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THE TAXONOMIC SIGNIFICANCE OF BARK STRUCTURE IN SOUTHERN AFRICAN ANACARDIACEAE

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THE TAXONOMIC SIGNIFICANCE OF BARK STRUCTURE IN SOUTHERN AFRICAN ANACARDIACEAE

by

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CHAPTER 1

INTRODUCTION

The Anacardiaceae is a natural family consisting of some 60—80 genera and perhaps 600 species, chiefly pantropical in distribution, but with some species in temperate regions (Cronquist 1981). It is closely related to the Burseraceae and Julianaceae and broadly akin to the Simaroubaceae, Aceraceae, Sapindaceae and Hippocastanaceae (Cronquist 1981, Dahlgren 1983). In southern Africa the family is represented by 13 genera (3 of which are exotic) and 105 species (Arnold & De Wet 1993, incorporating subsequent updates).

Engler (1892) distinguished five tribes in the Anacardiaceae, namely Dobineeae, Mangifereae (Anacardieae), Rhoeae (Rhoideae), Semecarpeae, and Spondieae. Except for the Spondieae, the tribes and most of the genera conform to his earlier monographic treatment of the family (Engler 1892). Only three tribes are represented in southern Africa, namely Anacardieae, Rhoeae and Spondieae.

A study of the taxonomy of the Anacardiaceae raises some important questions (Von Teichman 1988). Whereas Cronquist (1981) regarded the Julianaceae as a separate family, Dahlgren (1983) included it in the Anacardiaceae. Dahlgren (1983), however, distinguished the Dobineeae as a separate family, the Podoaceae, thereby supporting the suggestion of Airy Shaw (1973). Wannan *et al.* (1987), on the other hand, recommended the retention of the Dobineeae within the Anacardiaceae. Airy Shaw (1973) also considers the Australian genus *Blepharocarya* F v Muell. as the type of a separate family, the Blepharocaryaceae, which he established earlier. However, Wannan *et al.* (1985, 1987) and Jessup (1985) advocated the retention of the Blepharocarya in the Anacardiaceae, and demonstrated its close affinity with the genera of the Rhoeae. *Pistacia* L. is another genus that at times has been separated from the Anacardiaceae, as the type of the family Pistaciaceae (Hou 1978).

The anatomy of bark may well assist in the classification of taxa. Unfortunately the microscopic structure of bark has received little attention (Brogli 1926, Chattaway 1959). Furthermore, little is known about the potential taxonomic value of bark characters (Mtombeni 1994, Roth 1981, Trockenbrodt 1990).

As a result of recent bark antomical studies, sufficient understanding of bark structure now prevails to commence a comparative study of the mature bark of the Anacardiaceae. In her studies of the bark anatomy of 48 families, Roth (1981) recorded several aspects of bark structure which can be used for species identification. Roth (1981), studied only five genera of the Anacardiaceae, of which none are found in southern Africa. From her studies, however, it is clear that bark anatomy holds considerable promise as a potential source of taxonomic evidence.

For a better understanding of the taxonomy of the Anacardiaceae it is necessary to draw data from all relevant botanical studies, including those on bark anatomy. In contrast to woody anatomy, the microscopic structure of bark has, unfortunately, received little attention. Mtombeni (1994) ascribes the little attention given to bark anatomy, in part, to difficulty in sectioning bark samples. Time is therefore overdue for bark anatomy to be given the attention it rightfully deserves (Palmer & Pitman 1972, Coates Palgrave 1981).

Despite all the advances made in modern and orthodox medicine, traditional remedies still play a significant role in the lives of many people in Africa. Members of the Anacardiaceae are particularly widely used for medicinal purposes in southern Africa, with bark being the most popular part.

South African traditional healers are currently making concerted efforts to register with the South African Medical and Dental Council and attempt to obtain the same privileges as conventional medical practitioners. For them to do so, it is important, *inter alia*, that the crude plant material, including bark samples, that they use for their medicines should be accurately and scientifically identified. Scientific identification will give valuable assistance to forensic laboratories in solving court cases involving traditional medicines of dubious

origins. There is an overdue need for the quality control of bark medicines dispensed by unscrupulous traditional healers, as well as by shrewd timber merchants who sell low quality timber at exorbitant prices.

Besides being of medicinal value, bark is an important commodity in other branches of ethnobotany (Mabogo 1990). The different cultures of Africa also find their expression in articles sculptured from wood and bark. In many countries, citizens still derive subsistence from the sale of articles carved from wood and bark.

Ten genera of the Anacardiaceae are indigenous to southern Africa and this project will deal with representatives of all of these. In addition to the ten indigenous genera, two naturalized alien genera will also be studied, namely *Mangifera* and *Schinus*. The two naturalized alien genera were included because of their important role in traditional medicine.

This study is the first to record scientifically and in comprehensive detail, the anatomical bark structure of the southern African Anacardiaceae. Southern Africa is here defined as the region covered by the Flora of southern Africa and thus includes South Africa, Lesotho, Swaziland, Botswana and Namibia. Special emphasis is laid on the taxonomic significance of the characters at the generic and the species levels. Features of the axial phloem parenchyma, phloem rays, sclerenchyma, dilatation tissue, calcium oxalate crystals, secretory structures and mature periderm have been given special attention.

The arrangement and compilation of bark descriptions is based on a slightly adapted character list first proposed by Mtombeni (1994). This chacter list has been compiled for use with the DELTA (DEscription Language for TAxonomy) computer programme (Dallwitz & Paine 1986). The salient aims of this study are the following:-

- To provide detailed bark anatomical descriptions for selected woody members of southern African Anacardiaceae.
- To evaluate the taxonomic significance of bark anatomical features in southern African Anacardiaceae.

- To explore the usefulness of bark anatomical characters for identifying unknown bark samples, for example, those used in medicinal bark trade.
- To test and, if necessary, refine a comprehensive bark anatomical character list previously developed for use with the DELTA computer programme.

In the subsequent chapters, the following will be discussed: Materials and Methods (Chapter 2); Southern African Anacardiaceae (Chapter 3); Bark Anatomical Descriptions of the species (Chapter 4); Taxonomic Significance of Bark Anatomical Characters (Chapter 5); Discussion and Conclusions (Chapter 6). For convenience, this dissertation is presented in two parts: Part 1 comprises the text on the bark samples studied, whereas Part 2 contains all tables and figures.

CHAPTER 2

MATERIALS AND METHODS

2.1 MATERIALS

Choice of the investigated species was determined primarily by the availability of research material, rather than being based on systematic considerations. Bark from as many as possible members of the Anacardiaceae was collected, provided that they displayed a mature bark pattern. Bark samples were collected from both naturally growing and cultivated plants. Samples from natural stands were, however, given preference. The aim was to cover as many genera of the family as possible within the southern African region.

Bark samples of 29 species representing ten genera of the southern African Anacardiaceae, as well as two alien genera were studied. A list of species and voucher specimens is supplied in Table 1 (see Part 2 of the thesis). Bark samples were taken at breast height from mainly vertical boles not less than 80 mm in diameter. Bark samples of 100 x 15 mm were cut by means of a chisel and a rubber hammer. Incisions were made up to the cambium or just beyond it. Two bark samples were cut per tree. The wound on the tree was covered with "Tree seal" (a commercially available bitumen-based preparation) to protect the plant from invasion by wood borers or potential rotting agents. The harvested bark samples were immediately fixed and preserved in formalin-acetic acid-alcohol (FAA, Johansen 1940) contained in numbered bottles. Voucher herbarium specimens were also collected for positive identification of the plants. Bark samples were collected from at least three individuals per natural stand, to assess variation and constancy of the bark characters.

2.2 METHODS

2.2.1 MICROSCOPY

After the bark samples were fixed for at least 48 hours in FAA, standard procedures for wood anatomy were used to prepare bark slides for the light microscope. Unembedded fixed material was softened with steam and cut at 15—20 μm on a sliding microtome. The more brittle materials were sectioned at 40—45 μm. Sections were stained with safranin O solution (Art. 5681120, Saarchim, Unilab.) and then counterstained with fast-green FCF (Johansen 1940). Microtome sections were supplemented by hand-cut sections. Anatomical features were studied in transverse, radial and tangential sections. Care was taken to make tangential sections in the portion before the dilatation zone. Stained sections were dehydrated in a graded ethanol-xylol series and mounted permanently in entellan (Art. 7961, E. Merck, Darmstadt).

The full procedure for staining and mounting is as follows (based on Van Wyk 1985):-

- Place cut sections in distilled water in Petri dishes.
- Stain in safranin O overnight.
- Rinse in 50% ethyl alcohol.
- Rinse in 70% ethyl alcohol.
- Rinse twice in 96% ethyl alcohol.
- Rinse twice in 100% ethyl alcohol.
- Counterstain in fast-green for about 3 minutes.
- Wash thoroughly twice in 96% ethyl alcohol.
- Wash twice in 100% ethyl alcohol.
- Rinse in 50:50 ethyl alcohol/xylene for about 10 minutes.
- Rinse twice in xylene (xylol).
- Mount in entellan.

- Turn slides upside down on absorbent tissue paper. Press to release excess mountant and to flatten the section.
- Leave slides for at least three weeks (at room temperature; not on a hot plate) before cleaning them of excess mountant. Use a razor blade (never xylene) to scrape off the excess mountant.

The following procedure was followed for observing sieve elements under the ultra-violet light microscope. Hand sections (both tangential and radial longitudinal sections) of bark tissue close to the cambium were prepared. Sections were washed thoroughly (at least twice) in distilled water. Sections were then transferred to a 0,1% Aniline Blue solution in 0,1M K_3PO_4 (pH 12,4), and left overnight (Martin 1959). Sections were mounted in Aniline Blue solution and observed under ultra-violet light.

2.2.2 THE DELTA COMPUTER PROGRAMME

The DELTA system (DEscription Language for TAxonomy) is a standardized format for coding taxonomic descriptions (Patridge *et al.* 1988). It is a generalised system for handling all the different kinds of descriptive data used by taxonomists, without information loss, in an easy-to-use format designed to minimize encoding errors (Watson & Milne 1972, Dallwitz & Paine 1986). Delta was adopted as the standard format for taxonomic descriptions at the 1988 meeting of the Taxonomic Databases Working Group for Plant Sciences.

2.2.3 CHARACTER LIST

The character list of anatomical bark features compiled by Mtombeni (1994) was used in this study (see Part 2).

2.2.4 ILLUSTRATIONS

Illustrations of bark sections were prepared with the aid of a projection light microscope. A well focused image was projected onto a sheet of white paper. Details of the projected image

were copied in the form of line drawings. These were drawn in ink and reduced photographically to fit on an A4 page (see Part 2 for individual species illustrations).

2.3 BARK TERMINOLOGY

2.3.1 Introduction

The terminology used in bark anatomy is in most cases adopted from the basic terms that are used in wood anatomy. The "Committee of Nomenclature" of the International Association for Wood Anatomists (IAWA) has compiled and repeatedly revised an internationally applied glossary on wood anatomy, known as the Multilingual Glossary of terms used in wood Anatomy, (IAWA 1964, 1981; Wheeler *et al.* 1989).

The following workers have contributed much towards the terminology of bark, Esau (1969, 1977); Schmidt (1979); Parameswaran (1980); Roth (1981); Parameswaran & Richter (1984); Baas (1985); and Trockenbrodt (1989, 1990).

Bark is a non-technical collective term for all tissues outside the vascular cambium of roots and stems (Esau 1977, Cutter 1980, Roth 1981, Fahn 1982, Trockenbrodt 1990). Bark tissues usually include sieve elements, parenchyma, sclerenchyma, dilatation tissue, secretory structures, periderm and various cellular inclusions, notably calcium oxalate crystals. Rhytidome constitutes the so-called outer bark and is composed of the dead portion of bark comprising layers of periderm and layers of dead secondary phloem (Esau 1977). See Figure 1 (Part 2) for a schematic diagram depicting the main tissues and zones in mature bark.

2.3.2 Sieve elements

Analogous with the classification of tracheary elements into vessel members, the conducting elements of angiosperm phloem, called collectively sieve tubes, may be segregated into sieve elements and companion cells (Esau 1965, Trockenbrodt 1990). Pits and perforation plates in tracheary elements are respectively analogous to sieve areas and sieve plates in sieve

elements (Esau 1965). Sieve areas are present on lateral walls of sieve elements as well as on end walls, which may be transverse or oblique. End walls which show one or more sieve areas are generally called sieve plates (Zahur 1959, Esau 1969, 1977, Fahn 1974).

A sieve plate with one sieve area is simple, whereas one with several sieve areas is compound (Trockenbrodt 1990). Sieve plates can be scalariform or reticulate, depending on the arrangement of sieve areas. Cell walls of sieve elements are commonly primary (Parameswaran & Liese 1970), although an additional layer, the so-called nacreous wall, is present in a few taxa (Esau 1977).

Sieve elements and companion cells develop from the same cambial initial. A cambial initial divides longitudinally, one cell forming a sieve tube member, and the other developing into companion cells (Fahn 1982).

2.3.3 **Axial phloem parenchyma**

These are parenchyma cells in the axial, longitudinal or vertical system of secondary phloem as contrasted with the horizontal ray parenchyma cells (Esau 1977). Their longer diameters are parallel with the main axis of the stem. Axial parenchyma cells are derived from fusiform cambial initials.

2.3.4 **Phloem rays**

Phloem rays are a continuation of the xylem rays. They are radially oriented in the secondary phloem and are derived from cambial ray initials.

2.3.5 **Sclerenchyma**

Sclerenchyma cells have secondary walls that are deposited over the primary wall after the latter has completed extension growth (Esau 1977). They are usually divided into two categories, sclereids and fibres. These two classes of cells are not sharply separated from each

other. In general the fibre is a long slender cell, many times longer than wide, whereas sclereids vary in form from approximately isodiametric to considerably elongated, with some kinds being much-branched. They may or may not retain their chloroplasts at maturity (Esau 1977).

Sclereid cells usually have thick secondary walls, strongly lignified and provided with numerous, commonly simple, pits. They have been categorized on the basis of form, but the classification is of limited utility because the various forms frequently intergrade (Esau 1977). The commonly listed categories of sclereids include brachysclereids, stone cells, roughly isodiametric or somewhat elongated, macrosclereids, rod cells, elongated and columnar (Esau 1977).

Sclereids may occur in more or less extensive layers or clusters, but frequently occur isolated among other types of cells from which they may differ sharply by their thick walls and often bizarre shapes. As isolated cells they are classified as idioblasts. The differentiation of idioblasts poses many still unresolved questions regarding causal relations in the development of tissue patterns in plants (Esau 1977).

Fibres are long cells with more or less thick secondary walls and usually occur in strands. Within the strand, the fibres overlap, a feature that imparts strength to the fibre bundles. A fibre-sclereid is a sclerenchyma cell with characteristics intermediate between those of a fibre and a sclereid (Esau 1977). Fibre-sclereids possess a polylamellate wall structure, but they are elongated through apical growth (Parameswaran 1975).

Trockenbrodt (1990) contends that many workers give contradictory definitions of sclerenchymatous cells. He holds that clarifying terminology of sclerenchyma requires extensive ontogenetical investigations at ultrastructural level. This is, however, not absolutely necessary for comparative anatomical studies.

2.3.6 **Dilatation tissue**

The tangential strain in bark tissues caused by secondary growth or development is compensated for by additional growth, called dilatation or expansion growth.

Dilatation growth occurs through cell divisions in axial phloem parenchyma and/or phloem ray parenchyma and results in the increase in circumference of the bark. The cortex and even the epidermis may show dilatation growth as well (Reinders & Reinders-Gouwentak 1986, Esau 1969, Roth 1981). Whitmore (1962) introduced the term pseudocortex, which applies to the cortex-like tissue zone beneath the periderm in some trees. Van Wyk (1985) refers to expansion tissue as a synonym for dilatation tissue. He also uses the term pseudocortex, but considers it to consist of both primary tissue (cortex remnants) and dilatation tissue, unlike Whitmore (1962), who considers pseudocortex to be derived through dilatation growth from the secondary phloem only.

2.3.7 **Calcium oxalate crystals**

Calcium oxalate crystals occur in bark tissues in different forms. These include prisms, druses, styloids, acicular crystals, raphides, and crystal sand.

Prisms are rectangular or pyramidal crystals; druses are star-shaped crystals; styloids are long prismatic crystals, tapered off at both ends; acicular crystals are thin, sharp-pointed and needle-shaped; raphides are aggregated bundles of thin elongated crystals with taperized ends and are enclosed in raphide sacs; and crystal sand are very small prisms usually occurring in masses (Fahn 1982). The appearance, location and type of a crystal is often used in taxonomy (Fahn 1982).

2.3.8 Secretory structures

Authors seem to differ with regard to the precise definition of secretory structures and their secretions. Roth (1981) divides the secretory systems into four categories, namely secretory idioblasts, secretory cavities, laticifers and secretory canals. This has lead to a multitude of terms referring to secretory systems (Trockenbrodt 1990).

Trockenbrodt (1990) recognises two categories of secretory structures, namely secretory cells and intercellular spaces. The category of secretory cells includes not only oil cells, mucilage or slime cells, tanniniferous cells, but also articulated laticifers (composed of several secretory cells) and non-articulated laticifers. He describes secretory intercellular spaces according to their shape and contents. The term "canals" or "ducts" he reserves for long slender intercellular spaces that are filled with secretions.

2.3.9 Periderm

Periderm is a protective tissue of secondary origin which replaces the epidermis in those stems and roots that increase in thickness through secondary growth. It develops along surfaces that are exposed after abscission of plant parts. Periderm formation is also an important stage in the development of protective layers near injured or dead tissues (Esau 1977).

Periderm includes phellogen (cork cambium), the meristem that produces periderm; phellem (commonly called cork), the protective tissue formed outward by the phellogen; and phelloderm, a living parenchyma tissue formed inwardly by the meristem. Dead tissues lying outside the periderm result from the insertion of non-living cork between these tissues and the living inner tissues of the stem (Esau 1977). Phellogen is relatively simple in structure as it has only one form of cell and is not of any taxonomic significance. Characters derived from the phelloderm and phellem show considerable variation between taxa and are, therefore, of considerable use in comparative anatomy.

2.3.10 **Rhytidome**

As a tree grows older, periderms often arise at successively greater depths and this causes an accumulation of dead tissues on the surface of the stem and root. This dead part of bark, composed of layers of tissues isolated by the periderms and of layers of no longer growing periderms is called rhytidome. Rhytidome constitutes the outer bark and is especially well developed in older stems and roots of trees (Esau 1977).

2.3.11 **Cortex**

Cortex is primary ground tissue occupying the region between the vascular system and the epidermis in stems and roots (Esau 1977). It does not belong to the epidermis, the periderm or the phloem (Trockenbrodt 1990).

CHAPTER 3

SOUTHERN AFRICAN ANACARDIACEAE

3.1 Introduction

Ten genera of the Anacardiaceae are indigenous to southern Africa. These belong to three of the five tribes in the family, namely the Anacardieae, the Rhoeae and the Spondieae. The intention of this study is to investigate representatives of all ten of these genera. The number of species examined in each genus was subject to on the availability of material. The twenty nine species studied are listed in Table 1 (Part 2). Based on the system of classification of flowering plants as presented by Cronquist (1981), the southern African Anacardiaceae can be classified as follows:

Division Magnoliphyta
Class Magnoliopsida
Subclass Rosidae
Order Sapindales
Family Anacardiaceae
Tribe Anacardieae
Genus **Mangifera*
Tribe Rhoeae
Genus *Heeria*
Laurophyllus
Loxostylis
Ozoroa
Protorhus
Rhus
**Schinus*
Smodingium

Tribe Spondieae

Genus *Harpephyllum*

Lannea

Sclerocarya

* = Alien genera

3.2 Medicinal and other uses of species studied

The mushrooming of street corner traditional chemists in our cities and towns calls for more information on the many uses of bark and plant products to be recorded. One of the aims of this study is to record the uses of all those species whose bark were studied anatomically. Uses of some of the species are highlighted in this chapter.

Contributions by workers like Breyer-Brandwijk (1962), De Winter *et al.* (1966), Coates Palgrave (1977), Rodin (1985), and Mabogo (1990), contain a wealth of information on the multiple uses of plant material in southern Africa.

This chapter records medicinal and economic uses of members of the Anacardiaceae sampled during the present study. Information was obtained from the literature, as well as directly from traditional healers.

Wherever they occur, the following species are widely utilized by local residents; **bark usages are printed in bold**:

- *Harpephyllum caffrum* (Wild plum; *Wilde pruim*).

The wood is pale reddish, fairly heavy, polishes well, but is not durable. It has been used for furniture, beams and as a general purpose timber. The species is frequently planted as a garden ornamental. **A decoction of bark is used by the Zulu as an emetic and blood "purifier"** (Breyer-Brandwijk 1962). **Bark is also used in washes for skin complaints by the Zulu** (Hutchings 1996).

- *Heeria argentea (Basboom)*

The bark and leaf are used for tanning (Breyer-Brandwijk 1962).

- *Lannea discolor* (Live-long; *Dikbas*).

The fruit is edible and popular with children. The wood is soft and does not crack easily. It is used for carving plates, bowls and to make floats for fishing nets. **Bark, carefully removed makes good cork stoppers for popguns. The bark of young twigs is stripped and made into twine. It is also used medicinally for a variety of ailments, in particular for children's complaints ranging from fever to constipation. The inner bark is used in East Africa as a diarrhoea remedy** (Breyer-Brandwijk 1962, Hutchings 1996).

- *Lannea schweinfurthii* var *stuhlmannii* (False marula; *Bastermaroela*).

The Tsonga and Venda name of this tree (*Ndivata* and *Mulivhadza* respectively) literally means "the tree of forgetfulness". **In fact it is the peculiar hair-like outgrowths of the periderm that are associated with the root system of this plant which are mixed with other magical powders and then used cause forgetfulness.**

The mixture may be used to discourage enemies from doing harm to a person by making them postpone their plans everytime they plan to attack. This material is also used to keep both people and domestic animals from straying (personal discussion with a herbalist selling the material in Sibasa, in the Northern Province — it is sold at R10-00 per match box). **The bark is used medicinally for treating sores, bleeding, abscesses, as a sedative and in magic sleeping** (Mabogo 1990). **A rather strange use is that of blowing the powdered bark of the root into the nostrils of a person who is dying from snake-bite to revive the person** (Van Wyk 1993).

- *Mangifera indica*

The plant is used medicinally in Angola and in Mozambique and has been used as an astringent in the East (Breyer-Brandwijk 1962). **The bark, which contains tannin, is used as an astringent in tropical Africa. It has been used for tanning and as a remedy for diarrhoea, dysentry and leucorrhoea** (Breyer-Brandwijk 1962). **In the West Indies an infusion of bark is used for the treatment of hypertension** (Ayensu 1981).

- *Ozoroa engleri* (White resin tree; *Witharpuisboom*)

A bark decoction is used by the Vhavenda to treat seeds before sowing as a precaution against insects and diseases. It is also used in the treatment of venereal diseases and as a purgative (Mabogo 1990). The Zulu use the **bark**, leaves and roots **medicinally** and fruit is traditionally used to dress hair (Hutchings 1996).

- *Ozoroa obovata* (Broad-leaved resin tree; *Breeblaarharpuisboom*)

The Zulu use the roots as traditional medicine. **The bark is used for dysentry and acute inflammation of the chest** (Hutchings 1996).

- *Ozoroa paniculosa* (Common resin tree; *Gewone Harpuisboom*)

The Zulu use powdered bark for acute inflammatory conditions of the chest and also for dysentry and abdominal problems in animals (Hutchings 1996).

- *Ozoroa sphaerocarpa* (Bastard currant resin tree; *Basterkorenteharpuisboom*)

The Zulu use the bark in the same way as that of *O. paniculosa* for dysentry and acute inflammation of the chest (Hutchings 1996).

- *Protorhus longifolia*

The gum which exudes from the bark is used by the Zulu to mount assegai blades onto handles (Breyer-Brandwijk 1962).

- *Rhus chirindensis* (Red Currant Rhus; *Bostaaibos*)

The fruit is edible, though not popular. The wood is used to carve smaller household utensils. The Zulu use this plant as a medicine for heart complaints. **The bark is used to strengthen the body, to stimulate circulation and for rhuematism** (Hutchings 1996).

- *Rhus guenzii* (Thorny karee; *Doringkaree*)

The Zulu use this species for eye complaints. Decorticated root infusions are used for schistosomiasis by the Sotho. The Tswana use it as an astringent and to check the haematuria, as well as biliousness (Breyer-Brandwijk 1962, Hutchings 1996).

- *Rhus lancea*

The wood works and polishes well. It is also used extensively for firewood. The leaves are used as fodder in times of drought and the berries are edible. The North Sotho make beer from the pounded fruit. The leaves are also used in the treatment of colds, headache and fever (Mabogo 1990). The patient inhales the vapours of leaves and then drinks the decoction. A leaf decoction is also used to bathe babies as a treatment of measles rash.

- *Rhus natalensis*

The plant is reported to be used as a taenacide in east Africa (Breyer-Brandwijk 1962), the leaf for gonorrhoea and the fruit for stomach disorders. **Root bark is also used as remedy for habitual abortion, repeated stillbirths and as a remedy for fits in children.**

- *Rhus pyroides*

Breyer-Brandwijk (1962) reports that the Kwena and the Tswana use an infusion of this species as an eye lotion.

- *Rhus undulata* (Kuni-bush; *Koeniebos*)

Breyer-Brandwijk (1962) reports that the Hottentots use a leaf decoction of this species as a remedy for postparturient troubles.

- *Schinus molle* (Pepper tree; *Peperboom*)

Besides being utilized as a shade tree in dry parts of southern Africa, an infusion of the leaves is used in the treatment of colds, fever and headache. **Bark decoctions are used in remedies for tumors, warts, amenorrhea, apostemes, blenorrhagia, bronchitis, cataracts, dysmenorrhea, gingivitis, gonorrhea, gout, opthalmia, rheumatism, sores, swellings, tuberculosis, ulcers, urethritis, urogenital and venereal disorders, and wounds. It is reported to be astringent, balsamic, collyrium, diuretic, emmenagogue, masticatory, piscicide, purgative, stomachic, tonic, viricidal, and vulnerary (Duke 1929).**

- *Sclerocarya birrea* subsp. *caffra* (Marula, *Maroela*)

The fruit is edible and is used to make wine and jelly. The kernels are extracted and eaten fresh or used as a condiment when cooking a variety of vegetables and meat. The Zulu formerly used kernel oil to preserve and soften skin skirts. The Ovambo use the oil as a cosmetic. The wood is soft and has been used for making a variety of utensils such as stamping blocks, spoons, plates, troughs and drums. **Bark infusions are used for a variety of treatments, such as in the support of pregnancy, for treatment of barreness and infertility, colds** (Mabogo 1990), **headaches, malaria and stomach troubles (dysentry and indigestion etc.)** (Duke 1929, Mabogo 1990). Van Wyk (1993) reports that it is used **in the selection of sex in an unborn child (male plant for a boy, and female plant for a girl).**

Powdered bark is an ingredient of medicines used for chronic ulcers suspected to be caused by witchcraft. The bark has been used to make a bitter brandy tincture used as an antidote against malaria (De Winter *et al.* 1966).

- *Smodingium argutum*

The handling of the foliage of *Smodingium argutum* may produce a skin reaction in sensitive people similar to that which follows contact with poison ivy, *Toxicodendron radicans* (Breyer-Brandwijk 1962, Ellis 1974). The latex is irritating and contact with the skin results in itching, swelling, a rash and even blistering.

CHAPTER 4

BARK ANATOMICAL DESCRIPTIONS

4.1. Introduction

The taxa described in this chapter are arranged alphabetically. Scientific names and author citations are followed by numbers, in brackets, of the FAA-preserved samples used. A representative diagram of the bark (in T.S.) is supplied for each taxon in Part 2. The descriptions were processed by the use of the DELTA computer programme.

Selected characters are summarized for each taxon in Table 4.1 (Part 2). Particularly significant diagnostic characters are **highlighted in bold.**

4.2. Bark anatomy

4.2.1 *Harpephyllum caffrum* Berhn. (3734, 3807, 3888)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, scalariform (compound); **sieve areas 4–7 per plate; lateral sieve areas with callose deposits absent or weakly developed.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells **axially elongated**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, in **tangential bands associated with fibres.**

PHLOEM RAYS. Phloem rays **heterocellular,** 2–4 rows of upright and/or square cells, rays 1–3-seriate; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified;** aggregate rays absent; storied structure absent; ray cells thin-walled, **abundantly pitted;** tile

cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prismatic**, sparsely distributed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present**, comprising **lignified fibres**, and **gelatinous fibres**, forming **regular** compact groups; **tangential in outline**; fibres **non-septate**, walls **very thin**; gelatinous fibres with S1 layer **distinctly lignified**; sclereids absent.

DILATATION TISSUE. Dilatation tissue **well developed**, derived from **phloem parenchyma and rays**; well-defined dilatation meristem(s) **present**; sclerenchyma present; **sclereids absent**; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate**, lignified-gelatinous fibres; tanniniferous cells (not notably enlarged) **absent**; calcium oxalate crystals sparse, **prismatic** sparsely distributed.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly in ray cells, crystalliferous cells, associated with fibres, dilatation tissue, and phelloderm; prisms, if associated with sclerenchyma, **encased within chambered axial strands**; encased within fibres; mainly associated with sclerenchyma, cell walls **sclerified.**

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts**, aranged mainly in **continuous tangential bands** of ducts. Bands **often double** for short sections. **Horizontal ducts** run through the ray; tanniniferous cells (not notably enlarged) abundant; **thick bands associated with secretory ducts.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present**, stratification **present, a scaly layer, followed by a highly lignified layer, and then a layer with wider cells on the inside**; phellem cells with tangential diameter greater than radial diameter; lignified cells (phellem/phelloid) with **tangential diameter greater than radial diameter**, all walls evenly thickened, and **distinctly pitted**; tanniniferous cells (not notably enlarged) **absent**; idioblasts absent; calcium oxalate crystals sparse, prismatic. Phelloderm well developed, stratification **present**; a more compact layer alternating with a less compact layer;

parenchymatous; parenchyma cells mainly with tangential diameter greater than radial diameter; tanniniferous cells **absent**; calcium oxalate crystals sparse, **prismatic** (in the phelloderm). Cortex **absent** in mature bark.

4.2.2 *Heeria argentea* (Thunb.) Meissner (3912, 3917, 3919)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 2–5 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals **sparse, prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2–4 rows of upright and/or square cells, rays 1–3-seriate; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma lignified; aggregate rays absent; storied structure absent; ray cells thin walled, abundantly pitted; tile cells absent; tanninferous cells (not notably enlarged) **abundant**; calcium oxalate crystals **abundant, prisms.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, comprising **lignified fibres**, forming loose tangential groups; tangential in outline; fibres **non-septate, walls very thin.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma** and **rays**; irregular ("diffuse" type); well-defined dilatation meristem(s) **present**; schlerenchyma present, spheroidal, vesiculose and vermiform sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres geletinous; tanniniferous cells (not notably enllarged) **abundant**; calcium

oxalate crystals (prismatic) **abundantly dispersed.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals, **minute prisms in cells, abundant mainly in rays and dilatation tissue; if associated with sclerenchyma not encased in scleretic elements.**

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts, with single cell sheath,** in weak tangential bands, **disturbed by dilatation at dilatation zone;** tanniniferous cells (not notably enlarged) **abundant throughout the whole bark.**

MATURE PERIDERM. Phellem compact; **lignified cells (phelloid/phellem) absent, stratification absent**; phellem cells with tangential diameter greater than radial diameter; tanninferous cells (not notably enlarged) absent; idioblasts absent; **calcium oxalate crystals absent**; phelloderm well developed, stratification p Dilatation tissue well developed, derived from **phloem parenchyma and rays**; irregular ("diffuse" type); well-defined dilatation meristem(s) **present**; sclerenchyma present, spheroidal, vesiculose and vermiform sclereids; irregularly dispersed abas clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary undan phloem fibres **gelatinous**; tanniniferous cells (not notably enlarged) t; calcium oxalate crystals **abundant, prisms abundantly dispersed.** resent; **parenchymatous**; parenchyma cells mainly with tangential diameter greater than radial diameter; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm)**.**

Cortex absent in mature bark.

4.2.3 *Lannea antiscorbutica* (Hiern) Engl. (3845, 3846, 3875)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 4–10 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells **axially elongated**; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals **absent**.

PHLOEM RAYS. Phloem rays **heterocellular**, 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays 4—12 per mm; ray height less than 1 mm; course, **a tendency towards undulation**; portion of rays traversing or adjacent to sclerenchyma remaining **parenchymatous**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, rarely **prisms**.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, comprising **lignified fibres, gelatinous fibres, and cellulosic fibres**, forming regular compact groups; in **tangential bands, alternating with tangential bands of secretory ducts**; fibres **septate**, walls **very thin**; gelatinous fibres with S1 layer **distinctly lignified**.

DILATATION TISSUE. Dilatation tissue **well developed**, derived from **phloem parenchyma and rays**; **irregular** ("diffuse" type); well-defined dilatation meristem(s) **absent**; sclerenchyma present, comprising **spheroidal, vesiculose, vermiform and fusiform** sclereids; **irregularly dispersed as clusters**; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate**, comprising lignified-gelatinous fibres; tanniniferous cells (not notably enlarged) **sparse**; calcium oxalate crystals sparse, **prisms** associated with fibre strands.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly **in axial phloem parenchyma**; prisms, if associated with sclerenchyma, **encased within chambered axial strands**; axially arranged chambered crystalliferous strands **present**, mainly **associated with sclerenchyma**, cell walls **remaining parenchymatous**.

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts**, in mainly **continuous tangential bands**, with **a few odd short bands**; tanniniferous cells (not

notably enlarged) **sparse**; mainly **in phloem parenchyma surrounding secretory ducts.** Also **present in the cambium.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present,** stratification **present,** cell layers on top of one another, **with vertical walls not aligned;** phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls **evenly thickened,** walls **distinctly pitted;** tanniniferous cells (not notably enlarged) **abundant;** idioblasts absent; calcium oxalate crystals **sparse.** Phelloderm well developed, stratification **present;** a **more compact cell layer alternating with a less compact cell layer; sclerified** sclereids **assembled in irregularly shaped groups;** parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal and vermiform** sclereids; walls **all evenly thickened;** tanniniferous cells **abundant;** calcium oxalate crystals **sparse, prisms** irregularly dispersed throughout the phelloderm. Cortex **absent in mature bark.**

4.2.4 *Lannea discolor* (Sond.) Engl. (3745, 3746)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 5—10 per plate; lateral sieve areas with callose deposits absent or weakly developed.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands,** cells **axially elongated;** tanniniferous cells (not notably enlarged) **sparse;** calcium oxalate crystals **sparse, prisms in tangential bands associated with gelatinous fibres.**

PHLOEM RAYS. Phloem rays **heterocellular,** 2—4 rows of upright and/or square cells, **larger rays commonly 4—10-seriate;** number of rays 4—12 per mm; ray height less than 1 mm; course **undulated;** portion of rays traversing or adjacent to sclerenchyma **lignified;**

aggregate rays absent; storied structure absent; ray cells **thin walled, abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) **sparse**; calcium oxalate crystals **sparse, prisms**, sparsely dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present**, comprising **gelatinous fibres**, forming **regular** compact groups; **tangential in outline**; fibres **septate**, walls **very thin**; gelatinous fibres with S1 layer **non lignified.**

DILATATION TISSUE. Dilatation tissue **well developed**, derived from **phloem parenchyma and rays**; **irregular** ("diffuse" type); well-defined dilatation meristem(s) **absent**; sclerenchyma **present, spheroidal, vesiculose, vermiform and fusiform** sclereids; **irregularly dispersed as clusters**; sclerenchyma ring (persistent primary phloem caps or fibres) **absent**; primary phloem fibres **polylamellate, lignified- gelatinous**; tanniniferous cells (not notably enlarged) **abundant**; calcium oxalate crystals **sparse, prisms associated with fibres.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals **sparse, prisms**, located mainly in **crystalliferous cells, associated with fibres; druses**, located **mainly in dilatation tissue**; prisms, if associated with sclerenchyma, encased within **chambered axial strands**; druses, if associated with sclerenchyma, **encased within fibres**; axially arranged chambered crystalliferous strands **present**, mainly **associated with sclerenchyma**, cell walls **sclerified.**

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts**, mainly **continuous tangential bands. Horizontal ducts run through the ray**; tanniniferous cells (not notably enlarged) **sparse**; **in tangential bands alternating with fibre bands. Present also in the cambium. Present also the sclereid lumens.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present**, stratification **present, regular tangential brick-like cell layers lying on top of one another.** Phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter

greater than radial diameter, all **walls evenly thickened**, walls **indistinctly pitted**; tanniniferous cells (not notably enlarged) **sparse**; idioblasts absent; calcium oxalate crystals **sparse**. Phelloderm well developed, stratification **present**; **more compact cell band followed by a less compact cell band**; **sclerified** sclereids **assembled in irregularly shaped groups**; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal and vermiform** sclereids; walls **all evenly thickened**; tanniniferous cells **abundant**; calcium oxalate crystals **sparse, prisms** sparsely dispersed throughout the phelloderm. Cortex **absent in mature bark.**

4.2.5 *Lannea schweinfurthii var. stuhlmannii* (Engl.) Kokwaro (3785, 3786, 3789, 3885, 3886, 3887)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 4–10 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells **axially elongated**; tanniniferous cells (not notably enlarged) **sparse**; calcium oxalate crystals **sparse, tangential bands, associated with gelatinous fibres.**

PHLOEM RAYS. Phloem rays **heterocellular**, 2–4 rows of upright and/or square cells, **larger rays, commonly 4–10-seriate**; number of rays 4–12 per mm; ray height less than 1 mm; course **undulated**; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells **thin walled, abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) **sparse**; calcium oxalate crystals **sparse, prisms** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present**, comprising **lignified fibres, and gelatinous fibres**, arranged **in discontinuous tangential bands**; tangential in outline; fibres **non-septate**, walls **very thin**;

gelatinous fibres with S1 layer **distinctly lignified; spheroidal** sclereids; walls **more-or-less even, round lumen.**

DILATATION TISSUE. Dilatation tissue **well developed,** derived from **phloem parenchyma and rays; irregular** ("diffuse" type); well-defined dilatation meristem(s) **absent;** sclerenchyma present, **spheroidal and vermiform** sclereids; **irregularly dispersed as clusters;** sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous;** tanniniferous cells (not notably enlarged) **sparse;** calcium oxalate crystals **sparse, prisms in crystaliferous chambers associated with fibre strands.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals **sparse, prisms,** located mainly in **axial phloem parenchyma, ray cells, and crystalliferous cells, associated with fibres;** prisms, if associated with sclerenchyma, **encased within chambered axial strands.**

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts, in continuous tangential bands;** tanniniferous cells (not notably enlarged) **sparse; in conspicuous bands associated with secretory ducts.** Already **formed in the cambium.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present,** stratification **present,** a layer of **lignified fibres, followed by a distinct layer of younger cells;** phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all **walls evenly thickened, walls distinctly pitted;** tanniniferous cells (not notably enlarged) **abundant;** idioblasts absent; calcium oxalate crystals **sparse.** Phelloderm **well developed,** stratification **present; a more compact cell band followed by a less compact cell band; partially** sclerified sclereids **irregularly scattered;** parenchyma cells **more-or-less isodiametric** and **some with tangential diameter greater than radial diameter; spheroidal and vermiform** sclereids; walls **all evenly thickened;** tanniniferous cells **sparse;** calcium oxalate crystals **sparse, prisms irregularly** dispersed throughout the phelloderm.

Cortex absent in mature bark.

4.2.6 *Laurophyllus capensis* Thunb. (3913, 3914, 3915)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 2–6 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) **abundant; calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays **heterocellular, one row of upright and/or square cells**, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of ray traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, abundantly pitted; tile cells absent; tanniniferous cells (not notably enlarged) **abundant; calcium oxalate crystals absent.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising lignified fibres**, forming loose tangential groups; tangential in outline; fibres **non-septate, walls very thin.**

DILATATION TISSUE. **Dilatation tissue well developed, derived from rays only, continuous, interdigitizing with secondary phloem**; well-defined dilatation meristem(s) **present**; sclerenchyma present, spheroidal, vesiculose and vermiform sclereids irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres polylamellate, lignified-gelatinous fibres; tanniniferous cells (not notably enlarged) **abundant; calcium oxalate crystals absent.**

CALCIUM OXALATE CRYSTALS. **Calcium oxalate crystals absent.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **with single cell sheath sparsely dispersed in tangential lines**; tanniniferous cells (not notably enlarged) **abundant, with the concentration increasing outwards.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present, stratification absent**; phellem cells with tangential diameter greater than radial diameter; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, walls distinctly pitted; tanniniferous cells (not notably enlarged) **absent**; idioblasts absent; **calcium oxalate crystals absent**; phelloderm well developed, stratification present; distinct cell layers on top of one another; **parenchymatous**; parenchyma cells mainly with tangential diameter greater than radial diameter; tanniniferous cells **abundant**; **calcium oxalate crystals absent.**

Cortex absent in mature bark.

4.2.7 *Loxostylis alata* (Sprang.) f. ex Reichb. (3741, 3777, 3805, 3806)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 1–4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma **in conspicuous tangential bands**, cells axially elongated; tanniniferous cells (not notably enlarged) **abundant**; calcium oxalate crystals sparse, **prisms in tangential bands associated with gelatinous fibres.**

PHLOEM RAYS. Phloem rays **heterocellular**, 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays **12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) **sparse**; calcium oxalate crystals sparse, **prisms**.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres, and gelatinous fibres**, forming irregular compact groups; **tangential in outline**; fibres **non-septate, walls very thin**; gelatinous fibres with S1 layer **distinctly lignified**.

DILATATION TISSUE. Dilatation tissue **well developed**, derived from **phloem parenchyma and rays**; well-defined dilatation meristem(s) **present**; sclerenchyma **present, spheroidal, vesiculose and vermiform sclereids in continuous tangential bands associated with fibres**; mainly **associated with aggregates of primary sclerenchyma**; sclerenchyma ring (persistent primary phloem caps or fibres) **present, well developed**, primary phloem fibres **polylamellate lignified-gelatinous**; tanniniferous cells (not notably enlarged) **abundant**; calcium oxalate crystals sparse, **prism associated with sclereid strands**.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals **sparse, prisms, located mainly in crystalliferous cells, associated with fibres**; prisms, if associated with sclerenchyma, **encased within secondarily formed sclereids in the dilatation zone**.

SECRETORY STRUCTURES. Secretory structures **present**, composed of **ducts, sparsely** and **irregularly dispersed throughout the whole bark**. Also **occur just below the cambium. Horizontal ducts run through the ray**; tanniniferous cells (not notably enlarged) **abundant**; dispersed **throughout the whole bark**, also **enclosed in sclereid lumens**.

MATURE PERIDERM. Phellem **compact**; lignified cells (phelloid/phellem) **present**, stratification **present, a more compact cell layer followed by a less compact cell layer**; phellem cells with tangential diameter greater than radial diameter;conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, **all walls evenly thickened**, wall distinctly pitted; tanniniferous cells (not notably enlarged) **abundant**; idioblasts absent; calcium oxalate crystals **sparse**. Phelloderm **well developed**, stratification **present**; a **more compact cell layer on the outside, followed by a less compact cell layer; sclerified, sclereids assembled in irregularly shaped groups**; parenchyma cells **mainly with tangential diameter greater than radial diameter; spheroidal and vermiform sclereids**; walls **all evenly thickened**; tanniniferous cells **sparse**; calcium oxalate crystals sparse, **prisms associated with sclereids.**

Cortex absent in mature bark.

4.2.8 *Mangifera indica* L. (3751, 3793, 3794)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 3–6 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma **in weak tangential lines**, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals **sparse**, **prisms** rarely dispersed.

PHLOEM RAYS. Phloem rays **heterocellular**, 2–4 rows of upright and/or square cells, rays 1–3-seriate; number of **rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **moderately pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals **absent**; though absent, starch grains are observed down the ray cells, and ultimately accumulating in

abundance in the outer bark.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, comprising **lignified fibres**, and **gelatinous fibres**, forming regular compact groups; **tangential** in outline; **fibres non-septate**, walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue **well developed**, derived from **phloem parenchyma and rays**; irregular (`diffuse' type); well-defined dilatation meristem(s) **present**; sclerenchyma present, **spheroidal, vesiculose** and **vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals abundant, **prisms associated with fibres**, randomly dispersed.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, prisms, located mainly in axial phloem parenchyma, sclerenchyma, and crystalliferous cells, associated with fibres; prisms, if associated with sclerenchyma, not encased in scleretic elements.

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts, sheathed ducts sparsely scattered in weak tangential bands**; tanniniferous cells (not notably enlarged) abundant; **densely dispersed in the outer bark than in the inner bark.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present,** stratification **present**, a more compact layer of cells followed by a less compact layer of cells; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, **all walls evenly thickened, wall distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; calcium oxalate crystals sparse. Phelloderm well developed, stratification **present**; **collapsed and non-collapsed cell layers alternating**; sclerified sclereids assembled in irregularly shaped groups; parenchyma cells mainly with tangential diameter greater than radial diameter; spheroidal and vesiculose

sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms** associated with fibres (in the phelloderm).

Cortex absent in mature bark.

4.2.9 *Ozoroa engleri* R.A. Fernandes (3884, 3899, 3900)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 1–5 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** randomly dispersed.

PHLOEM RAYS. Phloem rays **heterocellular**, 2–4 rows of upright and/or square cells, rays 1–3-seriate; **number of rays 4–12 per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled , **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, mainly **druses, prisms at random.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising lignified fibres, and gelatinous fibres**, forming loose tangential groups; **tangential** in outline; fibres **non-septate**, walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue **well developed**, derived from **phloem parenchyma and rays**; irregular ("diffuse" type); well-defined dilatation meristem(s) **present**; sclerenchyma present, **spheroidal,vesiculose, vermiform, fusiform and filiform** sclereids;

irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified gelatinous**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **mainly prisms, rarely druses at random,** instead **starch grains are abundantly stored in the dilatation tissue.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses; prisms located mainly in dilatation tissue; druses located mainly in ray cells; prisms, if associated with sclerenchyma, encased within sclereids.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a double cell layer lining forming tangential bands. Bands are far apart in the inner bark but become close together towards the outside. Ducts have mainly red stained contents**; tanniniferous cells (not notably enlarged) abundant; **in both rays and phloem parenchyma, and more dense in the dilatation zone.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) absent, **stratification absent**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.** Phelloderm well developed, stratification **present**; more closely packed cell layer alternating with less compact cell layer; **partially sclerified** sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform** sclereids; walls **all evenly thickened**; tanniniferous cells abundant; calcium oxalate crystals sparse, mainly **druses,** with **rare prisms** (in the phelloderm).

Cortex absent in mature bark.

4.2.10 *Ozoroa mucronata* Behrn. ex Krauss (2600)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer

absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 2–5 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands,** cells axially elongated; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays **heterocellular,** 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays 4—12 per mm; ray height less than 1 mm; **course irregular;** portion of rays traversing or adjacent to sclerenchyma **lignified;** aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted;** tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **druses** in vertical columns.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising gelatinous fibres,** forming loose tangential groups; **tangential in outline;** fibres **non-septate,** walls very thin; gelatinous fibres with S1 layer **weakly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, **derived from rays only;** irregular ("diffuse" type); well-defined dilatation meristem(s) **present;** sclerenchyma present, **spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **partially lignified gelatinous fibres;** tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **druses in lumps in the expanded rays,** with **rare prisms** at random intervals.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses,** prisms mainly **in ray cells;** druses located mainly in **dilatation tissue.**

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts, in discontinuous tangential bands. Distance between the bands roughly maintained throughout the whole bark**; tanniniferous cells (not notably enlarged) abundant; mainly in phloem parenchyma, also in rays, **leaving the dilated portion of ray free.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present,** stratification **present, compact cell layer, alternating with a less compact cell layer;** phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, **all walls evenly thickened,** walls **distinctly pitted;** tanniniferous cells (not notably enlarged) abundant; idioblasts absent; calcium oxalate crystals sparse (prisms and druses). Phelloderm well developed, **stratification present; a more compact cell layer alternating with a less compact cell layer; partially sclerified,** sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **mainly druses and rarely prisms** (phelloderm).

Cortex absent in mature bark.

4.2.11 *Ozoroa namaquensis* (Sprague) Von Teichman & Van Wyk (1322)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 1–5 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, **cells more-or-less isodiametric**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; **course irregular**; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **druses** randomly dispersed, but **in addition starch grains are observed down the ray cells, and ultimately stored in abundance in dilatation tissue.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising gelatinous fibres, forming regular compact groups.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma only**; phloem parenchyma **regularly dilated, wedge-shaped**; well-defined dilatation meristem(s) present; sclerenchyma present, **spheroidal and vesiculose sclereids**; mainly associated with aggregates of primary sclerenchyma; sclerenchyma ring (persistent primary phloem caps or fibres) absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses sparsely imbedded in sclereid surfaces. Druses also present in phloem parenchyma.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals abundant, **prisms**, located mainly in axial phloem parenchyma; prisms, if associated with sclerenchyma, **encased within secondarily formed sclereids in the dilatation zone**; axially arranged chambered crystalliferous strands absent. **Druses** absent (in secondary phloem not affected by dilatation).

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell layer in closely spaced discontinuous tangential bands**; tanniniferous cells (not notably enlarged) **abundant; equally distributed throughout the whole bark.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, **stratification present, collapsed cell layer followed by a less collapsed cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged

phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, wall **distinctly pitted**; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; calcium oxalate crystals sparse. Phelloderm well developed, stratification present; **collapsed cell layer, followed by a sclereid layer, and then by a non-collapsed cell layer**; sclerified sclereids **assembled in irregularly shaped groups**; parenchyma cells mainly with tangential diameter greater than radial diameter; spheroidal, vesiculose and vermiform sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms and druses associated with sclereids at random** (in the phelloderm).

Cortex absent in mature bark.

4.2.12 *Ozoroa obovata* (Oliv.) R.A. Fernandes (3779, 3890, 3891, 3892, 3893)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform (compound); **sieve areas 1—4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** randomly dispersed.

PHLOEM RAYS. Phloem rays **heterocellular**, 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays 4—12 per mm; ray height less than 1 mm; **course more-or-less straight**; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **druses** randomly dispersed, **in addition, starch grains are observed down the ray cells, and ultimately stored in abundance in dilatation tissue.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising lignified fibres, forming regular compact groups**; fibres **non-septate**, walls very thin.

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays**; **continuous, forming a broad zone ("pseudocortex")**; well-defined dilatation meristem(s) **present**; sclerenchyma present, **spheroidal, vesiculose and vermiform** sclereids; **irregularly dispersed as clusters**; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses randomly dispersed and rarely prisms.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses**, prisms located mainly in dilatation tissue; druses located mainly in axial phloem parenchyma; prisms, if associated with sclerenchyma, **not encased in scleretic elements**; axially arranged chambered crystalliferous strands absent.

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a double cell lining layer in continuous tangential bands. Distance between bands maintained throughout the whole bark. Ducts with red stained contents**; tanniniferous cells (not notably enlarged) abundant; in both rays and phloem parenchyma, **with density increasing in the dilatation tissue.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) **present,** stratification **present, more compact cell layer outside a less compact cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, **all walls evenly thickened**, wall **distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; **calcium oxalate crystals absent.** Phelloderm well developed, stratification **present; compact cell layer alternating with a less compact cell layer**; partially sclerified sclereids irregularly scattered; parenchyma cells mainly with

tangential diameter greater than radial diameter; **spheroidal sclereids with tannin in their lumens, as well as unidentified red stained substances**; walls all evenly thickened; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.13 *Ozoroa paniculosa* (Sond.) R. A. Fernandes (3812, 3813)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 1–4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses sparsely distributed.**

PHLOEM RAYS. Phloem rays **heterocellular**, 2–4 rows of upright and/or square cells, **larger rays commonly 4–10-seriate**; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cell thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **druses** randomly distributed, but **in addition starch grains are observed down the ray cells, and ultimately stored in abundance in dilatation tissue.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising gelatinous fibres**, forming regular compact groups; **tangential in outline**; fibres **septate**, walls very thin; gelatinous fibres with S1 layer **non-lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; continuous, forming a broad zone ("pseudocortex")**; well-defined

dilatation meristem(s) **present**; sclerenchyma present, **spheroidal sclereids; irregularly dispersed as clusters**; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms and druses** randomly scattered.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses**, prisms located mainly in dilatation tissue; druses located mainly in ray cells; prisms, if associated with sclerenchyma, **encased within fibres**; druses, if associated with sclerenchyma, **encased within fibres.**

SECRETORY STRUCTURES. Secretory structures present, composed of **ducts, with a double cell membrane in discontinuous tangential bands associated with tanniniferous cells. Odd bands at random.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, compact cell layer followed by a less compact cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, **all walls evenly thickened**, walls **distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; calcium oxalate crystals sparse. Phelloderm well developed, stratification **present; compact cell layer followed by less compact cell layer**; partially sclerified sclereids irregularly scattered; **spheroidal, vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms and druses** randomly dispersed (in the phelloderm).

Cortex absent in mature bark.

4.2.14 *Ozoroa sphaerocarpa* R. A. Fernandes (3782, 3783)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime

not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 1—4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in **conspicuous tangential bands**, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays 4—12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified;** aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted;** tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** sparsely dispersed, and **in addition, starch grains are observed down the ray cells, and ultimately stored in the dilatation tissue.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising gelatinous fibres,** forming loose tangential groups; **fibres non-septate,** walls very thin; gelatinous fibres with S1 layer **non-lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; irregular ("diffuse" type);** well-defined dilatation meristem(s) present; sclerenchyma present, **spheroidal and vermiform sclereids;** irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified fibre clusters;** tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** in rays.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **druses,** located mainly in ray cells; druses, if associated with sclerenchyma, **not encased in scleretic elements;** axially arranged chambered crystalliferous strands **present, mainly associated with sclerenchyma,** cell **walls sclerified.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with single cell lining in discontinuous tangential bands. Ducts are fewer in dilatation tissue**; tanniniferous cells (not notably enlarged) abundant.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, a compact cell layer alternating with a less compact cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; **lignified cells (phellem/phelloid) with irregular shape**, all walls evenly thickened, walls **distinctly pitted**; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification present; cell layers separated by a layer of sclereids; sclerified **sclereids assembled in irregularly shaped groups**; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal sclereids**; walls all evenly thickened; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.15 *Protorhus longifolia* (Bernh.) Engl. (3743, 3744)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plate orientation oblique; sieve plates scalariform(compound); **sieve areas 1–4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** at random.

PHLOEM RAYS. Phloem rays heterocellular, 2–4 rows of upright and/or square cells, rays 1–3-seriate; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**;

aggregate rays absent; storied structure absent; ray cells thin walled, abundantly pitted; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, **comprising lignified fibres, and gelatinous fibres**, forming regular compact groups; tangential in outline; fibres **non-septate**, walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma only**; **irregular** ("diffuse" type); well-defined dilatation meristem(s) present; sclerenchyma present, **spheroidal, vesiculose, fusiform, filiform and palosclereid** sclereids; **irregularly dispersed as clusters**; sclerenchyma ring (persistent primary phloem caps or fibres) absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses**, prisms located mainly in dilatation tissue; druses located mainly in axial phloem parenchyma, ray cells, and dilatation tissue; prisms, if associated with sclerenchyma, **not encased in scleretic elements**; druses, if associated with sclerenchyma, **not encased in scleretic elements.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with single cell sheath in regular tangential bands**; tanniniferous cells (not notably enlarged) abundant; mainly in rays and dilatation tissue, also **in lumens of sclereids.**

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, tangential rows**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged)

sparse; idioblasts absent; **calcium oxalate crystals absent.** Phelloderm well developed, stratification **present; dark stained bands alternating with light stained bands**; sclerified sclereids assembled in irregularly shaped groups; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal and vesiculose** sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms associated with sclereids** (in the phelloderm).

Cortex absent in mature bark.

4.2.16 *Rhus batophylla* Codd (3778)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1—6 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **druses and prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays 4—12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified;** aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted;** tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses and prisms** randomly dispersed, and **in addition starch grains abundantly dispersed.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) present, comprising **lignified fibres, and gelatinous fibres**, forming loose tangential groups; tangential in outline; fibres **non-septate,** walls very thin; gelatinous fibres with S1

layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; irregular** ("diffuse" type); well-defined dilatation meristem(s) present; sclerenchyma present, **spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous** fibres; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses,** prisms located mainly in ray cells; druses located mainly in ray cells; prisms, if associated with sclerenchyma, **encased within fibres;** druses, if associated with sclerenchyma, **encased within fibres;** mainly associated with sclerenchyma, **cell walls sclerified.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell sheath in tangential bands;** tanniniferous cells (not notably enlarged) abundant; throughout the whole bark, but more concentrated in dilatation tissue.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, distinct layers on top of one another;** phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, walls **distinctly pitted;** tanniniferous cells (not notably enlarged) absent; idioblasts absent; **calcium oxalate crystals absent.** Phelloderm well developed, stratification **present; parenchymatous layer, followed by a layer with groups of lignified-gelatinous fibres; parenchymatous;** parenchyma cells mainly with tangential diameter greater than radial diameter; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex present, forming a distinct zone in the bark.

4.2.17 *Rhus chirindensis* Bak. f. (1795, 3808)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1—4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; number of rays 4—12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres, and gelatinous fibres,** forming regular compact groups; tangential in outline; fibres **non-septate**, gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; irregular** ("diffuse" type); well-defined dilatation meristem(s) present; sclerenchyma **present, spheroidal, vesiculose and vermiform in expanded secretory ducts;** irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** rarely found.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located **mainly in ray cells**; prisms, if associated with sclerenchyma, **encased within sclereids**; axially arranged chambered crystalliferous strands absent.

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell sheath in irregular discontinuous bands. Ducts in older section of the bark encase sclereids, thus being the sole expansion tissue**; tanniniferous cells (not notably enlarged) **abundant; mainly in rays, but also in phloem parenchyma.** The concentration increases in older bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) absent, stratification **present, more compact cell layer followed by less compact cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; **calcium oxalate crystals absent.** Stratification **present; sclereid free compact cell layer followed by a layer with sclereid bands**; partially sclerified sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.18 *Rhus gueinzii* Sond. (3876, 3877, 3878)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–3 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) sparse;

calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals present; **prisms** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres**, arranged in discontinuous tangential bands; tangential in outline; fibres **non-septate, walls thin to thick**; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue **poorly developed** or absent, derived from **phloem parenchyma only**; **irregular** ("diffuse" type); well-defined dilatation meristem(s) absent; sclerenchyma **present, spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** at random, **mainly in groups with newly formed sclereids.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly in dilatation tissue; prisms, if associated with sclerenchyma, **encased within fibres.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell sheath in irregular and weak tangential bands. In older bark ducts encase sclereids, thus forming the sole site for dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) sparse; in both rays and phloem parenchyma, concentration increases in older bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) absent, **stratification absent**; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; **calcium oxalate crystals absent.** Phelloderm well developed, stratification **present; collapsed cell layer followed by non-collapsed cell layer**; partially sclerified sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.19 *Rhus lancea* L. f. (3809)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1—3 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals absent; instead **starch grains are observed, and ultimately stored in dilatation tissue.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres, forming loose tangential groups**; tangential in outline; fibres **non-septate**, walls very thin.

DILATATION TISSUE. Dilatation tissue **poorly developed** or absent, **irregular** ("diffuse" type); well-defined dilatation meristem(s) **absent**; sclerenchyma **present, spheroidal and vesiculose sclereids**; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** at random.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly **in axial phloem parenchyma**; prisms, if associated with sclerenchyma, **encased within fibres.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts irregularly dispersed in weak tangential bands throughout the whole bark. Peculiar red stained substances in almost all ducts, thus making it difficult to observe the lining sheath.** In older bark **ducts encase sclereids, and become the sole site of dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; abundantly dispersed throughout the whole bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, collapsed cell layer followed by a non-collapsed cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, walls **distinctly pitted**; tanniniferous cells (not notably enlarged) absent; idioblasts absent; **calcium oxalate crystals absent.** Phelloderm well developed, stratification **present; more compact cell layer followed by a less compact cell layer; parenchymatous**; tanniniferous cells abundant; calcium oxalate crystals **absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.20 *Rhus leptodictya* Diels. (3738)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1—4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells present; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres**, arranged in discontinuous tangential bands; tangential in outline; fibres **non-septate**, walls very thin.

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays**; **irregular (`diffuse' type)**; well-defined dilatation meristem(s) absent; sclerenchyma **present, spheroidal, vesiculose and vermiform** sclereids; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals absent.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly in dilatation tissue; prisms, if associated with sclerenchyma, **encased within sclereids.**

SECRETORY STRUCTURES. Secretory structures present, composed of regular cavities, in regular tangential bands. **Ducts encase sclereids in older bark, thus becoming the sole site of dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; throughout the whole bark, but more concentrated in the outer bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, distinct cell layers on top of one another**; phellem cells with tangential diameter less than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter less than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; layers free of sclereids alternating with sclerified layers**; sclerified sclereids assembled in irregularly shaped groups; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform sclereids**; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals **absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.21 *Rhus natalensis* Berhn. (3896, 3897, 3898)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prisms** sparsely dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres**, forming loose tangential groups; irregular in outline; fibres **non-septate**, walls very thin; gelatinous fibres with S1 layer **distinctly lignified**.

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays**; **irregular ("diffuse" type)**; well-defined dilatation meristem(s) absent; sclerenchyma present, **spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous** fibres; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals(**prisms**) sparse, but concentrated in the middle bark.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals abundant, **prisms**, located mainly in axial phloem parenchyma, dilatation tissue, and phelloderm; prisms, if associated with sclerenchyma, encased within fibres; axially arranged chambered crystalliferous strands **present**, arranged in short tangential lines, cell walls **sclerified**.

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell sheath, with purple stained contents, irregularly and abundantly dispersed throughout the whole bark. Ducts in the older bark encase sclereids, and act as the sole site of dilatation**. Horizontal ducts run through the rays; tanniniferous cells (not notably enlarged) abundant; slightly sparse in the conducting phloem, but more concentrated in the older bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, tangentially arranged cell layers distinctly packed on top of one another**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) absent; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; sclereid free layers alternating with sclerified layers**; partially sclerified **sclereids predominantly solitary**; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform sclereids**; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed (in the phelloderm).

Cortex absent in mature bark.

4.2.22 *Rhus pendulina* Jacq. (3737)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–6 per plate; lateral sieve areas with callose deposits conspicuous**.

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2–4 rows of upright and/or square cells, rays 1–3-seriate; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed, **in addition starch grains were observed and are**

ultimately stored in abundance in dilatation tissue.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres**, forming loose tangential groups; **tangential** in outline; fibres **non-septate**, walls very thin.

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays**; **irregular** ("diffuse" type); well-defined dilatation meristem(s) present; sclerenchyma present, **spheroidal,vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly in dilatation tissue; prisms, if associated with sclerenchyma, **encased within fibres.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with red contents irregularly dispersed in weak tangential bands. Ducts in the older bark encase sclereids, which act as the sole site of dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; throughout the whole bark, but concentration increases towards the outer bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, distinct tangential layers lying on top of one another**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; crushed cell layer on the outside, followed by a sclerified layer, and then a layer of less crushed cells**; sclerified, sclereids assembled in irregularly shaped groups; parenchyma cells mainly with tangential diameter greater than radial

diameter; **spheroidal, vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals **absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.23 *Rhus pyroides* Burch. (3791, 3792, 3795)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1—4 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres**, forming loose tangential groups; **tangential in outline**; fibres **non-septate**, walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays**; **irregular ("diffuse" type)**; well-defined dilatation meristem(s) absent; sclerenchyma **present, spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed

as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals abundant, **prisms, located mainly in axial phloem parenchyma**; prisms, if associated with sclerenchyma, **encased within fibres.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts observed mainly in dilatation tissue encasing sclereids, acting as the sole site of dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; distributed throughout the whole bark, but concentration increasing towards the outer bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, **stratification absent**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; sclerified layers alternating with sclereid free layers**; partially sclerified sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal,vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.24 *Rhus rehmanniana* Engl. (1437)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–3 per plate;**

lateral sieve areas with callose deposits conspicuous.

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3-seriate; **number of rays 12 or more per mm**; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres,** forming regular compact groups; **tangential in outline**; fibres **non-septate,** walls very thin.

DILATATION TISSUE. Dilatation tissue **poorly developed** or absent, sclerenchyma **present, spheroidal, vesiculose and vermiform sclereids**; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified and cellulosic**; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

CALCIUM OXALATE CRYSTALS. **Calcium oxalate crystals absent.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell sheath irregularly dispersed in the old bark. Ducts encase sclereids, and act as the sole site for dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; throughout the whole bark, but concentration is high in the dilatation zone.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, compact cell layer, alternating with less compact cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, all **distinctly pitted**; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; layers free of sclereids alternating with sclerified layers**; partially sclerified sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal sclereids**; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals **absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.25 *Rhus* sp. (3889)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–3 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** at random.

PHLOEM RAYS. Phloem rays heterocellular, 2–4 rows of upright and/or square cells, rays 1–3-seriate; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified**; aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres, arranged in discontinuous tangential bands**; tangential in outline; fibres **non-septate**, walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays**; well-defined dilatation meristem(s) present; sclerenchyma **present, spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres lignified; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse (prisms and druses).

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses**, prisms located mainly in axial phloem parenchyma and ray cells; druses located mainly in dilatation tissue; prisms, if associated with sclerenchyma, **encased within fibres**; druses, if associated with sclerenchyma, **encased within sclereids and encased within fibres**; axially arranged chambered crystalliferous strands **present**, mainly associated with sclerenchyma, **cell walls sclerified.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts irregularly dispersed throughout the whole bark in rough tangential bands. Ducts in the old bark encase sclereids, and are the only site of dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; throughout the whole bark, but concentration increases towards the outer bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, distinct layers of cell lying on top of one another**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; calcium oxalate crystals absent. Phelloderm well

developed, stratification **present; parenchymatous layer followed by sclerified layer; partially sclerified inner layers more or less forming a sclerenchyma ring;** parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal and vesiculose** sclereids; walls all evenly thickened; tanniniferous cells abundant; **calcium oxalate crystals absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.26 *Rhus undulata* Jacq. (3739)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1—3 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

PHLOEM RAYS. Phloem rays heterocellular, 2—4 rows of upright and/or square cells, rays 1—3 seriate; **number of rays 12 or more per mm;** course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **not observed;** aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted;** tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres,** forming loose tangential groups; **tangential in outline;** fibres **non-septate,** walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; irregular ("diffuse" type)**; well-defined dilatation meristem(s) present; sclerenchyma present, **spheroidal, vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous fibres**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms** sparsely dispersed.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms**, located mainly in dilatation tissue; prisms, if associated with sclerenchyma, **encased within fibres**.

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts with a single cell sheath irregularly dispersed throughout the whole bark in rough tangential bands. In the older bark ducts encase sclereids, and are the only site of dilatation. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) abundant; throughout the whole bark but more concentrated in the middle and outer bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, distinct tangential cell layers on top of one another**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; layers sclereid free followed by sclerified layer**; partially sclerified sclereids irregularly scattered; **spheroidal, vesiculose and vermiform sclereids**; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms associated with sclereids** (in the phelloderm).

Cortex absent in mature bark.

4.2.27 *Schinus molle* L. (3742, 3748)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–6 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) sparse; **calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays heterocellular, 2–4 rows of upright and/or square cells, **larger rays commonly 4–10-seriate; number of rays 12 or more per mm;** ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **lignified;** aggregate rays absent; storied structure absent; ray cells thin walled, **abundantly pitted;** tile cells absent; tanniniferous cells (not notably enlarged) sparse; **calcium oxalate crystals absent.**

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres, and gelatinous fibres, forming regular compact groups; tangential in outline;** fibres **septate,** walls very thin; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; irregular** ("diffuse" type); well-defined dilatation meristem(s) present; **sclerenchyma absent;** primary phloem fibres **polylamellate lignified-gelatinous;** tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals absent.

CALCIUM OXALATE CRYSTALS. **Calcium oxalate crystals absent.**

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts in tangential bands between rays, surrounded completely in a band of tanniniferous cells;** tanniniferous cells (not notably enlarged) sparse; in ray columns and in tangential bands associated with secretory ducts, with density becoming thickest in the outer bark.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, compact cell layer followed by a less compact cell layer**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, walls **distinctly pitted**; tanniniferous cells (not notably enlarged) abundant; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, **stratification absent**; **parenchymatous**; tanniniferous cells abundant; calcium oxalate crystals absent; **chloroplast present** (in the phelloderm).

Cortex absent in mature bark.

4.2.28 *Sclerocarya birrea* (A. Rich.) Hochst. subsp. caffra (Sond.) Kokwaro (3730, 3731, 3732, 3733, 3747, 3784, 3901)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, sieve plates scalariform (compound); **sieve areas 1–6 per plate; lateral sieve areas with callose deposits conspicuous.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prisms in tangential bands associated with fibres.**

PHLOEM RAYS. Phloem rays heterocellular, 2–4 rows of upright and/or square cells, **larger rays commonly 4–10-seriate**; number of rays 4–12 per mm; ray height less than 1 mm; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma

lignified; storied structure absent; ray cells thin walled, **abundantly pitted**; tile cells absent; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prisms** rarely dispersed, in addition starch grains are observed in rays and ultimately stored in dilatation tissue.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres, and gelatinous fibres, forming regular compact groups; tangential in outline**; fibres **septate**, walls **thin to thick**; gelatinous fibres with S1 layer **distinctly lignified.**

DILATATION TISSUE. Dilatation tissue well developed, derived from **phloem parenchyma and rays; continuous, forming a broad zone** ("pseudocortex"); well-defined dilatation meristem(s) **absent**; sclerenchyma **present, spheroidal and vermiform sclereids**; mainly associated with aggregates of primary sclerenchyma; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **polylamellate lignified-gelatinous fibres**; tanniniferous cells (not notably enlarged) sparse; calcium oxalate crystals sparse, **prisms** sparsely dispersed.

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, located mainly in crystalliferous cells, associated with fibres**; prisms, if associated with sclerenchyma, **encased within chambered axial strands; cell walls sclerified.**

SECRETORY STRUCTURES. Composed of ducts, **ducts between rays in tangential bands. A conspicuously large space between the first band and the cambium. Horizontal ducts run through the rays**; tanniniferous cells (not notably enlarged) sparse; in continuous tangential bands, alternating with fibre bands.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, stratification **present, distinct cell layers lying on top of one another**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter,

all walls evenly thickened, thickened cells: **wall distinctly pitted**; tanniniferous cells (not notably enlarged) sparse; idioblasts absent; calcium oxalate crystals sparse. Phelloderm well developed, stratification **present; distinct more or less isodiametric cell layers on top of one another**; partially sclerified sclereids irregularly scattered; parenchyma cells mainly with tangential diameter greater than radial diameter; **vesiculose and vermiform sclereids**; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals **absent** (in the phelloderm).

Cortex absent in mature bark.

4.2.29 *Smodingium argutum* E. Mey. ex Sond. (3780, 3781)

SIEVE ELEMENTS. Sieve elements in groups; of intermediate length, type II; slime not observed; junction complexes between elements not observed; walls with nacreous layer absent; sieve plates oblique, scalariform (compound); **sieve areas 1–4 per plate; lateral sieve areas with callose deposits absent or weakly developed.**

AXIAL PHLOEM PARENCHYMA. Axial phloem parenchyma in conspicuous tangential bands, cells axially elongated; tanniniferous cells (not notably enlarged) abundant; **calcium oxalate crystals absent.**

PHLOEM RAYS. Phloem rays heterocellular, more than 4 rows of upright and/or square cells, rays **1–3-seriate** and **large rays commonly 4–10-seriate; number of rays 12 or more per mm; ray height more than 1 mm**; course more-or-less straight; portion of rays traversing or adjacent to sclerenchyma **not observed**; aggregate rays absent; storied structure absent; ray cells thin walled, abundantly pitted; tile cells absent; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **druses** randomly dispersed.

SCLERENCHYMA. Sclerenchyma (in secondary phloem not affected by dilatation growth) **present, comprising lignified fibres**, forming loose tangential groups; **tangential in outline**; fibres **non-septate**, walls **thin to thick.**

DILATATION TISSUE. Dilatation tissue **poorly developed** or absent, **derived from phloem parenchyma only**; **irregular** ("diffuse" type); well-defined dilatation meristem(s) absent; sclerenchyma present, **spheroidal,vesiculose and vermiform** sclereids; irregularly dispersed as clusters; sclerenchyma ring (persistent primary phloem caps or fibres) absent; primary phloem fibres **lignified**; tanniniferous cells (not notably enlarged) abundant; calcium oxalate crystals sparse, **prisms associated with sclereids.**

CALCIUM OXALATE CRYSTALS. Calcium oxalate crystals sparse, **prisms, and druses**, located mainly in ray cells; prisms, if associated with sclerenchyma, **encased within secondarily formed sclereids in the dilatation zone**; druses, if associated with sclerenchyma, **not encased in scleretic elements**; axially arranged chambered crystalliferous strands absent.

SECRETORY STRUCTURES. Secretory structures present, composed of ducts, **ducts irregularly scattered throughout the whole bark. Ducts in the middle and outer bark encase sclereids, thus acting as dilatation centers**; tanniniferous cells (not notably enlarged) abundant; uniformly dispersed throughout the dilatation tissue.

MATURE PERIDERM. Phellem compact; lignified cells (phelloid/phellem) present, **stratification absent**; phellem cells with tangential diameter greater than radial diameter; conspicuous radially enlarged phellem cells absent; lignified cells (phellem/phelloid) with tangential diameter greater than radial diameter, all walls evenly thickened, thickened cells: wall **distinctly pitted**; tanniniferous cells (not notably enlarged) absent; idioblasts absent; calcium oxalate crystals absent. Phelloderm well developed, stratification **present; irregular because of the abundant nature of sclereids**; sclerified sclereids assembled in irregularly shaped groups; parenchyma cells mainly with tangential diameter greater than radial diameter; **spheroidal, vesiculose and vermiform** sclereids; walls all evenly thickened; tanniniferous cells abundant; calcium oxalate crystals sparse, **prisms associated with sclereids** (in the phelloderm).

Cortex absent in mature bark.

CHAPTER 5

TAXONOMIC SIGNIFICANCE OF BARK ANATOMICAL CHARACTERS

5.1 INTRODUCTION

Roth (1981) did pioneering work on a broad spectrum of tropical barks representing 48 plant families. One of these families is the Anacardiaceae, of which she studied five genera. None of these genera are represented in southern Africa. Nonetheless, the knowledge provided by Roth (1981) forms the basis for the present comparative bark antomical study on the south African members of the family.

In this study an attempt is made to assess the taxonomic importance of the various bark anatomical features in southern African Anacardiaceae. The anatomical features investigated include various characters of the phloem parenchyma, phloem rays, sclerenchyma, dilatation tissue, calcium oxalate crystals, tanniniferous cells, secretory structures, mature periderm and cortex.

The taxonomic significance of the various bark tissues will be discussed separately. Attention will be given to both lower and higher taxonomic levels. Statements made refer to the taxa of the present investigation, unless stated otherwise.

A summary of the taxonomic variation of each tissue is given in the form of tables: Table 5.1 (Axial phloem parenchyma); Table 5.2 (Phloem ray characters); Table 5.3 (Sclerenchyma); Table 5.4 (Dilatation tissue); Table 5.5 (Calcium oxalate crystals); Table 5.6 Secretory structures; and Table 5.7 (Mature periderm), (see Part 2).

5.2 ANATOMICAL CHARACTERS

5.2.1 Axial phloem parenchyma

Roth (1981) concluded that parenchyma cells which are distinguished from ordinary parenchyma by their special content, such as oil, mucilage, tannin, crystals, may be referred to as idioblasts when occurring as individual cells or in small groups. Such cells can be of considerable **diagnostic** value.

In the present study, the distribution of axial phloem parenchyma in **conspicuous tangential bands** is a consistent feature in all the taxa, with the exception of *Mangifera indica*, which shows **weak tangential bands**.

The shape of phloem parenchyma cells is **axially (vertically) elongated** for all members, except in *Ozoroa namaquensis*, which has **more-or-less isodiametric** cells.

Tanniniferous cells are **present** in the axial phloem parenchyma of all members, except *Rhus rehmanniana*, where they are **absent**.

Calcium oxalate crystals are generally **present** even though a few samples (in the family as a whole) were without crystals in their axial phloem parenchyma. **Prisms** and **druses** are the only two crystal types that were observed. On the whole, where crystals occur, they are **sparsely** dispersed within the axial phloem parenchyma.

5.2.2 Phloem rays

Roth (1981) noted that there are several ray characters, such as ray width, homo- or heterogeneity of cells, frequency of rays, which are used by taxonomists for species identification. Metcalfe & Chalk (1965) also noted that the presence of exclusively uniseriate rays or of very wide pluriseriate ones is a rarely occuring character that may be used to distinguish closely related genera or species.

It is therefore concluded that phloem rays may be helpful in the identification of species, especially when they impose a certain conspicuous pattern on the bark.

Sclerification of rays may proceed in very different ways, but yet be very characteristic of the species.

In the present study, phloem rays were found to be **heterocellular** in all members, with **2–4 rows** of upright and or square cells, **except** in *Laurophyllus capensis* which has **only one row**, and *Smodingium argutum*, which has **more than 4** rows.

Ray width is generally in the category **1–3 seriate,** even though a few rays are **larger commonly 4–10 seriate,** as shown in Table 5.2. The number of rays per mm fall into two categories, **4–12 rays per mm** and **13 or more rays per mm**. Further details are provided in Table 5.2.

Ray height is **less than 1 mm**, except in *Smodingium*, where it is **more than 1 mm.**

The course of phloem rays is **more-or-less straight**, except in *Lannea*, which displays **a tendency towards undulation.**

In most cases those portions of rays traversing or adjacent to sclerenchyma are **lignified**, except in *Lannea antiscorbutica*, where it **remains parenchymatous** and in *Rhus undulata* and *Smodingium*, where it was **not observed** due to **the abundant presence of tanniniferous cells in the ray cells.**

Aggregate rays, storied structure,and tile cells are **absent within the family members studied.**

All ray cells are **thin walled** and **abundantly pitted,** except in the case of *Mangifera*, where the cells are **moderately pitted.**

Tanniniferous cells are **present** in the ray cells **of all members** of the family.

Calcium oxalate crystals are **generally present. A few taxa are however without** any calcium oxalate crystals in their ray cells, **as is shown in Table 5.2.** The types of crystals present are also shown in the latter table.

As shown in Table 5.2, **differences in phloem rays** appear to be **taxonomically useful on both generic and species level.**

5.2.3 Sclerenchyma

Roth (1981) concluded that for diagnostic purposes, the arrangement of fibres and sclereids in the bark is most important. She also notes that the formation of giant sclereids occurs relatively seldom and that it is restricted to certain families.

In sclerenchyma classification, qualitative and quantitative features are to be taken into account. Qualitative features involve composition - whether it is made of fibres, sclereids, fibre-sclereids or a mixture of all three, as well as its distribution or arrangement, which may be peculiar to the family, genus or species concerned. Quantitative features are represented by the size of sclerenchyma groups and the distance between adjacent groups.

In the present study, the sclerenchyma features discussed below pertain to that part of the **secondary phloem that is not affected by dilatation growth.**

Sclerenchyma is **present in all members** of the family as **fibres, except in** *Lannea schweinfurthii* **where sclereids are also found** and *Ozoroa engleri*, **where it is absent or poorly developed.**

The cells comprising the sclerenchyma can be grouped into **three types**, namely **lignified fibres, gelatinous fibres and sclereids.** The general sclerenchyma type in the family is **lignified fibres associated with gelatinous fibres, arranged in tangential bands.**

Fibres are **mainly non-septate**, except for a few which are **septate** as shown in Table 5.3.

Fibre walls are **mainly very thin**, except in a **few** taxa where it is **thin to thick.**

Gelatinous fibres have the S1 layer **distinctly lignified** throughout the family, with the exception of a few cases where S1 layers are either **weakly lignified** or **non-lignified.**

Table 5.3 **shows clearly that differences in sclerenchyma appear to be taxonomically useful on both generic and species level.**

5.2.4 Dilatation tissue

Roth (1981) noted that the pattern of dilatation growth is very specific and may be used for identification. The rays may dilate in a regular manner, which is known as funnel-shaped, or they may expand in a more irregular pattern, which is the state most commonly found. Very highly developed rays dilate through a special dilatation meristem in central position. Margin ray meristems also exist.

The dilatation tissue in **the species studied** is **well developed,** except for all members of *Rhus* and *Smodingium*, where dilatation is **solely in the form of expansion of the secretory ducts.**

Dilatation tissue is **generally** derived from **both phloem parenchyma and phloem rays,** with **some exceptions** where it is derived from only one of these two tissues.

Dilatation tissue type is **mainly irregular / "diffuse",** except in two members of *Ozoroa* and in *Sclerocarya*, where dilatation **is continuous in the form of a pseudo-cortex.** In *Ozoroa namaquensis*, **rays are regularly dilated and wedge shaped** and in *Laurophyllus capensis*, **they are continuous and interdigitizing with secondary phloem** are also exceptions.

Well-defined dilatation tissue **meristems** are **present in more than 50 % of the cases, as shown in Table 5.4.**

A sclerenchyma ring is **absent in all the taxa, except in *Loxostylis,* where it is present.**

Secondary sclereids of variable shapes and sizes are **either irregularly dispersed as clusters, or as aggregates mainly associated with the primary sclerenchyma.**

Tanniniferous cells (not notably enlarged) **are present** in dilatation tissue of members of the family, **except in *Harpephyllum*.**

Prisms and druses are the **only two types** of calcium oxalate crystals observed in the family. Druses are **mainly present in members of *Ozoroa*.**

Table 5.4 supports the conclusion that variations in dilatation tissue appear to be taxonomically useful at both generic and species levels.

5.2.5 Calcium oxalate crystals

As stated by Roth (1981), crystals of calcium oxalate are often diagnostic. Crystals can be used diagnostically only when they are of a particular type, show a peculiar distribution or arrangement, or when they become very conspicuous by reaching giant sizes.

In the present study, only two types of calcium oxalate crystals, namely **prisms** and **druses**, were observed. **Druses are characteristic of members of *Ozoroa*,** whereas **prisms** are found, **generally, throughout the family, except in *Schinus*, *Laurophyllus* and *Rhus rehmanniana*, in which crystals are absent.**

Where crystals are present, they are generally **sparsely dispersed.** They are occur **mainly in axial phloem parenchyma, ray cells, dilatation tissue, phellem and phelloderm** as shown in Table 5.5.

If crystals are associated with sclerenchyma they are mainly not encased in sclerotic elements.

In *Laurophyllus capensis*, *Schinus molle* and *Rhus rehmanniana* calcium oxalate crystals are **absent.**

Table 5.5 shows that calcium oxalate crystals are taxonomically useful on both generic and species level.

5.2.6 Secretory structures

According to Roth (1981) secretory structures supply excellent diagnostic criteria. The secretory structures may be surrounded, very characteristically, by a special parenchyma sheath.

In the present study, secretory structures **in the form of ducts are present in all members of the family.**

There is a **general tendency for the ducts to be aligned in continuous tangential bands, associated with tanniniferous cells.** In **tangential sections, horizontal ducts are seen running through rays** in a number of taxa, as shown in table 5.6.

Both single-celled and double-celled sheaths may line the secretory ducts. The **nature and abundance of tanniniferous cells, however, makes it difficult to observe sheaths in some members** of the family (Table 5.6)

Tanniniferous cells **are always associated with secretory ducts.** The **density of** tanniniferous cells **increases from the cambium towards the periderm, where it is highest.**

Rhus and *Smodingium* are **conspicuously different from other genera in that secretory ducts may encase sclereids and act as sites of dilatation.**

It is clear from **Table 5.6 that differences in secretory ducts are taxonomically useful at both generic and species level.**

5.2.7 Mature periderm

Roth (1981) noted that phellem characters, especially those of scarce occurrence, provide excellent diagnostic criteria. Phellem prickles and aerenchyma are particularly diagnostic because of their scarcity.

A well developed and differentiated phelloderm may help in identification, especially when species within the same genus are to be distinguished.

5.2.7.1 Phellem

In the present study, phellem of the taxa studied is **compact.** Lignified cells **are present in phellem, except in *Ozoroa engleri, Rhus chirindensis* and *R. gueinzii.***

Phellem cells are **axially elongated in all taxa.** Phelloid cells where **present are axially elongated,** except **in *Ozoroa sphaerocarpa*, where they are of irregular shapes. All walls of phelloid cells are evenly thickened.** Thickened cell walls are **mainly distinctly pitted, except in *Lannea discolor,* in which the pits are indistinct.**

Tanniniferous cells are **generally present, but absent in *Harpephyllum caffrum*, *Heeria argentea*, *Laurophyllus capensis*; *Ozoroa engleri*, *Rhus batophylla*, *R. lancea*, *R. natalensis*** and ***Smodingium argutum***.

5.2.7.2 Phelloderm

Phelloderm is **well developed and stratified** in all members of the family. It is **either parenchymatous or sclerified, as indicated in Table 5.7**. The following sclereid types are present: **spheroidal, vesiculose and vermiform.**

Parenchyma cells in the phelloderm are **axially elongated,** except **in *Lannea schweinfurthii*, where they are more-or-less isodiametric.**

Where sclereids are present, **walls are evenly thickened.**

Tanniniferous cells are **mainly abundant**, but are **absent** in *Harpephyllum caffrum* and *Ozoroa sphaerocarpa*.

Calcium oxalate crystals are either **present or absent, as is shown in Table 5.7.**

The summary in Table 5.7, indicates that differences in mature periderm are useful at both the generic and species level.

5.2.8 Cortex

Cortex is **absent** in the mature bark of most members of this family, however in *Rhus batophylla*, it is **present, forming a distinct zone.**

5.3. SUMMARY OF INFRAGENERIC VARIATION

Major bark anatomical differences between species within each selected genus are recorded here. Significant diagnostic characters are in bold.

-Tribe: Spondieae

Genus: *Lannea*

Species: *L. antiscorbutica* — sieve areas 4—10 per plate; **lateral sieve areas with callose deposits conspicuous**; calcium oxalate crystals absent in axial phloem parenchyma; phloem rays 1—3 seriate, sclerenchyma (in phloem not affected by dilatation) comprising lignified, gelatinous and fibres; gelatinous fibres with S1 layer distinctly lignified; axial chambered crystalliferous strands with cell walls **remaining parenchymatous**; horizontal secretory ducts absent; phelloid cells (in phellem) with walls distinctly pitted; parenchyma cells (in phelloderm) axially elongated.

Species: *L. discolor* — sieve areas 5—10 per plate; **lateral sieve areas with callose deposits absent or weakly developed**; calcium oxalate crystals present in axial phloem parenchyma; phloem rays 4—10 seriate; sclerenchyma (in secondary phloem not affected by dilatation) comprising gelatinous fibres; gelatinous fibres with S1 layer **non-lignified**; axially chambered crystalliferous strands with cell walls sclerified; **horizontal secretory ducts present**; Phelloid cells (in phellem) with walls indistinctly pitted; parenchyma cells (in phelloderm) **axially elongated.**

Species: *L. schweinfurthii* — sieve areas 5—10 per plate; **lateral sieve areas with callose deposits conspicuous**; calcium oxalate crystals present in axial phloem parenchyma; phloem rays 4—10 seriate; sclerenchyma (in secondary phloem not affected by dilatation) comprising lignified, gelatinous fibres and **sclereids**; gelatinous fibres with S1 layer distinctly lignified; axially chambered crystalliferous strands with cell walls sclerified; **horizontal secretory ducts absent**; phelloid cells (in phellem) with walls distinctly pitted; parenchyma cells (in phelloderm) **more-or-less isodiametric.**

-Tribe: Rhoeae

Genus: *Ozoroa*

Species: *O. engleri* – **sieve areas 1–5 per plate**; phloem parenchyma cells axially elongated; **prisms and druses** present in phloem rays; phloem rays tanniniferous; sclerenchyma (in secondary phloem not affected by dilatation) comprising lignified fibres; fibres **non-septate**; gelatinous fibres with S1 layer **distinctly lignified**; prisms associated with sclerenchyma encased within sclereids; secretory ducts with double celled sheath; phelloid cells (in phellem) absent; phellem stratification absent.

Species: *O. mucronata* – **sieve areas 2–5 per plate**; phloem parenchyma cells axially elongated; **fibres non-septate**; gelatinous fibres with S1 layer **weakly lignified**; dilatation derived from **phloem rays**; secretory ducts in discontinuous tangential bands.

Species: *O. namaquensis* – **sieve areas 1–5 per plate**; phloem parenchyma cells **more-or-less isodiametric**; **phloem rays 12 or more per mm**; **fibres non-septate**; gelatinous fibres with S1 layer **distinctly lignified**; dilatation derived from phloem parenchyma; **dilatation tissue wedge-shaped**; primary **fibres lignified**; prisms within secondarily formed sclereids in dilatation tissue; secretory ducts in discontinuous tangential bands; **secretory ducts with single celled sheath.**

Species: *O. obovata* – **sieve areas 1–4 per plate**; phloem parenchyma cells axially elongated; sclerenchyma (in secondary phloem not affected by dilatation) comprising lignified fibres; **fibres non-septate**; gelatinous fibres with S1 layer **distinctly lignified**; **dilatation tissue continuous forming pseudocortex**; primary fibres lignified; secretory ducts in continuous tangential bands; secretory ducts with double celled sheath.

Species: *O. paniculosa* – **sieve areas 1–4 per plate**; phloem parenchyma cells axially elongated; **phloem rays 4–10 seriate**; **fibres septate**; gelatinous fibres with S1 layer **distinctly lignified**; **dilatation tissue continuous forming pseudo-cortex**; calcium oxalate crystals associated with sclerenchyma encased within fibres; secretory ducts in discontinuous tangential bands; **odd short secretory duct bands present**; secretory ducts with double celled

sheath.

Species: *O. sphaerocarpa* — **sieve areas 1—4 per plate**; phloem parenchyma cells axially elongated; **fibres non-septate**; **gelatinous layer with S1 layer non-lignified**; druses associated with sclerenchyma not encased in scleretic elements; druses encased within chambered axial strands; secretory ducts in discontinuous tangential bands; **secretory ducts with single celled sheath**; **phelloid cells (in phellem) irregularly shaped.**

Genus: *Rhus*

Species: *R. batophylla* — sieve areas 1—6 per plate; phloem rays 4—12 per mm; sclerenchyma (in secondary phloem not affected by dilatation) comprising **lignified and gelatinous** fibres; dilatation meristem present; primary fibres polylamellate lignified-gelatinous fibres; calcium oxalate crystals, **druses and prisms**; calcium oxalate crystals associated with sclerenchyma encased within fibres; axially chambered crystalliferous strands present, cell walls sclerified; secretory ducts in continuous tangential bands; phelloderm, sclereids absent; **cortex present forming distinct zone.**

Species: *R. chirindensis* — sieve areas 1—4 per plate; phloem rays 4—12 per mm; sclerenchyma (secondary phloem not affected by dilatation) comprising **lignified and gelatinous** fibres; dilatation meristem present; primary fibres polylamellate lignified-gelatinous; phelloid cells(in phellem) absent; **phelloderm, tangential sclereid bands.**

Species: *R. gueinzii* — sieve areas 1—3 per plate; phloem rays **12 or more per mm**; sclerenchyma (in phloem parenchyma not affected by dilatation) lignified fibres; **fibre walls thin to thick**; calcium oxalate crystals associated with sclerenchyma encased within fibres; phelloid cells (in phellem) absent; **phellem stratification absent.**

Species: *R. lancea* — sieve areas 1—3 per plate; sclerenchyma (in secondary phloem not affected by dilatation) comprising lignified fibres; secretory ducts in continuous tangential bands; **phelloderm, sclereids absent.**

Species: *R. leptodictya* — sieve areas 1—4 per plate; phloem rays 12 or more per mm; sclerenchyma (in secondary phloem not affected by dilatation) lignified fibres; prisms associated with sclerenchyma encased within sclereids; secretory ducts in continuous tangential bands.

Species: *R. natalensis* — sieve areas 1—4 per plate; phloem rays 12 or more per mm; sclerenchyma (in phloem parenchyma not affected by dilatation) comprising **lignified and gelatinous** fibres; primary fibres polylamellate lignified-gelatinous; prisms associated with sclerenchyma encased within fibres; chambered axial crystalliferous strands present; axially chambered crystalliferous strands, cell walls sclerified; **phelloderm, sclereids predominantly solitary.**

Species: *R. pendulina* — sieve areas 1—6 per plate; phloem rays 4—12 per mm; sclerenchyma(in secondary phloem not affected by dilatation) comprising lignified fibres; dilatation meristem present.

Species: *R. pyroides* — sieve areas 1—4 per plate; phloem rays 12 or more per mm; sclerenchyma (in secondary phloem not affected by dilatation) comprising **lignified and gelatinous** fibres; phellem stratification absent.

Species: *R. rehmanniana* — sieve areas 1—3 per plate; sclerenchyma (in secondary phloem not affected by dilatation) comprising lignified fibres; dilatation meristem present; primary fibres polylamellate, **lignified-gelatinous**; phelloderm, spheroidal sclereids only.

Species: *Rhus sp.* — sieve areas 1—3 per plate; phloem rays 4—12 per mm; sclerenchyma (in secondary phloem not affected by dilatation) comprising **lignified and gelatinous** fibres; dilatation meristem present; calcium crystal oxalate crystals, **druses and prisms**; axially arranged chambered crystalliferous strands, cell walls sclerified; phelloderm, **inner layer forming more-or-less sclerenchyma ring.**

Species: *R. undulata* — sieve areas 1—3 per plate; phloem rays **12 or more per mm**; sclerenchyma (in secondary phloem not affected by dilatation) comprising lignified and gelatinous fibres; primary fibres polylamellate; prisms associated with sclerenchyma encased within fibres.

5.4. DICHOTOMOUS BARK ANATOMICAL KEY TO THE SPECIES

Reference to sclerenchyma, fibres and sclereids in the key refers to elements contained in those parts of the secondary phloem not affected by dilatation growth. In some cases more than one species are keyed out at the same lead because further differentiation on the basis of bark structure is not possible.

1a Sclerenchyma exclusively fibres (lignified and/or gelatinous 2
1b Sclerenchyma comprising fibres and sclereids . . . . . *Lannea schweinfurthii*

2a Fibres septate 3
2b Fibres non-septate 4

3a S1 layer lignified 5
3b S1 layer non-lignified . . . . . *Lannea discolor*

4a S1 layer lignified 7
4b S1 layer non-lignified . . . . . *Ozoroa sphaerocarpa*

5a Phloem ray course more-or-less straight 6
5b Phloem ray course undulate . . . . . *Lannea antiscorbutica*

6a Calcium oxalate crystals mainly prisms . . . . . *Sclerocarya birrea*
6b Calcium oxalate crystals mainly druses . . . . . *Ozoroa paniculosa*

7a Phloem rays 4—12 per mm 8

7b Phloem rays more than 12 per mm 9

8a Secretory ducts regularly dispersed 18

8b Secretory ducts irregularly dispersed 22

9a Secretory ducts regularly dispersed 10

9b Secretory ducts irregularly dispersed 13

10a Ducts in continuous tangential bands 11

10b Ducts in discontinuous tangential bands . . . . . *Ozoroa namaquensis*

11a Horizontal radial ducts present . . . . . *Loxostylis alata*

11b Horizontal radial ducts absent 12

12a Calcium oxalate crystals present . . . . . *Mangifera indica*

12b Calcium oxalate crystals absent . . . . . *Laurophyllus capensis*; *Schinus molle*

13a Ray height less than 1 mm 14

13b Ray height more than 1 mm . . . . . *Smodingium argutum*

14a Prisms present in ray cells 15

14b Prisms absent in ray cells . . . . . *Rhus leptodictya*

15a Sclerenchyma comprising exclusively of lignified fibres . . . . . *Rhus gueinzii*
Heeria argentea

15b Sclerenchyma comprising both lignified and gelatinous fibres 16

16a Dilatation meristem present . . . . . *Rhus undulata*

16b Dilatation meristem absent 17

17a Primary phloem fibres polylamellate . . . . . *Rhus natalensis*

17b Primary phloem fibres lignified . . . . . *Rhus pyroides*

18a Odd short duct bands present . . . . . *Harpephyllum caffrum*

18b Odd short duct bands absent 19

19a Ducts with single-cell sheath . . . . . *Protorhus longifolia*

19b Ducts with double-cell sheath 20

20a Phellem stratification present 21

20b Phellem stratification absent . . . . . *Ozoroa engleri*

21a Calcium oxalate crystals in phellem present . . . . . *Ozoroa mucronata*

21b Calcium oxalate crystals in phellem absent . . . . . *Ozoroa obovata*

22a Sclerenchyma comprising exclusively lignified fibres 23

22b Sclerenchyma not exclusively lignified fibres 24

23a Tangential dilatation meristem present . . . . . *Rhus pendulina*

23b Tangential dilatation meristem absent . . . . . *Rhus lancea*

24a Calcium oxalate crystals encased within chambered axial strands 25

24b Calcium oxalate crystals not encased within chambered axial strands 26

25a Phelloderm sclerified . . . . . *Rhus sp.*

25b Phelloderm not sclerified . . . . . *Rhus batophylla*

26a Phelloderm with tangential sclereid bands . . . . . *Rhus chirindensis*

26b Phelloderm without tangential sclereid bands . . . . . *Rhus rehmanniana*

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.1 INTRODUCTION

According to Arnold & De Wet (1993), the Anacardiaceae is represented by 13 genera and 105 species in the Flora of southern African region. Ten genera are indigenous, and three, namely *Anacardium*, *Mangifera* and *Schinus*, are aliens which have been naturalized in the region. This study includes representatives of all the indigenous genera of southern African Anacardiaceae, as well as two alien genera, namely *Mangifera* and *Schinus*. The latter were included because they have become well-established in the region and are widely utilized in traditional medicine.

Recent work by Cronquist (1981) regarding the Julianaceae as a separate family and that by Dahlgren (1983), which includes the Julianaceae in the Anacardiaceae whist separating the Dobineeae from Anacardiaceae, suggest that new taxonomic evidence needs to be gathered to resolve these conflicting taxonomic decisions. Meaningful comparison of the bark structure of local Anacardiaceae with their counterparts elsewhere in the world is not possible at present because of the lack of any published bark anatomical information on the Anacardiaceae. The present study has nevertheless shown that bark anatomy is an attractive potential source of evidence for resolving taxonomic problems.

This study represents the first comprehensive study of bark structure in the southern African Anacardiaceae. This is regarded as a valuable contribution to the identification of the family since traditional remedies, where bark is mainly used, is gaining momentum despite the advances in modern and orthodox medicine. Knowledge of the bark anatomical structure of local members could thus be put to good use in the identification of bark samples belonging to the Anacardiaceae.

6.2 MATERIALS AND METHODS

6.2.1 Materials

Mature bark samples yielded more informative results than immature ones. From the experience gained in the present study it is strongly recommended that only bark samples collected from mature boles be used for this type of comparative study.

No significant differences were noted in the structure of bark collected from plants in natural stands, and that collected from plants grown in gardens.

The practice of collecting at least three different bark samples per species is recommended as this helps in guarding against artifacts and helps to establish the infraspecific variability of characters.

6.2.2 Microscopy

It was noted that in the process of sectioning, the use of steam is essential for softening the material, making it possible to obtain sufficiently thin sections. The more brittle and harder bark samples, however, could hardly be sectioned below 40 micro-meters.

Whilst preparing the material to observe sieve elements, care should be taken to cut sections as thin and close to the cambium as possible, otherwise observation may be difficult due to the fact that the sieve tubes are collapsed towards the dilatation zone.

The procedure of staining and permanent mounting of the bark sections based on Van Wyk (1985) yields excellent results and is recommended for future studies.

6.2.3 The DELTA Computer Programme

The use of the programme for generating bark descriptions proved to be effective and a great time saver. The character list used (included in Part 2), covered all relevant characters and character states found in this family. It is concluded that the character list is functional and relevant. Evidence encoded in this way could be used in future efforts to produce an interactive computer key for the identification of bark samples.

6.2.4 Illustrations

The bark of the Anacardiaceae has a complicated pattern of fibre arrangement which could not be adequately depicted in the simple line drawings conventionally used to illustrate bark anatomy. The abundant presence of gelatinous fibres in the secondary phloem portion not affected by dilatation led to the exclusion of the black shading normally used for fibres (or other sclerenchyma elements) in the illustrations. Such shading would have resulted in the whole portion not affected by dilatation being shaded black. Only secondary sclereids are shaded black in the line drawings. A caption is written below each illustration to indicate those types of fibre found in the secondary phloem that is not affected by dilatation growth.

6.3 SOUTHERN AFRICAN ANACARDIACEAE

6.3.1 Taxonomic representation

Three tribes, ten indigenous and two exotic genera and twenty nine species representing all southern African genera of the family, were studied.

6.3.2 Medicinal or economic uses of the species studied

The study has noted that street corner "chemists", dealing in bark samples and other plant materials are mushrooming in our towns and cities, despite the level of development in science and technology. It is clear that a large number of people are still using bark as medicine. The

potential for new remedies to be discovered in bark exists. It is the duty of plant anatomists to systematically record bark structure so that these can be used in the correct identification of bark samples.

Current literature clearly shows that the increase in the use of crude plant drugs is a world-wide phenomenon. In this study, this section serves as a `spice' to `season' this important `dish' of bark anatomical structure. This intends to serve as a catalyst for the future research on bark structure of other families, thus facilitating the controlled use of bark in traditional medicine.

6.4 TAXONOMIC SIGNIFICANCE OF BARK ANATOMICAL CHARACTERS

In this study the following observations and conclusions were made and arrived at respectively for southern African Anacardiaceae.

- **Sieve plates**

Tribe: Anacardieae - sieve areas number 3—6; lateral sieve areas with callose deposits conspicuous

Tribe: Rhoeae - sieve areas in three categories viz. number 1—4, *Loxostylis, Ozoroa*, and *Smodingium* number 1—6, *Schinus* number 1—3, *Rhus* number 2—6, *Heeria*, and *Laurophyllus*; lateral sieve areas with callose deposits conspicuous.

Tribe: Spondieae - Sieve areas in two categories viz. number 4—10, *Harpephylum*, and *Lannea* number 1—6, *Sclerocarya* ; Lateral sieve areas with callose absent or weakly deposited in *Harpephyllum*, and *Lannea discolor.*

Sieve plates are of taxonomic significance at tribal, genera and species level.

■ Axial phloem parenchyma

The classification of *Mangifera indica* into its own tribe Anacardieae is supported by the fact that its axial phloem parenchyma depicts weak tangential bands, whereas all other taxa show conspicuous tangential bands.

Phloem parenchyma cells of *Ozoroa namaquensis* and those of *Protorhus longifolia* differ in that those of the former are more-or-less isodiametric, whereas those of the latter are axially elongated. This difference supports their separation into two genera distinguished by Von Teichman & Van Wyk (1994).

The presence of druses in the investigated species of *Ozoroa* is a constant character. The presence of druses in *Protorhus longifolia* suggests close relationship to *Ozoroa*.

Rhus batophylla, with druses of calcium oxalate in the axial phloem parenchyma, is somewhat anomalous because all the other investigated *Rhus* species have prisms. Incidentally, *R. batophylla* appears to be quite isolated morphologically among other members of the genus in southern Africa (Moffet 1993).

■ Phloem rays

It would be interesting to compare phloem rays in the bark with the findings of Kromhout (1975) on wood, but since only 5 species belong to Anacardiaceae, it is considered not sufficient to make any conclusions about similarities or differences between wood and bark as far as rays are concerned.

The general tendency in the family is that of phloem rays with 2—4 rows of upright and or square cells. *Laurophyllus capensis*, however, shows only one row of cells while *Smodingium argutum* has more than 4 rows. Both of these taxa represent monotypic genera.

Lannea discolor and *L. schweinfurthii* stand out with larger rays, commonly 4—10 seriate. In this character *L. antiscorbutica* differs from the rest in having 1—3 seriate rays. *Ozoroa paniculosa* is also exceptional in having 4—10 seriate rays.

Ray height in this case separates *Smodingium argutum* from the rest of the family, in that rays are larger than 1 mm in height.

The course of phloem rays display a tendency towards undulation in *Lannea* as a genus, whereas it is more or less straight in the rest of the family.

In the case of *Lannea antiscorbutica*, a portion of rays traversing or adjacent to sclerenchyma remains parenchymatous, in contrast with the rest of the family.

■ **Sclerenchyma** (portion not affected by dilatation)

It is concluded that for diagnostic purposes, the arrangement of fibres and sclereids are the most important distinguishing characteristics. Quantitative and qualitative properties of sclerenchyma play an important part in isolating at family, genus and species levels.

It is particularly noteworthy that all investigated members of the family are without sclereids in this portion of the phloem except *Lannea schweinfurthii,* which has a few. On the other hand, *Ozoroa engleri* has no "sclerenchyma", in that even the fibres are absent or poorly developed. Viewed superficially, axial parenchyma cells may be mistaken for gelatinous fibres in *O. engleri* - it is only proved otherwise when these are viewed under polarized light. The absence of a "G" layer also supports the fact that they are not gelatinous fibres.

An outstanding diagnostic character for the family is the presence of abundant gelatinous fibres which in most cases completely fill the whole portion of phloem not affected by dilatation.

Primary fibres, however, are generally polylamellate, lignified-gelatinous.

Fibres are predominantly non-septate. However, the presence of septate fibres in *Lannea antiscobutica, L. discolor, Ozoroa paniculosa* and *Sclerocarya birrea* is, however, of diagnostic significance.

■ Dilatation tissue

The dilatation tissue of *Rhus* and *Smodingium* set these two genera apart from the rest of the family. In both genera dilatation takes place in the form of sclereids which develop in the secretory ducts, thus causing the expansion of the ducts. It is especially interesting to note that the secretory ducts are the sole site of dilatation in these two genera, a strong taxonomic character indeed.

Dilatation tissue of all other members of the family is generally derived from both phloem parenchyma and phloem rays. *Laurophyllus capensis* stands out in that its dilatation tissue is mainly derived from the phloem rays.

Although dilatation tissue is mainly irregular/ "diffuse", it is noteworthy that in *Ozoroa obovata, O. paniculosa* and *Sclerocarya birrea* dilatation is continuous, forming a pseudo-cortex while in *Ozoroa namaquensis*, the rays are dilated and wedge-shaped. In *Laurophyllus capensis* it is continuous, interdigitizing with the secondary phloem.

Tangential dilatation meristems were found to be present in more than 50% of the cases. One can therefore conclude that this kind of meristem is probably characteristic of the family. This type of dilatation meristem has apparently not been previously reported.

■ Calcium oxalate crystals

Laurophyllus capensis, Rhus rehmanniana and *Schinus molle* differ from the rest of the investigated taxa in that they do not have calcium oxalate crystals. Where crystals are found,

they are sparsely distributed except in *Heeria argentea, where the* crystals are small but abundantly dispersed within the cells.

Druses and prisms are the only types of calcium oxalate crystals observed in this study. Druses are always present in *Ozoroa* and are thus diagnostic for the genus.

■ Secretory structures

Secretory ducts tie the Anacardiaceae together in that they are present in all members. They generally display a tendency towards arrangement in continuous tangential bands associated with tanniniferous cells.

Of potential taxonomic significance is the presence of a distinct sheath of secretory cells lining the ducts in some members of the family. Single-celled sheaths are present in *Mangifera indica, Ozoroa namaquensis* and *O. sphaerocarpa*, whereas double-celled sheaths are present in *O. engleri, O. obovata* and *O. paniculosa.*

The presence of horizontal radial ducts is another good taxonomic character. Ducts were observed in *Lannea discolor*, all the *Rhus* species and in *Sclerocarya birrea.* Kromhout (1975) recorded secretory ducts in the xylem rays of *Harpephyllum caffrum.* Contrary to what one would expect, no such ducts were noted in the phloem rays of this species in the present study.

Tanniniferous deposits are conspicuously present in sclereid lumens in *Heeria argentae, Laurophyllus capensis, Loxostylis alata* and *Protorhus longifolia.*

The separation of *Ozoroa namaquensis (=Protorhus namaquensis)* and *Protorhus longifolia* (Von Teichman & Van Wyk 1994) is further supported by the fact that only *Protorhus longifolia* has such deposits in its sclereid lumens. Moreover, *Ozoroa namaquensis* has a sheath surrounding the secretory ducts, whereas in *Protorhus longifolia* this is absent.

Laurophyllus capensis differs from all other investigated taxa in having the secretory structures in the outer bark conspicuously enlarged, oval in shape and completely surrounded by sclereids.

- **Mature periderm**

The presence of phelloid cells in the phellem is a general tendency in the family as a whole, but they are absent in *Ozoroa engleri*, *Rhus chirindensis*, and *R. gueinzii*. *Ozoroa sphaerocarpa* is quite distinct in that the phelloid cells are of irregular shapes. This phenomenon is of taxonomic significance. The thickened walls are distinctly pitted, except in *Lannea discolor*, where the cells are indistinctly pitted, thus separating this species from the rest of the family.

The following species differ from the rest in that they lack tanniniferous cells in the phellem cells: *Harpephyllum caffrum, Heeria argentae, Laurophyllus capensis, Ozoroa engleri, Rhus batophylla, R. lancea, R. natalensis* and *Smodingium argutum.*

Phelloderm is either sclerified or parenchymatous. The following species can be singled out in that their phelloderms are exclusively parenchymatous: *Harpephyllum caffrum, Heeria argentae, Laurophyllus capensis, Rhus batophylla, R. lancea* and *Schinus molle.*

The arrangement of sclereids in the phelloderm can be used to distinguish between taxa at genus and species levels (see illustrations in Part 2).

Parenchyma cells in the phelloderm can also be used to identify species. Parenchyma cells in *Lannea schweinfurthii*, for example, are peculiarly more or less isodiametric, whereas in all other members these cells are axially elongated.

The presence or absence of tanniniferous cells in the phelloderm is also of taxonomic importance. Tanniniferous cells are absent from this part of the bark in *Harpephyllum caffrum* and *Ozoroa sphaerocarpa.*

Cortex was only observed in *Rhus batophylla,* as is shown in the illustrations in Part 2. The presence of cortex in the sample might be attributable to it being from a relatively young plant with the cortex being shed in older, mature specimens. This study concludes that in Anacardiaceae cortex is absent in mature bark.

SUMMARY

THE TAXONOMIC SIGNIFICANCE OF BARK STRUCTURE IN SOUTHERN AFRICAN ANACARDIACEAE

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This study is the most comprehensive to date on bark structure in members of the Anacardiaceae. The bark structure of 29 species belonging to 12 genera of southern African Anacardiaceae was studied to assess its diversity and taxonomic significance. A comprehensive bark anatomical description is provided for each species supplemented by comparative tables and illustrations. The principal aims of this study are to provide detailed bark anatomical descriptions for selected woody members of southern African Anacardiaceae; to evaluate the taxonomic significance of bark anatomical features in southern African Anacardiaceae; to comment on interesting tissues and structures; to explore the usefulness of bark anatomical characters for identifying unknown bark samples, for example, those used in the medicinal bark trade; to test and, if neccessary, refine a comprehesive bark anatomical list previously developed for use with the DELTA computer programme.

A total of 112 characters were studied for each species. These include characters pertaining to the sieve plates, axial phloem parenchyma, phloem rays, sclerenchyma in portions not affected by dilatation, dilatation tissue, secretory structures and the mature periderm. Several of these characters were found to have taxonomic significance at species, genus and even at tribal level. The DELTA computer programme was employed to generate bark anatomical descriptions.

Bark of the investigated members of the family is characterised by abundant gelatinous fibres in the portion not affected by dilatation, vertical secretory ducts in conspicuous tangential bands, radial secretory ducts in the rays, and polyllamelate lignified-gelatinous primary fibres. Tribal differences include sheaths surrounding secretory ducts, types of fibres, dilatation tissue, and distribution of sclereids. Genera are more or less clearly differentiated. Most species could be distinguished from each other.

The study has clearly shown that bark structure is of great potential taxonomic significance in the Anacardiaceae. Once anatomical data are available for more members of the family, such evidence could contribute towards an improved infrafamilial classification. Knowledge of anatomical bark structure can also help in ensuring control over the identity of bark sold in the traditional medicinal industry. It may also assist in forensic investigations.

OPSOMMING

DIE TAKSONOMIESE BETEKENIS VAN BASSTRUKTUUR BY DIE SUIDER-AFRIKAANSE ANACARDIACEAE

deur

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Hierdie verhandeling verteenwoordig die mees omvattende ondersoek van die basstruktuur van lede van die Anacardiaceae wat tot op hede onderneem is. Basanatomie van 29 spesies behorende tot 12 genusse van Suider-Afrikaanse Anacardiaceae is ondersoek ten einde die strukturele diversiteit en taksonomiese betekenis van sodanige kenmerke te bepaal. 'n Omvattende bas-anatomiese beskrywing word vir elke spesie verskaf, aangevul met vergelykende tabelle en illustrasies. Die hoofdoel van hierdie ondersoek was om gedetailleerde bas-anatomiese beskrywings vir geselekteerde verteenwoordigers van Suider-Afrikaanse Anacardiaceae te verskaf; om die taksonomiese betekenis van bas-anatomiese kenmerke by Suider-Afrikaanse Anacardiaceae te bepaal; om te verwys na interessante basweefsels en -strukture; om die nut van bas-anatomiese kenmerke by die identifisering van onbekende bas-eksemplare te bepaal, byvoorbeeld in die geval van bas wat in die tradisionele medisyne handel gebruik word; om 'n omvattende bas-anatomiese kenmerklys wat vir die DELTA-rekenaarprogram ontwikkel is te toets en, indien nodig, te verbeter.

Vir elke spesie is 'n totaal van 112 kenmerke ondersoek. Dit sluit in kenmerke wat betrekking het op die sifplate, aksiale floëemparenchiem, floëemstrale, sklerenchiem in gedeeltes nie beïnvloed deur uitsetting, uitsettingsweefsel, sekreetstrukture en die volwasse periderm. Daar is gevind dat verskeie van hierdie kenmerke taksonomies betekenisvol is op spesie-, genus- en selfs tribus-vlak. Die DELTA rekenaarprogram is gebruik om bas-anatomiese beskrywings te genereer.

Bas van die ondersoekte lede van die Anacardiaceae word gekenmerk deur talryke gelatienvesels in gedeeltes wat nie uitsetting ondergaan het, vertikale sekreetkanale in tangensiale bande, radiale sekreetkanale in the strale, en gelignifiseerde gelatienvesels met polilamellêre wande. Tribusverskille sluit in die teenwoordigheid van parenchiematiese skedes om die sektreetkanale, veseltipe, uisettingsweefsel en die verspreiding van sklereide. Genera is min of meer duidelik gedifferensieer. Meeste spesies kon van mekaar onderskei word.

Die studie het oortuigend aangetoon dat basstruktuur van groot taksonomiese betekenis is. Soos wat bas-anatomiese inligting vir meer lede van die famililie beskikbaar raak, behoort hierdie tipe getuienis by te dra tot 'n verbeterde klassifikasie van die familie. Resultate van die huidige ondersoek kan ook 'n bydrae lewer tot verbeterde kontrole oor die identiteit van bas wat in die tradisionele medisyne handel verkoop word, asook in die geval van forensiese ondersoeke.

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CURRICULUM VITAE

Luvhimba Isaac Ramovha was born at Gertrudsburg, Louis Trichardt, on 18 January 1957. He obtained his primary education at Muungadi Combined School, in Zamenkomst, to which his family was relocated. He received his junior secondary education at Kutama Junior Secondary School from 1972 to 1974. He completed matric at Tshivhase High School in 1975—1976.

In 1977 he enroled for the B.Sc. degree at the University of the North, which he completed in 1980. During the same period 1977—80 he spent December holidays working at the South African Broadcasting Corporation (SABC), collecting donations for Radio Venda's Christmas Fund in Louis Trichardt.

In 1981 he assumed a teaching post at Sinthumule High School, where he introduced the first physical science class in Standard 10 and, in addition, taught Maths and Geography at Standard 10 level. In the same year he was appointed a junior sub-examiner (marker) for Standard 8 external examinations in the Department of Education in the former Venda. In 1982 he was appointed a senior sub-examiner in the same subject, a position he held until 1991 when the external examination system for Standard 8 ceased in Venda. Whilst serving as a teacher at Sinthumule High School he obtained the HED (post-graduate) from the University of South Africa. In 1985 he moved to Luvhivhini Secondary School where he introduced physical science classes in Standard 9 as well as biology classes in Standard 10. Early in 1986 he briefly moved to David Luvhimba Secondary School, where he was to help in the establishment of the first Standard 9 class there. His stay at David Luvhimba Secondary School was short lived, however, as in March 1986 he was promoted to the post of principal at Mmilige Secondary School, a position that he still holds. In 1995 he was asked to chair a commission of enquiry into alleged mishaps that occurred during the appointment of a teacher at a particular school in the Vhulorwa circuit in the Tshitandani school inspection area, a task which he successfully accomplished.

In 1991 he enrolled for the B.Sc.(Hons.) degree in Botany at the University of Venda as a part-time student. He completed the course in 1992. It is during this time that he made contact with Prof. A.E. van Wyk, who was external examiner for his honours project, which dealt with the ethnobotany and conservation of *Milletia stuhlmannii*. He also attended an ecology course under the auspices the University of Cape Town at Bain's Kloof with the Bot. 305 class of the same university, under Prof. E. Moll. In 1993 he read a paper on his honours project at the ninenteenth annual congress of the South African Association of Botanists held at the University of the Western Cape.

He is a Christian (Lutheran Church), and is married to Rachel. They are blessed with a son, Lutendo, and three daughters Martha, Livhuwani and Mulalo.

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PART 2

TABLES AND FIGURES

TABLE 1.1 SPECIES STUDIED AND VOUCHER SPECIMENS COLLECTED

Taxon	Voucher specimen number (housed in PRU)	Locality (grid reference)	FAA Bottle Number	National Tree number	De Dalla Torre & Harms genus number
Harpephyllum caffrum Berhn.	Ramovha 027 Ramovha 083 Ramovha 106	2528AB 2528AB 2632DD	3734 3807 3888	361 361 361	4562 4562 4562
Heeria argentea (Thunb.) Meissner	Van Wyk 12870 Van Wyk 12875 Van Wyk 12877	3418BD 3419AA 3419AA	3912 3917 3919	368 368 368	4589 4589 4589
Lannea antiscorbutica (Hiern) Engl.	Ramovha 090 Ramovha 092 Ramovha 093	2232AD 2232AD 2232AD	3845 3846 3875	- - -	4563 4563 4563
Lannea discolar (Sond.) Engl.	Ramovha 036 Ramovha 037	2428CD 2329BD	3745 3746	362 362	4563 4563
Lannea schweinfurthii var *stuhlmannii* (Engl.) Kokwaro	Ramovha 071 Ramovha 072 Ramovha 075 Ramovha 103 Ramovha 104 Ramovha 105	2230CA 2230CA 2230CA 2632CD 2632CD 2632CD	3785 3786 3789 3885 3886 3887	363 363 363 363 363 363	4563 4563 4563 4563 4563 4563
Laurophyllus capensis Thunb.	Van Wyk 12871 Van Wyk 12872 Van Wyk 12873	3419AC 3419AC 3419AC	3913 3914 3915	366 366 366	4585 4587 4587
Loxostylis alata Sprang. f. ex Reichb.	Ramovha 032 Ramovha 060 Ramovha 061 Ramovha 062	2528AB 2528AB 2528AB 2528AB	3741 3777 3805 3806	365 365 365 365	4586 4586 4586 4586
Mangifera indica L.	Ramovha 057 Ramovha 058 Ramovha 059	2030CD 2030CD 2030CD	3751 3795 3794	X632 X632 X632	4545 4545 4545
Ozoroa engleri R.&A. Fernandes	Ramovha 102 Ramovha 116 Ramovha 117	2232CD 2232CD 2232CD	3884 3899 3900	371 371 371	4589 4589 4589
Ozoroa mucronata (Berhn.ex Krauss) R.&A Fernandes	Herman 884	3326DB	2600	373	4589
Ozoroa namaquensis	Van Wyk 8738	2818CD	1322	373	4589

Taxon	Voucher specimen number (housed in PRU)	Locality (grid reference)	FAA Bottle Number	National Tree number	De Dalla Torre & Harms genus number
Ozoroa obovata (Oliv.) R.&A. Fernandes	Ramovha 065 Ramovha 108 Ramovha 109 Ramovha 110 Ramovha 115	2528AB 2632DD 2632DD 2632DD 2632DD	3779 3890 3891 3892 3893	374 374 374 374 374	4589 4589 4589 4589 4589
Ozoroa paniculosa (Sond.) R.&A. Fernandes	Ramovha 088 Ramovha 089	2329BD 2428AC	3812 3813	375 375	4589 4589
Ozoroa sphaerocarpa R.&A. Fernandes	Ramovha 068 Ramovha 069	2528AA 2528AA	3782 3783	377 377	4589 4589
Protorhus longifolia (Berhn.) Engl.	Ramovha 034 Ramovha 035	2528AB 2528AB	3743 3744	364 364	4576 4576
Rhus batophylla Codd	Ramovha 063 Ramovha 064	2528AB 2528AB	3778 3778		4594 4594
Rhus chirindensis Bak. f.	Ramovha 084	2528AB	3808 1795	380 380	4594 4594
Rhus gueinzii Sond.	Ramovha 091 Ramovha 094 Ramovha 095	2232AD 2232AD 2232AD	3876 3877 3878	384 384 384	4594 4594 4594
Rhus lancea L.f.	Ramovha 085	2528AB	3809	386	4594
Rhus leptodictya Diels.	Ramovha 029	2528AB	3738	387	4594
Rhus natalensis Berhn.	Ramovha 112 Ramovha 113 Ramovha 114	2632DD 2632DD 2638DD	3896 3897 3898	390 390 390	4594 4594 4594
Rhus pendulina Jacq.	Ramovha 028	2528AB	3737	396	4594
Rhus pyroides Burch.	Ramovha 076 Ramovha 077 Ramovha 078	2329BB 2329BB 2329BB	3791 3792 3795	392 392 392	4594 4594 4594
Rhus rehmanniana Engl.	Abbot 4394	3030CC	1497	393	4594
Rhus sp.	Ramovha 107	2632DD	3889	-	4594
Rhus undulata Jacq.	Ramovha 030	2528AB	3739	395	4594
Schinus molle L.	Ramovha 033 Ramovha 045	2528AB 2329BB	3742 3748	X638 X638	4582 4582

Taxon	Voucher specimen number (housed in PRU)	Locality (grid reference)	FAA Bottle Number	National Tree number	De Dalla Torre & Harms genus number
Sclerocarya birrea (A.Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro	Ramovha 001	2329BB	3730	360	4558
	Ramovha 002	2230CD	3731	360	4558
	Ramovha 003	2329BC	3732	360	4558
	Ramovha 004	2329BD	3733	360	4558
	Ramovha 038	2329BD	3747	360	4558
	Ramovha 039	2329BD	3747	360	4558
	Ramovha 070	2230CA	3784	360	4558
	Ramovha 118	2232CD	3901	360	4558
Smodingium argutum E. Mey.	Ramovha 066	2528AB	3780	367	4588
	Ramovha 067	2528AB	3781	367	4588

TABLE 4.1 SUMMARY OF SELECTED BARK ANATOMICAL CHARACTERS

KEY: 1 = Tanniniferous cells in part not affected by dilatation; 2 = Secretory ducts in part not affected by dilatation; 3 = Dilatation tissue; 4 = Sclerenchyma in part not affected by dilatation; 5 = Lignified fibres in part not affected by dilatation; 6 = Gelatinous fibres in part not affected by dilatation; 7 = Sclereids in part not affected by dilatation; 8 = Calcium oxalate crystals in part not affected by dilatation; 9 = Prisms in part not affected by dilatation; 10 = Druses in part not affected by dilatation; 11 = Phellem; 12 = Phelloderm; 13 = Cortex in mature bark

+++ = abundant; ++ = sparse; + = present; - = absent; Cs = crystaliferous strands; Cc = crystaliferous chambers; t = tangential bands;
Rc = ray cells; r = random; h = horizontal ducts; v = vertical ducts

TAXON	1	2	3	4	5	6	7	8	9	10	11	12	13
Harpephyllum caffrum	+++ t	+ t v h	+	+	+ t	+ t	-	+	++ Rc	-	+	+	-
Heeria argentae	+++ t	+ t v	+	+	+ t	-	-	+	++ + Rc	-	+	+	-
Lannae antiscorbutica	++ t	+ t v	+	+	+ t	+ t	-	+	++ Cc	-	+	+	-
Lannea discolar	++ t	+ t v h	+	+	-	+ t	-	+	++ Cs	-	+	+	-
Lannea schweinfurthii	++ t	+ t v	+	+	+ t	+ t	+	+	++ t Cc Rc	-	+	+	-
Laurophyllus capensis	+++ t	+ t v	+	+	+ t	-	-	-	-	-	+	+	-
Loxostylis alata	+++ t	+ t v h	+	+	+ t	+ t	-	+	++ t	-	+	+	-
Mangifera indica	+++ t	+ t v	+	+	+ t	+ t	-	+	++	-	+	+	-
Ozoroa engleri	+++ t	+ t v	+	+	+ t	+ t	-	+	++	+ +	+	+	-

TAXON	1	2	3	4	5	6	7	8	9	10	11	12	13
Ozoroa mucronata	+++ t	+ t v	+	+	-	+ t	-	+	-	+ +	+	+	-
Ozoroa obovata	+++ t	+ t v	+	+	+	-	-	+	-	+ +	+	+	-
Ozoroa paniculosa	+++ t	+ t v	+	+	-	+ t	-	+	-	+ +	+	+	-
Ozoroa sphaerocarpa	+++ t	+ t v	+	+	-	+ t	-	+	-	+ +	+	+	-
Ozoroa namaquensis	+++ t	+ t v	+	+	-	+ t	-	+	-	+ +	+	+	-
Protorhus longifolia	+++ t	+ t v	+	+	+ t	+ t	-	+	-	+ +	+	+	-
Rhus batophylla	++ t	+ t v	+	+	+ t	+ t	-	+	++	+ +	+	+	-
Rhus chirindensis	+++ t	+ t v	+	+	+ t	+ t	-	+	++	-	+	+	-
Rhus gueinzii	++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-
Rhus lancea	+++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-
Rhus leptodictya	+++ t	+ t v h	+	+	+ t	-	-	-	-	-	+	+	-
Rhus natalensis	+++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-
Rhus pendulina	+++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-

TAXON	1	2	3	4	5	6	7	8	9	10	11	12	13
Rhus pyroides	+++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-
Rhus rehmanniana	+++ t	+ t v h	+	+	+ t	-	-	-	-	-	+	+	-
Rhus sp.	+++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-
Rhus undulata	+++ t	+ t v h	+	+	+ t	-	-	+	++	-	+	+	-
Schinus molle	++ t	+ t v	+	+	+ t	+ t	-	+	++	-	+	+	-
Sclerocarya birrea	++ t	+ t v h	+	+	+ t	+ t	-	+	++	-	+	+	-
Smodingium argutum	+++ t	+ r v	+	+	+ t	-	-	+	-	+ +	+	+	-

TABLE 5.1 SUMMARY OF AXIAL PHLOEM PARENCHYMA CHARACTERS

Key: + = present; - = absent; H = *Harpephyllum*; L = *Lannea*; Lox = *Loxostylis*; M = *Mangifera*; O = *Ozoroa*; Pro = *Protorhus*;R = *Rhus*; Sch = *Schinus*; Scl = *Sclerocarya*; Smo = *Smodingium*; Hee = *Heeria*; Lau = *Laurophyllus*

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
in conspicuous tangential bands	+	+	+	+	+	-	+	+	+	+	+	+
in weak tangential bands	-	-	-	-	-	+	-	-	-	-	-	-
cells axially elongated	+	+	+	+	+	+	+[1]	+	+	+	+	+
more-or-less isodiametric	-	-	-	-	-	-	+[2]	-	-	-	-	-
tanniniferous	+	+	+	+	+	+	+	+	+[3]	+	+	+
calcium oxalate crystals	-	+	+[4]	-	+	+	+[5]	+	+[6]	-	+	-
prisms	-	+	+[7]	-	+	+	-	-	+	-	+	-
druses	-	-	-	-	-	-	+	+	+[8]	-	-	-

1 Except in *Ozoroa namaquensis*
2 Present only in *Ozoroa namaquensis*
3 Except in *Rhus rehmanniana*
4 Except in *Lannea antiscorbutica*
5 Except in *Ozoroa sphaerocarpa* and *O. mucronata*
6 Except in *Rhus rehmanniana*
7 Except in *Lannea antiscorbutica*
8 Present only in *Rhus batophylla*

TABLE 5.2 SUMMARY OF PHLOEM RAY CHARACTERS

Key: + = present; - = absent; H = *Harpephyllum*; L = *Lannea*; Lox = *Loxostylis*; M = *Mangifera*; O = *Ozoroa*; Pro = *Protorhus*;R = *Rhus*; Sch = *Schinus*; Scl = *Sclerocarya*; Smo = *Smodingium*; Hee = *Heeria*; Lau = *Laurophyllus*

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
2–4 rows	+	+	+	[18]	+	+	+	+	+	+	+	-
more than 4 rows	-	-	-	-	-	-	-	-	-	-	-	+
1–3 seriate	+	+	+[1]	+	+	+	+[2]	+	+	-	-	-
4–10 seriate	-	-	+[3]	-	-	-	+[4]	-	-	+	+	+
4–12 rays/mm	+	+	+	-	-	-	+[5]	+	+[6]	-	+	-
13 or more rays/mm	-	-	-	+	+	+	+[7]	-	+[8]	+	-	+
more-or-less straight	+	+	-	+	+	+	+	+	+	+	+	+
undulate	-	-	+	-	-	-	-	-	-	-	-	-
lignified	+	+	+[9]	+	-	-	-	-	+[10]	-	-	[11]
remain parenchyma tous	-	-	[12]	-	-	-	-	-	-	-	-	-
abundantly pitted	+	+	+	+	+	-	+	+	+	+	+	+
moderately pitted	-	-	-	-	-	+	-	-	-	-	-	-
calcium oxalate crystals	+	+	+	-	+	-	+	+	+	-	+	+
prisms	+	+	+	-	+	-	-	-	+[13]	-	+	-
druses	-	-	-	-	-	-	+	+	-	-	-	+
prisms & druses	-	-	-	-	-	-	+[14]	-	+[15]	-	-	-
height less than 1 mm	+	+	+	+	+	+	+	+	+	+	+	-
height more than 1 mm	-	-	-	-	-	-	-	-	-	-	-	+

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
tannin cells abundant	-	+	-	+	-	-	+[16]	-	+	-	-	+
tannin cells sparse	+	-	+	-	+	+	+[17]	+	-	+	+	-

1 Present only in *Lannea antiscorbutica*
2 Except in *Ozoroa paniculosa*
3 Except in *Lannea antiscorbutica*
4 Present only in *Ozoroa paniculosa*
5 Except in *Ozoroa namaquensis*
6 Present in *Rhus batophylla, R. chirindensis, R. pendulina*, and *Rhus sp.*
7 Present only in *Ozoroa namaquensis*
8 Present in *Rhus guenzii, R. leptodictya, R. natalensis, R. pyroides*, and *R. undulata*
9 Except in *Lannea antiscorbutica*
10 Not observed due to abundant tanniniferous cells
11 Not observed due to abundant tanniniferous cells
12 Present only in *Lannea antiscorbutica*
13 Except in *Rhus lancea, R. leptodictya* and *R. rehmanniana*
14 As a combination present only in *Ozoroa engleri*
15 As a combination present only in *Rhus batophylla*
16 Present only in *Ozoroa engleri* and *O. sphaerocarpa*
17 Except in *Ozoroa engleri* and *O. sphaerocarpa*
18 One row of upright and/or square cells

TABLE 5.3 SUMMARY OF SCLERENCHYMA CHARACTERS

Key: + = present; - = absent; H = *Harpephyllum*; L = *Lannea*; Lox = *Loxostylis*; M = *Mangifera*; O = *Ozoroa*; Pro = *Protorhus*;R = *Rhus*; Sch = *Schinus*; Scl = *Sclerocarya*; Smo = *Smodingium*; Hee = *Heeria*; Lau = *Laurophyllus*

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
lignified fibres	+	+	+[1]	+	+	+	+[2]	+	+	+	+	+
gelatinous fibres	+	-	+	-	+	+	+[3]	+	+[4]	+	+	-
fibres absent or poorly developed	-	-	-	-	-	-	[5]	-	-	-	-	-
septate fibres	-	-	+[6]	-	-	-	+[7]	-	-	-	+	-
non-septate fibres	+	+	+[8]	+	+	+	+[9]	+	+	+	-	+
walls very thin	+	+	+	+	+	+	+	+	+[10]	+	-	-
walls thin to thick	-	-	-	-	-	-	-	-	+[11]	-	+	+
sclereids	-	-	[12]	-	-	-	-	-	-	-	-	-
S1 layer distinctly lignified	+	-	[13]	-	+	+	+[14]	+	+	+	+	-
weakly lignified	-	-	-	-	-	-	+[15]	-	-	-	-	-
non-lignified	-	-	[16]	-	-	-	+[17]	-	-	-	-	-

1 Except in *Lannea discolor*
2 Present only in *Ozoroa obovata*
3 Except in *Ozoroa engleri* and *O. obovata*
4 Except in *Rhus guenzii, R. lancea, R. leptodictya, R. pendulina* and *R. rehmanniana*
5 Present only in *Ozoroa engleri*
6 Except in *Lannea schweinfurthii*
7 Present only in *Ozoroa paniculosa*
8 Present only in *Lannea schweinfurthii*
9 Except in *Ozoroa paniculosa*
10 Except in *Rhus gueinzii*
11 Present only in *Rhus gueinzii*
12 Present only in *Lannea schweinfurthii*
13 Except in *Lannea discolor*
14 Except in *Ozoroa mucronata* and *O. sphaerocarpa*

[15] Present only in *Ozoroa mucronata*
[16] Present only in *Lannea discolor*
[17] Present in *Ozoroa sphaerocarpa*

TABLE 5.4 SUMMARY OF DILATATION TISSUE CHARACTERS

Key: + = present; - = absent; H = Harpephyllum; **L** = *Lannea*; **Lox** = *Loxostylis*; **M** = *Mangifera*; **O** = *Ozoroa*; **Pro** = *Protorhus*;**R** = *Rhus*; **Sch** = *Schinus*; **Scl** = *Sclerocarya*; **Smo** = *Smodingium*; **Hee** = *Heeria*; **Lua** = *Laurophyllus*

Genera / Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
derived from phloem parenchyma	+	+	+	-	+	+	+[1]	+	-	+	+	-
derived from phloem rays	+	+	+	+	+	+	+[2]	-	-	+	+	-
derived from secretory ducts	-	-	-	-	-	-	-	-	+	-	-	+
dilatation meristem	+	+	-	+	+	+	+	+	+[3]	+	-	-
irregular	+	+	+	-	+	+	+	+	+	+	-	+
continuous forming pseudo-cortex	-	-	-	-	-	-	+[4]	-	-	-	+	-
wedge-shaped	-	-	-	-	-	-	+[5]	-	-	-	-	-
sclerenchyma	+	+	+	+	+	+	+	+	+	+	+	+
fibres	+	+	+	+	+	+	+	+	+	+	+	+
spheroidal sclereids	-	+	+	+	+	+	+	+	+	-	+	+
vesiculose sclereids	-	+	+[6]	+	+	+	+[7]	+	+	-	-	+
vermiform sclereids	-	+	+	+	+	+	+[8]	-	+[9]	-	+	+
fusiform sclereids	-	-	[10]	-	-	-	[11]	+	-	-	-	-
filiform sclereids	-	-	-	-	-	-	[12]	+	-	-	-	-
palosclereids	-	-	-	-	-	-	-	+	-	-	-	-
sclerenchyma ring	-	-	-	-	+	-	-	-	-	-	-	-
sclereids irregularly dispersed as clusters	-	+	+	+	-	+	[13]	+	+	-	-	+

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
sclereids associated with aggregates of primary sclerenchyma	-	-	-	-	+	-	[14]	-	-	-	+	-
tannin cells	-	+	+	+	+	+	+	+	+	+	+	+
druses	-	-	-	-	-	-	+	-	-	-	-	-
prisms	+	+	+	-	+	+	[15]	+	[16]	-	+	+
fibres polylamellate	+	-	+	+	+	-	[17]	-	[18]	+	+	-
lignified	+	-	+	+	+	+	+	+	+	+	+	+
gelatinous	+	+	+	+	+	-	[19]	+	[20]	+	+	-
dilatation continuous interdigitizing with secondary phloem	-	-	-	+	-	-	-	-	-	-	-	-

[1] Except in *Ozoroa mucronata*
[2] Except in *Ozoroa namaquensis*
[3] Except in *Rhus gueinzii, R. lancea, R. leptodictya, R. natalensis*, and *R. pyroides*
[4] Present only in *Ozoroa obovata* and *O. paniculosa*
[5] Present only in *Ozoroa namaquensis*
[6] Except in *Lannea schweinfurthii*
[7] Except in *Ozoroa paniculosa* and *O. sphaerocarpa*
[8] Except in *Ozoroa paniculosa* and *O. namaquensis*
[9] Except in *Rhus lancea*
[10] Except in *Lannea schweinfurthii*
[11] Except in *Ozoroa mucronata, O. namaquensis, O. obovata, O. paniculosa,* and *O. sphaerocarpa*
[12] Present only in *Ozoroa engleri*
[13] Except in *Ozoroa namaquensis*
[14] Present only in *Ozoroa namaquensis*
[15] Except in *Ozoroa namaquensis* and *O. sphaerocarpa*
[16] Except in *Rhus batophylla, R. leptodictya* and *R. rhemanniana*
[17] Except in *Ozoroa namaquensis* and *O. obovata*
[18] Present only in *Rhus batophylla, R. chirindensis, R. natalensis, R. undulata* and *R. rhemanniana*
[19] Except in *Ozoroa namaquensis* and *O. obovata*
[20] Present only in *Rhus batophylla, R. chirindensis, R. natalensis* and *R. undulata*

TABLE 5.5 SUMMARY OF CALCIUM OXALATE CRYSTAL CHARACTERS

Key: + = present; - = absent; H = *Harpephyllum*; L = *Lannea*; Lox =*Loxostylis*; M = *Mangifera*; O = *Ozoroa*; Pro = *Protorhus*;R = *Rhus*; Sch = *Schinus*; Scl = *Sclerocarya*; Smo = *Smodingium*; Hee = *Heeria*; Lau = *Laurophyllus*

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
crystal type : prisms	+	+	+	-	+	+	+[1]	+	+[2]	-	+	+
: druses	-	-	+[3]	-	-	-	+[4]	+	+[5]	-	-	+
Mainly in: axial phloem parenchyma	-	-	+	-	-	+	+[6]	+[7]	+[8]	-	-	-
: ray cells	+	+	+[9]	-	-	-	[10]	-	[11]	-	-	+
: dilatation tissue	+	+	[12]	-	+	-	[13]	+	[14]	-	-	-
: phellem	-	-	+	-	+	+	[15]	-	-	-	+	-
: phelloderm	-	-	+	-	+	+	[16]	+	[17]	-	-	+
If associated with sclerenchyma: not encased in scleretic element	-	+	+	-	-	+	[18]	+	-	-	-	-
: encased within sclereids	-	-	-	-	-	-	[19]	-	[20]	-	-	-
: encased within fibres	+	-	-	-	-	-	[21]	-	[22]	-	-	-
chambered axial strands associated with fibres only	+	-	-	-	-	-	-	-	-	-	-	-
encased within chambered axial strands	-	-	+	-	-	-	[23]	-	[24]	-	+	[25]
within secondarily formed sclereids in dilatation tissue	-	-	-	-	+	-	[26]	-	-	-	-	[27]

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
axially arranged chambered crystaliferous strands	-	-	+	-	-	-	-	-	[28]	-	-	-
Distribution of axial chambered crystal strands in secondary phloem: randomly	-	-	-	-	-	-	-	-	-	-	-	-
:tangentially	+	-	+	-	+	-	-	-	[29]	-	-	-
:mainly associated with sclerenchyma	+	-	+	-	+	-	-	-	-	-	-	-
Axially chambered crystaliferous strands lignification of cell walls												
: sclerified	+	-	[30]	-	-	-	+	-	[31]	-	+	+
: remaining parenchymatous	-	-	[32]	-	-	-	-	-	-	-	-	-

[1] Except in *Ozoroa sphaerocarpa*
[2] Except in *Rhus rehmanniana*
[3] Present only in *Lannea discolor*
[4] Except in *Ozoroa namaquensis*
[5] Present only in *Rhus batophylla* and *Rhus sp.*
[6] Druses in *Ozoroa obovata*
[7] Only druses
[8] Present only in *Rhus lancea, R. natalensis*, and *R. pyroides*
[9] Present only in *Lannea schweinfurthii*
[10] Present only in *Ozoroa engleri* (druses), *O. obovata* (prisms), *O. mucronata* (prisms), and *O. paniculosa* (druses)
[11] Present only in *Rhus batophylla, R. chirindensis*, and *R. pyroides*
[12] Present only in *Lannea discolor*
[13] Present only in *Ozoroa engleri* (prisms), *O. mucronata* (druses) and *O. paniculosa* (prisms)
[14] Present only in *Rhus gueinzii, R. leptodictya, R. natalensis* and *R. undulata*
[15] Except in *Ozoroa engleri, O. obovata* and *O. sphaerocarpa*

16 Except in *Ozoroa obovata* and *O. sphaerocarpa*
17 Except in *Rhus natalensis* and *R. undulata*
18 Present only in *Ozoroa sphaerocarpa* (druses)
19 Present only in *Ozoroa engleri* (prisms)
20 Present only in *Rhus leptodictya*
21 Present only in *Ozoroa paniculosa* (prisms and druses)
22 Present only in *Rhus batophylla, R. gueinzii, R. natalensis* and *R. undulata*
23 Present only in *Ozoroa sphaerocarpa*
24 Present only in *Rhus batophylla, R. natalensis*, and *Rhus sp.*
25 Only druses
26 Present only in *Ozoroa namaquensis*
27 Only prisms
28 Present only in *Rhus natalensis*
29 Present only in *Rhus natalensis*
30 Except in *Lannea antiscorbutica*
31 Present only in *Rhus batophylla, R. natalensis*, and *Rhus sp.*
32 Present only in *Lannea antiscorbutica*

TABLE 5.6 SUMMARY OF SECRETORY STRUCTURES CHARACTERS

Key: + = present; - = absent; H = *Harpephyllum*; L = *Lannea*; Lox = *Loxostylis*; M = *Mangifera*; O = *Ozoroa*; Pro = *Protorhus*;R = *Rhus*; Sch = *Schinus*; Scl = *Sclerocarya*; Smo = *Smodingium*; Hee = *Heeria*; Lau = *Laurophyllus*

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
secretory ducts	+	+	+	+	+	+	+	+	+	+	+	+
continuous tangential bands	+	-	+	-	-	+	+[1]	+	+[2]	+	+	-
discontinuous tangential bands	-	+	-	+	-	-	+[3]	-	-	-	-	-
irregularly dispersed	-	-	-	-	+	-	-	-	+	-	-	+
odd short bands	+	-	+	-	-	-	+[4]	-	-	-	-	-
sheath	-	+	-	+	-	+	+	+	-	-	-	-
single cell sheath	-	+	-	+	-	-	+[5]	+	-	-	-	-
double cell sheath	-	-	-	-	-	-	+[6]	-	-	-	-	-
contents	-	-	-	-	-	-	-	-	+	-	-	+
site of dilatation	-	-	-	-	-	-	-	-	+	-	-	+
horizontal ducts	+	-	+[7]	-	+	-	-	-	+	-	+	-
tannin cells	+	+	+	+	+	+	+	+	+	+	+	+
in phloem parenchyma	-	+	+	+	-	-	+[8]	-	+	+	-	-
in ray cells	-	+	-	+	-	-	+[9]	+	+	+	-	-
present in cambium	-	+	+	+	+	-	-	-	-	-	-	-
in sclereid lumens	-	+	-	+	+	-	-	+	-	-	-	-

[1] Present only in *Ozoroa obovata*

[2] Present only in *Rhus batophylla, R. lancea*, and *R. leptodictya*

[3] Present only in *Ozoroa mucronata, O. namaquensis, O. paniculosa* and *O. sphaerocarpa*
[4] Present only in *Ozoroa paniculosa*
[5] Present only in *Ozoroa sphaerocarpa* and *O. namaquensis*
[6] Present only in *Ozoroa engleri. O. obovata*, and *O. paniculosa*
[7] Present only in *Lannea discolor*
[8] Present only in *Ozoroa engleri*
[9] Present only in *Ozoroa engleri* and *O. mucronata*

TABLE 5.7 SUMMARY OF MATURE PERIDERM CHARACTERS

Key: + = present; - = absent; H = *Harpephyllum*; L = *Lannea*; Lox = *Loxostylis*; M = *Mangifera*; O = *Ozoroa*; Pro = *Protorhus*;R = *Rhus*; Sch = *Schinus*; Scl = *Sclerocarya*; Smo = *Smodingium*; Hee = *Heeria*; Lau = *Laurophyllus*

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
phelloid cells	+	-	+	+	+	+	+[1]	+	+[2]	+	+	+
phellem stratification	+	-	+	-	+	+	+[3]	+	+[4]	+	+	–
phelloid cells: axially elongated	+	-	+	+	+	+	+	+	+[5]	+	+	+
irregularly shaped	-	-	-	-	-	-	+[6]	-	-	-	-	-
walls distinctly pitted	+	-	+	+	+[7]	+	+	+	+	+	+	+
walls indistinctly pitted	-	-	+[8]	-	-	-	-	-	-	-	-	-
phellem: tanniniferous	-	-	+	-	+	+	+[9]	+	[10]	+	+	-
phellem: calcium oxalate crystals	-	-	+	-	+	+	[11]	-	-	-	+	-
Phellodem: sclerified	-	-	+	-	+	+	+	+	[12]	-	+	+
spheroidal	-	-	+	-	+	+	+	+	+	-	-	+
vesiculose	-	-	-	-	-	+	[13]	+	[14]	-	+	+
vermiform	-	-	+	-	+	-	[15]	-	[16]	-	+	+
parenchyma cells : axially elongated	+	+	[17]	+	+	+	+	+	+	+	+	+

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
more-or-less isodiametric	-	-	[18]	-	-	-	-	-	-	-	-	-
phelloderm tanniniferous	-	+	+	+	+	+	[19]	+	+	+	+	+
phelloderm calcium oxalates	-	-	+	-	+	+	[20]	+	[21]	-	-	+
crystals loose in cells	-	-	+	-	-	-	+	-	-	-	-	-
crystals associated with fibres	-	-	-	-	-	+	-	-	-	-	-	-
crystals associated with sclereids	-	-	-	-	+	-	-	+	-	-	-	+
Sclereids assembled in irregularly shaped groups	-	-	+	-	+	+	[22]	+	[23]	-	-	+
irregularly scattered	-	-	-	-	-	-	+	-	[24]	-	+	-
tangential sclereid bands	-	-	-	-	-	-	-	-	[25]	-	-	-
sclereids predominantly solitary	-	-	-	-	-	-	-	-	[26]	-	-	-
inner layer forming more-or-less sclerenchyma ring	-	-	-	-	-	-	-	-	[27]	-	-	-

Genera Characters (+/-)	H	Hee	L	Lau	Lox	M	O	Pro	R	Sch	Scl	Smo
cortex	-	-	-	-	-	-	-	-	[28]	-	-	-

[1] Except in *Ozoroa engleri*
[2] Except in *Rhus chirindensis* and *R. gueinzii*
[3] Except in *Ozoroa engleri*
[4] Except in *Rhus guenzii* and *R. pyroides*
[5] Except in *Rhus chirindensis*
[6] Present only in *Ozoroa sphaerocarpa*
[7] Except in *Lannea discolor*
[8] Present only in *Lannea discolor*
[9] Except in *Ozoroa engleri*
[10] Except in *Rhus batophylla, R. lancea*, and *R. natalensis*
[11] Except in *Ozoroa engleri, O. obovata* and *O. sphaerocarpa*
[12] Except in *Rhus batophylla* and *R. lancea*
[13] Except in *Ozoroa obovata* and *O. sphaerocarpa*
[14] Except in *Rhus rehmanniana*
[15] Except in *Ozoroa obovata* and *O. sphaerocarpa*
[16] Except in *Rhus rhemanniana*
[17] Except in *Lannea schweinfurthii*
[18] Present only in *Lannea schweinfurthii*
[19] Except in *Ozoroa sphaerocarpa*
[20] Except in *Ozoroa obovata* and *O. sphaerocarpa*
[21] Except in *Rhus natalensis* and *R. undulata*
[22] Present only in *Ozoroa sphaerocarpa* and *O. namaquensis*
[23] Except in *Rhus pendulina*
[24] Present only in *Rhus guenzii, R. pyroides, R. rehmanniana* and *R. undulata*
[25] Present only in *Rhus chirindensis*
[26] Present only in *Rhus natalensis*
[27] Present only in *Rhus sp.*
[28] present only in *Rhus batophylla*

CHARACTER LIST

Family: .....
Genus: .....
Species: .....
Slide no.: .....

A = absent (0%); B = very rarely (<2%); C = rarely (2–4%); D = very occasionally (5–10%); E = occasionally (11–30%); F = often (31–54%); G = very often (55–64%); H = usually (65–94%); I = nearly always (95–99%); J = always (100%)

Sieve elements

#1. sieve elements <arrangement in phloem parenchyma>/

☐☐ 1. scattered singly/

☐☐ 2. in groups (`pore multiples')/

☐☐ 3. forming interrupted tangential bands<especially noticeable in collapsed zone of the secondary phloem>/

#2. sieve element type/

☐☐ 1. essentially long, usually with oblique plates with 10 or more sieve areas (typeI)/

☐☐ 2. intermediate in length, usually sieve plates with under 10 sieve areas (type II)/

☐☐ 3. usually short with slightly oblique to transverse, simple sieve plates (type III)/

#3. sieve elements <width>/

☐☐ 1. wider than surrounding parenchyma cells/

☐☐ 2. narrower than surrounding parenchyma cells/

☐☐ 3. of similar width to parenchyma cells/

#4. <sieve elements> slime/

☐☐ 1. copious and persistent, occurs as a spindle-shaped body with a definite outline/

☐☐ 2. copious and dispersed/

☐☐ 3. scanty/

☐☐ 4. not observed/

#5. <sieve tube> junction complexes between elements/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. not observed/

#6. <sieve element> walls <of certain sieve elements> with nacreous layer/

☐☐ 1. present, well defined/

☐☐ 2. present, poorly defined/

☐☐ 3. absent/

#7. sieve plates <orientation>/

☐☐ 1. oblique/

☐☐ 2. transverse/

#8. sieve plates/

☐☐ 1. simple <bearing only one sieve area>/

☐☐ 2. scalariform (compound) <sieve areas arranged in one row>/

☐☐ 3. reticulate (compound) <sieve areas arranged in a net-like pattern>/

☐☐ 4. compound (reticulate or scalariform)/

#9. sieve areas <number: record range>/

. . . . . per plate

#10. <companion cells, e.g. abundance, shape>/

companion cells . . . . . .

Axial phloem parenchyma

#11. axial phloem parenchyma <arrangement, as seen in T.S.>/

☐☐ 1. diffuse between sieve tube elements/

☐☐ 2. in weak tangential lines/

☐☐ 3. in conspicuous tangential bands/

#12. <axial phloem parenchyma cell shape, to be established in L.S. in secondary phloem not affected by dilatation growth, preferably in the non-collapsed zone> cells/

☐☐ 1. axially elongated/

☐☐ 2. more-or-less isodiametric/

#13. <axial phloem parenchyma> tanniniferous cells (not notably enlarged)/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/

#14. <axial phloem parenchyma> calcium oxalate crystals/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/ → #16

#15. <distribution of calcium oxalate crystals, e.g. randomly dispersed; in short tangential rows of crystal cells alternating with rows of phloem parenchyma>/

. . . . . .

Phloem rays

#16. phloem rays <homocellular vs heterocellular>/

☐☐ 1. homocellular, typical procumbent/

☐☐ 2. homocellular, typically square and/or upright cells/

☐☐ 3. homocellular, typically hexagonal/isodiametric/

☐☐ 4. heterocellular, one row of upright and/or square cells/

☐☐ 5. heterocellular, 2—4 rows of upright and/or square cells/

☐☐ 6. heterocellular, more than 4 rows of upright and/or square cells/

☐☐ 7. heterocellular, multiseriate portion(s) as wide as uniseriate portions/

☐☐ 8. heterocellular, with procumbent, square and upright cells mixed/

☐☐ 9. not present <rayless>/ →

#17. rays <width categories>/

☐☐ 1. exclusively uniseriate/

☐☐ 2. 1—3 seriate/

☐☐ 3. larger rays commonly 4—10 seriate/

☐☐ 4. larger rays commonly wider than 10 seriate/

#18. number of rays <per linear millimeter>/

☐☐ 1. less than 4 per mm/

☐☐ 2. 2—12 per mm/

☐☐ 3. 12 or more per mm/

#19. ray height <the larger rays commonly exceeding 1 mm or not, as seen in L.S.>/

☐☐ 1. less than 1 mm/

☐☐ 2. more than 1 mm

#20. course <of phloem rays>

☐☐ 1. more-or-less straight/

☐☐ 2. irregular/

☐☐ 3. undulated/

☐☐ 4. anastomosing <rare>/

#21. portion of ray traversing or adjacent to sclerenchyma/

☐☐ 1. lignified/

☐☐ 2. remaining parenchymatous/

☐☐ 3. not observed/

#22. aggregate rays <record degree of fusion of neighbouring cells in ITEMS file>/

☐☐ 1. present/

☐☐ 2. absent/

#23. <phloem rays> storied structure <as seen in tangential L.S. in secondary phloem not affected by dilatation growth, preferably near the vascular cambium>/

☐☐ 1. present<rare>/

☐☐ 2. absent/

#24. <ray cell features e.g. thin walled, abundantly pitted>/

ray cells .....

#25. tile cells <apparently empty upright ray cells intermediate horizontal series usually interspersed among the procumbent cells; rare, not yet recorded in uniseriate rays>/

☐☐ 1. present/

☐☐ 2. absent/

#26. <phloem rays> tanniniferous cells (not notably enlarged)/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/

#27. <phloem rays> calcium oxalate crystals/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/ → #29

#28. <calcium oxalate crystals e.g. type, variability, distribution patterns>/

. . . . . .

Sclerenchyma

#29. sclerenchyma (in secondary phloem not affected by dilatation growth), <preferably established in the non-collapsed zone; note that walls of elements may remain unlignified, e.g. gelatinous or cellulosic; the latter state easily overlooked and best detected under polarised optics; lignified chambered crystalliferous strands considered under #67, #68 & #69>/

☐☐ 1. present/

☐☐ 2. absent/ → #41

#30. <sclerenchyma type> comprising/

☐☐ 1. lignified fibres/ → #31, [#32], #33, #40

☐☐ 2. lignified fibre-sclereids <all transitional states between fibres and sclereids >/ → #31, [#32], #37, #39—40

☐☐ 3. lignified sclereids/ → #31, [#32], #38, #39—40

☐☐ 4. gelatinous fibres/ → #31, [#32], #36, #38, #39—40

☐☐ 5. cellulosic fibres → #31, [#32], #33—35, #40

☐☐ 6. cellulosic sclereids/ → #31, [#32], #38, #39—40

#31. sclerenchyma distribution/

☐☐ 1. scattered with solitary elements/

☐☐ 2. forming scattered aggregates of loosely arranged elements/ → #32

☐☐ 3. forming loose tangential groups/ → #32

☐☐ 4. forming regular compact groups/ → #32

☐☐ 5. forming irregular compact groups/ → #32

☐☐ 6. forming compact staggered plates/ → #32

☐☐ 7. forming compact storied plates <superposed>/ → #32

☐☐ 8. arranged in discontinuous tangential bands/

☐☐ 9. forming discontinuous concentric rings <rare>/

☐☐ 10. forming continuous concentric rings <rare>/

☐☐ 11. forming <short, long or undulating> radial rows <rare>/

#32. <outline of plates and aggregates in transverse section, e.g. circular, tangential, elliptic, ovate, obovate, lenticular and irregular>/

. . . . . .

#33. fibres <radial diameter best established in T.S.>/

. . . . . .

#34. fibres <type>/

☐☐ 1. septate/

☐☐ 2. non-septate/

#35. <fibre> walls/

☐☐ 1. very thin/

☐☐ 2. thin to thick

☐☐ 3. very thick

#36. gelatinous fibres <wall staining characters> with S1 layer/

☐☐ 1. distinctly lignified/

☐☐ 2. weakly lignified/

☐☐ 3. non-lignified/

#37. <fibre-sclereid type e.g. radially elongated>/

fibre-sclereids . . . . . .

#38. <sclereid shape, e.g. spheroidal, vesiculose, vermiform, fusiform, filiform, polymorphic, (for a sub-division of this category see Rao & Bhupal 1973); size of lumen>/

sclereid shape . . . . . .

#39. <sclereid> wall <course>/

☐☐ 1. more-or-less even/

☐☐ 2. slightly uneven/

☐☐ 3. undulating/

#40. <lumen characteristics e.g. dimensions, shape, (irregular, round, square, hexagonal, with prisms of calcium oxalate, etc.)>/

lumen .....

Dilatation tissue

#41. dilatation tissue/

☐☐ 1. well developed/

☐☐ 2. poorly developed or absent/ → #53

#42. <dilatation tissue>/

☐☐ 1. phloem parenchyma only/

☐☐ 2. rays only/

☐☐ 3. phloem parenchyma and rays/

#43. <type of dilatation tissue>/

☐☐ 1. irregular ("diffuse" type)/

☐☐ 2. continuous, forming a broad zone ("pseudocortex")/

☐☐ 3. continuous, interdigitizing with the secondary phloem/

☐☐ 4. rays dilated, but not regularly wedge-shaped/

☐☐ 5. rays regularly dilated, wedge-shaped/

☐☐ 6. phloem parenchyma regularly dilated, wedge-shaped/

#44. well-defined dilatation meristem(s)/

☐☐ 1. present/

☐☐ 2. absent/

#45. sclerenchyma <in dilatation zone; only secondary formed sclereids (excluding primary phloem fibres), best established in old dilatation tissue>/

☐☐ 1. present/

☐☐ 2. absent/ → #50

#46. <type of secondary derived sclereids e.g. spheroidal, vesiculose, vermiform, fusiform, filiform,polymorphic (for a sub-division of this category see Rao & Bhupal 1973), fibres, fibre-sclereids>/

sclereids .....

#47. <distribution of secondarily-formed sclerenchyma in dilatation tissue>/

☐☐ 1. irregularly scattered as idioblasts/

☐☐ 2. irregularly dispersed as clusters/

☐☐ 3. mainly associated with aggregates of primary sclerenchyma/

#48. sclerenchyma ring (persistent primary phloem caps or fibres)/

☐☐ 1. present, well developed/

☐☐ 2. present, poorly developed/

☐☐ 3. present, very poorly developed, only caps/

☐☐ 4. absent/

#49. primary phloem fibres <sclerenchyma attributes; wall characters, e.g. cellulosic, lignified, polylamellate>/

. . . . . .

#50. <dilatation tissue> tanniniferous cells (not notably enlarged)/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/

#51. calcium oxalate crystals <in dilatation tissue>/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/ → #53

#52. <calcium oxalate crystals e.g. type, variability, distribution pattern>/

. . . . . .

Calcium oxalate crystals

#53. calcium oxalate crystals/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/ → #70

#54. <crystal type>/

☐☐ 1. prisms/ → #55, #61

☐☐ 2. druses/ → #56, #62

☐☐ 3. styloids/ → #57, #63

☐☐ 4. acicular/ → #58, #65

☐☐ 5. raphides/ → #59, #65

☐☐ 6. crystal sand/ → #60, #66

#55. <prisms, as seen in T.S.> located mainly in/

☐☐ 1. axial phloem parenchyma/

☐☐ 2. ray cells/

☐☐ 3. sclerenchyma/

☐☐ 4. crystalliferous cells, wreathing the sclerenchyma/

☐☐ 5. crystalliferous cells, associated with fibres/

☐☐ 6. dilatation tissue/

☐☐ 7. phellem/

☐☐ 8. phelloderm/

☐☐ 9. cortex/

#56. <druses, as seen in T.S.> located mainly in/

☐☐ 1. axial phloem parenchyma/

☐☐ 2. ray cells/

☐☐ 3. sclerenchyma/

☐☐ 4. crystalliferous cells, wreathing the sclerenchyma/

☐☐ 5. crystalliferous cells, associated with fibres/

☐☐ 6. dilatation tissue/

☐☐ 7. phellem/

☐☐ 8. phelloderm/

☐☐ 9. cortex/

#57. <styloids, as seen in T.S.> located mainly in/

☐☐ 1. axial phloem parenchyma/

☐☐ 2. ray cells/

☐☐ 3. sclerenchyma/

☐☐ 4. crystalliferous cells, wreathing the sclerenchyma/

☐☐ 5. crystalliferous cells, associated with fibres/

☐☐ 6. dilatation tissue/

☐☐ 7. phellem/

☐☐ 8. phelloderm/

☐☐ 9. cortex/

#58. <acicular crystals, as seen in T.S.> located mainly in/

☐☐ 1. axial phloem parenchyma/

☐☐ 2. ray cells/

☐☐ 3. sclerenchyma/

☐☐ 4. crystalliferous cells, wreathing the sclerenchyma/

☐☐ 5. crystalliferous cells, associated with fibres/

☐☐ 6. dilatation tissue/

☐☐ 7. phellem/

☐☐ 8. phelloderm/

☐☐ 9. cortex/

#59. <raphides, as seen in T.S.> located mainly in/

☐☐ 1. axial phloem parenchyma/

☐☐ 2. ray cells/

☐☐ 3. sclerenchyma/

☐☐ 4. crystalliferous cells, wreathing the sclerenchyma/

☐☐ 5. crystalliferous cells, associated with fibres/

☐☐ 6. dilatation tissue/

☐☐ 7. phellem/

☐☐ 8. phelloderm/

☐☐ 9. cortex/

#60. <crystal sand, as seen in T.S.> located mainly in/

☐☐ 1. axial phloem parenchyma/

☐☐ 2. ray cells/

☐☐ 3. sclerenchyma/

☐☐ 4. crystalliferous cells, wreathing the sclerenchyma/

☐☐ 5. crystalliferous cells, associated with fibres/

☐☐ 6. dilatation tissue/

☐☐ 7. phellem/

☐☐ 8. phelloderm/

☐☐ 9. cortex/

#61. prisms, if associated with sclerenchyma/

☐☐ 1. not encased in scleretic elements/

☐☐ 2. encased within sclereids/

☐☐ 3. encased within fibre-sclereids/

☐☐ 4. encased within fibres/

☐☐ 5. encased within chambered axial strands associated with fibres only/

☐☐ 6. encased within chambered axial strands/

☐☐ 7. encased within secondarily formed sclereids in the dilatation zone/

#62. druses, if associated with sclerenchyma/

☐☐ 1. not encased in scleretic elements/

☐☐ 2. encased within sclereids/

☐☐ 3. encased within fibre-sclereids/

☐☐ 4. encased within fibres/

☐☐ 5. encased within chambered axial strands associated with fibres only/

☐☐ 6. encased within chambered axial strands/

☐☐ 7. encased within secondarily formed sclereids in the dilatation zone/

#63. styloids, if associated with sclerenchyma/

☐ ☐ 1. not encased in scleretic elements/

☐ ☐ 2. encased within sclereids/

☐ ☐ 3. encased within fibre-sclereids/

☐ ☐ 4. encased within fibres/

☐ ☐ 5. encased within chambered axial strands associated with fibres only/

☐ ☐ 6. encased within chambered axial strands/

☐ ☐ 7. encased within secondarily formed sclereids in the dilatation zone/

#64. acicular crystals, if associated with sclrenchyma/

☐ ☐ 1. not encased in scleretic elements/

☐ ☐ 2. encased within sclereids/

☐ ☐ 3. encased within fibre-sclereids/

☐ ☐ 4. encased within fibres/

☐ ☐ 5. encased within chambered axial strands associated with fibres only/

☐ ☐ 6. encased within chambered axial strands/

☐ ☐ 7. encased within secondarily formed sclereids in the dilatation zone/

#65. raphides, if associated with sclerenchyma/

☐ ☐ 1. not encased in scleretic elements/

☐ ☐ 2. encased within sclereids/

☐ ☐ 3. encased within fibre-sclereids/

☐ ☐ 4. encased within fibres/

☐ ☐ 5. encased within chambered axial strands associated with fibres only/

☐ ☐ 6. encased within chambered axial strands/

☐ ☐ 7. encased within secondarily formed sclereids in the dilatation zone/

#66. crystal sand, if associated with sclerenchyma/

☐ ☐ 1. not encased in scleretic elements/

☐ ☐ 2. encased within sclereids/

☐ ☐ 3. encased within fibre-sclereids/

☐ ☐ 4. encased within fibres/

☐ ☐ 5. encased within chambered axial strands associated with fibres only/

☐ ☐ 6. encased within chambered axial strands/

☐ ☐ 7. encased within secondarily formed sclereids in the dilatation zone/

#67. axially arranged chambered crystalliferous strands <to be established in L.S. in that secondary phloem not affected by dilatation growth, preferably in the non-collapsed zone>/

☐ ☐ 1. present/

☐ ☐ 2. absent/ → #70

#68. <distribution of axial chambered crystalliferous strands in secondary phloem; to be established in T.S.>/

☐ ☐ 1. randomly dispersed throughout secondary phloem/

☐ ☐ 2. arranged in short tangential lines/

☐ ☐ 3. mainly associated with sclerenchyma/

#69. <axial chambered crystalliferous strands; lignification of> cell walls/

☐ ☐ 1. sclerified/

☐ ☐ 2. remaining parenchymatous/

Secretory structures

#70. secretory structures/

☐ ☐ 1. present/

☐ ☐ 2. absent (except for not notably enlarged tanniniferous cells)/ → #73

☐ ☐ 3. absent/ → #75

#71. <secretory structures> composed of/

☐ ☐ 1. oil cells/

☐ ☐ 2. mucilaginous <slime> cells/

☐ ☐ 3. enlarged tanniniferous cells <c.f. #70.2>/

☐ ☐ 4. <secretory> ducts <canals>/

☐ ☐ 5. articulated laticifers/

☐ ☐ 6. non-articulated laticifers/

☐ ☐ 7. regular <secretory> cavities <more-or-less spherical>/

☐ ☐ 8. an irregular system of cavities/

#72. <distribution and other attributes of secretory structures, e.g. branching. Where duct sheath is present record whether aliform, aliform-confluent, in tangential bands or in concentric rings>/

. . . . . .

#73. <secretory structures> tanniniferous cells (not notably enlarged)/

☐ ☐ 1. abundant/

☐ ☐ 2. sparse/

#74. <distribution and other attributes of tanniniferous cells (c.f. #70), e.g. mainly in rays, mainly in phloem parenchyma, mainly in phelloderm, mainly in dilatation tissue; differential staining of different types of cells apparent>/

. . . . . .

Periderm

First-formed periderm

#75. first-formed periderm originating <only possible to establish in young twigs>/

☐ ☐ 1. epidermally/

☐ ☐ 2. subdermally/

☐ ☐ 3. in cortex/

☐ ☐ 4. in primary phloem/

☐ ☐ 5. in secondary phloem <rare>/

#76. first-formed periderm <course>/

☐ ☐ 1. as a continuous cylinder around the stem circumference/

☐ ☐ 2. discontinuous, initiated locally in certain areas from where it spreads, eventually becoming continuous/

Mature periderm

#77. mature periderm <type; best established macroscopically>/

☐ ☐ 1. consisting of interconnected scallop-shaped segments (scale bark)/

☐ ☐ 2. forming a continuous ring around the whole circumference of the stem; different periderms not anastomosing (ring bark) <rare>/

#78. periderm <thickness>/

. . . . . mm thick

#79. <number of> periderms <best established on the transverse plane of dried unsectioned material>/

☐☐ 1. one in number/

☐☐ 2. two to three in number/

☐☐ 3. four or more in number/

#80. <periderm arrangement as seen in T.S.>/

☐☐ 1. ramified (net-like)/

☐☐ 2. superposed in stories <chiefly in ring bark>/

#81. <periderm> course/

☐☐ 1. straight/

☐☐ 2. undulating/

☐☐ 3. irregular <without defined pattern>/

#82. <periderm colour; determined mainly by phellem, best to establish in T.S. of dry unstained material>/

colour .....

#83. <periderm> penetrated by <presence of other tissues in periderm, best established in intact bark under low magnification>/

☐☐ 1. fibres/

☐☐ 2. sclereids/

☐☐ 3. fibre-sclereids <all transitional states between fibres and sclereids>/

☐☐ 4. secretory structures <laticifers, secretory ducts, secretory tubes, etc. ; rare>/

#84. <type of> phellem <development of intercellular spaces>/

☐☐ 1. compact/

☐☐ 2. aerenchymatous <rare>/

#85. lignified cells phelloid/phellem) <walls stain red with safranin O>/

☐☐ 1. present/

☐☐ 2. absent/

#86. phellem <width; best established in T.S. of dried, unsectioned material>/

..... mm wide

#87. <phellem> stratification/

☐☐ 1. present/

☐☐ 2. absent/ → #89

#88. <elements and pattern of stratification>/

. . . . . .

#89. <predominant shape of> phellem cells with/

☐☐ 1. tangential diameter greater than radial diameter <tangentially elongate>/

☐☐ 2. tangential diameter less than radial diameter <radially longate>/

☐☐ 3. tangential diameter equal to radial diameter <square>/

#90. conspicuous radially enlarged phellem cells <presence or absence>/

☐☐ 1. present/

☐☐ 2. absent/

#91. lignified cells (phellem/phelloid) with <shape in T.S.>/

☐☐ 1. tangential diameter greater than radial diameter tangentially elongate>/

☐☐ 2. tangential diameter less than radial diameter <radially elongate>/

☐☐ 3. tangential diameter equal to radial diameter <square>/

☐☐ 4. more-or-less isodiametric/

☐☐ 5. irregular shape/

#92. pattern of cell-wall thickening of lignified cells (phellem/phelloid)>/

☐☐ 1. all walls evenly thickened/

☐☐ 2. all walls irregularly thickened/

☐☐ 3. only outer and inner tangential walls evenly thickened/

☐☐ 4. only radial walls thickened/

☐☐ 5. U-shaped thickening <inner tangential wall is thickened together with adjoining parts of the radial wall> with clear lumen/

☐☐ 6. U-shaped thickening <inner tangential wall is thickened together with adjoining parts of the radial wall> with obscure cell lumen/

☐☐ 7. reversely U-shaped thickening <outer tangential wall is thickened together with adjoining parts of radial wall>/

☐☐ 8. inner tangential wall dentately thickened <rare>/

☐ ☐ 9. outer tangential wall dentately thickened <rare>

☐ ☐ 10. walls perforated <rare; pit transformed into large air-filled holes>/

#93. thickened cell wall <pitting>/

☐ ☐ 1. indistinctly pitted/

☐ ☐ 2. sparsely pitted/

☐ ☐ 3. distinctly pitted/

#94. <phellem cells> tanniniferous cells (not notably enlarged)/

☐ ☐ 1. abundant/

☐ ☐ 2. sparse/

☐ ☐ 3. absent/

#95. idioblasts <in the case of sclereids, these should differ markedly from phelloids/lignified phellem cells>/

☐ ☐ 1. present <rare>/

☐ ☐ 2. absent/ → #98

#96. composed of <idioblast type>/

☐ ☐ 1. sclereids/

☐ ☐ 2. crystalliferous cells/

☐ ☐ 3. secretory structures/

#97. <attributes of idioblasts, e.g. distribution, associated with lenticels, etc.>/

. . . . . .

#98. calcium oxalate crystals <phellem>/

☐ ☐ 1. abundant/

☐ ☐ 2. sparse/

☐ ☐ 3. absent/

#99. phelloderm <best established in oldest phelloderm>/

☐ ☐ 1. well developed <more than 3 layers>/

☐ ☐ 2. absent or very poorly developed/ → #110

#100. stratification <of phelloderm>/

☐☐ 1. present/

☐☐ 2. absent/ → #102

#101. <stratification pattern>/

. . . . . .

#102. phelloderm <type; sclereids absent or present and pattern of distribution>/

☐☐ 1. parenchymatous <sclereids absent>/

☐☐ 2. partially sclerified, sclereids predominantly solitary/

☐☐ 3. partially sclerified, sclereids irregularly scattered/

☐☐ 4. partially sclerified, inner layers more or less forming a sclerenchyma ring/

☐☐ 5. sclerified, sclereids assembled in irregularly shaped groups/

☐☐ 6. sclerified (at least inner portion), sclereids forming a sclerenchymatous ring <sclereid ring>/

#103. parenchyma cells <shape in phelloderm; best established near the phellogen in T.S.>/

☐☐ 1. more-or-less isodiametric/

☐☐ 2. mainly with tangential diameter greater than radial diameter <tangentially elongate>/

☐☐ 3. mainly with tangential diameter less than radial diameter <radially elongate>/

☐☐ 4. mainly with tangential diameter equal to radial diameter <square>/

#104. <sclereid type, e.g. spheroidal, vesiculose, vermiform, fusiform, filiform, polymorphic, (for a sub-division of this category see Rao & Bhupal 1973)>/

sclereids . . . . . .

#105. walls <thickening of sclereids>/

☐☐ 1. all evenly thickened/

☐☐ 2. with U-shaped thickening <inner tangential wall is thickened together with adjoining parts of the radial wall>/

☐☐ 3. with reversely U-shaped thickening <outer tangential wall is thickened together with adjoining parts of radial wall>/

#106. tanninferous <phelloderm> cells/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/

#107. calcium oxalate crystals <phelloderm>/

☐☐ 1. abundant/

☐☐ 2. sparse/

☐☐ 3. absent/

#108. <calcium oxalate crystals, e.g. type, variability, distribution patterns>/

. . . . . .

#109. chloroplasts <best established in living samples of phelloderm>/

☐☐ 1. present/

☐☐ 2. absent/

#110. lenticels <frequently; established macroscopically>/

☐☐ 1. numerous/

☐☐ 2. scarce/

☐☐ 3. arranged in transverse rows/

Cortex

#111. cortex <present in young stems, persistent>/

☐☐ 1. present, forming a distinct zone in mature bark/ → #112

☐☐ 2. absent in mature bark/

#112. <cortex attributes; scattered sclereids ,presence of crystals, tanniniferous cells, presence of secretory structures>/

. . . . . .
. . . . . .

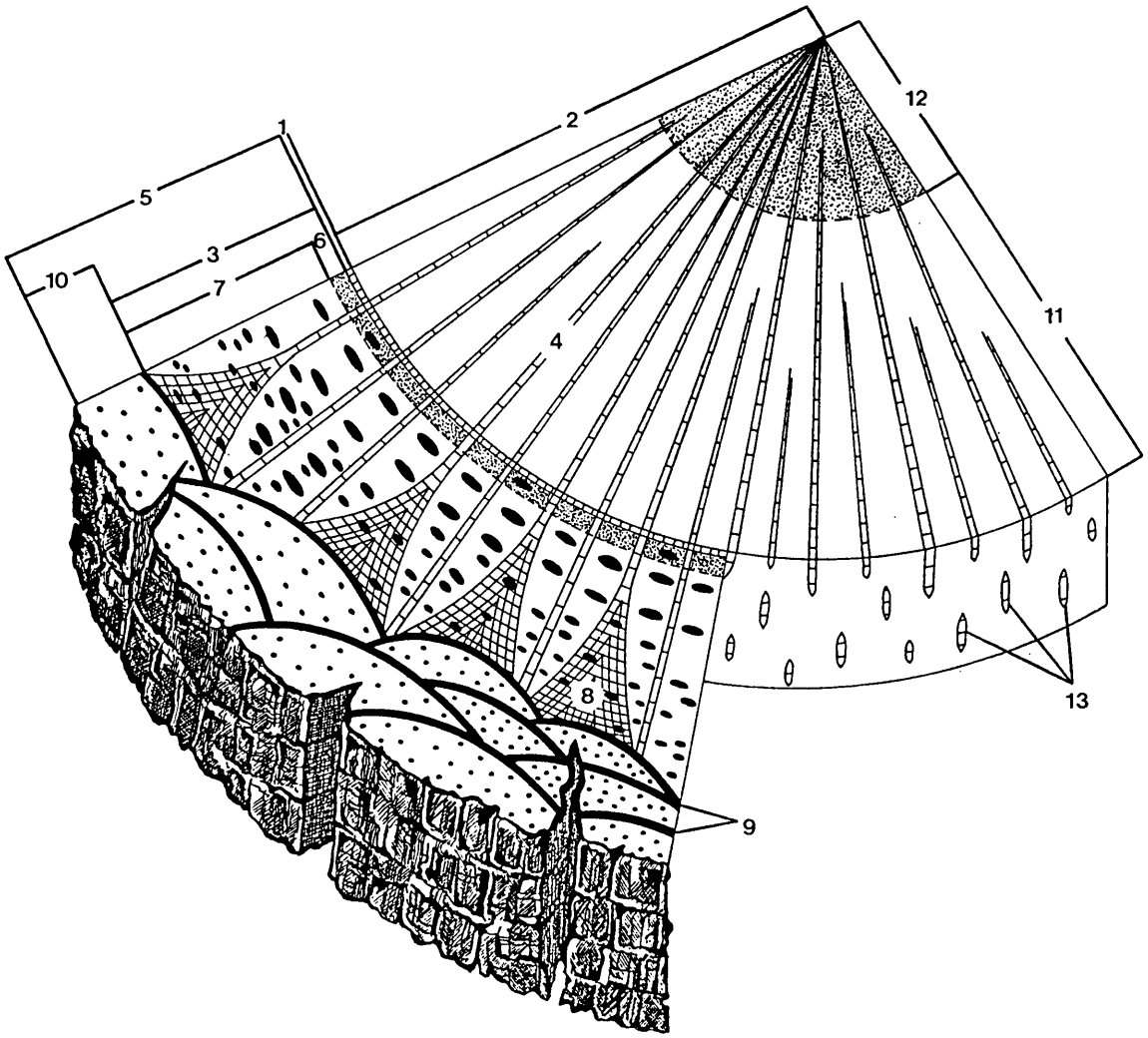

Figure 1. Schematic diagram of a portion of a partly debarked tree trunk showing the position of tissues in the mature bark and associated parts.

1. Vascular cambium
2. Secondary xylem (wood)
3. Secondary phloem
4. Vascular ray (phloem & xylem)
5. Bark
6. Conducting (non-collapsed) phloem
7. Non-conducting (collapsed) phloem
8. Dilatation (expansion) tissue
9. Periderm
10. Rhytidome
11. Sapwood (alburnum)
12. Heartwood (duramen)
13. Xylem rays (exposed ends)

LEGEND

FIGURES 2—30

1. Thick horizontal line (bottom of figure) = cambium
2. Thin horizontal lines = fibre bands
3. Radial lines = rays
4. Circles = secretory structures
5. Black features = sclereids
6. Dotted band = phelloderm
7. Clear band (top) = phellem
8. Bulging of rays = dilatation

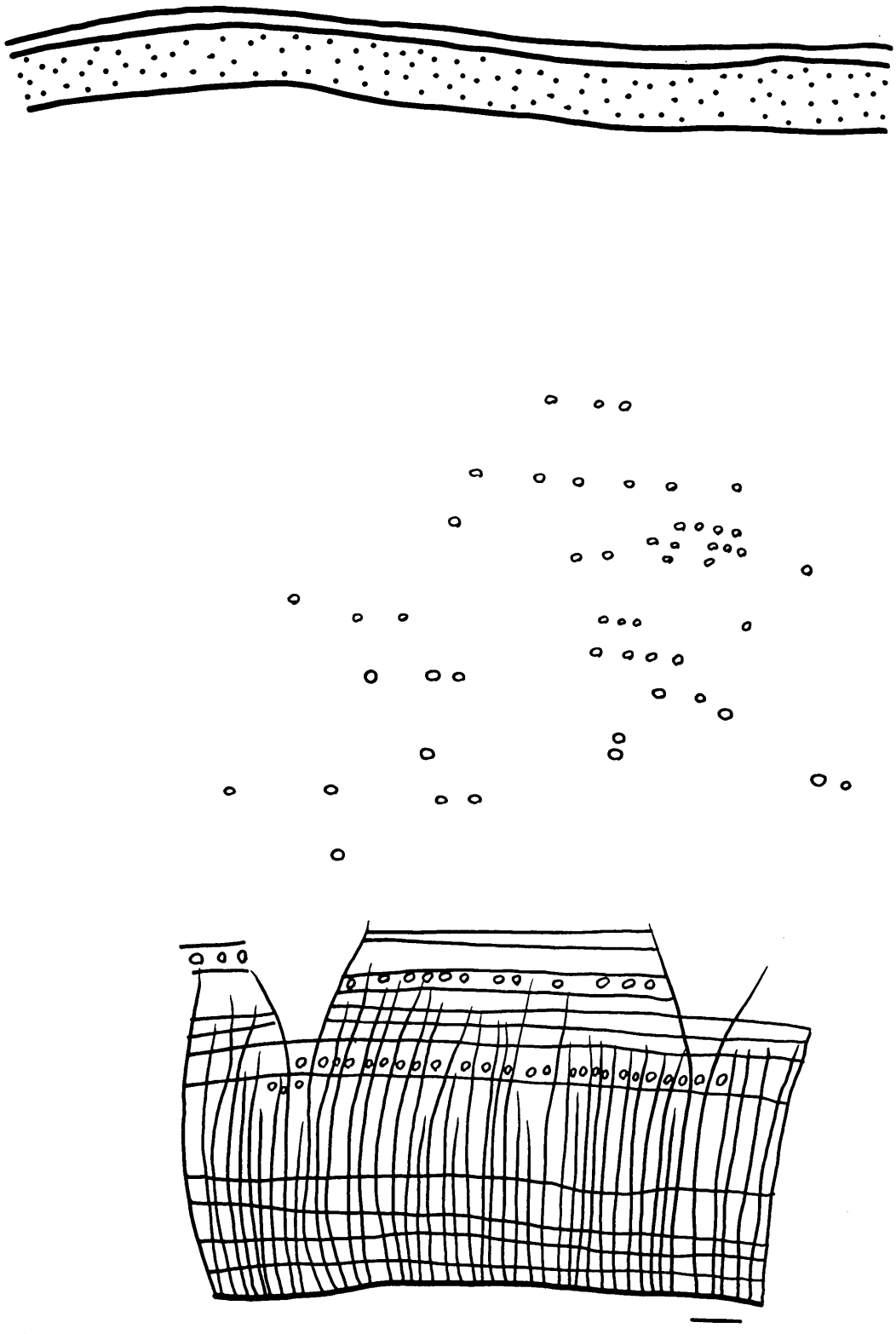

Figure 2. *Harpephyllum caffrum* (3734, 3888). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

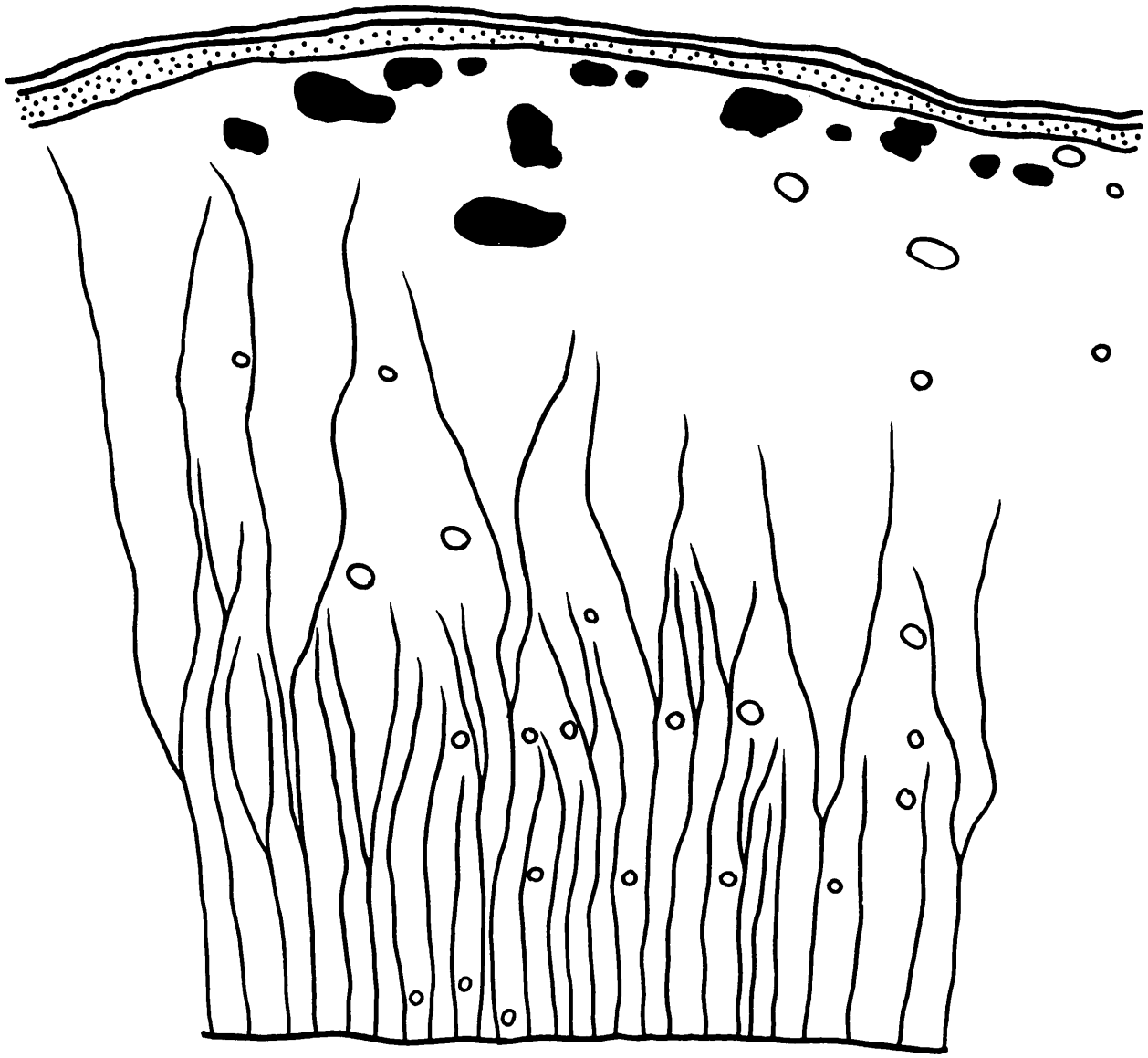

Figure 3. *Heeria argentae* (3912, 3917, 3919). Sclerenchyma comprising lignified fibres. Scale = 50μm

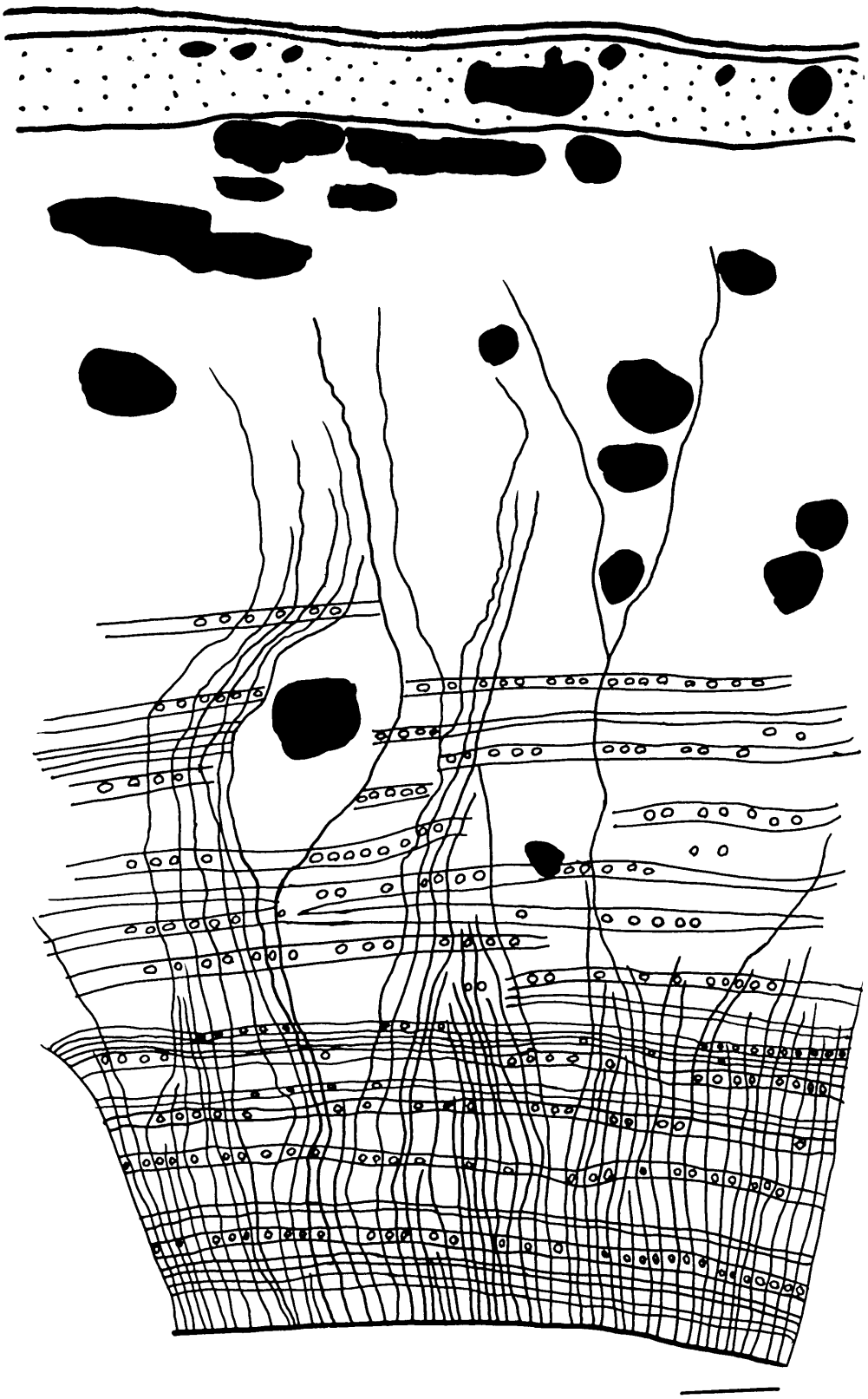

Figure 4. *Lannea antiscorbutica* (3845, 3846, 3875). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 100μm

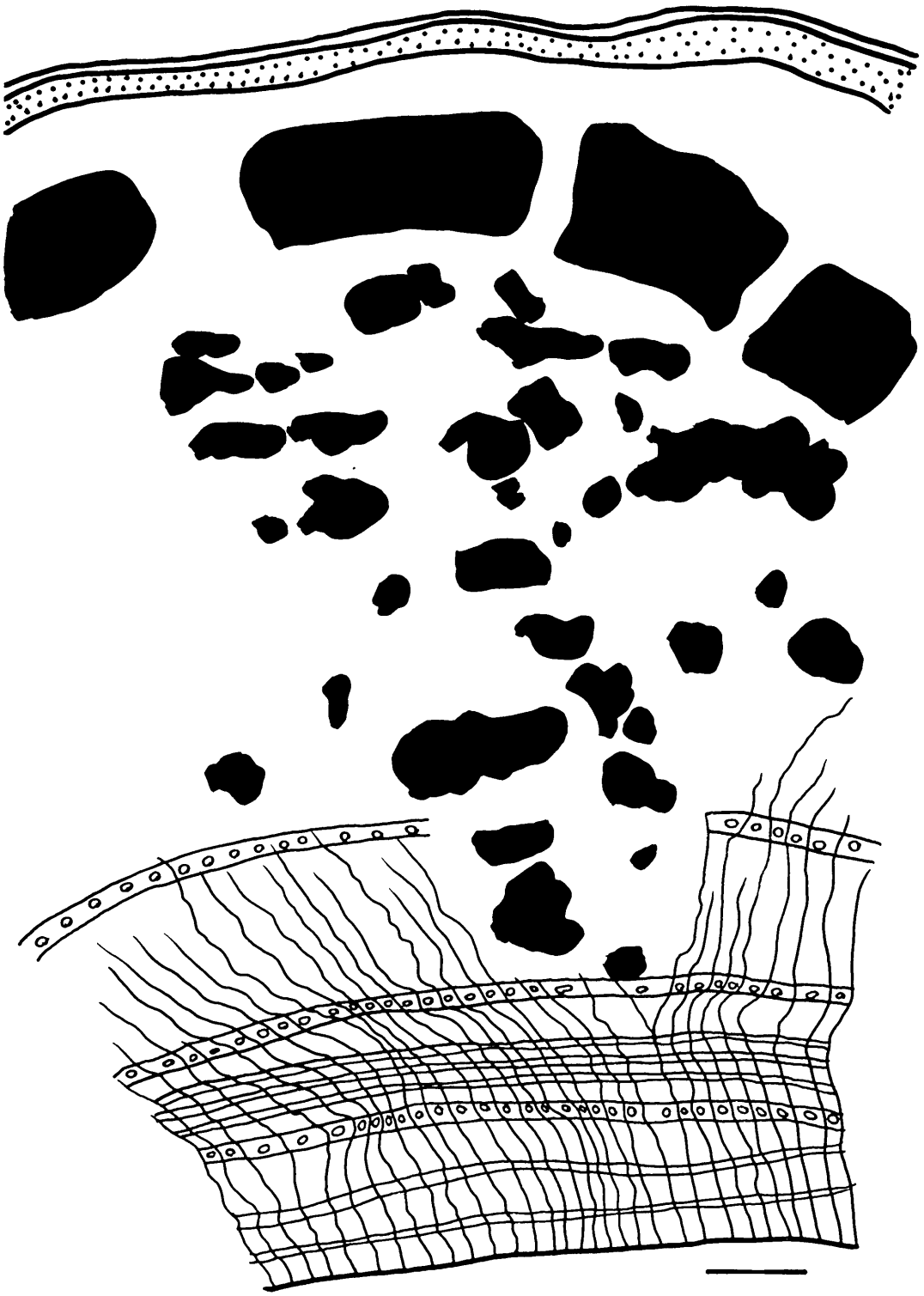

Figure 5. *Lannea discolor* (3745, 3746). Sclerenchyma comprising gelatinous fibres. Scale = 100μm

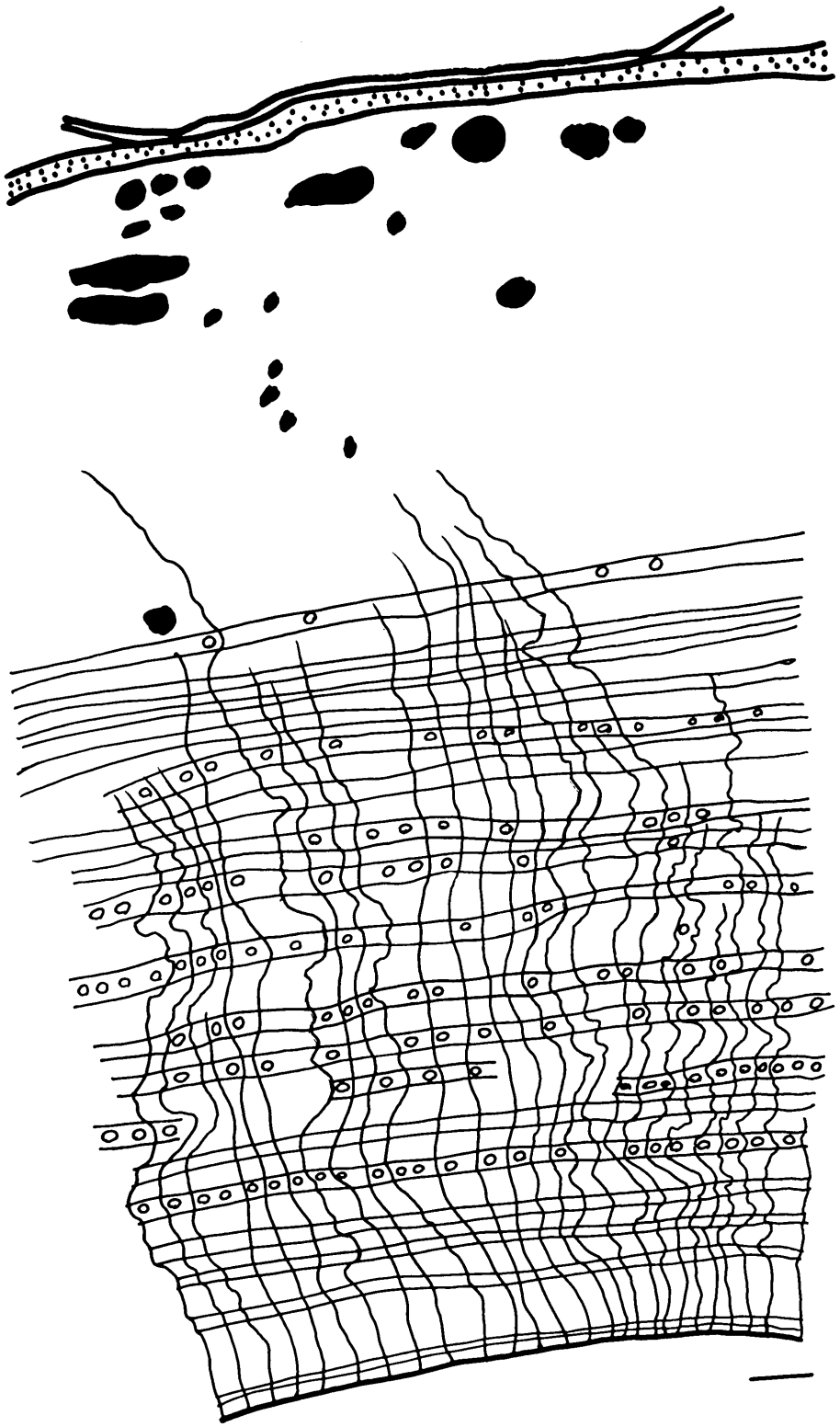

Figure 6. *Lannea schweinfurthii* (3785, 3885, 3887). Sclerenchyma comprising lignified, gelatinous fibres and sclereids. Scale = 50μm

Figure 7. *Laurophyllus capensis* (3913, 3914,3915). Sclerenchyma comprising lignified fibres. Scale = 15μm

Figure 8. *Loxostylis alata* (3741, 3777, 3805, 3806). Sclerenchyma comprising lignified and gelatinous fibres. Gelatinous fibres overshadow the whole inner bark. Scale = 50μm

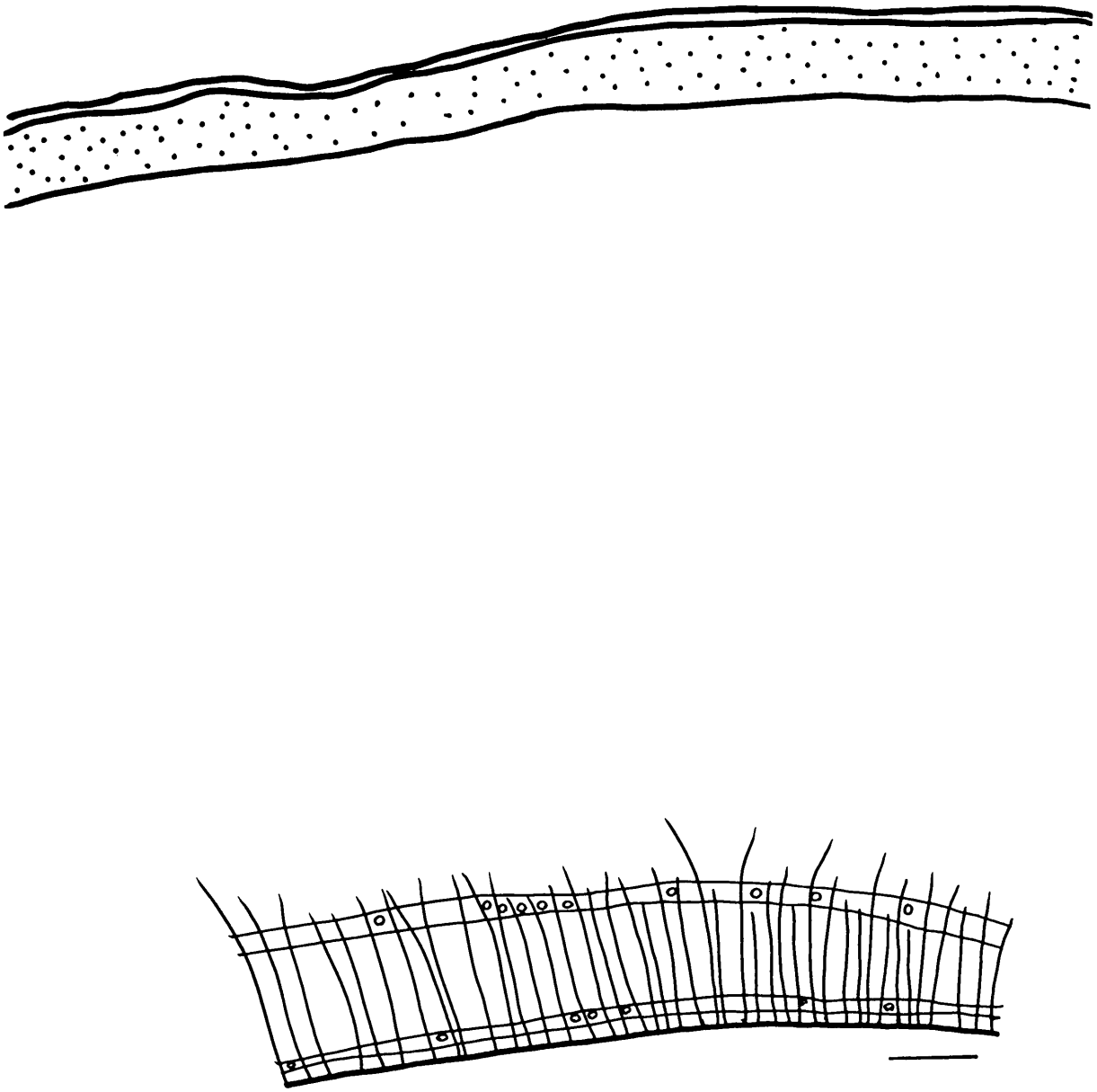

Figure 9. *Mangifera indica* (3751, 3794). Sclerenchyma predominatly lignified fibres. Scale = 50μm

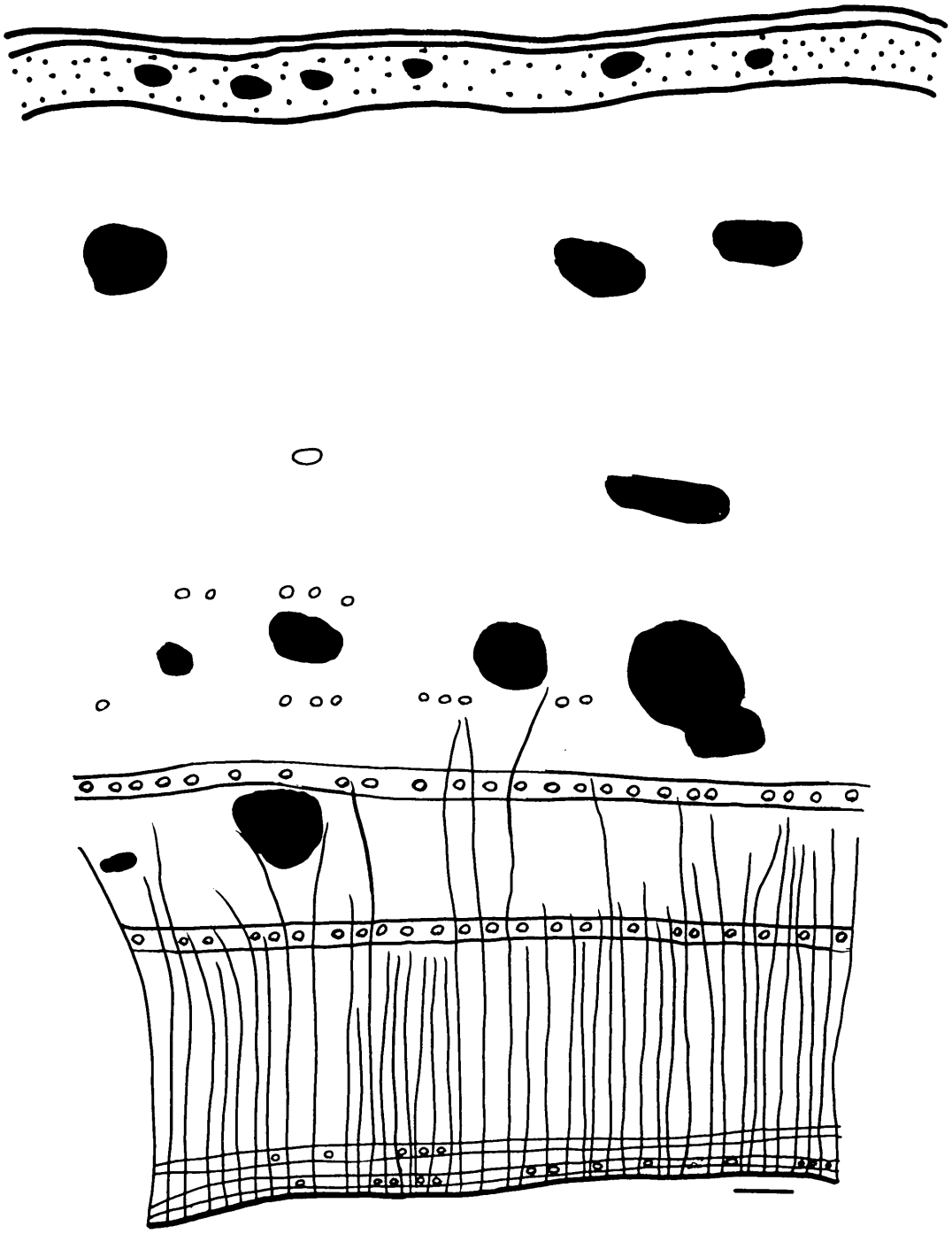

Figure 10. *Ozoroa engleri* (3884, 3899, 3900). Sclerenchyma absent or poorly developed, with a tendency to look like gelatinous fibres but without clear `G' layer. Scale = 50μm

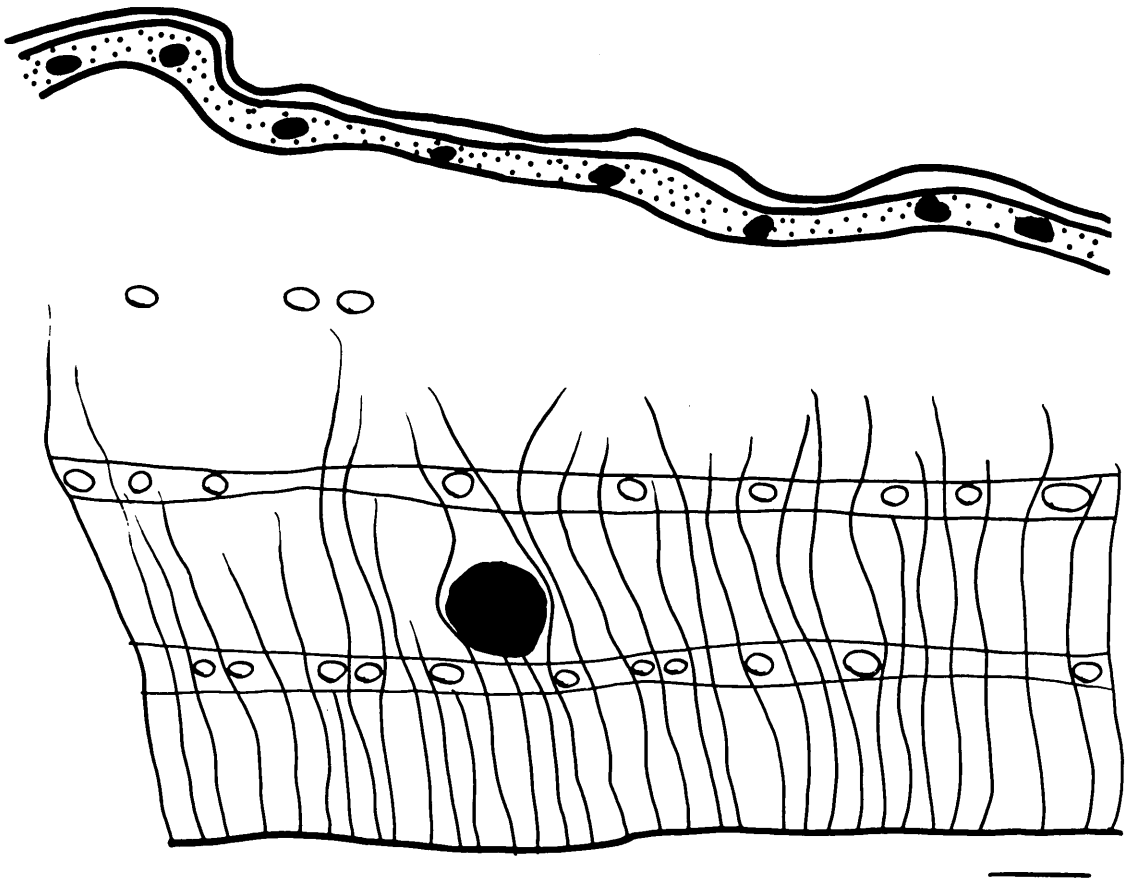

Figure 11. *Ozoroa mucronata* (2600). Sclerenchyma comprising gelatinous fibres. Scale = 50μm

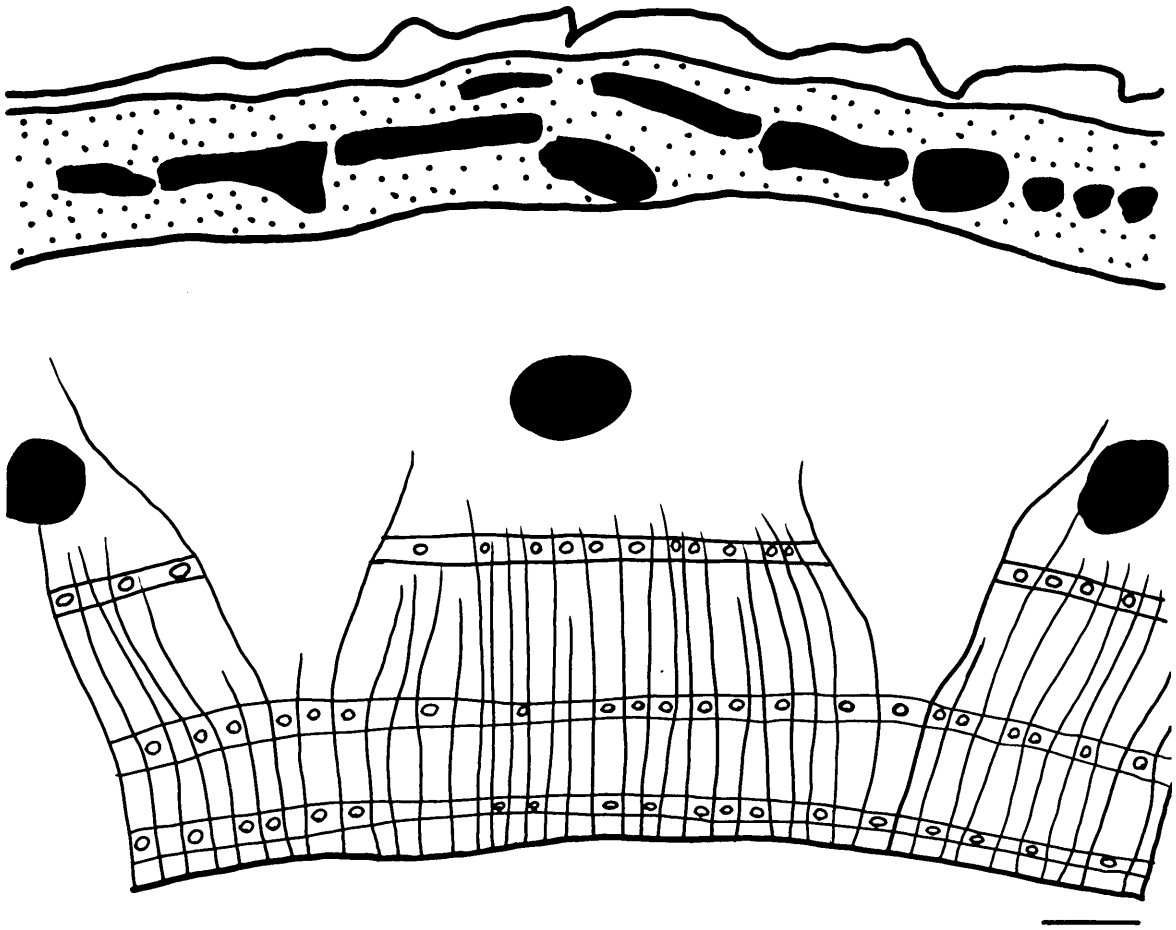

Figure 12. *Ozoroa obovata* (3779, 3890, 3891, 3893). Sclerenchyma comprising lignified fibres. Scale = 50μm

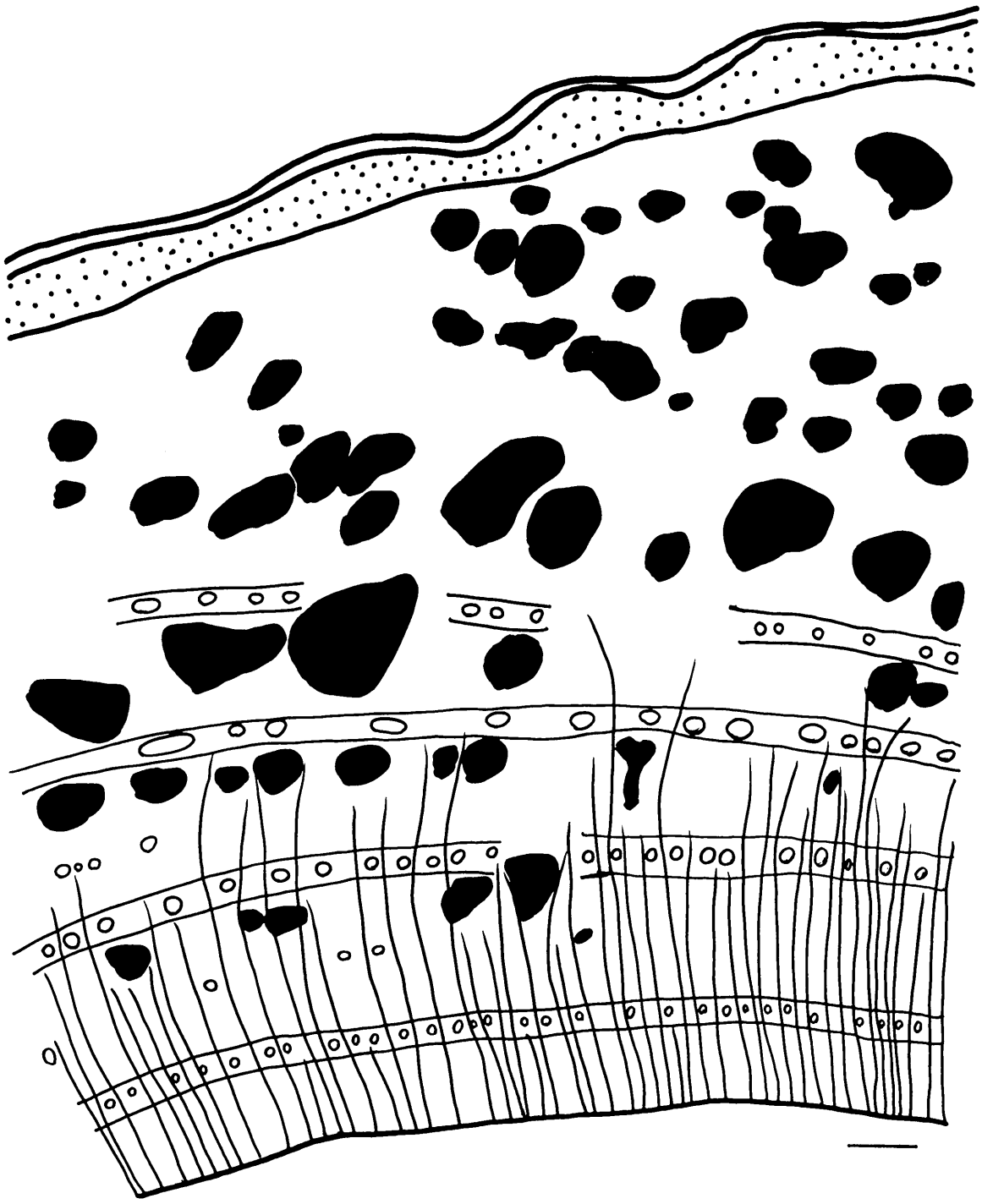

Figure 13. *Ozoroa paniculosa* (3812, 3813). Sclerenchyma comprising gelatinous fibres. Scale = 50μm

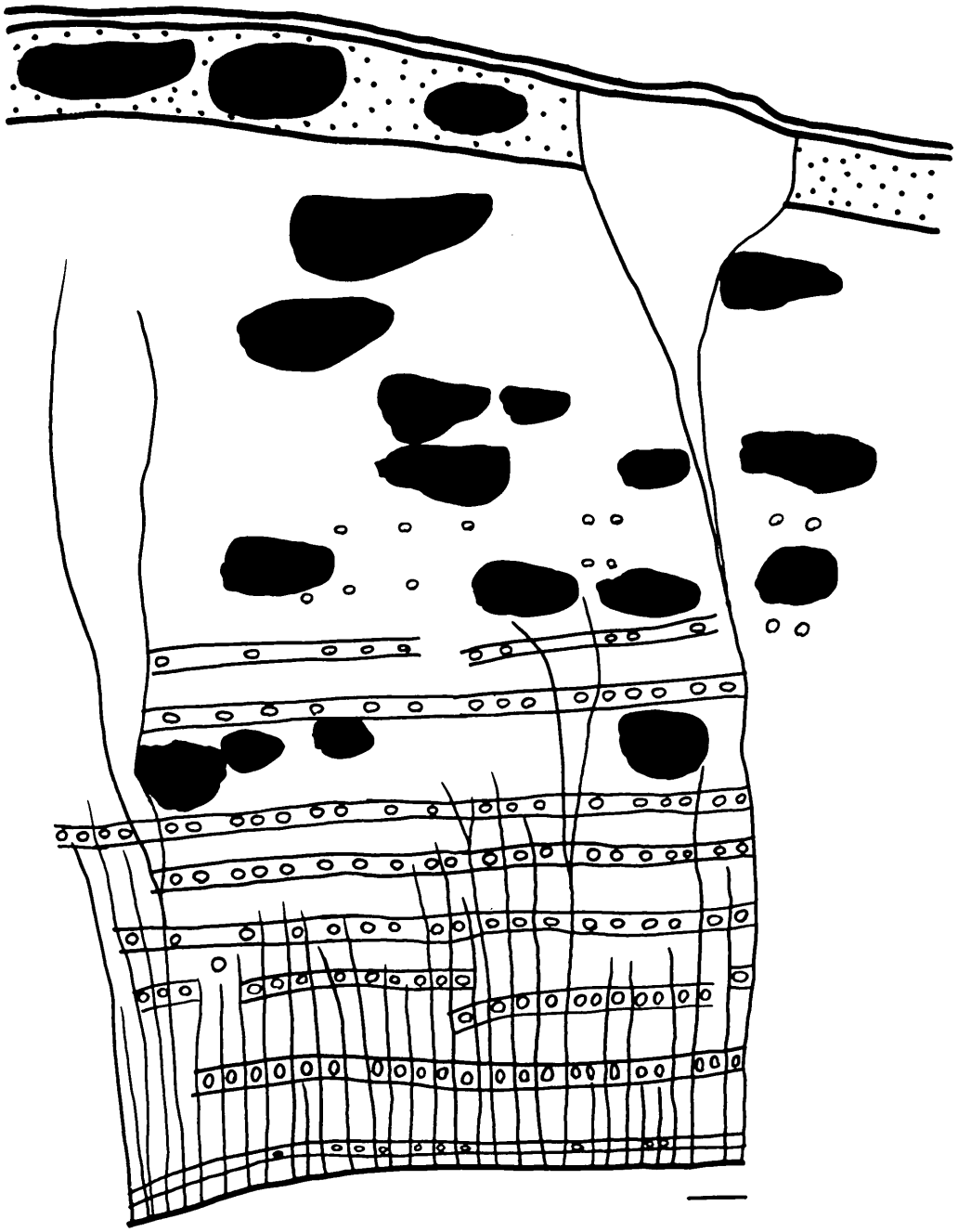

Figure 14. *Ozoroa sphaerocarpa* (3782, 3783). Sclerenchyma comprising gelatinous fibres. Scale = 50μm

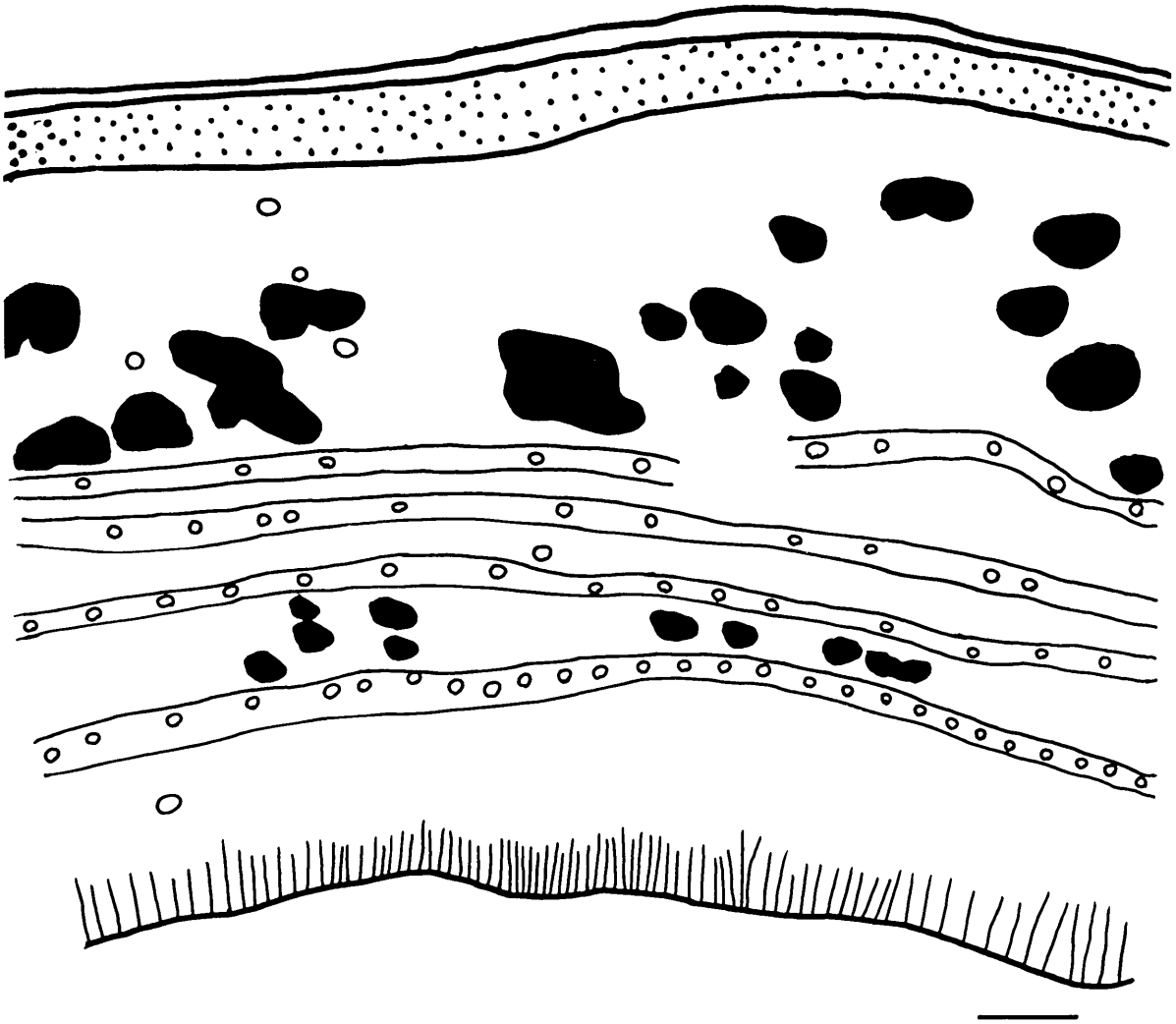

Figure 15. *Ozoroa namaquensis* (1322). Sclerenchyma comprising gelatinous fibres. Scale = 50μm

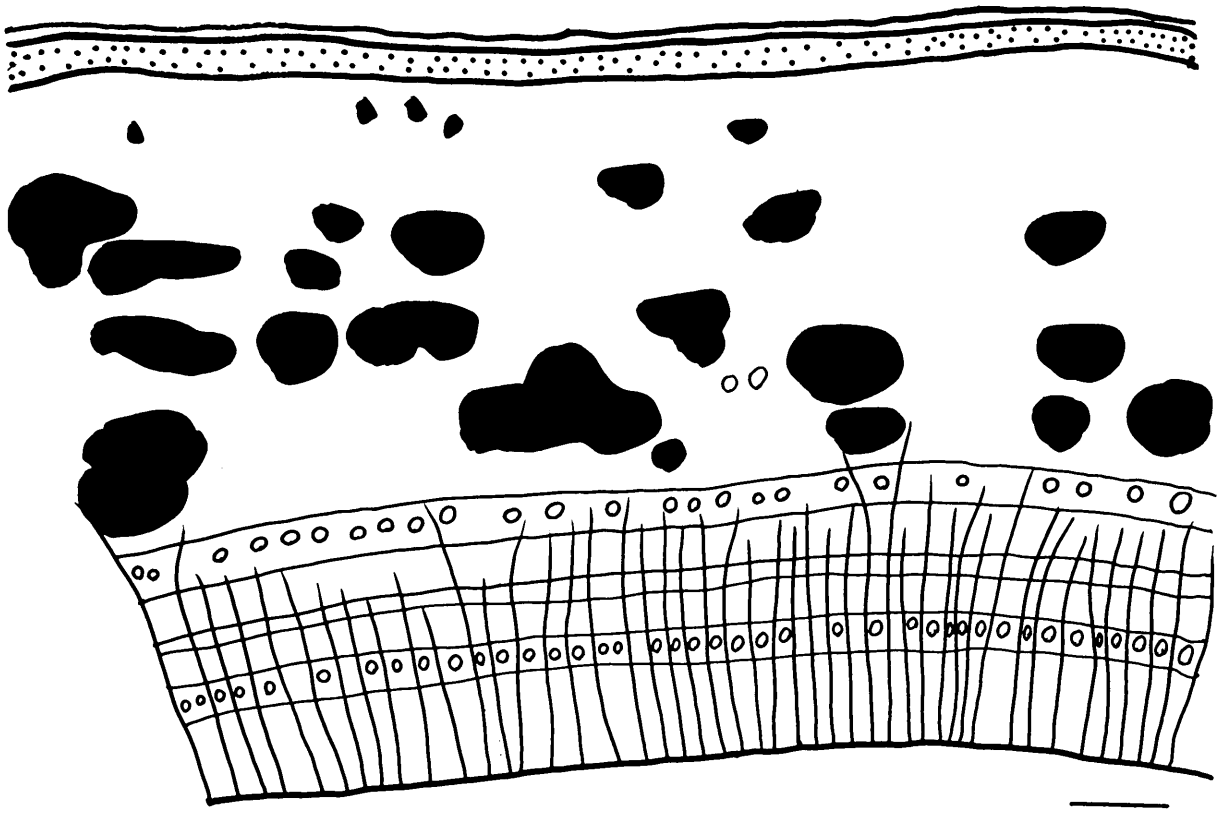

Figure 16. *Protorhus longifolia* (3743, 3744). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

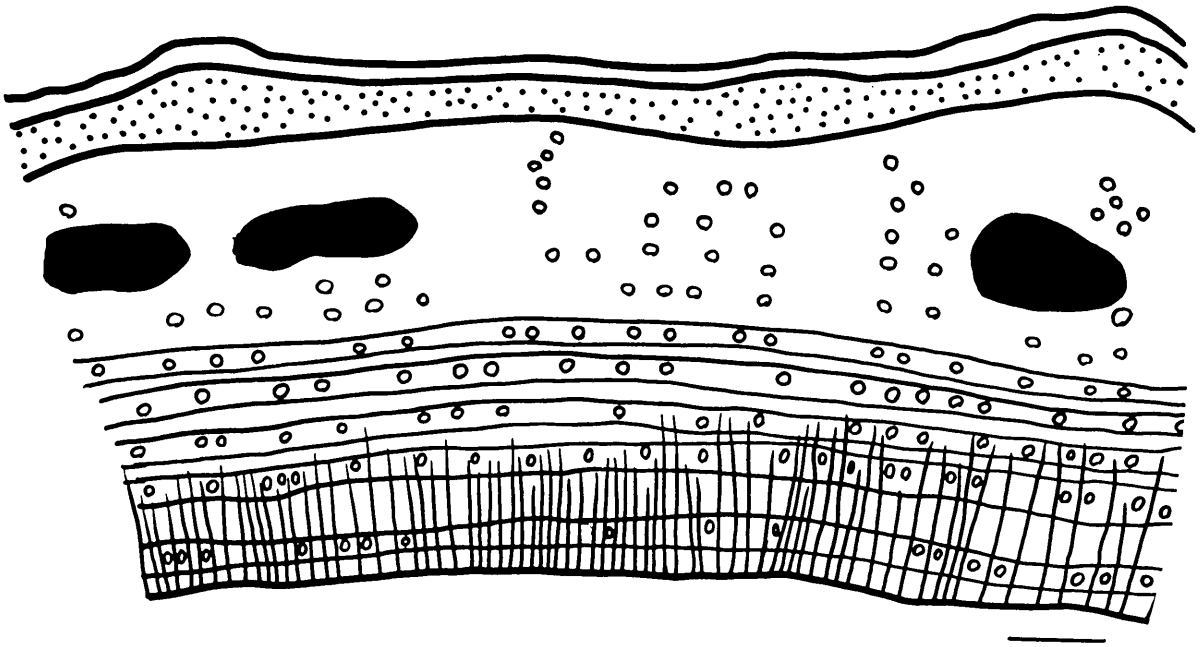

Figure 17. *Rhus batophylla* (3778). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

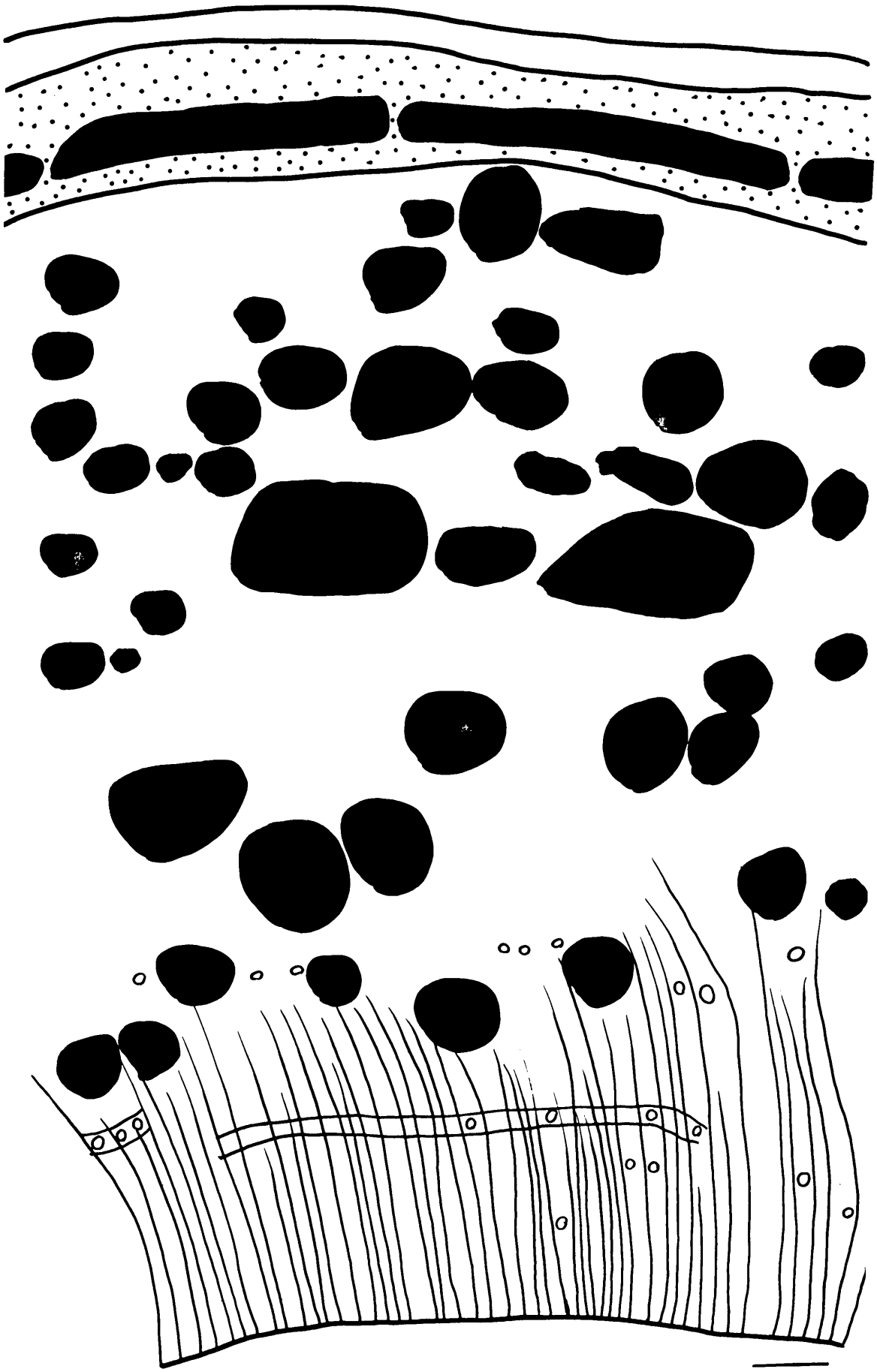

Figure 18. *Rhus chirindensis* (3808). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

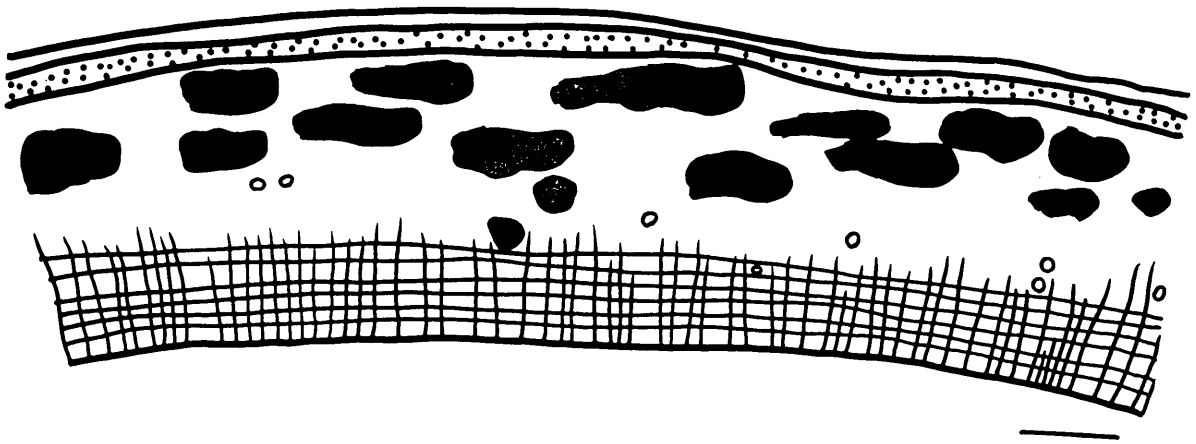

Figure 19. *Rhus guenzii* (3876, 3877, 3878). Sclerenchyma comprising lignified fibres. Scale = 50μm

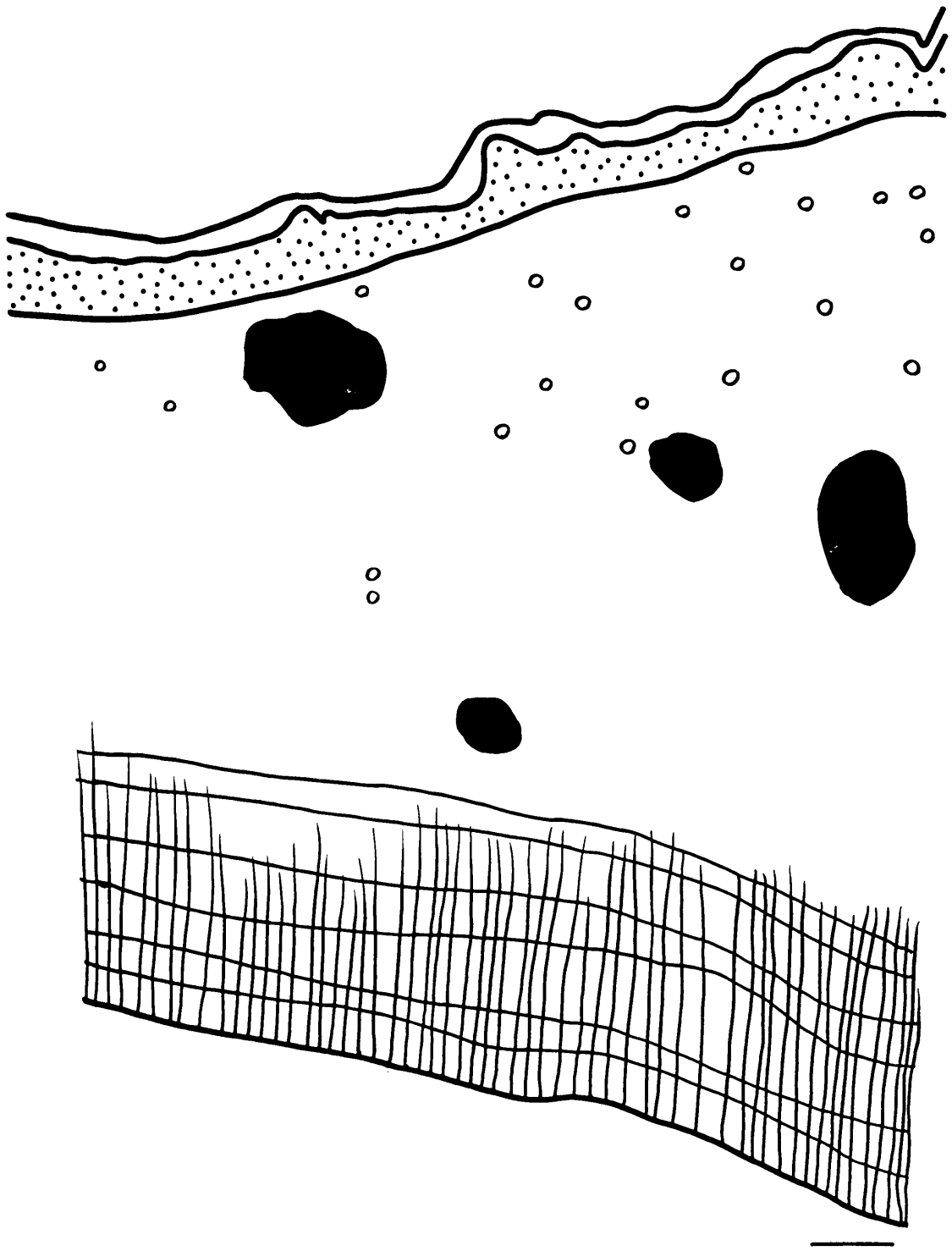

Figure 20. *Rhus lancea* (3809). Sclerenchyma comprising lignified fibres. Scale = 50μm

Figure 21. *Rhus leptodictya* (3738). Sclerenchyma comprising lignified fibres. Scale = 25μm

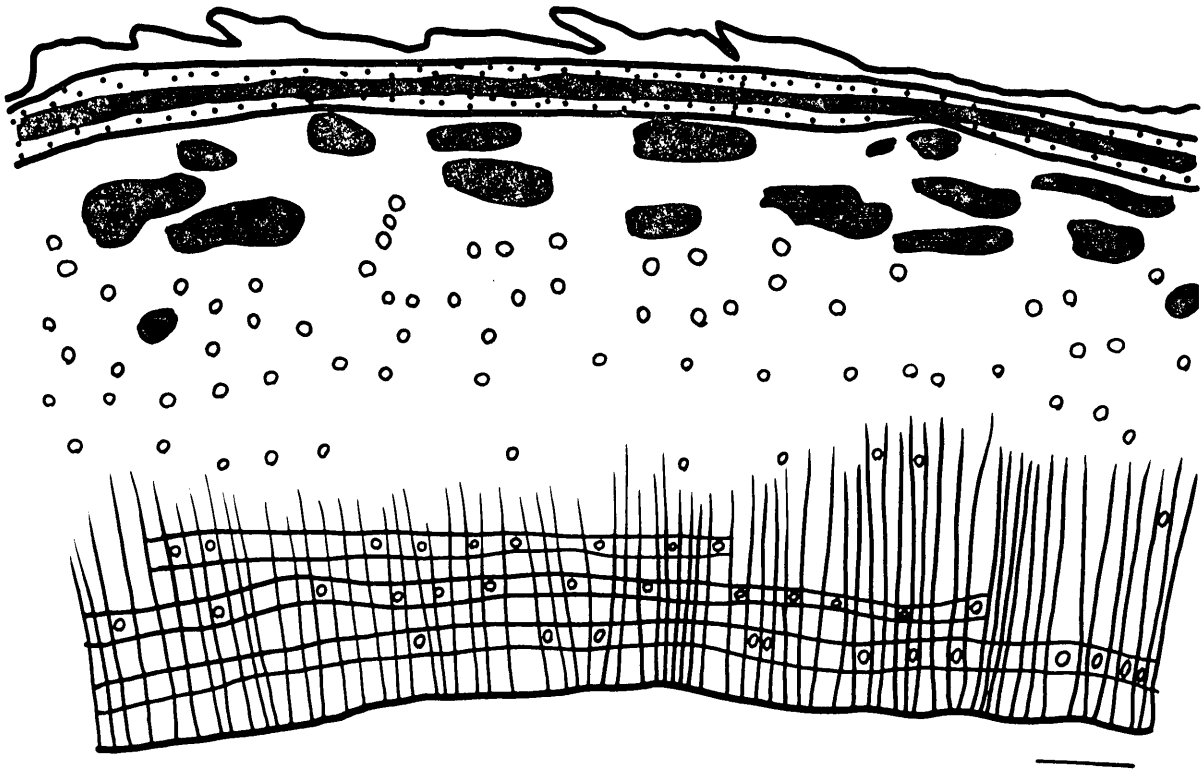

Figure 22. *Rhus natalensis* (3896, 3897, 3898). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

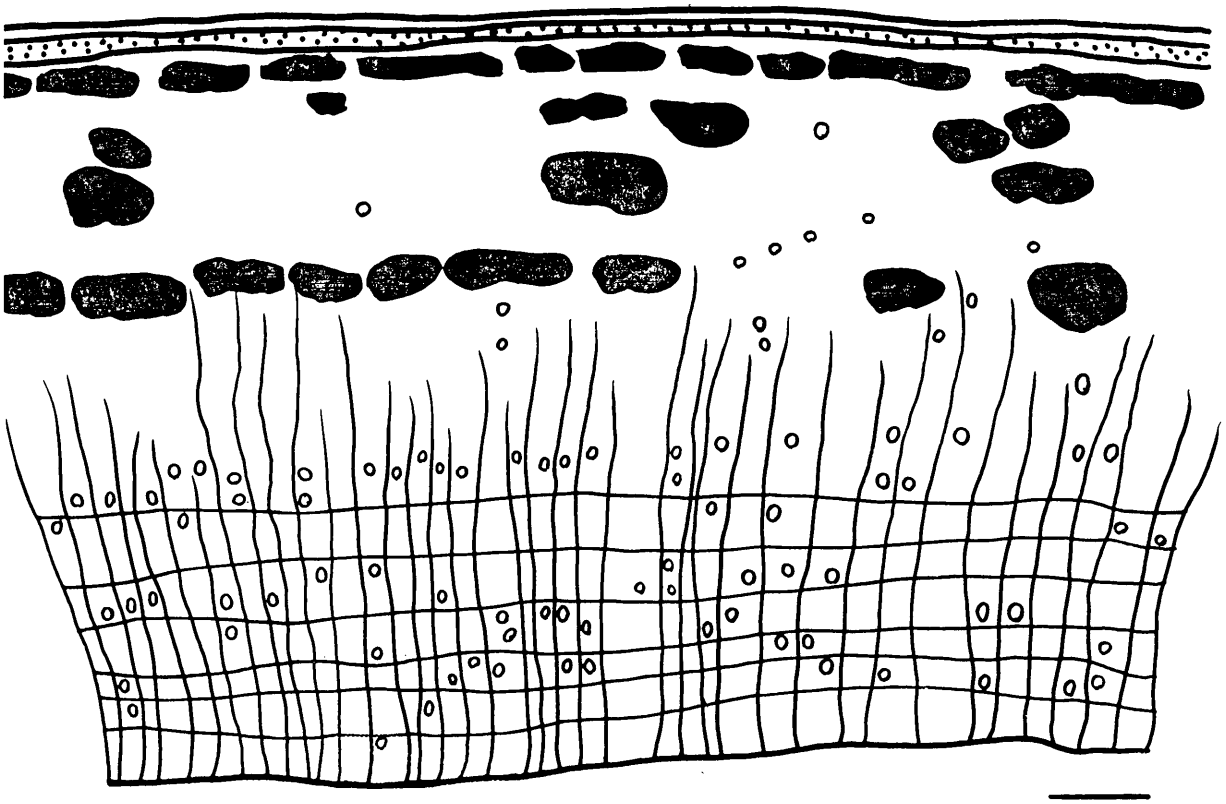

Figure 23. *Rhus pendulina* (3737). Sclerenchyma comprising lignified fibres.
Scale = 50μm

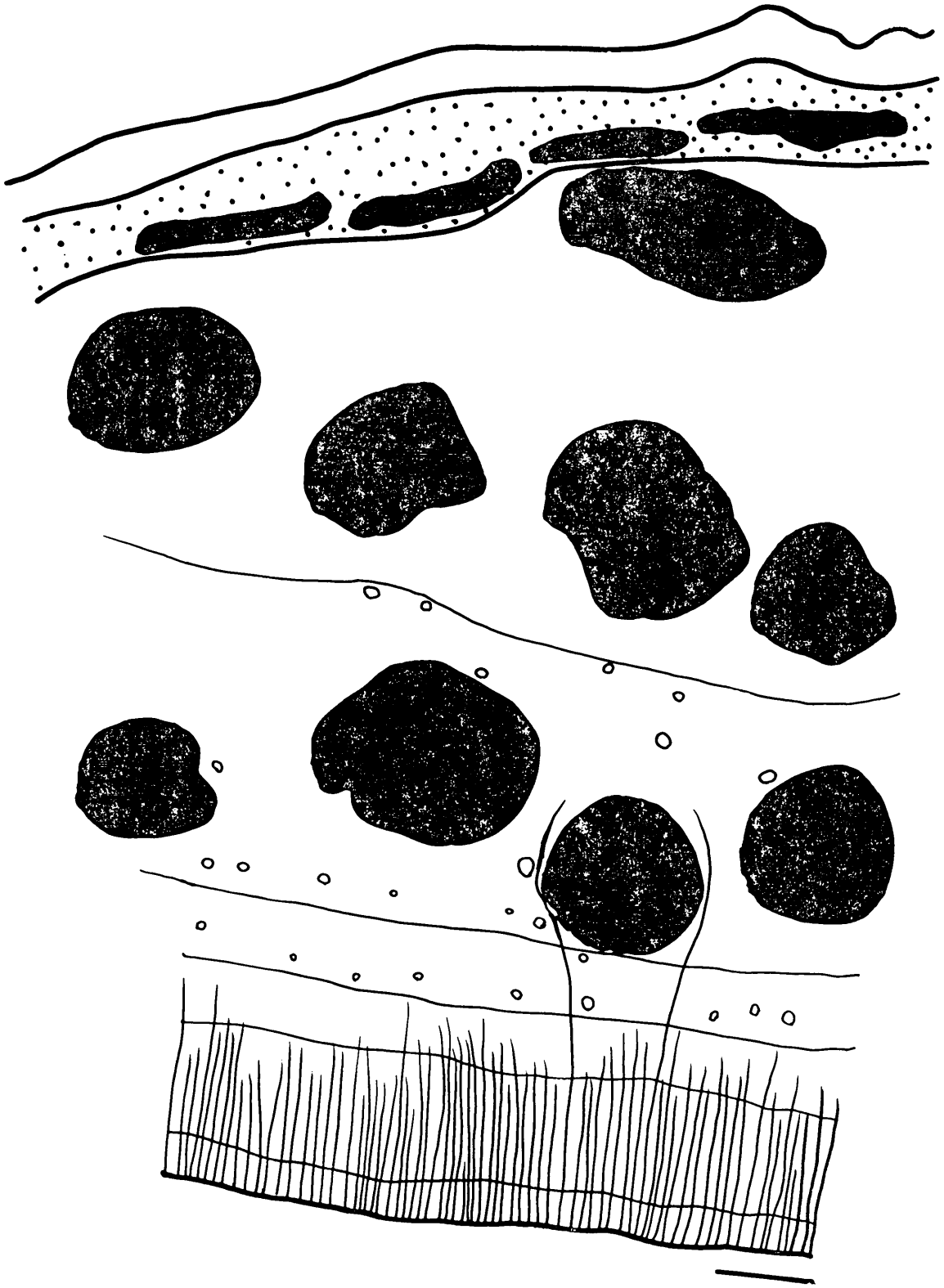

Figure 24. *Rhus pyroides* (3791, 3792, 3795). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 25μm

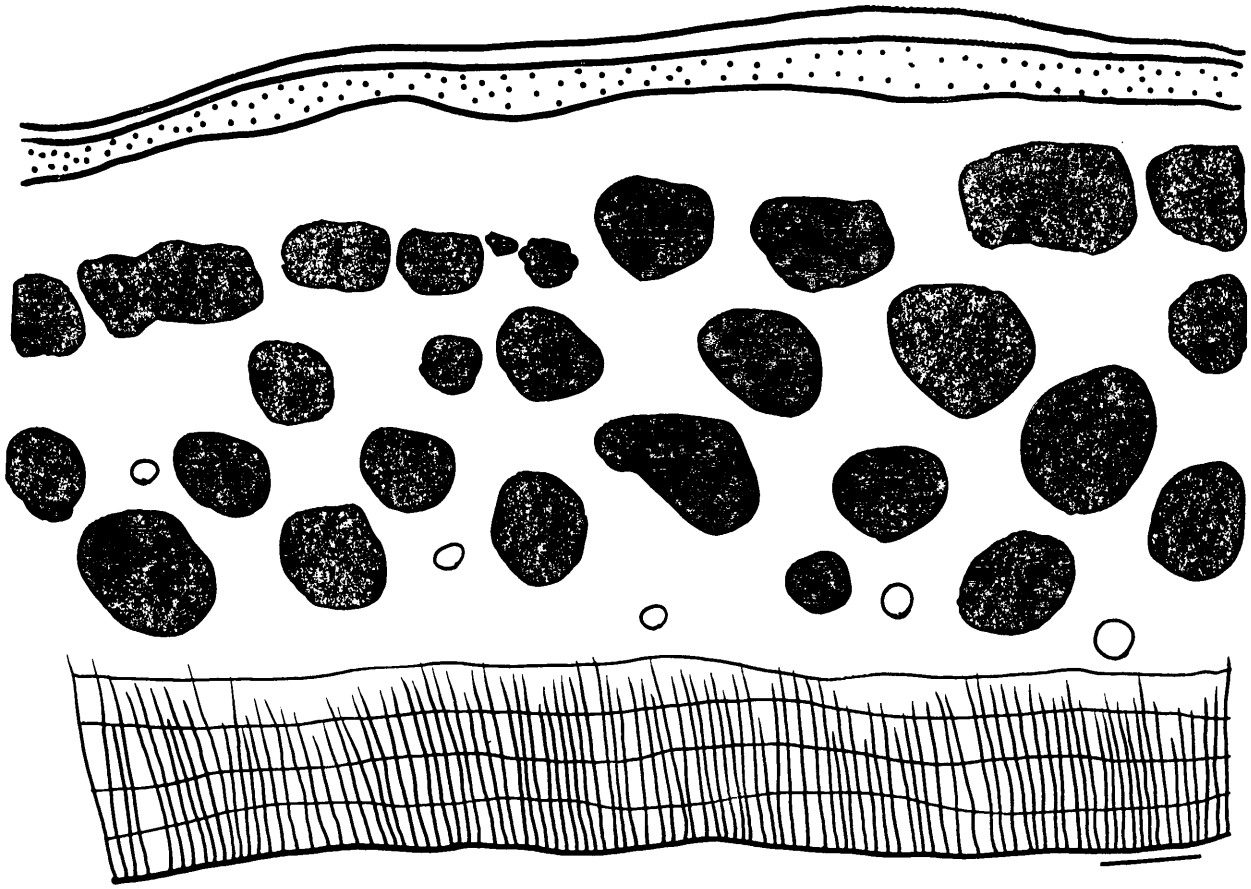

Figure 25. *Rhus rehmanniana* (1473). Sclerenchyma comprising lignified fibres.
Scale = 50μm

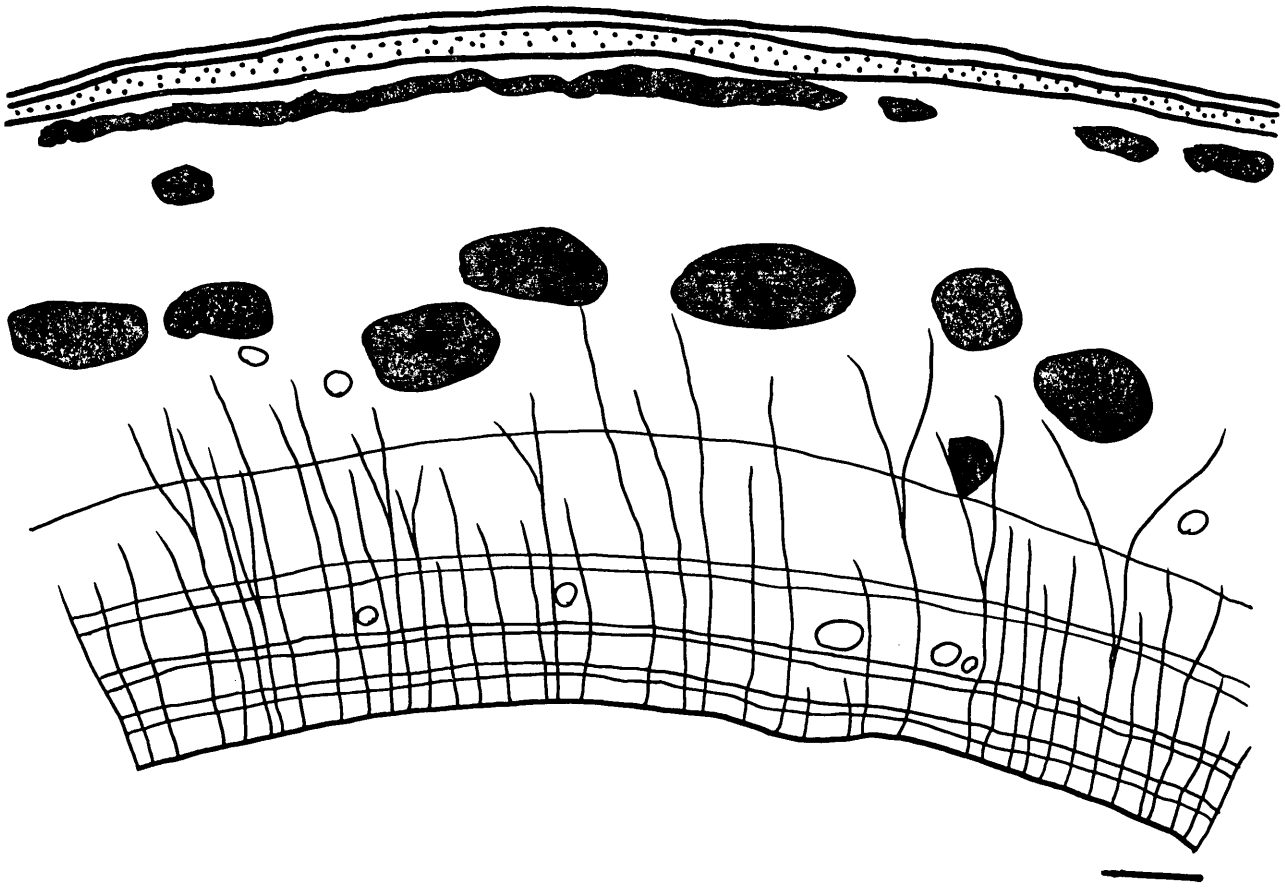

Figure 26. *Rhus sp.* (3889). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

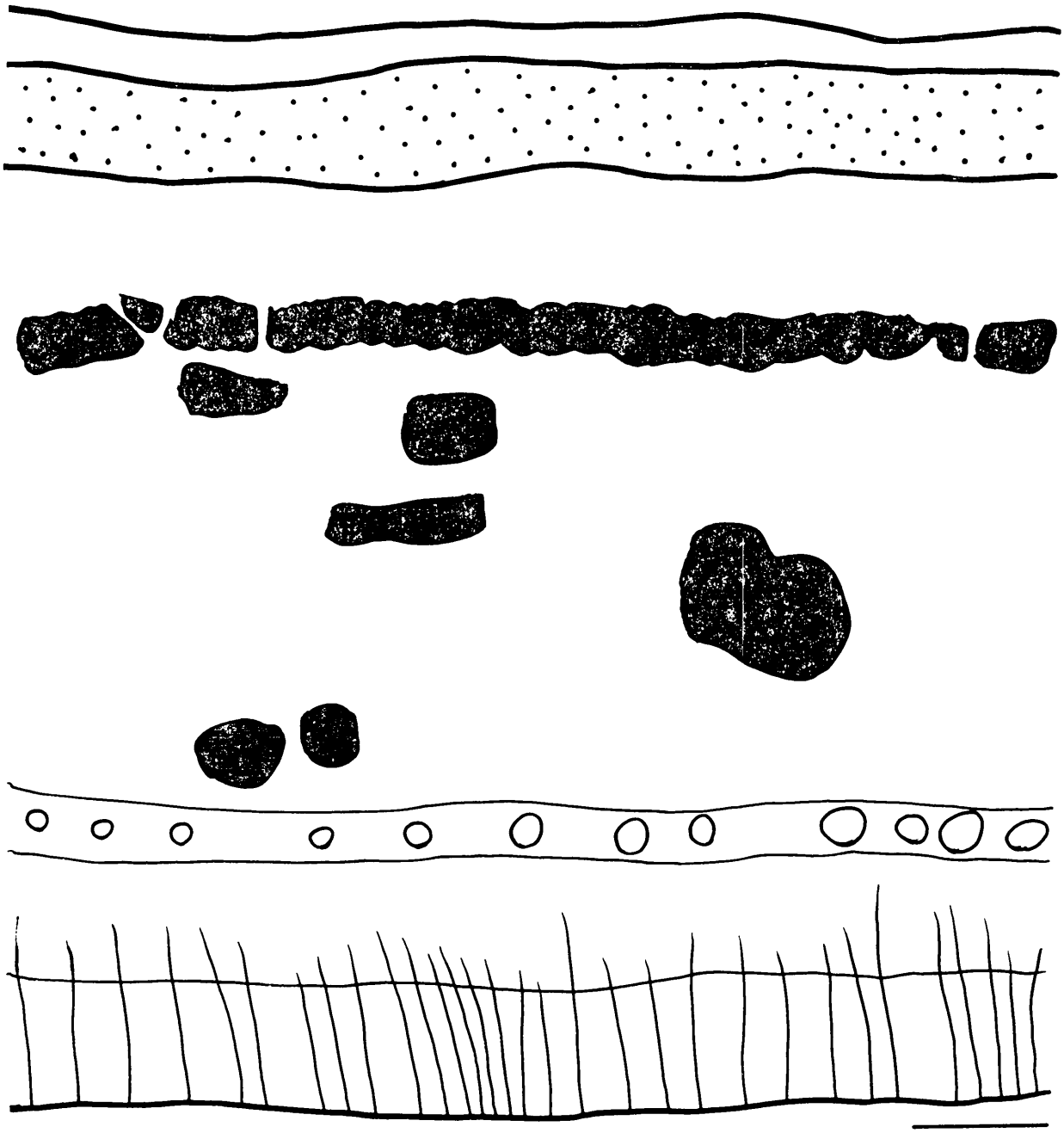

Figure 27. *Rhus undulata* (3739). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 20μm

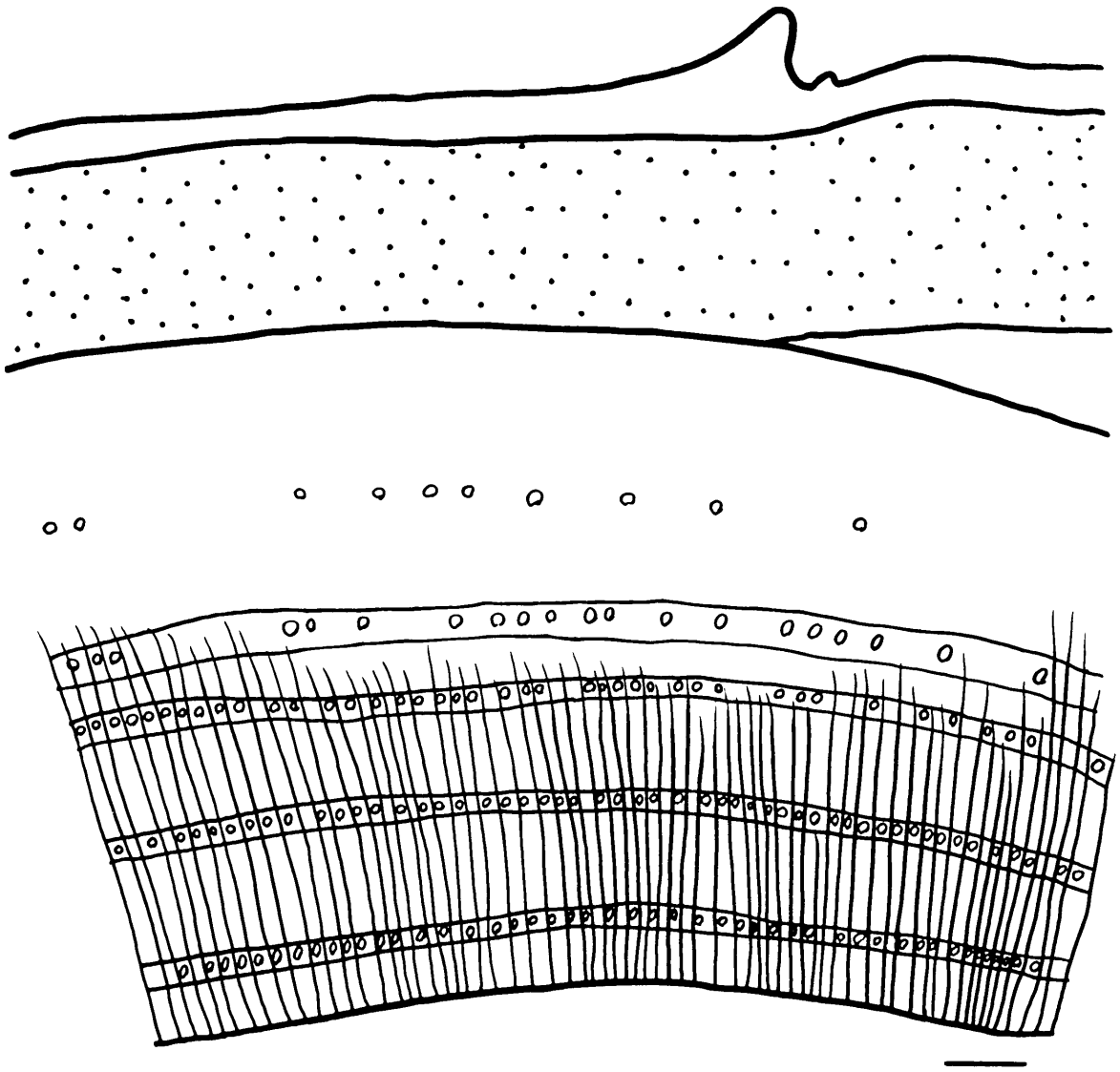

Figure 28. *Schinus molle* (3742, 3748). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

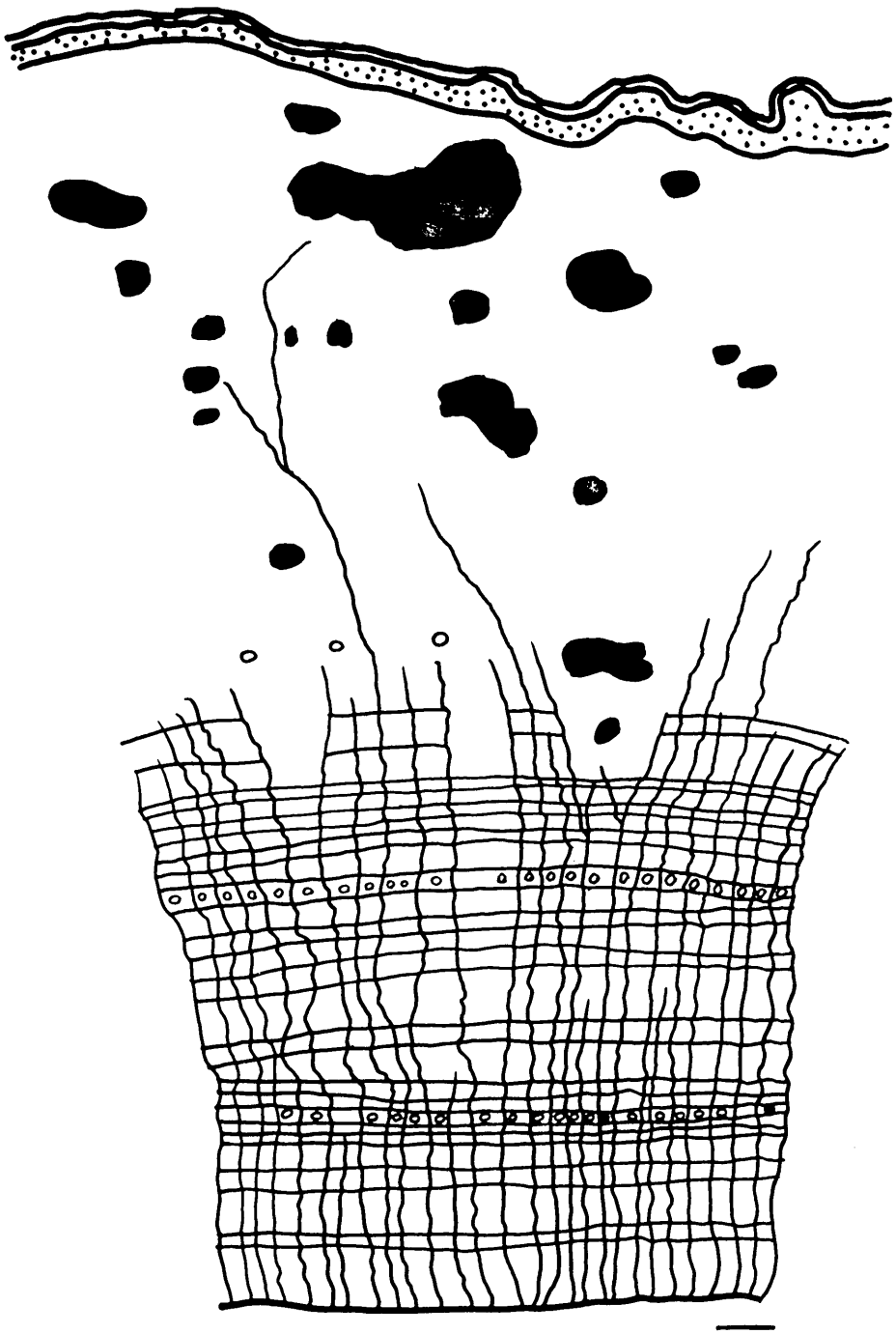

Figure 29. *Sclerocarya birrea* (3747, 3784, 3901). Sclerenchyma comprising lignified and gelatinous fibres. Scale = 50μm

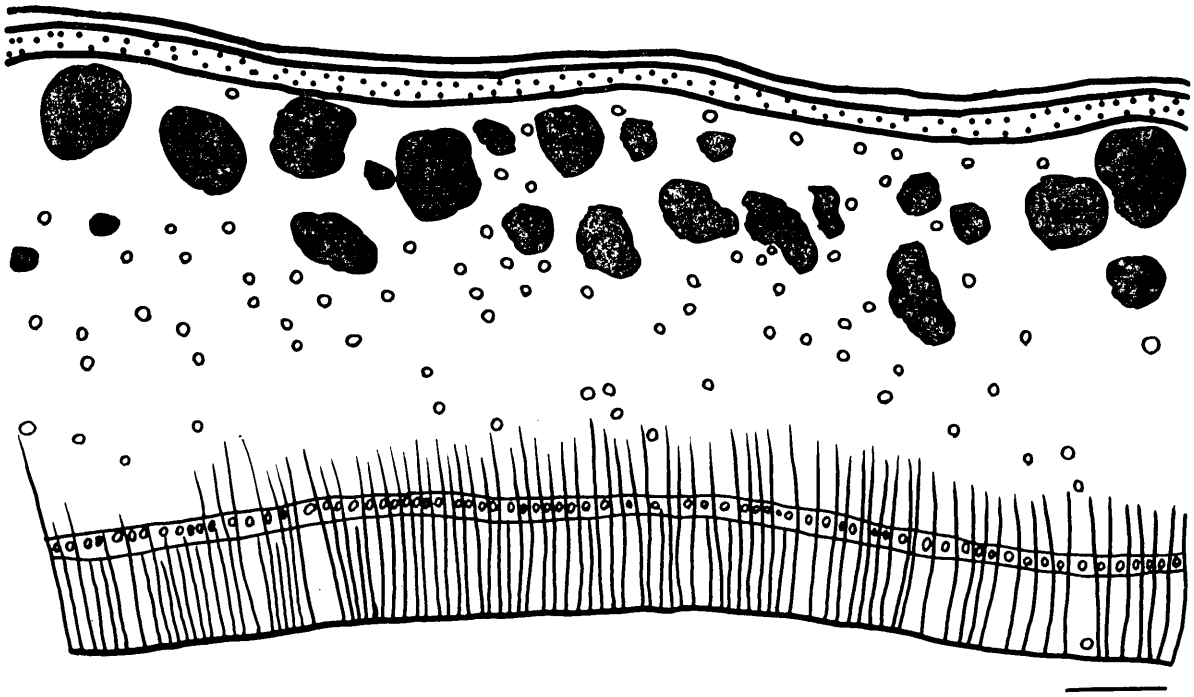

Figure 30. *Smodingium argutum* (3780, 3781). Sclerenchyma comprising lignified fibres. Scale = 50μm.