

ON THE OCCURRENCE OF CRYSTALS IN SOME AUSTRALIAN TIMBERS.

By R. T. BAKER, F.L.S.

[With Plates XXV - XXXIII.]

[Read before the Royal Society of N. S. Wales, December 5, 1917.]

WHEN examining micro-sections of our timbers it was noticed that crystals occurred rather frequently amongst the wood elements. In certain species they were either isolated or varied in number from a few to as many as over forty in an individual parenchyma, and even masses of deposits in particular cases.

Searching through publications at my disposal, no mention could be found of this feature amongst Australian woods, either in letter press or illustrations, and so I am moved to record the specific instances of such occurrences which have come under my notice.

Amongst works on timbers, S.J. Record, in his "Economic Woods of U.S.A.," p. 20, states, that crystals occur in all species of *Quercus*, though they are more commonly abundant in live Oaks (evergreen) than in deciduous species. In *Juglans* (Walnut), *Hicoria*, and *Diospyros*, crystals are often quite conspicuous. He also gives micro-photographs of timber *Hicoria pecan* and *Diospyros virginiana* showing crystals *in situ*, but in the latter instance not easy to detect, and these were determined as calcium-oxalate. He also mentions that these crystals are only slightly soluble in the strongest acids.

Henry Kraemer, in his "Applied and Economic Botany" 1914, p. 187, figures crystals (diagrammatic) identical in form to those found by me in Australian woods, but they are from the bark of *Glycyrrhiza*.

Mr. H. G. Smith has recorded¹ calcium oxalate from the bark of various Eucalypts, (10 species), obtained by breaking the bark down, boiling and then recovering the crystals.

A very large number of instances of the occurrence of calcium oxalate crystals in the vegetable kingdom are given by Solereder in his "Systematic Anatomy of Dicotyledons," but the majority of these instances are in the leaves, bark and root.

In the case of the leaves he almost invariably states that this substance in its various crystalline forms is excreted, meaning of course in the process of metabolism. But in my opinion the word "deposited" would more correctly describe the action, in any case at least in the secondary wood if not the leaves. Again, this fixation of lime by the oxalic acid seems to prove in the opinion of the author that the latter is not deleterious to the plant any more than manganese, but is specially formed by the tree for this particular function, in order to free the sulphur from the calcium sulphate for the formation of sulphuric acid so essential in the construction of albuminous substances.

Various authors record that oxalate of lime is found in several forms, viz.:—as ordinary solitary crystals, clustered crystals, styloid-like crystals, raphides, small circular crystals, and crystal sand.

From the result of this investigation it would appear, that each of the above is restricted to a particular organ of the plant, such as leaves, bark, root and timber, but in the case of the latter only ordinary solitary crystals were found, which seems to prove that this is the usual form for wood structure.

In the timbers examined to illustrate this paper, the crystals were so numerous that sufficient definition was

¹ This Society, 1905, Vol. xxxix, pp. 23 to 32.

obtained which made it possible to determine the crystalline system without any breaking down of the wood or any preparation whatever, viz. plates or prisms of the monoclinic forms.

They occur with few exceptions in a specialised form of chambered wood parenchyma, with partitions dividing it into cells of about equal size containing as a rule an individual crystal, but, in one case of ray parenchyma, as many as four were found in a cell, viz:—*Mallotus philippinensis*, Natural Order Euphorbiaceæ.

The micro-sections of timber were prepared by long immersion in strong hydrofluoric acid, which, however, appears to have had no effect upon these crystals of calcium oxalate, and this insolubility is no doubt further aided by the protective property of the cell walls.

In the case of *Strychnos arborea*, N.O. Loganiaceæ, however, they were found in long pockets in great abundance, giving the wood the appearance of having been marked with chalk streaks on a longitudinal section, or as distinct white spots on a cross section, as shown in Plates XXX, XXXI. The hydrofluoric acid, however, appears to have had some effect on this material, or at least the greater part was lost in the slide preparation. It is possible, however, that the diameter of these sacs or pockets being so large the substance fell away. Plate XXX shows this substance *in situ* with numerous crystals amongst the matrix. I am indebted to Mr. J. H. Maiden for this particular specimen of timber upon which the research was made.

It is common amongst artisans to speak of a particular wood as "having a grit," two Australian woods being notorious for this special physical property, viz:—*Eucalyptus pilularis*, "Blackbutt," and *Tristania conferta*, "Brush Box." An examination of these showed them to be more or less permeated in the vessels with silica rather than with this substance.

Solereder mentions that in some instances a certain form of crystal is characteristic of an entire Natural Order, yet in other cases it serves to distinguish only genera and species, but so far as my investigations have gone, this does not seem to obtain in Australian woods, for a uniformity appears to hold throughout, the variation being only in size and number.

In order to give some idea of the character of the wood in which these crystals occur, a short anatomical description of the texture of each species is given.

Twenty-two (22) orders were examined, and of these, crystals were found to occur in the secondary wood of (15) viz:—

Pittosporæ. Sterculiaceæ. Rutaceæ. Olacineæ.
 Meliaceæ. Rhamneæ. Sapindaceæ. Anacardiaceæ.
 Leguminosæ. Saxifrageæ. Myrtaceæ. Ebenaceæ.
 Loganiaceæ. Euphorbiaceæ. Casuarineæ.

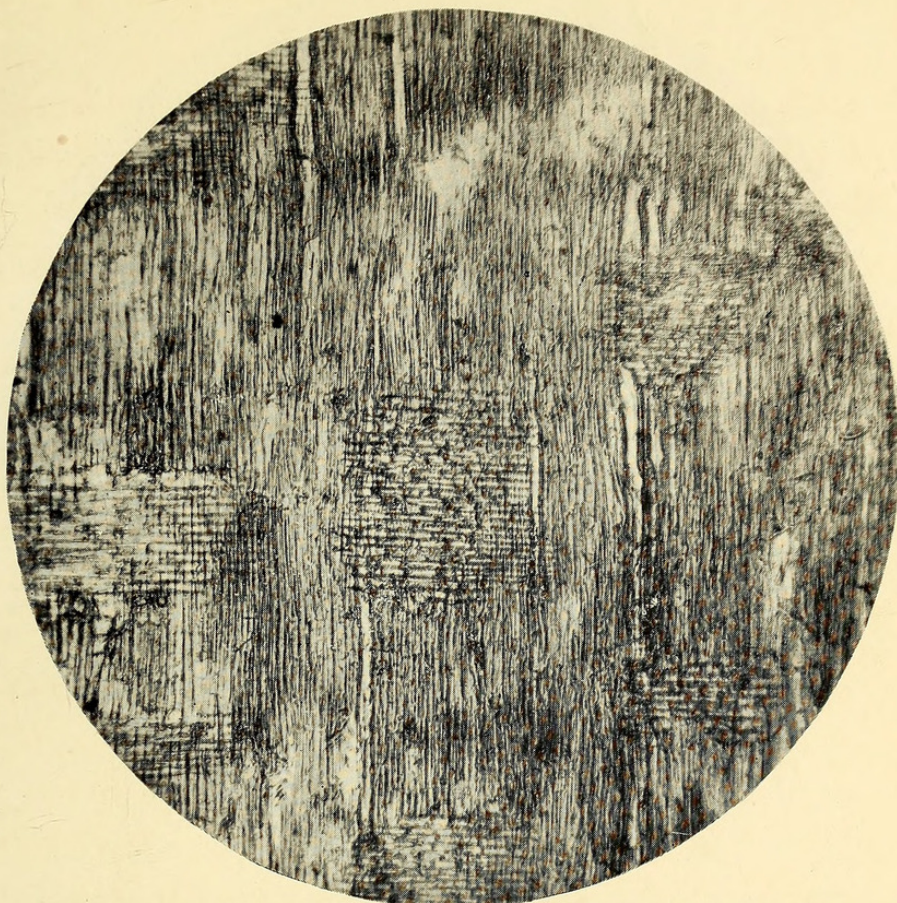
List of Species in which Crystals are found:—

1. *PITTOSPORUM UNDULATUM*, Vent. N.O. Pittosporæ.

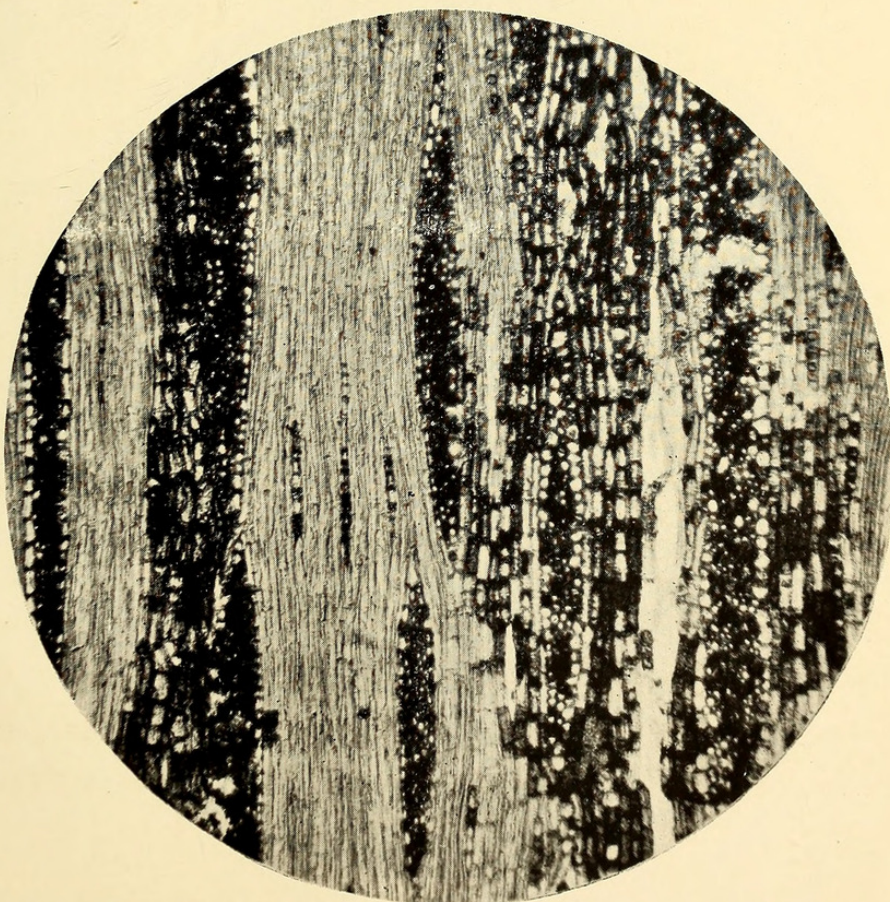
The pores have a comparatively small diameter, and the wood parenchyma is very limited. The rays are of the heterogeneous type and have fairly thick walls; the unusually large wall markings of the vessels are a distinct feature of this species. The fibres are numerous, with few exceedingly minute wall perforations. A crystalline deposit of monoclinic crystals, plates or short prisms,—calcium oxalate, was seen in some of the cells of the ray parenchyma which have very delicate walls, otherwise the wood elements were free of any deposit.

2. *TARRIETIA ARGYRODENDRON*, Benth. N.O. Sterculiaceæ.

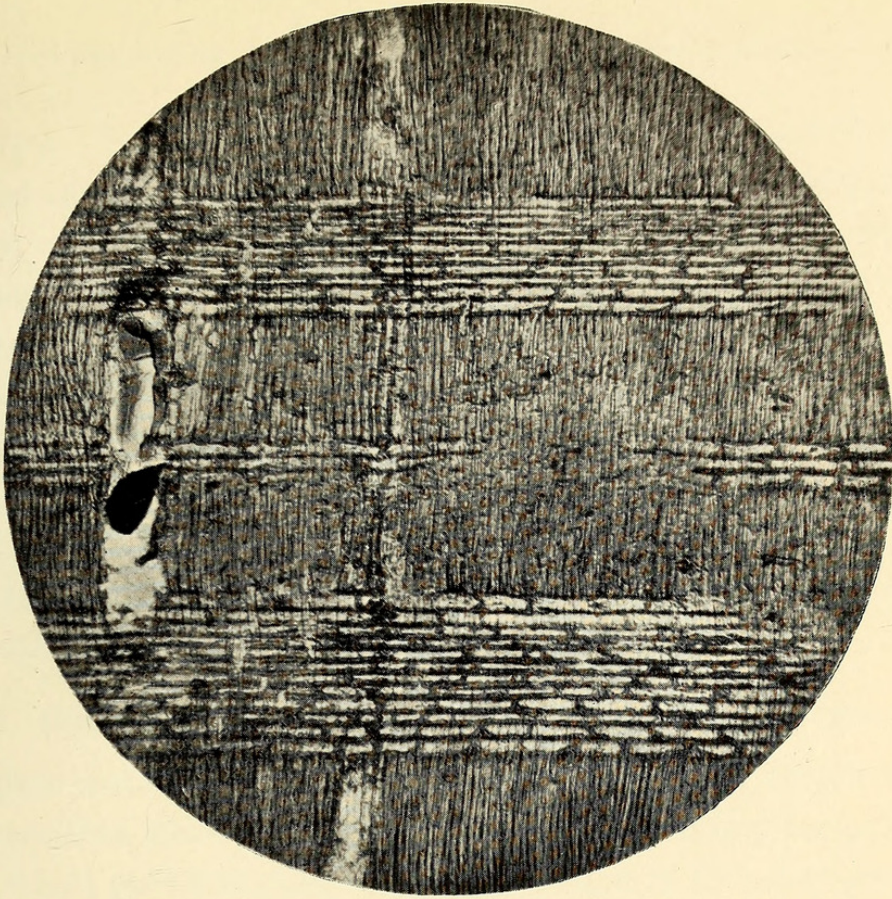
The two main characteristics of the anatomy of this timber are the disposition of the wood parenchyma and the presence of a brown deposit in its cells as well as that of



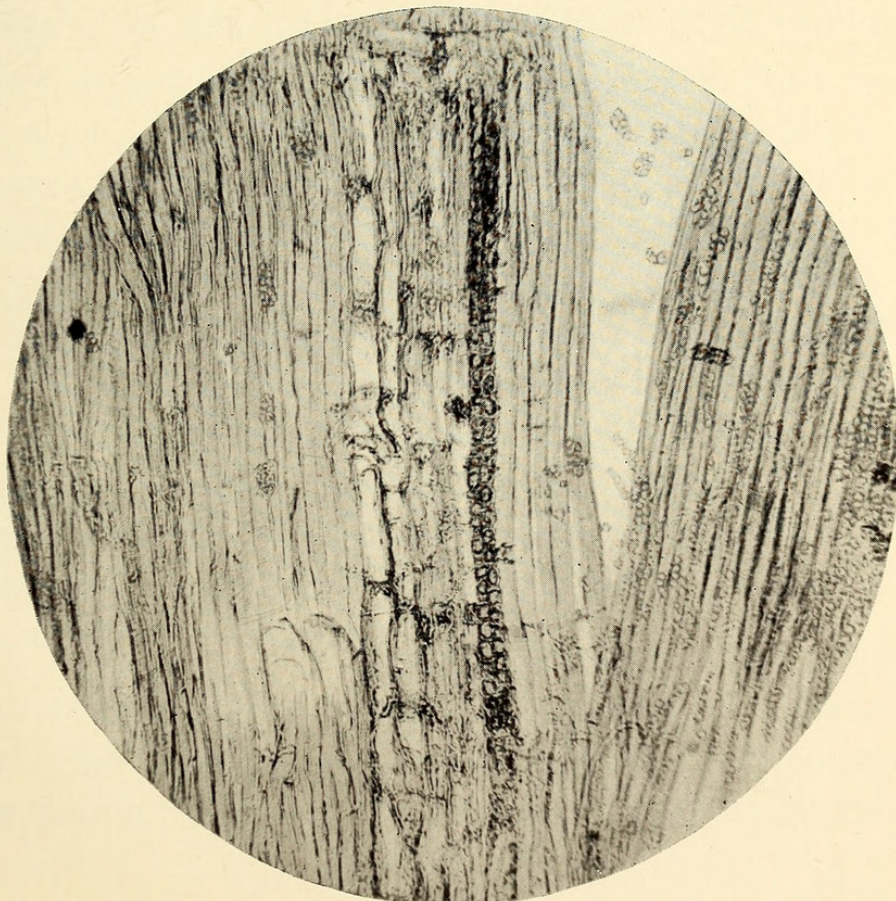
Pittosporum undulatum.—Radial section showing crystals in ray cells on the extreme left. $\times 45$.



Tarrietia argyrodendron.—Tangential section showing crystals at the top and extreme right. $\times 45$.



Flindersia australis.—Radial section shewing vertical view of crystals in middle of top ray, and other places. $\times 45$.



Flindersia australis.—Radial section showing a conjugate crystal parenchyma with a calcium oxalate crystal in each cell; to the left, wood parenchyma, the remainder fibres. $\times 100$.

the rays. It is not unlike some of the *Grevilleas* and *Orites excelsa* in having fibres and parenchyma arranged in alternating concentric bands. The fibres are thick-walled leaving very little space for the lumen, and perforations appear to be almost entirely absent. The vessels are rather large and mostly clear of tyloses, and around them wood parenchyma occurs as well as in the position stated above. The predominating rays belong to the multiseriate class, and in a radial section are seen to be heterogeneous, the outer row of cells containing monoclinic crystals, plates, or short prisms of calcium oxalate.

3. BOSISTOA EUODIFORMIS, F.v.M. N.O. Rutaceæ.

A pale coloured, hard, close grained timber, which in a cross section shows the fibres arranged in bands alternating with wood parenchyma,—amongst which is found a special form containing simple monoclinic crystals in the individual cells. They are quite absent from the ray parenchyma.

4. VILLARESIA (CHARIESSA) MOOREI, Ruiz. N.O. Olacineæ.

The features of this wood are quite specific in a transverse section, for the fibres appear to stand alone, being separated by compressed wood parenchyma, or a continuation of the walls of the latter or surrounded by them. The fibre walls are very thick, leaving a very small lumen, the wall perforations being very numerous and run in the long axis. The vessels are numerous and rather free from tyloses, but show some very fine examples of scalariform apertures. The rays are mostly free from the ordinary deposit, but a fair number of crystals were detected; the multiseriate kind of ray predominates, which is occasionally bounded by tracheid cells.

5. FLINDERSIA AUSTRALIS, R.Br. N.O. Meliaceæ.

An exceedingly close-textured wood, the very numerous fibres having thick walls, leaving only a small space for the

lumen, the wall apertures being very few and very small, ovate and longitudinal. The pores are not numerous, the wood parenchyma running in lines between the solid mass of fibres, and also around them. A few crystal wood parenchyma were present. The vessels have very numerous wall-pits, the partition walls of the cells belong to the scalariform variety; some contain a brown deposit. The rays are fairly numerous, varying from uniseriate to three and four cells wide and several cells high.

6. EMMENOSPERMUM ALPHITONIOIDES, F.v.M.

N.O. Rhamneæ.

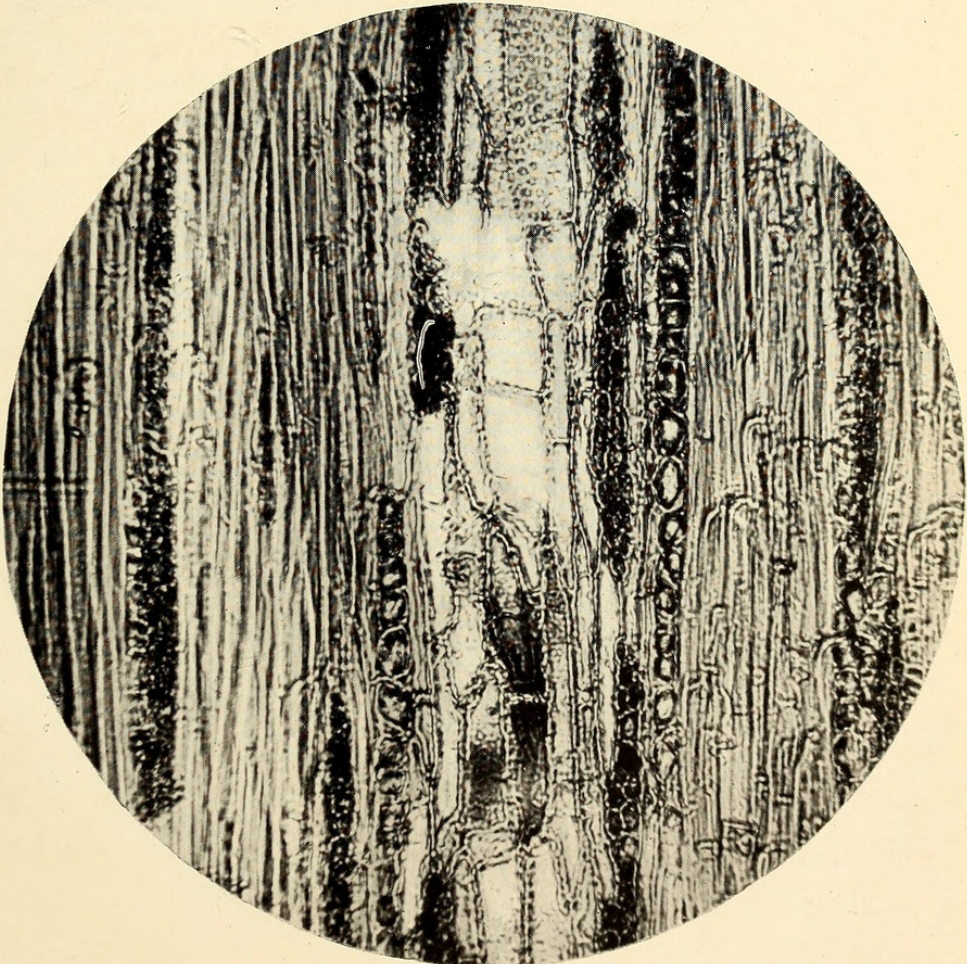
This is not so uniformly structured as its congener *Alphitonia excelsa*. The fibres are arranged in regular radial rows, but of varying diameters, and have only a medium thickness of wall, giving a comparatively large lumen, the wall perforations being few. The vessels are fairly numerous, but often two or three conjugate, the walls being strong and full of perforations, but free from tyloses. The wood parenchyma is exceptionally sparse, whilst the rays are numerous and from one to several cells wide and also in height; a few crystals were seen in the latter.

7. RATONIA TENAX, Benth. N.O. Sapindaceæ.

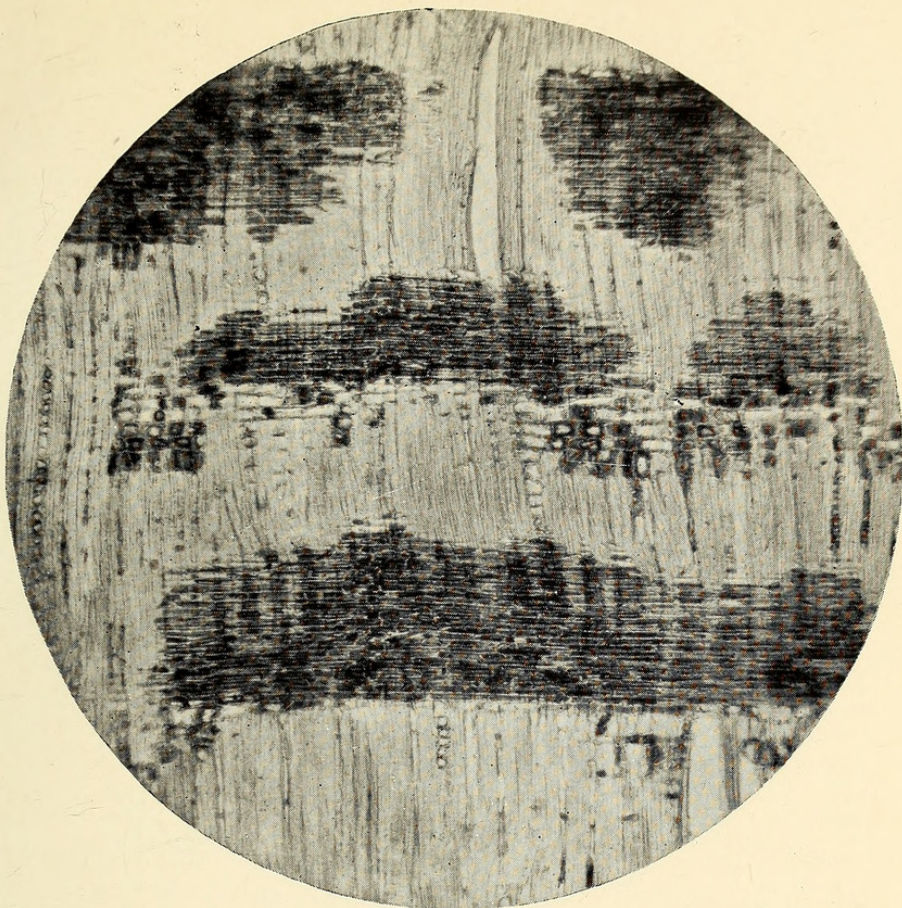
This wood is of a uniform texture, the fibres being of equal diameter, with walls of medium thickness, thus leaving a fair sized lumen; the numerous wall perforations running with the long axis of the fibres. The vessels are rather small, but fairly numerous and scattered irregularly throughout the other wood elements, and with an absence of tyloses. The wood parenchyma is more limited than that of most timber examined, and the few seen had their cells filled with crystals. The ray parenchyma had in almost every instance a deposit in the narrow horizontal cells; vertical cells border these top and bottom. They



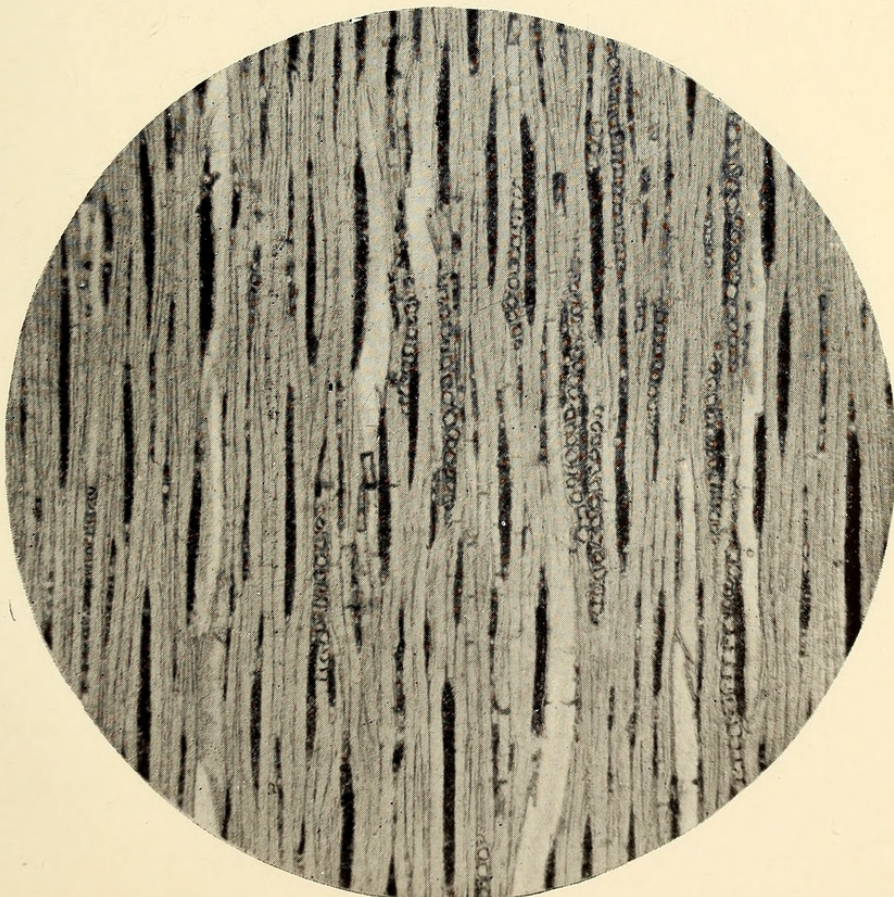
Acacia pendula.—Tangential section showing numerous wood parenchyma with crystals. $\times 45$.



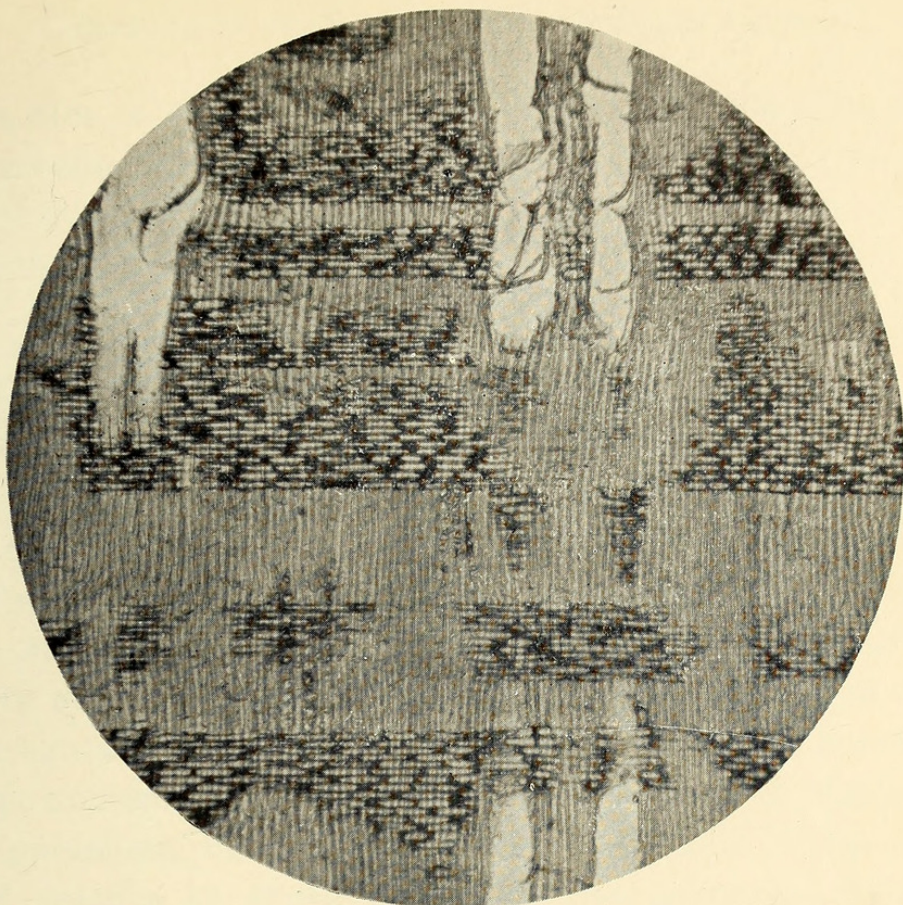
Acacia pendula.—Tangential section, with two highly magnified wood parenchyma, with calcium oxalate crystals. $\times 200$.



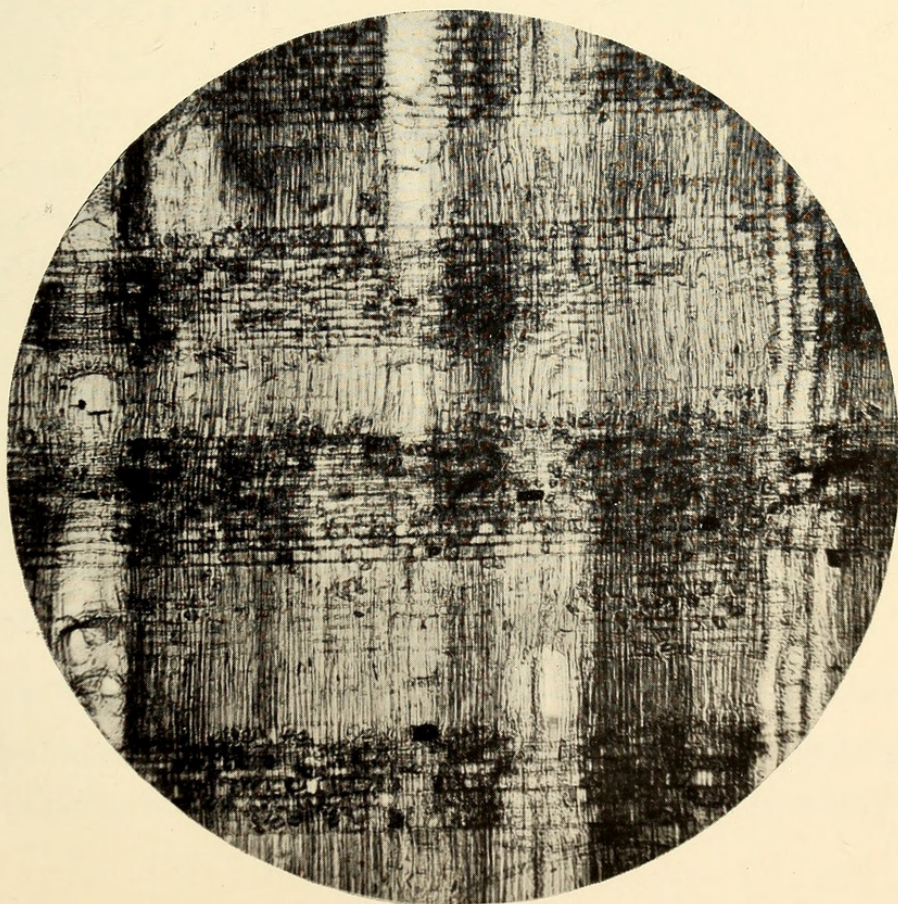
Weinmannia lachnocarpa.—Radial section showing several wood parenchyma containing crystals. $\times 45$.



Weinmannia lachnocarpa.—Tangential section showing wood parenchyma containing calcium oxalate crystals. $\times 45$.



Rationia tenax.—Radial section; a crystal parenchyma is seen just below the centre and low left from that. $\times 45$.



Rhodosphæra rhodanthema.—Radial section showing rays with numerous crystals in the cells. $\times 45$.

were, almost without exception, of the uniseriate form and a few cells high.

8. RHODOSPHERA RHODANTHEMA, F.v.M.

N.O. Anacardiaceæ.

A very regularly constructed timber, the fibres running in radial rows parallel to the rays, having walls of medium thickness with a lumen a third the diameter of this wood element, the perforations were not distinctly discernible. The only instance seen of septate fibres of the species microsectioned. Parenchyma of the wood rare, but the rays numerous, and these are especially interesting as nearly all the cells contain the monoclinic crystals of calcium oxalate, and in no other instance were they found to be so numerous in the rays, except perhaps in *Mallotus philippinensis*. The vessels have rather thin walls—the chief feature of these organs is the polygonal figures surrounding the pits.

9. ACACIA PENDULA, A. Cunn. N.O. Leguminosæ.

A very dark almost black coloured timber, a feature due very largely to the dark deposit in almost all the wood elements. The vessels are large with thick walls and a dark coloured deposit apparently of a similar nature to that found in the fibres and certain wood parenchyma and the rays. The wood parenchyma is very numerous and is either clustered around the pores or running in lines amongst the early and late growth, and in the majority of cases the cells are filled with calcium oxalate crystals, in fact they are more numerous in the wood parenchyma of this timber than any other examined. In the rays the cells are filled with a substance similar to that of the vessels.

10. WEINMANNIA LACHNOCARPA, F.v.M. N.O. Saxifrageæ.

The most characteristic sections in this connection are the tangential and radial, the crystals being seen clearly in

both, especially the former, as shown in the illustration. The wood parenchyma, which is exceedingly narrow, except where the crystals occur, runs in single rows between the rays separating two, three or more rows of thick-walled fibres rather devoid of wall perforations and a very limited lumen. The rays are multiseriate mostly, and filled with a secretion similar to the narrow wood parenchyma cells. The vessels are narrow with well-marked wall perforations; no tyloses were detected.

11. *EUCALYPTUS ALBENS*, Miq. N.O. Myrtaceæ.

In a transverse section the pores seem to be most numerous, disposed in rings alternating with solid rings of fibres, the rays being very fine and numerous, wood parenchyma is sparse, but mostly the cells contain crystals; the vessels are nearly all plugged with tyloses, and the fibres forming the bulk of the timber are very compact with a very narrow lumen, and pits running longitudinally, the borders showing better in the tangential wall. It is this predominance of fibres that, no doubt, adds so considerably to the weight of the timber.

12. *EUCALYPTUS DAWSONI*, R.T.B. N.O. Myrtaceæ.

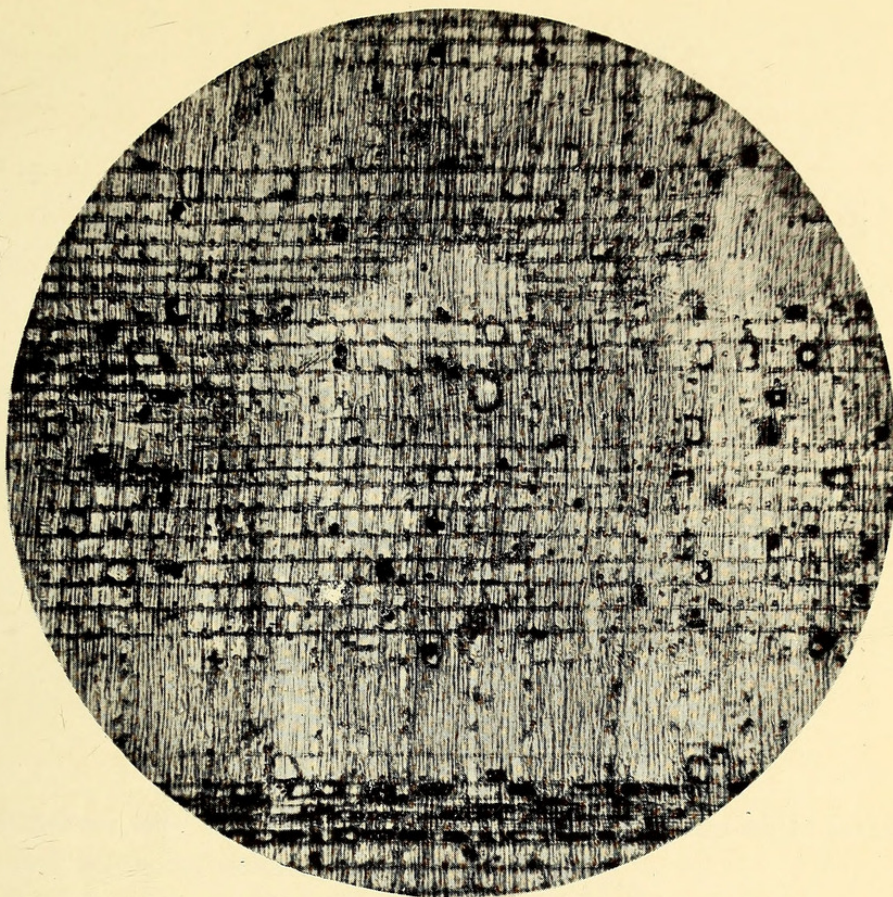
An extremely hard, close, compact timber, the fibres predominating over all other wood elements, wood parenchyma is limited, and only a few crystals were seen in these cells.

13. *EUCALYPTUS PILULARIS*, Sm. N.O. Myrtaceæ.

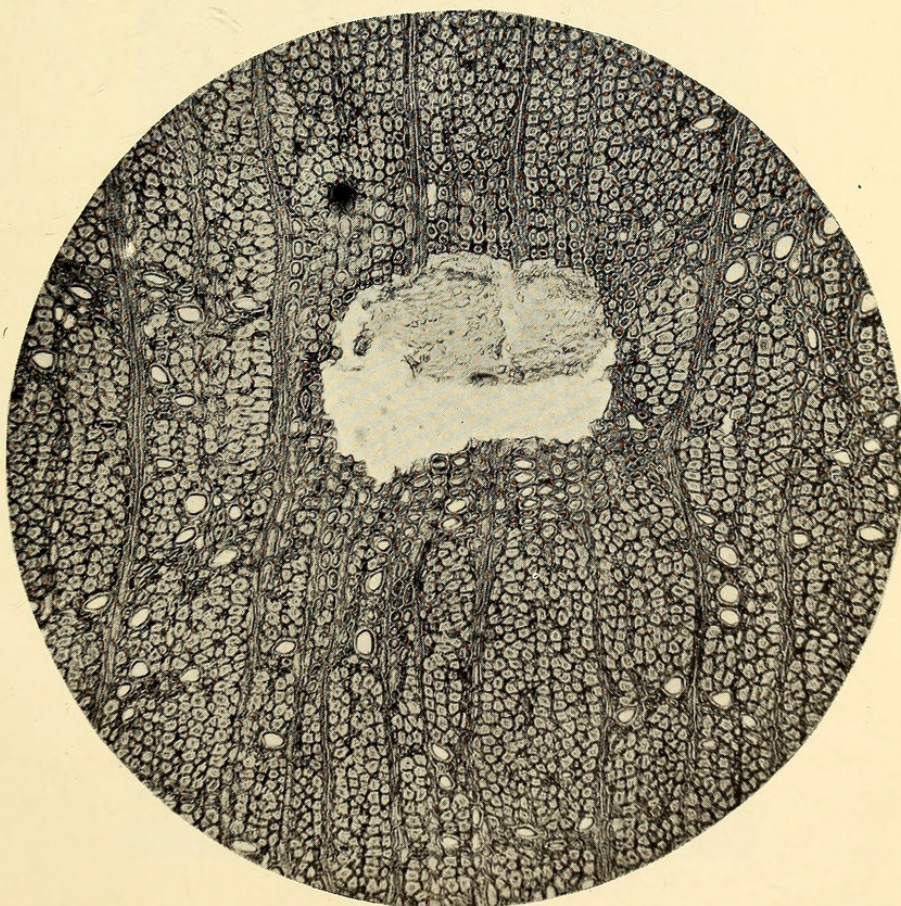
This timber has the reputation amongst workmen of having a grit. This is due however not to the presence of calcium oxalate but silica, from a test made by Mr. H. G. Smith, F.C.S.

14. *EUCALYPTUS POLYANTHEMA*, Schau. N.O. Myrtaceæ.

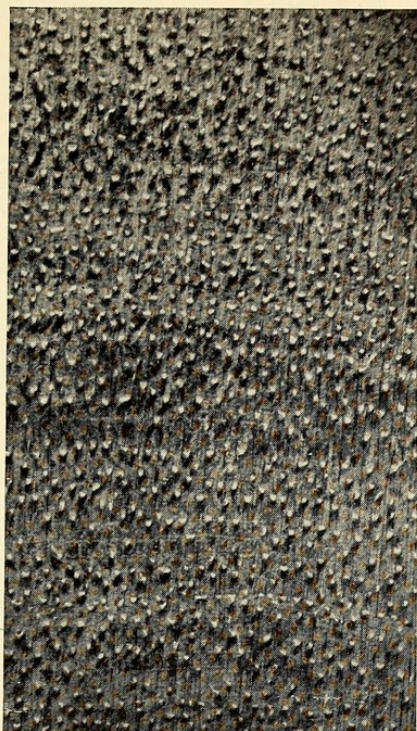
A very compact wood, the fibres arranged in radial rows, the lumen, like most red timbers, contains a deposit of that



Diospyros pentamera.—Radial section showing crystals in some of the ray cells. $\times 45$.



Strychnos arborea.—Cross section showing crystals in the large wood parenchyma pockets. $\times 45$.



Strychnos arborea.—Cross section, natural size. The white markings are not pores but calcium oxalate cavities.



Strychnos arborea.—Tangential section showing wood parenchyma (white streaks) filled with calcium oxalate.

colour. The crystals are not very numerous, but occur in both wood and ray parenchyma, especially the former, the latter also contains a red deposit.

15. *EUCALYPTUS MELLIODORA*, A. Cunn. N.O. Myrtaceæ.

The fibres may be classed as thick-walled, of a rather uniform dimension, with a lumen about one-third of the whole diameter. The perforations are numerous, opening by longitudinal slits which are often bordered. The pores are very numerous. The vessels have a rather delicate system of tyloses, and like the wood parenchyma (which is rather sparsely found), have no secretory substance as obtains in so many Eucalypts. The rays are small, numerous, uniseriate, some of the cells have a yellowish secretion. The radial wall perforations of the cells are unusually large, round, and not of uniform diameter. The wood parenchyma is fairly well scattered amongst the wood elements, and in several instances crystals were found.

16. *EUCALYPTUS* SPP. IRONBARKS.

Most of the species forming the Ironbark group of Eucalypts contain calcium oxalate, more or less in the wood parenchyma, being most numerous in *E. Fergusoni* and least in *E. paniculata*.

17. *DIOSPYROS PENTAMERA*, F.v.M. N.O. Ebenaceæ.

A characteristic timber, and one not easily confounded with others, the fibres have fairly thick walls and small lumen, whilst the vessels also have unusually thick walls, both the wood and ray parenchyma are very interesting, as they contain in the cells three kinds of contents, crystals, a brown substance, and a very small spherical green body in malachite green.

18. *STRYCHNOS ARBOREA*, A.W. Hill. N.O. Loganiaceæ.

A close, hard grained timber, with irregularly packed fibres, numerous broad rays and small pores. Wood paren-

chyma is clustered around a very large one, in which is found a great deposit of apparently fine substance, described in the former part of this paper. See Plate XXX.

19. *BRIDELIA EXALTATA*, F.v.M. N.O. Euphorbiaceæ.

A fairly compact timber, the fibres of rather small diameter, and pores also small. Crystals are fairly numerous in the wood parenchyma.

20. *MALLOTUS PHILIPPINENSIS*, F.v.M. N.O. Euphorbiaceæ.

A timber with quite an unusual structure, the wood parenchyma being arranged in rows parallel to the rays and fibres, the latter having an exceedingly small diameter. The rays are of the multiseriate type, many of the larger cells containing large crystals, in some cases smaller ones were seen. It is the only instance in which a cell was found to contain more than one crystal.

21. *CASUARINA TORULOSA*, Ait. N.O. Casuarineæ.

A close, compact wood, the fibres nearly always containing a brown deposit, as well as the vessels, which are thick walled. The large multiseriate rays are a distinguishing feature of this and all the Casuarinas, except *C. Cambagei*. The wood parenchyma is fairly numerous and extends in parallel narrow lines to the early and late growth, and appears to be of two kinds, one without and one with a deposit—amorphous and crystalline.

22. *CASUARINA GLAUCA*, Sieb. N.O. Casuarineæ.

Crystals are fairly numerous in the wood parenchyma and of rather large size, and are seen in the transverse, radial and tangential sections, a very unusual circumstance.

Plates,—Micro-sections.

- Plate XXV. *Pittosporum undulatum*. *Tarrietia argyrodendron*.
 „ XXVI. *Flindersia australis*.
 „ XXVII. *Acacia pendula*.
 „ XXVIII. *Weinmannia lachnocarpa*.
 „ XXIX. *Ratonia tenax*. *Rhodosphaera rhodanthema*.
 „ XXX. *Diospyros pentamera*. *Strychnos arborea*.
 „ XXXI. *Strychnos arborea*.
 „ XXXII. *Mallotus philippinensis*.
 „ XXXIII. *Mallotus philippinensis*.



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