal surface. Two stomata are sectioned in the ventral surface, the air cavities here separating the palisade cells (red),—which are well packed below the hypodermal cells of the dorsal side. The transfusion cells (purple) can be detected by the cross bars. Stained with hæmatoxylin and safranin. *Araucaria Cunninghamii*, × 378.

of the typical spongy nature towards both surfaces, and corresponds in character to that of the abnormal leaf.

The central bundle is normally orientated and is supported by subordinate ones about equidistant from it on both sides and in the same plane, and situated medianly in the fundamental tissue. They are each surrounded by endodermal cells enclosing, in the case of the primary bundle at least, tracheids of the xylem, the phloem, and sclerenchymatous cells on the outer edge of the latter material (Figures 231–2). Midway between these and the assimilatory surface are found in the fundamental tissue three or more oil glands or cavities, which are surrounded by a protective sheath of cells.

The bulk of the leaf substance is composed of irregularly-shaped cells of the spongy tissue of the mesophyll with small intercellular spaces, so well seen in Figures 235–6, whilst transfusion tissue is very limited in the normal leaves, only a few cells being found, and these removed several cells from the protoxylem, In the case of the abnormal leaves scarcely any such tissue was seen.

(*c*) Chemistry of the Leaf Oil.

This material consisted of the terminal branchlets alone and was quite fresh and green. It was collected in the month of November at Woolgoolga, northern New South Wales, and was steam distilled in the usual manner.

The amount of essential oil in the leaves of this tree is very small, and 200 lb. of material gave only 5 grams of oil, which is equal to 0·005 per cent.

In odour and appearance the oil resembled somewhat the inferior crude oils obtained from the leaves of the *Callitris*. It apparently consisted largely of the higher boiling terpenes.

The specific gravity at 21° C. = 0·8974; refractive index at same temperature, 1·4977; saponification number = 4·4 or 1·54 per cent. ester, considered as bornyl-acetate. It was insoluble in 10 volumes of 90 per cent. alcohol. The oil from the leaves of this tree is thus of little importance.

IV. TIMBER.

(*a*) Economic.

This giant of our coast forests attains sometimes a height of over 200 feet, and consequently it is possible to cut some very fine flitches from it. It is a whitish-coloured, easy-working, straight-grained timber, and for preference is used generally for all kinds of indoor work, as it is not lasting on exposure.

It is largely used for furniture, as safes, dressers, kitchen tables, &c., Occasionally it is found to possess a beautifully-grained figure. It is also good for carving.

Transverse Tests of Timber, *Araucaria Cunninghamii*, New South Wales.

(Standard sizes, 38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 2·92; D 2·93	B 2·92; D 2·90	B 2·90; D 2·91
Area of cross section, square inches	8·55	8·46	8·43
Breaking load in lb. per square inch ...	6,735	6,600	5,200
Modulus of rupture in lb. per square inch ...	10,168	12,963	11,470
,, elasticity ,, ,, ...	2,659,977	2,777,142	2,742,857
Rate of load in lb. per minute	361	414·5	472

Transverse Tests of Timber, *Araucaria Cunninghamii*, Queensland.

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 3·00; D 3·00	B 3·00; D 3·00	B 2·96; D 2·95
Area of cross section, square inches	9·00	9·00	8·73
Breaking load in lb. per square inch ...	5,000	5,350	5,000
Modulus of rupture in lb. per square inch ...	10,000	10,700	11,250
,, elasticity ,, ,, ...	1,986,206	2,133,333	1,944,000
Rate of load in lb. per minute	455	446	500

(*b*) Anatomy.

Several botanical workers in Europe have recorded distinctive differences in the xylem of the *Araucarias* and *Abietineæ*, but, so far, we have not been able to find any references concerning the comparative structure between this genus and *Callitris*, or other Australian genera.

Macroscopically there is little resemblance between the timbers of the *Callitris* and *Araucarias*, although the latter more approaches that of *Agathis* than any other Australian genus.

Microscopically the differences between Hoop Pine and *Callitris* is marked, especially so in the tangential and radial sections, although the disposition of the bordered pits, and parenchymatous cells of the medullary rays indicate an affinity with *Agathis*.

C. E. Bertrand has carried out some anatomical work on the *Araucarias* in general, but more particularly on non-Australian, although this species received

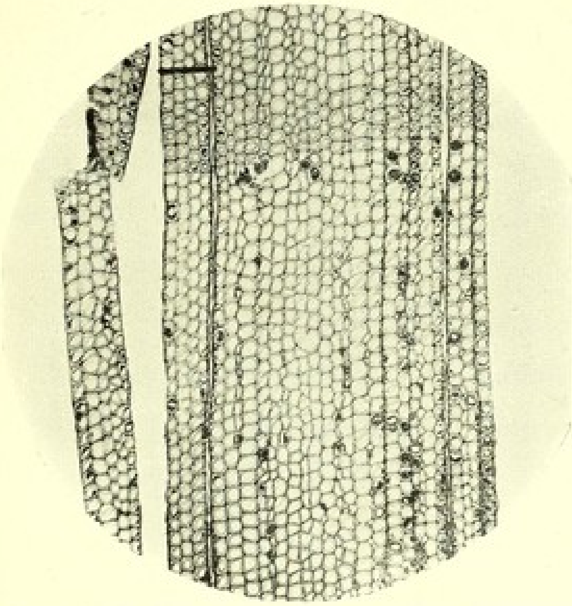


Figure 237.—Transverse section of timber. A well-defined line of tracheids near the top mark the limit of the autumnal growth. *A. Cunninghamii*, × 80.

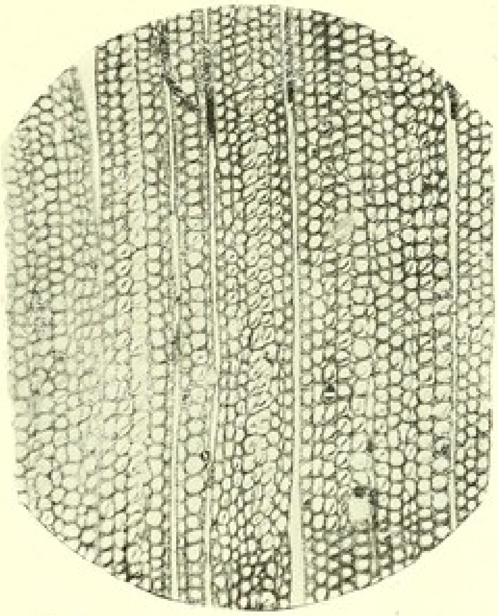


Figure 238.—Transverse section of timber. The cells of the medullary rays are mostly empty, but towards the top ends some content is present, and in one case a portion has come out of the cell, and forms an obtuse angle with the enclosed part. *A. Cunninghamii*, × 80.

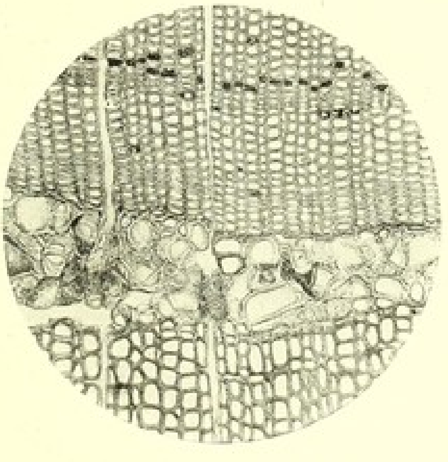


Figure 239.—Transverse section through timber containing a traumatic resin cavity below the centre of the picture extending downwards to the larger spring tracheids. The small rectangular black patches towards the top of the picture are deposits of manganese compound. *A. Cunninghamii*, × 50.

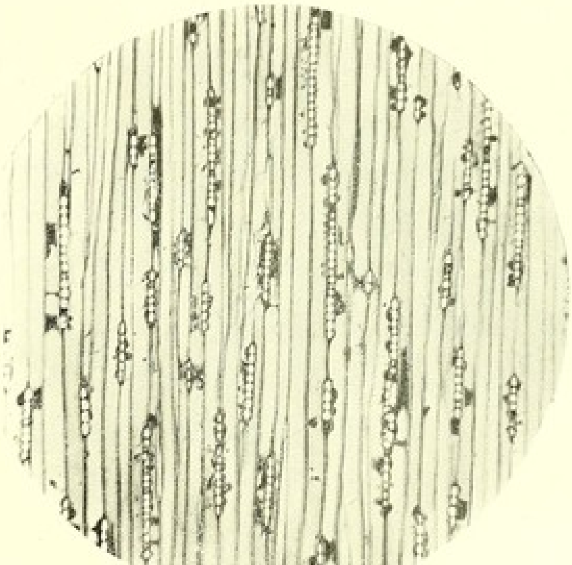


Figure 240.—Tangential section through timber. The ray cells are mostly empty, whilst the lumina of the tracheids give evidence—the black patches—of some amount of the presence of manganese compound. *A. Cunninghamii*, × 50.

Sections of timbers of Araucaria Cunninghamii, Ait.

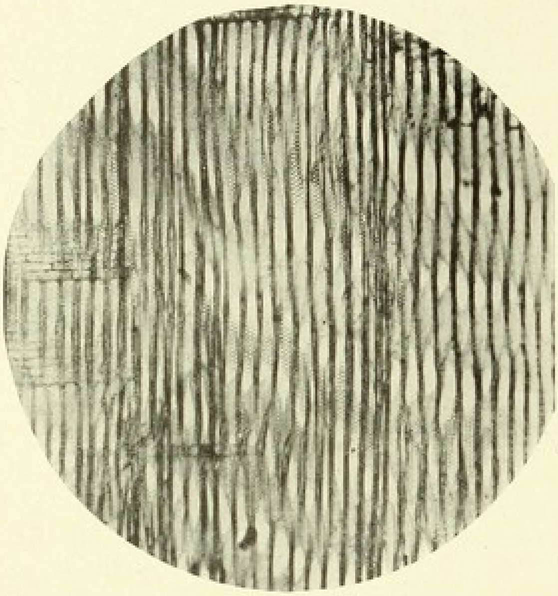


Figure 241.—Radial section through timber of *A. Cunninghamii*, × 50.

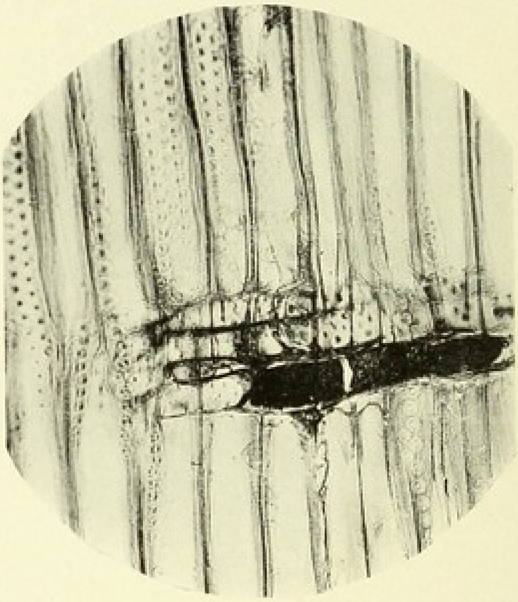


Figure 242.—Radial section of timber through portion of ray, showing numerous simple pits in each lumen. *A. Cunninghamii*, × 145.

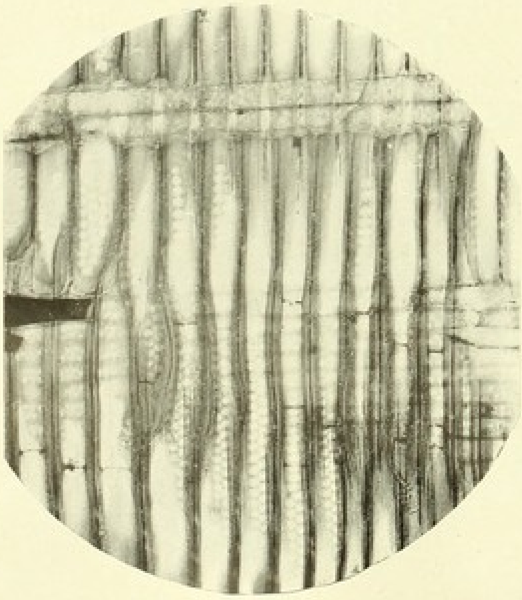


Figure 243.—Radial section of timber, showing the alternate rows of bordered pits of the tracheids and the numerous simple pits of the rays. The dark patch on the left of the picture is a deposit of manganese compound in one of the ray cells,—and that an outer one. *A. Cunninghamii*, × 120.

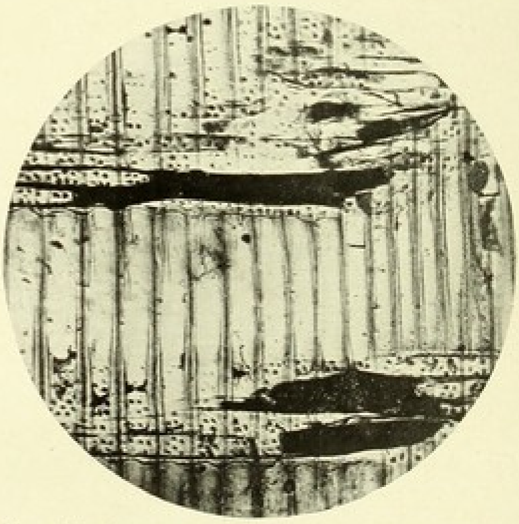


Figure 244.—Similar section to, but showing more clearly than Figure 243 the numerous simple pits and the large amount of the manganese compound in the rays. *A. Cunninghamii*, × 100.

Sections of timber of **Araucaria Cunninghamii**, **Ait.**

some attention at his hands. His investigations were rather with earlier growth than the mature material with which, however, we are more directly concerned, as it serves more the technological side, and so it is on the latter that the following remarks are based, the secondary wood being more particularly dealt with here.

A cross-section through a portion of two seasons' growth (Figure 237) shows the lumina of the tracheids of the xylem to be of varying diameters, whilst the cell walls are fairly thickened, those of the autumnal period being more so.

The outer walls of the tracheids are seen in this picture to be irregularly hexagonal in shape, but mostly circular or oval internally. It will be noted that not many of the tracheids contain a dark-brown substance,—the manganese compound, and these are all well defined in Figure 237. The medullary rays are two in number here, situated three and four rows from the left and right side respectively, and extend the whole length of the specimen from top to bottom; the particular point of interest is that they are entirely empty, and this fact should be noted, as throughout the whole series of plates it is an important generic, specific, and phylogenetic character—this *almost entire absence* of cell content in the parenchymatous cells of the rays in the *Araucaria*. Figure 238 shows, however, at the top of the figure the manganese compound substance in three of the rays, and in the case of the left one, a portion has come out of the cell and bent over in the form of an obtuse angle.

Attention might also be drawn to this dark-brown cell content of the tracheids in the spring growth, for in this respect it is similar, with the exception of *Podocarpus*, to all Australian living Conifers, and other living representatives of the Conifer family. In this connection one might mention the researches of Professors Jeffrey and Chrysler in Palæo-Botany, who have found similar features in fossil and living pines of North America. Figure 239 shows the intrusion of a traumatic resin cavity between the two seasons' growth; a similar feature has already been recorded under *Actinostrobus pyramidalis* (Figures 208–211), the dark-cell contents of the tracheids are here much in evidence in the upper portion of the picture in the spring wood, whilst the other parts are almost quite free from this manganese compound. There are two medullary rays, one in the centre and one midway between it and the left edge, and it should be noted that both contain none of this substance.

The tangential section in Figure 240 shows the emptiness of the medullary cells more clearly depicted, for practically no dark-brown coloured cell contents can be seen in them. In this view the linear outline of the rays is clearly defined as they intrude between the tracheid walls, and in no instance are they more than one cell in width, whilst the number of horizontal cells in each ray varies from two to over twenty. The dark patches in the lumina of the tracheids correspond to the dark-cell contents referred to in previous Figures (237–9). Several of the

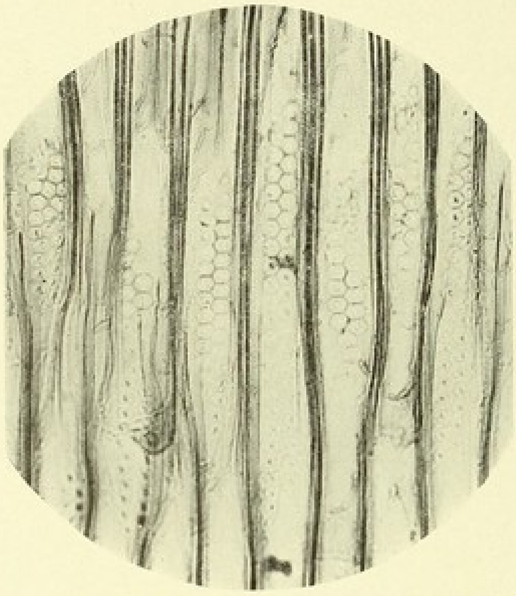


Figure 245.—Radial section of timber cut clear of a ray. The alternate rows of pitted cells are well marked on the tracheid walls, which latter show a thickened lamella containing manganese in its composition. *A. Cunninghamii*, × 210.

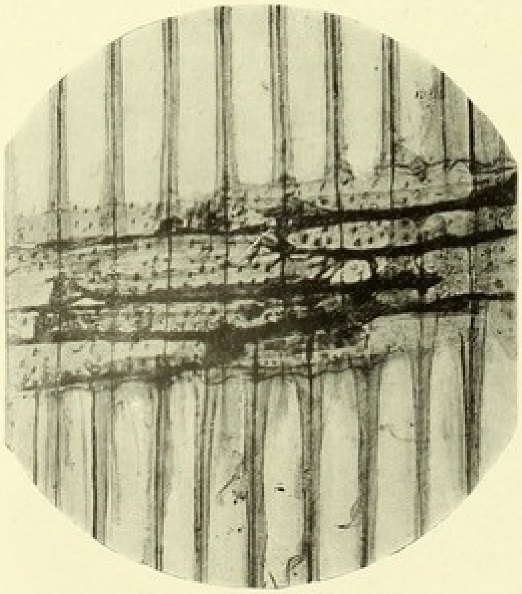


Figure 246.—Section through a single ray of wood, showing numerous single pits connecting with the tracheids. *A. Cunninghamii*, × 210.

Longitudinal sections of timber of Araucaria Cunninghamii, Ait.

radial walls show series of pitted cells in section. A radial section is given in Figure 241 with two medullary rays on the left of the plate, and their short axes walls show them to be parenchymatous in character, and further they are all empty, or at least have no dark substance in their cells in this instance, and what is of further phylogenetic importance the outer cells are identical in character with the inner ones—features that seem to point to a recent (geological) evolution of the genus.

In these plates (Figures 242–5) will be seen on almost every tracheid wall, double or triple contiguous rows of pitted cells, exactly as obtains in *Agathis* (*Dammara*), a fact that establishes a connection with these congeners of the forest of past geological times, and is in contradistinction to the uniform single row of *Callitris*. These pitted cells are shown under a 210-magnification (Figure 245); only rarely are pitted cells found on the tangential walls,—a generic difference from *Agathis robusta*.

The simple pits, which communicate with the lumina of the tracheids by circular perforations are comparatively numerous, ranging in number from six to ten, as against two to four in *Callitris* (Figure 246).

V. BARK.

(*a*) Economic (*vide* Chemistry, *infra*—Chemistry of the Latex).

(*b*) Anatomy.

One reason for working upon the mature bark of this and the cognate species, *A. Bidwilli*, was to try and trace the origin of the respective exudations, at this stage of the tree's age, which are fully dealt with under their chemistry.

The barks resemble each other in some characters, although their exudations differ in their several constituents, that of *A. Cunninghamii* containing most oleo-resin, whilst *A. Bidwilli* yields gum principally.

This latter substance also occurs in this species, for what is probably one of its conveyors (bast fibre) is distinctly seen in Figure 247, on the right-hand side of the picture, just below the periderm—the white band in the middle of the picture; and just below this can be seen a stone cell, showing that these are apparently two distinct substances or structures.

The composition of the bark is even less regular than in *A. Bidwilli*, for with the exception of the concentric periderm layers nothing else is regularly arranged, and these occur in parallel bands on the outside of the cortex. Stone cells are found scattered throughout both inner and outer cortex, as also are the oleo-resin cells, Figure 248, in fact, the above together with parenchymatous cells, and sieve tubes, compose the whole bark substance.

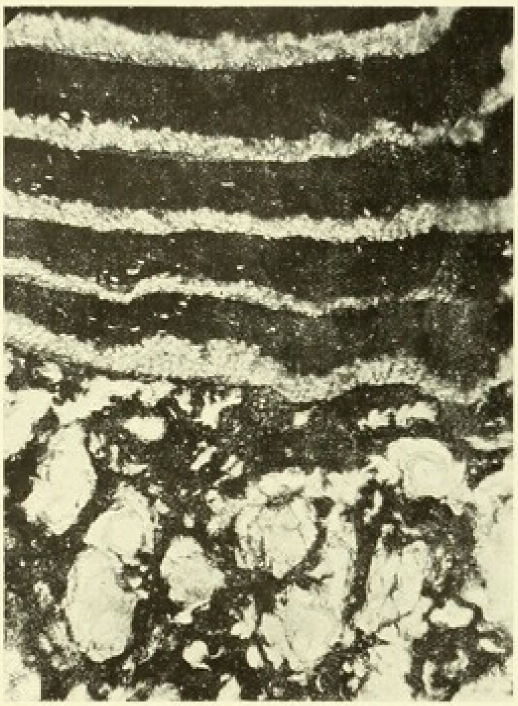


Figure 247.—Transverse section through portion of inner and outer bark. The concentric bands across the top of the section are periderm layers. A few bast fibres can be seen on the inner cortex. *A. Cunninghamii*, × 70.

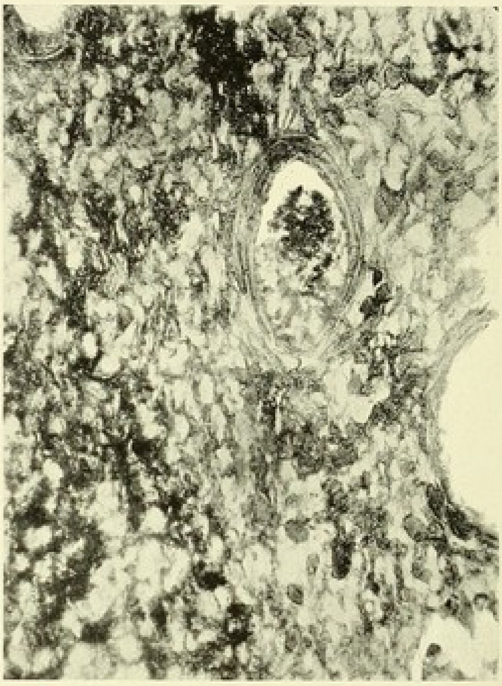


Figure 248.—Transverse section through bark, showing unconformity of composing vessels, compared to that of its Australian congeners. The one whole cell shown is almost filled with gum-resin. *A. Cunninghamii*, × 100.

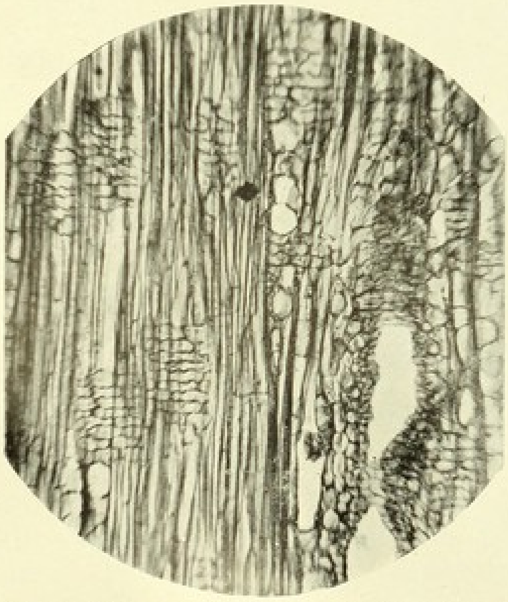


Figure 249.—Radial section of bark. The rays are clearly defined and the sieve tubes can also be seen to the left of the field. The arge cavities are oleo-resin cells. *A. Cunninghamii*, × 55.

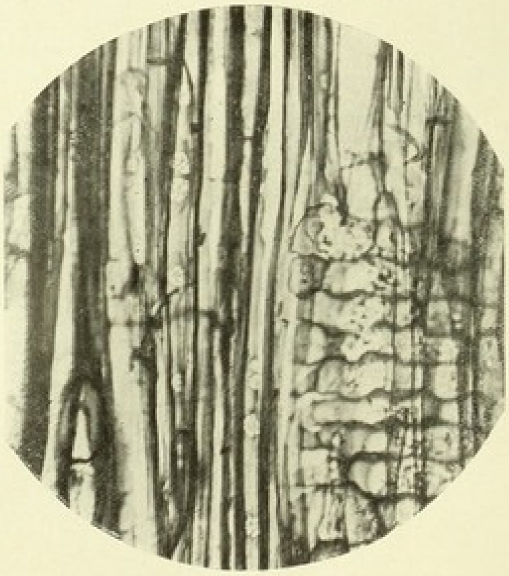


Figure 250.—Radial section through bark. The sieve plates are quite distinct in the tubes running through the centre of the field from top to bottom. *A. Cunninghamii*, × 175.

Sections of the bark of Araucaria Cunninghamii, Ait.

Frank H. Taylor, Photo.

Araucaria Cunninghamii, AIT.

FASCIATION AT TOP OF A TREE UNDER CULTIVATION, AT BEECROFT, N.S.W.

(A rare instance of teratology.)

(*c*) Chemistry.

This sample of bark was collected at Murwillumbah, New South Wales, in November, 1907. It was an average sample of the bark of this tree, and a fair section through the outer and inner bark was taken for analysis. The outer layer of bark encircling the tree, which, separating in hoop-like forms, gives the name "Hoop Pine" to this tree, was 2 to 3 mm. thick, hard and compact, and red in colour; it was greyish externally and somewhat rough; the furrows, which are not deep, have the peculiarity of running around the tree instead of vertically. The inner layer is about 10 mm. in thickness, is somewhat soft, porous, and fibrous, the fibres running longitudinally. The bark powdered fairly well, but the extract was dark coloured, poor in tannin, and would make a dark-coloured leather. It acts only fairly well on hide powder, staining it brownish in colour. The results show it to be of little value as a tan bark. The non-tannin extract contained some gum.

The following results were obtained on analysis:—

Moisture	12·60 per cent.
Total extract ...	12·24 ,,
Non-tannin ...	7·24 ,,
Tannin	5·00 ,,

The aqueous extract gave a green colour with ferric salts, and the other general reactions were also those for a catechol tannin.

CHEMISTRY OF THE LATEX.

Theoretical.

The fresh latex was obtained from the trees of this species so that its constituents might be compared with the gum-resins exuded by other species of this genus.

The exudations of the *Araucarias* were shown by Heckel and Schlagdenhauffen in 1887 (Compt. rend., 105, 359) to contain both gum and resin, and the exudation of *A. Cunninghamii* has long been known to contain a gum as well as a resin (see paper by Maiden, "Proc. Roy. Soc.," Queensland, Vol. VII, 1890, also paper by Dr. Lauterer, "Botany Bulletin," No. XIII, Queensland). As no other data were available in reference to the exudation of *A. Cunninghamii*, it was thought desirable to undertake as complete an investigation as possible of the latex of the plant, in preference to that of the solidified gum-resin, which is found at times occurring in some quantity on the exterior of the tree. Attempts were made to draw the latex from the living trees, and those growing in Northern New South Wales were utilised for the purpose; poor results were obtained in this way, although a little gum-resin had accumulated at the injured places after a week, yet, the amount was very small during that time. Better results were, however,

obtained by collecting the material which had accumulated upon the stumps of trees felled some time previously. Masses of gum-resin were found upon these stumps, mostly at the junction of the inner and outer bark. The material was quite fluid beneath the crust which had early formed upon the surface, and it was evident that the liquid material beneath this crust had been forced up from below by root pressure, the film of partly hardened resin protecting the material forced up later, and so retarded, if not prevented, the evaporation of its volatile constituents. That this is so appears evident from the large masses which had accumulated upon the stumps of the trees, and by the presence of the volatile constituents found in this exudation. Corresponding results were also obtained under our own observation with the exudation of a large tree of *A. Bidwilli* growing near Sydney (see under that species).

This fact is also interesting as suggesting the possible formation, or completion, of some of the constituents of the plant in the root portion of the tree, and not in the leaves, because the upper portion of the tree having been removed, the "laboratory" must have been below the ground, as the only place from which the material could have been derived. Had it not accumulated in this way it is certain that the very volatile hydrocarbon found in the latex would not have been discovered. The occurrence in this tree of natural hydrocarbons belonging to the $C_{10}H_{20}$ series, and probably also to the $C_{10}H_{18}$ series, is particularly interesting, and may, perhaps, assist somewhat towards the elucidation of some of the problems concerning the natural formation of the terpenes and of the resins.

Heusler ("Chemistry of the Terpenes," p. 18) suggests that hexahydrocymene does not occur in nature; and Gildemeister and Hoffman ("Ethereal Oils," p. 182) that the hydrocarbons of the formulæ $C_{10}H_{18}$ and $C_{10}H_{20}$ are not known with certainty in ethereal oils. If the formation of the saturated hydrocarbon is completed in the root portion of the tree, as from the results of this investigation appears to be the case, then it is hardly to be expected that the saturated hydrocarbons will be found in ethereal oils as usually obtained from the leaf portion of the plant, because alteration rapidly takes place under the active influences of the growing tree, with the ultimate formation of unsaturated hydrocarbons, terpenes, and resins.

The trend of the reactions which take place in the plant during the formation of these complex substances is not known with any degree of certainty, although evidently produced from simpler compounds. Baeyer (Ber. d. Chem. Gesell. 3, 66, 1870) offered an explanation for the formation of Butlerow's methylenitane, by the simple combination of six molecules of formaldehyde. By similar reasoning a suggestion might be advanced for the formation of members of the $C_{10}H_{20}$ group of hydrocarbons, from which the terpenes and resins would ultimately be derived. The menthane molecule can be arranged from ten molecules of formaldehyde, all the oxygen atoms being eliminated.

Again if one molecule of isobutyric acid could be combined with three molecules of acetic acid, the whole of the oxygen atoms being eliminated, the molecule of hexahydrocymene could be arranged, the migration of one hydrogen atom in the methyl group of two acetic acid molecules being necessary for valency purposes. The carbon and hydrogen atoms thus derived from the three acetic acid molecules represent 60 per cent. of the whole in the above arrangement, those of butyric acid 40 per cent. The free acids occurring in the latex of *A. Cunninghami* were found to be butyric and acetic, and the percentage of barium-acetate in the barium salt obtained from these acids was 60·38 per cent.; that of the barium butyrate being 39·62 per cent. The somewhat close agreement between the theoretical requirements for these acids in the arrangement suggested above for a $C_{10}H_{20}$ hydrocarbon of this series, and the amount of each acid actually present in the latex, appears to be a remarkable coincidence.

The formation of these acids goes on continuously; and if these are not used up in the constructive metabolism of the plant, would ultimately become in excess, if not otherwise removed or fixed. Liebig was of the opinion that some, at any rate, of the organic acids were formed from carbon dioxide and water in the cells of the plant (see letter on Chemistry, XVIII). The constituents required for the completion of the compounds found in this latex appear to have been derived more largely from below, as the upper portion of the tree had been removed previous to the accumulation of the exudation, and as this was continuously forced up there must have been sufficient material obtainable to assist in the metabolic process of the plant.

That some of the fatty acids do enter into the process of constructive metabolism, being thus subjected to complete alteration, is generally accepted, and the increase of carbohydrates, corresponding to the diminution in acidity in some portions of the plant, is a case in point.

That the changes which go on are continuous, is indicated by the fact of the alteration of the unsaturated hydrocarbons into resinous products, even after they had been obtained by steam distillation from the latex and kept in closed bottles. It was this alteration that enabled the purer saturated hydrocarbon, $C_{10}H_{20}$, to be obtained, as this had undergone no alteration during the time necessary for the resinification of the unsaturated bodies; so that when distilled directly the menthane was obtained practically pure at the first distillation.

It thus appears that the fully saturated hydrocarbons are the first formed bodies of this group, and that the alteration by oxidation commences at once, the more stable and less volatile substances, as the terpenes and the resins, being eventually formed.

It might be suggested that the formation of some of the constituents of the latex might be due to the injury to which the trees had been subjected, and that,

therefore, the conditions were abnormal. We think, however, that there has been no alteration in the formation of the chemical constituents to what maintained in the uninjured trees. When the bark of *A. Bidwilli* was cut through there was an exudation at once from the cut cells or canals, both from above and below. The downward flow soon ceased, but the upward flow continued for months, the exuded material being collected each week. The material forced up months after the injury was identical in composition with that which exuded when the trees were first injured.

Although many members of the terpene series have been converted into hydrocarbons of the formula $C_{10}H_{20}$, yet, it is probable that none have been isolated from essential oils, for the reasons above stated.

The natural hydrocarbon $C_{10}H_{20}$, as obtained from this latex, is a very limpid, colourless, volatile liquid, with an odour somewhat reminding of menthene, but more pleasant and delicate, and not so strong. It had specific gravity at $\frac{19°}{15}$ C. = 0·7927; refractive index at the same temperature *n*D = 1·4437; it boiled at 155° C. (cor.), and was inactive to light. Bromine acted slowly upon it by substitution; nitric acid and sulphuric acid did not act upon it in the cold, but warm nitric acid oxidised it. A dilute solution of potassium permanganate acted very slowly upon it, but the products formed could not be determined for want of material.

Wallach and Berkenheim (Ann. Chem. 268, 225) prepared a hydrocarbon, tetra-hydropinene $C_{10}H_{20}$, by the hydration of pinene hydrochloride. It boiled at 162° C., had specific gravity 0·795, and a refractive index *n*D = 1·43701 at 20° C.

Wallach (Ann. Chem. 284, 326) prepared tetra-hydrofenchene $C_{10}H_{20}$, which in chemical behaviour resembed tetrahydropinene; it boiled at 160–165° C.; had specific gravity 0·7945; and index of refraction *n*D = 1·4370 at 22° C.

Wagner (Ber. 27, 1638) prepared a hydrocarbon, $C_{10}H_{20}$, by the action of sulphuric acid on menthol. It boiled at 168–169°, and had specific gravity 0·8088 at 0° C.

Knoevenagel and Wiedermann (Ann. Chem. 297, 169) prepared 1 : 3 methyl-isopropylcyclohexane by reducing the iodide of symmetrical menthol. It boiled at 167–168°; had specific gravity 0·8033 at 14° C.; and a refractive index *n*D = 1·44204.

Similar products have been prepared synthetically by W. H. Perkin and coadjutors, the results of which are published in the Journ. Chem. Soc. for the year 1905. The orthomenthane boiled at 171° C.; the para form at 169° C.

From the above it is seen that the natural hydrocarbon, $C_{10}H_{20}$, from this latex, boils at a lower temperature than the artificially prepared compounds from

members of the terpene group, although the other physical constants are similar. The synthetically prepared menthanes boiled at a still higher temperature.

From the results recorded under the experimental portion, it is probable that the hydrocarbon, $C_{10}H_{18}$, was present in the latex also; but it was not isolated, so that its physical characteristics were not determined.

The occurrence of nitrogenous substances in the latex is also of some importance in this connection, as indicating the presence of enzymes. Yoshida (Trans. Chem. Soc. 1883, 83, 472) discovered an oxidising enzyme which is supposed to play an important part in the production of the lacquer varnish from the sap of the lacquer tree. It was shown by Bertrand (Compt. rend. 1897, 124, 1032) that the ash contained up to 2 per cent. of manganese, and that the activity of the enzyme was influenced by the amount of manganese present, so much so that its action was in some cases considerably increased by the addition of manganese salts. This enzyme "laccase" is, however, an oxidising one.

In the latex of *Araucaria Cunninghamii*, manganese is also present, apparently in weak combination. The manganese compound is, however, easily altered, even on drying in the air, the formation of a higher oxide of manganese being most pronounced. The influence of manganese here, if entering into the reaction, may be due to the facility with which it forms compounds varying in the amount of oxygen present, and may thus act an important part in the organic arrangement of the atoms in the compounds which are found eventually in the latex. The action of reducing enzymes (reductases) is not so well understood as is that of the oxidising enzymes, although considerable advance has recently been made in this direction.

The gum found in the latex was apparently identical with the gum of gum arabic; it differed in some respects from the gum freshly obtained from *A. Bidwilli*, as it did not form an insoluble jelly when it was agitated with ether for a very long time.

The resin of the latex of *Araucaria Cunninghamii* consisted of two resin acids, together with neutral resins, a bitter principle, &c. The investigation of this resin was carried out in a similar manner to that of the resin of *Agathis robusta*, (see under that species). The acid of high melting point was dextro-rotatory, crystalline, and was identical with the corresponding acid obtained from *Agathis robusta*; it was, therefore, Dundathic acid. The acid of low melting point could not be obtained in a crystalline condition, but was separated from an aqueous solution as a soda salt; it was not, however, so completely separated in this way as was the corresponding acid in the resin of *Agathis robusta*. It gave results indicating the formula $C_{20}H_{30}O_2$. It was lævo-rotatory, thus differing from the low melting acid of *Agathis robusta*, which was dextro-rotatory.

This acid appears to be an isomeric form of abietic acid, if the formula $C_{20}H_{30}O_2$ be accepted for that substance, although it melted at a considerably lower temperature than ordinary abietic acid. (For much data concerning abietic or sylvic acid, see article in "Allen's Commercial Organic Analysis," Vol. II, Part 3, 1907, page 158; also Dr. Henry's Paper on the "Sandarac Resins," Journ. Chem. Soc., 1901, page 1144.)

The bitter principle was most pronounced in the neutral ether extract after separation from the acid portion. It was extracted from this residue by water, and afterwards obtained as microscopic needles on evaporation. It appears to be a distinct body, and not directly in combination with the acids themselves. The neutral portion of the resin was lævo-rotatory, thus agreeing in rotation with the acid of low melting point.

The general composition of the resin of *Araucaria Cunninghamii*, as first prepared from the latex, may be stated as follows:—

Dundathic acid ($C_{21}H_{32}O_3$)	= 14·5	per cent.	
An isomeric form of abietic acid ($C_{20}H_{30}O_2$)...	= 62·0	,,	(about).
Neutral resins, bitter principle, &c.	= 23·5	,,	

Considered from an economic point of view, the exudation of *A. Cunninghamii* should have some commercial value for the resin and gum it contains, if collected in quantity. It does not, however, appear naturally to yield an exudation in abundance, so that it would be necessary to systematically wound the trees, cutting quite through the bark, and at the same time forming a box-like receptacle for the material. It might then be collected as it accumulated.

Experimental.

The material was collected at Murwillumbah, New South Wales, 28th November, 1907, and was investigated immediately on receipt at the Museum. It was a semi-opaque, cream-coloured liquid, of a pasty consistency, with lumps of a more solid, resinous-like substance throughout. It had a sour, butter-like odour, and was strongly acid to litmus. On adding water, a thin emulsion was at once formed, and it was evident that the semi-opaqueness of the latex was largely due to the water present and to the suspended resin. It was practically soluble in an excess of hot aqueous solution of carbonate of soda, but mostly separated out again on cooling. The resins were readily and almost entirely extracted from the aqueous latex by ether, and were somewhat soft and slightly aromatic. After removal of the resins the remainder was poured into a large amount of alcohol, when a quantity of a colourless gum precipitated. On drying, however, this gum became smoky and dirty in appearance from the formation of a higher oxide of manganese.

A thin emulsion was formed by adding 500 c.c. water to 420 grams of latex, and this mixture was distilled for six hours by direct heat, adding more water as required. It was found preferable to boil the solution directly, because when steam was passed into it, an objectionable projection of the material took place. A water-white oil came over with the steam and separated easily into a well-defined layer upon the surface of the water, which was markedly acid, due to the presence of the volatile acids. On continued boiling the gum went into solution, the resin separating in a more or less powdery condition. After the distillation was completed the resins were allowed to solidify and cool in the flask, the aqueous portion being thus more readily removed than when filtration was attempted. The aqueous portion thus obtained from the resins was filtered clear, evaporated down, and the gum precipitated by the addition of a large amount of alcohol.

The Volatile Oil.

The oil floating on the surface of the distillate was separated; it measured 20 c.c. = 3·8 per cent. of the latex. It was colourless, and had a characteristic odour, somewhat aromatic, but recalling slightly that of the hydrocarbon menthene. It had a specific gravity at $\frac{22}{15}$° C. = 0·80577; refractive index at 22° C. = 1·457; rotation a_D = + 3·2°. These results indicated that bodies other than terpenes were present.

On redistilling the oil (765 mm. pressure) it commenced to distil at 150° C. (uncor.), and between that temperature and 155° C., 55 per cent. distilled. This had specific gravity at $\frac{22}{15}$° C. = 0·7907; refractive index at 22° C. = 1·4482; rotation a_D = + 4·8°.

In a chloroform solution it readily discoloured a weak solution of bromine; the fraction was thus partly unsaturated, and active to light. Unfortunately, at this stage the bottle was broken and the contents lost. It is evident, however, that the results indicated the presence of compounds other than the members of the terpene group.

The remainder of the latex received (260 grams) was then distilled as previously stated, and 12 c.c. of the oil obtained. The bottle containing this oil was placed aside, having at the time no intention of proceeding further with it, but ten months afterwards a layer of a resin-like substance had formed at the bottom of the bottle. It was then thought desirable to distil it again, and so endeavour to locate the mode of alteration. After separating the first few drops, there were obtained 4 c.c. boiling between 151–153° C., equal to 33·3 per cent. of the oil. This separated quite sharply, and the remainder had a much higher boiling point. That the 4 c.c. thus obtained was an almost pure product is shown by the results of the analysis. It boiled somewhat constantly at the corrected

temperature of 154–155° C.; was inactive to light; had a specific gravity at 19° C. = 0·7927; and a refractive index at 19° C. = 1·4437. This gives by the Lorenz-Lorentz formula a molecular refraction very closely approaching that required for the $C_{10}H_{20}$ molecule. When dissolved in chloroform and a very dilute solution of bromine in chloroform added, this was not discoloured at once, but the bromine slowly acted upon it by substitution, hydrobromic acid being evolved. An analysis gave the following results:—

0·1251 gram gave 0·1593 gram H_2O and 0·3934 gram CO_2.

C. = 85·77 per cent. and H. = 14·15 per cent.

$C_{10}H_{20}$ requires C. = 85·71; H. = 14·29 per cent.

This hydrocarbon is thus shown to belong to the $C_{10}H_{20}$ or menthane series. Its inactivity to light, its saturated nature, its stable character, the results of its physical properties and analysis, all go to show that this is so. The known menthenes too, all have a higher specific gravity. The activity and unsaturated nature of the product of the first distillation, however, indicate that menthene or menthenes were present originally in the latex, but that it, or they, had undergone alteration during the time which had elapsed since the oil was first separated, and their original character had been greatly changed. From the results of the distillation there was originally in the oil about 20 per cent. of unsaturated hydrocarbons belonging, probably, to the menthene group, but which had evidently undergone considerable alteration.

Free Acids.

The aqueous distillate from the 420 grams of the latex was filtered through wet paper; it measured 750 c.c.; 100 c.c. required 12·5 c.c. $\frac{N}{10}$ NaOH to neutralise, so that the 750 c.c. contained 0·562 gram volatile acid considered as acetic, or 0·134 per cent. The remainder was neutralised with barium hydrate, evaporated to dryness and heated at 100–105° C. to constant weight. 0·3228 gram of the barium salt gave 0·2738 gram barium sulphate = 84·82 per cent.

Both butyric and acetic acids were shown to be present in the distillate, so that if these acids were alone present, they were in the following proportions:— Barium acetate = 60·38 per cent., Barium butyrate = 39·62 per cent.

The Gum.

The air-dried gum boiled out from the 680 grams of the latex, and precipitated by alcohol, weighed 50 grams = 7·35 per cent. A small amount was extracted later from the residue after the resin had been removed, thus bringing the total gum in the latex to 8 per cent.

As the air-dried gum had become quite smoky and dirty in appearance, although it was quite colourless when first precipitated, an effort was made to determine the cause. It was again dissolved in water, but the solution was then quite turbid and evidently contained some insoluble substance, and this was readily removed by agitating the aqueous solution with alumina cream. The filtrate was perfectly clear, bright, colourless, and on testing a solution of considerable strength it was found to be inactive to light. When again precipitated by alcohol and dried (spread on glass as before), it did not become dark coloured, but remained perfectly clear and transparent, thus showing that no fresh alteration of the manganese salt had taken place.

The purified gum had all the properties of gum arabic, and gave all the reactions with reagents necessary for that substance. It was odourless and tasteless, had marked adhesive properties, and would make an excellent commercial gum. It contained a minute trace of a reducing sugar.

The alumina cream when filtered off was dark coloured, and when fused with sodium carbonate and potassium nitrate in the usual way gave a marked reaction for manganese. A manganese bead was also readily obtained with borax. The ash of the first precipitated gum also gave a reaction for manganese, while that of the purified gum did not. The presence of a soluble form of manganese in the latex of this tree was thus demonstrated, and also that it formed the higher oxide on drying in the air. Further information will be found in the article dealing with the presence of manganese in the Australian Coniferæ.

The amount of moisture in the purified air-dried gum was 15·5 per cent., and the amount of ash was 2·9 per cent. This consisted principally of the carbonates of lime and magnesia.

In the preparation of mucic acid, 2 grams of the gum were heated with nitric acid on the water bath until the formation of the acid was complete. Half the amount of water was then added and stood on one side for twenty-four hours, when the oxalic acid was removed by alcohol. The mucic acid formed was 23 per cent., calculated on the air-dried gum.

The sugar formed by hydrolysis was prepared by boiling the gum in a dilute solution of sulphuric acid for several hours, and removing the excess of acid by barium carbonate. The filtrate was quite clear and almost colourless, was dextro-rotatory, and it strongly reduced Fehling's solution. When evaporated down it did not crystallise, but gave reactions which indicated the presence of arabinose. When boiled with phloroglucinol in hydrochloric acid the reaction was similar to that given by arabinose supplied by Kahlbaum. The osazone was formed, but not readily, and although it was somewhat dark coloured, yet it melted at about 155–160° C.

The Resin.

The solidified resin in the flask, after removing the gum solution, was dried as much as possible, and treated with ether, until practically the whole of the resin had been dissolved. The ether solution of the resin was filtered, evaporated to dryness, and heated in thin layers on the water bath until all the ether had been removed. When cold the resin was light coloured, and soon became powdery on the surface; it broke with a bright fracture, was somewhat soft, but quite brittle, and in appearance strongly resembled sandarac resin. The amount of resin thus obtained from the 680 grams of latex was 320 grams, = 47 per cent. The resin was entirely soluble in 80 per cent. alcohol, and was not precipitated on the addition of a considerable amount of the same alcohol. It was entirely soluble in acetone, but only partly soluble in chloroform or in ether.

A solution of 1 gram resin in 10 c.c. acetone was lævo-rotatory — 2·9° in 100 mm. tube. (This rotation is in the opposite direction to that of the similarly obtained resin from *Agathis robusta*.)

The specific gravity of the resin was 1·061 at 16° C., and the acid number 107. It was mostly soluble in a hot aqueous solution of carbonate of soda, but formed a considerable precipitate on cooling.

For analysis, 25 grams of resin were again treated with ether, but the whole was not soluble; the insoluble portion weighed 1·52 grams, equal to 6·08 per cent. When this insoluble portion was dissolved in alcohol and solid potash added, it was almost entirely precipitated as an insoluble potash salt. This salt was dissolved in water, the solution acidified with hydrochloric acid and boiled, and the separated acid dried and heated at 100–105° C. It melted at 233° C., and appeared to be similar to the corresponding acid from *Agathis robusta*. The ether solution containing the soluble resin was neutralised with alcoholic potash and water added. The solution was then placed in a separator, and the neutral bodies, &c., entirely removed with ether. The aqueous portion was then boiled to remove the ether and alcohol, water added, the solution acidified with hydrochloric acid and boiled. The separated resin melted in the boiling water, but when cold formed a hard, brittle lump of a yellowish resin. It was then dried, powdered, dissolved in alcohol, and solid potash added, when a portion became at once insoluble and eventually formed a thick pasty mass. This insoluble salt was dissolved in water, acidified, and the acid separated and dried. It weighed 2·115 grams, equal to 8·46 per cent. It melted at 232° C., and was identical with the acid insoluble in ether at first, so that both portions were added together for purification. The amount of this acid (Dundathic acid) in the resin of *Araucaria Cunninghamii* was 14·54 per cent. It was purified by reprecipitating from an alcoholic solution by alcoholic potash, and finally dissolving in absolute alcohol, adding a little water, and crystallising out. This crystallisation from alcohol was repeated three times, and the

acid was finally heated to 100–105° C. It was then a colourless powder, and melted at 234–235° C. to a yellow resin. It was dextro-rotatory, and 0·4 gram dissolved in 10 c.c. absolute alcohol, rotated 2·2° to the right in a 100-mm. tube; the specific rotation was, therefore, $[\alpha]_D$ + 55°, agreeing very closely with the specific rotation of the same acid isolated from the resin of *Agathis robusta*.

The acid was practically insoluble in chloroform and in ether. It did not dissolve in the cold when acetic anhydride was added to the chloroform, but it went into solution on boiling. When cold, one drop of sulphuric acid changed the solution to a very slight pink colour, which altered to a brownish tint on standing. On titration the following results were obtained:—

0·1717 gram dissolved in absolute alcohol required 5·1 c.c. decinormal NaOH to neutralise it, therefore 40 grams NaOH would neutralise 336 grams acid.

0·141 gram required 4·2 c.c. $\frac{N}{10}$ NaOH, or 40 grams NaOH would neutralise 335 grams acid.

Analysis gave the following results:—

0·1554 gram gave 0·4278 gram CO_2, and 0·1383 gram H_2O.

C. = 75·1; H. = 9·88 per cent.

$C_{21}H_{32}O_3$ requires 75·84 per cent. C.; and 9·7 per cent. H.

The silver salt was prepared in the usual way, and this gave the following results:—

0·1651 gram silver salt gave 0·0399 gram silver = 24·2 per cent. Ag.

0·1518 ,, ,, ,, 0·0372 ,, ,, = 24·5 ,, Ag.

$C_{21}H_{31}A_gO_3$ contains 24·6 per cent. silver.

The molecular determinations, and the titration results, together with the results of analysis, indicate the formula $C_{21}H_{32}O_3$ for the acid of high melting point in the resin of *Araucaria Cunninghamii*. The melting point and rotation also agree with Dundathic acid isolated from the resin of *Agathis robusta*.

The acid of low melting point, which was present to the extent of over 60 per cent. in the resin of *Araucaria Cunninghamii*, was soluble in an excess of alcoholic potash. It was removed from the insoluble pasty salt, water added, and boiled to expel the alcohol. When cold, water was added, and the solution acidified with hydrochloric acid and boiled. The separated acid melted in the hot water, but when cold it was a yellow lump of resin. The above process was repeated, but only a very small quantity of the first acid was again obtained.

The acid of low melting point was purified as follows:—It was powdered, dissolved in the smallest quantity of alcohol, neutralised with an alcoholic solution of soda, water added and boiled to expel the alcohol. When cold a

sufficient amount of a 10 per cent. aqueous solution of soda was added to form a dense precipitate, and it was then heated to dissolve the precipitated salt. On cooling, a considerable amount of the soda salt separated, but the separation was not quite complete because, on the addition of solid caustic soda a further precipitate was obtained, but this being dark coloured it was discarded. The soda salt was dissolved in water, acidified, and the solution boiled, the separated substance melting in the hot water to a yellow brittle lump of resin. The above process was repeated three times, and the resin was then heated on the water bath till quite dry. Although melting at a low temperature, it was quite brittle, and when powdered was of a light yellowish colour.

This freshly prepared acid melted at 84°–85° C., and the melting point was the same after one month, but after six months the melting point had increased to 90°–91° C. Although acting similarly in some respects, yet, it is a different acid from the corresponding one in *Agathis robusta*. It was soluble in the cold in 70 per cent. alcohol, but not very readily, and on slow evaporation of the alcoholic solution, no crystalline product was obtained. The acid was dissolved in chloroform, and acetic anhydride added, when one drop of sulphuric acid changed this solution at once to a deep violet colour, which soon altered to an olive-green tint.

The acid was lævo-rotatory, but not very markedly so, and 0·8 gram in 10 c.c. alcohol in 100 mm. tube rotated the ray 0·9° to the left; the specific rotation was, therefore, $[\alpha]_D$ — 11·25°.

0·2408 gram acid dissolved in alcohol, required 8 c.c. decinormal NaOH to neutralise it; 40 grams NaOH would, therefore, neutralise 301 grams acid.

0·1664 gram in alcohol required 5·5 c.c. $\frac{N}{10}$ NaOH, so that 40 grams NaOH would neutralise 302 grams acid.

0·1559 gram required 5·1 c.c. $\frac{N}{10}$ NaOH, or 40 grams NaOH would neutralise 305 grams acid.

Analysis gave the following:—

0·1476 gram gave 0·4285 gram CO_2, and 0·1292 gram H_2O.

C. = 79·2; H. = 9·73 per cent.

$C_{20}H_{30}O_2$ requires 79·4 per cent. C, and 10 per cent. H.

The silver salt gave the following result:—

0·2184 gram silver salt gave 0·0574 gram silver = 26·28 per cent. Ag.

$C_{20}H_{29}AgO_2$ contains 26·4 per cent. silver.

From the molecular determinations, and the result of analysis, the formula $C_{20}H_{30}O_2$ is indicated for the acid of low-melting point in the resin of *Araucaria Cunninghamii*.

Ether Extract from the Resin Acids.

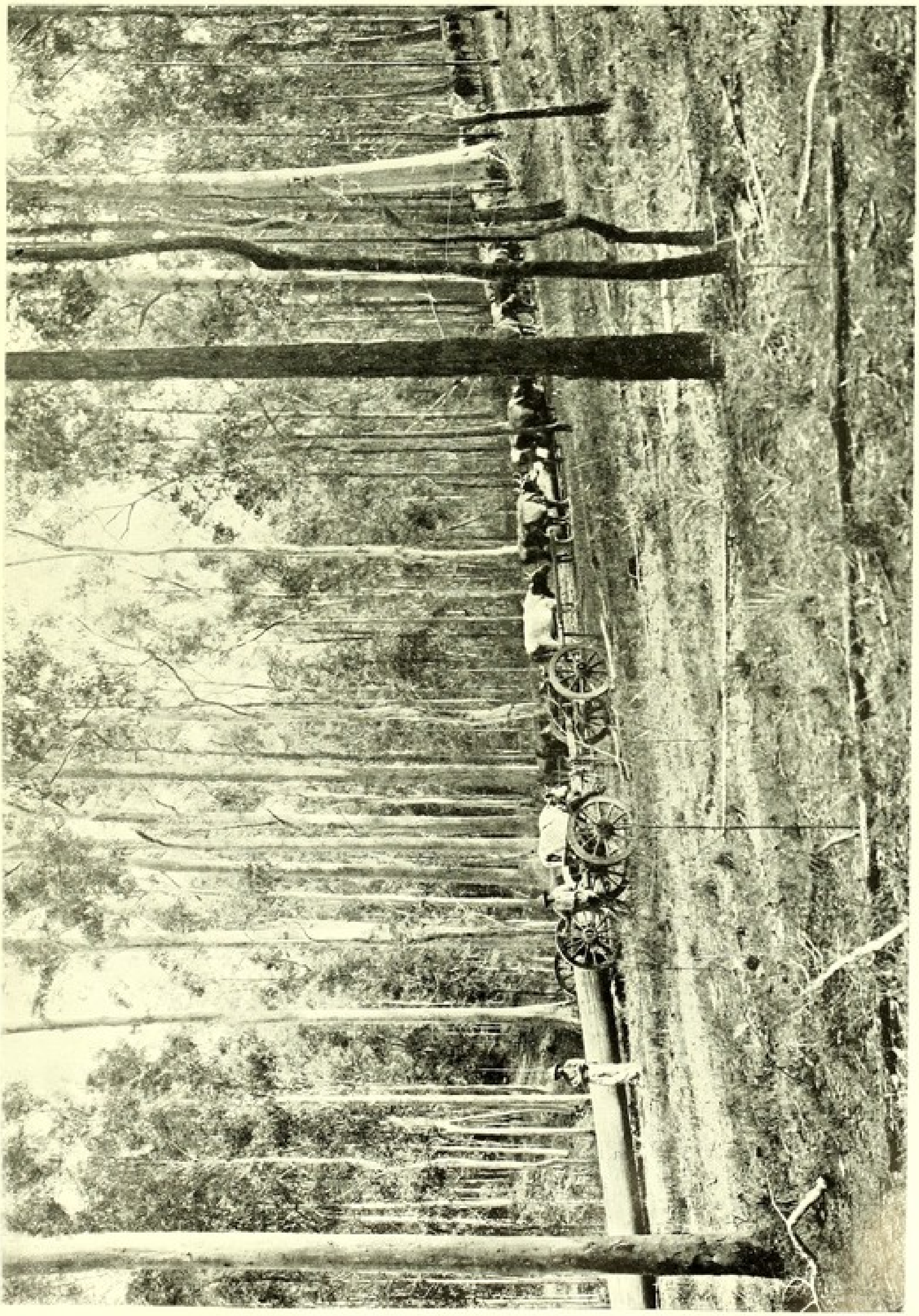
The ether from the 25 grams of resin, after the acids had been removed, was evaporated to dryness, and the residue heated on the water bath till constant. It weighed 5·86 grams, equal to 24·44 per cent. It was a soft, yellowish resin. and had a very bitter taste. It was lævo-rotatory, and 0·7293 gram dissolved in 10 c.c. alcohol in 100 mm. tube had a rotation of 4·4° to the left. The specific rotation was, therefore, $[\alpha]_D$ — 60·3°. It thus agrees in the direction of rotation with the acid of low melting point.

Nitrogenous Substances.

The residue, after the removal of the resins, was treated with alcohol for two days to remove possible traces of resinous bodies. When filtered off it was a swollen mass, light drab in colour, and when air-dried had shrunk considerably in bulk. It was powdered, and treated with water to remove any remaining gum and similar substances. When again dried it was powdered and finely sieved to remove a few particles of wood, &c. The powder thus obtained weighed 3·5 grams, or 0·51 per cent. of the latex. It was quite insoluble in water, alcohol, and similar solvents, and also in dilute acids, but it was mostly soluble in alkalis, even in the cold, and became yellow when heated with potash. When heated with soda-lime, ammonia was readily evolved. The amount of nitrogen present was determined by Kjeldahl's method, and the ammonia from 1 gram neutralised 2·1 c.c. H_2SO_4 = 2·94 per cent. nitrogen in the powder. It is thus apparent that the latex contained albuminous substances or other nitrogenous bodies, and it would be interesting to determine their identity. The severe treatment to which the latex had been subjected by continued boiling had evidently altered these bodies considerably, and destroyed the enzymes. Only the merest trace of manganese could be detected in the ash, so that that substance had been precipitated with the gum from the aqueous portion of the latex.

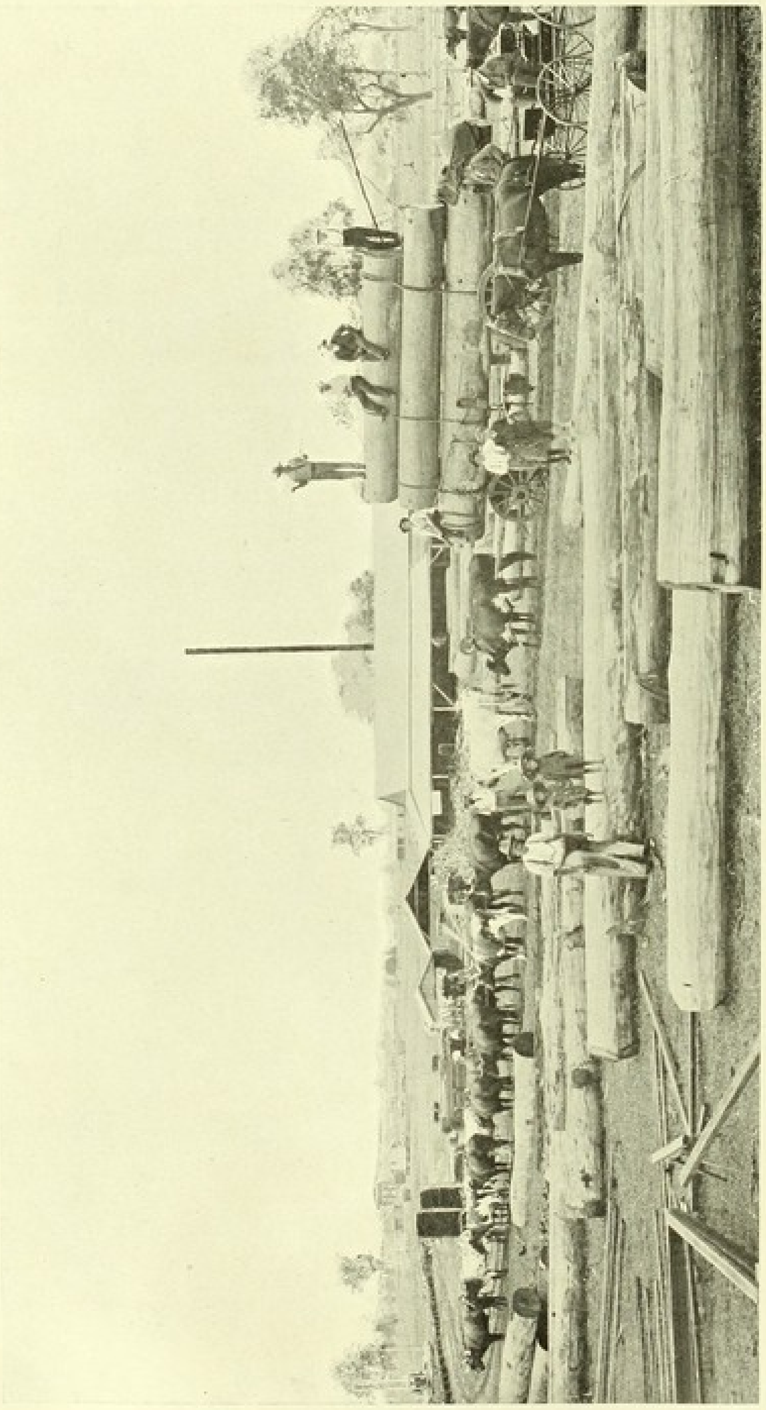
From the foregoing results the general composition of the latex of *Araucaria Cunninghamii* may be stated as follows:—

Volatile oil	=	3·800	per cent.
Free acids (calculated as acetic) ...	=	0·134	,,
Gum	=	8·000	,,
Resin	=	47·000	,,
Nitrogenous substances, &c. ...	=	0·510	,,
Woody residue	=	0·600	,,
Water and undetermined constituents by difference	=	39·956	,,
		100·000	

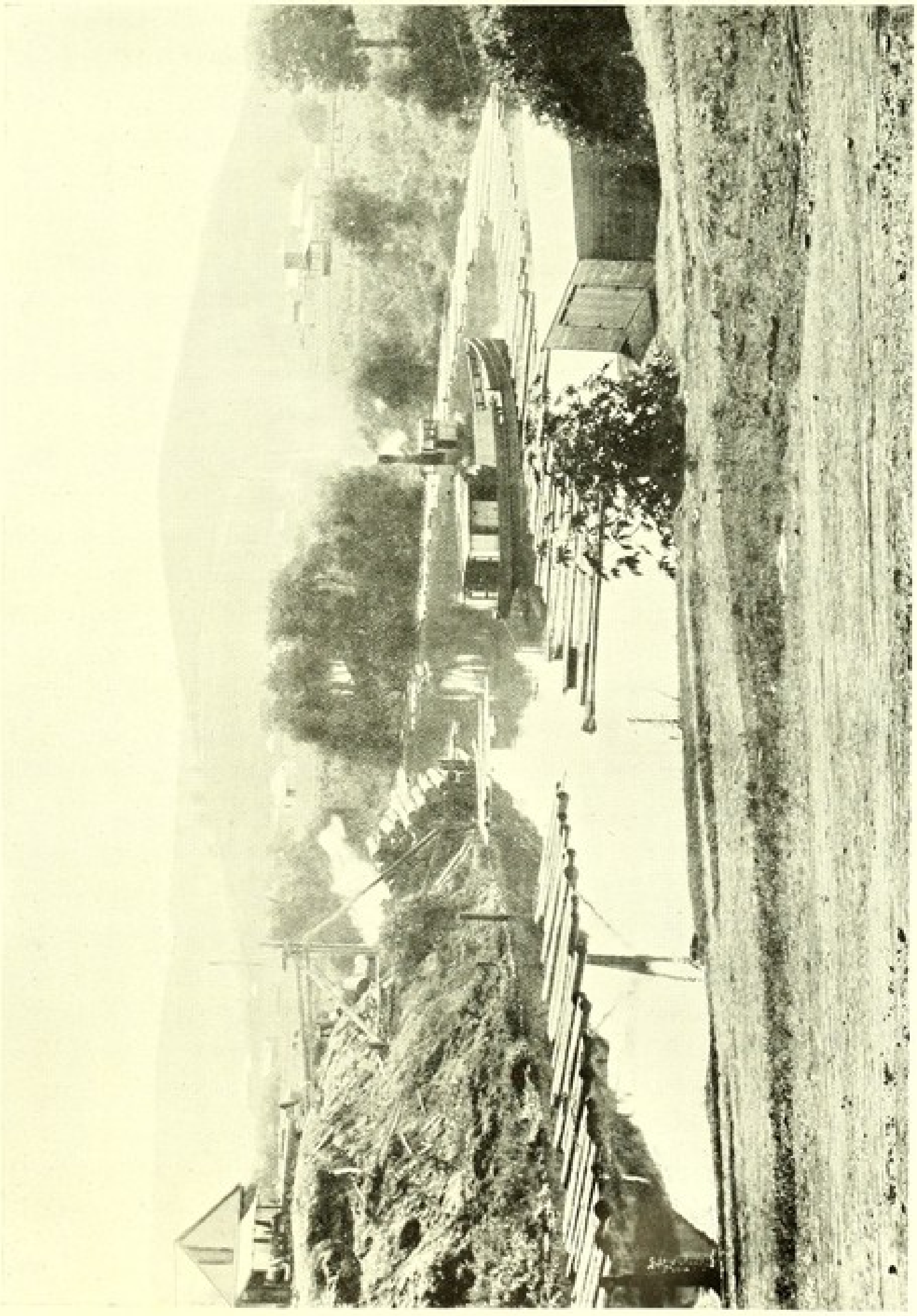


Frank H. Taylor, Photo.

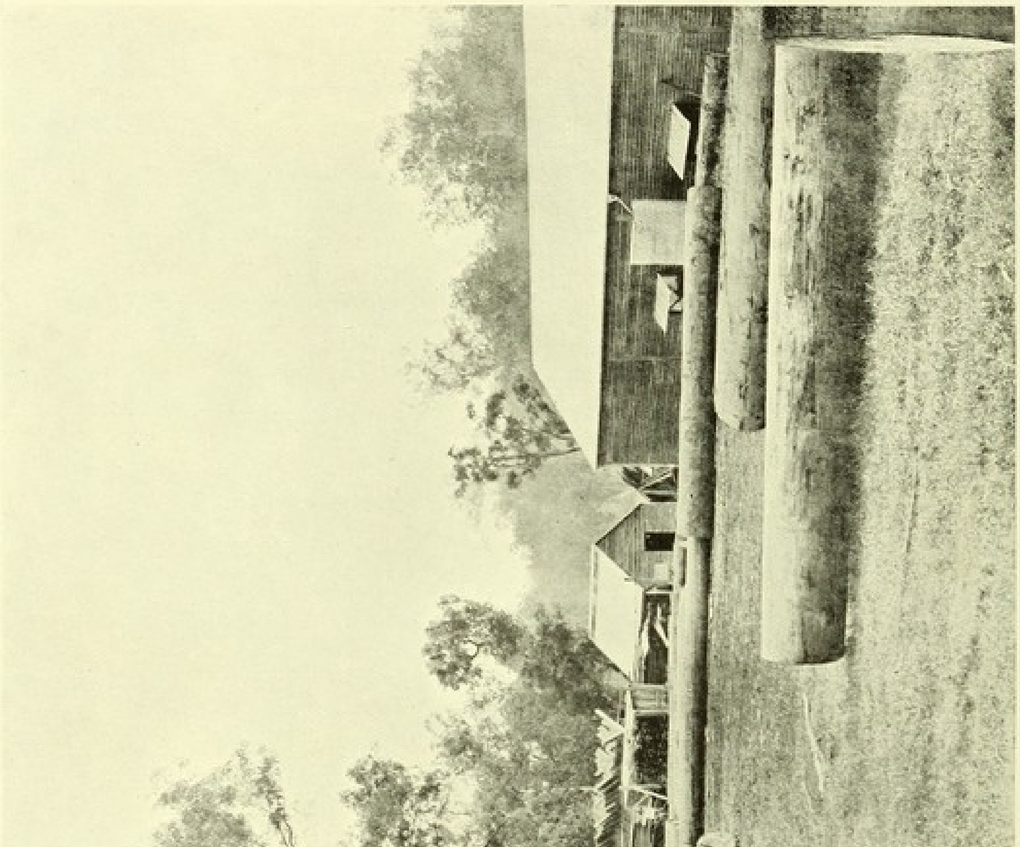
Araucaria Cunninghamii. HAULING LOGS AT SANDILANDS RANGE, N.S.W.



MODE OF LAND CARRIAGE OF LOGS OF *Araucaria Cunninghamii* TO SAW MILL, CASINO, N.S.W.



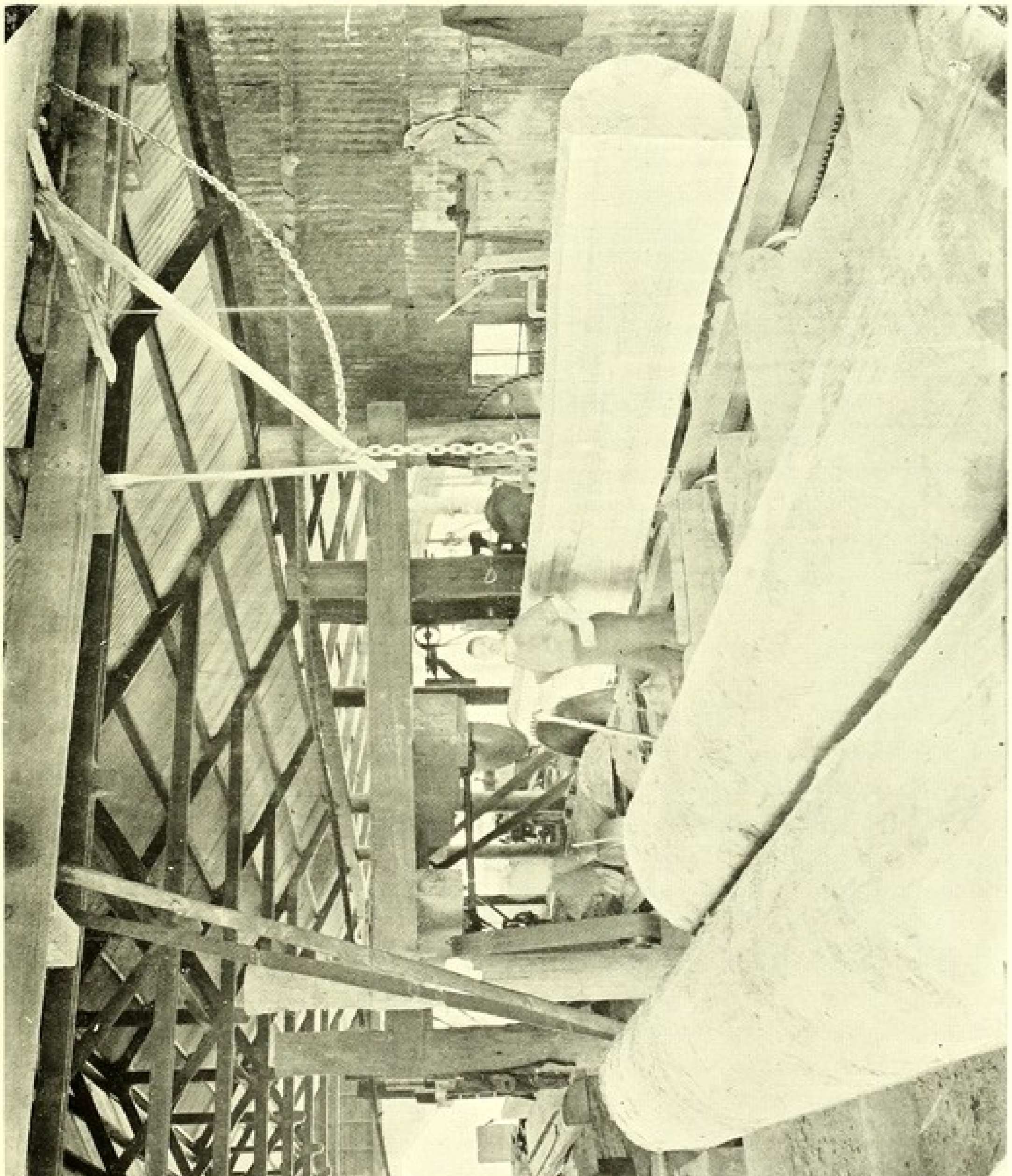
Mode of water carriage of rafts to Mill, Lismore, Richmond River, N.S.W. *Araucaria Cunninghamii*, Ait.



Frank H. Taylor, Photo.

"HOOP PINE." *A. Cunninghamii*, SANDILANDS RANGE SAW-MILL, N.S.W.

There are 250,000 ft. of Sawn Pine in the background. The logs average 6 ft. 6 in. girth.



Frank H. Taylor, Photo.

FLITCHING *Araucaria Cunninghamii* LOGS AT SANDILANDS RANGE SAW MILL, N.S.W.

ARAUCARIA CUNNINGHAMII, Ait.

"COLONIAL," "RICHMOND RIVER," OR "HOOP PINE."

Botanical Survey of the Species in New South Wales from data supplied by Public School Teachers and other correspondents, (*See Map.*)

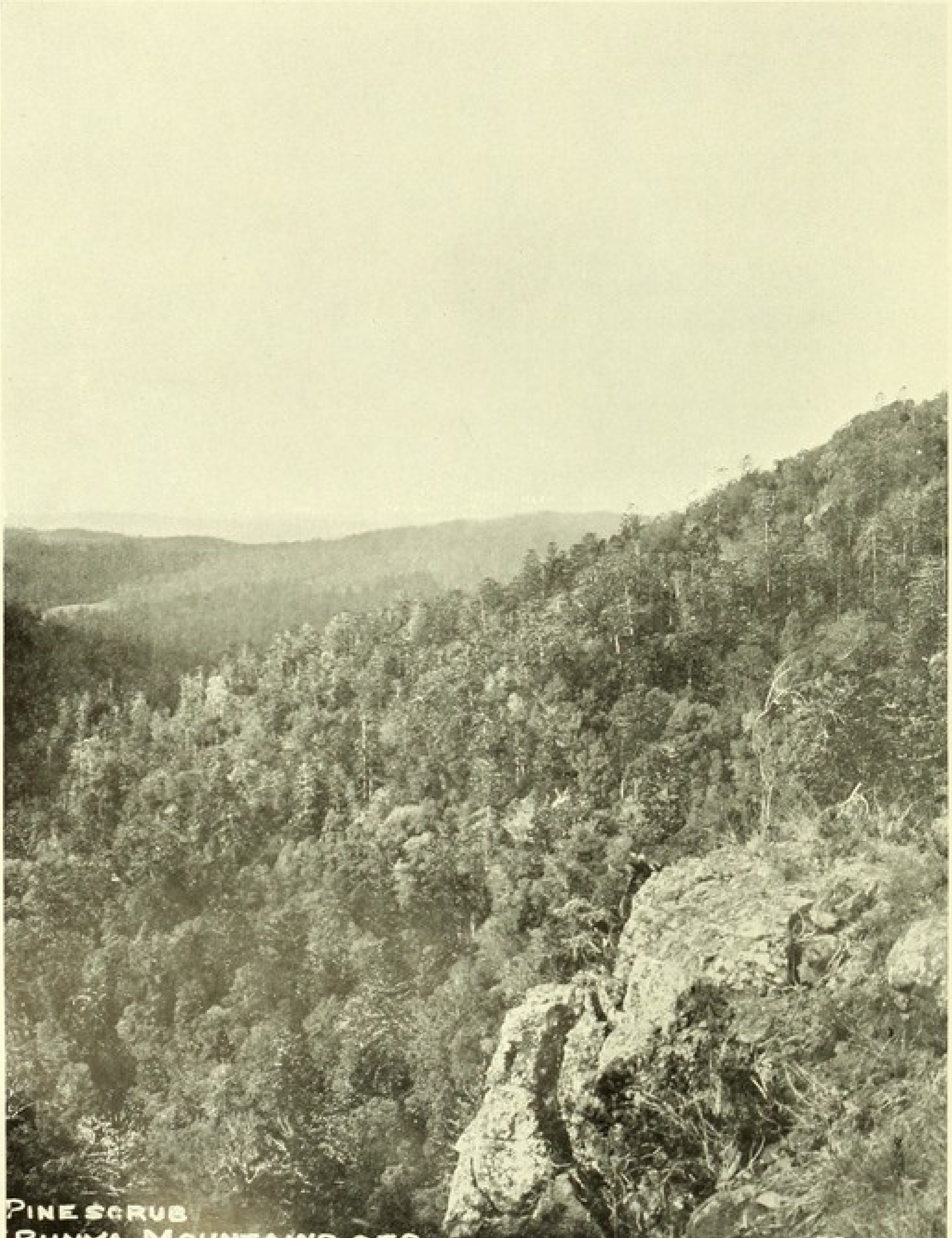
Locality.	County.	Remarks.
Acacia Creek	Buller	The Hoop Pine clothes the sides of the ranges for many miles, and it is impossible to give an idea of the area covered. Wherever the scrubs occur the Hoop Pine is very much in evidence. Every upland or scrubby flat or steep range has more or less pine growth. All the ranges dividing the waters of the various creeks in this northern coast district throughout their course are covered with scrub, and immense areas of pine are growing thereon. *Timber.*—The average height of this splendid tree cannot be less than 140 feet; diameter, 3½ feet to 4½ feet. I have seen logs taken to mills, girth 15 feet. *Resin.*—Hoop Pine gives a quantity, but none of these give the resin unless incisions are made, and that completely destroys the tree for timber if left. (W. E. Carpenter.)
Bonville, Coff's Harbour ...	Raleigh	Roughly, about 20,000 acres, inland 20 miles from Coff's Harbour. (J. J. Farrell.)
Boverie, Lismore	Rous	Occurs in belts or patches mixed with other timber. *Resin.*—The Hoop Pine exudes a deal of it, that is when the tree is cut or injured in any way, but not unless. (J. Jones.)
Burringbar	Rous	Grows on flat or hilly country amongst other timbers; area about 40 square miles. *Timber.*—Average height, 110 feet; average diameter, 2 feet 6 inches. (F. T. Clarke.)
Byron Bay	Rous	Plentiful. *Timber.*—150 to 200 feet high, 2 feet to 5 feet in diameter. (H. McLennan.)
Casino	Richmond ...	On the ranges at the head of the Richmond River, miles above Casino, there is a vast supply, which one would think inexhaustible. (J. C. Law.)
Dalmorton	Gresham ...	In patches on the mountains; thousands of acres. *Timber.*—Height, 80 to 100 feet; diameter, 2 feet 6 inches. (J. Cook.)
Dorrigo	Fitzroy	(C. F. Laseron.)

ARAUCARIA CUNNINGHAMII, AIT.—Botanical Survey of the Species—*continued.*

Locality.	County.	Remarks.
Guy Fawkes	Clarke	Grows plentifully.
Maryland, Tenterfield ...	Buller	A few trees. (J. S. Moss.)
Mullumbimby	Rous	Thousands of acres. *Timber.*—150 feet in height, and 3 feet in diameter. *Resin.*—Exudes a whitish substance; extremely sticky; highly inflammable. (Henry R. Anstey.)
Murwillumbah	Rous	(C. F. Laseron.)
Nambucca Heads	Raleigh	About 6,000 acres. (J. G. Myers.)
New Italy	Richmond ...	Scarce now, cut out some years back. (T. T. Morgan)
Pimlico North	Richmond ...	Only a few trees left. (Edward Tysoe.)
Sandilands Range	Drake	Some miles from Casino on the Tenterfield Road this species is abundant. (F. H. Taylor.)
Tintenbar	Rous	(L. C. Shaw.)
Tirrania Creek, Lismore ...	Rous	Found everywhere in the brushes and scrubs. (W. L. Lucas.)
Tuckombil, Alstonville ...	Rous	Occurs here. (W. M. Miller.)
Tumbulgum	Rous	In all the brushes. (John Cameron.)
Wardell	Richmond ...	Grows on the sides of nearly all the ridges in the Richmond and Tweed River Valleys. (A. Cousins.)
Woolgoolga	Fitzroy	(C. F. Laseron.)
Wyrallah	Rous	The local supply is almost exhausted, but near the upper waters of the Richmond, on the slopes of the McPherson Range, and on the Richmond Range hundreds of acres are covered with dense pine forests. (James Jacobs.)

A. Cunninghamii, var. *glauca*.

The tree which occurs on the rocky portions and islands of Northern Queensland, is considered by some authorities not to be identical with *A. Cunninghamii*, and has been placed under the varietal name *glauca*, but material was not procurable for this research.

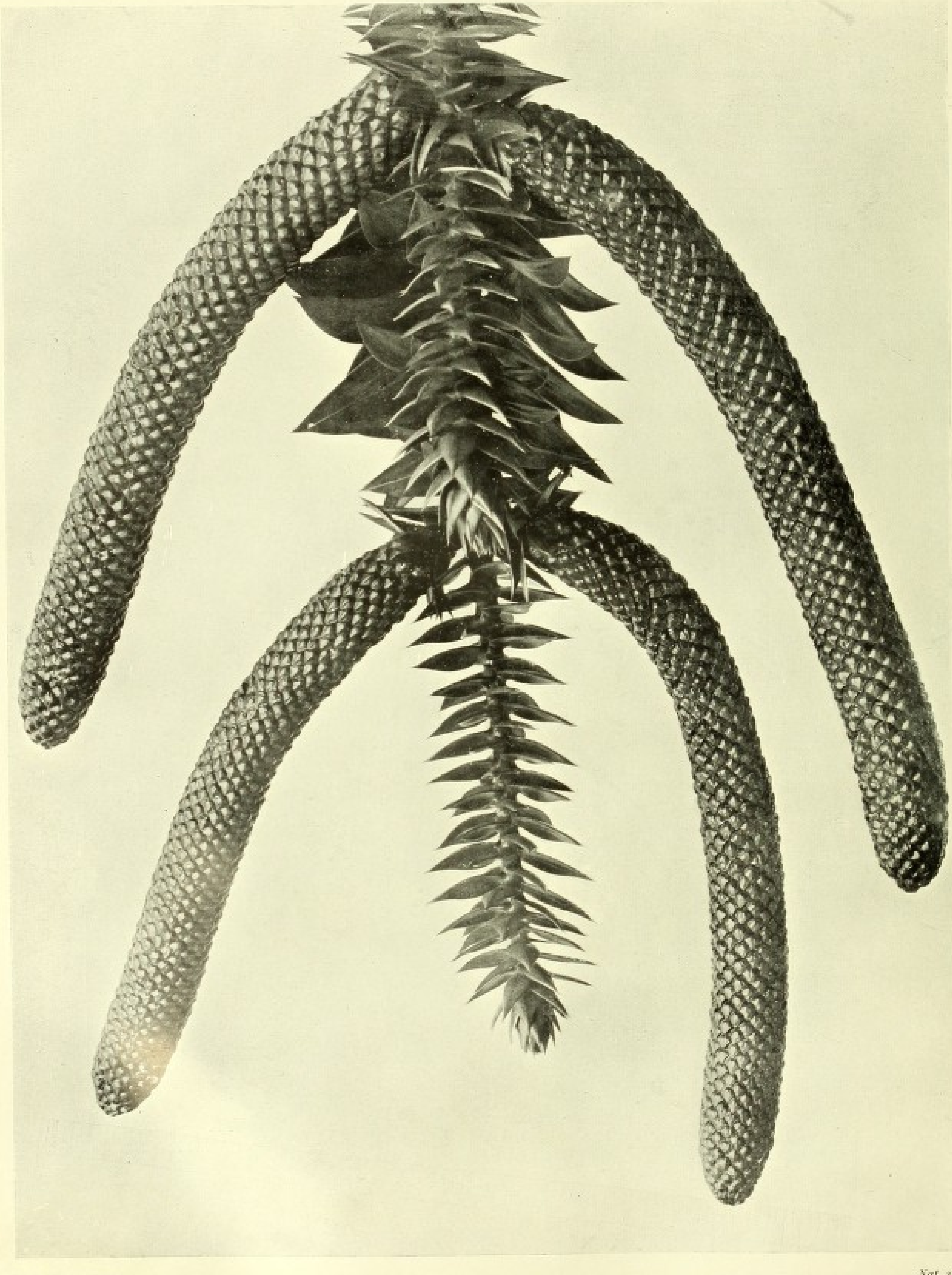


A Forest of *Araucaria Bidwilli*, Hook, Queensland.

F. H. Taylor, Photo.

Araucaria Bidwilli, "BUNYA BUNYA."

CULTIVATED AT ASHFIELD, N.S.W.



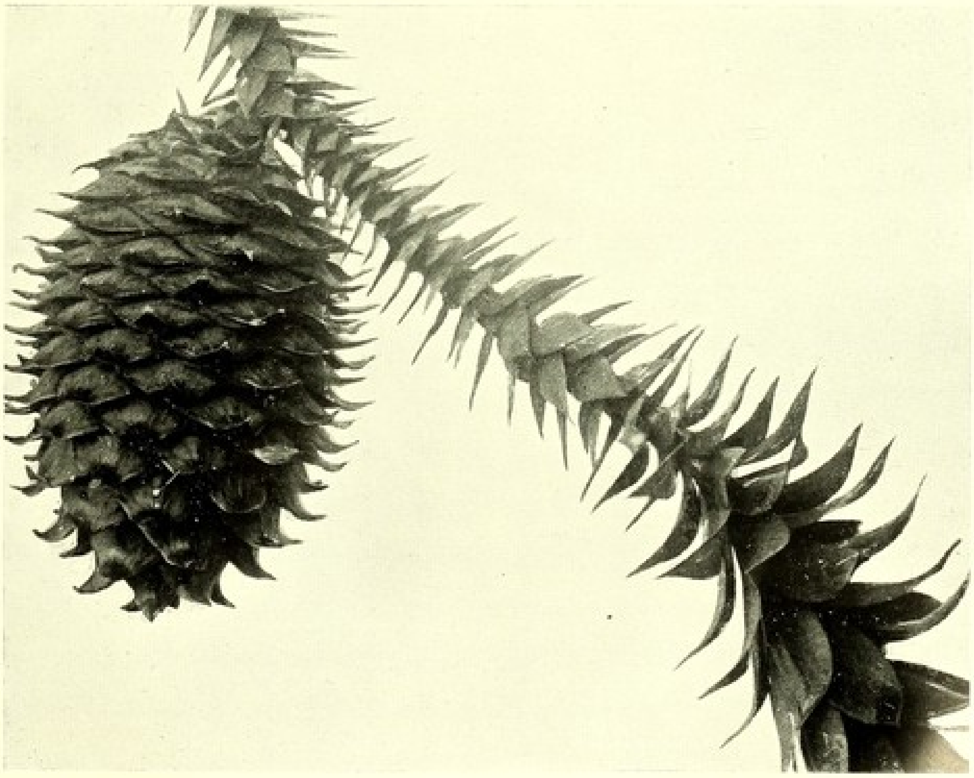
F. H. Taylor, Photo.

Nat. size.

MALE AMENTA OF *Araucaria Bidwilli*, HOOK. "BUNYA BUNYA."

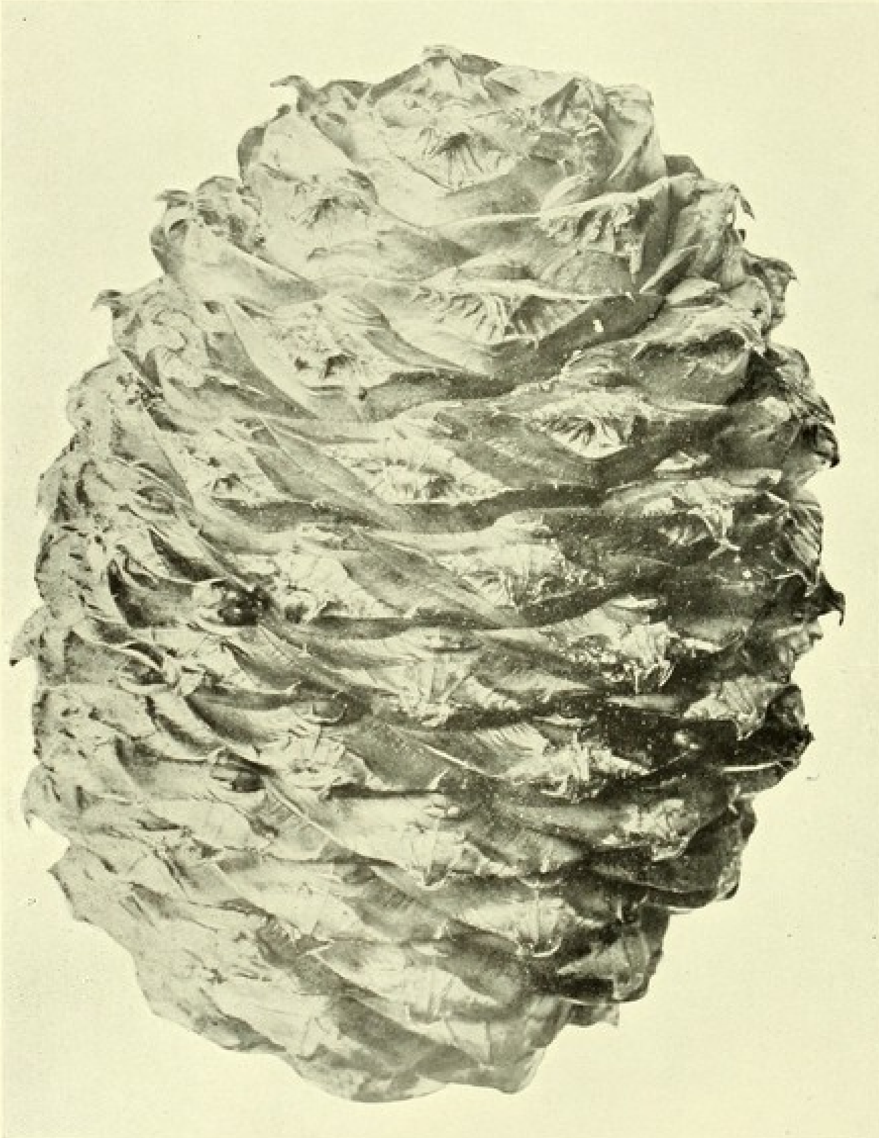
Much reduced;

MALE AMENTA TOWARDS THE TOP OF A TREE, OF *Araucaria Bidwilli.*



Frank H. Taylor, Photo. FEMALE AMENTUM IN EARLY STAGE OF GROWTH, *Half nat. size.*

Araucaria Bidwilli, HOOK.



Frank H. Taylor, Photo. *Half nat. size.*

CONE OF *Araucaria Bidwilli*, HOOK. "BUNYA BUNYA."

Frank H. Taylor, Photo. Nat. size.

Araucaria Bidwilli, HOOK. "BUNYA BUNYA."

1. LOWER PORTION OF CONE WITH TOP SCALES REMOVED. 2. INDIVIDUAL SCALE. 3. SEED. 4. TWO HALVES OF NUT SHELL.

2. Araucaria Bidwilli.

Hook., Lond. Jour. Bot. II, 498, t. 18.

"BUNYA BUNYA" OR "BON-YI."

HABITAT.

Coast district of Queensland.

I. HISTORICAL.

"Bon-yi," the native name for the pine *Araucaria Bidwilli*, has been wrongly accepted and pronounced "bunya." To the blacks it was "bon-yi," the "i" being sounded as an "e" in English—"bon-ye." The bon-yi tree bears huge cones, full of nuts, which the natives are very fond of. Each year the trees will bear a few cones, but it was only in every third year that the great gatherings of the natives took place, for then it was that the trees bore a heavy crop, and the blacks never failed to know the season. (From "Tom Petrie's Reminiscences of Early Queensland" by his daughter. Brisbane, 1904, p. 11.)

This valuable forest tree appears to have been first made known to white men by Mr. Andrew Petrie, Superintendent of the Government Works at Moreton Bay in 1838, who gave specimens to Mr. J. S. Bidwill. The latter gentleman took material with him to England, and the tree was described by Sir William Hooker, *l.c. supra*.

This species is interesting as it is closely allied to its congener *A. imbricata*, Pav., of South America, and to which species it is certainly very much more closely connected than to *A. Cunninghamii*. In fact, we are strongly inclined to suggest that the genus be subdivided, taking the two Australian species as types of the two groups, between which there are marked differences.

II. SYSTEMATIC.

This is a beautiful forest tree attaining over 150 feet in height, and now much cultivated for its symmetrical shape and the remarkable appearance of its whorled branches, with their spirally arranged leaves, which give it a facies more nearly approaching the South American *A. imbricata* than its Queensland congener, *A. Cunninghamii*. It is, however, a very much quicker grower than the South American pine.

The leaves are numerous, homomorphic, imbricate, spirally arranged, lanceolate to ovate-lanceolate, sessile, under 2 inches long, shining, and broad at

the base, midrib not more developed than the numerous lateral veins, very sharply pointed. Male amentum is sessile, arranged in closely and spirally packed catkins* towards the end of the branches, sometimes over 6 inches long, and ½ inch in diameter, the imbricate scale-like apices of the stamens four-sided.

Fruit cones on the higher branches, ovoid, globose up to 12 inches high, and 9 inches in diameter; the scales imbricate, 4 inches long and 3 inches broad, tapering towards their winged base, the point of the sporophyll recurved and spinescent. A cone 10 lb weight was obtained from a tree, having also male catkins.

III. LEAVES.

(*a*) Economic (none known to us).

(*b*) Anatomy.

A cross-section of the outer portion of a leaf is given in Figure 251, which gives a fair idea of the position of the various cells in that portion of the leaf, and similar to the other structure, which goes to make up the whole leaf substance.

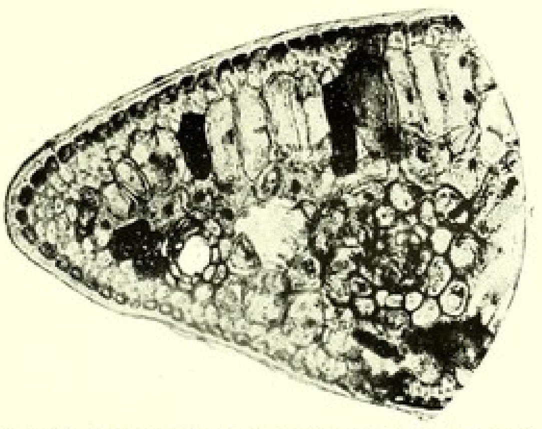


Figure 251.—Transverse section through one edge of a leaf, showing how the hypodermal cells are packed below the single row of epidermial cells at the extreme edge. One oil gland surrounded by secretory cells is seen to the left, and to the right is a bundle surrounded by endodermal cells. The two rectangular black patches on the palisade parenchyma are manganese compound from their original cells. *A. Bidwilli*, x 260.

The assimilatory surface is the outer one, and the cuticle of this is backed by a single row of very numerous, small, epidermal cells, followed by one of thick-walled hypodermal cells, and these in turn are succeeded by a row of palisade parenchymatous cells, having their long axes at right angles to the cuticle, and forming about a third of the whole leaf tissue, although absent from the transpiratory surface.

The epidermal and hypodermal cells extend right round the leaf but the latter are packed at the edges of the leaves, and more pronounced on the outer surface.

*To determine the amount of pollen, two of the green but mature catkins were taken. They each measured 13 centimetres long, by a mean diameter of 16 millimetres. They were placed in glass dishes on 22/9/09, and by the 14th of the following month the whole of the pollen had been shed, the catkins then being quite dry. The pollen was sulphur yellow. The amount shed by one catkin weighed 1·2946 grams, and that from the other 1·626 grams, or together 2·9206 grams.

The fundamental tissue is composed of spongy mesophyll consisting of thin-walled, irregularly shaped cells, with intercellular spaces, and running through the length of which, at regular intervals, are oil cavities and bundles.

The bundles have their xylem abnormally orientated, and are surrounded by a protective sheath of endodermal or parenchymatous cells enclosing, along with the bundle, a small number of sclerenchymatous cells on the outer edge of the phloem.

Scattered through the spongy mesophyll are nucleated or pitted cells,—the transfusion tissue.

The oil glands are small and surrounded with regular secretory as well as protective cells, and occur in the same plane as the bundles.

The stomata occur on the inner face of the leaf, the physiological significance of which is identical with that of *A. Cunninghamii* and the *Callitris*.

By comparing this structure with that of *A. Cunninghamii* distinct differences are found. Here the oil cavities and bundles are in the same plane, the hypodermal cells are less numerous, and the transfusion cells belong to a different class,—features that support the differentiation of the species, if not a sub-class.

IV. TIMBER.

(*a*) Economic.

This is a fine forest tree attaining sometimes a height of over 150 feet, and possessing a pale-coloured, fissile timber, utilised for similar commercial purposes as "Hoop Pine," *A. Cunninghamii*.

It is widely distributed on the Coast District of Queensland, and flourishes well as an introduced tree in the other States, and is here strongly recommended for forest culture as one of our future supplies of softwood.

Transverse Tests of Timber, *Araucaria Bidwilli*.

(Standard size, 38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen, inches	B 2·98; D 2·96	B 2·99; D 2·97	B 2·98; D 2·98
Area of cross section, square inches	8·82	8·88	8·88
Breaking load in lb. per square inch ...	3,165	2,290	1,742
Modulus of rupture in lb. per square inch ...	6,553	4,721	3,555
,, elasticity ,, ,, ...	1,822,500	1,600,000	959,210
Rate of load in lb. per minnte	452	381	387

(*b*) Anatomy.

Unlike its congener, no work appears to have been done concerning the anatomical structure of the wood.

The various sections examined show good specific differences, for instance, it is seen that in the tangential section the medullary rays, whilst otherwise resembling those of *A. Cunninghamii*, yet have their cells filled with the brown or dark substance, the manganese compound, as shown in Figures 252–4, and the perforations between the cells of the medullary rays and the lumina of the tracheids, differ from those of *A. Cunninghamii*, being fewer in number and having circular orifices. The disposition, however, of the pitted cells corresponds with those of *A. Cunninghamii*, and the simple cells communicating with each lumen of the tracheids generally number about four.

In a radial section the cells of the medullary rays are often found filled with this substance, but their walls appear to be very delicate, as they break easily, and stain a darker colour than those of *A. Cunninghamii*. They are well seen in Figure 254, where it will be noticed that all the cells, both outer and inner of the rays, have practically right-angled end walls, which shows, as regards the character of the outer cells, a distinction from some non-Australian genera of the Coniferæ.

The walls as stated above are very thin, and in sectioning are almost invariably folded over between the end walls, *vide* Figure 254.

The principal features of difference in a transverse section compared with *A. Cunninghamii* are, (1) the dark-brown content of the medullary rays running through the picture like black bands, Figure 252, (2) the general absence of this dark substance in the tracheids of the xylem so plainly seen in *A. Cunninghamii*.

In Figure 254 are also shown the double rows of bordered pits in the walls of the tracheidal cells.

(*d*) Forestry (*vide* introduction to this genus.)

V. BARK.

(*a*) Economic.

(*Vide* Chemistry, *infra*—Composition of the Exudation, &c.)

(*b*) Anatomy.

The structure of the mature bark differs entirely from that of any Conifer examined during this research, or any other figured and described, so far as we

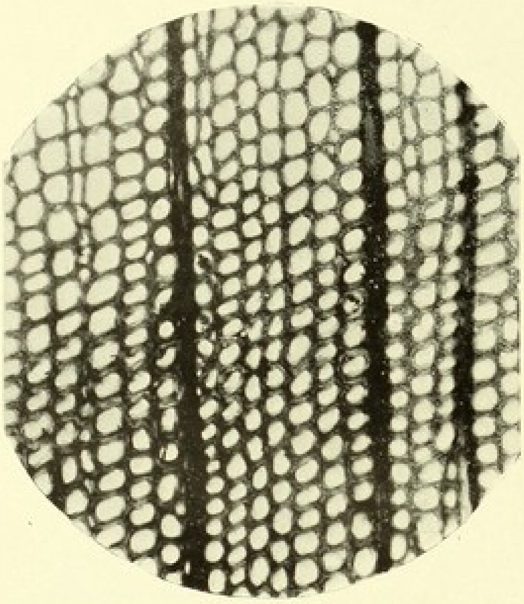


Figure 252.—Transverse section of timber. The dark lines mark the rays. *A. Bidwilli*, × 120.

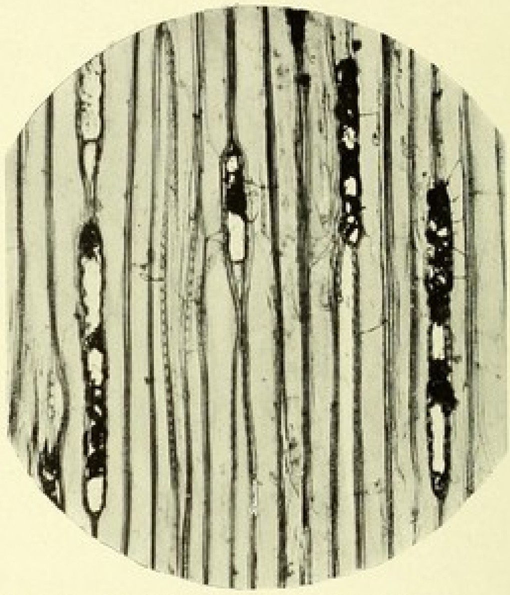


Figure 253.—Tangential section of timber of *A. Bidwilli*, × 120.

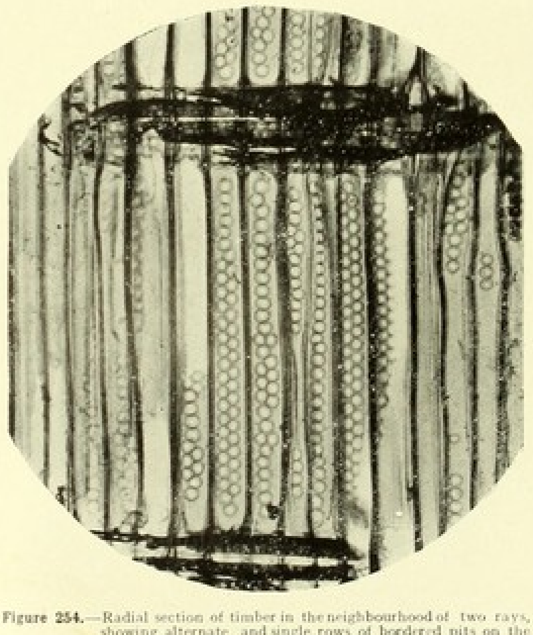


Figure 254.—Radial section of timber in the neighbourhood of two rays, showing alternate and single rows of bordered pits on the radial walls of the tracheids. *A. Bidwilli*, × 120.

Sections of timber of Araucaria Bidwilli, Hook.

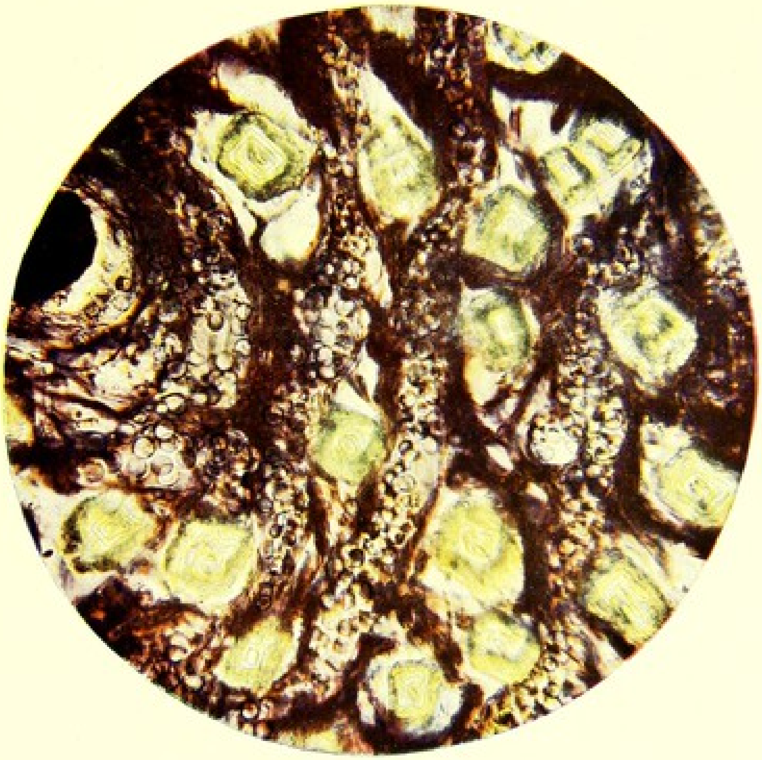


Figure 256.—Transverse section through a portion of inner bark, showing the predominance and irregular distribution of bast fibres in this part of the cortex. They are the yellowish-coloured rectangular bodies with a thick outer wall substance, and a laminated wall structure towards the mid-channel. The medullary rays extend from top to bottom of the plate in sinuous bands. The circles indicate the starch granules. The dark patch on the left marks an oleo-resin cavity. Stained with hæmatoxylin. *Araucaria Bidwilli*, × 120.

have been able to ascertain, for apart from other distinctive features there appears to be no regular concentric layers of cells such as one finds in the *Callitris*, and figured in this work. From the cambium outwards the whole collection of cells and fibres is a complete medley, and even the medullary rays, which almost invariably preserve some disposition in conformity to their name, fail in this respect in this species of *Araucaria*.

The medullary rays run through the bark in a sinuous course and are thickly studded with starch granules, distinctly seen in Figure 256. The rays are not many cells high, and only one in width, and can be traced running obliquely across the picture in Figure 255, which is not so great a magnification as the coloured Figure 256; they became less in definition as the outer cortex is reached.

The rest of the material between the cambium and periderm bands which forms the extreme outer layers of the cortex, is composed, apparently, of two forms of cells, viz., the sclerenchymatous fibres, and short parenchymatous cells either empty or starch containing. In shape and perhaps character, the former are quite in accord with Australian Conifers as far as our knowledge goes, and possess features which occur in barks other than in this genus. They are true canals in character, having no septa, but preserve an unobstructed direct communication with the roots, from which each extends as a continuous body or substance; when viewed in cross-section (Figure 256) they are rectangular in shape, with thickened borders, the substance extending to the central canal being of a laminated structure, apparently formed by deposition from fluid content similar perhaps to deposits of carbonate of lime found in tubes or pipes, formed from water carrying this mineral in solution. The median channel is well shown in Figures 256 and 260. The continuity and solidity of this substance is seen in Figure 260, where, after all the surrounding tissue has been removed, they remain intact, whilst still a part of the surrounding cell is embedded or contained in solid bark material. The median line seen is the central channel. A cluster of parenchymatous cells are shown at the bottom between the two left bast fibres.

Under a quarter-inch objective it was found that the sides and ends of this substance were thickly studded with crystals of a rhombus form similar to those figured in De Bary, p. 132, after Sach, and who describes them as crystals of calcium oxalate; but ours are not that substance as proved by chemical tests; but what they are we are not prepared to say at present as they require further investigation, and the same remarks apply to the body substance itself. These long rod-like bodies have been classed as sclerenchyma fibres, or bast cells. They certainly do not differ much from the bast cells of *Callitris* in structure, and form, as it were, part and parcel of the whole matrix. These substances appear to be formed by the slow deposition of the altered liquid moving in the cells

Figure 259.—Longitudinal section through bark. *A. Bidwilli*, × 80.

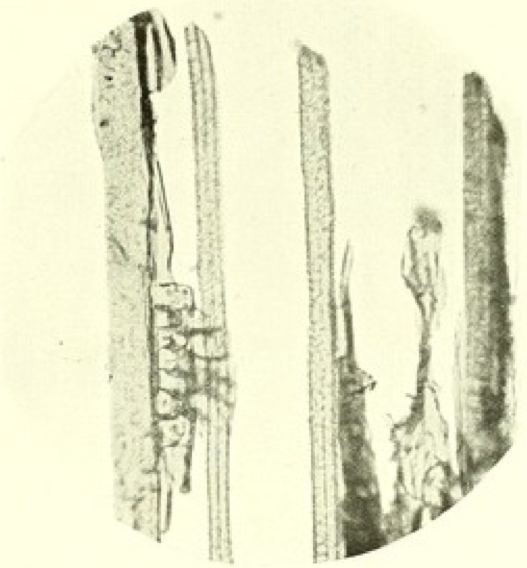
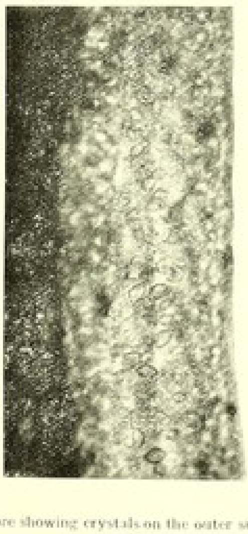
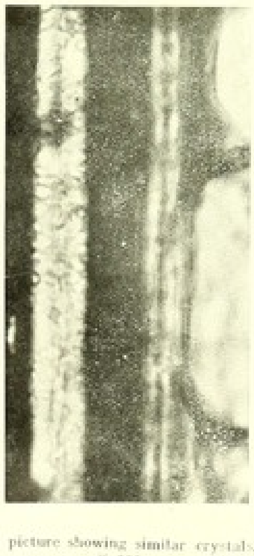


Figure 260.—Longitudinal section through bark, showing the rigidity of bast fibres, for in this instance four fibres remain standing after the intervening tissue has been removed. The median channel is seen in the two centre fibres. *A. Bidwilli*, × 150.



Portion of a bast fibre showing crystals on the outer surface. *A. Bidwilli*, × 350.



Bast fibre on left of picture showing similar crystals. *Callitris robusta*, × 500.

Sections of bark of Araucaria Bidwilli, Hook.

themselves; each, apparently, has no connection with the neighbouring cell walls, from which they are quite free; in fact they may be likened to so many hollow glass rods in a number of tubes. It is quite possible they may be an intermediate stage in the formation of cellulose. They are identical in character with the bast fibres of *Callitris*, which also have similar crystals on the outside.

Their chemical composition was not ascertained on this occasion, as such an investigation would have further delayed publication.

At irregular intervals, or rather scattered throughout the bark substance, are clusters of stone cells, Figure 258 (the mass in the centre of figure from top to bottom). Two or three parallel periderm layers occur close to the outer edge of the cortex, the intervening inner and outer cortex being composed of masses of stone cells, parenchymatous cells, and rod-like bast cells above described. No sieve tubes were found.

(*c*) CHEMISTRY.

The bark of this tree was somewhat of a spongy nature and was astringent, so that a determination for tannins was made. The bark when dry was readily powdered, and when extracted with boiling water gave an extract of good colour, which acted readily on hide powder. The determination was made with chromed hide powder, according to modern methods, and the following results were obtained:—

Total extract	19·67 per cent.
Tannins	10·40 ,,
Non-tannins	9·27 ,,
Moisture	10·66 ,,

The tannins gave a green coloration with ferric chloride, and the indications were altogether those for a commercial tanning material, although, unfortunately, the percentage of available tannin in the bark of this species is not great. The non-tannins consisted largely of gum precipitated by alcohol. The bark was found to contain a marked amount of starch, but no calcium oxalate was detected. There was also present some material soluble in alkalis and precipitated again by acids, and this reaction was particularly marked with dilute ammonia, the substance dissolving to a purplish colour, and it had some of the other reactions characteristic of Stahlschmidt's polyporic acid. It was, however, stained a deep blue with iodine, and was quite insoluble in boiling water, even after some time. The presence of starch in the bark, and the peculiar nature of the gum, which in the jelly form particularly is coloured bright yellow by iodine, indicate that these bodies are somewhat nearly related to some modification of the members of the cellulose group, and may, perhaps, be connected with the peculiar cellular arrangement of portions of the bark of this tree.

CHEMISTRY OF THE EXUDATION.

This exudation, which consisted almost entirely of gum, was obtained from a large cultivated tree, 2 feet in diameter, growing at Marrickville, near Sydney, and was collected during the last three months of the year 1908. Sex appears to have no influence upon the composition of the exudation ; because, when the large green fruits were cut through, they were found to be charged with sap identical in appearance and composition with that obtained from the trunk of the tree. When dried, this gum from the fruits had the same slightly aromatic odour, was quite as brittle, dissolved just as readily in water to a turbid solution, due to the presence of the same small amount of oleo-resin, and formed the same insoluble jelly when agitated with ether.

Dr. Lauterer (loc. cit.) says that the percentage amount of gum and resin in the exudation of this tree varies much at different times of the year, but our results do not confirm that statement. The material obtained from our specimen was identical in composition, whether obtained in September or in December, and a specimen of the gum of *A. Bidwilli* in our possession, which was collected in Brisbane in July, the colder time of the year, was found to be identical in composition with that of our own collecting. It had the same slightly aromatic odour, and an analysis showed it to contain less than 2 per cent. of oleo-resin. The gum was also readily soluble in cold water, just as adhesive, and on agitating with ether it eventually changed largely into the jelly-like insoluble form, only this change took place less readily than with the freshly procured material. The tree growing near Sydney was wounded, September, 1908, by cutting quite through the bark in places, and also by cutting off the old scars left by the decayed branches. A very fluid liquid quickly exuded from the wounds, and formed tears which soon dried, becoming quite hard and brittle. In the places where the bark had been cut through, the upward flow continued for months; this has been referred to previously under *A. Cunninghamii*. The exudation when dried resembled in appearance some kinds of wattle gum. It was amber-coloured, mostly semi-transparent, very brittle, bright in the fracture, and was slightly aromatic. This gum-like substance dissolved somewhat readily in water to a turbid, slightly acid solution, which gave a dense precipitate on the addition of excess of alcohol. The precipitate, when spread on glass, became quite a transparent gum which again dissolved readily in water. It did not become dark coloured on drying like the gum of *A. Cunninghamii*, although manganese was detected in it. There were present in the exudation very small amounts of volatile oil and resin, thus differing from that of *A. Cunninghamii*, and also from the exudations of the Coniferæ generally. Four grams of picked gum, dissolved in water, and agitated with 25 c.c. of ether, soon separated the gum as an insoluble jelly, and from which the ether had removed most of the resin,

and 10 c.c. of the ether gave 0·026 gram of a soft aromatic resin = 1·62 per cent. A determination with alcohol gave the following result:—Two grams of the air-dried gum, dissolved in water, were precipitated by excess of alcohol; the clear filtrate was evaporated to dryness, treated with ether to remove a small amount of gum, and the ether evaporated. The amount of soft resin thus obtained was 0·044 gram, equal to 2·2 per-cent. of oleo-resin. One might thus suppose that the manganese in the exudation of *A. Cunninghamii* was utilised more largely in the formation of the resins. When the air-dried exudation was ignited it gave 2·02 per cent. of a perfectly white ash, which consisted almost entirely of the carbonates of lime and magnesia:—$CaCO_3$ = 49·7 per cent., $MgCO_3$ = 49·9 per cent., Mn.. = 0·019 per cent.

The moisture in the air-dried material was 15·12 per cent. and this was almost entirely taken up again on standing in the air.

The mucic acid was determined in the usual way, and 2 grams of air-dried material gave 0·351 gram mucic acid = 17·55 per cent. This is a little less than was obtained with the gum of *A. Cunninghamii*.

The gum after treatment with ether was quite insoluble even in boiling water, and gave a bright yellow colour with iodine.

There was an absence of reducing sugars in this exudation, and Fehling's solution was not reduced.

For the determination of the sugar formed by hydrolysis, the gum was boiled for some hours with a dilute solution of sulphuric acid. The acid was removed by barium carbonate, the filtrate evaporated down, and the unaltered gum removed by alcohol. On evaporation, a syrup was obtained which eventually became somewhat crystalline. The sugar formed was dextrorotatory, and it strongly reduced Fehling's solution. The indications, however, for either arabinose or xylose were not convincing, and its identity remains in abeyance.

It is, perhaps, remarkable that a soluble gum giving mucic acid on oxidation, should be rendered insoluble and changed into a jelly by the simple agitation with ether. The reaction is of interest and worthy of further study. On keeping the gum of *A. Bidwilli* for many years, it did not entirely lose this property, although it became modified somewhat, and less distinctive. No jelly of an insoluble nature could be obtained with the gum of *A. Cunninghamii* by this reaction, thus indicating a different molecular arrangement of the carbo hydrates in the two trees.

THE GENUS AGATHIS.

Salisb. in Trans. Linn. Soc., viii., 311, t. 15, non Gaertn.

I. HISTORICAL.

This name is adopted in this work, following the example of Bentham and Hooker in "Genera Plantarum," but for want of literature it is difficult to express an opinion as to whether Rumphius's name of *Dammara* should claim priority. Baron von Mueller, 2nd Cens. 1889, uses Rumphius's name *Dammara*, 1741, as against Salisbury's *Agathis*, 1807.

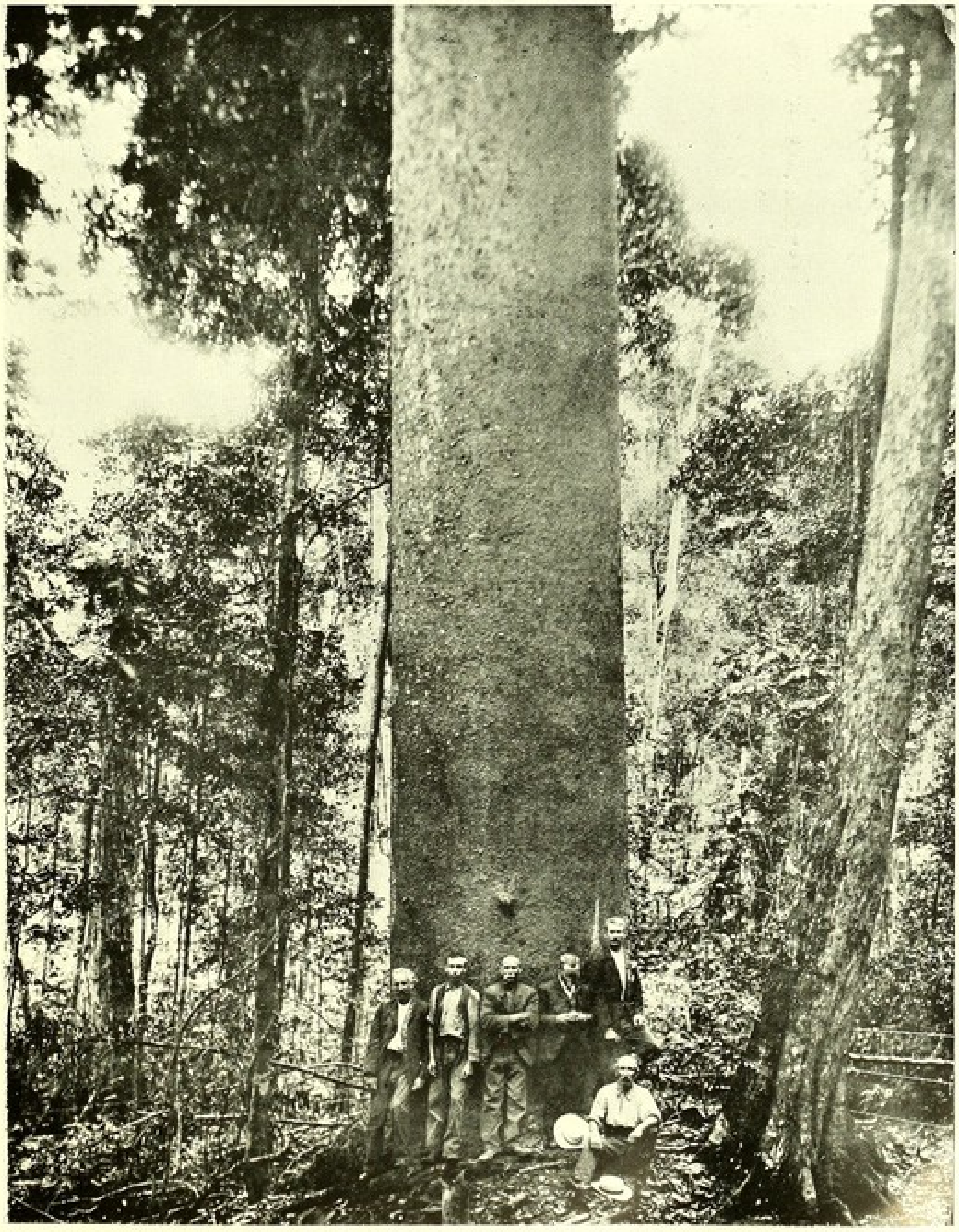
Only two species occur in Australia and these are found in the dense forests of the Queensland coast. They are lofty trees, having spirally arranged, flat leaves, similar to their congeners in New Zealand, Fiji, New Caledonia, Malay Archipelago, Brazil, and Chili.

Ettingshausen (l.c. pp. 98 et 99, pl. viii) records two species of *Dammara* from the Tertiary period occurring at Tingha, N.S.Wales.

II. SYSTEMATIC.

The flowers are diœcious, the amenta being sessile or nearly so Male amentum catkin-like, axillary or lateral, surrounded by a few imbricate scales at the base; the microsporophylls occur in a close spiral series, each being dilated at the top and slightly incurved. Microsporangia numerous, cylindrical, pendulous. Female amentum globose, terminal or lateral, macrosporophylls spirally arranged, continuous with imbricate scales at the base. Macrosporangia solitary, pendulous. Fruit cone medium size, ovoid-globular, macrosporophylls closely imbricate, deciduous, flattened, broadly cuneate, more or less winged, almost woody. Seeds oblong-cuneate, flattened, truncate or emarginate at the end, one margin produced into a horizontal, erect, or decurved wing.

Agathis robusta. "QUEENSLAND KAURI."



A FINE TREE OF THE "QUEENSLAND KAURI." *Agathis robusta*,

Agathis robusta. CULTIVATED IN PERADENIYA GARDENS, CEYLON.

LEAVES OF *Agathis robusta*, C. MOORE. "QUEENSLAND KAURI."

Nat. size.

Agathis robusta.

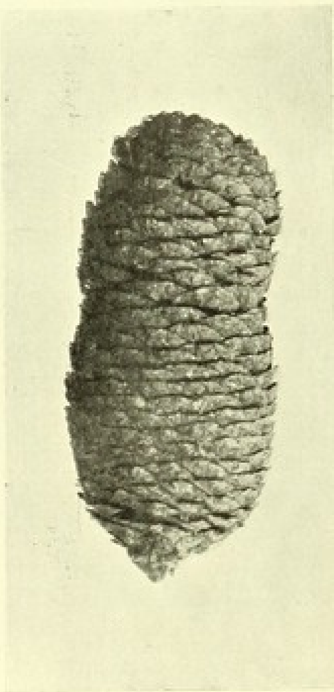
C. Moore, F.v.M., in Trans. Pharm. Soc. Vict. II, 174.

"QUEENSLAND KAURI" OR "DUNDATHU PINE."

(Syn.:—*Dammara robusta*, C. Moore, B. Fl. VI, 375.)

I. HISTORICAL.

(*Vide* supra.)



Agathis robusta. FRUIT CONE.

II. SYSTEMATIC.

This is a fine, tall, upstanding tree, attaining a height of 150 feet and over, generally with a long straight barrel free from branches. Leaves more often ovate than lanceolate, thick, from 4 to 6 inches long, and up to 1 inch wide, mostly obtuse, shortly petiolate, midrib not prominent, finely striated longitudinally from secondary bundles. Male amentum catkin-like, axillary or lateral, surrounded by a few imbricate scales at the base, under 2 inches long. Fruit cones ovoid-globular, under 5 inches long, and rather less than 4 inches in diameter; macrophylls as broad as long, closely imbricate, deciduous, flattened, broadly cuneate, more or less winged. Seeds oblong-cuneate, flattened or emarginate, at the end one margin produced into a horizontal, erect, or decurrent wing.

III. LEAVES.

(Not investigated.)

IV. TIMBER.

(*a*) ECONOMIC.

This is a rather attractive, pale-brownish coloured timber when dressed; it planes easily, and takes a good surface as well as a good polish. It is short

in the grain and, therefore, should not be subjected to too much weight in the case of beams, &c., but is an excellent timber for joinery and finishing work generally. Mr. P. MacMahon states, "That it has always been regarded as the most valuable of Queensland Pines, but it is unfortunately becoming scarce; and although it seems to be readily cultivable, or can be readily produced with reasonable protection, supplies are not obtainable in anything like the quantity that they were some time ago."

Transverse Tests of Timber, *Agathis robusta*.

(Standard size, 38 in. x. 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 3·03; D 3·03	B 3·03; D 3·03	B 3·04; D 3·02
Area of cross section, square inches	9·12	9·12	9·18
Breaking load in lb.	3,600	3,500	3,800
Modulus of rupture in lb. per square inch ...	6,990	6,796	7,366
,, elasticity ,, ,, ...	970,786	900,000	911,250
Rate of load in lb. per minute	300	437	345

(*b*) Anatomy.

Both radial and tangential sections present microscopical features characteristic of the species and genus, and form good lines of demarcation between it and the cognate genera.

The pitted cells are found on the radial walls in alternating rows, generally in threes, but occasionally in fours, as against a single row in the corresponding space of the *Callitris* and *Podocarpus*, and having the appearance of a tessellated pavement or mosaic, a character, however, in which it much resembles the *Araucarias*. (Figures 265–6.)

These elongated colonies of pits form conspicuous figures in the radial sections, and show an affinity between the xylems of *Araucaria* and *Agathis*, the latter, however, having more frequently four rows. Hollick and Jeffrey, ("Amer. Nat." Vol. XL, No. 471, pl. 5, Figure 1), show two rows of pits occurring in *Brachyphyllum macrocarpum*, Newb., a fossil timber from Staten Island, N.Y.

The medullary rays are composed of narrow parenchymatous cells more often not containing any manganese compound substance, whilst cells of the xylem tracheids are also devoid of this substance, a feature still further emphasised in transverse sections, Figures 261-2, and one that differentiates the timber from *Araucaria*. The rays are not many cells high, and only one broad.

The large number (up to twelve) of simple cells between the walls of the lumina is also a good diagnostic character of the genus.

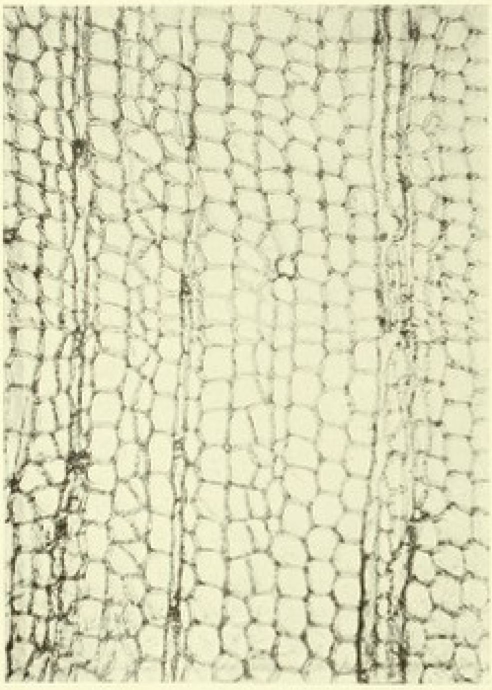


Figure 261.—Transverse section of timber of *A. robusta*, × 100.

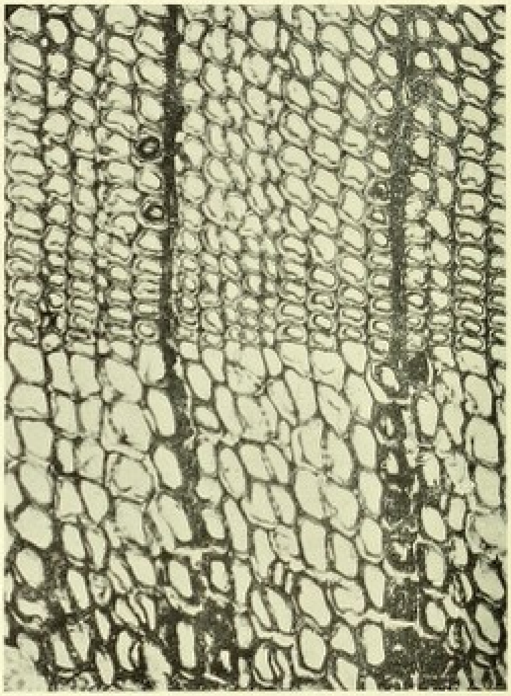


Figure 262.—Transverse section through timber. The smaller closer-packed cells running from left to right belong to the autumnal growth. The two dark bands from top to bottom of the picture mark the rays. *A. robusta*, × 100.

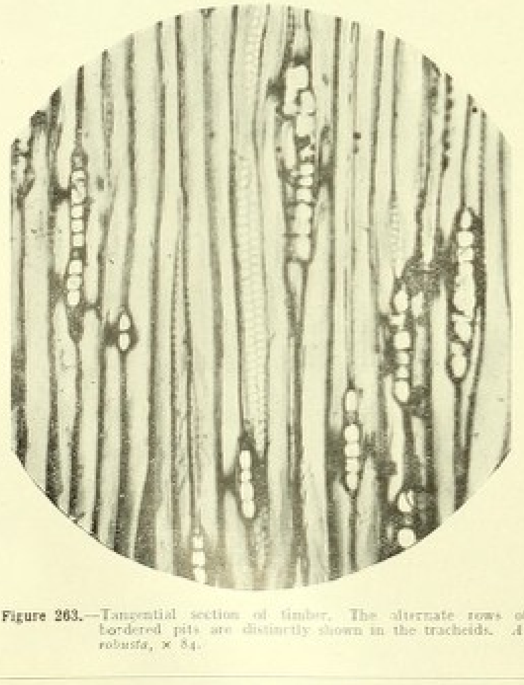


Figure 263.—Tangential section of timber. The alternate rows of bordered pits are distinctly shown in the tracheids. *A. robusta*, × 84.

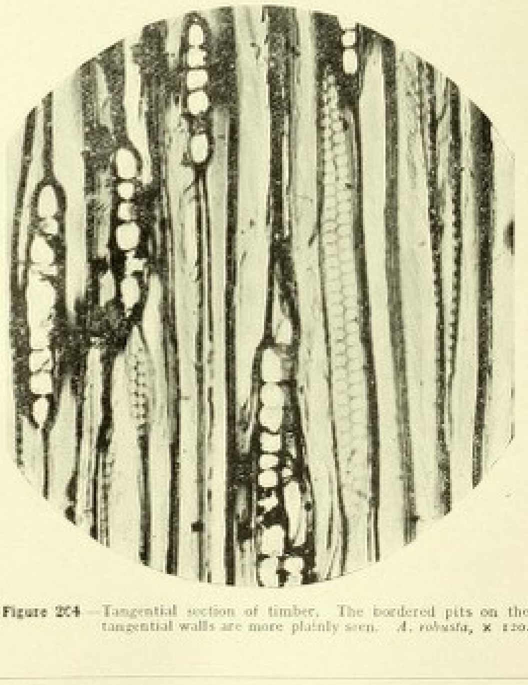


Figure 264.—Tangential section of timber. The bordered pits on the tangential walls are more plainly seen. *A. robusta*, × 120.

Section of timber of **Agathis robusta, C. Moore.**

The tangential section is microscopically no less a beautiful object than the radial, and Figures 263-4 show clearly the main features of distinction between it and cognate genera, the most important being the occurrence in well-defined elongated groups of pitted cells on the tangential walls, a rare occurrence in Australian Conifers.

The "string of bead-like" structures, Figures 263–4, so clearly shown on the tracheid walls, are the pitted cells cut vertically, or seen in profile.

The transverse sections in Figures 261-2 show the less regular polygonal shape of the tracheids of the xylem of this genus, and also the scarcely distinguishable autumnal growth in the former, probably due to the equable seasons of its habitat.

V. BARK.

(*a*) Economic (*vide* Chemistry).

(*b*) Anatomy.

This bark in some respects resembles that of the *Araucarias*. It has not the well defined lines of structure to be found in *Callitris*, for the sclerenchymatous fibres resemble those of the *Araucarias* rather than the *Callitris*, and in cross-section, given in Figure 267, they can be seen scattered amongst parenchymatous cells and sinuous medullary rays. The large empty cell in the centre of the picture is an oleo-resin cavity. Throughout the bark substance are masses of sclerenchymatous fibres.

(*c*) CHEMISTRY OF THE OLEO-RESIN.

Theoretical.

This sample of freshly collected oleo-resin was sent to us by the Department of Agriculture, Queensland, and was obtained from trees growing in their natural habitat. When received it was of a thin, pasty consistency, contained a large amount of essential oil, and had a somewhat aromatic odour and a bitter taste. The material was freshly exuded, so that its constituents could hardly have undergone much change; the action of the air, and other contributing influences towards alteration, had been retarded, as the resin was sent in closed vessels. The oleo-resin was thus largely in its natural condition.

The general method of investigation was similar to that carried out with the latex of *Araucaria Cunninghamii*, and it was found to contain many similar substances to those isolated from that material; so that, broadly speaking, the general constituents are common to both trees. The oleo-resin of *Agathis robusta* contained a gum similar in composition with that isolated from the latex of *Araucaria Cunninghamii*, although it is present in less amount than in the exudation

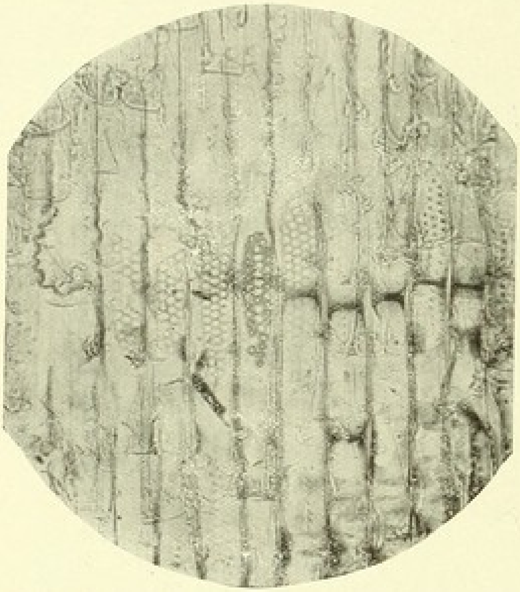


Figure 265.—Tangential section of timber showing as many as three or four rows of alternate bordered pits on the radial walls. The black markings extending across the picture from the centre to the right are not septa of the tracheids, but remains of manganese washed from the lumina. *A. robusta*, × 80.

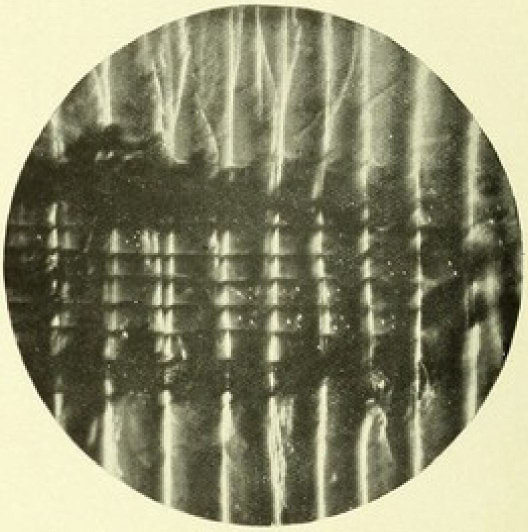


Figure 266.—Radial section through a ray of *A. robusta*, × 120.

Figure 267.—Transverse section of bark, showing irregular distribution of bast fibres and other structures of the bark. *A. robusta*, × 90.

Sections of timber and bark of Agathis robusta, C. Moore.

from the latter tree. The gum precipitate also contained a similar manganese-bearing compound, and the changes in colour which took place with the gum, when this was precipitated by alcohol, were even more pronounced than with that obtained from *Araucaria Cunninghamii*, as, on drying, it became almost of a jet-black colour.

So far as we are aware, gum has not previously been found in the class of resins exuded by the *Dammara* group, and to its presence may, perhaps, be traced the reason why a portion of the constituents of some resins are found to be insoluble in alcohol. The peculiarity of the freshly precipitated gum in changing on drying the first time to a jet-black colour is, perhaps, analogous to the formation of the black lacquer of the Japanese and Chinese, obtained from species of *Rhus*.

Agathis robusta, SHOWING FLOW OF OLEO-RESIN. QUEENSLAND.

This peculiarity of blackening with the gum precipitates of both *Agathis robusta* and *Araucaria Cunninghamii*, was distinctly traceable to the changing of the inorganic constituents, of which manganese and iron were present in some quantity. Manganese has been shown to be a constituent of the latex of *Rhus*, and the darkening

in all cases may, therefore, be traceable to the same cause. This blackening process appears to render certain of the inorganic substances less soluble, because, on again dissolving the dried black gum in water, the dark-coloured constituents could be removed, and the gum prepared in this way, when precipitated again by alcohol, was practically in a pure condition. The ash of the finally purified gum did not contain either manganese or iron, but consisted principally of lime and magnesia, although both manganese and iron were readily detected in the dark-coloured ash of the first precipitated gum. This blackening can hardly be due to the action of an enzyme, similar to laccase, because the solution had been boiled for seven hours in order to separate the gum, the volatile acids, and the essential oil. The formation of the various constituents in these oleo-resins may, perhaps, eventually be shown to be largely due to enzyme action, and also that the manganese and iron are simply contributing factors towards the final result. It may, perhaps, be shown also, that their action in some plants is more towards the formation of resins, because, in the exudation from *Araucaria Bidwilli*, manganese was in small amount, and only a trace of resin was present in that material.

That the manganese plays an important part in the metabolic processes of *Agathis robusta*, as well as in those of *Araucaria Cunninghamii*, can hardly be doubted, and this supposition is also supported by the results of recent investigations in other directions. Octave Dony-Hénault in his "Systematic Investigations of the Oxydases," ("Bull. Acad. Roy." Belg., 1907, 537; 1908, 105; and 1909, 342), shows that the typical properties of laccase can be reproduced by the catalytic association of manganous and ferric molecules with free alkali, and suggests that laccase does not exist in the latex of the lac tree, but that it is formed during the alcoholic precipitation. He also advances the idea that none of the oxydases are truly enzymic, and assumes that the oxidising action of Bertrand's laccase is fully accounted for by the presence of an organic salt of manganese and the accidental presence of alkali; it is also asserted that the activity of this substance is practically paralysed in the presence of acids.

The changes which take place with the alcoholic precipitate from the latex of *Araucaria Cunninghamii*, also with that from the exudation of *Agathis robusta*, are almost identical with those given with similar material from the latex of *Rhus* (See G. Bertrand, "Bull. Soc. Chim.," 1896, and "Compt. rend." 1896); also "Oxydases et les Reductases" by M. Emm. Pozzi-Escot, Paris, 1902, p. 130, &c.). The reason why these exudations from *Agathis* and *Araucaria* remain colourless under ordinary conditions is probably the preventative action of the acids present, and it was not until the volatile acids and the resin acids had been entirely separated, that the blackening of the precipitate took place, which was apparently due to the oxidising influences of the air. It thus appears that the blackening of the gum precipitate from these trees is primarily due to the particular form of manganese compound present.

From these results it may be assumed that manganese is an essential constituent of these trees, and that their natural habitat is in those soils in which an available form of manganese is present; so that they should grow better and become more robust in localities where this food material is available. It is interesting to notice in this connection that most satisfactory results have recently been obtained with manganese as a fertiliser, from which it appears that other plants besides *Rhus*, *Agathis*, and *Araucaria* have need of sufficient manganese to enable them to carry on their constructive functions in the most satisfactory manner. (See article on the manganese compound in this work.)

Reducing sugars were found in the oleo-resin of *Agathis robusta*, and their amount determined. Reducing sugars were also detected in the latex of *Araucaria Cunninghamii*.

Similar nitrogenous constituents were also shown to be common to both trees. The volatile acids were also similar in both trees and were present in about the same amount.

The essential oil, removed from the oleo-resin of *Agathis robusta* by steam distillation, consisted almost entirely of pinene, and this steam-distilled product may be considered to be an excellent commercial "oil of turpentine." It is also present in some quantity (about 14 per cent.). *Agathis robusta* is thus a possible turpentine-producing plant, and its commercial exploitation in this direction is worthy of serious attention. From our present knowledge this is the only species of pine growing naturally in Australia from which a product, agreeing in composition with ordinary "oil of turpentine," can be distilled in commercial quantities; and this fact, together with the excellence of its timber, to say nothing of the value of its resin, suggests the advisability of largely utilising this tree in forest cultivation, because of its economic possibilities. The present policy of indiscriminate destruction of Australian vegetation, now going on all round us, is to be deplored, and we raise our voices in protest; while, on the other hand, we would indeed welcome a vigorous policy in the opposite direction. Nature has been good to us in Australia in providing such a natural vegetation suitable to the climatic and other conditions of the country, of which we should not be slow to take advantage for our own welfare and profit.

The more saturated hydrocarbons, similar to those isolated from the latex of *Araucaria Cunninghamii*, appear to be absent in the oleo-resin of *Agathis robusta*, or, if any were present, it could only be so in very small amount.

The principal constituent in the oleo-resin of *Agathis robusta* was resin, and this was found to consist very largely of two resin acids, with about 10 per cent. of neutral bodies, together with the remainder of the oil, &c. One of the resin acids was readily obtained in a crystalline condition, and it melted at a high temperature. The other, and more abundant acid, melted at a low temperature,

and could not be obtained in a crystalline condition, but was, however, prepared in a pure form by repeated precipitation of the soda salt in cold aqueous solution.

The method of separation of these resin acids with dilute alkaline solvents was not found to be satisfactory with either the resin of *Agathis robusta* or with that of *Araucaria Cunninghamii*, and the method was abandoned, because on purifying and analysing the portion of resin insoluble the second time in ether, this was found to consist almost entirely of an acid, the potassium salt of which was insoluble in excess of alcoholic potash, and that it melted at about 233° C. We did not succeed in isolating an acid with alkaline solvents, having a higher melting point than 200° C., so that this was evidently not quite free from admixture with the acid of lower melting point. It was also found that the remainder of the acid whose potassium salt was insoluble in excess of alcoholic potash, could be isolated from the resin soluble in ether the second time, after the neutral bodies and oily constituents had been removed by ether. On analysing this acid, results were obtained which agreed with those given by the acid at first insoluble in ether' and it was undoubtedly the same resin acid. The small amount of oil present, together with the neutral bodies, had evidently assisted largely towards the solution in ether of the second portion of this acid.

Both these resin acids were dextro-rotatory, the one of higher melting point having the higher rotation. The neutral portion was also dextro-rotatory. The acid of higher melting point was not very readily soluble in alcohol, if at all dilute, and was practically insoluble in chloroform and in ether. The acid of low melting point was completely and readily soluble in 70 per cent. alcohol in the cold, and in organic solvents generally. The acid of higher melting point appears to be the next higher homologue but one, from the acid of lower melting point.

The Queensland kauri, *Agathis robusta*, is botanically allied to the New Zealand kauri, *Agathis* (Dammara) *australis*, and the other species of *Agathis* of the South Sea Islands; the constituents of their resins might, therefore, be expected to show some similarity of composition. Tschirch and Niederstadt ("Arch. d. Ph." 239, 1902, p. 145) have investigated the resin acids occurring in a specimen of recent fossil kauri resin from New Zealand. (See also Tschirch, "Die Harze und die Harzbehälter," p. 725.) They isolated from this resin an acid (kauric acid) melting at 192° C., which was dextro-rotatory, the formula being $C_{10}H_{16}O_2$. The resin, however, consisted principally of acids of low-melting point, and to which they give the formulæ $C_{12}H_{20}O_2$. The principal resin acid isolated by us from the resinous portion of the oleo-resin of *Agathis robusta* had also a low-melting point, similar to that of the main acids isolated by Tschirch and Niederstadt from the New Zealand kauri resin, but all our results with this acid of low-melting point, obtained from *Agathis robusta*, indicated the formula to be $C_{19}H_{28}O_3$, and that its molecular weight was 304. The acid of high-melting point from *Agathis robusta* melted at 234–235° C., was dextro-rotatory, and had a molecular

weight of 332, the formula being $C_{21}H_{32}O_3$. If these acids are eventually shown to be similar in origin, then the differences in molecular weight may, perhaps, be traceable to the prolonged influences exerted during the process of fossilisation. It would be interesting if, on further investigation, it becomes possible to show whether these changes do take place with the acids of these Coniferous resins, and, if so, in what direction.

The name Dundathic acid is proposed for the acid of high-melting point, as it was first obtained from *Agathis robusta*, the "Dundathu Pine." We have isolated this acid from the resins of both *Agathis robusta* and *Araucaria Cunninghamii*, and although the acid of low-melting point in the resin of *Agathis robusta* was dextro-rotatory, that of the corresponding acid in the resin of *Araucaria Cunninghamii* was lævo-rotatory, yet, the Dundathic acid from the resin of the latter tree was dextro-rotatory like that from *Agathis*. The neutral constituents of the resins of both plants agree in rotation with that of the acid of low-melting point. This seems to indicate a somewhat close connection between those resinous bodies not acids, and those that contain a carboxyl group, and an exhaustive investigation of these neutral bodies might throw some light upon the formation of the resins themselves, both acid and neutral. The bitter principle was also largely concentrated in this portion, and the aqueous solution, after the slow deposition of the neutral bodies from an alcoholic solution, was intensely bitter. Dundathic acid is evidently formed from material common to both *Agathis* and *Araucaria*, and in a similar manner, because the physical and chemical characters of the acid from both trees were in agreement.

The acid of low-melting point, of which the resin of *Agathis robusta* principally consisted, did not crystallise by any method, but always appeared to separate in an amorphous condition. It was, however, precipitated from an aqueous solution as a soda salt, and was separated almost completely in this way, after the Dundathic acid had been removed. A peculiarity which takes place with this acid, and which is worthy of notice, is the slow increase in melting point after separation from the other constituents of the resin, until the final melting point, 101–102° C. is reached. When first prepared, this acid melted at 77° C.; after the lapse of about two weeks the melting point had increased to 88° C., and after one month to 99° C. After this increase in the melting point had been detected, a fresh sample of the resin was prepared, and this also melted at first at 77° C., after one week at 83° C., after two weeks at 89° C., after three weeks at 96° C., after four weeks at 98° C., after five weeks at 99–100° C., and after four months 101–102° C. (The method of taking the melting points of these resins was to place a small portion of the powder on a micro-slide cover-glass, and float this on a vessel of mercury of sufficient depth to entirely cover the bulb of the thermometer.) We propose the name Dundatholic acid for this constituent of low-melting point isolated from the oleo-resin of *Agathis robusta*.

The general composition of the resin as first prepared from the oleo-resin may be stated as follows:—

Dundathic acid ($C_{21}H_{32}O_3$)	=	16·0 per cent.
Dundatholic acid ($C_{19}H_{28}O_3$)	=	73·2 ,, (about).
Neutral resins, bitter principle, &c.	=	10·8 ,,

Experimental.

The thick, cream-coloured, pasty mass readily formed a white emulsion when stirred with warm water, but if sufficient water were added, it formed a milky liquid, with small lumps of somewhat hardened resin suspended through it. It was strongly acid, and had a slightly aromatic although sour odour, and was mostly dissolved in excess of hot solution of carbonate of soda, but partly separated out again on cooling; although if sufficient water was added, the precipitated salt again dissolved. 400 grams of the oleo-resin, as received, were made into a thin emulsion by adding an equal amount of water; this solution was then distilled by heating directly, as by this method the material boiled more steadily, and was not projected in such an objectionable manner as when steam was passed directly into it. Fresh water was added from time to time, and the distillation continued until the distillate became practically neutral, and no more oil came over—a result which took about seven hours to accomplish. A considerable layer of a colourless oil floated on the surface of the acid water. As the oil came over, and the gum went into solution, the resin separated in lumps and globular masses, floating in the aqueous liquid. The resin was then allowed to cool and solidify in the flask, the aqueous portion removed, and filtered as clear as possible.

The Essential Oil.

The oil floating on the acid distillate, when separated, measured 54 c.c., equal to 11·64 per cent. of the oleo-resin by weight, or about 14 per cent. by volume. It soon obtained the characteristic odour of ordinary "oil of turpentine," although at first it was slightly aromatic. It was water-white, and gave the following results:—

Specific gravity at $\frac{16}{15}$° C.	=	0·8629
Rotation a_D in 100-mm. tube	=	+ 20·2°
Refractive index at 16° C.	=	1·4766

30 c.c. of the oil were distilled under atmospheric pressure, when nothing came over below 155° C.; between 155° and 156° C., 53·3 per cent. distilled; and between 156° and 159° C., 33·3 per cent. more came over. The residue in the flask, 13·3 per cent., was also determined.

The first fraction had—

Specific gravity at $\frac{17}{15}$° C.	=	0·8625
Rotation a_D	=	+ 14·4°
Refractive index at 17° C.	=	1·4755

The second fraction had—

Specific gravity at $\frac{17}{15}$° C.	... ... =	0·8603
Rotation a_D	... ... =	+ 20·4°
Refractive index at 17° C.	... ... =	1·4763

The portion remaining in the flask had—

Specific gravity at $\frac{17}{15}$° C. ...	... ... =	0·8610
Rotation a_D...	... ... =	+ 38·6°
Refractive index at 17° C.	... ... =	1·4791

These results indicated that the oil consisted principally of one constituent, and that that was pinene.

The nitrosochloride was readily prepared with it, and this, when finally precipitated from a chloroform solution by methyl alcohol, melted with decomposition at 108° C. The nitrolbenzylamine compound was prepared with the nitrosochloride in alcoholic solution in the usual way, and after finally crystallising from alcohol, it melted at 123–124° C. It is thus shown that the essential oil in the oleo-resin of *Agathis robusta* consisted almost entirely of pinene. That a small amount of another body was present was indicated by the slight differences in the physical properties of the several fractions, but it is evident that this constituent, whatever it may be, could only be present in a very small amount. The sylvestrene reaction was not obtained.

Free Acids.

The distilled water from which the floating oil had been separated was filtered through wet paper. It measured 950 c.c., and was strongly acid to litmus. 100 c.c. required 7·4 c.c. decinormal NaOH to neutralise, or the 950 c.c. would require 70·3 c.c. The water, therefore, contained 0·422 gram volatile acids considered as acetic, or 0·1055 per cent.

The remainder was neutralised with barium hydrate solution, evaporated to dryness, and heated to 100–105° C. ; 0·158 gram of the barium salt gave 0·1382 gram barium sulphate, equal to 87·47 per cent. Acetic acid was proved to be present and butyric acid strongly indicated, so that if the volatile acids consisted of acetic and butyric alone, they were present in the proportion of 76·3 per cent. barium acetate, and 23·7 per cent. barium butyrate.

The Gum.

The aqueous portion when removed from the solidified resin in the flask, was filtered as clear as possible, evaporated down, the gum precipitated with alcohol, and the precipitate spread on glass to dry. Although colourless at first, it soon became dark coloured on drying, until at last the fully air-dried gum was quite black, and had a very glossy surface. The filtrate from the gum precipitate was

evaporated down and again precipitated, but only a very small quantity of gum was again obtained. The amount of air-dried gum from the 400 grams of oleo-resin was 9 grams; a further 0·5 gram was afterwards obtained from the residue after the resin had been removed, making the total amount 9·5 grams, or 2·37 per cent. The gum is thus shown to be present in a considerably less amount than in the latex of *Araucaria Cunninghamii*.

The air-dried gum was again dissolved in water, and the dark-coloured turbid solution agitated with alumina cream; the filtrate was evaporated down and again precipitated by alcohol and spread on the glass as before. This gum precipitate on drying was still slightly coloured, indicating that owing to the comparatively large amount present, the complete alteration of the inorganic constituents had not taken place during the first drying. On again repeating the process the gum was obtained colourless, as with the gum of *Araucaria Cunninghamii*. This purified gum was similar to the substance obtained from *Araucaria Cunninghamii*, and had all the properties of gum arabic, was odourless and tasteless, and had marked adhesive properties. The air-dried gum contained 14·9 per cent. of moisture, and gave 2·6 per cent. of ash, which consisted principally of the carbonates of lime and magnesia. When heated with nitric acid in the usual way, mucic acid was formed to the extent of 19 per cent., calculated on the air-dried gum. A well marked manganese reaction was obtained with the ash of the black gum, and also with the ignited alumina-cream precipitate, but was not obtained with the ash of the purified gum. Sufficient of the gum could not be spared to determine the sugars formed by hydrolysis, but there is no reason to suppose that this result would have been different from that obtained with the gum of the latex of *Araucaria Cunninghamii*.

The Reducing Sugar.

After the gum had been finally precipitated, the filtrate was evaporated down to expel the alcohol, water added, and the solution clarified; it was then made up to 200 c.c. and filtered. This solution was titrated with Fehling's solution, and 4 c.c. equalled ·05 gram glucose. The 400 grams of oleo-resin, therefore, contained 0·62 per cent. of reducing sugars.

The Resin.

The solidified resin in the flask was dried as much as possible, and treated with ether until practically the whole of the resin had been dissolved. The resin at this stage was very soluble in ether, and went readily into solution. The ether solution of the resin was filtered, evaporated to dryness, and the resin heated on the water bath in thin layers until all the ether had been removed. As thus obtained the dried resin was somewhat soft, was light amber coloured, and distinctly darker in colour than the resin from the latex of *Araucaria Cunninghamii* obtained

in the same way; it was also less hard and brittle. The weight of the thus dried resin was 248 grams, equal to 62 per cent. of the 400 grams of oleo-resin taken. It was entirely soluble in 80 per cent. alcohol, was very soluble in acetone, but only partly so in ether.

A solution of 1 gram resin in 10 c.c. acetone in 100-mm. tube was dextrorotatory $a_D + 3{\cdot}4°$. (This rotation is in the opposite direction to that of the similarly obtained resin of *Araucaria Cunninghamii.*)

The specific gravity of the resin was 1·053 at 17° C. The acid number was 148, and as the formula of the most abundant resin acid was determined as $C_{19}H_{28}O_3$, this result would indicate that about 80 per cent. of this resin acid was present.

For the analysis, 25 grams of the resin were treated with ether, but the whole of the resin was not soluble. This insoluble portion was treated with fresh ether until all the soluble resin had been removed; and when dried it weighed 2·6 grams, equal to 10·4 per cent. of the whole. It was then dissolved in alcohol, filtered, and excess of solid potash added. The pasty, insoluble resin salt which thus formed, was washed with alcohol, dissolved in water, the acid precipitated with excess of hydrochloric acid, and well boiled. The resin was filtered off, washed, dried on porous plate, and heated to 100–105° C. It then weighed 2·5 grams, showing that this resin was almost entirely precipitated by excess of alcoholic potash. This resin acid melted at 234° C., and 0·1547 gram required 4·6 c.c. decinormal NaOH solution to neutralise it, so that 40 grams would neutralise 336 grams of acid. The silver salt was readily prepared from the soda salt on adding silver nitrate solution, and if the precipitate was well washed the dried salt was but slightly coloured. It was heated to 100–105° C., when 0·1616 gram of the silver salt gave 0·0394 gram silver, equal to 24·38 per cent.

The ether, containing the resins in solution, was neutralised with alcoholic potash, using phenolphthalein as indicator; when neutral, water was added, the liquid then becoming quite clear. It was placed in a separator, when the ether readily formed a distinct layer, and the aqueous solution was repeatedly agitated with fresh ether until all the unfixed bodies were removed. The aqueous portion was then boiled to remove all the ether and alcohol, water added, and the whole acidified with hydrochloric acid and boiled. The separated resin melted in the boiling water, forming, when cold, a yellowish lump of resin. It was then powdered, dissolved in alcohol, and solid potash added, a portion was rendered insoluble at once, and this eventually formed a pasty mass, more quickly on gently warming, from which the alcoholic solution was readily removed. This insoluble salt was washed with alcohol, dissolved in water, acidified with hydrochloric acid, and boiled. When dry it weighed 1·5 grams, equal to 6 per cent. of the whole resin taken. It melted at 233° C., and the results of titration, together with the

determination of the silver salt, showed it to be identical with the previous acid. Both portions were then mixed and purified together. The amount of this acid (Dundathic acid) in the resin of *Agathis robusta* is thus 16 per cent. It was purified by twice repeating the precipitation from alcohol with solid potash, then finally dissolved in absolute alcohol, adding a few drops of water and crystallising out. The first portion precipitating was removed, as it contained a small amount of ash, and the crystallisation from alcohol was repeated four times. It was finally dried on a porous plate and heated at 100–105° C. The acid was a colourless powder, and melted at 234–235° C. to a yellow resin. It was dextro-rotatory, and 0·4 gram dissolved in 10 c.c. absolute alcohol had a rotation in 100-mm. tube + 2·25°, thus the specific rotation was $[a]_D$ + 56·25°.

It was practically insoluble in chloroform and ether, but soluble in alcohol, acetone, and ethyl acetate. A portion in chloroform did not dissolve on the addition of acetic anhydride in the cold, but did so on boiling. When cold, one drop of sulphuric acid to this solution gave a very slight pink colouration, which on standing eventually changed to a brownish tint.

0·1516 gram dissolved in alcohol required 4·5 c.c. decinormal NaOH to neutralise it, so that 40 grams NaOH would neutralise 336 grams acid.

0·1547 gram required 4·65 c.c. decinormal soda, or 40 grams NaOH would neutralise 333 grams acid.

Analysis gave the following results:—

0·1516 gram gave 0·419 gram CO_2, and 0·1342 gram H_2O.

C. = 75·38; H. = 9·83 per cent.

0·1258 gram gave 0·3478 gram CO_2, and 0·1119 gram H_2O.

C. = 75·41; H. = 9·88 per cent.

$C_{21}H_{32}O_3$ requires 75·84 per cent. C, and 9·7 per cent. H.

The silver salt was prepared in the usual way from two distinct portions of acid, and the following results were obtained:—

0·1642 gram silver salt gave 0·0401 gram silver = 24·42 per cent. Ag.

0·1610 gram silver salt gave 0·0394 gram silver = 24·47 per cent. Ag.

$C_{21}H_{31}AgO_3$ contains 24·6 per cent. silver.

From the molecular determinations and the titrations, supported by the results of the analyses, the formula $C_{21}H_{32}O_3$ appears to be the correct one for this acid, especially as corresponding results were obtained with the same acid isolated from the resin of *Araucaria Cunninghamii*

The acid of low-melting point, of which the bulk of the resin consisted, was soluble in an excess of alcoholic potash. The alcoholic solution was removed from the pasty acid salt, water added and boiled to expel all the alcohol. When cold, water was added until the solution was quite clear, acidified with

hydrochloric acid, and boiled. The acid melted in the hot water, forming a semi-fluid mass, and when cold it was a solid lump of a sulphur-yellow coloured resin. The process was repeated, but only a trace of the pasty salt was obtained the second time.

The acid was purified as follows:—It was powdered, dissolved in the smallest quantity of alcohol, neutralised with an alcoholic solution of soda, water added, and the alcohol removed by boiling. When cold, sufficient 10 per cent. aqueous soda was added to form an abundant precipitate; it was then heated until the precipitate had dissolved, and allowed to cool. When cold, the greater portion of the acid had precipitated, and no further precipitate was obtained on the addition of solid caustic soda. The sodium salt, which was minutely crystalline, was then dissolved in water, acidified with hydrochloric acid, and boiled. The resin readily melted in the hot water, but when cold was very brittle and powdered readily. This process was repeated three times, the resin being finally obtained of a sulphur-yellow colour when in the lump, but when powdered was almost colourless, being only slightly tinged yellow. It was finally dried on a porous slab and heated in a melted condition on the water bath for some time until thoroughly dry. This freshly prepared resin melted at 77° C.; another sample prepared specially from a fresh portion of the resin also melted at 77°C., but the melting point slowly increased until after one month or five weeks it had reached the melting point 99–100° C., and after some months 101–102°C., which appears to be the stable melting point. It was readily soluble in 70 per cent. alcohol in the cold, and in organic solvents generally. On addition of water till turbid, and slowly evaporating in the air, no crystalline product was formed, the separated resin being quite amorphous, and by no process could a crystalline substance be obtained with this acid.

The purified acid was dissolved in chloroform, acetic anhydride added, and afterwards one drop of sulphuric acid; the solution instantly became of a deep purple colour, which soon changed to a purplish brown. This colour reaction differed from that of the corresponding acid of *Araucaria Cunninghamii* in being less violet, and in changing to purple-brown after a short time, instead of to an olive-green colour.

The acid was dextro-rotatory in solution; and 1 gram dissolved in 10 c.c. alcohol rotated the ray 2·15° to the right, the specific rotation was thus $[a]_D$ + 21·5°. Another determination from freshly prepared material gave identical results.

0·2311 gram acid dissolved in alcohol required 7·55 c.c. decinormal NaOH to neutralise it; therefore 40 grams would neutralise 306 grams acid.

0·2777 gram dissolved in absolute alcohol, required 9·15 c.c. $\frac{N}{10}$ NaOH to neutralise it; therefore 40 grams would neutralise 303 grams acid.

0·8 gram acid was dissolved in 10 c.c. semi-normal alcoholic potash, water added and titrated. The excess of alkali requires 4·7 c.c. semi-normal sulphuric acid to neutralise it ; therefore 56 grams KOH would neutralise 303 grams acid.

Analyses gave the following results:—

0·1475 gram gave 0·4008 gram CO_2, and 0·1279 gram H_2O.

C. = 74·2; H. = 9·63 per cent.

0·1492 gram gave 0·4097 gram CO_2, and 0·1281 gram H_2O.

C. = 74·88; H. = 9·54 per cent.

$C_{19}H_{28}O_3$ requires 74·94 per cent. C, and 9·28 per cent. H.

The silver salt was prepared in the usual way, and this gave the following results:—

0·2236 gram silver salt gave 0·0592 gram silver = 26·47 per cent. Ag.

0·1691 gram silver salt gave 0·0454 gram silver = 26·84 per cent. Ag.

$C_{19}H_{27}AgO_3$ contains 26·28 per cent. silver.

From the molecular determinations, titration results, and the analyses, the formula $C_{19}H_{28}O_3$ is indicated for the acid of low-melting point occurring in the resin of *Agathis robusta*.

That the above two acids were alone present in the resin was indicated by the results obtained with the acid of low-melting point, when this was first separated from the other acid, and before the final purification with aqueous soda. The titration result indicated one acid with a molecular weight 302, and the silver salt gave 26·4 per cent. silver.

Ether Extract from the Resin Acids.

The ether solution from the 25 grams of resin, after the acids had been removed, was evaporated to dryness, and heated on the water bath till constant. The residue weighed 2·7 grams, equal to 10·8 per cent. It was a soft, slightly yellow resinous mass, had a somewhat aromatic odour and a very bitter taste. It was dissolved in alcohol, and made up to 30 c.c.; the solution was dextro-rotatory to the extent of + 3·2° in 100-mm. tube ; the specific rotation was thus $[\alpha]_D$ + 35·6°. It thus agrees in rotation with the acid of low-melting point.

To the solution a small amount of water was added and evaporated in the air, and although the neutral resinous bodies appeared to be quite amorphous, yet a few, somewhat long needle crystals could be detected in the thinner portions. Under the microscope these were seen to be terminated prisms, and they were soluble in water, and the aqueous solution had an intensely bitter taste; on evaporating, microscopic crystals were again formed. This crystalline substance is apparently the bitter principle occurring in these resins, and may, perhaps, be isolated in this manner.

Nitrogenous Residue.

The residue, after the removal of the resins by ether, was dried and powdered, and was then treated with alcohol to remove any remaining resin; and again dried and treated with water to remove the gum. The residue, when dried, was a cream-coloured powder, and when heated with soda-lime gave abundance of ammonia. It thus agreed with the similar substance obtained from *Araucaria Cunninghamii*. When dry it weighed 0·8 gram, equal to 0·2 per cent.

The general composition of the oleo-resin of *Agathis robusta* may be stated as follows:—

Essential oil (by weight)	=	11·64	per cent.
Volatile acids (as acetic)	=	0·1055	,,
Gum	=	2·37	,,
Reducing sugars	=	0·62	,,
Resin	=	62·00	,,
Nitrogenous residue	=	0·20	,,
Water, and undetermined by difference...	=	23·0645	,,
		100·0000	

2. Agathis Palmerstoni.

F.v.M. "Victorian Naturalist," June, 1891.

This recently described Pine occurs on the Coast Ranges of North Queensland, but it was found impossible to procure material for investigation It is said to be a tall tree, and Mueller states that it differs from *A. robusta* in that its leaves are never lanceolate, are much smaller, narrower, and always obtuse. The cones are much smaller, narrower, and the scales more numerous than any other species, its nearest ally being *A. Moorei* of New Caledonia.

THE GENUS DACRYDIUM.

Soland. in Forst. Pl. Escul. 80.

I. HISTORICAL.

Solander in G. Forster, "Plant. Esculent.," established this name in 1786. The genus does not occur on the mainland, being restricted to Tasmania so far as Australia is concerned.

It has, however, a wide geographical range, being found in New Zealand, New Caledonia, the Malay Archipelago and Peninsula, Borneo, and Chili. Ettingshausen (l.c., p. 101, pl. VIII) describes and figures one fossil species of *Dacrydium* from Emmaville, New South Wales.

II. SYSTEMATIC.

The Dacrydiums are average forest trees, having linear, flat, and spreading dimorphic leaves in the young stage, and in the mature state small and closely imbricated ones.

The flowers are diœcious. Male amentum terminal, ovoid or cylindrical. The microsporophylls spirally arranged, imbricate, sessile, shortly contracted at the base, with an introrse spur-like connective ; microsporangia 6 to 20, in two rows opening laterally. Microspore oval or oblong.

The development of the pollen in the gymnospermous genus *Dacrydium* is interesting, because, according to the account contributed by Miss M. S. Young to the *Botanical Gazette*, September, 1907, a number of cells are formed in what is technically known as the microgametophyte. The spore passes out of the single-cell stage when a small prothallial cell is cut off; by another division of the vegetative nucleus a second prothallial cell is formed, and in a similar way a third, the generative cell, is produced. The generative cell gives rise to a sterile and a so-called body cell, the progenitor of the sperm cells. As the second prothallial cell not infrequently divides, the mature pollen grain may show as many as seven nuclei.

Female amentum terminal, solitary, consisting of a few small, thick macrosporophylls in a short spike, or one individual sporophyll, with a macrosporangium at first anatropous and finally orthotropous.

Fruit cones small, erect, surrounded at the base by a cup or disk, ovoid, oblong, the outer integument membranous, the inner thickened and hard.

Dacrydium Franklini, HOOK, F. "HUON PINE," TASMANIA.

Dacrydium Franklini, Hook. f. "Huon Pine," Tasmania.

Nat. size.

Dacrydium Franklini.

Hook. f. in Hook. Lond. Journal, IV, 152, t. 6; and Fl. Tasm. i, 351, t. 100.

"HUON PINE."

HABITAT; Tasmania.

I. HISTORICAL (*vide supra*).

II. SYSTEMATIC.

This tree is one of the best known in the Island, and yields one of Tasmania's finest pine timbers. It attains a height sometimes of over 100 feet.

Leaves small, acute, and spreading on the young plant, in the mature plant closely appressed, thick, keeled, spirally arranged.

Male amentum small, terminal, cylindrical, with twelve to fifteen stamens. Fruit cones very small, terminal, about same size as the leaves, scales about four to eight in number.

Seeds globular, about 1 line in diameter.

III. LEAVES.

CHEMISTRY OF THE LEAF OIL.

THEORETICAL.

The results from the investigation of the oil from the leaves of this tree, and also of those from the oil of the timber are interesting. The principal constituent occurring in the leaf oil is apparently a previously undetected terpene of the formula $C_{10}H_{16}$, and for which, if this supposition is correct, the name Dacrydene is proposed. This terpene readily forms a nitrosochloride, melting sharply, and with decomposition at 120–121° C. (corr), which is far away from the melting point of any nitrosochloride formed with a previously known terpene. The boiling point of Dacrydene appears to be 165–166° C. (corr.); the specific gravity at 22° C. = 0·8524; the refractive index at 22° C. = 1·4749; and the rotation $a_D = +12{\cdot}3°$, or a specific rotation $[a]_D + 14{\cdot}48°$. It is a colourless mobile oil, with a turpentine-like odour, but slightly more aromatic and less pungent than pinene. It is very volatile, and quickly and entirely evaporated from a watch glass without leaving any residue whatever.

As it occurs in this oil, together with a small quantity of lævo-rotatory pinene and dextro-rotatory limonene, it was, of course, impossible to obtain it pure by fractional distillation; but by continued redistillations 10 per cent. of the oil was obtained, boiling between 165–166° C., which gave the results recorded above.

The presence of the small amount of Dacrydene still remaining with the pinene fraction, raised the melting point of the nitrosochloride prepared with that substance several degrees, and no melting point less than 110° C. was obtained.

Dacrydene forms a liquid bromide, and no crystalline product was formed when the oil was saturated with dry hydrochloric acid. Scarcely any colour was produced when concentrated sulphuric acid was added to a solution of the terpene in acetic anhydride, but when treated with nitric acid a yellow nitro-compound was obtained. When dissolved in light petroleum and treated with sodium nitrate and acetic acid, no crystalline product separated, but after some hours, a thick, dark-coloured mass formed at the junction of the liquids. After two days this was washed in ether and then dissolved in ether-alcohol, from which solution on evaporation a yellow-coloured substance separated, and after drying on a porous plate an ochre-yellow powder was left. This darkened much at about 130° C. and melted with decomposition at about 150° C. It readily dissolved in nitrobenzine, but did not become blue on heating. On further investigation it may become possible, perhaps, to prepare a nitrosonitrate more definite in character with this terpene.

The higher boiling portion of the leaf oil contained the methyl ether of eugenol, and veratric acid was prepared from it by oxidation. This methyl ether is the main constituent of the oil from the timber of this tree.

Experimental.

This material was obtained from the Gordon River, on the West Coast of Tasmania, and distilled on the 18th September, 1908, the leaves with terminal branchlets only being used. The oil was difficult to obtain, and it was necessary to steam distil the leaves for eleven hours before the whole of the oil came over. The amount obtained was equal to 0·5 per cent.

The crude oil was of a very light amber colour, and the odour somewhat resembled that given by the oil from the wood, thus indicating the presence of the methyl ether of eugenol, as the constituents of the wood oil had previously been determined. The leaf oil was very mobile, and had a low specific gravity. As it was mostly a terpene oil, it was but little soluble in alcohol, and it required one volume of absolute alcohol to form a clear solution, but it was soluble in all proportions afterwards.

An ester determination showed that there was an entire absence of both esters and free acids, as no alteration in the titration value of the alcoholic potash was detected.

The specific gravity of the crude oil at $\frac{17}{15}$° C. was 0·8667; the rotation a_D = + 20·5°; and the refractive index at 25° C. = 1·4815.

On redistilling 100 c.c., only a small amount was obtained boiling below 160° C. Between 160–170°, 68 per cent. came over; between 170–175°, 10 per cent.; between 175–183°, 9 per cent.; the thermometer then rose rapidly to 245°, and between that temperature and 250°, 6 per cent. distilled.

Boiling Point.	Per cent.	$d\,\frac{15}{15}$° C.	a_D 1 dcm. tube	Refractive Index at 25° C.
160–170° C.	68	0·8477	+ 15·6°	1·4747
170–175° C.	10	0·8481	+ 39·9°	1·4763
175–183° C.	9	0·8549	+ 51·6°	1·4796
245–250° C.	6	0·9433	+ 22·7°	1·5034

The first fraction was again distilled when 11 c.c. were obtained boiling between 156–159° C., and 27 c.c. between 159–162°. The second and third previously obtained fractions were then added to the remainder in the flask. Between 162–166°, 19 c.c. came over; between 166–169°, 10 c.c.; and between 169–178°, 8 c.c.

Boiling Point.	$d\,\frac{15}{15}$° C.	a_D 1 dcm. tube.	Refractive Index at 23° C.
156–159° C.	0·8517	− 1·8°	1·4741
159–162° C.	0·8487	+ 5·4°	1·4747
162–166° C.	0·8487	+ 26·8°	1·4760
166–169° C.	0·8471	+ 41·5°	1·4771
169–178° C.	0·8477	+ 57·0°	1·4776

The above results indicated that the lowest boiling portion was probably lævo-rotatory pinene, the highest probably dextro-rotatory limonene, and the main portion was a dextro-rotatory terpene boiling about 160–165° C.

The fractions were again systematically distilled, when the following results were obtained:—

Boiling Point.	C.C. of Oil.	a_D 1 dcm. tube.	Refractive Index at 25° C.
156–159° C.	12	− 15·5°	1·4735
161–165° C.	17	+ 12·6°	1·4741
165–171° C.	16	+ 39·3°	1·4757
173–177° C.	7	+ 59·4°	1·4771

This had again further separated the three main constituents.

The Limonene.

The fraction 173–177° C. was treated with bromine, in a well cooled acetic acid solution, for the preparation of the tetrabromide. Crystals did not readily form, but eventually they were obtained in some quantity; when filtered at the pump, and purified from acetic ether, the crystals melted at 104° C. This result shows that the higher boiling strongly dextro-rotatory terpene is limonene, and that dipentene is absent. The amount of limonene in the oil can hardly exceed 10 per cent.

The Pinene.

The fraction 156–159° C. was treated with amyl-nitrite in a well-cooled acetic acid solution, when crystals of the nitrosochloride soon formed. These were filtered off, dried on a porous plate, and purified by dissolving in chloroform and precipitating with methyl alcohol. The melting point was 110–111° C. As all the indications were in favour of pinene, this high-melting point of the nitrosochloride was evidently due to the presence of a small amount of the principal terpene still remaining with the pinene. The lower boiling portion of the oil is evidently lævo-rotatory pinene, of which constituent the oil contains about 10–15 per cent.

The Principal Terpene.

The nitrosochloride prepared from a portion of the oil boiling at 161–165° C. melted at 119–120° C. (cor.). It thus appeared that a previously undetected terpene was present in this oil and in some quantity. It could not be camphene, because the nitrosochloride was formed with it so easily, even surpassing pinene in this respect.

The nitrosochloride prepared from the finally rectified oil boiling at 165–166° C. melted at 120–121° C. (cor.); so that it was only possible to increase the melting point by 1 degree above that of the nitrosochloride prepared from the fraction 161–165° C.

Nitrosochlorides of the menthenes, which had a high melting point, have been prepared by Kremers and coadjutors, and also by Baeyer, but the physical results, and the analysis of Dacrydene, show that it cannot belong to the $C_{10}H_{18}$ series of hydrocarbons. The odour, too, had no resemblance to menthene. (See also under *Callitris Macleayana*, in this work.)

An analysis was made with results which showed Dacrydene to have the $C_{10}H_{16}$ formula.

0·1108 gram gave 0·1162 gram H_2O, and 0·3581 gram CO_2. H. = 11·65 per cent., and C. = 88·14 per cent.

$C_{10}H_{16}$ requires C. = 88·24 and H. = 11·76 per cent.

The Bromide.

Dacrydene is an unsaturated terpene, and on addition of the bromine it also gave hydrobromic acid at the same time. When treated in a chloroform solution until no more bromine was absorbed and the chloroform allowed to evaporate entirely, the bromide left was quite liquid and colourless, and did not decompose on standing in the air for some days. So far, no crystallised bromide has been obtained in any direction. On analysis of the liquid bromide 0·4518 gram gave 0·689 gram AgBr, = 0·2932 Br, = 64·89 per cent. This result shows that slightly more bromine than that required for a tribromide was present, and indicated that the HBr formed had also become largely absorbed. Ordinary bromination thus appears to act similarly as with pinene, and is not more satisfactory than with that terpene.

The Methyl Ether of Eugenol.

The fourth fraction of the first series of distillations was oxidised with a neutral solution of potassium permanganate, and finally with an acid solution, considerable heat being evolved. When cold, the product was extracted by ether, the ether distilled off, and a thick oil obtained which crystallised on standing. The mass was then placed on a porous plate until the liquid portion had been absorbed, and the crystals which remained were purified from alcohol. They melted at 178–179° C., which result showed the crystals to be veratric acid, and they were identical with the veratric acid obtained in larger quantities from the wood oil of the same tree. The presence of the methyl ether of eugenol in the leaf oil of "Huon Pine" is thus confirmed. Eugenol itself was not detected in the leaf oil.

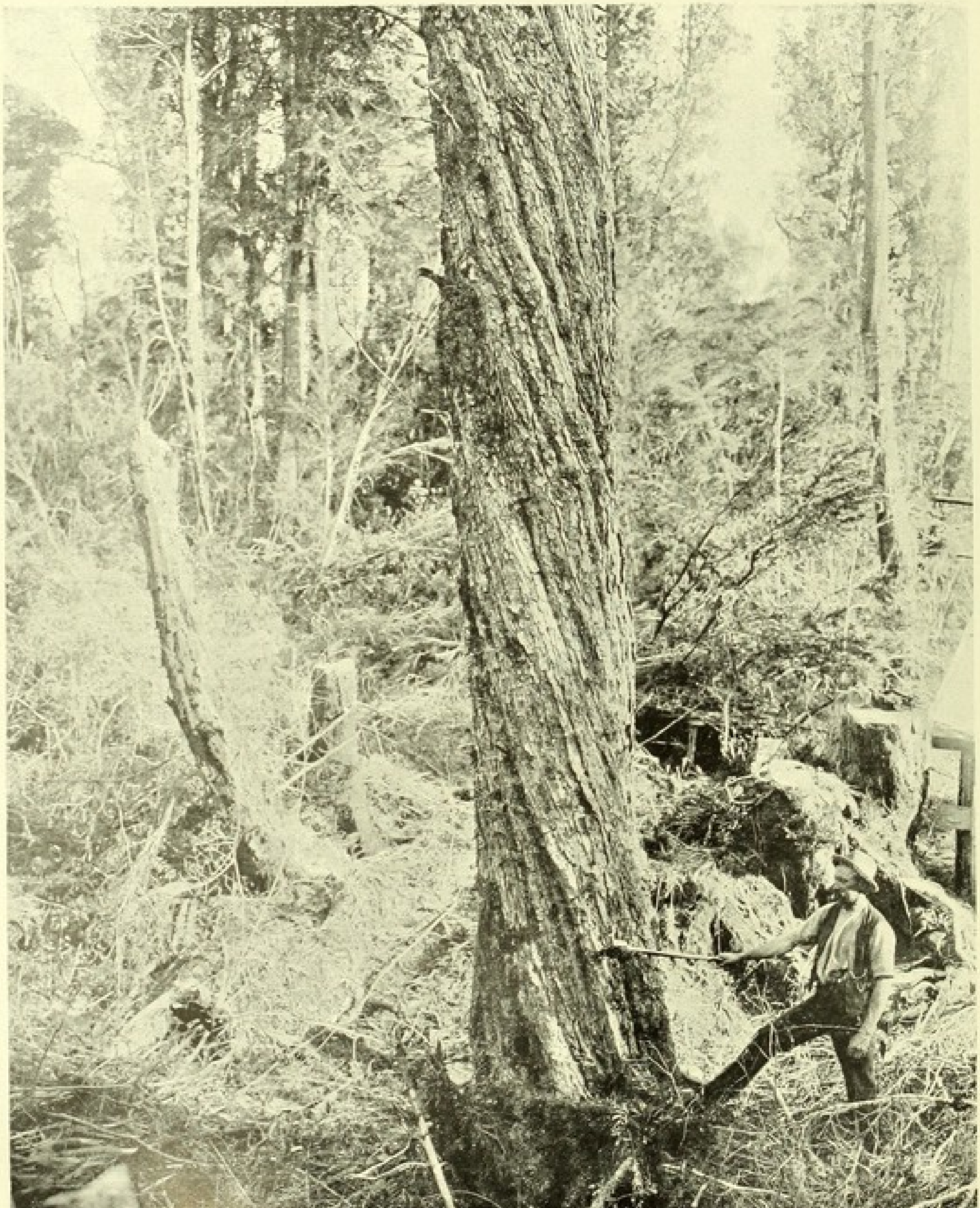
IV. TIMBER.

(*a*) Economic.

The timber has a fairly strong aroma, due to the presence of an essential oil, which has been investigated (*infra*). There can be little doubt that the durability of the timber is owing to the presence of this oil.

The timber is light in colour, toning down to a dull yellow on exposure; it is easy to work, straight grained, but only occasionally possesses a figure, and is suitable for cabinet work, panelling, fancy boxes, and interior decoration, carving, &c. It also takes a good polish. Some specimens are of rare beauty, equalling bird's-eye maple.

It is a fairly heavy wood, but is short in the grain.



Dacrydium Franklini, HOOK. F. "HUON PINE." TASMANIA.

Dacrydium Franklini, HOOK. F. "HUON PINE" LOGS FOR MARKET.

Tranverse Tests of Timber, *Dacrydium Franklini.*

(Standard size, 38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 2·97; D 3·00	B 3·00; D 2·98	B 3·00; D 3·00
Area of cross section, square inches	8·91	8·94	9·00
Breaking load in lb.	4,515	4,350	3,000
Modulus of rupture in lb. per square in. ...	9,121	8,835	6,000
,, elasticity ,, ,, ...	2,445,283	1,620,000	1,270,588
Rate of load in lb. per minute	410	290	500

(*b*) Anatomy.

The most distinguishing characters of the wood are the fineness of the wall structure of the various cells, a delicateness that differentiates it from any other Australian Conifer.

Another distinguishing feature is the almost entire absence of any cell contents corresponding to those found in *Callitris* and in the *Araucarias.*

The medullary rays have very long cells and all are parenchymatous, the outer being of the same character as the inner, and the walls are exceedingly slender. They are a few cells in height and one in width, there being an unusual number of single-cell rays; all are empty of the dark brown substance. The large circular perforations are single to each lumen, and are exceptionally large.

A few pitted cells were detected on the tangential walls, but those on the radial walls are not too well defined, thus giving the idea of delicate bodies.

The diameter- of the autumnal lumina are very small, although the walls of the tracheids in this part are the thicker of the two seasons' growth, and show outwardly a gradation of size and wall thickness from the extremities of the combined seasons' ring.

Figures 268–270 illustrate the above remarks.

(*c*) Chemistry of the Oil from the Timber.

The timber of this tree, which usually has a mild and somewhat pleasant aromatic odour, was received from Tasmania. It was reduced to shavings by the aid of a planing machine, and 67 lb., when distilled for nine hours, gave 6 oz. oil, equal to 0·56 per cent. The particular sample of wood used was very dry, and had comparatively little odour, so that under the most favourable conditions in this respect, more than 1 per cent. of oil should be obtained

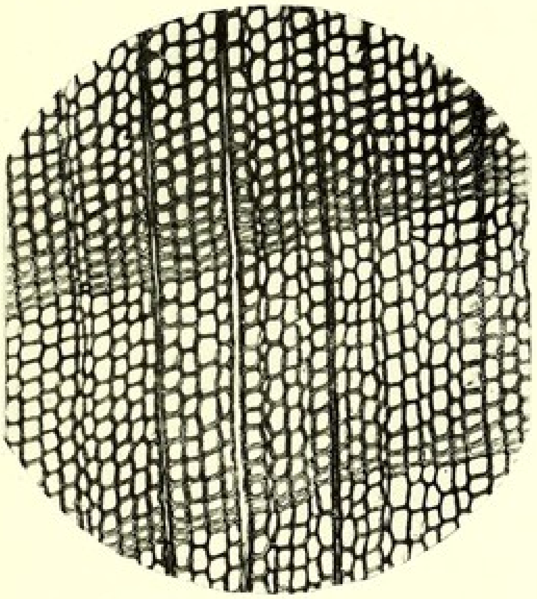


Figure 268.—Transverse section of timber. Two annular rings occur obliquely across the field. *D. Franklini*, × 100.

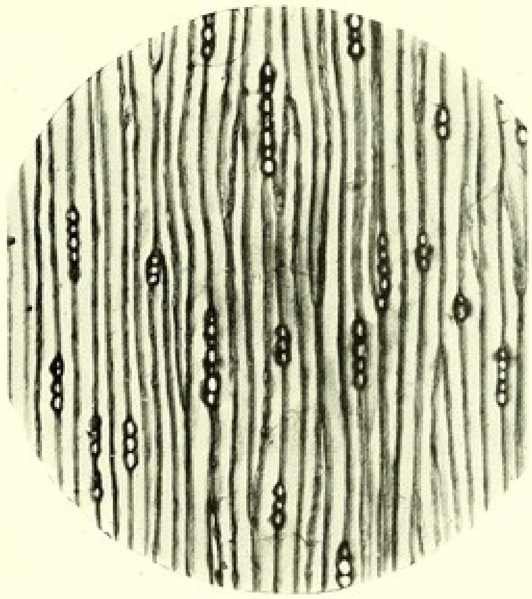


Figure 269.—Tangential section of timber. All the ray cells are empty. *D. Franklini*, × 100.

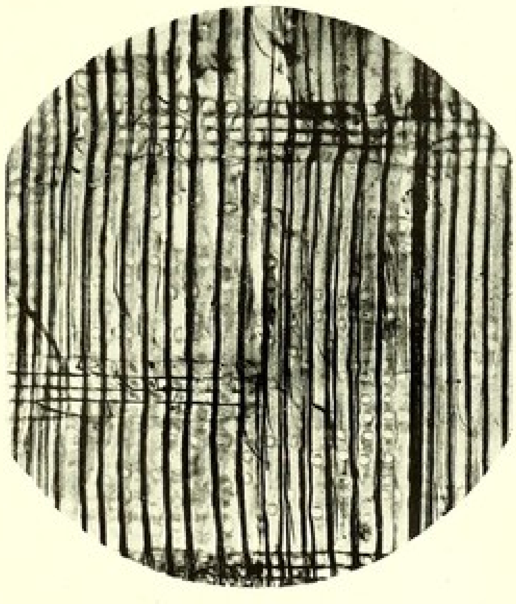


Figure 270.—Radial section of timber. The rays are of a uniform character and quite empty of manganese, which, however, is marked in the walls of the tracheids running from top to bottom of the picture. The simple cells of the rays are large and single. *D. Franklini*, × 100.

Sections of timber of Dacrydium Franklini, Hook. f.

from the timber of this tree. As the oil was heavier than water it was somewhat difficult to collect, and it was necessary for the condensed water to stand two days before the whole of the oil had deposited. The crude oil was of a yellowish tint, inclining to primrose, and had an odour strongly resembling that of methyl eugenol. It was soluble in an equal volume of 70 per cent. alcohol (by weight), and in all proportions after.

The specific gravity of the crude oil at $\frac{18°}{15}$ was 1·035; rotation $a_D = + 1·4°$; and refractive index at 23° C. = 1·5373.

The amount of ester was very small, and the saponification number for both the ester and free acid was only 3·1.

On redistilling 100 c.c. of the oil, only a few drops came over below 242° C., and only 2 c.c. below 245° C. Between 245° and 250° C., 80 per cent. distilled; and between 250° and 255° C., 10 per cent. No less than 86 per cent. of the total oil came over between 245° and 252° C.

The specific gravity of the large fraction at $\frac{19°}{15}$ C. was 1·0335; the rotation was less than half a degree to the right; and the refractive index at 20° C. = 1·5378. These results closely approach those required for pure methyl eugenol, and it thus appears that the oil from the timber of this tree consists principally of that constituent.

An analysis of a portion of the large fraction gave the following:—

0·1646 gram gave 0·1209 gram H_2O, and 0·4492 gram CO_2.

H = 8·16 per cent. and C = 74·4 per cent.

$C_{11}H_{14}O_2$ requires 7·86 per cent. H, and 74·16 per cent. C.

As the material could hardly be pure, this result is very satisfactory.

Preparation of the Bromide.

The bromide was obtained by treating a solution of the oil in carbon tetrachloride with bromine until the reaction was complete. The solvent was then evaporated off, when a thick mass was left, which readily crystallised. When purified and finally re-crystallised from alcohol, it melted at 77–78° C. Corresponding crystals were obtained when the oil was brominated in light petroleum, and these also melted at the same temperature.

0·526 gram gave 0·703 gram AgBr, = 0·2991 gram Br, = 56·86 per cent. bromine.

$C_{11}H_{13}Br_3O_2$ contains 57·55 per cent. bromine, so that the crystals were the tribromide of methyl eugenol.

Preparation of Veratric Acid.

Six grams of the large fraction were first treated with neutral permanganate of potassium, and the oxidation finally completed in an acid solution. The product was then cooled and extracted with ether. The ether was distilled off, and the crystalline mass which remained, repeatedly re-crystallised from hot alcohol. The melting point of the crystals was 178–179° C. The yield was excellent. The crystals were but slightly soluble in water, readily in ether, and less so in cold alcohol. An analysis gave the following:—

0·1512 gram gave 0·3284 gram CO_2, and 0·0756 gram H_2O,
$C = 59·23$ per cent. and $H = 5·55$ per cent.

$C_9H_{10}O_4$ requires 59·34 C. and 5·49 per cent. H.

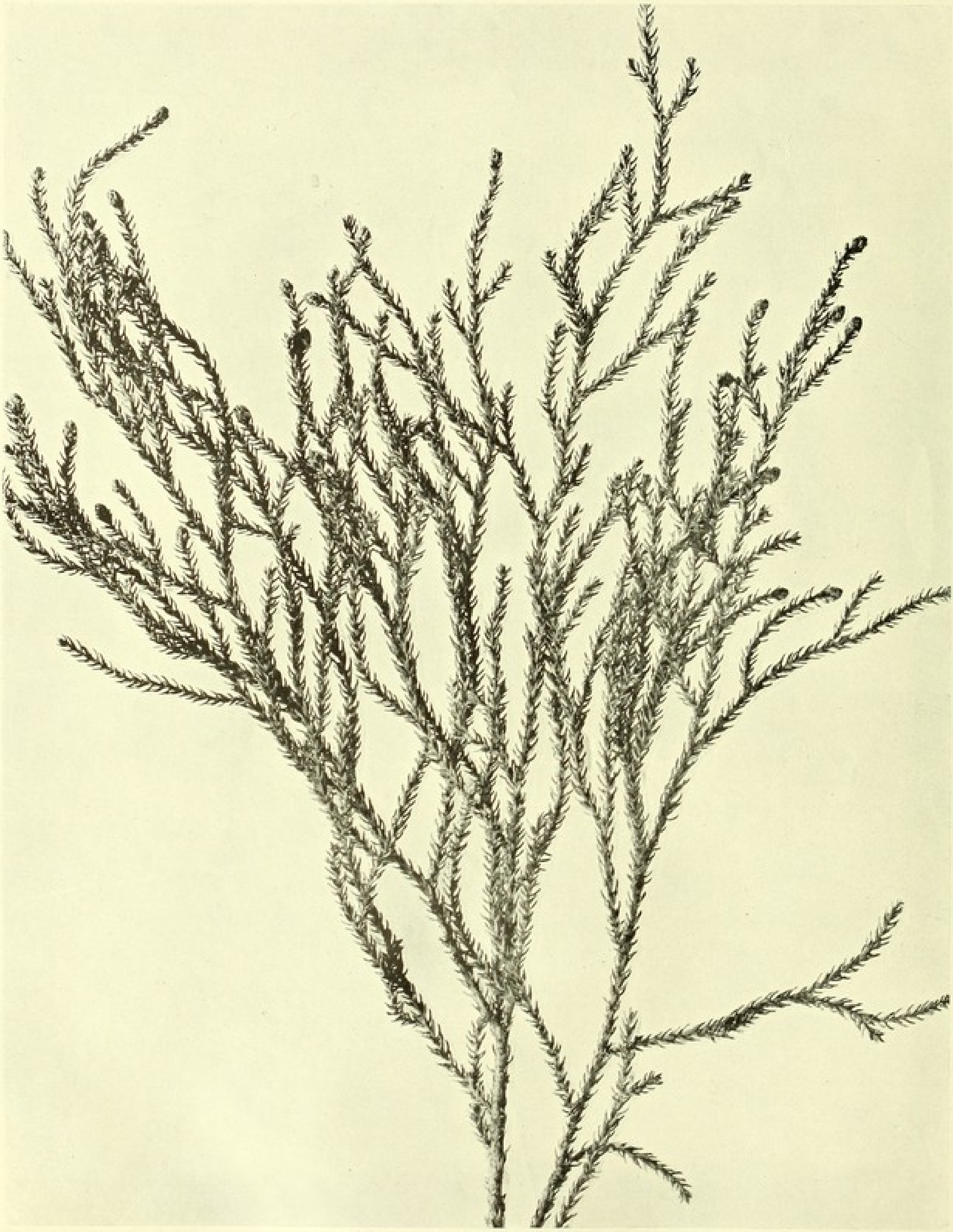
0·1504 gram acid dissolved in excess of decinormal NaOH and titrated back had required 8·3 c.c. of the soda solution to neutralise. This represents a molecular weight of 181·2. $C_9H_{10}O_4 = 182$.

Veratric acid is, therefore, the acid formed on oxidising the oil.

When the oil was boiled with hydriodic acid, with precautions as with Zeisel's method, an abundance of silver iodide was obtained, indicating the presence of methoxy groups.

From the results of the physical properties, the analysis, the formation of the bromide, and the preparation of the veratric acid, it is evident that the greater portion of the oil obtained from the timber of the "Huon Pine" is the methyl ether of eugenol (allyl veratrol), $C_6H_3 \cdot C_3H_5(1) \cdot OCH_3(3) \cdot OCH_3(4)$, and that the odour of the wood is largely due to that substance. The phenol, eugenol, was not detected in the oil.

The higher boiling portion of the oil gave the colour reactions for cadinene, but, with the small amount of a possible sesquiterpene present in the oil, no satisfactory reaction was obtained, and the crystalline hydrochloride for cadinene was not formed. The identity of a possible sesquiterpene thus remains in abeyance.



Nat. size.

Pherosphæra Fitzgeraldi, F.v.M. BLUE MOUNTAINS, N.S.W.

THE GENUS PHEROSPHÆRA.

Arch. in Hook. Kew Journ., ii, 52, pro parte.

I. HISTORICAL.

This genus, established by Archer in Hooker's Journal of Botany in 1850, is limited to two species which occur, one on the mainland and one in Tasmania,—where it was originally found by Gunn on the mountains near Lake St. Clair, whilst in the former it grows on the Blue Mountains west of Sydney. It is closely allied to Dacrydium.

II. SYSTEMATIC.

They are small, low-growing shrubs, occurring generally under shelving rocks at the base of waterfalls.

The leaves are small, decussate, spirally imbricate, and the flowers diœcious. Male amentum ovoid, globular, terminal, microsporophylls few, spirally arranged, subsessile, the incurved apex narrower than the anther; the microsporangia parallel, opening outwards in two cells. The female amentum ovate, the macrosporophylls being spirally arranged, imbricate, and bearing at the base of each an individual erect macrosporangium.

The fruit cones are ovoid, with concave scales thickened at the base.

Seed ovoid-oblong, contracted into a neck and crenulate at the orifice, and occasionally longitudinally winged.

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1. Pherosphæra Hookeriana.

Archer in Hook. Kew Journ., ii, p. 52; Hook. f. Tas. I, 355, t. 99.

Habitat.

This densely branched shrub is restricted in its distribution to the alpine regions of Tasmania, where it has been recorded from the mountains near Lake St. Clair (*Gunn*); and the high alpine flats of Mount Field East (*F. Mueller*).

I. HISTORICAL.

When first described in 1850, it was regarded as having great affinity with the "Huon Pine," *Dacrydium Franklini*, and is still included by some botanists under that Genus, but the investigations of this research show these Genera to be quite distinct.

II. SYSTEMATIC.

It is a densely branched, erect shrub, with leaves closely imbricate, decussate, thick, very obtuse, keeled, about half a line long and broad, of 4 or 5 rows. Male amentum erect, terminal, very small ; microsporophylls subsessile, spirally arranged. Female amentum decurved, very small, with about 4 to 8 imbricate scales, thickened at the base into an obtuse external protuberance, acuminate at the apex, but obtuse, with one solitary anatropous ovule, but ultimately orthotropous. Seed small.

III. LEAVES.

Not investigated.

IV. TIMBER.

Too small for any economic purpose.

Pherosphæra Fitzgeraldi,

F.v.M. in Hook. Icon. pl. xiv, 64, t. 1383 (1882).

Habitat.

In New South Wales this species is found at the base of most of the chief falls on the Blue Mountains. The material upon which this investigation is based was obtained at Lower Falls at Leura, where it is a small dense shrub, and only grows where it can catch the drips from the falls.

Pherosphæra Fitzgeraldi, F.v.M. BLUE MOUNTAINS, N.S.W.

I. HISTORICAL.

It was not until thirty-two years after the Tasmanian species became known that this species was described, and it is certainly remarkable that these two species should occur so far apart geographically.

II. SYSTEMATIC.

A densely branched, scrambling shrub. Leaves a dark-olive green colour, imbricate, keeled, obtuse, about three mm. long. Male amentum terminal, erect, about seven mm. long, and composed of about ten to fifteen microsporophylls. Female amentum, solitary towards the ends of the branchlets, with few microsporophylls, spirally arranged, each having a single orthotropous ovule. Cones small, with four to eight scales, thickened at the base into an obtuse external protuberance, acuminate at the apex.

Chemistry of the Leaf Oil.

This material, which was somewhat difficult to obtain, consisted of the terminal branchlets of this little prostrate Conifer, and fruits were quite absent. It was collected at Leura, New South Wales, 66 miles west of Sydney, 20th February, 1907. The yield of oil was small, and 145 lb. of material gave only $2\frac{1}{2}$ oz. of oil, equal to 0·108 per cent. The crude oil was of a light lemon colour, and had a turpentine-like odour, not at all distinctive. It was largely a terpene oil, consequently was but little soluble in alcohol, and it did not form a clear solution with 10 volumes of 90 per cent. alcohol. Only a very small amount of ester was detected, and as the oil at our disposal was small in quantity, its identity could not be determined.

The oil consisted principally of dextro-rotatory pinene, probably a little limonene or dipentene, and cadinene—the latter in some quantity.

The specific gravity of the crude oil at $\frac{22}{15}$° C. = 0·8705; rotation $a_D = +15{\cdot}1°$; refractive index at 23° C. = 1·4841. The saponification number was only 2·4, equal to 0·84 per cent. of ester as bornyl or geranyl acetate.

Only a small amount of oil could be spared for redistillation, but nothing came over below 155° C. Between 155° and 159°, 44 per cent. distilled; and between 159° and 178°, 27 per cent.; only a comparatively small amount came over between 178° and 265°; but 15 per cent. distilled between 265° and 280° C.

The specific gravity of the first fraction at 21° C. = 0·8483; of the second, 0·8433; of the third, 0·9216. The rotation of the first fraction $a_D = +27{\cdot}6°$; and

of the second, + 27·1°. The rotation of the third fraction could not be taken with certainty, but when dissolved in ether it was lævo-rotatory. The refractive index at 21° C. of the first fraction was 1·4736; of the second, 1·4733; and of the third, 1·5093.

The somewhat close agreement between the first and second fractions would seem to indicate that pinene is the principal terpene in this oil, but the lower specific gravity of the second fraction suggests that limonene was also present. The small amount of oil did not, however, allow of its separation. The nitrosochloride was prepared with the first fraction, and this melted at 108° C. This result, taken with the others, confirms the presence of pinene in the oil of this species.

The higher boiling fraction, when dissolved in chloroform and agitated with a few drops of sulphuric acid, became at first greenish in colour and eventually passed through purple to blue. On heating the blue solution it became red, and the same results were obtained when the oil was dissolved in glacial acetic acid. The oil was sparingly soluble in alcohol and in acetic acid, but readily in ether.

The ethereal solution was saturated with hydrochloric acid gas and stood on one side for some days; it was of a blue colour. The ether was then evaporated off, and the residue allowed to stand. After about two weeks a crystalline mass had formed; this was placed on a porous plate to absorb the liquid portion, and the crystals were then purified from hot ethyl-acetate. The crystals melted at 116° C. which is very close to that required for cadinene dihydrochloride.

The above results show that the sesquiterpene cadinene occurs in the oil of this plant.

When agitated with a concentrated solution of sodium bisulphite, a small amount of a crystalline substance formed, thus indicating the presence of an aldehydic body; but the quantity was too small for it to be determined.

IV. TIMBER.

It is too small for commercial purposes.

CLADODIA OF *Phyllocladus rhomboidalis*, RICH. "CELERY TOP PINE," TASMANIA. *Nat. size.*

(The leaves are seen like minute bracts.)

THE GENUS PHYLLOCLADUS.

L. C. Rich. Conif. 129, t. 3.

I. HISTORICAL.

This genus was established in 1826 by L. C. Richard (Con. 130, t.), and comprises one Australian species which is endemic, one in New Zealand, and one in Borneo. In using this name the "Index Kewensis" is followed, although as a matter of priority Sprengel's *Thalamia*, 1817, perhaps should take precedence.

Species have been traced to the Cretaceous times (Renault) in Nebraska and Spitzbergen, whilst Ettingshausen, l.c., p. 103, Pl. VIII, records and figures a species under the name of *P. asplenoides* as Tertiary from Tingha, New South Wales.

II. SYSTEMATIC.

The distinguishing characteristic of these Conifers is their flattened, entire, or lobed phylloclades or branchlets, the true leaves being reduced to small appressed scales.

The flowers are monœcious or diœcious. Male amentum cylindrical, stalked, solitary, or two or three together in the axils of leafy bracts ; microsporophylls imbricate, on a short stipes, with a small connective having an apiculation or crest ; the microsporangia are adnate, and two in number. The female amentum very small, terminal, occurring along the edges of the phylloclade, consisting of a few macrosporophylls in a short spike, or a single one, and individually bearing a solitary, erect macrosporangium, the upper macrosporophyll occasionally being sterile.

Fruiting scales thick and fleshy, enclosing the base of the seed, which is ovoid, in a cup-shaped disk, the outer integument membranous and not winged ; the inner one crustaceous.

Phyllocladus rhomboidalis.

Rich., Conif. 130, t. 3.

"CELERY TOP PINE."

Habitat.

Tasmania, Derwent River, R.Br., and dense forests in the mountains and southern parts of the island (J. D. Hooker).

I. HISTORICAL.

(*Vide supra.*)

II. SYSTEMATIC.

A small tree, reaching its maximum height (60 feet) on the lower levels, and becoming dwarfed on the higher altitudes of the mountain ranges, the branches showing a tendency to a verticillate form of growth; the cladodia cuneate, or rhomboidal, obtuse, bluntly toothed or lobed, 1 to 2 inches long, the leaf scales very small, and subulate. Male and female amenta, fruit and seed as described above.

Remarks.

This tree occurs associated with *Athrotaxis selaginoides* in the dense scrubs surrounding Williamsford, Tasmania. Like *Athrotaxis*, it occurs on the summits of the neighbouring mountains, in a much stunted form. Normally, *Phyllocladus* is a medium-sized tree, with a height up to 60 feet, and a diameter from 2 to 3 feet. It is very unlike a pine in appearance. The unbranched stem varies from 20 to 40 feet, and the only pine-like character is the tapering shape of the foliage on the branches. The branches are irregular and thick in proportion to their length.—(C. F. Laseron.)

III. LEAVES.

These are too small for any economics, and, in view of the rudimentary part played by them in the life history of the plant, being practically superseded by cladodia, their investigation has been passed over for these latter, and, in this case, more important organs which are, in spite of their origin and the position assigned to them, to all intents and purposes leaves,—for it is a question whether function or origin should decide a designation.

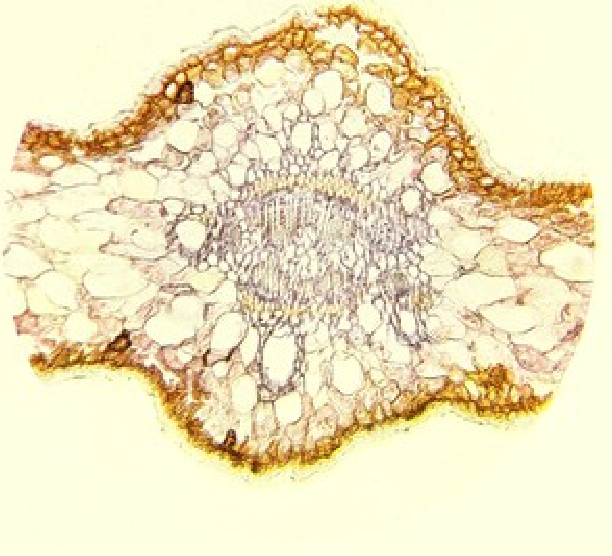


Figure 273.—Transverse section through the median portion of a phylloclade, showing the number of bundles composing the midrib surrounded by five oil cavities of varying sizes. The rest of the tissue partakes of the character of an ordinary leaf. Stained with hæmatoxylin and safranin. *Phyllocladus rhomboidalis*, × 80.

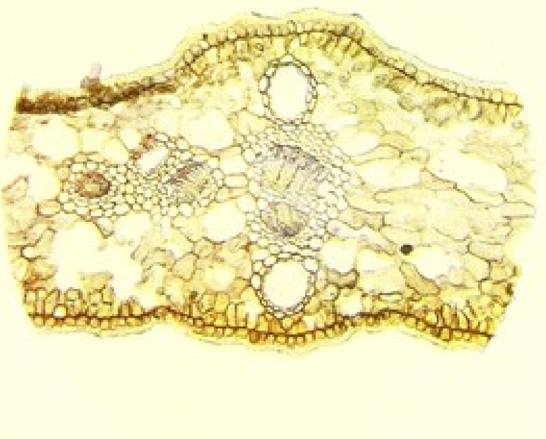


Figure 275.—Transverse section through the median area of a phylloclade, showing cluster of bundles in central axis and one on left side with a lateral orientation. An oil cavity with secretory cells occurs near each phloem of the leaf bundle. The two kinds of parenchyma are well defined,—the palisade being more pronounced on the assimilatory or upper surface of the phyllode. Several stomata backed by air cavities can also be seen. Stained with hæmatoxylin. *Phyllocladus rhomboidalis*, × 70.

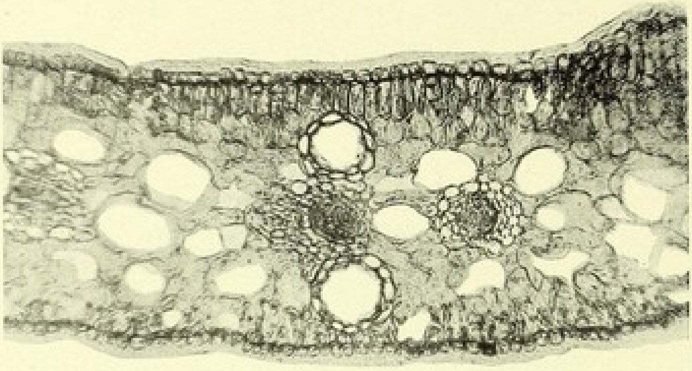


Figure 277.—Transverse section through three parallel bundles in a phyllode, each of which is surrounded by endodermal cells, the middle bundle having an oil gland above and below it, and surrounded by secretory cells. The other areas are air spaces or cavities. *P. rhomboidalis*, × 85.

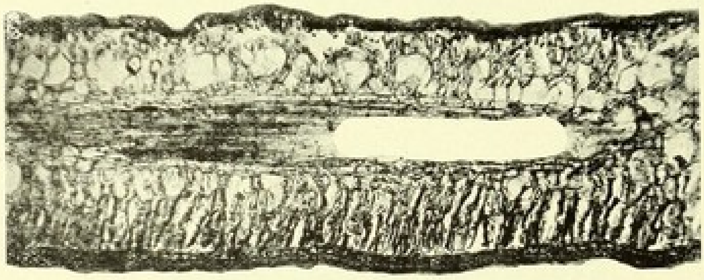


Figure 278.—Longitudinal section through an oil cavity in a phyllode of *P. rhomboidalis*, × 65.

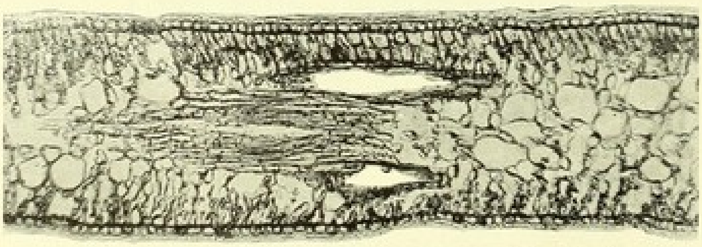


Figure 279.—Longitudinal section through two oil cavities having a bundle between them in a phyllode of *P. rhomboidalis*, × 65.

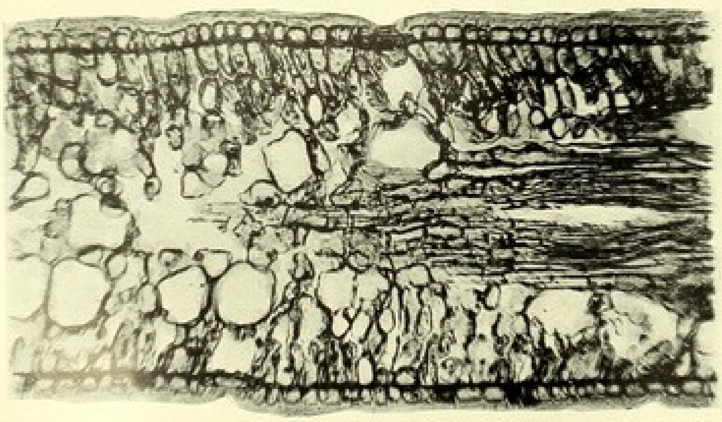


Figure 280.—Longitudinal section through phyllode with a bundle in the right field of vision. *P. rhomboidalis*, × 120.

Longitudinal sections through portions of a phylloclade. Phyllocladus rhomboidalis, Rich.

CLADODIA.

(*a*) ECONOMIC (*vide* Chemistry).

(*b*) ANATOMY.

Figures 271 and 272, taken through the median bundle and low down, give some idea of the general structure in that portion of these organs.

In Figures 273–274, the central vascular cylinder is seen to be divided into several bundles, surrounded and separated individually by parenchymatous cells, which also enclose between them and the phloem a comparative large number of sclerenchyma cells, which, in some cases, quite surround the lateral bundles.

The fundamental tissue consists of spongy and palisade mesophyll, and large parenchymatous cells; the former, as obtains in normal leaves, predominating in amount; through this and equi-distant from each surface at fairly regular intervals are bundles, and often accompanying these are oil cavities surrounded by strengthening and secretionary cells or cavities, as in the case of that of the median bundle. The epidermis is characterised by a very thick cuticle or outer wall, whilst hypodermal cells are not often found. The palisade layer extends around the whole phyllode, supported inwardly by the spongy mesophyll, intermixed with large intercellular water or air cavities. Stomata occur irregularly scattered on both surfaces. The sections illustrated were taken at various distances in the cladodia. (Figures 271–280.)

Masters in "Linn. Soc. Trans.," Vol. XXI, No. 205, p. 7, states—"The leaves have small resin canals close to the exoderm on the lower surface of the leaf (*P. alpinus*), and a single bundle." Speaking of the phylloclade of *P. alpinus* he states that—"beneath the upper epidermis is a layer of perfect parenchyma, traversed by a central and by numerous lateral fibro-vascular bundles." From the illustrations here given it is seen that similar characters occur in the Tasmanian *Phyllocladus*.

CHEMISTRY OF THE LEAF (CLADODIA) OIL.

THEORETICAL.

The oil from this portion of the tree is of particular interest, because it contains the only solid crystallisable diterpene so far known. The principal constituent of the oil is pinene, which is lævo-rotatory, although the rotation is not very high, and it appears to be the only $C_{10}H_{16}$ substance present. Practically pure pinene can be obtained in quantity from the cladodia oil of this species by fractional distillation alone. The only other constitutent of importance in the oil, besides the diterpene, is probably a sesquiterpene, but owing to the presence of the solid body it was difficult to separate by distillation, so that it was only possible to obtain a small quantity of it, and its chemistry could not be completed; some results, however, are recorded below.

The diterpene was readily prepared in a perfectly pure condition, so that it was possible to determine satisfactorily its composition and physical properties. This well crystallised body is thus one of the very few members of this class of plant substances, which can be prepared from natural sources in a perfectly pure condition. Our sample of the oil was obtained by steam distillation, and contained about 3 per cent. of the solid diterpene. The oil was almost free from compounds containing oxygen, and esters, alcohols, aldehydes, and similar bodies were practically absent, only a very small amount (about 1 per cent.) of an alcohol being determined by acetylating the oil. The higher boiling liquid portion showed no tendency to resinify, so that when the semi-solid crystalline mass, which contained the diterpene, was spread upon porous plates for a few days, the whole of the liquid portions were absorbed, the diterpene remaining in a perfectly white, and even at this stage, almost pure condition. It was little soluble in cold alcohol, but more readily in hot alcohol, and dissolved easily in chloroform, ether, petroleum ether, and benzene. The best method for purification, after the first separation from alcohol, was to dissolve it in chloroform and precipitate by the addition of alcohol. If the chloroform was in excess, so that on the addition of alcohol no precipitate was formed, then on slow evaporation, crystals readily separated. These crystals were microscopic needles, but were not well defined. When only a small amount of chloroform was used as solvent, then on addition of the alcohol the solid substance at once crystallised out. When this was dried on the slab it had more of a platy structure, was pure white, of a nacreous lustre, and was practically without odour. It was dextro-rotatory, and the determination of the specific rotation was made with both benzene and chloroform, the specific rotation, $[\alpha]_D = +16{\cdot}06^\circ$, being identical with both solvents. Its ready solubility in benzene enabled the molecular weight to be determined by the cryoscopic method, and this, together with the results of the analyses, showed it to have the formula, $C_{20}H_{32}$. Its melting point was 95° C. (cor.), and it did not matter what the solvent had been. The fused substance also melted again at the same temperature. It is perhaps a concidence that the melting point of this solid diterpene is practically double that of the melting point of camphene, the solid $C_{10}H_{16}$ terpene, and which has of course half its molecular weight.

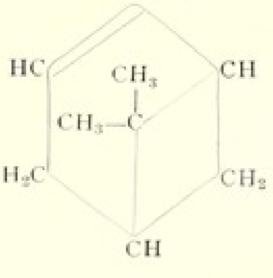
Although the diterpene crystallised so readily, yet it did not sublime, and it was not readily attacked by either dilute nitric or sulphuric acids, but was acted upon by the concentrated acids. The ordinary potassium dichromate oxidising mixture scarcely attacked it, but it was readily oxidised by chromic acid when dissolved in acetic acid. Strong nitric acid slowly dissolved the crystals in the cold to a yellow solution, and with continued evolution of a small amount of brown fumes. If the action was not allowed to continue too long, a yellow nitro-compound was separated on the addition of water. This gave a marked reaction for nitrogen, and melted to a thick dark-coloured liquid at about 115–120° C., but the melting point was not sharp, and it softened

several degrees lower. On allowing the diterpene to remain in contact with the nitric acid in the cold for some days a comparatively large amount of solid acids was formed, but when it was warmed with strong nitric acid, energetic action took place with evolution of abundant brown fumes. The principal products of alteration were of an acid nature, were solid, and almost colourless; they were easily dissolved by alkalis, and precipitated again on acidifying, but were not identified with any known acid.

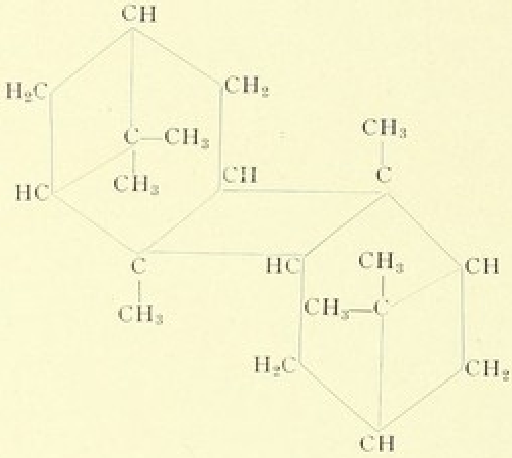
When warmed with concentrated sulphuric acid the diterpene was readily dissolved, and on continued heating soon became of a very dark coffee colour, with an indication of a greenish fluorescence. A sulphonic acid was apparently formed, as on the addition of a little water a dark precipitate was obtained, but this was almost entirely soluble in water. Aqueous alkalis had no action upon the diterpene, nor was there any alteration when it was boiled with acetic anhydride for a long time. When the diterpene was dissolved in acetic acid a solution of bromine was not discoloured, nor was the colour removed at once when very dilute bromine was added to a chloroform solution, or to a carbon-tetrachloride solution. On the addition of more bromine, and allowing the solution to remain some time, there was a slow evolution of hydrobromic acid, so that a substitution product should eventually be obtained. It is evident, however, that the diterpene is a saturated compound. A dilute neutral solution of potassium permanganate had no action upon it, and no change of colour took place even on heating, nor was there any alteration when the solution was acidified.

When more material shall have been obtained, further investigations will be undertaken in order to determine the products of nitration, bromination, oxidation, &c.

The diterpene is a saturated substance, and in this respect differs from both the accompanying pinene, and the sesquiterpene. As the formula of this hydrocarbon is $C_{20}H_{32}$ and the molecule saturated, it may, perhaps, be composed of two molecules of a bicyclic terpene, the severing of a double bond in the terpene molecule providing the connection. The bicyclic terpene in the oil, and which answers to this requirement, is pinene, and it might be suggested, therefore, that the diterpene may be composed of two molecules of pinene. The generally accepted structure for pinene is



so that the arrangement of the molecule for the diterpene may be stated as follows :—



The other possible arrangement with two molecules of pinene would be expected to yield an inactive compound. In this arrangement one of the pinene molecules has been rotated in the plane of the paper. The reactions of this diterpene are in many respects similar to those of diphenyl, which substance it somewhat resembles in appearance, and this similarity might perhaps suggest a corresponding linkage, but the results did not indicate a molecule with 34 hydrogen atoms, and from three analyses the following percentages of hydrogen were obtained: 11·75, 11·74, and 11·74, and over 88 per cent. of carbon with each.

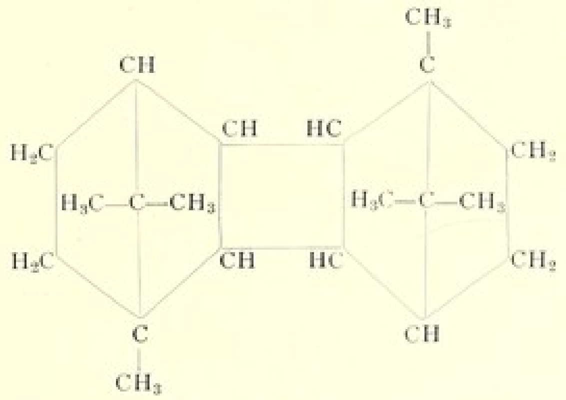
A. Etard and G. Meker, ("Compt. rend." 1898, 126, 526–529) prepared a crystalline dicamphene hydride by treating pinene hydrochloride with sodium. This substance melted at 75°, boiled at 326–327°, and had specific rotatory power $[\alpha]_D = + 15° 27'$.

E. A. Letts, ("Ber." 13, 793–796) by treating pinene hydrochloride with sodium, had previously obtained, in addition to other bodies, a crystalline substance which melted at 94°, and to which the formula $C_{20} H_{34}$ was given.

The close agreement between the specific rotation of Etard and Maher's substance, and that of Phyllocladene, might suggest a similarity, but there is a difference of 20° in their melting points. The melting point of Letts' substance is, however, in closer agreement.

The results of the analyses of Phyllocladene show the molecule to have 32 hydrogen atoms, so that the molecule cannot be constructed with only a single linkage.

If it be considered that the terpene taking part in the construction is camphene, then by a similar arrangement to the above the structure of the molecule may be stated as



But camphene does not occur in the oil of this plant. There is, however, a very close relationship between the molecule of pinene and that of camphene, and the former may be without much difficulty transformed into the latter. From the above considerations it appears that pinene is the bicyclic terpene agreeing with the constitution of this diterpene, particularly as pinene occurs in the oil in such an exceptionally pure condition. Whether the pinene is derived from the breaking down of the diterpene, or the diterpene from the combination of the pinene must remain at present an open question.

The name Phyllocladene is proposed for this diterpene, as indicating the genus from which it has been derived. From its reactions, melting point and analysis, it cannot belong to the paraffin series, and it thus differs from those solid hydrocarbons previously recorded from the essential oils of a few plants.

The nitrosochloride was readily obtained with the pinene and in abundance, and when purified from chloroform by precipitating with methyl alcohol, it melted at 107–8° C., as did also the similar compound obtained with the pinene from *Callitris Drummondi* and from those other species of *Callitris* in which the pinene was a pronounced constituent, but in each case the nitrosopinene prepared from it melted at 132° C.

Experimental.

This material was collected at Williamsford, Tasmania, and distilled 30th July, 1908. The yield of oil was only fair, and 524 lb. of leaves with terminal branchlets, gave 18 oz. of oil, equal to 0·215 per cent. The crude oil was of a light lemon-yellow colour, was mobile, and with a very slight aromatic odour, distinctive from that of the "pine-needle oils" generally, but apparently characteristic. The oil was very insoluble in alcohol, and it required one volume absolute alcohol to form a clear solution. The specific gravity at 16° C., was

0·8892 ; the rotation a_D = — 12·3° ; and the refractive index at 16° C., 1·4903. When a small quantity of the oil was placed in a shallow dish, as soon as the more volatile constituents had evaporated, a semi-crystalline mass formed.

Only a very small amount of ester was present in the crude oil, as shown by the following:—1·8804 gram of oil, after boiling half an hour, required 0·0028 gram KOH, or a saponification number, 1·5. A second determination gave S.N., 1·4.

A portion of the oil was acetylated in the usual way by boiling with acetic anhydride and anhydrous sodium acetate, and the perfectly neutral oil saponified; 2·501 grams required 0·0112 gram KOH, or a saponification number 4·5. As 1·5 was obtained with the unacetylated oil, the saponification number of the esters formed from the small amount of alcohol present was only 3, this result representing less than 1 per cent. of a free alcohol. It is perhaps partly to the presence of this small amount of an alcohol that the slight aromatic odour of the crude oil is due.

When redistilled, (170 c.c. of oil taken) nothing came over below 155° C.; between 155–160° C., 36 per cent., distilled; between 160–165°, 21 per cent., and between 165–210°, 16 per cent. The thermometer then rapidly rose to 280°, between that temperature and 300°, 4 per cent. distilled, thus 23 per cent. remained in the still. The residue was poured into a vessel and set aside to crystallise. After two days it had become a semi-solid crystalline mass, and was then spread on porous plates to absorb the liquid portions. The comparatively large amount of high boiling constituents considerably retarded, towards the end, the distillation of the lower boiling terpene, although the results generally of the first three fractions agreed somewhat closely. These results were as follows:—

Boiling Point.	Per cent.	$d\,\frac{15}{15}$° C.	a_D 1 dcm. tube.	Refractive Index at 22° C.
155–160° C.	36	0·8527	− 20·1°	1·4738
160–165° C.	21	0·8526	− 19·3°	1·4741
165–210° C.	16	0·8548	− 15·1°	1·4771
280–300° C.	4	0·9336	+ 3·6°	1·5103

The Pinene.

The two first fractions were again distilled, when no less than 50 c.c. came over within 1 degree of temperature (155–156° C.), the third fraction was then added to the residue in flask and the distillation continued, when 32 c.c. were again obtained boiling between 155–156°, and 18 c.c. between 156–159°; thus over 48 per cent. of the total oil was obtained boiling at the temperature for pure

pinene, and 60 per cent. between 155–159°. These fractions gave the following results:—

Boiling Point.	C.C.	$d\ \frac{24}{15}$ ° C.	a_D 1 dcm. tube.	Refractive Index at 24° C.
155–156° C.	50	0.8546	– 20·5°	1·4727
155–156° C.	32	0.8545	– 19·6°	1·4733
156–159° C.	18	0·8546	– 18·2°	1·4735

The fractions had the appearance and odour of pinene, the first particularly so. The nitrosochloride was prepared with the first two fractions, and when this was finally purified by dissolving in chloroform and precipitating with methyl alcohol, it melted at 108° C. The nitrosopinene was prepared from this in the usual way, and when finally purified from acetic ether it melted at 132° C.

The principal constituent in this oil is thus pinene, the results pointing to the absence of the other members of the terpene group.

The (?) Sesquiterpene.

The fourth fraction of the first distillation was again distilled, and 5 c.c. obtained boiling between 285–295° C. This oil was lemon-yellow in colour, and is evidently the constituent which gives the colour to the crude oil. Its specific gravity at 24° C. = 0·9209; rotation a_D = + 3·4°; and refractive index at 23° C. = 1·5065.

When dissolved in chloroform and shaken with a few drops of sulphuric acid, the colour soon became of a deep red, darkening quickly to red-brown and crimson; it still had a crimson tint after twenty-four hours, but after two days the colour inclined to violet, which colour remained constant for some days.

When dissolved in chloroform and one drop of bromine added, the solution was instantly discoloured; on adding more bromine the colour quickly changed to green, soon becoming deeper in colour and then blue-green; in half an hour the colour was indigo blue, this blue colour remaining constant for days. This substance is thus active to light, is unsaturated, boils at a high temperature, and has the refractive index and specific gravity corresponding closely to the requirements for a sesquiterpene. When obtained in larger quantity it will be again investigated.

The Diterpene.

The residue left in the flask on the first distillation was poured into a basin and allowed to crystallise; after two days a semi-crystalline mass had formed, and this was spread on porous plates and allowed to remain for five days, by which

time all of the liquid portion had been absorbed. The solid which remained was quite white, and practically without odour. It was dissolved in boiling alcohol, filtered, and allowed to cool, when much of the solid separated. The crystals were not well defined, were inclined to be tabular, and when dried on the slab had a nacreous lustre. It was finally purified, as previously stated, by dissolving in chloroform and precipitating by alcohol. The melting point was 95° C. It was optically active, and three determinations gave results as follows:—

(1) 0·3398 gram dissolved in 10 c.c. chloroform rotated the ray + 0·55° in a 1-dcm. tube, thus the specific rotation $[a]_D = + 16{\cdot}18°$.

(2) 0·6268 gram dissolved in 10 c.c. chloroform rotated + 1·0° in 1-dcm. tube, therefore $[a]_D = + 15{\cdot}95°$.

(3) 0·5925 gram dissolved in 10 c.c. benzine rotated 0·95° in 1-dcm. tube, therefore $[a]_D = + 16{\cdot}04°$.

Mean $[a]_D = + 16{\cdot}06°$.

Analyses gave the following, the substance being fused in the boat before weighing:—

(1) 0·1566 gram gave 0·5067 gram CO_2 and 0·1656 gram H_2O.
C = 88·244, and H = 11·75 per cent.

(2) 0·1304 gram gave 0·4216 gram CO_2 and 0·1376 gram H_2O.
C = 88·11, and H = 11·74 per cent.

(3) 0·1455 gram gave 0·47 gram CO_2 and 0·1546 gram H_2O.
C = 88·14, and H = 11·74 per cent.

$C_{20}H_{32}$ requires C = 88·24 and H = 11·76 per cent.

The molecular weight determinations were made with benzene as solvent.

(1) 0·5988 gram in 21·5 grams benzene reduced the freezing point by 0·515°; MW = 264.

(2) 0·5104 gram in 15·5 grams benzene reduced the freezing point by 0·605°; MW = 267.

$C_{20}H_{32}$ (C = 11·91, H = 1·0) = 270.

These results show the solid substance in the oil of this tree to be a hydrocarbon, and to have the formula $C_{20}H_{32}$.

When the crystals were dissolved in chloroform and shaken with a few drops of sulphuric acid there was no colouration, even after twenty-four hours.

The reactions with acids, &c., have been referred to in the earlier portion of this article.

IV. TIMBER.

(*a*) Economic.

The timber is pale-coloured, and much harder than the "King William Pine." It planes well and has an attractive figure, is close, yet short grained, and should make good panels. Apparently it is suitable for violin sounding boards.

Though a somewhat harder wood, it has not a reputation for durability equal to that of the "King William Pine." It has also a greater number of knots and flaws. The local estimation of the weight of the timber is 370 super. feet to the ton, that is about 73 lb. to the cubic foot.

Tranverse Tests of Timber, *Phyllocladus rhomboidalis*.

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 3·00; D 3·00	B 2·98; D 3·00	B 3·00; D 2·98
Area of cross section, square inches	9·00	8·94	8·94
Breaking load, lb.	5,000	5,470	5,050
Modulus of rupture in lb. per square inch ...	10,000	11,013	10,236
,, elasticity ,, ,, ...	1,600,000	1,728,000	1,690,434
Rate of load in lb. per minute	455	547	561

(*b*) Anatomy.

For all practical purposes this timber has similar anatomical characters with those of *Dacrydium Franklini* (Huon Pine), except that pitted cells occur in the tangential walls, otherwise a description of one is practically a description of the other. (Figures 281–283.)

V. BARK.

The bark is hard, thin, and scaly, the surface of the scales being smooth.

(*a*) Anatomy.

This bark has a peculiarity of structure quite unique compared to that of any of its congeners examined. The chief points of distinction are—first the occurrence of an inordinate number of sieve tubes with their accompanying sieve plates; and, secondly, the want of any regular stratification of the various cells, tubes, and fibres as obtains in many other Conifer barks. Sieve tubes occur throughout almost the whole bark substance, both inner and outer, the only place where they really do not occur is in the periderm layer in the outer cortex. There appear to be two kinds of tubes, those with elongated narrow cells with only one sieve-plate in the diameter, and those with more than one sieve-plate in a transverse wall, and are much broader and shorter cells than the

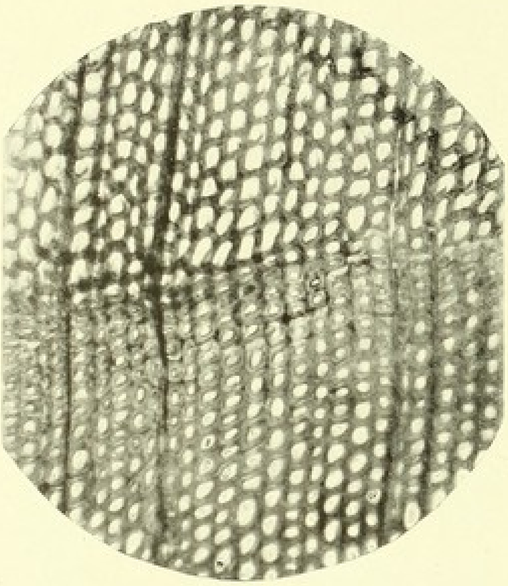


Figure 281.—Transverse section of timber, the narrow lumina marking the limit of autumnal growth. *P. rhomboidalis*, × 100.

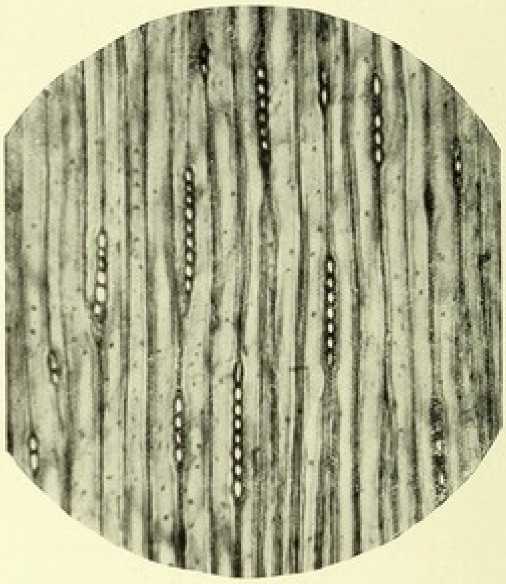


Figure 282.—Tangential section of timber, showing the unusual occurrence of bordered pits on tangential walls in a Conifer. Nearly all the cells of the rays are empty. *P. rhomboidalis*, × 100.

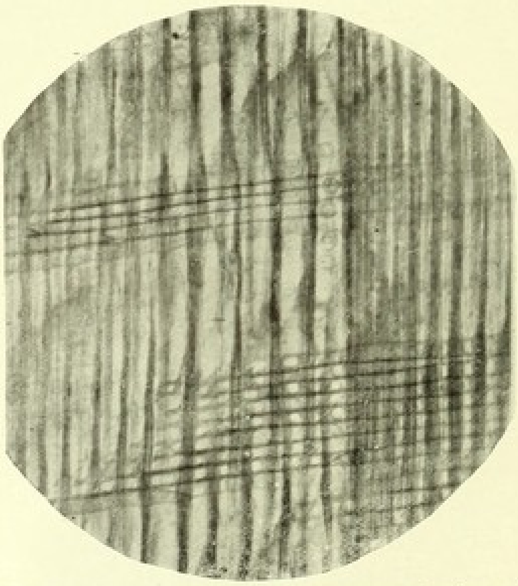


Figure 283.—Radial section of timber through autumnal and vernal growth. Bordered pits can just be detected on the radial walls. *P. rhomboidalis*, × 100.

Sections of timber of Phyllocladus rhomboidalis, Rich.

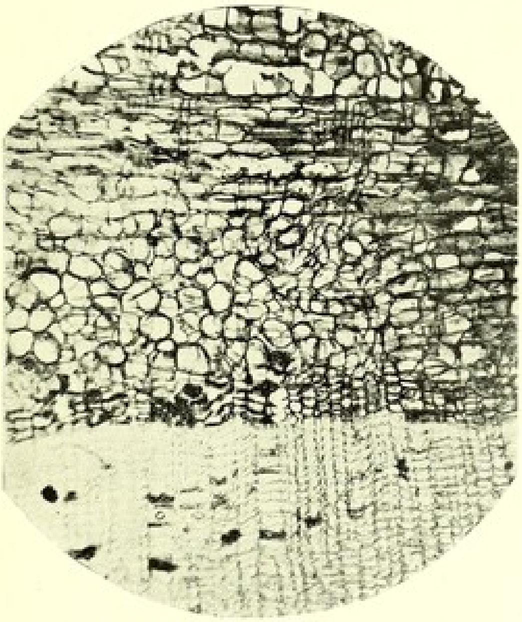


Figure 284.—Radial section through junction of inner (lower) and outer bark. *P. rhomboidalis*, × 68.

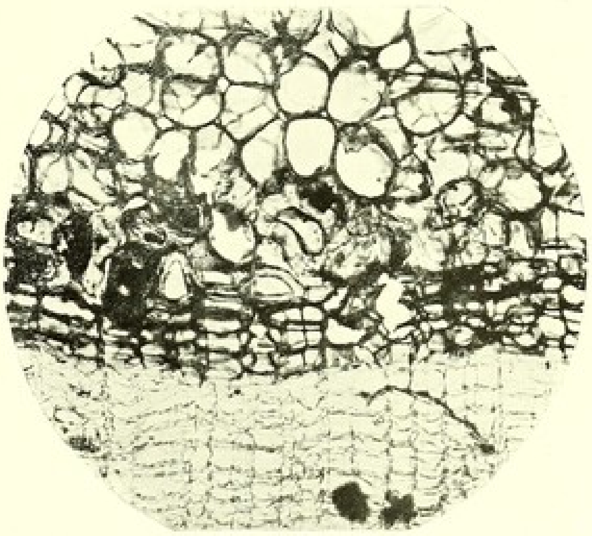


Figure 285—Transverse section at junction of inner and outer bark. Several sclerenchymatous cells can be seen in the centre of the picture. *P. rhomboidalis*, × 135.

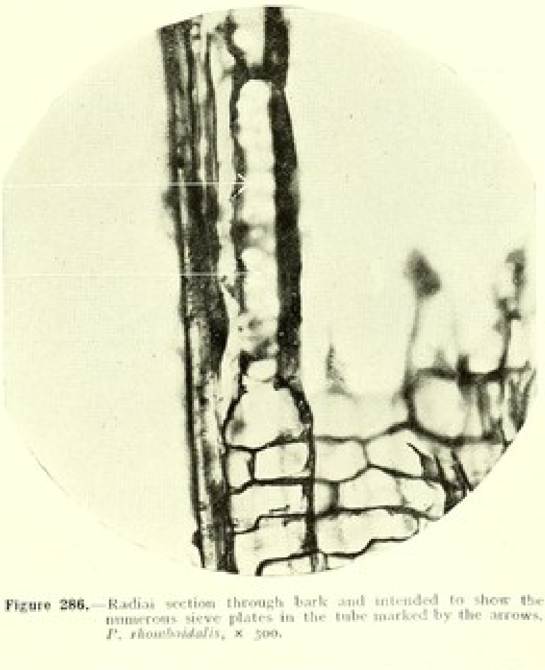


Figure 286.—Radial section through bark and intended to show the numerous sieve plates in the tube marked by the arrows. *P. rhomboidalis*, × 500.

Sections of bark of Phyllocladus rhomboidalis, Rich.

former, as shown in Figure 286. Bast fibres, parenchyma vessels, and sclerenchymatous cells are all intermixed with scarcely any order or regularity whatever.

The medullary rays are distinct objects in the transverse sections, winding in a sinuous manner amongst the parenchymatous vessels and sieve tubes. The bast fibres are of comparatively small area in the cross-section and form a fair proportion of bark substance, but are seen to better advantage in a longitudinal section.

The periderm cells present the only regular feature of the cortex, and this portion of the bark is comparatively broad and forms a distinct feature in the exterior material. Figure 284 is a 68-magnification of the outer bark, the lighter portion is a periderm layer. Figure 285, an increased magnification on Figure 284, shows in the centre of the picture sclerenchymatous cells. Figure 286.—In this it was hoped to show, in a 300-magnification, a broad sieve tube with double plates, but is not so clear as was expected.

(*b*) Chemistry.

This sample of *Phyllocladus* bark was obtained from Tasmania, and was collected from a fair-sized tree. It had a fibrous nature, was not very thick, and had an outer coating of a thin, papery consistency, which was of a darker colour than that of the general mass. The total thickness of the bark ranged from five to seven millimetres, and was of an orange-brown to a light burnt-sienna colour. The powdered bark was of a sienna-brown color and was somewhat fibrous. When extracted with boiling water and filtered through cloth, the filtrate on cooling separated a considerable amount of an orange-brown substance, which being very finely divided took a considerable time to deposit.

The clear filtrate from the first precipitated material, after clarifying with kaolin, contained a considerable amount of a substance which was evidently of a glucosidal nature. It had tanning properties, as well as acting as a dye material, and was almost entirely removed from solution by hide-powder. That this was so was clearly indicated, as no deposit of an insoluble substance formed after boiling the filtrate from the hide-powder with sulphuric acid.

The clear solution, before treatment with hide-powder, gave a dull salmon colour to cloth mordanted with alumina, and the whole range of tints with various mordants were more delicate and less red than were those formed with the sienna-brown powder, although the same range of colors were given by both the powder and the solution.

That the clear solution, before treatment with hide-powder, contained a glucoside was shown as follows: A little sulphuric acid was added and the

solution boiled for a long time; when cold a considerable amount of an orange-brown substance precipitated, and when this was removed it was found to be identical in every respect with the first precipitated powder from the hot extraction of the bark. From the clear filtrate the sulphuric acid was removed by barium carbonate, the organic substances by lead acetate, and the lead by sulphuretted hydrogen. The filtrate, when evaporated down, reduced Fehling's solution copiously, and contained a considerable amount of reducing sugars.

It thus appears that the original substance in the bark of this tree is largely a glucoside, and that it has tanning properties, as it combines with hide substance. It appears to be slowly hydrolised naturally, and the insoluble substance of the glucoside is deposited in the bark cells in a powdery condition, which gives the characteristic colour to the bark. The dry powder from the hydrolised glucoside is but little soluble in cold water, although the glucoside itself is largely soluble.

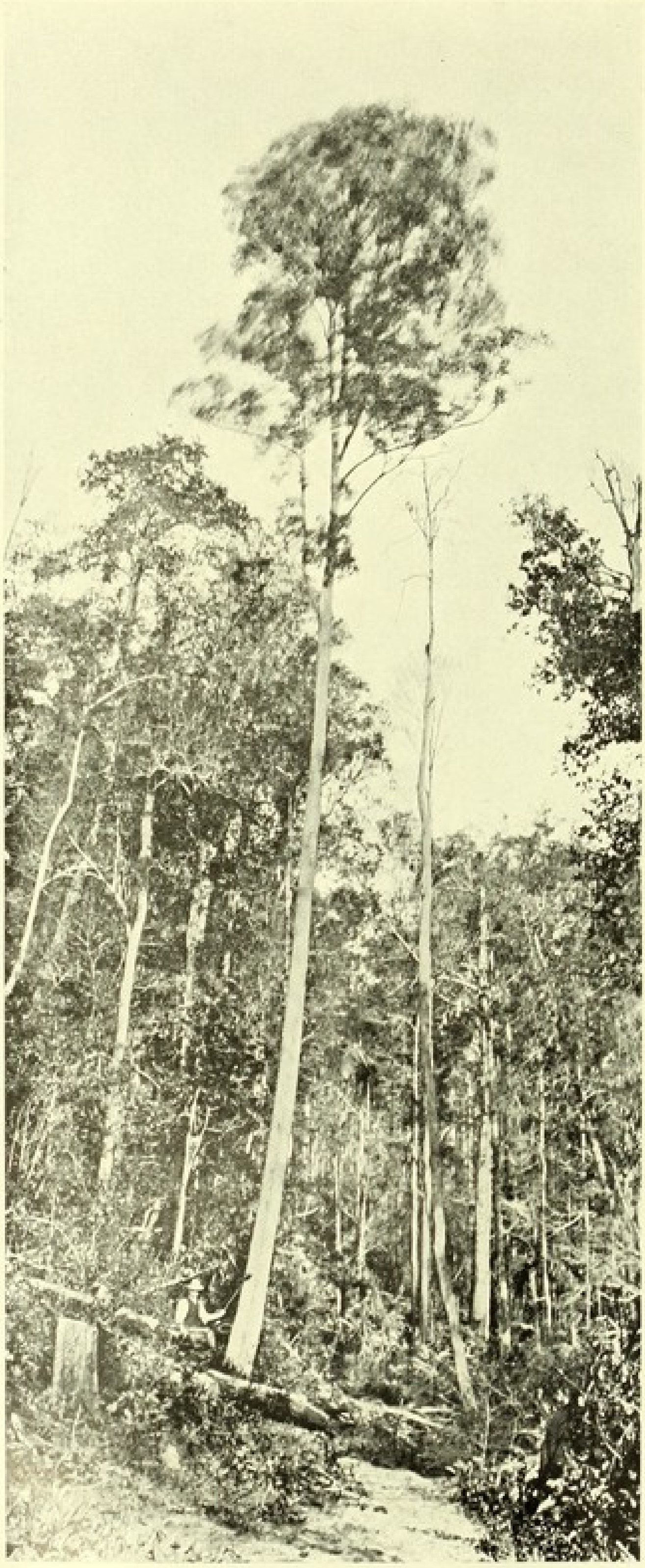
The total amount extracted from the air-dried bark with boiling water was 33.8%.

The clear tannin solution, after removal of the substances insoluble in cold water, contained 24.1%. After treatment with hide-powder in the usual way the corrected non-tannins equalled 12.2%, so that the substances absorbed by hide-powder represented 11.9%.

The amount of moisture in the bark was 11.8%.

In Kirk's "Forest Flora of New Zealand," p. 10, it is stated that a red dye was formerly extracted by the Maoris from the bark of the New Zealand tree, *Phyllocladus trichomanoides*, also that the bark of that tree possesses a special value in the preparations of basils for kid gloves, and has realised from £30 to £50 per ton in London for that purpose, but that the demand is intermittent.

The Museum sample of the bark of this species of *Phyllocladus* from New Zealand has a strong resemblance to that of the Tasmanian species, but it is thicker, and less brightly coloured.



Frank H. Taylor, Photo.

Podocarpus elata, R.BR.

"BROWN," "YELLOW," OR "PLUM PINE," GOSFORD, N.S.W.

THE GENUS PODOCARPUS.

I. HISTORICAL.

This genus was established by L'Heritier in 1788, although Baron von Mueller claims priority for Gaertner's *Nageia* of the same year, a name, however, which the "Index Kewensis" only acknowledges as *partim*. It is placed by Bentham and Hooker ("Gen. Pl.," Vol. III, 435) as a division of the Conifers.

It is one of the most widely distributed Pines of the Order, being dispersed over the tropical and subtropical regions of both hemispheres, from South Africa and New Zealand to Japan, and over the whole of South America. The Australian species are all indigenous.

It is claimed that evidences exist showing its occurrence in the Miocene beds of Central Europe. (Masters.)

The representatives of the genus are either tall trees or shrubs.

II. SYSTEMATIC.

The leaves vary in attachment, are usually alternate, rarely opposite, flat, with a prominent midrib. The flowers are diœcious or monœcious. Male amentum narrow, cylindrical or catkin-like, solitary, terminal on the ends of short axillary shoots, stipitate, stipes surrounded by short scales. Microsporophylls imbricate, numerous, slightly contracted at the base, connective apiculate; microsporangia two, dehiscing longitudinally. Female amentum axillary, pedunculate, consisting of two to four succulent macrosporophylls (or what may be regarded as such), which unite with the peduncle in an oblong, fleshy receptacle. Macrosporangia one or two, exserted, anatropous, and adnate to an erect stipes from within the larger macrosporophyll of the receptacle. Cotyledons two, with an inferior radicle.

Seed drupaceous, the nucleus enclosed in a double integument, the outer one succulent, the inner one long.

Frank H. Taylor, Photo.

Nat. size

Podocarpus elata, R.Br. [Male amenta.] "Brown," "Yellow," or "Plum Pine."

Nat. size.

Podocarpus elata, R.Br., in fruit.

1. Podocarpus elata.

R.Br., Mirb. in Mem. Mus. Par. xiii, 75.

"BROWN" OR "YELLOW PINE."

(Syn.—*P. ensifolia,* R.Br., Mirb., *l.c.*, *P. falcata,* A. Cunn. Herb.)

Habitat.

One of the largest trees of the brushes of the North Coast district of New South Wales and Southern Coast district of Queensland, where it attains a height of over 100 feet. Also *vide* appended list.

I. HISTORICAL.

This species was described by Robert Brown in 1826, and afterwards placed by Mueller under *Nageia* in his "First Census of Australian Plants," 1882.

II. SYSTEMATIC.

Leaves variable in length, measuring from 2 to 6 inches and occasionally 9 inches long and about ¼ to ½ inch broad, oblong, lanceolate, obtuse, midrib alone prominent, shortly petiolate. Male amenta, two or three together, sessile up to 2 inches long, subtended by short bracts. Female amentum very short, 4 cm. long, solitary in the lower axils of the leaves. Fruiting receptacle 1½ cm. long, with one ovoid or globular seed 1¼ cm. in diameter.

III. LEAVES.

(*a*) Economic.

None known, but it may possibly be a stand-by for stock in times of drought.

(*b*) Anatomy.

This bifacial leaf has the upper surface assimilatory and the lower transpiratory. The epidermal and hypodermal cells occur in a single row on both sides, Figures 287–8, the latter being also massed at the edges of the leaf; the palisade cells are only present behind the assimilatory or upper surface, the rest of the leaf substance being composed of spongy tissue—a structure in this case that does not conform to the usual shape of the vessels of this portion of a mesophyll, or at least in a transverse section of a leaf, when it will be noticed in Figure 289 that the cells are arranged with the long axes parallel to the upper and lower surfaces of the leaf and closely packed; whilst a longitudinal section of the leaf shows these in an interesting cross section for spongy tissue, forming quite a bead-like series,

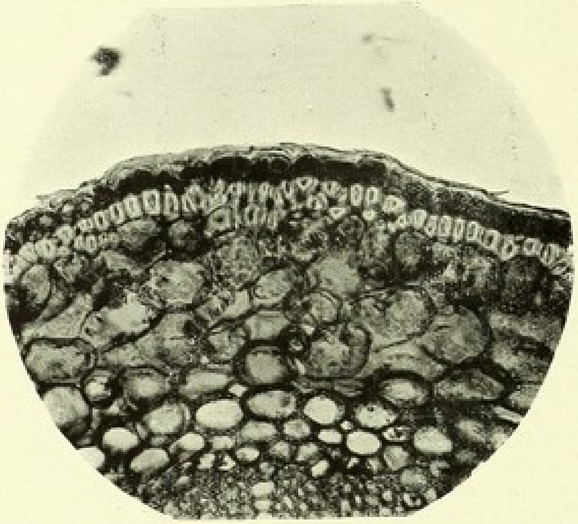


Figure 288.—Transverse section through a median portion of the assimilatory surface of a leaf. *P. elata*, × 190.

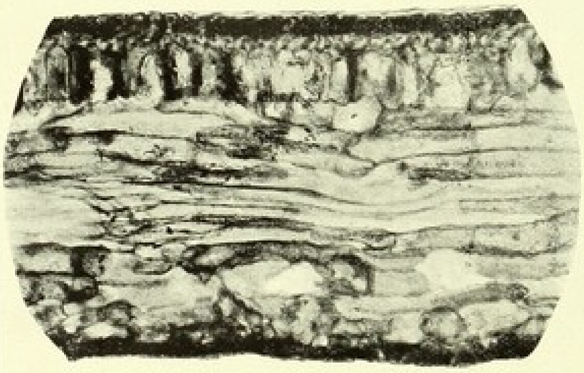


Figure 289.—Transverse section through portion of a leaf cut clear of the central bundle. *P. elata*, × 150.

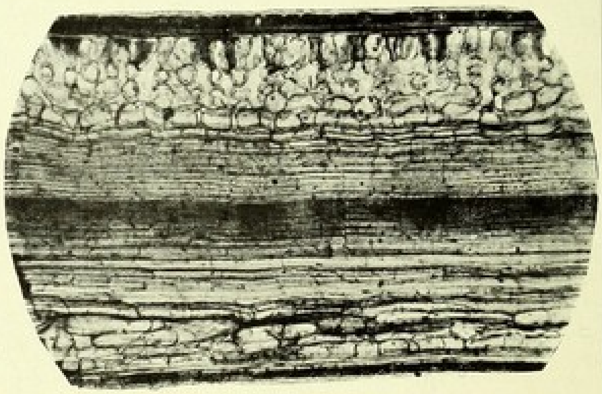


Figure 290.—Longitudinal section through the midrib of a leaf. *P. elata*, × 90.

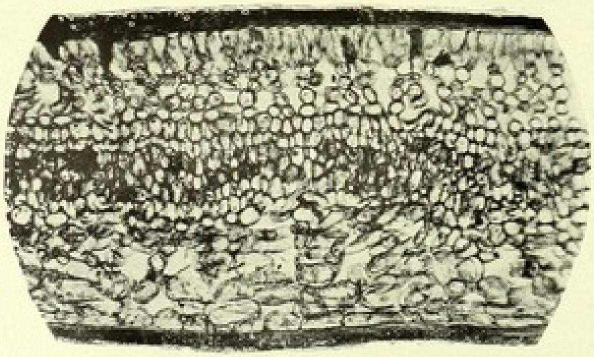


Figure 292.—Longitudinal section through portion of a leaf showing the structure clear of the bundles. *P. elata*, × 90.

Sections of leaves of Podocarpus elata, R.Br.

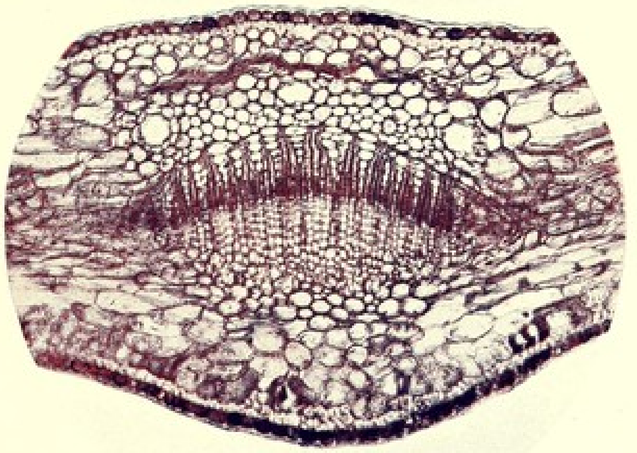


Figure 287.—Transverse section through a median portion of a leaf showing the conical arrangement (in section) of the phloem cells of the normally orientated vascular bundle. The reticulated cells of the transfusion tissue can just be made out on the right and left of the phloem, and which divide the endodermal cells into two masses, one protecting the protoxylem and the other with its three oil glands protecting the phloem. Stained with hæmatoxylin and safranin. *Podocarpus elata*, x 95.

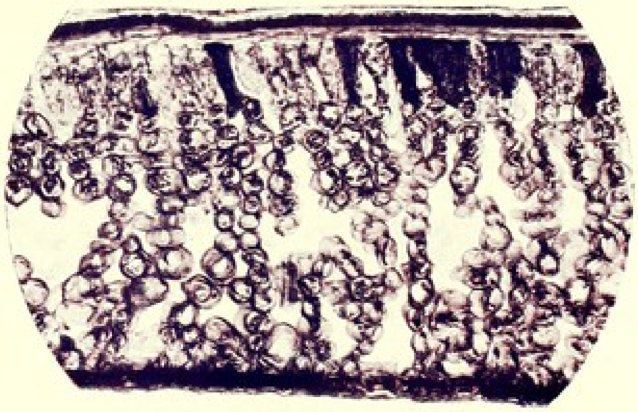


Figure 291.—Longitudinal section through a portion of a leaf midway between the midrib and the edge, showing how the spongy parenchyma cells are arranged transversely across the blade, as they are here seen to be in cross sections. The palisade parenchyma is at the top of the leaf. Stained with hæmatoxylin and safranin. *Podocarpus elata*, x 150.

Figures 291–2. This disposition of cells is not shown by C. E. Bertrand, *l.c.* Only one bundle abnormally orientated was found, and that a median one corresponding to a midrib, the phloem vessels being separated, as seen in section, by triangular masses of medullary rays (apex inwards) into triangular masses with the apex outwards, Figure 287, these two forming the outer edge of the fan-shaped bundle which is here backed by a number of collenchyma cells, three or four rows wide, and both these and the protoxylem cells are bounded above and below by parenchymatous cells, in which also occur very small oil cavities surrounded by a single row of cells. One or two sclerenchymatous cells were found in this tissue. On each side of the median bundle and scattered in the spongy tissue are small reticulated or spiral cells, the transfusion tissue as described by C. E. Bertrand, *l.c.*, under *P. elongata* of South Africa, and shown in Figure 287.

The twisting of the petiole of the leaf is evidently due then to the presence of the stomata on the underside; the torsion being also due to the leaf protecting its transpiratory surface from the sun's rays or other atmospheric adverse conditions, or per contra in a position favourable to its physiological requirements.

IV. TIMBER.

(*a*) Economic.

This is one of the largest trees of the coast district gullies. It has a straight grain, and is inclined to turn slightly brown on exposure. It is one of the finest of our all-too-few soft timbers, and is very useful for all such economics as pertain to these, such as joinery, carpentry, &c., and is also useful for carving.

It has a reputation for white-ant-and teredo-resisting properties; piles of this timber with the bark on are said to be lasting.

Mr. Jasper Morgan of New Italy, writing on the "Brown Pine," states:—"This species is, unfortunately, almost extinct, the only specimens being saplings of very little value. It grew in profusion about the Williams River long ago, and was used for ship decking, &c."

Transverse Tests of Timber—*Podocarpus elata.*

(Standard size, 38 in. x 3 in. x 3 in.)

	No. 1.	No. 2.	No. 3.
Size of specimen in inches	B 3·00; D 3·00	B 3·00; D 2·97	B 2·98; D 2·92
Area of cross section, square inches	9·00	8·91	8·70
Breaking load, lb. per square inch	4,254	3,390	4,450
Modulus of rupture in lb. per square inch ...	8,508	6,917	9,475
,, elasticity ,, ,, ...	1,053,658	1,403,508	1,366,875
Rate of load in lb. per minute	425	565	635

(*b*) Anatomy.

Microscopically the timber of this and other *Podocarpus* species cannot lay any great claim to affinity with that of either *Agathis* or *Araucaria*, being more closely related in structure, perhaps, to that of *Callitris*.

The walls of the tracheids and medullary rays are more slender than in almost any other Australian genus of the Order, whilst the lumina are the narrowest of all; altogether the sections convey the idea of slenderness, compared with those of cognate genera. No traces of marginal tracheids in the rays were found. The bordered pits are on the radial and occasionally tangential walls, and are both single and distant in the lumina.

In the xylem there are no linear stretches of the manganese compound, as in *Callitris*, and although a transverse section shows it fairly distributed, yet the other two sections prove that there are only small particles present. In the ray cells it is exceptional to find it. In fact, there is less of this substance in the wood material than obtains in the other genera. (See article on the manganese compound.)

The tangential section is of some value in diagnostic work, for one does not find the regular fusiform character of the *Callitris* rays or the linear features of the *Araucaria*, but here and there the spindle-shaped rays are composed of varying numbers of cells in height, intermixed with numerous rays one or two or three cells high, giving the walls a chain-like appearance. This feature does not realise in any other Conifer examined.

The simple cells are not very pronounced in the rays, and mostly only one occupies the space between the lumina; the perforation is sometimes circular and sometimes an oblique slit, as in Figures 293–6.

(*d*) Forestry.

(*Vide* remarks under Timber.)

V. BARK.

Anatomy.

This is a characteristic bark, although showing some affinities to that of the *Callitris* species, the main point of differentiation being the almost entire absence of periderm bands, and the more fully developed sieve tubes, for they occupy a much larger space between the sclerenchymatous fibres and the parenchymatous vessels, and are well shown in Figure 297.

The cambium is a very narrow band, and is succeeded in regular concentric uniseriate rings of sclerenchymatous fibres, sieve tubes, and parenchymatous tissue. Figures 297–8.

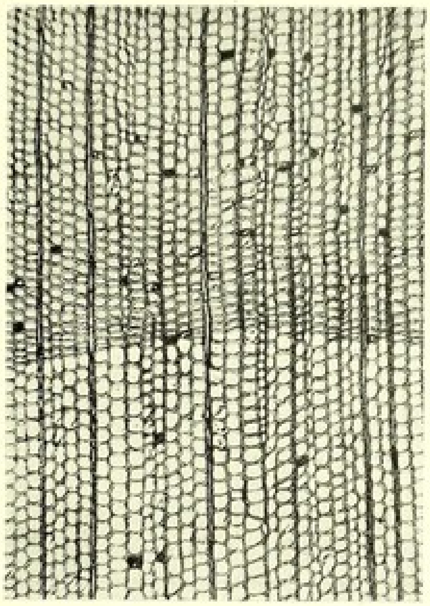


Figure 293—Transverse section through timber at the junction of the autumnal and spring growth. *P. elata*, × 65.

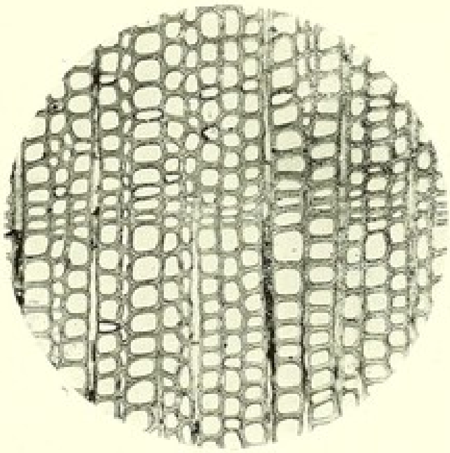


Figure 294—Similar section to Figure 293. The only manganese compound is seen in the lower part of the ray, all on the right centre of the picture. *P. elata*, × 80.

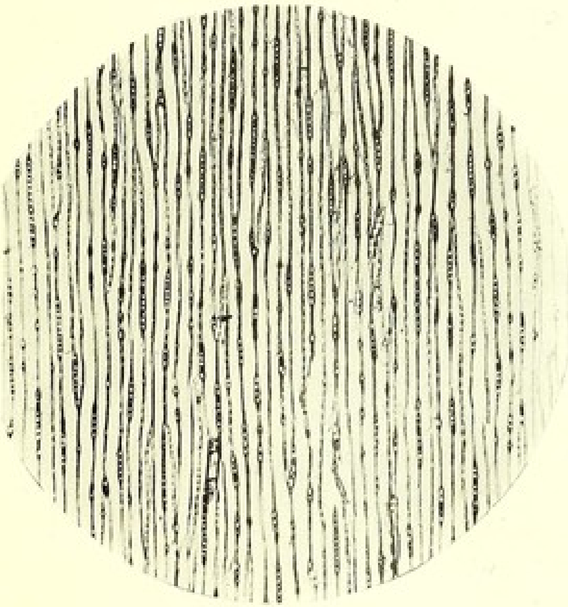


Figure 295—Tangential section of timber. *P. elata*, × 50.

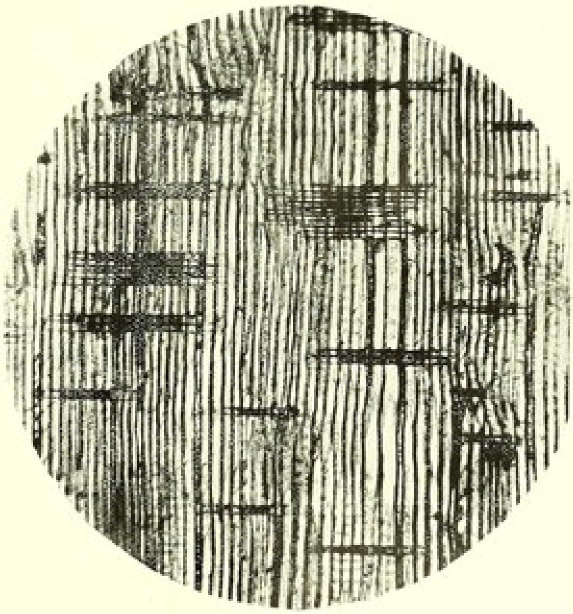


Figure 296—Radial section of timber. The ray cells are of a uniform parenchymatous character, stained dark by the presence of the manganese compound, which effect is also seen in the thickened lamella of the tracheid walls—the dark lines running from top to bottom of picture. Bordered pits are seen to be fairly numerous. *P. elata*, × 50.

Sections of timbers of Podocarpus elata, R.Br.

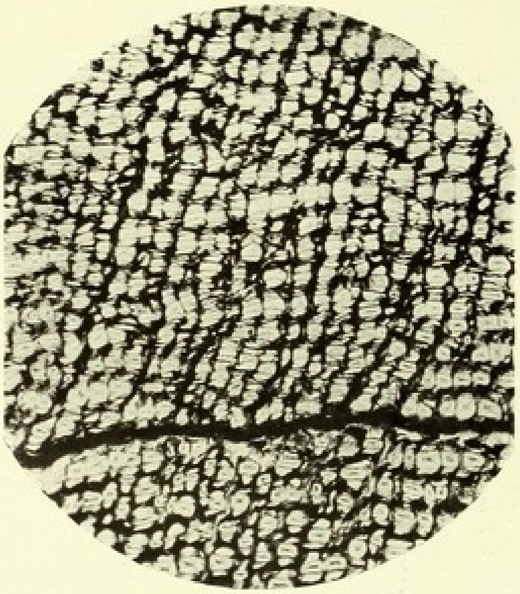


Figure 297.—Transverse section of bark. The bast fibres form a conspicuous feature in the structure, with their rectangular shape and central canal. *P. elata*, × 76.

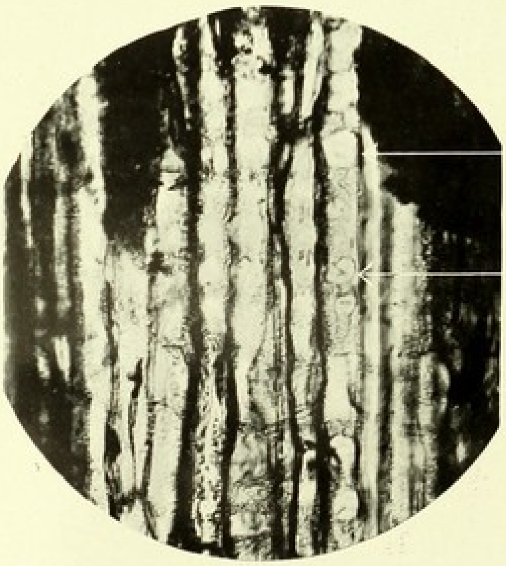


Figure **298**.—Longitudinal section of bark showing the numerous sieve plates in the tubes. *P. elata*, × 350.

Sections of bark of Podocarpus elata, R.Br.

PODOCARPUS ELATA, R.Br.

Botanical Survey of the Species in New South Wales.
(From data supplied by Public School Teachers and other Correspondents.)

Locality.	County.	Remarks
Ashlea, *viâ* Wingham ...	Macquarie ...	It is sparsely scattered over about 30 square miles. (A. J. Yarrington.)
Boggumbil	Rous	Occurs in the scrub. (E. J. Blanch.)
Boverie, Lismore	Rous	Occurs in belts or patches mixed with other timber. (James Jones.)
Burringbar	Rous	Grows on flat or hilly country amongst other timber (40 square miles). *Timber.*—Average height 50 feet; 1 foot 6 inches diameter. *Resin.*—Exudes little or none. (F. T. Clarke.)
Byron Bay	Rous	*Timber.*—80 to 200 feet high; 3 feet in diameter. (H. McLennan.)
Carrabolla, *viâ* Lostock ...	Durham ...	Knotty Pine. Only a few in the district. *Timber.*—100 feet high; 2 feet 6 inches diameter. *Resin.*—None. (B. A. Sheath.)
Colstoun, Gresford	Durham ...	There are a number of trees growing about here along the river bank and in the brushes. *Resin.*—These pines do not exude any resin.
Mosquito Island, Newcastle	Northumberland	A few trees. (W. Coombes.)
Mt. Rivers, Lostock, Upper Paterson.	Durham ...	A few trees. (Amy Leer.)
Mullumbimby	Rous	Thousands of acres. *Timber.*—80 feet high; 20 inches diameter. *Resin.*—Brown Pine is not resinous. (Henry R. Anstey.)
New Italy	Richmond ...	Only a few saplings. Cut out during last fifty years. (J. Morgan.)
Rous Hill	Cumberland ...	A few trees. (A. J. West, thro. Thos. Burling.)
Tirrania Creek, Lismore ...	Rous	About 2,000 acres. (W. L. Lucas.)
Tuckombil, Alstonville ...	Rous	Occur here. (W. M. Miller.)

2. Podocarpus pedunculata,

Bail. Ql. Ag. Jl., 1899.

"BLACK PINE."

Habitat.

Herberton District, Queensland.

I. HISTORICAL.

This is the most recently described species of the *Podocarpus*.

II. SYSTEMATIC.

Material of this species could not be obtained for investigation, but Bailey, *l.c.*, states it is a small tree with a very dark black bark. Leaves oblong-linear or

linear-lanceolate, resembling those of *P. elata*, R.Br., only that those of the young plants are usually much longer. Male amenta usually three, sessile at the end of a peduncle, shorter, and the basal scales or bracts absent or not prominent as in *P. elata*, R. Br. Fruit crimson, about the size of a pigeon's egg, solitary or in pairs, on the top of an angular, rather slender peduncle. Peduncle about 1¼ in. long, near the end of the branchlets, pedicels narrow, angular, only a few lines long.

IV. TIMBER.

This is a tree of smaller proportions to *P. elata*, R.Br., yet its timber may prove to be of equal value, if experimented with by the various Forestry Departments of the Commonwealth, for the number of native softwoods is limited.

3. Podocarpus alpina.

R.Br., Mirb. in Mem Par. xiii, 75; Hook. f. in Hook. Lond. Journ. IV, 151.

(Syn.:—*P. Lawrencii*, Hook. f. in Hook. Lond. Journ. IV, 151.)

Habitat.

Victoria,—Mount Butler, Hardinge's Range, Cobberar Mountain at an elevation of 3,000 to 6,000 feet (F. v. Mueller).

Tasmania,—Mount Wellington (R. Brown); Mountain localities at an elevation of 3,000 to 6,000 feet (J. D. Hooker).

I. HISTORICAL.

This species was described by Robert Brown in 1825, along with *P. elata*.

II. SYSTEMATIC.

No material of this species was procurable for investigation. Bentham in "Flora Australiensis," Vol. VI., p. 248, describes it as a straggling densely-branched shrub, usually low, but sometimes attaining a height of 12 feet. Leaves crowded, linear, straight or falcate, rigid, varying from ¼ in. long, and obtuse to ½ in. and acute, especially on luxuriant barren branches. Male amentum two to three lines long, usually solitary and sessile or nearly so in the axils. Fruits much smaller than in any other species, the fleshy receptacle about 1½ lines long, sessile in the axil, the ovoid seed not much longer.

4. Podocarpus Drouyniana.

F. v. Muell., Fragm. IV, 86 t., 31.

This in our opinion may be the Western or robust form of *P. spinulosa*, the principal differences being entirely those of size in all the organs, and economically it comes in the same category, in both timber and want of oil, for no oil was obtained from leaves which were sent to us all the way from Western Australia by the Department of Agriculture of that State.

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5. Podocarpus spinulosa.

R.Br., Mirb. in Mem. Mus. Par. xiii, 75.

Syn.:—*Taxus spinulosa*, Sm. in Rees Cycle, XXXV; *P. pungens*, Caley, Don, in Lamb. Pin. ed., 123. (Parlatore).

"NATIVE PLUM," OR "DAMSON."

HABITAT.

Sandstone country, near the coast, County of Cumberland, N.S.W.

I. HISTOLOGY.

Both Bertrand and Masters have worked out the leaf structure of some non-Australian species.

II. SYSTEMATIC.

A small shrubby plant with straight rigid, pungent, pointed leaves measuring up to 2 inches in length. Lateral veins not well marked. Male amenta numerous in sessile axillary clusters. Female amentum 6 mm. long in the axils of the lower leaves or bracts on the lower part of the young branches, having two small opposite bracteoles under the cylindrical two-lobed receptacle.

Seeds larger than in *P. elata*, R.Br.

IV. TIMBER AND ECONOMICS.

Being a small shrub its timber is of no avail, and although its common name might carry some impression of usefulness, yet the plant is of very little value even in this direction. Nor can it be classed as an oil yielder, for none was obtained from the leaves.

Podocarpus spinulosa, R.Br.
[Female amenta.]

Frank H. Taylor, Photo. *Two-thirds nat. size.*

Podocarpus spinulosa, R.Br.
[Showing Male amenta.] "Native Damson."

Appendix A.

SYSTEMATIC VALUE OF THE CHEMICAL PRODUCTS OF NATURALLY GROWING PLANTS AS AN AID TO THEIR BOTANICAL STUDY.

It is now generally accepted that, under varying influences of soil and climate, certain cultivated plants may change considerably the character of their chemical constituents, and so develop alterations of a more or less well-defined nature.

Much of the evidence so far produced in support of this statement, has, however, been derived from cultivated material, and very largely from annuals. A considerable amount of work has already been undertaken in the attempt to arrive at some conclusions in this direction, and MM. Charabot and C. L. Gatin in "Le Parfum chez la Plante," Paris, 1908, have brought together a considerable amount of data bearing on this question, so far as it relates to the alterations in the constituents of the essential oils obtained from certain genera. From the results already formulated they arrive at the following conclusion:—"Toute cause venant influencer la nutrition et par conséquent le chimisme d'une plante produit forcément une modification dans la composition de l'huile essentielle qu'elle sécrète, . . . mais il est juste d'ajouter que les caractères anatomiques et morphologiques des végétaux varient également sous les influences qui modifient les conditions de la nutrition, ce qui ne les empêche pas de posséder une valeur systématique." By selection and suitable treatment it has, of course, been possible to increase certain chemical constituents necessary for the successful commercial exploitation of some plants, particularly in the increase of sugar in beet-root. There seems to be no just reason why, corresponding suitable treatment of certain plants should not also increase their oil constituents in the direction of furthering their commercial possibilities. Exhaustive study in this direction would be of considerable value, and possibly rewarded with results of a satisfactory nature. It seems possible that in some such way Nature has already differentiated into distinct species, the members of such large genera as the *Callitris* and *Eucalyptus* of Australia, because it is to be expected that similar alterations to those which have brought about changes in the chemical constituents of the plant, would also act directly in other directions, and thus cause marked alterations in their morphological characters, such as would be in agreement with these chemical changes. That this is so is demonstrated by the characteristic venations of the leaves of the Eucalypts, which characters we have shown to be contemporaneous with the alterations in the main constituents of their essential oils.*

Corresponding to these well-marked differences, other changes have also taken place, which have become discernible in the varying barks and woods of the Eucalypts, as for instance, representing the several groups, there are the "Stringybarks," the "Ironbarks," the "Smoothbarks," or "Gums," the "Boxes," the "Ashes," &c. The exudations or Kinos have also varying chemical characters, which are as constant as those of the oils.

With the *Callitris* certain changes in morphological characters are also discernible, so much so, that vernacularly the species are distinguished by the people themselves by such terms as "White Cypress Pine," "Black Cypress Pine," "Stringybark Pine," &c., and these distinctive features, we now find, are always accompanied by corresponding alterations in the characters of their

* "Research on the Eucalypts," Sydney, 1902.

essential oils. That selective influences have been active in bringing about these changes is indicated by the fact of territorial selection by the species themselves, and the chemical peculiarities of certain situations and soils have undoubtedly had marked influences upon the location chosen by the young trees, where it would be possible for them to establish themselves and flourish—a study which is now receiving much attention under the name of Ecological botany. In New South Wales there are districts where the *Callitris* do not naturally occur, and this is apparently due to the peculiarities of these localities being unsuited for their natural establishment. Portions of this State known as the "Black Soil P ains" may particularly be mentioned in this connection, and although some of the species approach these districts on al sides, yet they do not invade them, and to the *Callitris* they evidently are forbidden fields. The reason for this peculiarity is at present little understood, because researches have not extended very far towards solving the problem of the selective peculiarities of plants generally. In the satisfactory unravelling of this question lies the scientific afforestation of this country, because it must certainly be more judicious and scientifically correct to plant those trees which are most suited by habit and constitution to the situation and soil required to be utilised, than to deal with the matter in a haphazard way, and any system of artificially supplying the necessary constituents to overcome any natural defect would be quite out of the question. The results obtained from the study of the Eucalypts, growing *under natura' conditions* in Australia, showed a remarkable constancy in the oil const tuents of the several species, and i was found during that investigation, that any well-defined species of *Eucalyptus* would always give practically the same products, not only in oil constituents, but in other chemical peculiarities also. Subsequent investigations have added considerably to our knowledge in this direction, and no marked differences in the general character or constituents of the oil distilled from any one species has yet been found, no matter in what part of the country the trees were grown. It might, of course, be feasible to bring about alteration in the chemical constituents of the plant by artificial methods, extending over a sufficiently long period, but under natural conditions such alterations as have taken place must have been slow, although eventually succeeding in establishing such marked differences, both in botanical and chemical characters, as has warranted for classification purposes their separation into distinct species.

It was felt that the importance of this question required extended investigations with other large Australian genera besides the Eucalypts, and for this purpose material of some of the species of *Callitris* has been obtained from various localities very far apart, and during several years. It will be seen from the results recorded under the several species, particularly *C. glauca*, that the chemical constituents of the essential oils of the *Callitris* are remarkably constant when grown under *natural conditions*, notably their ester content.* The tannins in the barks are also in agreement, so that it is possible by chemical reactions to distinguish the tannin of *C. glauca* and allied species, from that of *C. calcarata* and all the specimens we have so far determined, answered to these distinguishing tests. Spreading over such a large extent of territory as do the *Callitris*, and being all the time subjected to such diverse climatic and other d rect influences as maintains over such a large continent, it is perhaps surprising that there are so few well-defined species of *Callitris* in Australia.

The constancy of chemical characters found to occur in the several species has thus been of considerable help in deciding the differentiation governing their

* The differences in the amount of the predominant limonene at certain times of the year have been ignored in this connection, as we know little about this peculiarity at present, and it is still the same terpene.

classification. Not only has it been possible by this method of investigation to indicate the possible economics belonging to the several well-defined species, but at the same time to correlate the differences of alteration in the species themselves, and so allot specific values to those botanical characters which evidently have been established under exactly similar conditions and influences as those which fixed their chemical differences. The determination of the possible changes which may be brought about by specific treatment of the several species must be left to other investigators. In this work, only those plants established under natural conditions have been dealt with, and the results which have thus far been obtained with these, do not warrant the supposition that alterations are now taking place with sufficient rapidity to enable one to discern them. Evidently time is one of the main factors in these alterations, and human life is too short for their discernment. Results having been obtained from nearly the whole of the genus *Callitris*, gathered throughout the whole range of its distribution, it has been possible to formulate conclusions, which could not have been advanced if the study had been restricted to any one species.

In both *Callitris* and *Eucalyptus* the leaves are persistent during the whole year, and the flowering period seems to play a comparatively small part in the chemical changes of the essential oils in both genera, so that the results which have been obtained in Europe, by the study of those chemical changes which take place in the oils of such plants as *Mentha piperita*, *Pelargonium odoratissimum*, &c., during their several periods of growth and flowering, appear scarcely to assist when applied to such genera as *Callitris* and *Eucalyptus*. The changes which occur in the oils of these plants seem to be specific, and no periodic alterations of a very marked character have been found in any one well-defined species, so that only slight differences in the constitution of the essential oils are perceptible during any part of the year. Supposed differences in this direction have often been found to be due more to differences of opinion as regards nomenclature, than to the alterations in the constituents of the specific species themselves. It is thus seen that the chemical products manufactured by individual species, both in *Callitris* and *Eucalyptus*, have a considerable systematic value, and their study, therefore, becomes of some importance when seeking for specific differences in plant classification.

The conditions—largely of a chemical nature—which succeeded in establishing such definite alterations, also brought about marked differentiations in the character of the species themselves. This conclusion may be supported by such well-defined species as *Callitris glauca*, and *C. calcarata*, the former growing almost exclusively on the plains, the latter species on the hills. In districts where both occur it is possible to roughly follow the margin of the location of either species on the map, and at the same time indicate fairly well the contour of the hilly country. Wherever *C. glauca* occurs, its chemical peculiarities are found to be specific in all directions, and markedly so in contradistinction with those of *C. calcarata*, or *vice versa*. It seems necessary, therefore, that the conditions which were originally responsible for the establishment of these characteristic chemical peculiarities should persist, if the results are to be of a permanent nature. It is thus reasonable to consider that the well-defined chemical constituents of the plant are, for all practical purposes, as systematically valuable as the morphological characters, and that, when all this evidence is correlated, the species so founded will be established with a considerable degree of stability. *C. Tasmanica*, growing in Tasmania, gave an oil which agreed entirely with that from the same species growing on the highlands of New South Wales, hundreds of miles away. Evidently here the natural conditions under which the species had become established were

uniform. The morphologically closely agreeing species *C. rhomboidea* of the coast of New South Wales, was found to differ in its chemical characters from those of *C. Tasmanica*.

If we consider the time necessary for the genus *Callitris* to have spread itself over the whole of Australia, it is not difficult to understand why it is that several species have been able to adapt themselves to their environment, and thus to slowly overcome adverse conditions which might have prevented their distribution except in very restricted areas.

It has been suggested that the various chemical substances found in the vegetable kingdom, such as essential oils, resins, &c., are largely waste products. This supposition, however, does not take into consideration their distribution, alteration, and use in the constructive metabolism of the plant, and the evidence obtained by numerous workers does not seem to support the view that they are waste products. It is more reasonable to suppose that they play an important part in the life of the plant, and assist in the ultimate formation of its several parts. The oleo-gum-resin which forms the greater portion of the latex of *Araucaria Cunninghamii*, certainly does not appear to be a waste product, because of its abundance at any time, and to its continuous formation. In uninjured trees the oleo-gum-resin is rarely found on the exterior, so that if it is not material in a state of transition, one wonders what becomes of it. We have recently found, on severing the branches of a young tree of *Tristania conferta*, that a small amount of an aromatic oleo-resin exuded from the centre or pith of the severed portion of the trunk. This is interesting for plants of this group, and we are not aware that oleo-resin or resinous products have previously been found in this tree; so that in this instance the utilisation of this oleo-resin in the construction of the tree is evident, and also that it is quickly used up after it is formed.

It is shown under *Araucaria Cunninghamii* that in the formation of the oleo-gum-resin in the latex of that tree, other agents than those supplied by the leaf portion of the plant have evidently been employed, and it would be interesting to find out whether this is not largely due to enzyme action. In the formation of the leaf oils in the *Callitris* the reactions which have taken place appear to be due to reduction rather than to oxidation, because although the alcohol geraniol is present in abundance in some species—*C. Tasmanica* particularly—yet, no indication of citral, or other oxidised similar product of the alcohols, has been detected in the leaf oil of any *Callitris* species. In the Eucalypts, oxidised products often occur, and in the oil of some species in large quantities, as citral in *E. Staigeriana*; citronellal in *E. citriodora;* and aromadendral in numerous species allied to the "Boxes.' M. Emm. Pozzi-Escot (Oxydases et Reductases, Paris, 1902, p. 51) suggests that the reductases play a considerable part in plant formation, and says:—"On peut dire avec de *Rey-Pailhade*, que le philothion ou plus exactement les réductases, dans la cellule vivante, sont la porte, on l'une des portes, par lesquelles l'oxygène libre pénètre dans l'édifice cellulaire vivant."

Whether this is so or not further researches will disclose, but it seems to us conclusive that the chemical productions of the plant are of such importance in its construction, that for each species peculiarities will eventually arise. The determination of these, wherever possible, should give somewhat exact results, being chemical, and so help towards a deeper knowledge of the peculiarities of the several members of most plant genera. The utilisation of the knowledge thus obtained with both *Callitris* and *Eucalyptus* has been of the greatest help in our studies of these peculiarly Australian genera. It seems feasible, therefore, to expect that results of corresponding value would reward similar efforts with other genera peculiar to other parts of the world.

Appendix B.

TABLE SHOWING DISTIBUTION OF PINES IN NEW SOUTH WALES.

Illustrated by accompanying maps.

				Callitris.										Cunninghamii.	elata.	Fitzgeraldi.
No.	Counties.	Territorial Divisions—Western, Central, Eastern.	Land Districts.	verrucosa.	propinqua.	glauca.	arenosa.	gracilis.	calcarata.	rhomboidea.	Tasmanica.	Muelleri.	Macleayana.	Araucaria.	Podocarpus.	Pherosphaera.
1	Poole	W	Willyama	...	...	◆	...	...	...	...	...	...	...	...	...	...
2	Evelyn	W	do	...	...	◆	...	...	...	...	...	...	...	...	...	...
3	Farnell	W	do	...	...	◆	...	...	...	...	...	...	...	...	...	...
4	Yangowinna	W	do	...	...	◆	...	...	...	...	...	...	...	...	...	...
5	Menindee	W	do	...	...	◆	...	...	◆	...	...	...	...	...	...	...
6	Windeyer	W	do and Wentworth	...	...	...	...	...	...	...	...	...	...	...	...	...
7	Tara	W	do	...	...	◆	...	...	...	...	...	...	...	...	...	...
8	Tongowoko	W	Wilcannia and Willyama	...	...	◆	...	...	...	...	...	...	...	...	...	...
9	Yantara	W	do do	...	...	◆	...	...	...	...	...	...	...	...	...	...
10	Mootwingee	W	do do	...	...	◆	...	...	...	...	...	...	...	...	...	...
11	Tandora	W	do do	...	...	◆	...	...	...	...	...	...	...	...	...	...
12	Delalah	W	do and Bourke	...	...	...	...	...	...	...	...	...	...	...	...	...
13	Ularara	W	do do	...	...	...	...	...	...	...	...	...	...	...	...	...
14	Fitzgerald	W	do do	...	...	...	...	...	...	...	...	...	...	...	...	...
15	Yungnulgra	W	do and Willyama	...	...	◆	...	...	...	...	...	...	...	...	...	...
16	Young	W	do do	...	...	◆	...	...	...	...	...	...	...	...	...	...
17	Livingstone	W	do	...	...	◆	...	...	...	...	...	...	...	...	...	...
18	Perry	W	do ... ... Wentworth ... ... Balranald	◆	...	...	...	...	...	...	...	...	...	...	...	...
19	Wentworth	W	Wentworth	...	...	◆	...	...	...	...	...	...	...	...	...	...
20	Taila...	W	do and Balranald	...	...	◆	...	...	◆	...	...	...	...	...	...	...
21	Thoulcanna	W	Bourke	...	...	...	...	...	...	...	...	...	...	...	...	...
22	Killara	W	Wilcannia and Bourke	...	...	...	...	...	...	...	...	...	...	...	...	...
23	Werunda	W	Wilcannia	...	...	...	...	...	...	...	...	...	...	...	...	...
24	Manara	W	do and Balranald	◆	...	...	...	...	...	...	...	...	...	...	...	...
25	Kilfera	W	Balranald	...	...	◆	...	...	...	...	...	...	...	...	...	...
26	Caira	W & C	do	...	...	...	...	...	...	...	...	...	...	...	...	...
27	Wakool	C	Balranald South & Deniliquin	...	...	◆	...	...	...	...	...	...	...	...	...	...
28	Irrara	W	Bourke...	...	...	◆	...	...	...	...	...	...	...	...	...	...
29	Barrona	W	do	...	...	...	...	...	...	...	...	...	...	...	...	...
30	Landsborough	W	do	...	...	...	...	...	...	...	...	...	...	...	...	...
31	Rankin	W	do Wilcannia, and Cobar..	...	...	...	...	...	...	...	...	...	...	...	...	...
32	Woore	W	Wilcannia and Cobar...	...	...	...	...	...	...	...	...	...	...	...	...	...
33	Waljeers	W	Hay North & Hillston North	...	...	◆	...	...	...	...	...	...	...	...	...	...
34	Waradgery	C	Hay	...	...	◆	...	...	...	...	...	...	...	...	...	...
35	Townsend	C	Deniliquin	...	...	◆	...	...	...	...	...	...	...	...	...	...
36	Cadell	C	do	...	◆	◆	...	...	◆	...	...	...	...	...	...	...
37	Gunderbooka	W	Bourke	...	...	◆	...	...	...	...	...	...	...	...	...	...
38	Yanda	W	do and Cobar ...	...	...	◆	...	...	...	...	...	...	...	...	...	...
39	Booroondarra	W	Cobar	...	...	◆	...	...	...	...	...	...	...	...	...	...
40	Mossgiel	W	Hillston North ...	◆	...	◆	...	...	...	...	...	...	...	...	...	...
41	Franklin	W	do and Hay North	...	...	◆	...	...	...	...	...	...	...	...	...	...
42	Nicholson	C	Hay and Hillston ...	...	...	◆	...	...	...	...	...	...	...	...	...	...
43	Sturt	C	Hay	...	...	◆	...	...	...	...	...	...	...	...	...	...
44	Boyd	C	do and Narrandera ...	...	...	◆	...	...	...	...	...	...	...	...	...	...
45	Denison	C	Corowa...	...	...	◆	...	...	...	...	...	...	...	...	...	...
46	Robinson	W	Cobar	◆	...	◆	...	...	◆	...	...	...	...	...	...	...
47	Mouramba	W	do	◆	...	◆	...	...	◆	...	...	...	...	...	...	...

Table showing Distribution of Pines in New South Wales.—*continued.*

No.	Counties.	Territorial Divisions—Western, Central, Eastern.	Land Districts.	Callitris verrucosa.	Callitris propinqua.	Callitris glauca.	Callitris arenosa.	Callitris gracilis.	Callitris calcarata.	Callitris rhomboidea.	Callitris Tasmanica.	Callitris Muelleri.	Callitris Macleayana.	Araucaria Cunninghamii.	Podocarpus elata.	Pherosphæra Fitzgeraldi.
48	Blaxland	W	Hillston North...	◆												
49	Dowling	C	Hillston...	◆		◆										
50	Cooper	C	Narranderra			◆			◆							
51	Urana	C	Urana ...			◆										
52	Hume	C & E	Corowa and Albury ...			◆			◆							
53	Culgoa	W	Brewarrina and Bourke			◆			◆							
54	Cowper	W	Bourke...			◆										
55	Canbelego	W & C	Cobar and Nyngan ...			◆										
56	Flinders	C	Nyngan...													
57	Cunningham	C	Parkes and Condobolin			◆										
58	Gipps	C	Condobolin ... / Forbes and Wyalong ...			◆										
59	Bourke	C	Barmedman & Wagga Wagga	◆		◆										
60	Mitchell	C	Wagga Wagga & Narrandera			◆			◆							
61	Goulburn	E	Albury ...			◆			◆							
62	Narran	W	Brewarrina			◆										
63	Clyde	W & C	do and Nyngan			◆										
64	Gregory	C	Nyngan and Warren ...			◆										
65	Oxley	C	do do			◆										
66	Kennedy	C	Parkes ...			◆										
67	Bland	C & E	Grenfell, Barmedman East / Cootamundra ...			◆										
68	Clarendon	C & E	Cootamundra / Gundagai and Wagga Wagga			◆			◆							
69	Wynyard	C & E	Wagga Wagga, Gundagai, and Tumberumba North.			◆			◆							
70	Finch	W	Walgett North...			◆										
71	Leichhardt ...	C	Walgett and Coonamble			◆										
72	Ewenmar	C	Warren and Dubbo ...			◆										
73	Narromine ...	C	Dubbo ...			◆			◆							
74	Ashburnham	C & E	Forbes, Molong, and Parkes...			◆			◆							
75	Forbes	C & E	Grenfell and Cowra ...			◆			◆							
76	Monteagle ...	E	Young and Burrowa ...			◆			◆							
77	Harden	E	Gundagai and Burrowa			◆			◆							
78	Buccleugh ...	E	Yass and Tumut													
79	Selwyn	E	Tumberumba ...													
80	Denham	C	Walgett and Narrabri			◆										
81	Baradine	C	Narrabri and Coonabarabran			◆										
82	Gowen	C	Coonabarabran and Coonamble			◆										
83	Lincoln	C	Dubbo ...			◆			◆							
84	Gordon	E	Molong and Dubbo ...			◆			◆							
85	Bathurst	E	Orange, Bathurst, and Carcoar			◆			◆							
86	King	E	Gunning, Burrowa, and Yass...						◆							
87	Cowley	E	Queanbeyan ...						◆							
88	Wallace	E	Cooma ...						◆							
89	Benarba	C	Moree ...			◆										
90	Jamison	C	Narrabri			◆			◆							
91	White	C	do and Coonabarabran...			◆										
92	Napier	C	Coonabarabran...			◆			◆							
93	Bligh	E	Mudgee...			◆			◆							
94	Wellington ...	E	Wellington, Mudgee, & Orange			◆			◆							
95	Roxburgh	E	Rylstone and Bathurst			◆			◆							
96	Georgiana	E	Carcoar and Lithgow						◆							
97	Murray	E	Queanbeyan and Braidwood...						◆							
98	Beresford	E	Cooma ...						◆							
99	Wellesley	E	Bombala		◆				◆							
100	Stapylton	C	Moree, and Warialda ...			◆										
101	Courralie	C	Moree...			◆										
102	Nandewar ...	C	Narrabri and Gunnedah			◆			◆							
103	Pottinger	C	Gunnedah			◆			◆							

Table showing Distribution of Pines in New South Wales.—*continued.*

No.	Counties.	Territorial Divisions—Western, Central, Eastern.	Land Districts.	Callitris.										Cunninghamii.	elata.	Fitzgeraldi.
				verrucosa.	propinqua.	glauca.	arenosa.	gracilis.	calcarata.	rhomboidea.	Tasmanica.	Muelleri.	Macleayana.	Araucaria.	Podocarpus.	Pherosphaera.
104	Phillip	E	Mudgee and Rylstone	...	...	◆	...	◆	◆	...	◆	...	...	...	...	...
105	Westmoreland	E	Bathurst, Lithgow, and Picton	...	...	...	...	...	...	...	...	...	...	...	...	...
106	Argyle	E	Goulburn	...	...	...	...	...	...	...	...	...	...	...	...	...
107	Dampier	E	Moruya and Bega	...	...	...	...	...	...	...	◆	...	...	...	...	...
108	Auckland	E	Eden and Bega	...	...	...	...	...	...	...	◆	...	...	...	...	...
109	Burnett	C	Warialda	...	...	◆	...	...	◆	...	...	...	...	...	...	...
110	Murchison	C & E	Bingara and Inverell	...	...	◆	...	...	...	...	...	...	...	...	...	...
111	Darling	E	Tamworth	...	...	◆	...	...	◆	...	...	...	...	...	...	...
112	Buckland	E	Murrurundi and Tamworth	...	...	◆	...	...	◆	...	...	...	...	...	...	...
113	Brisbane	E	Muswellbrook and Scone	...	...	◆	...	...	◆	...	...	...	...	...	...	...
114	Hunter	E	Muswellbrook and Windsor	...	...	...	...	...	◆	...	...	◆	...	...	...	...
115	Cook	E	Lithgow, Windsor, and Penrith	...	...	...	...	...	◆	...	...	◆	...	...	...	◆
116	Camden	E	Moss Vale, Nowra, and Picton	...	...	...	...	...	◆	...	...	◆	...	...	◆	...
117	St. Vincent	E	Braidwood, Milton, & Moruya	...	...	...	...	...	◆	...	...	...	...	...	...	...
118	Arrawatta	E	Inverell and Warialda	...	...	◆	...	...	◆	...	...	...	...	...	...	...
119	Hardinge	E	do and Armidale	...	...	...	...	...	◆	...	...	...	...	...	...	...
120	Inglis	E	Tamworth and Armidale	...	...	◆	...	...	◆	...	...	...	...	...	...	...
121	Parry	E	Tamworth	...	...	◆	...	...	...	...	...	...	...	...	...	...
122	Durham	E	Singleton, Dungog, & Maitland	...	...	...	...	...	...	...	...	...	...	...	◆	...
123	Northumberland	E	Gosford Newcastle Maitland and Singleton	...	...	...	...	...	◆	...	...	...	...	...	◆	...
124	Cumberland	E	Windsor Picton Penrith Parramatta Metropolitan	...	...	...	...	...	...	◆	...	◆	...	...	◆	...
125	Gough	E	Glen Innes, Inverell, Tenterfield	...	...	...	...	...	◆	...	...	...	...	...	...	...
126	Sandon	E	Armidale	...	...	...	...	...	◆	...	...	...	...	...	...	...
127	Vernon	E	Walcha	...	...	...	...	...	...	...	...	...	...	...	...	...
128	Hawes	E	do Scone, Stroud, & Taree	...	...	...	...	...	...	...	...	...	...	...	...	...
129	Clive	E	Tenterfield and Glen Innes	...	...	...	...	...	◆	...	...	...	...	...	...	...
130	Gresham	E	Glen Innes and Grafton	...	...	...	...	...	...	...	...	...	...	◆	...	...
131	Clarke	E	Armidale	...	...	...	...	...	...	...	...	...	...	◆	...	...
132	Gloucester	E	Stroud, Taree, and Dungog	...	...	...	...	...	◆	...	...	...	◆	...	◆	...
133	Buller	E	Tenterfield and Casino	...	...	...	...	...	...	...	...	...	...	◆	...	...
134	Drake	E	Casino, Glen Innes, & Grafton	...	...	...	...	...	...	...	...	...	...	◆	...	...
135	Fitzroy	E	Grafton and Bellingen	...	...	...	...	...	...	...	...	...	◆	◆	...	...
136	Raleigh	E	Kempsey and Bellingen	...	...	...	◆	...	...	...	...	...	◆	◆	...	...
137	Dudley	E	do	...	...	...	...	...	...	...	...	...	◆	...	...	...
138	Macquarie	E	Taree and Port Macquarie	...	...	...	...	...	...	...	...	...	...	...	◆	...
139	Rous	E	Casino Lismore Murwillumbah	...	...	...	◆	...	...	...	...	...	◆	◆	◆	...
140	Richmond	E	Casino and Lismore	...	...	...	◆	...	...	...	...	...	...	◆	◆	...
141	Clarence	E	Grafton	...	...	...	◆	...	...	...	...	...	...	◆	◆	...

SUMMARISED.

Callitris glauca occurs in 87 counties.
arenosa „ 4 „
propinqua „ 2 „
gracilis „ 1 „
calcarata „ 51 „
verrucosa „ 8 „
rhomboidea „ 1 „

Callitris Tasmanica occurs in 3 counties.
„ *Muelleri* „ 4 „
„ *Macleayana* „ 5 „
Araucaria Cunninghamii „ 9 „
Podocarpus elata „ 9 „
Pherosphæra Fitzgeraldi „ 1 „

Appendix C.

CORRESPONDENTS, MOSTLY PUBLIC SCHOOL TEACHERS, WHO ASSISTED IN COLLECTING DATA FOR THE PINE SURVEY OF N.S.W.

Abell, T., Eulah Creek, Narrabri.
Adamson, G. McD., Salisbury Plains, Uralla.
Adamson, T. W., Rocky River, *viâ* Uralla.
Aikins, Thomas, Murrumburrah.
Aikman, Alexander, South Forbes.
Anderson, James, Meranburn.
Anstey, H. R., Mullumbimby.
Aston, John, Coolah.
Armstrong, James, Bungonia.
Atkinson Henry, Warkworth.
Baker, H. E., Rutherfield, Quirindi.
Baker, S. R., Emmaville.
Balmain, H. David, Peel.
Barber A. B., Yarrahappini, Stuart's Point.
Barker, G. H., Booroomba.
Barratt, J. F., Round Swamp.
Bates, W. H., Vere, *viâ* Whittingham.
Bell, J. W., Brundah
Benson, G. G., Barham.
Benton, J., Coolamon.
Berman, F. T., Coonamble.
Bickerstaff, J., Grong Grong.
Black, Robert, Brawlin.
Blanch, E. J., Coorabell Creek.
Blumer, G. A. (M.A.), Tareena.
Boulton, George, Wheeo.
Bourke, A. J., Parkesborough.
Bourke, I. D., Stuart Town.
Bowyer, H. A., Great Central, Mount Hope.
Brettell, H. C., Uranquinty.
Beeyley, W. B., Ganmain.
Britten, C. H., Gentleman's Halt.
Brophy, C. M., Upper Manilla.
Brown, L. R., Daysdale.
Brown, R., Euston.
Browne, H. J., Condobolin.
Buchanan, R. T., Yarrahappini, Stuart's Point.
Bundock, A. J., Chain of Ponds, Gunning.
Burns, H. H., Milparinka.
Burns, May, Spring Ridge, Quirindi.
Byrne, J. A., Watergumben, *viâ* Cowra.
Byrnes, Sydney C., Quirindi.
Calov, J. R., Yarramolong
Cambowen, T. E., Windeyer, *viâ* Mudgee.
Cameron, John, Tumbulgum.
Campbell, F., Stonefield.
Campbell, E. V., Staggy Creek
Capon, W. H., Furill, *viâ* Mudgee.
Carmichael, A. C., The Grange, Lake Cudgellico.
Carpenter, W. E., Acacia Creek.
Carroll, A. B., Bynya, *viâ* Narrandera.
Carroll, Alfred, Chaucer and Wattle Grove.
Chalmers, C. O., Blair Tree, *via* Glencoe.
Champion, S., Dunbible, Tweed River.
Chaul, E. C., Whinstone Valley, *viâ* Cooma.
Chawner, C. H., Sapphire, Inverell.
Chudleigh, C. S., Bigga, Binda.
Clarke, F. T., Burringbar.
Clowes, John, Boonoo Boonoo.
Colleton, D., Canowindra.
Connerton, J., Suntop, Wellington.
Coombes, W., Mosquito Island, Newcastle.
Cormack, John, Swanvale, *viâ* Glen Innes.
Cormack, J. S., Staggy Creek.
Coulter, Jane, Gosford.
Court, E. C., Yallaroi.
Cousins, A., Wardell.
Crowley, Helen C., Boggumbil.
Cummings, G. E., Upper Colo.
Cunedy, A. K. West Cambewarra.
Curry, J. V., Coffey Hill, Orange.
Cutchley, H., Harden.
Dale, B. F., Bethungra.
Dalton, W. A., Jennings, Wallangarra.
Daly, J. B., Monteagle.
D'Aran, F., Goolagong.
Davies, E. S., Keepit, Somerton.
Davies, W. J., Lochiel, Pambula.
Davis, J., Cobbora.
Dawson, James, Umaralla Spring, near Cooma.
Dawson, J., Henbury, Rylstone.
Day, W. T., Lake Cudgellico.
Delmege, James, Carroll.
Dennis, John, Mulwala.
Deverell, E. J., Bellingen.
Dransfield, A. J., St. Albans.
Dunne, Morgan, West Narrabri.
Dyce, C. G., Murrumbateman.
Edwards, A. J., Maluorindi, Woolbrook.
Eggins, Herbert, Gladstone.
Elliott, Alex., Cocomingla, Cowra.
Ellis, Alice M., Lockhart.
Evans, J., Albion Park.
Evans, W. G., Queanbeyan.
Fairley, William, Tollbar and Clifford, Cooma.
Farrell, J. J., Coff's Harbour.
Fawcett, R. J., Bendolba.
Fitzell, R. W., Willandra, Dubbo.
Fitzpatrick, S. T., Oakey Creek and Woodlawn, Warialda.
Fraser, L. E., Clear Hills, Daysdale.
Freeman, B. G. N., Coolac.
Gambell, W., Berrima.
Garden, A. G., Berry.
Goard, W. S., Murrurundi.
Gould, E. T., Curia Creek, Tilba Tilba.
Grainger, F. J., Narromine.
Grant, E. A., "The Welcome," Parkes.
Greville, A. W., Mungindi, *via* Moree.
Griffith, W. A., Weetalabar, Tambar Springs, *via* Gunnedah.
Guthrie, J., Hay.
Hadley, J., Newbridge.
Hagan, William, Walhallow, Quirindi.
Hall, P. F., Warialda.
Hanify, Joseph, Yarrowyck, *viâ* Armidale.
Harding, J. S., Ulan, *viâ* Mudgee.
Harris, G. A., Winton, Tamworth.
Harrison, G. A., Dubbo.
Hatherly, W. C. H., Gunbar.
Hatherly, H., Hillston.
Hazelwood, J. W., Muswellbrook.
Heath, W. G., Narrandera.
Henry, T. W., Cootamundra.
Herd, P., Nullamanna.

Map showing extreme distances from which material was obtained for this research.

Note: An outline of South-west Europe is given to show comparative distances.

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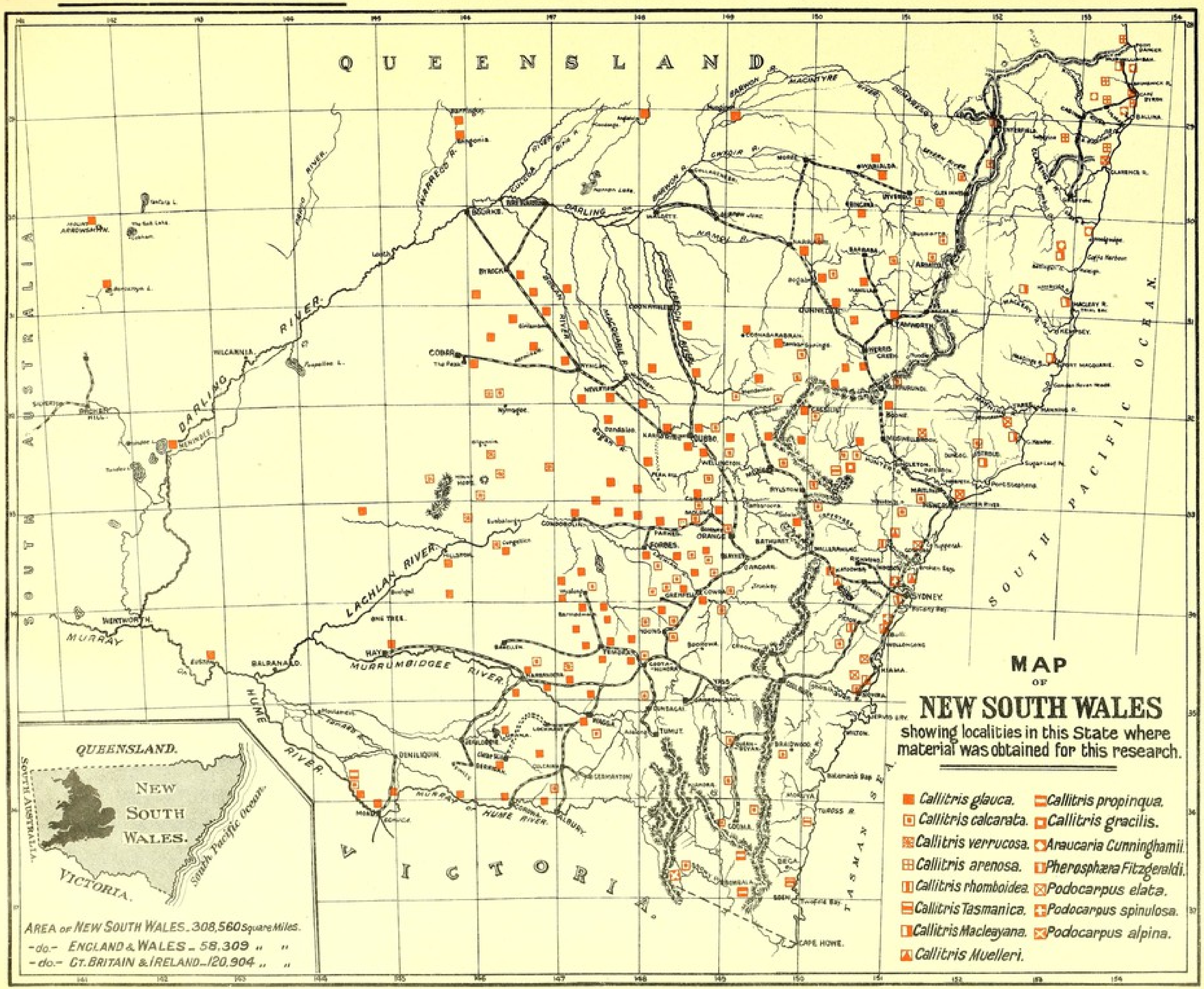

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CORRESPONDENTS WHO ASSISTED IN COLLECTING DATA—(*continued*).

Hewitt, A. A., Looby's, Parkes.
Hickey, Sarah, Warrangunyah, Ilford.
Holtsbaum, F. V., Brodie's Plains, near Inverell.
Hook, J. J., Tuena.
Hughes, B. C., Berrigan.
Jackson, H., Craigie.
Jacobs, James, Wyrallah.
James, S. E., Dilga, Cumnock.
Johnson, W., Denman.
Johnstone, S. F., Tataila, Moama.
Jones, James, Booerie, Lismore.
Kealy, Cecilia, Upper Manilla.
Kendall, A. E., Stockinbingal.
Kennelly, W. A., Piallaway.
Laird, C. A. C., Duncan's Creek, Woolomin.
Langbridge, E. R., Cullenbone, Mudgee.
Ledwidge, C., Pleasant Hills.
Leer, Amy, Mt. Rivers, Lostock, Gresford.
Lewis, Samuel, Quandong, Grenfell.
Lockhart, J., Duesbury and Wilgas, Nevertire.
Lucas, W. L., Tirrania Creek, Lismore.
Lynch, J. P., Boree Cabonne, Cheeseman's Creek.
Manson, W., Amaroo.
Maune, A., Gerogery.
Mavine, J., Gerogery.
McClelland, Christina, Swamp Oak, Moonbi Railway Station.
McDonnell, John, Tuena.
McDowell, Miss J. E., Bethungra.
McInnes, A., Morungulan, Dripstone.
McLennan, A., Clareval, *viâ* Stroud.
McLennan, J., Nevertire.
McLennan, H., Byron Bay.
McMahon, E. W., Pine Ridge, *via* Quirindi.
McMann, Thomas, Delegate.
McNamara, Annie, Lacmalac, Tumut.
McNamara, Susan, Gregador, Wagga Wagga.
McWhirter, A. A., Round Mount, Inverell.
Middenway, Mr., Wagga.
Miller, Thomas, Eugowra, *viâ* Orange.
Miller, W. M., Tuckombil, Alstonville.
Mitchell, E. V., Stroud.
Moore, A., Scone.
Morgan, T. J., New Italy.
Morrison, John, Bermagui.
Morrissey, J., Narrabri.
Moss, G. B., Woomargama.
Mulligan, T. B., Cootamundra.
Munday, A. F., Colstoun, Gresford.
Murray, Alexander, Coolongolook.
Musgrove, F. A., Pooncarie.
Mutton, H. P., Lewis Ponds.
Myers, J. G., Nambucca Heads.
Newman, P. F., Trelowarren, Parkes.
Nickson, J., Pinch Flat, Armidale.
Nicussengh, A., Narrabeen.
Nixon, L., Collendina.
Nixon, R., Yetman.
O'Brien, G. C., Golspie.
O'Hara, C., Enngonia.
O'Sullivan, J., Tintenbar.
Olde, Maggie R., Lockwood, Canowindra.
Paddison, A., New Angledool.
Parkins, J. W., Elsmore.
Patrick, G. A., Digilah, *viâ* Merrygoen.
Peacock, W. J., Forest Hill.
Peck, C. W., Lowesdale, *viâ* Corowa.
Perkins, W. H., Lake Cudgellico.
Perry, G. A., Lower Lewis Ponds.
Pittock, A. J., Moorwatha.
Postlethwaite, J. G., Grenfell.
Pritchard, Alfred, Attunga.
Readford, Charles, Spicer's Creek.
Richards, John, Tocumwal.
Rigg, Joseph, Brogan's Creek, Rylstone.
Rohan, E., Eureka.
Rose, S. C., Unanderra, Illawarra.
Ross, W. J., Menindie.
Rudd H., Manilla.
Sampson, B. E., Moor Creek, Tamworth.
Sampson, Bertha E., Summer Vale, Walcha.
Schaefer, M. J., Point Danger, Tweed Heads.
Shaw, L. C., Tintenbar.
Sheath, B. A., Carrabolla, *viâ* Lostock.
Sheehy, Theo., Boggabri.
Silcock, George, Armidale.
Sim, J. L., Eugowra.
Sims, R. (Junior), Dubbo.
Slack, A. I., Terra Bella.
Smith, H. W. (B.A.), Mossgeil.
Smith, H. W., Cassilis.
Smith, J. H., Dubbo.
Smith, S., Mathoura.
Squire, Francis, Berrigal Creek, Narrabri.
Strangways, H. W., Bollol Creek, Narrabri.
Strong, R., Box Ridge, *viâ* Sofala.
Sullivan, J., Woodstock.
Surtee, John, Nine Mile, Deepwater.
Tate, S. G., Marlow, Braidwood.
Taylor, E. H., Coonamble.
Taylor, F. D., Gouldsville.
Teitkins, W. H., Walgett.
Thomas, Henry, Cooma.
Thresher, Henry, Wallangra, *viâ* Inverell.
Tindale, A. N., Torrie Lodge, Bylong.
Tonking, A., Marengo.
Tutland, T. K., Little Narrawa.
Tysoe, Edward, Pimlico North.
Varcoe, Charles, Baker's Swamp, Dripstone.
Vindin, H. E., Burrowa.
Vivean, J. I., Adelong.
Walker, V. N., Baan Baa.
Watson, A. E., Nethercote, Pambula.
Watson, A. T., Burrumbuttock.
Wedlock, W. F., Baerami, Denman.
West, A. J., Rous Hill.
West, T. H., Guntawang.
Wharton, J. E. C., Pyramul.
Wheaton, A. J., Woodford Dale.
Wigg, H. V., Weddin, *viâ* Young.
Wilcox & Co., George, Circular Quay, Sydney.
Williams, E. G., Nimitybelle.
Williams, J. J., Wilcannia.
Wilshire, Osborne, Deniliquin.
Wilson, C. L. E., Walli.
Woalley, P., Lagoon.
Yarrington, A. I., Ashlea, *viâ* Wingham.
Young, L. C., Garra.

Index.

[The numbers printed in clarendon type refer to the full description of species, articles, and principal references.]

"LET NO MAN WHO WRITES A BOOK PRESUME TO SAY WHEN HE WILL HAVE FINISHED. WHEN HE IMAGINES THAT HE IS DRAWING NEAR HIS JOURNEY'S END, ALPS RISE ON ALPS, AND HE CONTINUALLY FINDS SOMETHING TO ADD AND SOMETHING TO CORRECT."

—GIBBON.

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1910