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HISTOLOGY OF BARKS OF CINCHONA AND SOME RELATED GENERA OCCURRING IN COLOMBIA

RUBY R. LITTLE
Junior Botanist

INTRODUCTION

In connection with the *Cinchona* bark procurement program in Colombia, South America histological studies were made of the barks of *Cinchona* and some related genera. These studies were made by the author in Bogotá, Colombia, from February 1944 to March 1945, for the Cinchona Division of the Foreign Economic Administration.

This is a preliminary report, submitted to the officials of the Foreign Economic Administration upon termination of my appointment in that organization. Some details are in doubt and some improvements probably can be included in a future revision of this paper. However, such changes could not invalidate the methods described here nor alter the criteria for identification of barks containing cinchona alkaloids.

The helpful supervision of Mr. Tom Bellis, chemist, and the valuable criticisms of the members of the Colombian *Cinchona* survey staff are gratefully acknowledged. The cooperation of the Mycology and Forest Pathology Divisions of the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, Beltsville, Maryland, in providing space, equipment, and materials needed in preparing slides for photomicrographs is deeply appreciated.

Some work was done on the histology of *Cinchona* barks in the past century, but the information available to us at the beginning (1) [a/] while valuable as a starting point, was inadequate to serve the purposes of the Colombian *Cinchona* procurement program.

In Columbia five species of the Rubiaceae: *Cinchona officinalis, C. pitayensis, C. pubescens, Remijia pedunculata,* and *Ladenbergia hookeriana* have been found to contain one or more of the crystallizable cinchona alkaloids: quinine, cinchonidine, cinchonine, and quinidine. Analyses of other barks have indicated that they yield either none or not more than traces of these crystallizable cinchona alkaloids, and in this paper they are collectively designated "false barks" to distinguish them from the five species which do yield quinine, cinchonidine, cinchonine, or quinidine. By this convention two species of *Cinchona* and two or more of *Remijia,* as well as many species of other genera, are regarded as false barks.

The botanical names used in this report are those assigned by the botanists of the *Cinchona* survey staff; most of them can be found in Fosberg's Colombian Cinchona Manual (2) or in Standley's Rubiaceae of Colombia (3). In the case of several barks final identifications have not yet been made. For this reason it has been necessary to use some names tentatively. Corrections in nomenclature will be available, it is hoped, before the paper is revised for publication. Histological terminology follows Eames and MacDaniels as closely as possible (4).

Numbers used to designate samples are those assigned to bark samples as they were received by the sample house and chemical laboratory for identification or analysis. Collection data and other records are kept on file in numerical order by sample number. A list of the samples cited, with corresponding collectors' numbers and localities where collected, is appended on page 424.

Altogether 102 bark samples have been examined. They are distributed by species as follows:

	authentic	others [a/]
Cinchona officinalis	251	82
C. officinalis "roja"	14	11
C. pubescens	151	68
C. pitayensis	25	47
C. barbacoensis (a false bark)	3	
C. henleana (a false bark)....	23	2
Cinchona probable hybrids....	4	
Remijia pedunculata	64	28
R. purdieana	3	2(?)
R. bracteata (a false bark)...	3	
R. machophylla (a false bark)	2	
Remijias not identified to species[b/]	28	
Ladenbergia hookeriana ("quina morada")	4	8
Other Landenbergias identified or tentatively identified.....	42	14
Ladenbergias not identified to species	17	
Other Cinchoneae identified...	12	
Miscellaneous (other Rubiaceae; mixed, misidentified, and unidentified samples)	40	54
Totals	686	316

OBJECTIVES

1. To learn to identify the species of barks found in Colombia which yield cinchona alkaloids and to distinguish between these and the false barks commonly mistaken for or substituted for them.

a/ Numbers in parentheses refer to items in "Literature Cited", page 423.

a/ "Other" samples are those which cannot be classified as "authentic"; that is, they were submitted by persons other than qualified members of the survey staff and usually were not accompanied by herbarium material. Most important classes of "other" samples are those taken from commercial lots and those submitted directly or indirectly by persons interested in selling bark to the Cinchona Division.

b/ An authentic unidentified sample is one collected by a botanist with accompanying herbarium material which may be identified at a later date.

2. To correlate microscopic characters of bark with area of origin of *Cinchona* species, and to correlate microscopic characters with morphological variations in *Cinchona* species.

3. To study the bark characters of *Cinchona* hybrids.

* * *

METHODS

Freehand radial longitudinal and cross sections of green or soaked dry bark, mounted directly in glycerine, have been almost the sole source of information; a few samples were macerated by the Jeffrey technique (5). First, in order to establish a good foundation for identification work, I studied authentic bark samples, that is, samples collected and identified by qualified botanists of the *Cinchona* survey staff and supplemented by herbarium material. As many of these as possible were studied in green condition, but dry barks also were studied in order to be prepared for identification of dry unknowns.

Examinations have not been confined to authentic, unquestionably identified samples. The information developed from the examination of authentic samples has been applied in the program of *Cinchona* bark procurement whenever it appeared that the use of microscopic technique might serve the ends of that program. The existence of certain correlations between species and chemical composition have added greatly to the utilitarian application of microscopic identifications.

Fiber measurements given in the descriptions represent the largest diameters of the largest fibers occurring in a standard area of normal phloem in cross section. The standard area chosen for use in measuring fibers of *Cinchona* species (except *C. henleana*) is called here "standard field 2". It is arbitrarily chosen as that part of the field which can be drawn in a 3-inch square at a linear magnification of 165 times. First, all the fibers of the area were outlined in the square with the help of a camera lucida then the largest three cells in the sketch were marked, and their greatest diameters recorded. Considerable work with the diameters of the smallest cells, with the largest and smallest diameters of given cells, and with roughly calculated figures representing "cross-sectional areas" (described on page 421), resulted in measurement figures of no more apparent value in identification than this simple device. For barks having smaller or more uniform fibers, measurements were made of sketches drawn at a linear magnification of 425 or 700 in order to attain a similar degree of accuracy.

In most cases the slides were kept for re-examination when new questions should arise regarding the samples. About 600 of these slides are still available. Drawings were made with the aid of a camera lucida and measurements with the aid of an ocular micrometer after those instruments were acquired about the middle of the year. Measurements were made also of camera lucida drawings by means of scales especially calibrated for drawings at the various magnifications.

Methods for the special study of Cinchona officinalis variants. For the special study of variants of *Cinchona officinalis* (page 418), cells to be studied were sketched in a 3-inch square at two diferent magnifications, as shown on page 67. Fibers were drawn from cross sections at linear magnifications of 100 times (referred to in the tables and elsewhere as "standard field 1") and 165 times (referred to in the tables and elsewhere as "standard field 2"). The two magnifications usually represented one portion of the slide; if variations occurred in a slide, two or more areas were drawn at each of the two magnifications. Areas were selected to represent the most mature characters available in the slide. Stone cells were drawn from longitudinal sections in the same manner. The intervening thin-walled cells of phloem and cortex were not drawn. Illustrations, reduced by one third, of some drawings of fibers of *Cinchona officinalis* in "standard field 2" (original magnification 165 times) are given in figure 4 A, B, C, D, and E.

Ocular micrometer measurements of fibers were made in cross sections (greatest and least diameters of each cell measured), and of stone cells in cross and longitudinal sections (length obtained from cross sections, and one or two diameters from longitudinal sections). Measurements were obtained also from camera lucida drawings.

Studies of the diagrams: All the 100-× (standard field 1) diagrams of fibers were spread out on a table for comparison, for a preliminary over-all view and estimated of what characters might most likely serve as key distinguishing characters. The 100-× diagrams of stone cells were reviewed similarly. Stone cells were counted in the 100-× diagrams. The fibers in each 100-× diagram were counted. The largest 5 fibers in each 165-× (standard field 2) diagram were measured and values obtained for their "cross-sectional areas" by multiplying the greatest by the least diameters. A value was obtained also to represent the sum of all the "cross-sectional areas" in the corresponding 100-× diagrams. Finally, all 100-× diagrams of fibers were again laid out on a table together for a study of shape, grouping, and distribution.

Maceration studies: In order to explore the possibility of using lengths of fibers in determining varieties of *C. officinalis,* barks of two variants were macerated. The macerated tissues were stained with Delafield's haematoxylin. Measurements of randomly selected fibers were made with the ocular micrometer.

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GENERAL DESCRIPTION OF BARKS

Reference may be made to figure 1 in the illustration, which is a diagrammatic representation

of bark, and to figure 2, a diagram of the bark of *Cinchona officinalis*.

The term "bark" as used here includes all tissues of a woody stem outside the cylinder of generative cells (cambium) sheathing the wood. In a *Cinchona* trunk of the size usually harvested in Columbia, bark makes up a relatively small proportion of the volume of the trunk.

The barks studied consist of three principal zones. These are, from the inside outward: phloem, cortex, and periderm. At the inner boundary of the phloem there is a cylinder of generative, or cambium cells, which are constantly dividing and the progeny of which become on the inside a part of the wood and on the outside a part of the phloem. The cambium is destroyed by the act of pulling bark from the tree, and is therefore not present on bark as normally harvested in Colombia.

The phloem is subdivisible into primary (outer) and secondary (inner) phloem; the latter region soon becomes predominant because new secondary phloem is constantly being added to the inner part. Phloem of the barks treated here contains four general types of cells: (1) ray parenchyma (thin-walled, with long axes radial); (2) phloem parenchyma and other thin-walled phloem elements (with long axes vertical); (3) phloem fibers (thick-walled, with long axes vertical); and (4) stone cells (thick-walled, with long axes vertical, tangential, or rarely radial when ray cells are transformed into stone cells). Vertical thin-walled cells of phloem include sieve tubes, which I have not identified. Fibers are long, pointed, needle-like cells with walls sometimes so thick that lumina (cell cavities devoid of protoplasm) are minute. Such thick walls are traversed by pits which are slender canals extending from lumen to outer surface. In surface or end view, pits sometimes appear circular, sometimes slit-like (often because of the oblique direction in which they may traverse the cell wall, and sometimes because of a flattened bulge between lumen and outer end of the pit). Many pits are once or twice branched. The fibers of most false barks studied differ from this description in being relatively short and rounded or truncate at the ends rather than pointed. Stone cells of the phloem are much shorter than fibers (length to 5 times the diameter), not pointed at the ends, more or less brick-shaped or cubical. They have pits which may or may not be canal-like and branched, depending on the thickness of the wall. In some false barks stone cells are predominant in the phloem or occur instead of fibers. Primary phloem contains a smaller proportion of fibers or stone cells than secondary phloem (except when stone cells of the cortex type extend into the phloem, when the reverse is true); a bark with secondary phloem is desirable for study, as "mature characters" are exhibited best in the secondary phloem. Not infrequently an inner band of secondary phloem has few or none of the characteristic fibers or stone cells. This I consider merely a region of immature tissue. The phloem cell complex forms a pattern which is of prime importance in the identification of a bark.

A circle of laticiferous ducts occurs at the juncture of cortex and phloem in most of the barks studied, but their persistence varies with species and age. Their characters have not been found very useful in identification. Their presence in Colombian *Cinchona* indicates a very young bark.

The cortex is a primary tissue and does not acquire secondary cells. On the contrary, the cortex becomes a less and less prominent part of structure as the bark ages. Cells of the cortex are more or less ovoid to cylindrical or tend to become brick-shaped with the long axes tangential, rather loosely packed together until crushed by the pressure of developing wood and phloem against them. As a rule, most of the cortex cells are parenchymous (thin-walled). There are usually stone cells, the characters of which are useful in identification.

The periderm, altogether of secondary origin, consists of three concentric layers: (1) Outer layer (phellem or cork), matured tissue, the outer cells of which are constantly dying and being lost. Cells of this tissue are probably in most cases cork cells, that is, have become suberized and thus almost impermeable to the passage of water. The walls are sometimes thin, sometimes thick. (2) Median layer (phellogen or cork cambium), the cells of which divide continually and the progeny of which develop into phellem and phelloderm. (3) Inner layer (phelloderm), made up of thin-walled cells which may or may not develop into a tissue several cells thick and similar to the cortex. The cells of the periderm differ from those of the cortex immediately within in that in cross sections they appear regularly brick-shaped and closely packed together like stacks of bricks whereas those of the cortex are arranged in alternating rows to resemble more nearly a brick wall. Periderm cells are polygonal in surface view, that is, when seen as if looking at the outside of the tree.

In any mature tissue except phellem there may occur scattered thin-walled cells containing a blackish amorphous substance which is perhaps mucilaginous in nature. Of similar distribution, but found only in a few false barks, are cells containing crystals. Starch grains are variable in abundance but may occur in any species and in any mature cell except fibers or cork cells.

The chief deviation from this pattern found to be of interest in identification of Colombia barks containing cinchona alkaloids is in the loss (sloughing) of tissues. In some species there is a tendency for the formation in relatively young bark of new cork cambiums and cork at some depth in the bark tissues with the eventual loss of all tissues thus cut off from their supply of water and food. The resulting bark as seen under the microscope may have lost part or all of its cortex and in many

cases has even lost some phloem. Frequently the remains of degenerating cortex stone cells or phloem fibers can be detected outside the true cork layer. Macroscopically these degenerating inner tissues resemble true cork very closely. Sloughing occurs consistently early in some species and rarely or late in others.

* * *

IDENTIFICATION OF BARK SAMPLES

Outline for the study of barks:

The following outline of structures and characters may be found useful in identification of bark samples. After observations are recorded on a work sheet such as that shown on page 68, the key (page 10) may be consulted for identification. With experience one can dispense with the work sheet for the identification of many samples.

I. Phloem — examine to see:

A. If thick-walled cells are absent (if so, the bark is false).

B. If thick-walled cells are stone cells (if so, the bark is false). (If this cannot be determined in cross section, examine longitudinal sections to see length of thick-walled cells; macerations may be necessary in some cases).

C. If thick-walled cells are fibers:

1. Distribution — single, or cemented in groups; shape of groups and number of fibers included; arrangement of single fibers or of the groups (radial, tangential, or without special arrangement). (Examine in cross section).

2. Size (the greatest diameter of the thickest fibers); whether various or uniform. (Examine in cross section).

3. Shape:

a. In cross section: flattened radially, flattened tangentially, or of other shape; angular or not; polygonal, square, circular, oblong, elliptical, etc.

b. In longitudinal view (section or maceration): ends pointed; or ends rounded or truncate (if ends are rounded or truncate, the bark is false).

4. Lumina (examine in cross section).
a. Size (large, medium, small, minute).
b. Shape (especially whether flattened tangentially).

5. Pits: whether they run in all directions or chiefly tangentially (in the latter case the bark may be *Remijia pedunculata* or a false bark). (Examine in cross section).

D. Crystals present or absent (if present, the bark is false).

II. Cortex. — Examine to see:

A. If complete, or if a part or all has been lost. (If cortex is not complete, the bark may be that of *Cinchona pubescens, C. officinalis* "roja" or it may be a false bark). (Cortex may be examined in either cross or longitudinal section to determine this character).

B. Whether stone cells are absent or present. If present:

1. Quantity rare is interpreted as being equivalent to none; *Cinchona* samples without stone cells are usually *C. pubescens* or *C. pitayensis*). (Examine in longitudinal section to determine quantity).

2. Single or cemented in groups (if in large, hard blocks, the bark is a false bark). (Can be determined in either cross or longitidinal sections).

III. Phellem (can be examined in either cross or longitudinal sections). To see:

A. If the cell walls are thin or thick.

B. (If thick-walled) whether the cells have somewhat the shape of a Syracuse watch glass (in the latter case the bark may be that of *Remijia*).

IV. Some features which have not been found especially useful in identification:

A. Color of tissues; of limited use, as in distinguishing *Remijia* and one or two false barks.

B. Relative thickness of periderm, cortex, and phloem; a function of age as well as of species or variety.

C. Crystals, presence or absence; have been seen only in a few false barks.

D. Starch; present in all species.

E. Mucilaginous cells; present in all species.

F. Laticiferous ducts; present in young bark of most Rubiaceous species studied but more persistent in *Remijia* and certain false barks than in *Cinchona* species.

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SHORT KEY FOR THE IDENTIFICATION OF COLOMBIAN BARKS YIELDING CINCHONA ALKALOIDS

1. Phellem made up entirely or partly of thick-walled cells (Part I) 2
Phellem made up entirely of thin-walled cells (Part II) 6

Part I

2. All phellem cells thick-walled, shaped like a Syracuse watch glass (inner wall thick, side walls tapering, and outer wall thin), breaking apart easily (cork brittle), with red

content; stone cells absent from phloem *(Remijia)* 3

Some phellem cells thin-walled; or if all are thick-walled not shaped like a Syracuse watch glass; or if shaped thus without content; or if phellem cells are as above, stone, cells present in phloem.. (about 9 species of false barks, including *Guettarda*).

3. Crystals present. ..... Samples 2474 and 3352 (some kind of *Remijia*?).

Crystals absent 4

4. Fibers numerous, occupying about half of cross section of mature phloem; stone cells common in cortex ..... *Remijia pedunculata*

Fibers relatively few, occupying a negligible proportion of cross section of mature phloem; stone cells absent from cortex.... *Remijia bracteata*

Fibers absent or exceedingly rare, a number of cells corresponding to fibers of *R. pedunculata* having slightly thickened orange-colored walls; stone cells absent or rare in cortex (*Remijia* type phellem cells difficult to find at times) ..... *Remijia purdieana*

Part II

6. Fibers the predominant thick-walled elements of phloem 7

Stone cells the predominant thick-walled element of phloem..... (about 12 species of false barks, including *Ladenbergia undata* (?), *L. macrocarpa* sample 204 type, and *Cosmibuena*).

7. Fibers having pits running in all directions..... 8

Fibers having most pits running tangentially (cells appearing elliptical in cross section) ..... (4 or more species of false barks, including *Remijia macrophylla, Ladenbergia magnifolia,* and *L. macrocarpa* sample 2023 type).

8. Fibers mostly long and slender, angular, usually polygonal to radially oblong in cross section, taper pointed; lumina minute (or small to large)..... 9

Fibers fairly short, with prominent lumina (some *Cinchona pubescens* forms have this character); or if without lumina, circular, non-angular, or elliptical in cross section; ends rounded to truncate (more inclined to be tapered in *C. pubescens, C. henleana,* and *Ladenbergia hookeriana)* 17

9. Stone cells of cortex grouped; long needle-like crystals present in numerous cells throughout the bark.... *Cosmibuena* sp.

Stone cells of cortex single or absent; crystals absent 10

10. Fibers not more than 30 to 40 microns in largest diameters 18

Fibers larger, largest diameters ranging from 45 to 250 microns *(Cinchona)*..... 11

11. Fibers long and slender, uniform throughout length, in cross section polygonal to radially oblong and usually hyaline, largest diameters ranging from 45 to 100 (rarely more) microns 12

Fibers more inclined to be stout, frequently gnarled, with diameter varying throughout length; shape in cross section various; color hyaline to yellow; larger diameters ranging from 100 to 250 microns 13

12. Stone cells present in cortex; fibers usually cemented together in groups of 2 to 16 and arranged in radial rows, often radially oblong in cross section..... 15

Stone cells absent or rare (or present in "replacement" cortex); fibers in

smaller groups with single predominant, scattered or showing tendency to radial arrangement, infrequently radially oblong in cross section..... 16

13. Stone cells present in cortex 14

Stone cells absent or rare in cortex..... *Cinchona pubescens*

14. Fibers 150 to 250 microns in largest diameters.....*Cinchona barbacoensis*

Fibers rarely up to 175 microns in largest diameters .....*Cinchona officinalis* "roja"

15. Cortex persistent; cork layer thin, simple, composed mostly or entirely of phellem (stone cells absent or rare in cortex of some forms).....*Cinchona officinalis*

Cortex absent in older barks; "cork" layer thick, soft, complex, consisting of phellem layers alternating with degenerating phloem or cortex (stone cells in phelloderm). *Cinchona officinallis* "roja"

16. Fibers numerous, 45 to 85 microns in largest diameters, uniform; cortex and phellem persistent (cortex may be crushed) (some *C. officinalis* forms may run to here) .....*Cinchona pitayensis*

Largest fibers variable in largest diameters (ranging from 60 to 100 microns in some, from 80 to 150 microns in others) and frequently non-uniform in cross-sectional shape, usually fewer than in *C. pitayensis;* cortex absent or irregular in older barks (some *C. officinalis* forms may run to here) . . . .*Cinchona pubescens*

17. Fibers with small to prominent lumina, scattered, very irregular as to size, the largest diameters ranging from 60 to 150 microns, with ends mostly taper-pointed; stone cells absent or rare in cortex....*Cinchona pubescens*

Fibers with small or no lumina, yellowish, uniform, largest diameters not more than 30 to 40 microns, long and slender with ends taper-pointed; stone cells common in cortex.. *Ladenbergia hookeriana, Cinchona henleana,* and "quina cacao" or "canela bark"

Fibers various as to size, shape, size of lumina, and grouping, but short, ends rounded to truncate; stone cells of cortex various or absent..... (about 9 species of false barks, including *Elaeagia karstenii, Joosia umbellifera,* and *Calycophyllum* sp.)

18. Fibers single, not angular *Ladenbergia hookeriana, Cinchona henleana,* and "quina cacao" or "canela bark".

Fibers as seen in cross section in squarish groups, themselves sharply angular.....Sample 3916 (a false bark).

* * *

SPECIFIC DESCRIPTION OF BARKS

The reader is asked to bear in mind the following conventions which have been adopted. An attempt has been made to describe the majority of the forms of a given species and the majority of cells of a given type without mention of all exceptions. For example, species described as having taper-pointed fibers may have some which are rounder or truncate at the ends. Such vague qualifying expressions as "more or less" and "usually" have been omitted in the interest of brevity and conciseness, in many instances when the inclusion of all known cases would necessitate their use. Identification of the barks treated in this study is as much a matter of experience with their general appearance as it is of enumeration of specific characters.

It should be understood that geometric terms, or terms indicating shape, adopted in biology are approximate, not exact, descriptions. For example, "oblong" is used here as a term to cover various angular shapes between rectangular and elliptical and "circular" to cover non-angular shapes approaching a perfect circle.

Lumina (cell cavities devoid of protoplasm) are classified as (1) large, when diameter is greater than thickness of wall; (2) medium, when about the same; (3) small, when lesser; (4) minute, when nearly obliterated by thickening of the wall. Lumina of the latter classification are sometimes referred to as "absent", but in the barks treated here lumina are never so completely obliterated

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as to be invisible. The cell cavities of fibers and stone cells are consistently called lumina although they frenquently contain starch or other matter.

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DESCRIPTIONS OF BARKS YIELDING CINCHONA ALKALOIDS

Cinchona officinalis (figures 2, 4, 6, 7, 8).

Tissues fairly regular and compact, brown if dried or exposed to air.

Phloem regular, with cells in radial rows. *Fibers* as seen in cross section medium and fairly uniform in diameter (largest diameters ranging from 55 to 120 microns), hyaline, polygonal to radially oblong, occurring in compact radial rows 3 to 10 cells long and 1 to 3 cells thick (single fibers always present, sometimes predominant); lumina minute; pits of moderate size and abundance, running in all directions from the center, branched. In milled bark the fibers cling together and are seen as broken bundles. As seen in longitudinal section or in maceration they have a length many times the diameter; diameter of cell and lumen uniform throughout length except at the pointed ends; pits appearing under low magnification like oblique slits, in broken rows; long axis strictly vertical. Stone cells of the type found in the cortex may occur in the parenchyma, especially in that of primary phloem, but are usually not very abundant.

Laticiferous ducts present in bark of twigs and very young branches, but disappear at an early age.

Cortex regular, persistent; the cells (including stone cells) cylindrical to brick-shaped with long axes tangential to the stem axis. *Stone cells* abundant, single (not coherent in blocks), sometimes composing more than half of the tissue, sometimes occurring also in the phelloderm; pits slit-like in surface view, not branched, medium in size, prominence, and abundance; walls hyaline, relatively thin for stone cells; lumina large.

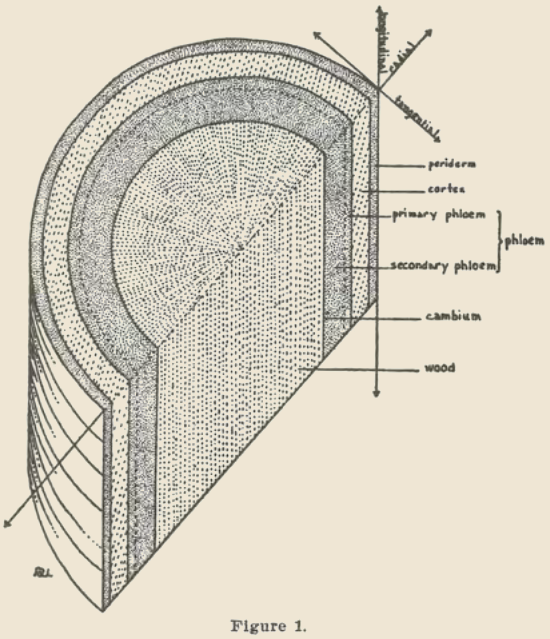

Figure 1.

Diagrammatic representation of part of a tree trunk to show the relation of bark to wood; relation of the principal bark zones to each other; and orientation of the principal directions mentioned in descriptions.

Cork cambium (phellogen) frequently forms phelloderm as well as phellem. *Phellem cells* brown, sometimes hyaline, compact, with walls thin and uniform; zone not very thick but persistent; cells coherent so that when the cork is broken the cells are torn in two rather than separated from each other.

Exceptions: (1) "Roja" bark (a form of *C. officinalis* low in alkaloidal content) (2) sloughs outer tissues early and as usually collected has a thick, soft, complex "cork" consisting of several layers of degenerating cortex or phoem or both sandwiched between layers of phellem tissue. The phloem fibers here sometimes degenerate and disappear before the parenchyma, leaving holes which perhaps contribute to the spongy character of the "cork". Stone

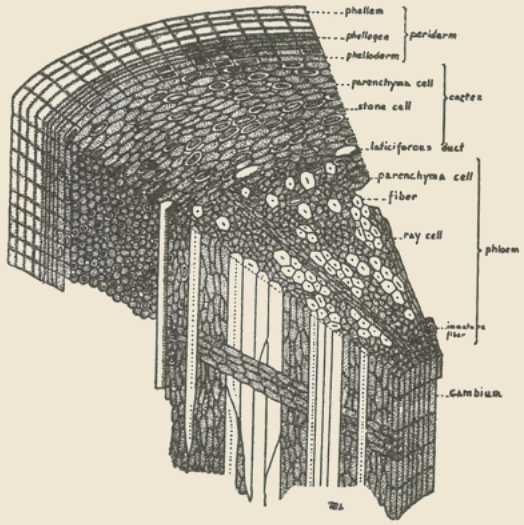

Figure 2.

CINCHONA OFFICINALIS: Semidia-grammatic representation of young bark, enlarged to about 70 times normal thickness. It has been observed that laticiferous ducts are absent from the Cinchona bark of age or thickness as it is usually harvested in Colombia. The cambium has not been studied, and therefore the form of cambium cells as shown here should be disregarded.

Similar drawings of barks of other species would differ from this chiefly in the following respects:

CINCHONA PUBESCENS: (1) absence of stone cells in cortex (or cortex absent); (b) fibers in phloem mostly isolated, and sometimes circular or elliptical in cross section.

CINCHONA PITAYENSIS: (a) absence of stone cells in cortex (or very few) (b) fibers in phloem mostly isolated or in groups of two to four, but numerous and somewhat smaller, square to polygonal in cross section.

REMIJIA PEDUNCULATA: (a) all phellem cells with thickened inner walls; (b) fibers much smaller, mostly elliptical in cross section, with lumina, and cemented to each other in irregular rows.

LADENBERGIA HOOKERIANA or **CINCHONA HENLEANA:** (a) fibers smaller, not angular in cross section; (b) fibers single but numerous and arranged in radial rows.

LADENBERGIA MAGNIFOLIA type of false bark: (a) fibers smaller elliptical in cross section, mostly having small, tangentially flattened lumina; (b) fibers cemented to each other in fairly wide radial rows (compare with **Remijia pedunculata;** the latter has trick-walled phellem cells).

LADENBERGIA UNDATA (?) (see page 412) tipe of false bark: (a) absence of fibers in phoem; (b) but presence in ploem of large square columns of stone cells; (c) presence of hard blocks of stone cells in cortex.

cells are abundant in the phelloderm of this form when the cortex has been lost. Young "roja" bark seems not to be distinguishable microscopically from young bark of other variants of *C. officinalis*.

(2) The number of fibers, or the number of fibers in groups, is small in some variants; sometimes this variation is associated with a small number of stone cells, but the two conditions may occur separately. There seems to be no correlation with other variations or with geographic origin of the samples.

(3) All samples of *C. officinalis* from Antioquia, and a few of those from Boyacá, are completely lacking in stone cells; I am not able to distinguish these variants fron *C. pubescens*. Samples with rare stone cells are found occasionally from other localities.

(4) Many samples of *C. officinalis* have, either in zones or scattered among normal fibers, abnormally small, yellowish, short, truncate fibers with lumina (figures 7, 8) which are not noticeable at lower magnifications but which alter slightly the general aspect of the phloem. The same type of cell occurs in *C. pubescens* and *C. pitayensis* (figures 10, 11, and 12). No correlation was found between the occurrence of these small fibers and any regional or varietal source of the samples.

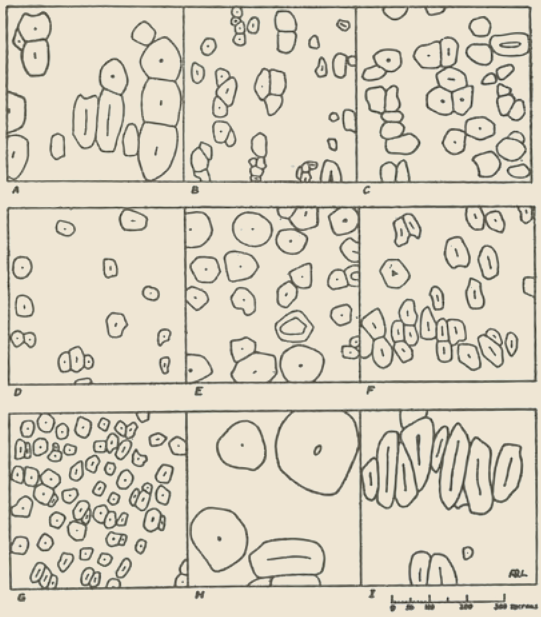

Figure 3.

CINCHONA spp. A series of drawings of fibers from cross sections to show comparative size and arrangement of fibers in the various species. Drawings made at the same magnification using "standard field 2" (page 405). Comparisons should be made with figures 4, 5, and 19.

A — **CINCHONA PUBESCENS.** Sample 2384.
B — **CINCHONA PUBESCENS.** Sample 2183.
C — **CINCHONA PUBESCENS.** Sample 3785.
D — **CINCHONA PUBESCENS.** Sample 3580.
E — **CINCHONA PUBESCENS.** Sample 3401.
F — **CINCHONA PUBESCENS.** Sample 3785.
G — **CINCHONA PITAYENSIS.** Sample 1253.
H — **CINCHONA BARBACOENSIS,** outer phloem. Sample 3790.
I — **CINCHONA BARBACOENSIS,** inner phloem. Sample 3790.

Cinchona pubescens (figures 3, 9, 10).

Tissues loose, irregular, brown if dried or exposed to air.

Phloem highly irregular in some forms, but in other variants the cells occur in radial rows. *Fibers* as seen in cross section hyaline, single, more or less variable in diameter (largest diameters ranging from 65 to 100 microns in some forms, from 80 to 150 microns in others) and variable in shape (circular to elliptical, polygonal to oblong either radially or tangentially); lumina very large to minute; arrangement scattered, radial, or tangential; forms with fiber diameters medium resemble some forms of *C. officinalis* in phloem characters; in most samples some groups of 2 to 4 fibers occur but usually not in radial rows; pits similar to those of *C. officinalis*. Milled bark shows a large proportion of fibers single and whole rather than in broken bundles. In longitudinal sections the fibers have a length several times the diameter, are often non-vertical, crooked, or varying in diameter from one end to the other; ends taper-pointed.

Laticiferous ducts present in twigs and young branches, but disappear at an early age.

Cortex cells cylindrical with the long axes tangential. *Stone cells* absent (rarely formed in phelloderm or in what may be termed "replacement"

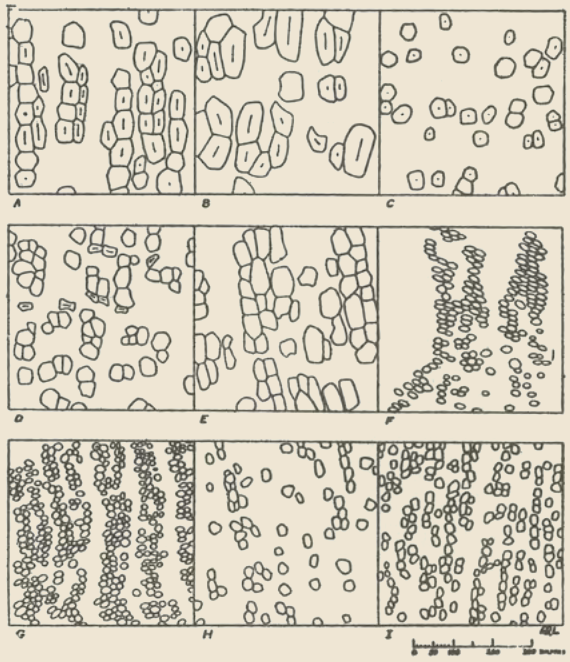

Figure 4.

CINCHONA spp. and **REMIJIA PEDUNCULATA:** A series of drawings of fibers from cross sections, to show comparative size and arrangement of fibers in the various species. All drawings made at the same magnification, using "standard field 2" (page 405). Comparisons sould be made with figures 3, 5, and 19.

A — **CINCHONA OFFICINALIS.** Sample 3248.
B — **CINCHONA OFFICINALIS** "roja". Sample 3629.
C — **CINCHONA OFFICINALIS.** Sample 3305.
D — **CINCHONA OFFICINALIS.** Sample 3300.
E — **CINCHONA OFFICINALIS.** Sample 3559.
F — **REMIJIA PEDUNCULATA.** Sample 3185.
G — **REMIJIA PEDUNCULATA.** Sample 3337.
H — **CINCHONA HENLEANA.** Sample 3379.
I — **CINCHONA HENLEANA.** Sample 3374.

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tissue). Cortex in barks other than quite young partially or wholly sloughed off; phellem frequently subtends degenerating cortex or phloem, but there is less tendency for the degenerating tissues to persist than in *C. officinalis* "roja" (page 410) so that in *C. pubescens* only one layer, if any, of degenerating inner tissue is to be found outside the phellem.

Periderm similar to that of *C. officinalis.*

Exceptions: (1) Some variants approach *C. officinalis* in fiber characters but can usually be distinguished by other characters (lack of stone cells, loss of cortex). A few cases of hybrids with *C. officinalis* may have been included in the study of *C. pubescens.*

(2) Abnormal fibers such as those described for *C. officinalis* sometimes occur (figure 10).

Cinchona pitayensis (figures 3, 11, 12).

Tissues more compact and uniform than in *C. officinalis.* Sections frequently richer brown in color than those of *C. officinalis* and *C. pubescens.*

Phloem regular, with cells in radial rows. *Fibers* in cross section hyaline, polygonal to square, single or 2 to 4 in radial rows, small and uniform in size (largest diameters ranging from 45 to 70 (85) microns); lumina minute; pits similar to those of *C. officinalis.* In milled bark the fibers are mostly single and unbroken. In longitudinal section, length of fibers several times the diameter; diameter uniform throughout length except at pointed ends; long axis strictly vertical; pits appearing like oblique slits, in broken rows. Stone cells have not been observed in the phloem.

Laticiferous ducts occur in young bark but disappear at an early age.

Cortex regular, persistent but often crushed; cells brickshaped to cylindrical with long axes tangential. *Stone cells* usually absent but, when present, similar to those of *C. officinalis.*

Periderm as in *C. officinalis.*

Exception: (1) Stone cells in a few samples so numerous as to suggest *C. officinalis.*

(2) Abnormal fibers similar to those described for *C. officinalis* sometimes occur (figures 11, 12).

Remijia pedunculata (figures 4, 14).

Thin-walled tissues have a characteristic reddish brown color.

Phloem showing a distinct inner band of tissue without matured fibers, regular except that frequently the rays are crooked. *Fibers* yellowish,

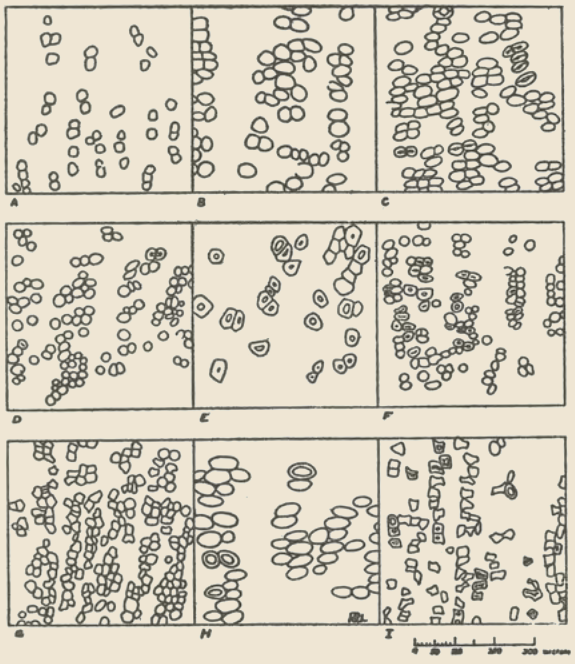

Figure 5.

LADENBERGIA HOOKERIANA ("quina morada") and some false barks. A series of drawings of fibers from cross sections to show comparative size and arrangement of fibers in the various species. All drawings made at the same magnification, using "standard field 2" (page 405). Comparisons should be made with figure 3, 4, and 19.

A — **LADENBERGIA HOOKERIANA** ("quina morada). Sample 2144.
B — **LADENBERGIA MACROCARPA** (sample 2023 type). For drawin of sample 204 type, see figure 19. Sample 3373.
C — **LADENBERGIA MAGNIFOLIA.** Sample 2967.
D — **REMIJIA MACROPHYLLA.** Sample 2615.
E — **MACROCNEMUM** sp. Sample 3912.
F — **JOOSIA UMBELLIFERA.** Sample 3453.
G — **CALYCOPHYLLUM** sp. Sample 3333.
H — **ELAEAGIA UTILIS.** Sample 1708.
I — **ELAEAGIA KARSTENII.** Sample 3506.

Figure 6.

CINCHONA OFFICINALIS. Drawings to ilustrate various cell types.
A — Phellem cells in section. Sample 3874.
B — Stone cells of cortex from longitudinal section. Sample 3031.
C — Stone cells of cortex from longitudinal section. Sample 3874.
D — Stone cells of cortex from cross section. Sample 3874.
E — Fibers from cross section. Laminations of cell wall are represented by dotted lines following the contour of the cell. Sample 2650.
F — Fibers from cross section. Sample 3248.
G — Part of fiber from longitudinal section. Sample 3874.
H — End of fiber from longitudinal section. Sample 3874.
I — Fiber from cross section. The radial direction of the phloem is represented by across-the-page direction of the drawing. Sample 3874.

somewhat flattened tangentially especially in outer phloem, small or medium in diameter (largest diameters ranging from 20 to 30 microns, often 40 to 60 or 75 microns near cortex), cemented together in radial rows up to 3 or 4 cells thick, angular, adjoining parencyma and therefore acute; lumina medium, often filled with reddish brown content; pits tangential, not branched. Fibers in longitudinal section long, slender, uniform, vertical; in milled bark occur as broken bundles. Stone cells of cortex type may occur in phloem parenchyma.

The general impression gained by viewing a cross section of phloem under low magnification is that of long yellow and red radial stripes because of the yellowish rows of fibers between reddish rows of ray and other thin-walled cells.

Laticiferous ducts more numerous than in *Cinchona* species and more persistent; possibly they persist as long as the cortex itself.

Cortex regular, persistent; the cells cylindrical with long axes tangential. *Stone cells* of medium abundance, single, with luminal small (to large) and walls (thin to) thick, pits sometimes branched; otherwise similar to those of *C. officinalis*.

Phellem brittle, in some forms too loosely attached to be sectioned. Phellem cells hexagonal in surface view; cell walls hyaline, thick on the inner side, thinner around the edge, and membranous on the outer side, an entire cell resembling somewhat a covered Syracuse watch glass; the inner walls marked with many fine, simple or branched pits; lumen a saucer-shaped depression containing a brownish red substance; cells easily separated from each other, especially laterally, a character which accounts for the brittleness of the phellem layer.

Ladenbergia hookeriana (figures 5, 15).

Bark of this species has been harvested commercially in Colombia under the name of "quina morada". It is indistinguishable microscopically from that of *Cinchona henleana,* a false bark.

Inner phloem not always mature, having only a few fibers. However, in relatively thick bark which contains a wide band of secondary phloem, the fibers occupy more than half the cross-sectional area of the phloem. *Fibers* in cross section circular to squarish but without sharp angles. whitish to yellowish, in radial rows but not cemented together (fundamentally single), small (largest diameters ranging from 30 to 40 microns); pits fine, not very prominent, running in all directions from the center; lumina small to minute. In longitudinal view fibers slender, straight, uniform throughout length, tapering at the ends.

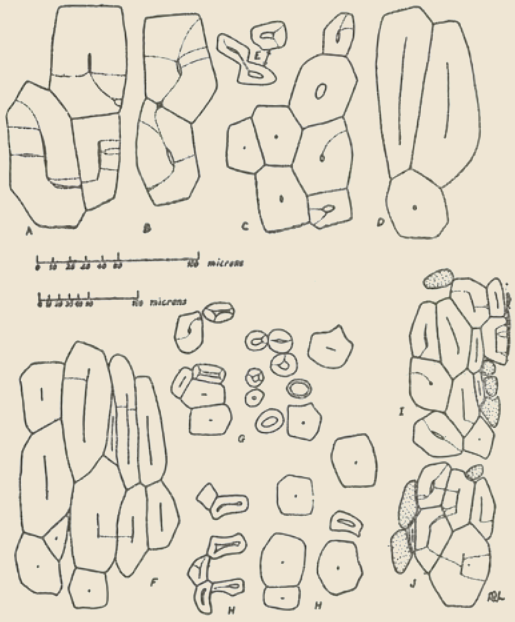

Figure 7.

CINCHONA OFFICINALIS. Drawings of fibers from cross sections, to show some common variations in size, shape, and grouping. Note that two different magnifications are used: micron scale for A, B, C, D, and E is shown above; for F, G, H, I, and J below.

A — Sample 3031.
B — Sample 3032.
C — Sample 3247.
D — Sample 3248.
E — Abnormal fibers (page 12). Sample 3516.
F — Sample 2881 ("Huila officinalis").
G — ormal and abnormal fibers. Sample 2618.
H — Normal and abnormal fibers. Sample 3369.
I — Fibers, and adjacent thin-walled cells. Sample 3777.
J — Fibers, and adjacent thin-walled cells. Sample 3777.

Figure 8.

CINCHONA OFFICINALIS. Drawings of fibers in longitudinal view, from macerations of bark.

A, B, C, D. Sample 2510.
E, F, G, H, I, J, K. Sample 2299.
L, M, N, O, P, Q, R. Sample 534 (C. officinalis "roja").
S, T, U. Abnormal fibers (page 411). Sample 2091.

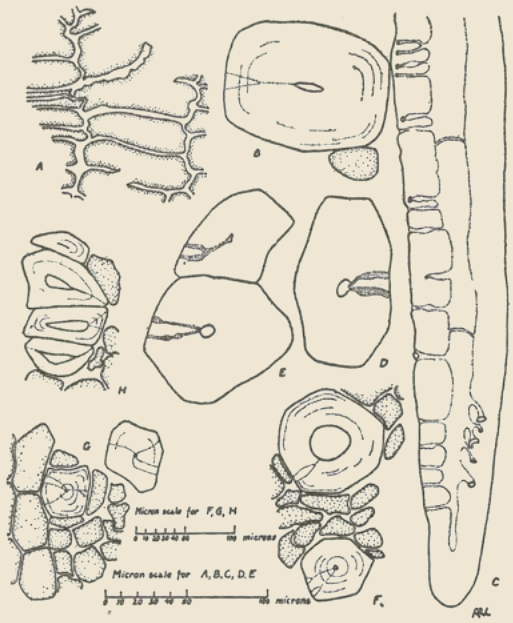

Figure 9.

CINCHONA PUBESCENS. Drawings of various cell types. Note that two different magnifications are used.

A — Phellem cells in section. Sample 3619.
B — Fiber from cross section. Sample 3890.
C — End of fiber from longitudinal section. Sample 2503.
D — Fiber from cross section. Sample 3768.
E — Fiber from cross section. Sample 3768.
F — Fibers and adjacent thin-walled cells. Sample 3890.
G — Fibers, adjacent thin-walled cells, and adjacent ray cells. Sample 2850.
H — Fibers and adjacent thin-walled cells. Sample 3259.

Laticiferous ducts plentiful in outer phloem, more persistent than in *Cinchona* species.

Cortex *stone cells* single, few to abundant, few in outer phloem, rare in phelloderm, pits large, walls thick to thin (lumina small to large).

Phellem cells thin-walled, adherent to each other, similar to those of *Cinchona officinalis.*

* * *

DESCRIPTIONS OF SOME FALSE BARKS

An undetermined number of species of false barks have been submitted as some kind of "quina". Many of them have been encountered in samples taken from commercial lots of *Cinchona* bark. Some are species of *Cinchona* and *Remijia;* most others are species of *Ladenbergia* or other Cinchoneae, or other Rubiaceae; and a very few are species in other families of plants. Some are described briefly with only those details useful in differentiating them from barks containing cinchona alkaloids. Since, excepting for the five species described above, the bark from any tree in Colombia is potentially a false bark, it is obviously impractical to study them all beyond this point.

Unknown false barks have not been identified other than a statement of the species they are nearest.

Figure 10.

CINCHONA PUBESCENS. Drawings of fibers in longitudinal view, from macerations of bark, to show some common variations.

A — Sample 2094.
B — One abnormal fiber (pages 411 and 412) shown. Sample 2111.

Cinchona barbacoensis (figures 3, 13).

Fibers relatively short and stout, highly variable in size, diameters ranging from 100 to 230 (260) microns, scattered, cylindric to somewhat compressed tangentially. *Stone cells* abundant in cortex, similar to those of *C. officinalis.* The bark of this species has characters suggesting a close relationship with *C. officinalis, C. pubescens,* and *C. pitayensis.*

Cinchona henleana (figures 4, 15).

Fosberg (2) states that this species should probably be transferred to the genus *Ladenbergia,* and the microscopic characters of the bark confirm this opinion. The bark seems indistinguishable microscopically from that of *Ladenbergia hookeriana* (page 417).

Remijia purdieana.

The bark of this species is said (6) to contain small amounts of cinchonine. It differs from that of *R. pedunculata* (page 417) in absence or extreme scarcity of *fibers;* the cells corresponding to fibers have cell walls only slightly thicker than those of parenchyma and ray cells, distinctly pale orange in color. *Stone cells* absent or rare. Thick *phellem* cells present but sometimes difficult to find except in inner phellem.

Remijia bracteata.

This species in described in Fosberg's *Colombian Cinchona Manual* (2), page 415, as *Remijia* sp. but called *R. bracteata* in a letter to me dated May 18, 1945. Bark differs from that of *R. pedunculata* in the following respects: *Fibers* scattered, yellowish, not flattened tangentially, with lumina small to none, mostly single and angular, the angles acute. This species also has the pale orange cell type described for *R. purdieana. Stone cells* absent. In microscopic characters of bark this species may be said to be intermediate between *R. pedunculata* and *R. purdieana.*

Remijia macrophylla (figure 5).

Phellem cells thin-walled; tissues hyaline, not reddish brown. *Fibers* similar to those of *Ladenbergia magnifolia.* Cortex *stone cells* single with lumina large. The microscopic characters of this bark do not suggest a very close relationship of *R. macrophylla* with the *R. pedunculata* group. Botanically *R. macrophylla* is said to belong to a different section of the genus.

Ladenbergia magnifolia (figures 5, 16).

Fibers in phloem cemented together in radial rows 2 to 4 cells wide, hyaline, often appearing angular outwardly because walls seem to extend into intercellular spaces between adjoining parenchyma cells but at higher magnifications elliptical or with small but tangentially flattened lumina so

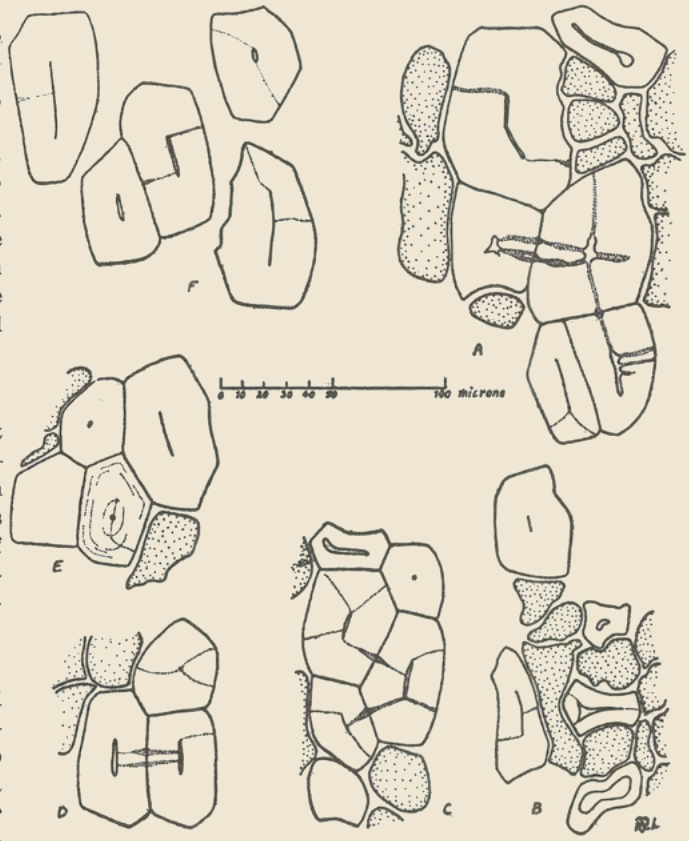

Figure 11.

CINCHONA PITAYENSIS. Drawings of fibers and adjacent thin-walled cells from cross sections to show some common variations in size and shape of fibers.

A — Sample 323.
B — Normal and abnormal fibers. Sample 329.
C — Sample 310.
D — Sample 310.
E — Sample 1253.
F — Sample 323.

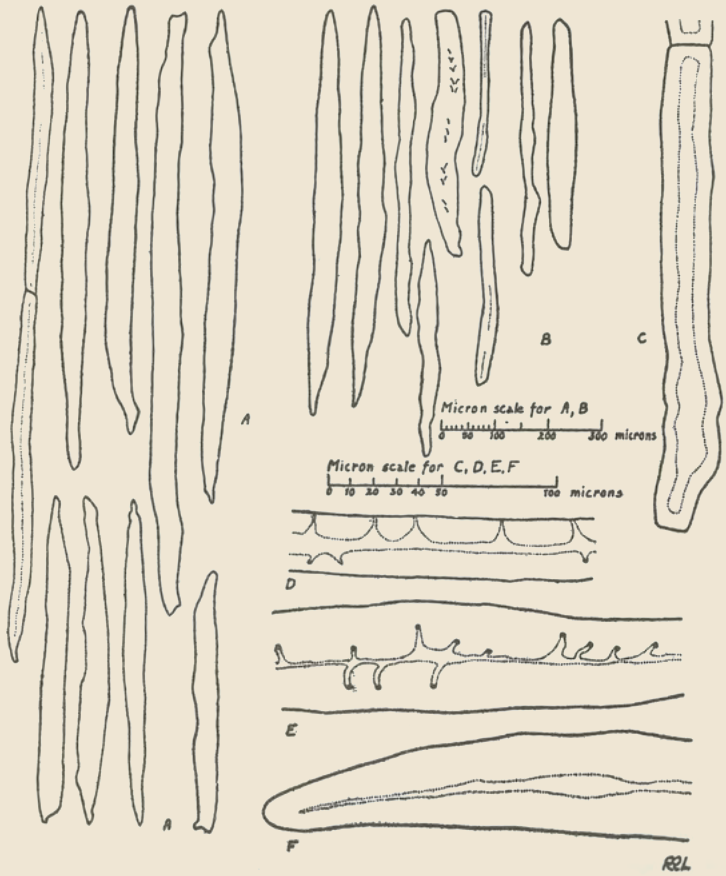

Figure 12.

CINCHONA PITAYENSIS. Drawings of fibers in longitudinal view, from macerations and longitudinal sections, to show common variations in length and shape.

A — Fibers from maceration. Sample 1949.
B — Fibers from maceration. One abnormally small fiber shown, and one with prominent pits which appear slit-like in low magnification. Sample 1684.
C — Abnormal fiber from longitudinal section. Sample 1309.
D — Part of fiber from longitudinal section. Sample 3747.
E — Part of fiber from longitudinal section. Sample 329.
F — End of fiber from longitudinal section. Sample 1255.

Figure 13.

CINCHONA BARBACOENSIS. Drawings of various cell types. In comparing A through G with drawings of comparable cells of **C. officinalis, C. pubescens,** and **C. pitayensis,** note should be made of differences in magnification.

A — Phellem cells. Sample 1256.

B — Stone cells of cortex from cross section. Sample 3791.

C — Stone cell of cortex from longitudinal section (this type rare). Sample 1256.

D — Fibers from cross section. Sample 3790.

E — Fibers from cross section of inner phloem. Sample 1256.

F — Fibers from cross section of outer (primary?) phloem. Sample 1256.

G — End of fiber from longitudinal section. Sample 3790.

H — Fibers from longitudinal section. Sample 3790.

arranged as to make the fibers appear elliptical; pits run tangentially to meet pits of adjacent cells. Some fibers in the inner phloem resemble those of *Cinchona* species in cross-sectional form, but fibers of outer and middle phloem are characteristic. Stone cells of cortex abundant, single, with large lumina and large slit-like pits in rows.

Ladenbergia undata (?) (figure 19).

The first bark studied under this name, sample 123, may be assigned to *Ladenbergia macrocarpa*. *L. macrocarpa,* however, has been used for species having two different types of bark, and the use of that name at present also presents difficulties. The specific name of the bark described below has not been determined as yet.

Fibers apparently absent. Large, hard blocks of stone cells predominate in phloem and cortex, accounting for the macroscopically prominent gritty character of the bark. *Stone cells of phloem* with small or no lumina, brick-shaped and cemented together in square columns; in cross section appear square, in solid square groups surrounded by narrow checks of parenchyma and ray cells. *Stone cells of cortex* similar to those of phloem except that in cross section they show their long axes and are found both singly and in ellipsoid groups.

Ladenbergia macrocarpa (figures 5, 16, 19).

Two very different kinds of bark have been submitted under the name *Ladenbergia macrocarpa,* both types with herbarium material to support the identification; probably one will be assigned to another species. They are designated in this paper by the numbers of the samples under which they were first studied.

Microscopically the bark of the sample 2023 type (figures 5, 16) is very similar to that of *L. magnifolia*. Perhaps the same species is frequently confused with *Cinchona pubescens* in the field when sterile.

The bark of the sample 204 type (figure 19) is similar to that of *Ladenbergia undata* (?) described above.

Incidentally, the microscopic characters of the *Ladenbergia* species suggest three different groups within the genus typified by *L. hookeriana, L. magnifolia,* and *L. macrocarpa* sample 204 type.

Elaeagia karstenii (figure 5, 17).

Bifore identification this species was referred to in reports as "Rubiaceae near Elaeagia".

Fibers acutely angular and interconnected at the angles, in networks rather than in blocks,

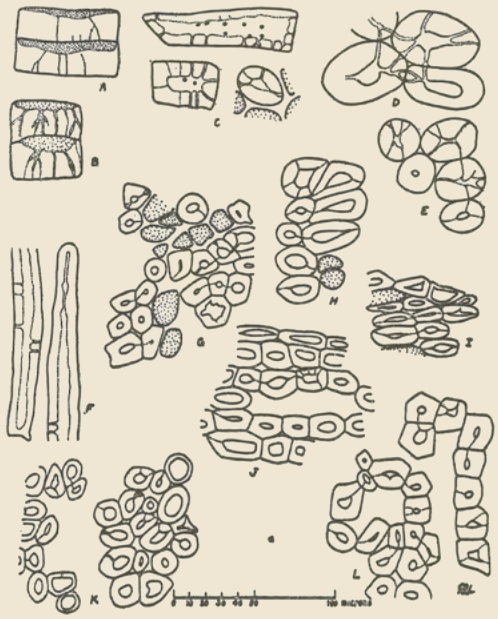

Figure 14.

REMIJIA PEDUNCULATA. Drawings illustrating the various cell types.

A — Phellem cells, from section. Sample 3330.

B — Phellem cells, from section. Sample 3185.

C — Stone cells of cortex, from sections. Upper cell from cross section; lower left from longitudinal section of phelloderm, and lower right from longitudinal section of cortex. Sample 3190.

D — Stone cells of cortex, from longitudinal section. Sample 3193.

E — Stone cells of cortex, from longitudinal section. Sample 3701.

F — Ends of fibers from longitudinal section. Sample 3193.

G — Fibers from cross section. Sample 3186.

H — Fibers from cross section. Sample 3186.

I — Fibers from cross section. This is the usual form of fibers as they occur in outer phloem. Sample 3192.

J — Fibers from cross section. Sample 3339.

K — Fibers from cross section. Sample 3337.

L — Fibers from cross section. Sample 3701.

hyaline, with medium to large lumina. *Stone cells* of cortex numerous, single; pits unusually large, circular in end or surface view, and irregularly scattered over cells. Stone cells extend far into phloem but are most numerous in the phelloderm; a layer several cells thick, apparently inner phelloderm, is made up entirely of stone cells.

Elaeagia utilis (figures 5, 17).

Bark differs from that of *E. karstenii* in size, shape, and arrangement of fibers — in *E. utilis* the fibers as seen in cross section occur in small irregular blocks rather than in networks.

Cosmibuena spp. (figures 18, 19).

Microscopic characters of the barks submitted suggest the existence of two species. Some samples have fibers fitting the descriptions of those of *Cinchona;* but all samples examined have numerous cells filled with fine needle-like crystals, and none has brown tissues.

Calycophyllum sp. (?) (figures 5, 17).

Fibers similar to those of *Ladenbergia magnifolia* in orientation of pits, but not elliptical; some stone cells of cortex with unusually thick walls and small lumina.

Guettarda sp. figures 18, 19).

Wet bark, either green or soaked, has a sweet odor. Phellem cells of the *Remijia* type except without red content. Stone cells in vertical cylinders the predominant thick-walled elements of phloem, but a few fibers occur at juncture of cortex and phloem.

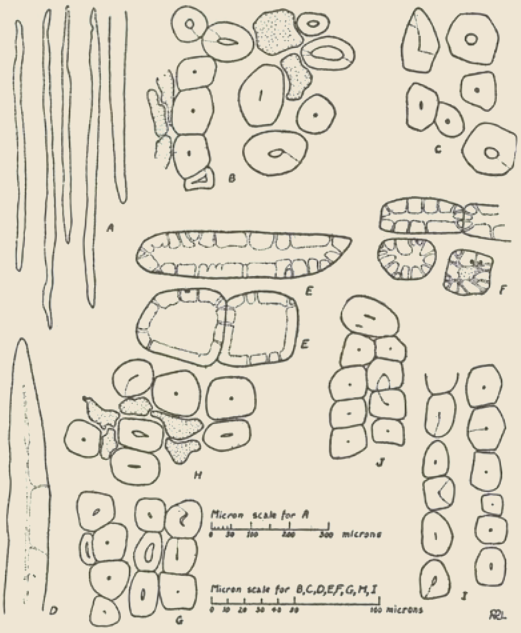

Figure 15.

LADENBERGIA HOOKERIANA ("quina morada") and **CINCHONA HENLEANA.** Fibers and stone cells.

LADENBERBIA HOOKERIANA.

A — Fibers from maceration. Sample 2144.
B — Fibers from cross section. Sample 1607.
C — Fibers from cross section. Sample 2144.

CINCHONA HENLEANA.

D — Fibers from longitudinal section. Sample 3519.
E — Stone cells of cortex from cross section. Sample 2662.
F — Stone cells of cortex from longitudinal section Sample 2658.
G — Fibers from cross section. Sample 3376.
H — Fibers from cross section. Sample 2766.
I — Fibers from cross section. Sample 3374.
J — Fibers from cross section. Sample 2659.

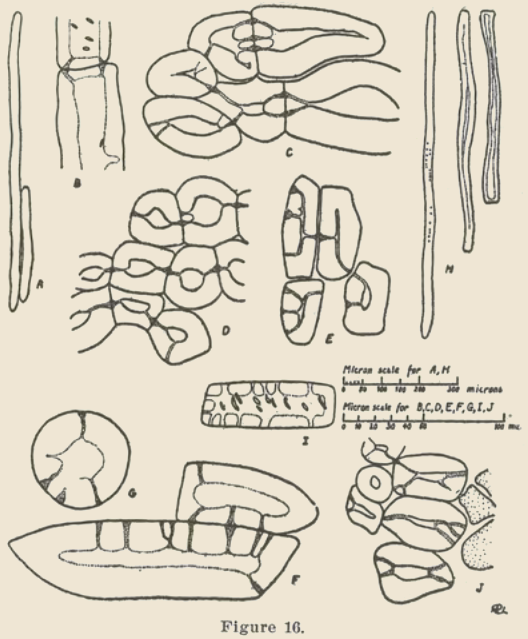

Figure 16.

LADENBERGIA MAGNIFOLIA and **L. MACROCARPA** (sample 2023 type). Drawings of fibers and stone cells.

LADENBERGIA MAGNIFOLIA.

A — Fibers from longitudinal section. Sample 2952.
B — Ends of fibers from longitudinal section. Sample 2952.
C — Fibers from cross section, outer phloem. Sample 2025.
D — Fibers from cross section, middle phloem. Sample 2025.
E — Fibers from cross section, inner phloem. The presence of these fibers suggesting **CINCHONA** spp. should not be confusing; the elliptical fibers of outer phloem mark the bark as false. Sample 2967.
F — Stone cells of cortex, from cross section. Sample 148.
G — Stone cell of cortex, from longitudinal section. Sample 209.

LADENBERGIA MACROCARPA (sample 2023 type).

H — Fibers from longitudinal section. Sample 2023.
I — Stone cell from cross section of cortex, showing pits in surface view; the pits of **L. MAGNIFOLIA** stone cells are similar; the size differences shown here are accidental. Sample 2612.
J — Fibers from cross section, outer phloem. Sample 2886.

Macrocnemum sp. (figures 5, 18).

Stone cells absent from cortex, present singly and in columns 2 to 4 cells thick in phloem; phellem cells thin-walled (or a few thick-walled?). One group of botanist-submitted samples of "Remijia" seem to belong to this genus.

Joosia umbellifera (figures 5, 17).

Bark similar to that of *Ladenbergia magnifolia.* Samples 2474 and 3352.

Non-authentic samples, submitted as a *Remijia.* Phellem cells similar to those of *Remijia pedunculata.* Large cubical crystals found in scattered cells throughout the phloem.

Other false barks.

Not all of the identified false barks have been described above. Many of the unidentified samples of false barks have characters of some of the species listed above, but there remain a few which could not be assigned to any of these groups. So

far they have all been found distinguishable from *Cinchona* and *Remijia* species by some definite and describable microscopic character.

* * *

DETAILED STUDY OF SOME VARIANTS OF *CINCHONA OFFICINALIS*

Samples of *Cinchona officinalis* from certain areas of Colombia have shown constant differences in the proportions of the four cinchona alkaloids contained. Some of these chemical-geographical variants have been spoken of by the chief botanist as morphological varieties (2), although they have not yet been definitely designated and named. In some such cases the barks differ in macroscopic aspect sufficiently to suggest the localities from which they came. Preliminary general observations gave the impression that some of these variants might be distinguishable by the microscopic characters of their stone cells and fibers. It seemed that stone cells might vary chiefly in number, perhaps size, perhaps wall thickness; and that fibers might vary in number, size, shape in cross section, grouping, and distribution. Some examples of variations in size, shape, and arrangement of fibers are shown in figure 5, A, B, C, D, and E. In order to ascertain whether this impression was true or

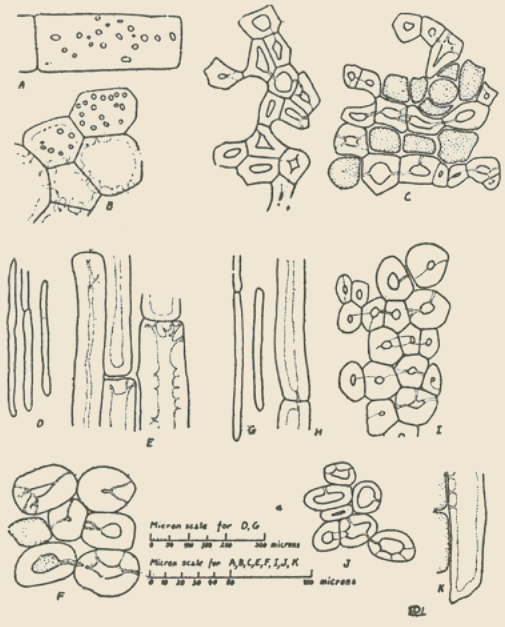

Figure 17.
Fibers and stone cells of some false barks.
ELAEAGIA KARSTENII.
A — Stone cell of cortex, from cross section, showing surface view of pits. Sample 2026.
B — Stone cells from longitudinal section. Sample 3506.
C — Fibers from cross section. Sample 2026.
JOOSIA UMBELLIFERA.
D — Fibers from longitudinal section. Sample 3453.
E — Ends of fibers from longitudinal section. Sample 3453.
F — Fibers from cross section. Sample 3458.
CALYCOPHYLLUM sp.
G — Fibers from longitudinal section. Sample 3333.
H — Ends of fibers from longitudinal section. Sample 3333.
I — Fibers from cross section. Sample 3333.
ELAEAGIA UTILIS.
J — Fibers from cross section. Sample 3509.
K — End of a fiber from longitudinal section. Sample 3509.

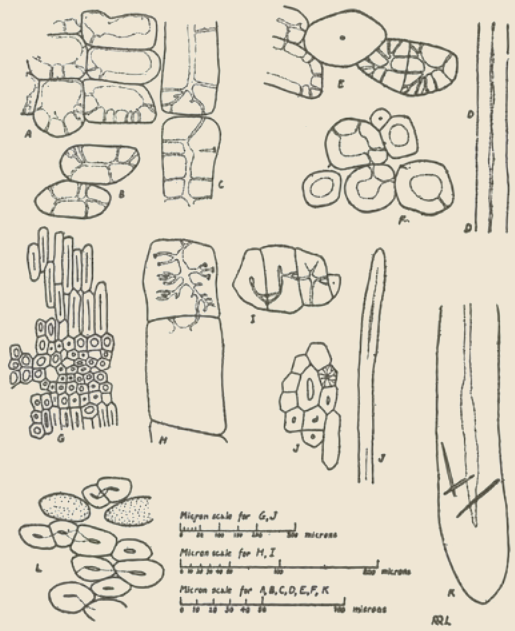

Figure 18.
Fibers and stone cells of some false barks.
GUETTARDA sp.
A — Phellem cells from section. Sample 1713.
B — Stone cells of phloem from cross section. Sample 1713.
C — Stone cells of phloem from longitudinal section. Sample 1713.
D — Fibers from longitudinal section. Sample 2607.
E — Fibers and stone cells of phloem, from cross section. Sample 2607.
F — Stone cells of cortex, from longitudinal section. Sample 2607.
G — Stone cells of phloem, from longitudinal section. Compare with figure 19, A. Sample 1713.
MACROCNEMUM sp.
H — Stone cells of phloem, from longitudinal section. Sample 2894.
I — Stone cells of phloem, from cross section. Sample 2894.
COSMIBUENA GRANDIFLORA.
J — Fiber and stone cells of phloem, from longitudinal section. Sample 3508.
K — Part of fiber, and some crystals, from longitudinal section of phloem. Sample 3508.
REMIJIA MACROPHYLLA.
L — Fibers from cross section. Sample 2617.

false, and to replace vague descriptive words such as "more numerous", "scattered", "somewhat radially arranged", "variable diameter", "wall thicker" or "wall thinner" with objective and concrete descriptions, I decided to make a series of counts, drawings, and measurements.

SELECTION OF SAMPLES:

The specimens selected represent those variants most likely, as far as we could determine, to be good varieties; selection was based, however, on chemical and geographic data rather than on the more customary and probably more fundamental morphological data. My only justifications for selecting specimens in this manner were absence of exact taxonomic determinations and a frequently expressed, although not wholly confirmed, opinion that correlations exist between morphology, alkaloidal content, and geographic origin of varieties of *C. officinalis*.

Selection procedure was as follows: Lists were made of samples of *C. officinalis* proceeding from a large number or regions, each sample number

Barks of two variants were macerated: 5 samples of "young roja", 5 samples of "mature roja", and 5 samples of "Huila officinalis". These samples were selected from those studied in cross section except for two additional samples of "young roja".

RESULTS

Results are given chiefly in a series of tables, each of which is accompanied by a brief discussion and conclusions.

Discussion of Table 1:

Because of the nature of the cortex —its decreasing thickness with increasing pressure upon it of growing inner tissues and in some cases loss by sloughing— it would be difficult to place the proper emphasis on number of stone cells therein. Moreover, cortex is frequently not thick enough to extend all the way across a "standard field 1".

Variant F and 3 specimens of variant C, show no, or very rare, stone cells. Variant E at an early age loses its cortex and has stone cells in the phelloderm only; this part of variant E keys out as "mature E", and has the characteristic "cork" described on page 15. The remaining samples —A, B, C(part), D, and E(part)— were studied to detect further differences in abundance of stone cells.

Of those samples having few to numerous stone cells, 7/12 of A and 9/13 of D are distinguishable from B, C(part), and E immature. There remain indistinguishable from each other on the basis of number of cortex stone cells all samples of B and parts of A, C, D, and E.

Table 1. Grouping of samples according to number of stone cells in cortex.

Variant, and number of samples [b/]		Number of cortex stone cells per standard field 1 [a/]							
		0	1–19	20–39	40–59	60–79	80–99	100–119	150–159
A	(12)		2	3	3		2	2	
B	(9)		8	1					
C	(14)	3	6	4				1	
D	(13)		1	3	5	1	2		1
E mature [c/]	(10)	10							
E immature	(5)		2	3					
F	(7)	7							
Totals	(70)	20	19	14	8	1	4	3	1

a/ Portion of a slide projected to a 3-inch square at a linear magnification of 100 times.

b/ A low number of samples means that in some cases the stone cells were not easily distinguished in sections or for other reasons reliable counts could not be made. A high number means that variations occurred within some samples, and more than one count was made.

c/ Cortex absent; stone cells in phelloderm only, and distinguishable from stone cells of cortex by their form. These samples perhaps should not be considered as truly having no stone cells in cortex.

Discussion of Table 2:

In some sections, because of thinness of the bark, the most mature characters were exhibited in only a narrow band and covered only a part of the standard area; in such cases the count was weighted roughly. As a result, several specimens of variant A, most of which were submitted as fairly thin bark, were shifted from one ten to the next, but all of those shifted were and remained in the groups from 40 to 99. It is a matter of speculation whether or not an extra millimeter's growth of the secondary phloem would have changed the picture as to the "mature characters" of fibers of these chin barks.

About half of C and half of D are separable from the other variants on the basis of number of fibers. The other specimens of both variants coincide with the bulk of specimens of variants A, B, and E(part). There remain A, B, C(part), D (part), and E (part), indistinguishable from each on this basis.

Discussion of Table 3:

To obtain a value for the "cross-sectional area" of a fiber the longest diameter was multiplied by the shortest diameter. Hence what is here called "cross-sectional area" of a fiber is more nearly the area of a circumscribing rectangle. As the cell outline approaches a circle and the circumscribing rectangle approaches a square the areas obtained stand in proportion to the true areas as 4 to *pi*. The largest 5 cells of the standard field were calculated in this manner; then, in order to avoid giving undue weight to freak fibers, the third largest fiber was used as the criterion for classifying the sample.

By value of largest fibers, 1/7 of D and 3/5 of E (mature 3/4, immature 3/7) are distinguishable from A, B, and C; 2/7 of D and 14/15 of E (mature 7/8, immature all) are distinguishable from the bulk of A, B, and C. However, there remain indistinguishable from each other on this basis A, B, part of C, part of D, and part of E.

Table 2. Grouping of samples according to abundance of fibers in phloem.

Variant, and number of samples [b]		Number of fibers per standard field 1 [a]						
		10–39	40–59	60–79	80–99	100–119	120–139	140–
A	(19)	2	4	8	5			
B	(8)	1	2	3	2			
C	(19)	1(k) [c]	1	4	5	3	4(1–k)	1(k)
D	(21)		1	7	7	3	3	
E mature (k)	(8)		1	6	1			
E immature	(6)		1	3	2			
F	(7)	1	5	1				
Totals	(88)	5	15	32	22	6	7	1

a/ Portion of a slide projected to a 3-inch square at a linear magnification of 100 times.
b/ A low number of samples means that in some cases no good areas were found which were large enuogh to diagram; a high number means that variations occurred within some samples, and more than one count was made in such cases.
c/ (k) signifies specimens keyed out on basis of absence of stone cells in cortex.

Table 3. Grouping of samples according to "cross-sectional area" of largest fibers.

Variant, and number of samples [b]		"Cross-sectional area" in square microns of largest fibers in standard field 2 [a]						
		1000–3000	3000–4000	4000–5000	5000–6000	6000–7000	7000–8000	8000–9000
A	(19)	13	4	2				
B	(8)	3	5					
C	(19)	7(2–k) [c]	8(1–k)	4				
D	(21)	5	10	3	1	2		
E mature (k)	(8)		1	1	2		1	3
E immature	(7)			4	1	1	1	
F (k)	(7)	1	2	2	1	1		
Totals	(89)	29	30	16	5	4	2	3

a/ Portion of slide projected to a 3-inch square at a linear magnification of 100 times.
b/ A low number of samples means that in some cases no good areas were found in the slide large enough to diagram; a high number means that variations occurred within some samples, and more than one set of measurements were made in such cases.
c/ (k) signifies specimens keyed out on basis of absence of stone cells in cortex.

Table 4. Grouping of samples according to the sum of "cross-sectional areas" of fibers in a standard field.

Variant and number of samples [b]		Sum of "cross-sectional areas" in square microns of all fibers in standard field Nº 1 [a]			
		less than 100,000	100,000–200,000	200,000–300,000	300,000–400,000
A	(19)	5	10	4	
B	(8)	1	6	1	
C	(19)	1(k) [c]	7(1–k)	9(1–k)	2
D	(21)		4	14	3
E mature (k)	(8)		1	3	4
E immature	(7)		2	4	1
F (k)	(7)	2	5		
Totals	(89)	9	35	35	10

a/ Portion of a slide projected to a 3-inch square at a linear magnification of 100 times.
b/ A low number of samples means that in some cases no good areas were found in the slide large enough to diagram; a high number means that variations occurred within some samples, and more than one set of measurements were made in such cases.
c/ (k) signifies specimens keyed out on basis of absence of stone cells in cortex.

Discussion of Table 4:

Using the method described on page 30, the "cross-sectional area" of the smallest cell recorded was obtained. This value plus that for the largest cell recorded, multiplied by half the number of fibers in "standard field 1", provided the values called "sums" used in classifying samples. These sums are excessive by the same proportion as the values used in Table 3, that is, approximately as 4 to *pi*.

One-seventh of C, 1/7 of D, and 1/7 of E immature are distinguishable from all of A and B on this basis; 5/8 of C, 17/21 of D, and 5/7 of E immature are distinguishable from 3/4 of A and 7/8 of B. There remain indistinguishable from each other, on the basis of sums of "cross-sectional areas" of fibers in a given field, A, B, C(part), D(part), and E(part).

* * *

Study of shape, grouping, and distribution of fibers:

While there seemed to be a tendency for some variants to have more or fewer fibers in groups, more or fewer fibers radially oblong in cross section, or more or fewer in radial groups or rows, in no variant except possibly F was the tendency strong enough to be called a character. In variant F the fibers are usually single, polygonal in cross section, and scattered in distribution. This variant is distinguishable from other variants of *C. officinalis* by the absence of stone cells in the cortex; however, I cannot distinguish it from *C. pubescens*.

Maceration study:

Diameters of fibers varied as much within samples as between samples, as might be expected from comparison with diameters taken from cross sections. Lengths (15 fibers from each sample) are summarized in Table 5.

Table 5. Lengths in microns (average and range) of fibers in macerated tissues of 15 samples of *Cinchona officinalis*.

"Huila officinalis"		"Mature roja"		"Young roja"	
756	(423–1159)	916	(682–1500)	741	(436–1077)
654	(328–1078)	929	(545–1432)	933	(654–1295)
776	(505–1227)	792	(409–1132)	722	(545–1091)
899	(409–1319)	873	(504–1268)	841	(518–1227)
891	(464–1091)	758	(409–1227)	765	(396–1050)

The samples studied show no tendency to fall into groups by lengths of fibers. Results of this preliminary study of macerated tissues do not seem to warrant extending the method to a study of other variants of *C. officinalis*.

DISCUSSION

Abundance, size, and wall thickness of stone cells vary almost as much within variant, even within samples, as between variants. Only one variant was found distinguishable from the others on the basis of characters of stone cells ("Antioquia" variant). Mature samples of another variant, "roja", are distinguishable by absence of cortex and presence of stone cells in the phelloderm.

Counts of fibers in the phloem, measurements of greatest diameters of the largest fibers, and measurements of "cross-sectional areas" of all fibers in a given field, all failed to give satisfactory means of differentiating the variants of *C. officinalis* studied.

It is possible that when selection of samples can be made taxonomically, a renewal of this type of study may lead to better results.

* * *

SUMMARY OF ACCOMPLISHMENTS

In connection with the *Cinchona* bark procurement program in Colombia, South America, histological studies were made of the barks of *Cinchona* and some related genera. Five species of the Rubiaceae: *Cinchona officinalis, C. pitayensis, C. pubescens, Remijia pedunculata,* and *Ladenbergia hookeriana,* have been found to contain one or more of the alkaloids: quinine, cinchonidine, cinchonine, and quinidine. All barks which have been found to contain not more than traces of any of these alkaloids are collectively designated "false barks". A total of 1002 samples —753 samples containing cinchona alkaloids and 249 false bark samples— were examined microscopically. About 160 were named from microscopic characters alone.

The normal forms of the five Colombian species of Cinchona and the three named *Remijia* species of the *R. pedunculata* group can now be determined from microscopic characters alone; and all false barks encountered can be differentiated from the foregoing by the same method. Descriptions, study outline, and keys for use in these determinations are provided.

Cinchona officinalis bark is characterized by (1) presence of cortex in older barks; (2) presence of stone cells in the cortex; (3) phellem cells thin-walled; (4) fibers in phloem, (a) greatest diameters from 60 to 90 microns (to 120 microns in variants from some localities, rarely more in the "roja" variety), (b) numerous, (c) radially oblong in cross section, (d) usually occurring in groups of 4 to 16 (but there are always single fibers also), (e) as seen in cross section arranged in radial rows, (f) with lumen minute, and (g) with ends taper-pointed.

Cinchona pubescens bark is characterized by (1) absence of cortex in older barks; (2) absence of stone cells in cortex, although rarely a few are present in tissues developed in place of lost cortex; (3) phellem cells thin-walled; (4) fibers in phloem, (a) greatest diameters from 70 to 150 (rarely to 180) microns, (b) relative to *C. officinalis,* few, (c) various in shape as seen in cross section, from radially oblong to circular to tangentially oblong or elliptical, (d) usually occurring singly (with sometimes a few groups of 2 to 4 fibers), (e) and as seen in cross section with little or no tendency

to arrangement in radial rows, (f) with lumen minute to large, and (g) with ends taper-pointed.

Cinchona pitayensis is characterized by (1) presence of cortex in older bark; (2) absence or scarcity of stone cells in cortex; (3) phellem cells thin-walled; (4) fibers in phloem, (a) greatest diameters from 55 to 70 (rarely 85) microns, (b) numerous, (c) square to radially oblong in cross section, (d) usually occurring singly and in groups of 2 to 6 fibers, (e) as seen in cross section arranged in radial rows, (f) with lumen minute, and (g) with ends taper-pointed.

Remijia pedunculata is characterized by (1) presence of cortex in older barks (with exceptions more common than in *Cinchona officinalis*); (2) presence of stone cells in cortex; (3) phellem cells with inner and lateral walls thickened, outer walls thin; (4) fibers in phloem, (a) greatest diameters 20 to 30 microns (often from 40 to 75 microns in outer phloem, nearest the cortex), (b) numerous, (c) tangentially oblong or elliptical in cross section, (d) occurring in large, irregular groups, (e) as seen in cross section making up long, continuous, yellowish radial rows extending through outer and median phloem but broken off at inner phloem, (f) with lumen small to large and prominent because of reddish-brown content, and (g) with ends truncate.

Other species of the *Remijia pedunculata* group differ from that species in abundance of fibers and stone cells.

Ladenbergia hookeriana ("quina morada") and *Cinchona henleana* are characterized by (1) presence of cortex in older barks; (2) presence of stone cells in cortex; (3) phellem cells thin-walled; (4) fibers in phloem, (a) greatest diameters 30 to 40 microns, (b) numeous, (c) as seen in cross section circular to squarish but not angular, (d) single, (e) but arranged in radial rows, (f) with lumen minute to small, and (g) with ends taper-pointed.

False barks of the *Ladenbergia undata* [a/] type are characterized by (1) presence or absence of cortex uncertain; (2) presence of large, hard blocks of stone cells in cortex and phloem; (3) phellem cells thin-walled; (4) fibers absent from phloem.

False barks of the *Ladenbergia magnifolia* type are characterized by (1) presence of cortex; (2) presence of numerous stone cells; (3) phellem cells thin-walled; (4) fibers in phloem, (a) numerous, (b) as seen in cross section tangentially elliptical especially in outer phloem, (c) occurring in large irregular groups, (d) as seen in cross section making up long, continuous, colorless radial rows extending through outer and median, sometimes also inner phloem, (e) with lumen small to large, and (f) with ends rounded to truncate.

Other false barks studied are all distinguishable from the species and groups described above in being unlike them in one or more features.

A preliminary survey of six of the most promising variants of *Cinchona officinalis* (selected on the basis of alkaloidal content and region of origin) showed that the characters of the variants, while falling into patterns perhaps more often than not, did not fall into those patterns consistently enough to identify the variants as having originated from certain localities.

Cinchona hybrids have received scant attention; only a few hybrids have been submitted by botanists, and those few apparently show no microscopic bark characters which can be used to mark them as hybrids, and indicate what might be their parentage.

a/ The samples studied under this name will probably be placed in **L. macrocarpa**; however, because two entirely different types of bark have been identified as **L. macrocarpa**, I cannot use that name here at present.

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ILLUSTRATIONS

Figures 1 and 2 are freehand drawings, not made to exact measurements. Figures 3 through 19 were drawn with the aid of a camera lucida at linear magnifications of 100, 165, 425, and 700 times; however, they were reduced considerably in reproduction.

In all drawings of fibers from cross sections, except where noted, the up-and-down direction of the page represents the radial direction of the phloem.

The photomicrographs were made by Mr. M. L. Foubert of the United States Department of Agriculture under the supervision of the author.

All drawings beginning with figure 3, and the photomicrographs, are identified as to the sample numbers of the bark from which taken. The samples cited are listed on page 424 with corresponding collector's numbers and other collection data.

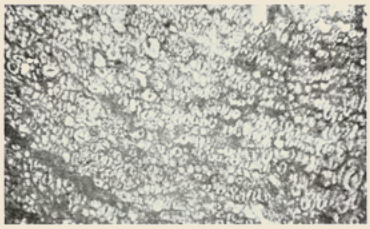
APPENDIX

List of Samples Cited

Sample Nº	Species	Collector	Location
123	Ladenbergia undata	Fosberg 19267	Río Neiva, Huila
148	Ladenbergia magnifolia	Fosberg 19461	Uribe, Meta
204	Ladenbergia macrocarpa	Fosberg 19796	Río Fortalecillas, Huila
209	Ladenbergia magnifolia	Fosberg 19881	Gigante, Huila
234	Cinchona officinalis "roja"	Fosberg 20053	San Agustín, Huila
310	Cinchona pitayensis	Fosberg 20300	Puracé, Cauca
323	Cinchona pitayensis	Fosberg 20432	Encano, Nariño
329	Cinchona pitayensis	Fosberg 20414	Encano, Putumayo
534	Cinchona officinalis "roja"	Valencia 7	Guadalupe, Huila
1253	Cinchona pitayensis	Fosberg 21112	Piedrancha, Río Guabo, Nariño
1255	Cinchona pitayensis	Fosberg 21154	Gualcalá Volcano, Nariño
1256	Cinchona barbacoensis	Fosberg 21221	Barbacoas, Nariño
1309	Cinchona pitayensis	Fosberg 21280	Volcán Doña Juana, Nariño
1607	Ladenbergia hookeriana	Fosberg 21405	Convención
1684	Cinchona pitayensis	Cerekof, CP 193	
1708	Elaeagia utilis	Little 7015	Limón, Tolima
1713	Guettarda	Kernan 32	Villa Caro, Norte de Santander
1914	Cinchona pubescens	Valencia 187	Río Valegrá, Norte de Santander
1919	Cinchona officinalis	Valencia 192	Río Valegrá, Norte de Santander
1949	Cinchona pitayensis	Deubner 167	Nariño
2023	Ladenbergia macrocarpa	Little 7283	Santa Ana, Huila
2024	Ladenbergia undata	Little 7268	Santa Ana, Huila
2025	Ladenbergia magnifolia	Little 7292	Santa Ana, Huila
2026	Elaeagia karstenii	Little 7300	Santa Ana, Huila
2091	Cinchona officinalis	McComb 9	Quetame, Cundinamarca
2094	Cinchona pubescens	Fosberg 21526	Carmen de Atrato, Chocó
2111	Cinchona pubescens	Core 298	Carmen de Atrato, Chocó
2144	Ladenbergia hookeriana	Kernan 55	El Tesero, Norte de Santander
2183	Cinchona pubescens var.	Fosberg 21634	Angostura, Antioquia
2299	Cinchona officinalis	McComb 20	Colombia, Huila
2384	Cinchona pubescens	Core 523 B	Dabeiba, Antioquia
2474	Unknown	Pizza 1303	Monte Oscuro
2493	Remijia pedunculata	Fosberg 21819	Jordán, Santander
2503	Cinchona pubescens var. rosulenta	Fosberg 21851	Moniquirá, Boyacá
2510	Cinchona officinalis	Little 7660	Río Granadillo, Huila
2607	Guettarda	Little 7713	Mosquera, Caquetá
2615	Remijia macrophylla	Little 7753	Las Guacamayas, Caquetá
2616	Remijia pedunculata	Little 7754	Las Guacamayas, Caquetá
2617	Remijia macrophylla	Little 7755	Las Guacamayas, Caquetá
2618	Cinchona officinalis	Little 7781	Aguas Claras, Caquetá
2650	Cinchona officinalis	Grant 9147	Yacopí, Cundinamarca
2658	Cinchona henleana	Fassett 25158	La Paz, Santander
2659	Cinchona henleana	Fassett 25163	La Paz, Santander
2662	Cinchona henleana	Fassett 25170	La Paz, Santander
2766	Cinchona henleana	Fassett 25282	Jordán, Santander
2850	Cinchona pubescens	Kernan 124	Sierra Nevada de Santa Marta
2886	Ladenbergia macrocarpa	Little 8000	El Pato, Meta
2894	Macrocnemum	Little 7942	Fortalecillas, Huila
2952	Ladenbergia magnifolia	Fassett 25317	Cimitarra
2965	Remijia pedunculata	Fassett 25341	San Juan, Santander
2967	Ladenbergia magnifolia	Fassett 25344	San Juan, Santander
3031	Cinchona officinalis	Grant 9494	Gachetá, Cundinamarca
3032	Cinchona officinalis	Grant 9513	Gachetá, Cundinamarca
3145	Cinchona pitayensis	Core 927	Río Blanco, Cauca
3185	Remijia pedunculata	Fosberg 22069	Villavicencio, Meta
3186	Remijia pedunculata	Fosberg 22068	Villavicencio, Meta
3190	Remijia pedunculata	Fosberg 22087	Villavicencio, Meta
3192	Remijia pedunculata	Fosberg 22073	Villavicencio, Meta
3193	Remijia pedunculata	Fosberg 22072	Villavicencio, Meta
3247	Cinchona officinalis	Grant 9645	Gutiérrez, Cundinamarca
3248	Cinchona officinalis	Grant 9648	Gutiérrez, Cundinamarca
3259	Cinchona pubescens	Grant 9725	Gutiérrez, Cundinamarca
3300	Cinchona officinalis	McComb 70	Salina, Boyacá
3305	Cinchona officinalis	McComb 75	Salina, Boyacá
3330	Remijia pedunculata	St. John 20637	Cordillera de la Paz, Santander
3333	Calycophyllum	St. John 20641	Cordillera de la Paz, Santander
3337	Remijia pedunculata	Fassett 25592	Galán, Santander

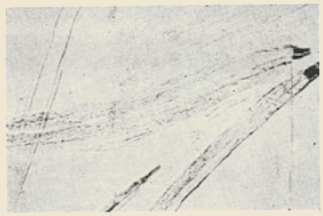
Sample Nº	Species	Collector	Location
3339	Remijia pedunculata	Fassett 25594	Galán, Santander
3352	Unknown	Nuñez	Río Sinú, Bolívar
3369	Cinchona officinalis	McComb 91 A	Quebrada Sismosá, Boyacá
3373	Ladenbergia macrocarpa	Little 8528	Alejandra, Huila
3374	Cinchona henleana	Little 8525	Alejandra, Huila
3376	Cinchona henleana	Little 8512	Alejandra, Huila
3377	Cinchona henleana	Little 8520	Alejandra, Huila
3379	Cinchona henleana	Little 8522	Alejandra, Huila
3398	Cosmibuena	Core 1075	Río Dinde, Cauca
3453	Joosia umbellifera	Grant 10118	La Esperanza, Meta
3458	Joosia umbellifera	Grant 10141	La Esperanza, Meta
3506	Elaeagia karstenii	Little 8652	Gigante, Huila
3508	Cosmibuena grandiflora	Little 8699	Gigante, Huila
3509	Elaeagia sp.	Little 8645	Gigante, Huila
3516	Cinchona officinalis	Fassett 25769	La Belleza
3519	Cinchona henleana	Fassett 26781	La Belleza
3559	Cinchona officinalis	McComb 98 A	Río Pauto, Boyacá
3593	Cosmibuena	Core 1423 a	Argelia, Cauca
3619	Cinchona officinalis	McComb 105	Australia, Boyacá
3629	Cinchona officinalis "roja"	Core 1462	Moscopan
3701	Remijia pedunculata	Grant 10403	Medina, Cundinamarca
3747	Cinchona pitayensis	Ewan 16339	El Encano, Putumayo
3768	Cinchona pubescens	Little 8754	La Colonia, Tolima
3770	Ladenbergia undata	Little 8835	Guayabero watershed, Meta
3777	Cinchona officinalis	Little 8855	Río Venado, Huila
3785	Cinchona pubescens	McComb 110	Ibagué, Tolima
3790	Cinchona barbacoensis	Core 1546 a	Córdoba, Valle
3791	Cinchona barbacoensis	Core 1555 a	Córdoba, Valle
3874	Cinchona officinalis	Little 8995	La Bodega, Huila
3890	Cinchona pubescens	St. John 20873	Santuario, Caldas
3910	Ladenbergia macrocarpa	Little 9008	La Bodega, Huila
3912	Macrocnemum	Little 9027	La Bodega, Huila

NOTA DE LA DIRECCION. — *Nos permitimos llamar la atención respecto de otros artículos que tratan de las Quinas de Nueva Granada y de Colombia, aparecidos en las páginas de esta Revista. Especialmente nos referimos a los magníficos estudios realizados por el doctor Nicolás Osorio o compilados por éste, y en donde se trata de los cultivos de las Quinas industriales. También incluímos en este programa los trabajos de Triana y la Quinología de Mutis.*



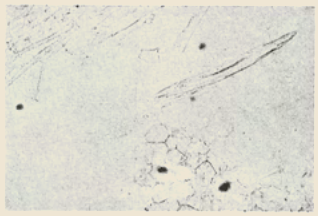
LADENBERGIA MAGNIFOLIA (above). Cross section of phloem to show form and arrangement of fibers. Sample 2967.

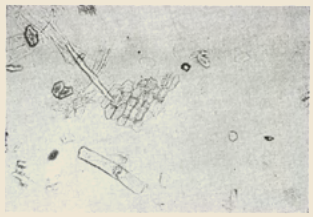
LADENBERGIA UNDATA (?) (below). Cross section of phloem to show form and arrangement of stone cells. Sample 3770.



CINCHONA OFFICINALIS (above). Macerated bark tissues showing fibers, stone cells, and phellem cells. Sample 1919.

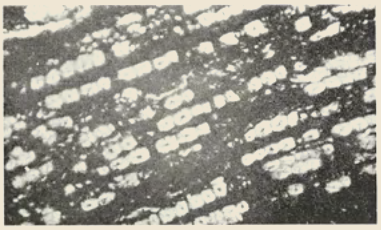
CINCHONA PUBESCENS (below). Macerated bark tissues showing fibers. Note variation in diameter and presence of one fiber with large lumen. Sample 1914.

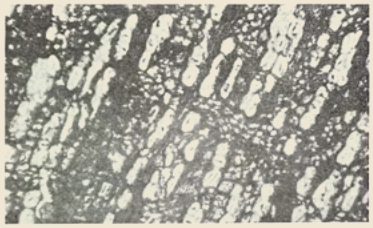




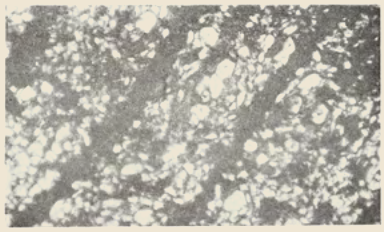
CINCHONA PITAYENSIS (above). Macerated bark tissues showing a fiber and several phellem cells. Sample 3145.

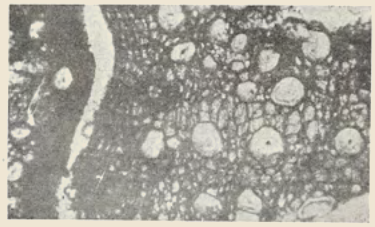
REMIJIA PEDUNCULATA (below). Macerated bark tissues showing a fiber, a cortical stone cell, and several phellem cells. Spots in the phellem cells are pits in the inner walls. Sample 2493.



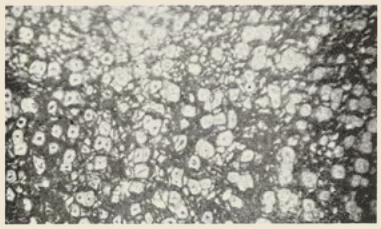


CINCHONA OFFICINALIS. Cross section of phloem to show form and arrangement of fibers. Above, sample 2650; below, sample 3777.



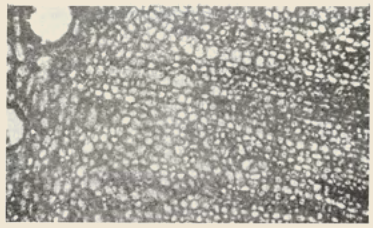


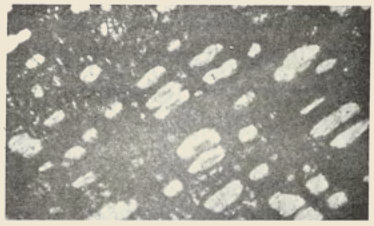
CINCHONA PUBESCENS. Cross sections of phloem to show form and arrangement of fibers. Above, sample 3768; below, sample 3890 showing phellem layer subtending a layer of phloem.



CINCHONA PITAYENSIS (above). Cross section of phloem to show form and arrangement of fibers. Sample 1253.

REMIJIA PEDUNCULATA (below). Cross section of phloem and part of cortex, to show form and arrangement of fibers, and position of laticiferous ducts. Sample 2965.





CINCHONA HENLEANA (above). Cross section of phloem to show form and arrangement of fibers and position of laticiferous ducts. (Fibers are not very numerous; they are identifiable by the presence of a dot in the center representing the lumen). Sample 3377.

CINCHONA OFFICINALIS "roja" (below). Cross section of phloem to show form and arrangement of fibers. Sample 234.