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Field identification of roots of woody plants of the savanna ecosystem study area, Nylsvley

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ABSTRACT

A key for the field identification of fresh root material of 21 woody plant species on the savanna ecosystem study area, Nylsvley, South Africa, is given. Descriptions of macroscopic features of roots as well as photographic descriptions of roots and root systems are provided.

RÉSUMÉ

IDENTIFICATION SUR LE TERRAIN DE RACINES DE PLANTES LIGNEUSES DANS LA RÉGION DE L'ÉCOSYSTÈME DE SAVANE ÉTUDIÉ À NYLSVLEY

On donne une clé pour l'indentification sur le terrain de matériel radiculaire frais concernant 21 *espèces de plantes ligneuses rencontrées dans la zone d'étude d'un écosystème de savane à Nylsvley en Afrique du Sud. Les caractères macroscopiques des racines sont décrits et l'on y joint des photographies des racines et des systèmes radiculaires.*

INTRODUCTION

During the course of root investigations in the *Burkea africana*-dominated savanna of the South African savanna ecosystem project study area on the Nylsvley Nature Reserve in the northern Transvaal, the need for species identification of roots has frequently arisen. In the nutrient-poor, often deep (> 2 m) sandy soil of this area, it has been found that roots of woody plants often extend well beyond the tree canopy's ground projection area. In some species the lateral roots commonly extend linearly up to seven times the extent of the canopy, that is, an area about 50 times the area covered by the canopy. The roots of some species do not often radiate symmetrically from the stem position, but may all lie to one side of this position, for example, sometimes in *Ochna pulchra*. The result is often a relatively high degree of different species root interpenetration (interdigitation) that is usually extremely difficult to predict from only a study of the distribution of the aboveground parts of the species. Species identification of roots is needed to increase the quality of root data derived from techniques including soil core and block or monolith sampling. Identification is also important when exposing entire root systems for determination of root distribution and biomass distribution of a limited set of species. Here positive identification is needed to 'weed out' roots of other species that occur in between the roots of the species under study as field work proceeds. Because many tons of soil would often need to be carefully removed to trace a particular root to its parent plant stem for identification, and more importantly since it has been found that it is usually impracticable to trace roots of several species simultaneously without destroying some of the roots that are still required, root identification based on easily observable characteristics in relatively small root samples is required.

The drawing up of keys to identify roots to the species based on macroscopic features in the field appears to have been seldom attempted. One work that has been found provides a key for the identification of roots of 11 conifer species in certain forest areas of north-western America (Gilbertson *et al.*, 1961). These workers report not finding any reference to such identification prior to their work. One of the great problems, also found by the above quoted writers, is that diagnostic characteristics for species identification of roots tend to disappear on small-diameter roots. Another factor that has undoubtedly discouraged devising field root identification keys is that below ground plant organs are usually far less clearly differentiated compared to the high degree of above ground plant organ differentiation that provides many possible diagnostic features for clear identification. Most taxonomic works on woody plant species seldom contain descriptions of roots. Although microscopic features undoubtedly provide much more information for root identification, such features are usually impracticable for use in rapid field identification.

In the present study, description of species roots is limited to roots usually greater than 5 mm in diameter. The species that were included were selected on the basis of a plant ecological survey carried out by Coetzee *et al.* (1976) on the site. All woody species that occurred with a frequency of > 20% in their defined "*Eragrostis pallens—Burkea* Tree Savanna" were included. Their sample plots were so large (each about 0,8 ha) that some of the species with a frequency of > 20% were not common. The 19 species included were therefore not limited to the most common species. Since two species (*Lannea edulis* and *Fadogia monticola*) with a frequency of just under 20% but probably in smaller plots of 0,02 ha, are known despite their non-woody above-ground habit to have large and extensive woody below-ground organs, these two species were also included resulting in a total species number of 21. These species also included those 11 species which together constituted more than 98% of the total above-ground woody plant biomass of the site (Rutherford, 1979). Since not all woody species are included, however, it is possible that in some situations, roots of other species may be present. Therefore inspection for above-ground evidence of rarer excluded species should be done and the roots of such species first examined to prevent misidentification using the key. This principle will obviously also apply when using the key in other similar *Burkea africana* communities. In the event of a particular difficulty arising when using the key, it should be borne in mind that often several species

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may be eliminated on their absence (viewed on above-ground evidence) within a radius of about 50 m from the sampling point.

Not all underground organs are roots, for example, the underground stems of *Fadogia monticola* and some other "rhizomatous" geoxylic suffrutices (White, 1976). To avoid the cumbersome repetition of "underground organ", the term "root" is used instead to indicate that part of the plant below the soil surface. After much secondary thickening has taken place, the difference between root and underground shoot becomes much reduced, so that particularly from a functional viewpoint, these two organ types may be regarded as much alike. Pith refers to the apparent original centre of growth in the root. Outer bark refers to the outer, dry and usually very thin, layer around the root. Inner bark refers to the rest of the bark and is distinguished by being moister and usually much thicker than the outer bark. In the key and descriptions, bark thickness (sum of two bark thicknesses over total root diameter) given is for roots further away from the stem position and not necessarily for the very thick roots near the plant base. Often in fresh root cross sections, pores are not visible or scarcely visible but, upon drying out (for example, in some of the photographs given), become clearly visible sometimes together with rays and rings. All cross section views (cut with pruning shears) and surface views in the photographs are of roots between 1–3 cm diameter. The root system views are scaled with a pole marked off in 10 cm divisions. The degree of tap root development indicated in some of the photographs depends upon the age of the individual. In smaller younger trees, tap roots are usually prominent, but in larger, older trees lateral and heart roots in most species develop far more than does the tap root. In the selection of root systems for photographing, juvenile individuals were avoided. Each root system was exposed by first removing all soil and roots vertically up to a point 30 cm in front of the stem(s) position, then using water under pressure to remove all soil up to a point immediately below the stem(s) and half a metre on each side of the (main) stem and down to about one metre depth. All roots of other species were pruned from this region. The photographs are only intended to give on a standard comparative basis, the type of root system in the immediate area of the stem base and in most cases only represents a very small proportion of the whole root system.

The roots of certain species are very variable in appearance and are sometimes keyed out more on negative characters than on positive characters. One character that may be particularly variable is the intensity (and pattern) of the colour of the outer bark, which often depends on the moisture content of the soil at the time of sampling. In a few species the inner bark or wood of the roots changes colour markedly after a relatively short period of exposure. Such characters have been employed in the key, although this inevitably implies that only totally fresh root material can be identified and that there are built-in time delays while using the key and inspecting for time-dependent colour changes. The key and descriptions do not apply to dead roots.

The following species are included and are listed alphabetically:

1. *Burkea africana* Hook. (Caesalpinioideae)
2. *Combretum molle* R. Br. ex G. Don (Combretaceae)
3. *Combretum zeyheri* Sond. (Combretaceae)
4. *Dichapetalum cymosum* (Hook.) Engl. (Dichapetalaceae)
5. *Dichrostachys cinerea* (L.) Wight & Arn. (Mimosoideae)
6. *Dombeya rotundifolia* (Hochst.) Planch. (Sterculiaceae)
7. *Euclea natalensis* A. DC. (Ebenaceae)
8. *Fadogia monticola* Robyns (Rubiaceae)
9. *Grewia flavescens* Juss. (Tiliaceae)
10. *Lannea discolor* (Sond.) Engl. (Anacardiaceae)
11. *Lannea edulis* (Sond.) Engl. (Anacardiaceae)
12. *Ochna pulchra* Hook. (Ochnaceae)
13. *Ozoroa paniculosa* (Sond.) R. & A. Fernandes (Anacardiaceae)
14. *Parinari capensis* subsp. *capensis* Harv. (Chrysobalanaceae)
15. *Pygmaeothamnus zeyheri* (Sond.) Robyns (Rubiaceae)
16. *Securidaca longipedunculata* Fresen. (Polygalaceae)
17. *Strychnos cocculoides* Bak. (Loganiaceae)
18. *Strychnos pungens* Soler. (Loganiaceae)
19. *Terminalia sericea* Burch. ex DC. (Combretaceae)
20. *Vitex rehmannii* Guerke (Verbenaceae)
21. *Ximenia caffra* Sond. (Olacaceae)

Field key to roots of woody species

1. Bark emits readily recognizable odour of menthyl salicylate (oil of wintergreen) ..... 16. *Securidaca longipedunculata*
   Bark has no discernible odour of menthyl salicylate 2
2. Outer bark consists of very corky ridges ..... 17. *Strychnos cocculoides*
   Outer bark not markedly corky 3
3. Bark exudes copious amounts of white latex when cut ..... 13. *Ozoroa paniculosa*
   Bark not exuding white latex when cut 4
4. Bark papery in very loose multi-layered shedding, pale cream (not brown) layers .. 5. *Dichrostachys cinerea*
   Bark not papery in very loose multi-layered shedding pale cream layers 5
5. Inner bark a bright orange colour (not reddish) especially when outer bark lightly scratched away with thumbnail ..... 3. *Combretum zeyheri*
   Inner bark not a bright orange colour 6
6. Inner bark with uniformly smooth texture in cross section appears yellowish green colour, often becoming a deeper green colour after about one minute exposure. Thumbnail scratch colour not pink to red ..... 20. *Vitex rehmannii*
   Green not the predominant colour of the inner bark 7
7. Inner layer or all layers of inner bark deep yellow with the inner bark easily stripped in long extremely tough fibrous lengths (virtually unbreakable by hand tension) ..... 19. *Terminalia sericea*
   Inner bark not deep yellow and not extremely tough 8
8. Wood pithy and loose grained and often presenting a speckled appearance in cross section ..... 18. *Strychnos pungens*
   Wood not pithy and not speckled in cross section 9
9. Light yellow colour of inner bark and wood in cross section changes to deep intense yellow very rapidly within half to one minute after exposure. This deep yellow colour is then in characteristically strong contrast to the very dark outer bark ..... 7. *Euclea natalensis*
   Inner bark and wood do not clearly change to a deep yellow colour within half to one minute after exposure 10
10. Wood in cross section has very characteristic alternation of light yellow and dark yellow wedges ..... 4. *Dichapetalum cymosum*
    Wood in cross section does not have characteristic alternation of light and dark coloured wedges 11

11. Markedly eccentric radial growth often present (test at several spots on the root sample) with the pith often on the extreme edge of the wood. Wood cross section with alternating clear lighter and darker yellow bands (not thin rings), outerbark very dark brown often with reticulate striations, or grooved ..... 9. *Grewia flavescens*
Radial growth usually not extremely eccentric and no alternating bands in wood cross section and outerbark not very dark brown 12
12. Non-continuous orange strands set amongst yellowish (not reddish) tissue visible when deep scratches are made through the outer bark well into the inner bark ..... 15. *Pygmaeothamnus zeyheri*
Orange strands set amongst yellow tissue not visible in deep scratches into the inner bark 13
13. Outer and inner bark together extremely thin 14
Outer and inner bark together not extremely thin 15
14. Protrusions on outer bark in whorls of three and all lying in the same direction longitudinally ..... 8. *Fadogia monticola*
If outer bark protrusions present, not in whorls of three ..... 2. *Combretum molle*
15. Roots usually distinctly contorted, outer bark light brown to reddish brown and easily visible fine alternating radial lines of lighter and darker yellow in cross section of the very close grained wood ..... 12. *Ochna pulchra*
Roots seldom contorted and outer bark not light brown to reddish brown and fine alternating radial lines of lighter and dark yellow in cross section of wood not easily visible 16
16. Inner surface of inner bark (at cambium layer) seen when bark partially stripped away from wood clearly changes from whitish to a deep brownish yellow within three minutes of exposure ..... 6. *Dombeya rotundifolia*
Inner surface of inner bark not clearly changing from whitish to deep brownish yellow within three minutes of exposure 17
17. Outer bark overall colour whitish grey (not cream) with brown blotches, roots may be contorted. Woody cambium layer often markedly striated, almost furrowed. Appearance of pores in wood cross section are often characteristic ..... 14. *Paranari capensis*
Outer bark not lighter than a creamish colour; if whitish usually without very obvious regular pattern of lenticellular structures; wood at cambium layer usually not markedly striated so as to almost form furrows 18
18. Bark thickness > 25% of root diameter; inner bark fleshy with relatively high water content 19
Bark thickness < 25% of root diameter; inner bark not particularly fleshy ..... 1. *Burkea africana*
19. Inner bark thick and rubbery and bark will not strip in long lengths but breaks off leaving clear yellow or orange fibres extending from inner half of inner bark ..... 21. *Ximenia caffra*
Inner bark not rubbery and bark will peel in long lengths 20
20. Bark often peels closely away from wood; outer bark often cracking in large block shapes; Pale tan coloured lenticellular structures often present on outer bark; pith often softer than remainder of wood ..... 11. *Lannea edulis*
Bark often starts to peel cleanly away from the wood but then leaves behind some innerlayered bark attached to the wood; outer bark seldom cracking in block shapes; lenticellular structures rare or absent; pith usually not softer than rest of wood ..... 10. *Lannea discolor*

1. **Burkea africana** *Hook.* (Figs 1 & 2)

Outer bark: Dark brown to cream; lenticellular structures often present and then scattered fairly evenly over bark and are a darker colour than most of the background. When bark is dark brown it often has a reticulate pattern of lighter and darker parts. When root is cream, bark is usually smoother but with many large lenticellular structures almost always present. There is a full gradation between these two root appearances. *Inner bark:* White on thin roots (<1 cm diameter) through light salmon pink to purple pink but a very pale colour on the innermost parts.

FIG. 1.—Root system of a *Burkea africana* individual 5,6 m high with a stem diameter of 13,3 cm at 20 cm above ground.

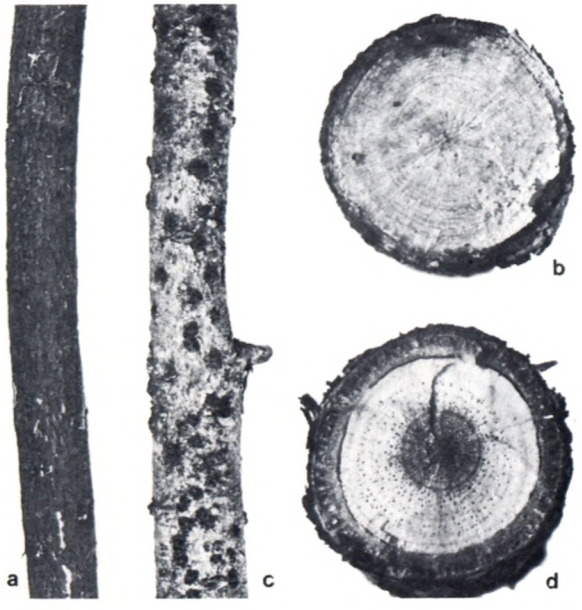

FIG. 2.—Exterior view and cross-section of (a, b) the darker striated type and (c, d) the light coloured lenticellular type of *Burkea africana* root.

Thumbnail scratch colour has the same range. Bark not hard or particularly soft, not fleshy, thickness commonly between 10 and 25% of root diameter. Samples from 15 trees gave a mean bark thickness as a percentage of root diameter as 15,1 with a standard deviation of 2,3. Bark peels relatively easily but strips in long lengths usually only on thin roots, bark of medium-tensile strength. *Wood:* Creamy white to yellow. Pith usually coloured differently to rest of

wood, pith colour varies from very light salmon pink through to purple pink which may spread over much of the wood section. Wood hard. Rings usually evident, rays not readily visible. Wood at cambium layer generally smooth or with small striations. *General:* Root system with lateral branching at base; roots usually fairly straight.

Because the appearance of *Burkea africana* roots may vary considerably, they are sometimes difficult to identify. Inner bark and wood colouration is usually distinctive, but may be confused with that of *Ximenia caffra,* and the two *Lannea* species, but it has a significantly (P=0,001) lower relative bark thickness than that of these three species and it has a usually drier inner bark than that of these species.

2. **Combretum molle** *R. Br. ex G. Don* (Figs 3 & 4)

Outer bark: Variable blotches of brown and dark blackish brown, golden brown and cream; irregular protrusions sometimes present; golden brown single layer papery flakes sometimes present. *Inner bark:* No inner bark apparent; thumbnail scratch colour shows the yellow wood; bark peels very difficultly and does not strip in long lengths, bark thickness commonly not more than 5% of root diameter. *Wood:* Yellow pith colour often slightly darker than that of wood; hard; rings with pores sometimes clear, rays not clearly visible; wood at cambium layer generally smooth. *General:* Root system extensively and laterally branched at base; roots usually fairly straight.

Extremely thin bark with a lack of protrusions arranged in whorls characterizes this species.

3. **Combretum zeyheri** *Sond.* (Figs 5 & 6)

Outer bark: Varying proportions of cream and brown blotches; usually smooth with few or no protrusions; usually has powdery fine scales that may be rubbed off slightly. *Inner bark:* Orange; thumbnail scratch colour very bright orange; not hard, medium fleshy; bark thickness commonly between 20 and 35% of root diameter; bark removable but not stripping in long lengths; low tensile strength. *Wood:* Yellowish to orangish; pith colour sometimes reddish; wood fairly close-grained; pores usually visible; ring-structures usually evident, rays not; wood at cambium layer with imperfectly parallel striations. *General:* Root system with branching near base; roots usually fairly straight.

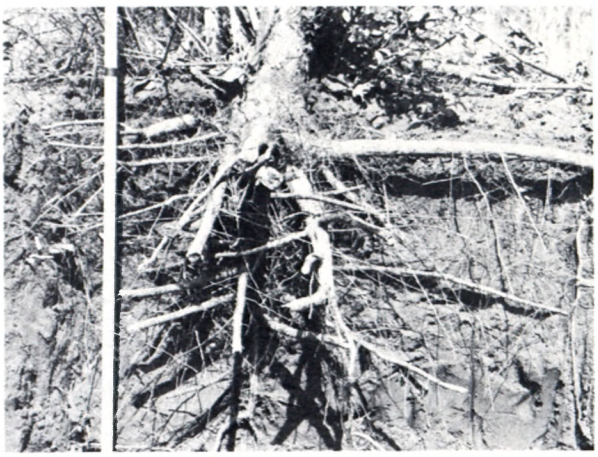

FIG. 3.—Root system of a two-stemmed individual of *Combretum molle* 5,7 m high with stem diameters of 12,2 cm and 12,5 cm at 20 cm above ground.

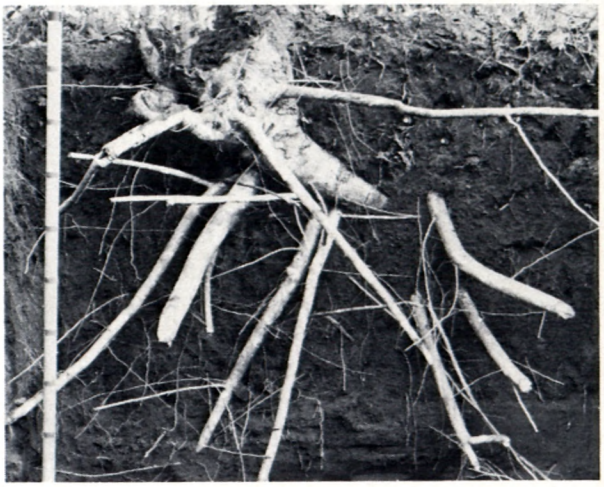

FIG. 5.—Root system of a *Combretum zeyheri* individual 6,3 m high with a stem diameter of 15,8 cm at 20 cm above ground.

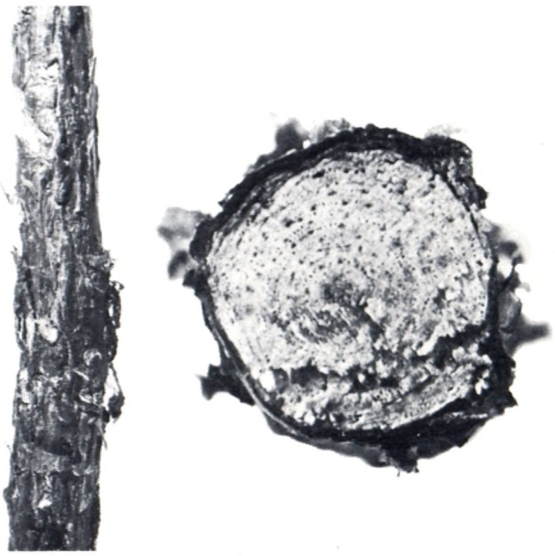

FIG. 4.—Exterior view and cross-section of a *Combretum molle* root.

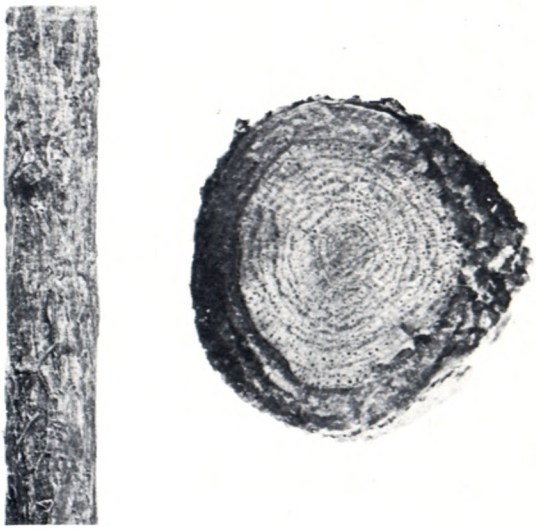

FIG 6.—Exterior view and cross-section of a *Combretum zeyheri* root

The bright orange colour that appears with the thumbnail scratch mark is unmistakable and clearly distinguishes this from the other species.

4. **Dichapetalum cymosum** (*Hook.*) *Engl.* (Figs 7 & 8)

Outer bark: Creamy yellow, protrusions sometimes present; fairly smooth with some evenly coloured reticulation pattern sometimes present.

Inner bark: White to light yellow; thumbnail scratch colour usually white; bark not hard nor particularly soft; not fleshy; thickness commonly between 10 and 20% of root diameter; bark peels relatively easily, but usually only strips in short lengths; bark of low tensile strength. *Wood:* Light and dark yellow; wood not hard; cross-section shows regular alternation of dark yellow and light yellow wedges; wood at cambium layer has striations that change in width. *General:* Root system with shallow lateral connections between individuals; roots usually less than 1 cm in diameter and fairly straight.

FIG. 7.—Root systems of interconnected individuals of *Dichapetalum cymosum.*

FIG. 8.—Exterior view and cross-section of a *Dichapetalum cymosum* root.

Wood cross-section with its very characteristic alternation of light yellow and dark yellow wedges and the non-corky outer bark characterize *D. cymosum.*

5. **Dichrostachys cinerea** (*L.*) *Wight & Arn.* (Figs 9 & 10)

Outer bark: Cream; no protrusions; very loose flakes layered on top of one another forming irregular stacks; outer bark usually as thick as inner bark. *Inner bark:* Greenish white; thumbnail scratch colour whitish, sometimes greenish; bark soft, not fleshy; total bark thickness in the order of 10% of the root diameter (flaking makes measurement approximate); bark peels easily, stripping in long lengths; at least medium tensile strength. *Wood:* Orangy yellow; wood close-grained; rings sometimes evident, rays not; wood at cambium layer has orange and yellow striations. *General:* Root system extensively branched at base; roots usually straight.

FIG. 9.—Root system of a two-stemmed individual of *Dichrostachys cinerea* 2,8 m high, with stem diameters of 5,7 and 4,7 cm at 20 cm above ground.

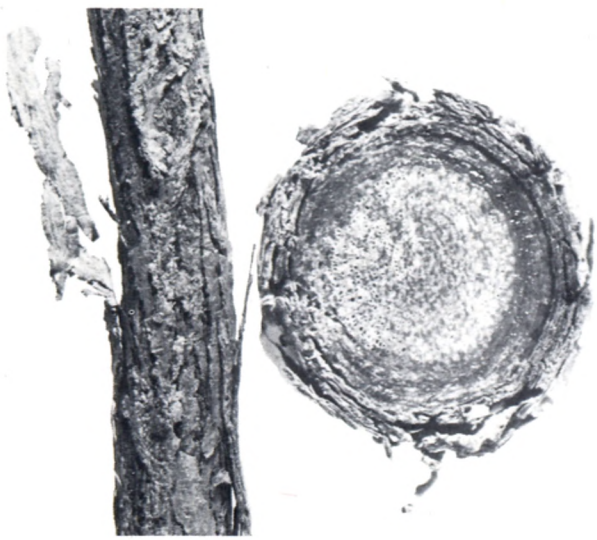

FIG. 10.—Exterior view and cross-section of a *Dichrostachys cinerea* root.

This species is clearly distinguished from *Combretum molle,* which may also have papery bark, by its cream bark colour, thicker bark and multi-layered papery bark layers.

6. **Dombeya rotundifolia** (*Hochst.*) *Planch.* (Figs 11 & 12)

Outer bark: Creamy with various usually brownish blotches; lenticellular protrusions often in short rows at right angles to the longitudinal axis of the root. *Inner bark:* Light pink (sometimes very light pink with orange spots under protrusions) in the outer area to clear, reddish or whitish in the inner area; the pink in the outer areas is often concentrated in longitudinal 'canals'; thumbnail scratch colour pale pink to very bright red; bark not hard, fairly fleshy; thickness commonly between 30 and 50% of the root diameter; bark peels relatively easily and strips in long lengths; medium tensile strength, but breakable by hand. *Wood:* Pale yellow; pith colour sometimes pink, particularly in those roots with deeper coloured bark; wood close-grained; very fine pores sometimes visible; rings sometimes clear, rays less evident; wood at cambium layer generally smooth or finely striated. *General:* Root system extensively branched at base; roots usually straight.

This species may be confused with *Ximenia caffra, Lannea edulis* and *Lannea discolor* and some forms of *Burkea africana* roots. However, the inner surface of the inner bark seen when the bark is partially stripped away from the wood changes from whitish to a deep brownish yellow within three minutes of exposure. The yellow colour of the wood also deepens with exposure. This character distinguishes *Dombeya rotundifolia* from the associated species.

7. **Euclea natalensis** *A. DC.* (Figs 13 & 14)

Outer bark: Blackish, dark brown to very dark brown; usually no protrusions; smooth but with slight reticulate longitudinal fissures. *Inner bark:* Light yellow, becoming deep yellow within half-a-minute to one minute of exposure; thumbnail scratch colour light yellow, deeper scratch light yellow becoming dark yellow half-a-minute to one minute of exposure; orange strands visible in deeply scratched bark but within half-a-minute of exposure change together with the rest of the bark to a deep yellow colour; bark not particularly soft or hard; fairly fleshy; thickness commonly between 30 and 40% of the root diameter; bark peels relatively easily, but does not strip in long lengths; low tensile strength. *Wood:* Light yellow becoming very deep yet bright yellow within half-a-minute to one minute of exposure; pith sometimes slightly darker than rest of wood; wood close-grained; rings may be visible, but rays not obvious; wood at cambium layer has striations more clearly seen within the first half minute of

FIG. 11.—Root system of a *Dombeya rotundifolia* individual 6,2 m high with a stem diameter of 25,6 cm at 20 cm above ground.

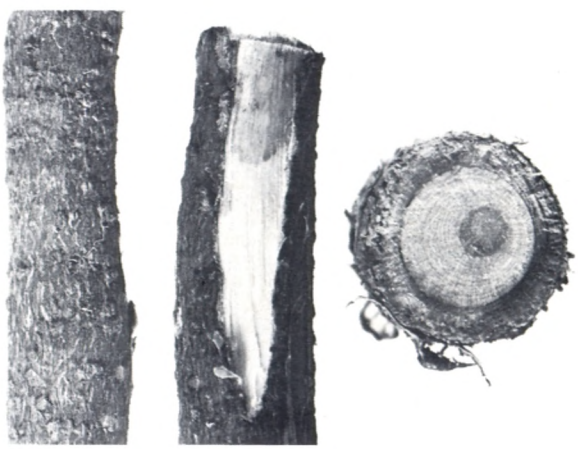

FIG. 12.—Exterior views and cross-section of a *Dombeya rotundifolia* root. A root with wood freshly exposed and exposed for 3 minutes indicates the differential colouration

FIG. 13.—Root system of a multi-stemmed individual of *Euclea natalensis* 1,5 m high.

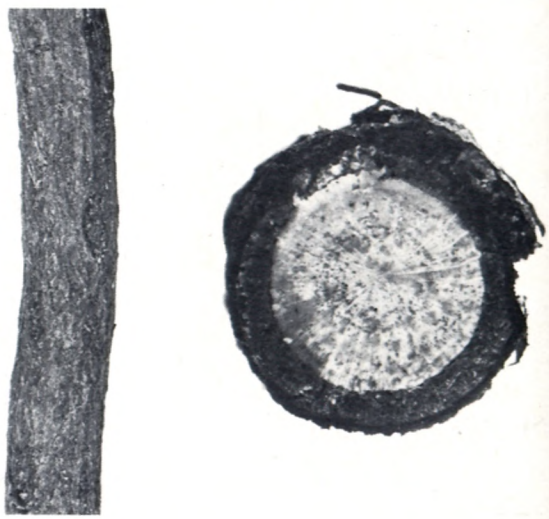

FIG. 14.—Exterior view and cross-section of a *Euclea natalensis* root.

exposure. *General:* Root system extensively branched at base; roots usually fairly straight.

Inner bark and wood colour changes form light yellow to deep yellow on exposure at a rate so rapid that one can see the colour changing; this character distinguishes *E. natalensis* from the other savanna species.

8. **Fadogia monticola** *Robyns* (Figs 15 & 16)

Outer bark: Light brown to brown; many regular protrusions all facing in one direction longitudinally and positioned in whorls of three; longitudinal fissures usually present. *Inner bark:* Too thin to see colour; thumbnail scratch colour shows whitish, light yellow colour of wood; bark not fleshy; thickness commonly less than 5% of root diameter; bark removes difficultly and does not strip in long lengths. *Wood:* Yellow; close-grained; rings and rays occasionally visible; wood at cambium layer usually smooth. *General:* Root system with shallow lateral connections between individuals; roots fairly straight to contorted.

FIG. 15.—Root systems of interconnected individuals of *Fadogia monticola* 0,5 m high.

FIG. 16.—Exterior view and cross-section of a *Fadogia monticola* root.

Protrusions in whorls of three characterize this species.

9. **Grewia flavescens** *Juss.* (Figs 17 & 18)

Outer bark: Dark brown to blackish brown; protrusions usually not obvious; reticulate pattern often present, sometimes grooved. *Inner bark:* Pinkish; thumbnail scratch colour pale pink to white; bark not particularly soft or hard; not fleshy; very fibrous; thickness very variable and depends on position of eccentricity of radical growth; bark peels easily and strips in long lengths; high tensile strength. *Wood:* Deep yellow; wood hard and close-grained; radial growth in most cases markedly eccentric, with the pith often at the edge of the wood; the eccentric growth is also reflected in the bark; pores sometimes visible; wood cross-section with alternating lighter and darker eccentric yellow bands; usually no rays visible; wood at cambium layer fairly smooth or with light striations. *General:* Root system with much branching at base; roots usually straight.

FIG. 17.—Root system of a multi-stemmed individual of *Grewia flavescens* 1,6 m high.

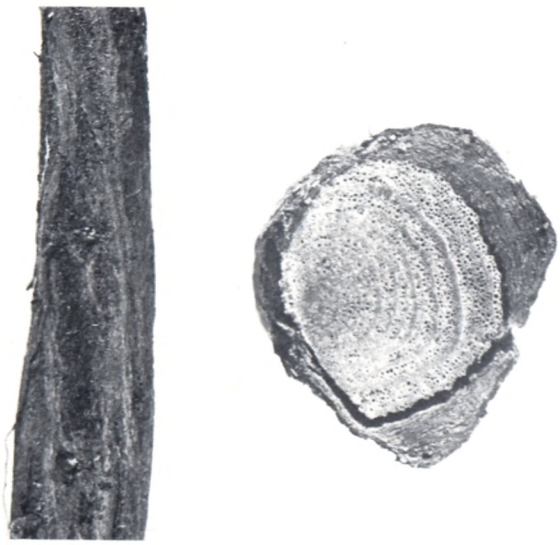

FIG. 18.—Exterior view and cross-section of a *Grewia flavescens* root.

Usually markedly eccentric radial growth together with lighter and darker alternating yellow bands in wood cross-section together with the usually dark brown outer appearance of the roots distinguishes this species from *Terminalia sericea.*

10. **Lannea discolor** (*Sond.*) *Engl.* (Figs 19 & 20)

Outer bark: Creamy blotches, though sometimes fairly evenly light brown to cream; usually at least some irregularly distributed rounded protrusions (corresponding to protrusions of the wood at the cambium layer); usually very few such protrusions on thinnest

(less than 5 mm diameter) roots; bark often flaking slightly. *Inner bark:* Reddish purple in the outer layers to pinkish, yellow, light yellow to yellowish clear in the inner layers; in very thin roots no red colour in inner bark only a uniform white colour; alternation of reddish and white longitudinal strands (occasionally with irregular large orange specks set in between) in outer layers; thumbnail scratch colour bright reddish purple, sometimes pink; bark soft; fleshy with relatively high water content; thickness commonly between 30 and 50% of root diameter; bark peels easily, although often tearing into a tapering (in thickness) strip; bark stripping in long lengths on thin roots; fairly high tensile strength. *Wood:* Yellowish white; on thicker roots purplish pink pith; close-grained; very fine pores sometimes visible in cross-section; rings sometimes visible; rays not obvious; wood at cambium layer generally smooth, but with very fine parallel striations. *General:* Root system with extensive lateral branching; roots usually fairly straight.

This species may be confused with *Dombeya rotundifolia, Ximenia caffra* and *Lannea edulis* as well as some forms of *Burkea africana* roots. However, it does not have the colour reaction of *Dombeya rotundifolia*; its inner bark is thicker than that of *Burkea africana*. The bark of this species usually peels in longer lengths than that of *Ximenia caffra*. Sometimes, however, it is difficult to distinguish this species from *Lannea edulis*, although *Lannea discolor* roots typically do not have the outer bark cracking in large regular block shapes, the bark often does not peel more cleanly away from the wood, pale tan coloured lenticellular structures are seldom present, the wood at the cambium layer has slightly less pronounced pale thread-like striations and the pith is usually not softer than the rest of the wood.

FIG. 19.—Root system of a *Lannea discolor* individual 6,7 m high with a stem diameter of 28,7 cm at 20 cm above ground.

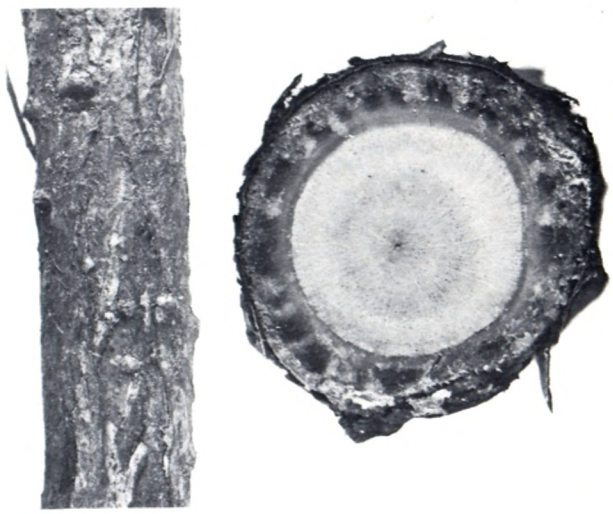

FIG. 20.—Exterior view and cross-section of a *Lannea discolor* root.

11. **Lannea edulis** (*Sond.*) *Engl.* (Figs 21 & 22)

Outer bark: Creamy to dark brown; often have large rounded protrusions and pale light brown lenticels with no corresponding marks on the wood surface below the bark; bark often cracking in large square patches on thicker roots. *Inner bark:* Pale to dark pink or purple and red on the outside to white on the inside; red and white longitudinal canals in the outer layers together with large orange specks; thumbnail scratch colour pale pink through to bright red; bark soft, very fleshy, thickness commonly in the order of 25 to 40% of root diameter; bark peels relatively easily and strips in long lengths without radial taper; medium tensile strength but breakable

FIG. 21.—Root systems of interconnected individuals of *Lannea edulis*.

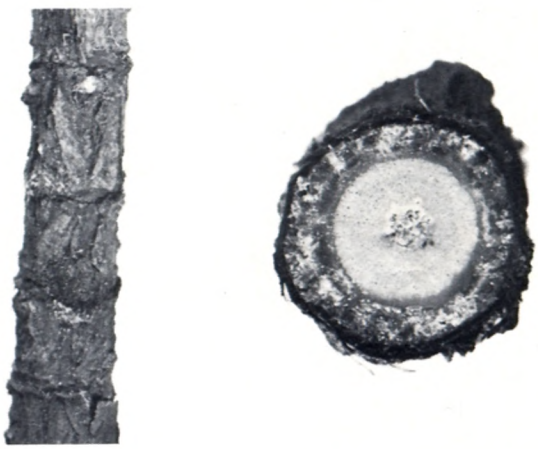

FIG. 22.—Exterior view and cross-section of a *Lannea edulis* root.

by hand. *Wood:* Pale yellow to yellow; pith usually light pink (pith colour sometimes spreading through most of the wood) and appears to be softer or more loosely packed than the rest of the wood; ring structures and rays not readily visible; pores sometimes clear in cross-section; wood at cambium layer has fine raised whitish thread-like striations. *General:* Root system with lateral connections between individuals; roots usually fairly straight.

This species may be confused with *Dombeya rotundifolia, Ximenia caffra* and *Lannea discolor* as well as some forms of *Burkea africana* roots. However, it does not have the colour reaction of *Dombeya rotundifolia;* its bark is thicker than that of *Burkea africana.* The bark of this species usually peels in longer lengths than that of *Ximenia caffra.* Sometimes, however, it is difficult to distinguish this species from *Lannea discolor,* although *Lannea edulis* roots typically have the outer bark cracking in large rectangular block shapes, the bark often peels more cleanly away from the wood, pale tan coloured lenticellular structures are often present and the wood of the cambium layer has slightly more pronounced striations than that of *Lannea discolor.*

12. **Ochna pulchra** *Hook.* (Figs 23 & 24)

Outer bark: Light brown to reddish brown; no regular protrusions; sometimes large flakes present especially on thicker roots. *Inner bark:* Purple to pink; thumbnail scratch colour reddish purple; bark hard; not fleshy; thickness commonly in the order of 25% of root diameter; bark removal possible but not readily and does not strip in long lengths; bark of low tensile strength. *Wood:* Light yellow; pith often pinkish or purplish; wood close-grained; rings usually not obvious but distinctly visible fine lines of alternating lighter and darker yellow rays; wood at cambium layer generally smooth with very fine striations. *General:* Root system very variable but usually with strong lateral development at about 30 cm depth with connections between individuals sometimes present; roots usually contorted.

Sometimes may be confused with roots of *Burkea africana,* mainly based on similar colouration, however, *Burkea africana* roots are very seldom contorted and do not have easily discernible wood rays.

13. **Ozoroa paniculosa** (*Sond.*) *R. & A. Fernandes* (Figs 25 & 26)

Outer bark: Creamy light brown; protrusions usually present in irregular pattern; smooth sometimes with a trace of reticulated fissures. *Inner bark:* Reddish; thumbnail scratch colour is pinkish orange or reddish with latex if scratch not very shallow; copious exudation of white latex from cut surfaces; bark soft, fleshy and thickness commonly in the order

FIG. 23.—Root systems of individuals of *Ochna pulchra* with mean height of 2,2 m and mean diameter at 20 cm above ground of 6,4 cm.

FIG. 24.—Exterior view and cross-section of an *Ochna pulchra* root.

FIG. 25.—Root system of a multi-stemmed individual of *Ozoroa paniculosa* 1,3 m high.

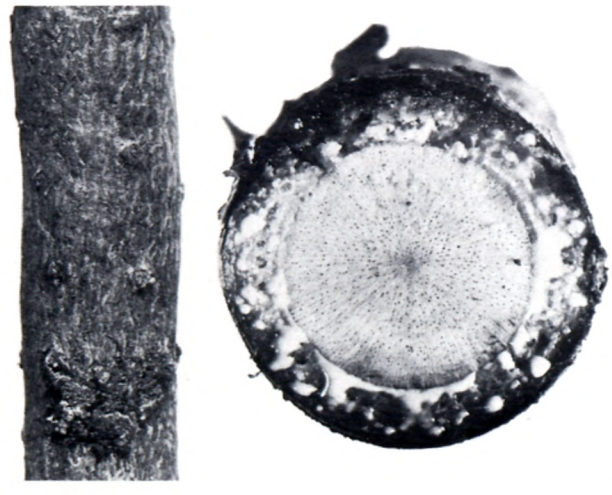

FIG. 26.—Exterior view and cross-section of an *Ozoroa paniculosa* root.

of 40% of root diameter; bark peels relatively easily but does not strip in long lengths; bark of low tensile strength. *Wood:* Light yellow; pith often pinkish; wood hard; rings and rays not always readily visible; wood at cambium layer with fine striations. *General:* Root system with lateral branching at base and roots usually straight.

The copious exudation of white latex from severed bark characterizes this species.

14. **Parinari capensis** *Harv.* (Figs 27 & 28)

Outer bark: Whitish grey with brown blotches; usually no protrusions; smooth with small wrinkles in places. *Inner bark:* Reddish purple; thumbnail scratch colour purple but changing to light salmon pink on thinner roots; bark neither hard nor soft and not fleshy; thickness commonly in the order of 20 to 25% of the root diameter; bark comes away relatively easily but does not strip in long lengths; bark of low tensile strength. *Wood:* Reddish near the centre to whitish on the outside; pith often reddish; wood close-grained; many evenly spread pores clearly visible in cross-section; few broad bands of rings sometimes visible; rays not readily visible; wood at cambium layer strongly striated with very clear and parallel striations (almost furrowed) and sometimes with reddish irregular patches on the wood particularly on thicker roots. *General:* Root system with lateral connections between individuals; roots sometimes contorted.

Possibly may be confused with the whitish form of *Burkea africana* roots, hoewever, *Burkea* does not have the same striations. Freshly excavated roots of *Parinari capensis* may then be separated from all other species on the basis of the overall colour of the outer bark being more white than cream and on having almost furrowed striations on the wood surface.

15. **Pygmaeothamnus zeyheri** (*Sond.*) *Robyns* (Figs 29 & 30)

Outer bark: Brown to dark brown; irregular rounded protrusions usually present. *Inner bark:* Yellow with orange specks; thumbnail scratch colour yellow, deeper scratches expose longitudinal non-continuous orange strands set in yellow (pale orange in thinner roots); bark neither hard nor soft and not fleshy; thickness commonly in the order of 20–25% of the root diameter; bark removable but does not strip in long lengths; low tensile strength. *Wood:* Yellow; pith sometimes purplish red and sometimes only a dark spot; wood close-grained; rings not readily visible but rays sometimes visible; wood at cambium layer has clear but often fine striations.

FIG. 27.—Root systems of interconnected individuals *Parinari capensis*.

FIG. 29.—Root systems of interconnected individuals of *Pygmaeothamnus zeyheri*.

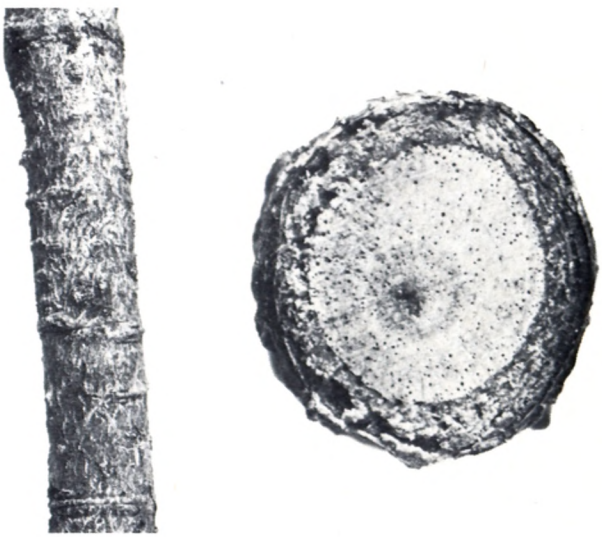

FIG. 28.—Exterior view and cross-section of a *Parinari capensis* root.

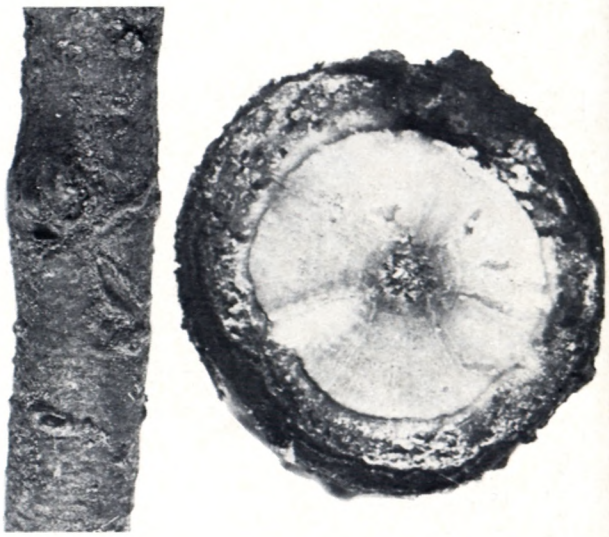

FIG. 30.—Exterior view and cross-section of a *Pygmaeothamnus zeyheri* root.

General: Root system with shallow lateral connections between individuals; roots sometimes contorted.

May be confused with *Lannea discolor, Lannea edulis, Ximenia caffra* or *Dombeya rotundifolia*. However, all these species have orange specks set in or positioned near reddish-pinkish tissue in the bark and the shape of the orange specks are often more round than those in *Pygmaeothamnus zeyheri* where they form longer strands set in yellowish (not reddish) tissue.

16. **Securidaca longipedunculata** *Fresen.* (Figs 31 & 32)

Outer bark: Uniform light to deep yellow colour; protrusions very seldom present; smooth but sometimes with circumferential wrinkles on the thicker roots. *Inner bark:* Yellow, thumbnail scratch colour very light yellow; bark soft and fairly fleshy; thickness commonly between 50 and 70% of the root diameter; bark with very distinctive smell of menthyl salicylate (oil of wintergreen); bark peels easily and sometimes strips in long lengths; low to medium tensile strength. *Wood:* Yellow but darker than the bark; not particularly close-grained; pores visible in cross-section; rings and rays not obvious; wood at cambium layer smooth or sometimes very slightly striated. *General:* Root system mainly a tap root but with several lateral roots. Roots normally straight.

FIG. 31.—Root system of a *Securidaca longipedunculata* individual 6,1 m high with a stem diameter of 19,5 cm at 20 cm above ground.

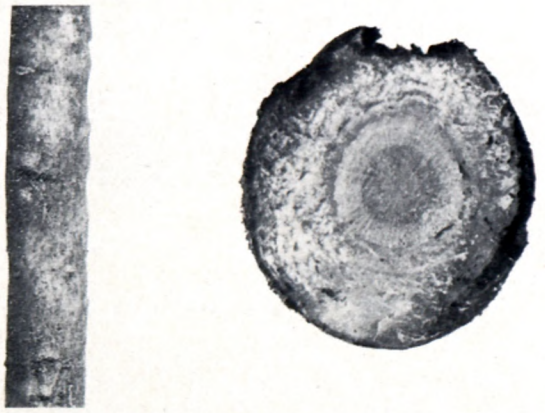

FIG. 32.—Exterior view and cross-section of a *Securidaca longipedunculata* root.

Cannot be confused with any other species, because of the distinctive smell of menthyl salicylate in the bark.

17. **Strychnos cocculoides** *Bak.* (Figs 33 & 34)

Outer bark: Yellowish beige; deeply furrowed corky bark. *Inner bark:* Creamy yellow; inner bark only $\frac{1}{3}$ to $\frac{1}{2}$ as thick as the outer bark; bark very soft, not fleshy; bark thickness commonly in the order of 35% of root diameter; bark does not remove easily and does not strip in long lengths; very low tensile strength. *Wood:* Creamy yellow; pith often a darker yellow than the wood; wood close-grained; ring structures clear and light yellow radial lines alternate regularly with darker yellow wedges; wood at cambium layer appears smooth. *General:* Root system with tap root and relatively little lateral branching at base; roots usually straight.

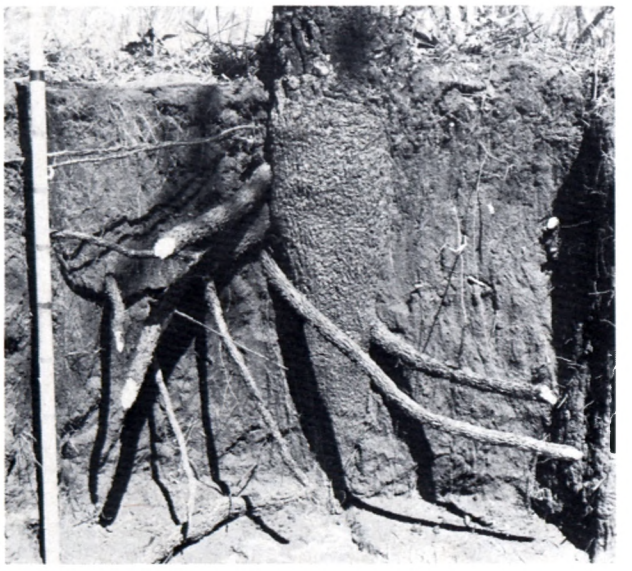

FIG. 33.—Root system of a *Strychnos cocculoides* individual 7,2 m high with a stem diameter of 30,0 cm at 20 cm above ground.

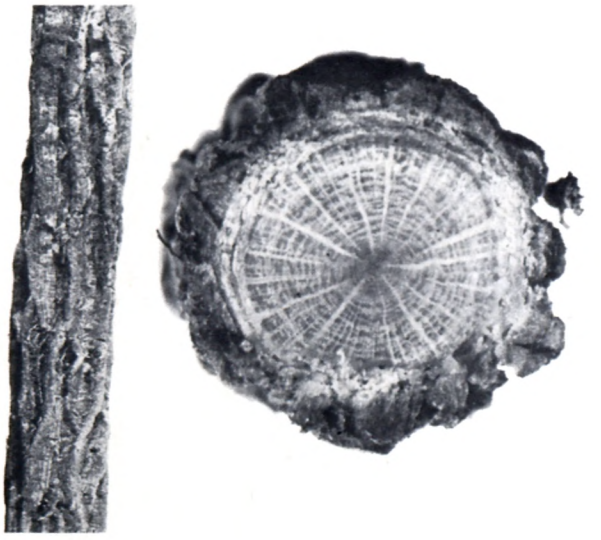

FIG. 34.—Exterior view and cross-section of a *Strychnos cocculoides root.*

May always be distinguished from other species by the extremely thick and corky outer bark.

18. **Strychnos pungens** *Soler.* (Figs 35 & 36)

Outer bark: Light brown; protrusions sometimes present; fairly smooth but sometimes wrinkled on thicker roots with a slightly reticulated furrow pattern on thinner roots. *Inner bark:* Yellow; bark thickness commonly in the order of 20 to 40% of root diameter; bark removable and does not strip in long lengths; low tensile strength. *Wood:* Creamy yellow to yellow: wood not close-grained and very pithy, sometimes monocotyledonous appearance in cross-section; no rings or rays readily visible; wood at cambium layer striated. *General:* Root system a tap root with relatively little lateral branching; roots straight to curved.

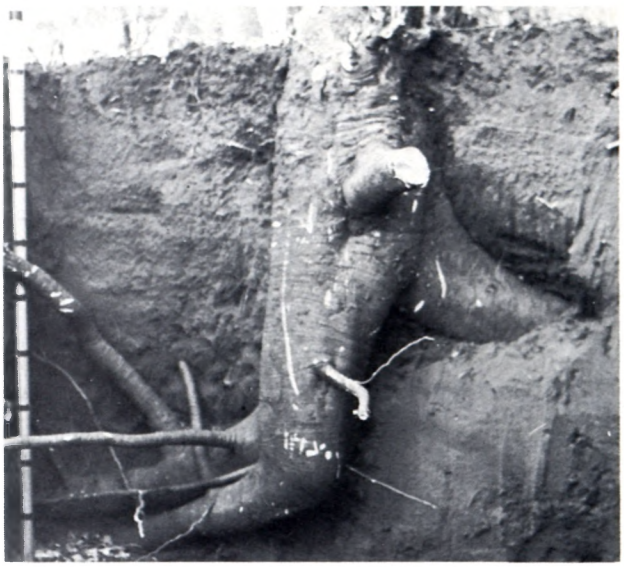

FIG. 35.—Root system of a *Strychnos pungens* individual 6,2 m high with a stem diameter of 28,5 cm at 20 cm above ground.

FIG. 36.—Exterior view and cross-section of *Strychnos pungens* root.

May always be distinguished from the other species by its particularly pithy wood.

19. **Terminalia sericea** *Burch. ex DC.* (Figs 37 & 38)

Outer bark: Cream to brown; sometimes with numerous pale lenticellular type structures; sometimes with longitudinal fissures. *Inner bark:* Yellowish but on thicker roots purple in the outer layers and yellow in the inner layers; thumbnail scratch slight pinkish to dark purplish; bark is fairly soft, not fleshy; thickness commonly between 30 and 50% of the root diameter; bark peels relatively easily and strips in long lengths; very high tensile strength. *Wood:* Yellow; pith sometimes darker shade than wood; wood hard; ring structures usually clear but rays not readily visible; wood at cambium layer smooth on thin roots but with definite striations on thicker roots. *General:* Root system with lateral branching usually also with very shallow lateral roots [also found by Cole & Brown (1976) in Botswana]; roots generally straight.

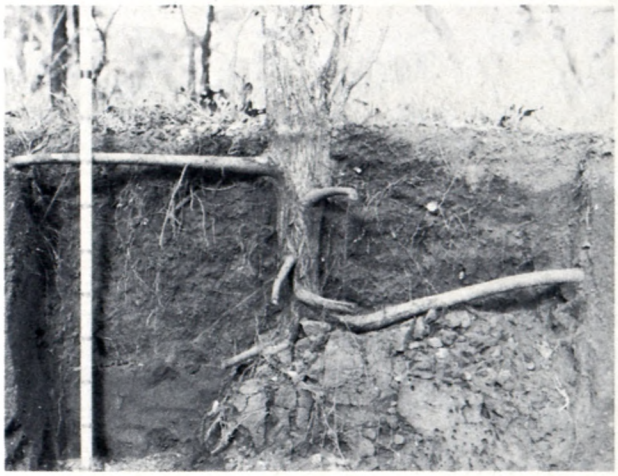

FIG. 37.—Root system of a *Terminalia sericea* individual 5,7 m high with a stem diameter of 12,9 cm at 20 cm above ground.

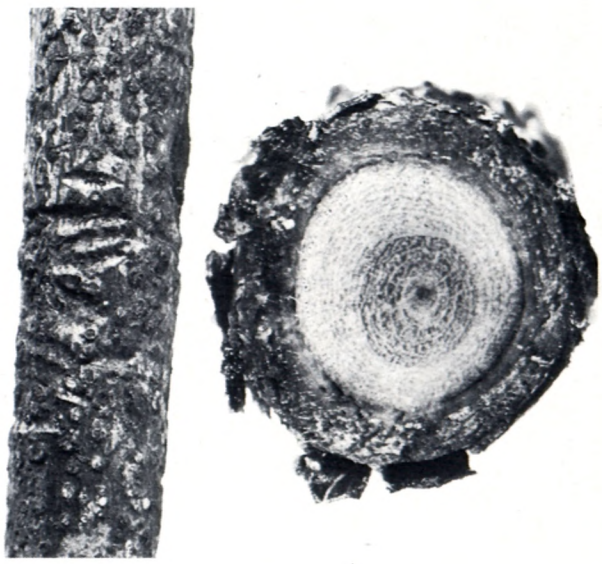

FIG. 38.—Exterior view and cross-section of a *Terminalia sericea* root.

Thinner roots may be sometimes confused with those of *Grewia flavescens,* however, the wood of *Terminalia sericea,* seen in cross-section, does not have lighter and darker yellow bands.

20. **Vitex rehmannii** *Guerke* (Figs 39 & 40)

Outer bark: Yellowy cream; no obvious protrusions; smooth with some small very soft flakes. *Inner bark:* Uniformly smooth when cut in cross-section; almost a translucent yellowish green, the green sometimes becoming more intense with exposure; thumbnail scratch colour is white; also often becoming greenish with exposure; soft and very fleshy; thickness commonly between 30 and 40% of the root diameter; bark separates easily but does not strip in long lengths; low tensile strength. *Wood:* Yellow; wood hard; rings and rays sometimes obvious; wood at cambium layer has fine striations. *General:* Root system extensively branching at base; roots usually fairly straight.

FIG. 39.—Root system of a *Vitex rehmannii* individual 5,1 m high with a stem diameter of 8,2 cm at 20 cm above ground.

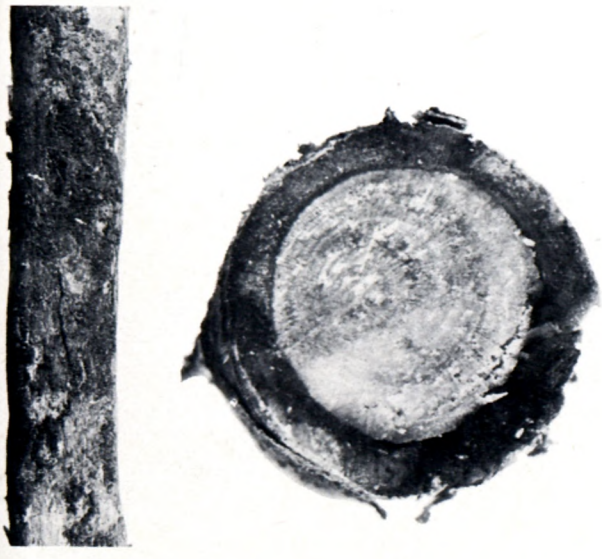

FIG. 40.—Exterior view and cross-section of a *Vitex rehmannii* root.

May always be distinguished from other species by the definite green colour contained in the fleshy inner bark. The bark is also non-flaky and has no discernible smell of menthyl salicylate.

21. **Ximenia caffra** *Sond.* (Figs 41 & 42)

Outer bark: Blotchy creamy to light brown; protrusions sometimes present; fairly smooth; sometimes with faint longitudinal wavy lines. *Inner bark:* Reddish purple on thicker roots to white on thinner roots with the deeper colour outside and paler towards the centre; thumbnail scratch colour white (on small roots) through pale pink to pinkish purple (usually mottled); deep scratch mark shows fine orange strands or yellow fibres set in red or pink tissue; bark soft to very soft, rubbery and fleshy; thickness commonly between 25 and 45% of the root diameter; peels relatively easily but does not strip in long lengths (breaks off in short chunks leaving yellowish orange or yellow strands emerging from those layers of the inner bark closer to the wood); low tensile stength. *Wood:* Deep yellow to yellowish brown; wood hard; rings and rays seldom obvious but rings visible on thicker roots; very many fine pores usually visible in cross-section; wood at cambium layer has clear fine parallel striations; pith sometimes darker on thicker roots. *General:* Root system with branching at base; roots usually fairly straight; fleshy root galls sometimes on roots.

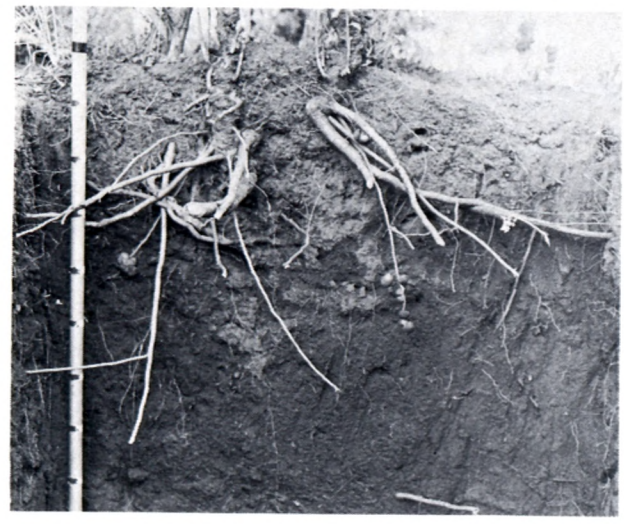

FIG. 41.—Root system of a multi-stemmed individual of *Ximenia caffra* 1,2 m high.

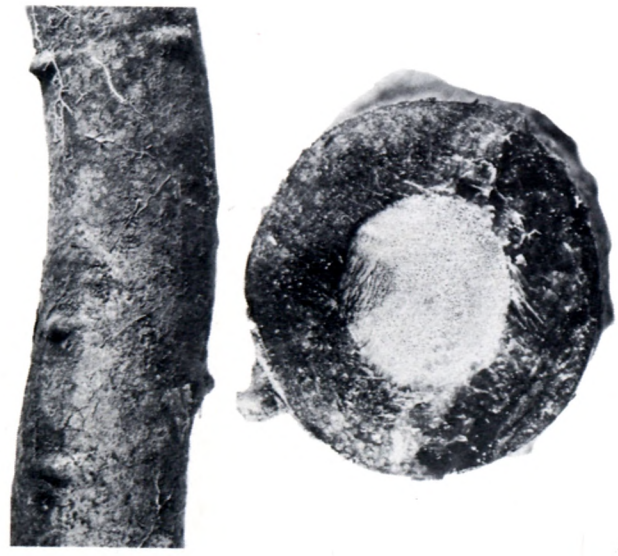

FIG. 42.—Exterior view and cross-section of a *Ximenia caffra* root.

The roots of this species may be confused with those of *Dombeya rotundifolia, Lannea discolor, Lannea edulis* and some forms of *Burkea africana.* However, it does not have the colour reaction of *Dombeya rotundifolia,* its bark is thicker than that of *Burkea africana* and it can be distinguished from both species of *Lannea* by having a more rubbery inner bark, that will not strip in long lengths but often breaks off in short chunks with characteristic yellow-orange or yellow strands or fibres emerging from the inner bark.

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