Use of wood anatomy to identify poisonous plants: Charcoal of Spirostachys africana

Spirostachys africana Sond. (tamboti/tamboite) is a woodland tree that is often found near water. It has a poisonous and purgative latex. The archaeological site of Sibudu, a rock shelter in KwaZulu-Natal, has evidence, from well-preserved charcoal and seeds, of past environments and wood use from approximately 77–38 thousand years ago (ka). As their uses and environmental indicators are different, it is critical to confidently distinguish among the three anatomically similar woods of the Euphorbiaceae: Spirostachys africana, Sclerocroton integerrimus and Shirakiopsis elliptica. A detailed anatomical study of reference and archaeological charcoal shows that xylem vessel width increases proportionally as vessel frequency decreases, from Spirostachys africana, Sclerocroton integerrimus to Shirakiopsis elliptica. Crystals of calcium oxalate are present in ray cells of Spirostachys africana, whereas silica bodies are present in ray cells of Sclerocroton integerrimus and Shirakiopsis elliptica. Using these features, the presence of Spirostachys africana was confirmed amongst hearth charcoal of the Spotty Camel layer, with an age of approximately 58 ka and of the Mottled Deposit occupational layer, with an age of approximately 49 ka. The presence of this charcoal, collected from ancient fireplaces or sieved from surrounding sediments, implies that people at Sibudu understood and used this poisonous tree to their advantage. We are encouraged in this view by the presence of many Cryptocarya woodii leaves found on the surface of 77-ka sedge bedding at Sibudu (Wadley l et al., Science. 2011;334:1388–1391). Cryptocarya woodii has insecticidal and larvicidal properties and members of the Laurel family are well known for their medicinal properties.

Introduction

General introduction

Three indigenous woods – Spirostachys africana (tamboti), Sclerocroton integerrimus (duiker-berry) and Shirakiopsis elliptica (jumping-seed tree) – were tentatively identified from charcoal recovered from archaeological deposits at the rock shelter Sibudu. The anatomy of charcoal reference material was compared with that of the recovered charcoal in order to confidently identify these taxa in the archaeological charcoal. The identification of these woods in the Middle Stone Age at Sibudu is significant because Spirostachys africana is particularly poisonous. Spirostachys africana Sond., Sclerocroton integerrimus Hochst. (=Sapium integerrimum (Hochst.) J.Léonard) and Shirakiopsis elliptica (Hochst.) Esser (=Sapipum ellipticum (Hochst.) Pax) are members of the family Euphorbiaceae, subfamily Euphorbioideae, tribe Hippomaneae A.Juss. ex Bartl. and subtribe Hippomaninae. 1

Sibudu

Sibudu is situated on the uThongathi River, KwaZulu-Natal. It has a sequence of archaeological layers from the Middle Stone Age, dated by single-grain optically stimulated luminescence to approximately 77–38 ka. 2-4 Some of the evidence for the behaviour of the anatomically modern people who visited and lived at Sibudu includes stone tools, ochre, bone, perforated seashells and hearths5-15, as well as evidence for the making and use of compound adhesives16, and circumstantial evidence of snares17 and bows and arrows18. There is evidence of the use of plant resources from pollen, phytoliths, seeds, nutlets, stems, charcoal and leaves excavated at Sibudu. 2-9, 19-27

The relevance of identifying Spirostachys africana

The presence of charcoal at Sibudu implies that people who visited and occupied the site burned wood. 2-4, 6 Spirostachys africana charcoal was tentatively identified from Sibudu in a previous study.20,21 Nowadays, the wood from this tree is not used as fuel for cooking because the smoke and fumes are poisonous. 28 People who live in a particular environment for long periods develop knowledge about local resources14-20,23 and the Spirostachys africana wood was almost certainly recognised for its toxic properties and utilised by ancient hunter-gatherers14. Therefore a secure identification of the archaeological charcoal is necessary in order to interpret behavioural strategies in the past.

Sclerocroton integerrimus wood anatomy is similar to that of Spirostachys africana. 20,23 Both were recorded as Spirostachys/Sapium in the scanning electron microscopy (SEM) study of charcoal from Sibudu. 20,21 so it is important to try to distinguish between the two taxa. Shirakiopsis elliptica wood anatomy is also similar.1,13 As it was not in the original charcoal reference collection for Sibudu, 20 new fresh material was gathered, charred and studied.

Anthracology

Archaeological charcoal is identified by means of wood anatomy22-25 to describe palaeoenvironments and palaeoclimate and to develop an understanding of past wood use26-28. Anatomical features of living or fresh woods, listed by the International Association of Wood Anatomists, accessed on InsideWood, an online database29, can
assist with charcoal identification\[34,35,36\] but charred reference material is more useful\[31-33\]. Woody taxa have been identified from charcoal assemblages from many sites elsewhere in southern Africa; a few examples are Diepkloof Rock Shelter\[44\] and Elands Bay Cave in the Western Cape\[45\] and from sites in Lesotho\[34,36\].

Habits, habitats and uses of the three woods

*Spirostachys africana* is a medium-sized, hardwood, deciduous tree, 10–18 m tall, and grows in woodland and valley bushveld. Often found in dense stands; in warm, dry areas along rivers and drainage lines; in poorly drained brackish and clay soils; or near underground water. Tambotto is distributed from KwaZulu-Natal to Tanzania.\[46\] *Sclerocroton integerrimus* is a small- to medium-sized, hardwood, deciduous tree, 2–10 m tall, and grows in coastal thicket, on forest margins and in wooded grassland.\[48\] *Shirakiopsis elliptica* is a medium to tall, softwood, deciduous tree, 12–20 m tall. It grows in wooded ravines and is common at the canopy edge of evergreen forests and as a canopy tree in swamp forests.\[49\] The timber of the three trees is similar.\[46\]

The bark, wood, stems and leaves of *Spirostachys africana* contain poisonous milky latex\[28\] which is used as a purgative in small doses\[50\].

*Staphylococcus aureus*, *Salmonella typhi*, *Vibrio cholera*, *Shigella dysenteriae* and for body markings.\[57\]

Poisonous tambotto from Sibudu’s Middle Stone Age hearths

Material

Comparative reference collection

A wood sample of *Spirostachys africana* from a Southern African Forestry Department woodblock stored in the Department of Archaeology, University of the Witwatersrand, was carbonised and studied as a reference of anatomical features (SJL 103, Table 1, Figure 1a–c). Inferred archaeological *Spirostachys africana* charcoal from Ndondondwane Iron Age site\[26\] in KwaZulu-Natal was used as intermediate reference material (NDO; Table 1, Figure 1d). Reference wood samples and voucher herbarium specimens of *Sclerocroton integerrimus* (SJL 88, Figure 1e) and *Shirakiopsis elliptica* (SJL 67, Figure 1f) were identified by local botanists and were collected ex hort in Durban and on a farm near Port Edward, KwaZulu-Natal (coordinates 31.04615°S, 30.16868°E) for a study of anatomical features (Table 1).

Archaeological specimens

Sibudu archaeological charcoal was examined from squares of occupational layer Spotty Camel (SPCA), which has not been dated but lies between layers with ages of 61.3 ± 2.0 ka and 56.2 ± 1.9 ka, and from Mottled Deposit (MOD) at approximately 49.7 ± 1.8 ka.\[3,4\] These layers were chosen because *Spirostachys/Sapium* charcoal was previously recorded from them by Allott\[32,33\].

Methods

Reference woodblocks were charred in a LENTON 0861 muffle furnace (Lentons, Hope, UK) for 3.5 h at 350 °C at the Palaeosciences Centre, University of the Witwatersrand. Archaeological charcoal was identified by comparing it with reference material, using standard techniques.\[20,21,44,45\] Charcoal blocks were viewed from three planes by means of stereomicroscopy (Olympus SZX16, Münster, Germany) and reflective and polarised light microscopy (Olympus BX51) at magnifications of 100X, 200X and 500X. Characteristic anatomy was digitally photographed using Olympus Stream Essentials\[5\] image analysis software with extended focal image capability. Anatomical features according to the International Association of Wood Anatomists’ list\[30,39\] were recorded for the comparative reference material and archaeological specimens. Identiﬁcations were also confirmed against published reference material.\[1,2,13,19,40\]

Useful distinguishing features

Prismatic crystals occur in *Spirostachys africana* ray and parenchyma cells, whereas silica bodies are absent in this species.\[3,30,39\] Silica bodies occur in *Sclerocroton integerrimus*\[34,36\] and *Shirakiopsis elliptica*\[26\] ray cells, whereas crystals are absent from ray cells\[26\]. Crystals are occasionally visible in the parenchyma cells of *Sclerocroton* and *Shirakiopsis*.\[26\]

Prismatic crystals are not common in wood anatomy and their occurrence may be sporadic.\[30\] Features such as crystals and silica bodies are therefore useful attributes and are listed as an anatomical feature when commonly observed. Prismatic crystals are solitary, rhombohedral or octahedral crystals of calcium oxalate which are birefringent (produce a rainbow effect) under polarised light\[5\] and appear shiny in charcoal specimens.

Silica bodies are spheroidal or irregularly shaped particles of silicon dioxide which are non-birefringent (do not produce a rainbow effect) under polarised light\[5\] and appear opaque. Silica is present in ray cells in *African Sapium* species in aggregates, which often fill the entire cell lumen, or as grains or small dark dots in *Asian Sapium* species such as...
Figure 1: Diagnostic characteristics of charcoal reference material: (a–c) Spirostachys africana (SJL 103), (d) Spirostachys africana (NDO), (e) Sclerocrotor integerrimus (SJL 88) and (f) Shirakiopsis elliptica (SJL 67). (a) In transverse section, Spirostachys africana has many small vessels (V) in long lines. Vessels are occasionally in pairs. The shiny cell contents may be resin or gum. These fibres (F) are thin-walled and regular. (b) The radial longitudinal section has crystals labelled (C) in the ray cells, which shine under polarised light. Ray cells (R) are mixed; the procumbent cells are as high as the square cells and occasionally there are upright cells in the margins. The rays are low. (c) The tangential longitudinal section has frequent, uniseriate rays. The prismatic crystals of calcium oxalate in ray cells which distinguish Spirostachys shine under polarised light. Vessels with alternate inter-vessel pits occur and the vessel walls are birefringent under polarised light. The insert shows these ray crystals at a lower magnification. (d) Inferred Spirostachys africana reference material from Ntendonondwana, KwaZulu-Natal (NDO) has prismatic, rhombic, crystals in the ray cells which shine under non-polarised light, in radial longitudinal section. (e) In Sclerocrotor integerrimus reference material, SJL 88, there are silica bodies labelled (S) in the ray cells. These are spheroidal or irregularly shaped particles which are opaque under polarised light. The ray cells are heterocellular, mixed procumbent, square and upright in radial longitudinal section. The cell walls of the vessels, rays and fibres are birefringent in polarised light. (f) In Shirakiopsis elliptica reference material, SJL 67, the silica bodies (S) in ray cells are granular, dark spots. Rays are heterocellular with upright and square cells seen in radial longitudinal section. These inter-vessel pits are alternate.
Results and discussion

Figure 1 illustrates reference charcoal of the three taxa. Figure 1d, *Spirostachys africana* (NDO), is of archaeological charcoal and is therefore an interpreted identification. Figure 2 illustrates the identified archaeological charcoal from Sibudu. Table 1 summarises the charcoal anatomy of the modern reference and archaeological material. Table 2 lists the most useful diagnostic features for identifying the three species, the environmental conditions required by the trees and the medicinal and other uses for their wood.

Table 1: The anatomical features of modern and archaeological charcoal specimens of *Spirostachys africana*, *Sclerocroton integerrimus* and *Shirakiopsis elliptica*

<table>
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<tr>
<th>Plant species</th>
<th>Charcoal specimen</th>
<th>Vessel radius</th>
<th>Vessel diameter</th>
<th>Vessel frequency</th>
<th>Ray width in cells</th>
<th>Heterocellular ray body cells</th>
<th>Ray marginal cells</th>
<th>Parenchyma</th>
<th>Ray crystals or silica bodies</th>
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<td><em>Shirakiopsis elliptica</em></td>
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Notes:
- Vessel radii: short (s), 1–3 vessels; or long (l), >4 vessels
- Vessel diameter: small (s), <50 µm; medium (m), 50–100 µm; large (l), 100–200 µm
- Vessel frequency: few (f), 5–20 per mm²; medium (m), 20–40 per mm²; abundant (a), 40–100 per mm²
- Heterocellular ray-body cells: procumbent (p); square (s); upright (u)
- Ray marginal cells: square (s); upright (u); (bracketed = occasional)
- Parenchyma: diffuse (d) or diffuse-in-aggregate (da); crystals (c)
- Ray crystals or silica bodies (s)

Attributes common to *Spirostachys*, *Sclerocroton* and *Shirakiopsis*

Vessels are commonly arranged in long, radial multiples (>4). Perforation plates are simple. Inter-vessel pits are alternate and polygonal; medium (8–10 µm) in *Spirostachys africana*; large (11–16 µm) in *Sclerocroton integerrimus* and large (16–20 µm) in *Shirakiopsis elliptica*. Vessel-ray pits are bordered and similar to inter-vessel pits in size and shape in *Spirostachys africana* and *Shirakiopsis elliptica*. Reduced borders, in *Sclerocroton integerrimus*, fibres are non-septate, with simple to minutely bordered pits. Fibres are short in *Sclerocroton africana*; in *Sclerocroton integerrimus*, they are medium length and regularly arranged. *Shirakiopsis elliptica* fibre length varies from short to long (Figure 1).

Diffuse parenchyma occurs in *Spirostachys africana*. Parenchyma which is diffuse-in-aggregate (S JL 103, Figure 1a), or in narrow bands or lines which are up to three cells wide, may be observed as a variation. Parenchyma which is diffuse or diffuse-in-aggregate is difficult to see. In *Sclerocroton integerrimus* parenchyma is diffuse-in-aggregate and/ or there are narrow bands or lines up to three cells wide. *Shirakiopsis elliptica* parenchyma is diffuse and/or diffuse-in-aggregate, with the variation of occasionally occurring in narrow bands or lines up to three cells wide. Axial parenchyma strand length is either 4 or 8 cells per parenchyma strand in all three woody taxa.

Rays are exclusively uniseriate, commonly heterocellular, with procumbent, square and upright cells mixed throughout the ray (S JL 88, Figure 1e), although this pattern varies within and between the three woody taxa (Table 1; S JL 103, Figures 1a–c; NDO, Figure 1d). *Shirakiopsis elliptica* reference charcoal ray cells are upright and square (S JL 67, Figure 1f). Very long rays occasionally occur in *Shirakiopsis elliptica* where two rays meet end to end, and are visible in both reference material (S JL 67) and archaeological material (SPCA B4c 45).

Rays are frequent, with up to 12 observed per millimetre. Laticifers – thin, radial tubes carrying latex which occasionally occur in Euphorbiaceae wood – were absent from the charcoal examined.

Distinguishing attributes of reference material

The charcoal of the three species differs in vessel size and frequency as well as in the presence or absence of crystals or silica bodies in ray cells. The differences in vessel size and pattern among the wood of the three species are recorded in a photographic study of endgrain woodblocks of Euphorbiaceae. *Spirostachys africana* has several to many, small to medium vessels in long radial lines. Charcoal reference, S JL 103, (Figure 1) and interpreted reference material, NDO, vessels are narrow (30–50 µm), at a frequency of between 40–100 vessels per mm² (an average of 80/mm²) and vessels are arranged in long radial lines (radial multiples >4). The prismatic crystals in ray cells are birefringent, appearing shiny under reflected polarised light. Shape may vary in different materials, from clearly rhombic in the archaeological specimen – which is an interpreted reference for *Spirostachys africana* (NDO in Figure 1d) – to irregular but shiny in the modern wood. Fibres are absent from ray cells. The vessel inclusions are either resin or gum. Resin occurs in the heartwood. Similar comparative images of *Spirostachys africana* have been recorded by Allott, Illic and Kromhout.

*Sclerocroton integerrimus* has few, medium to large vessels in radial lines. Charcoal reference material, S JL 88, vessels are narrower than 100 µm, at a frequency of 20–40 vessels per mm², and are arranged in short radial lines of two to four vessels. The silica bodies are non-birefringent and opaque under polarised light (S JL 88, Figure 1e). The silica bodies present in ray cells are spherical, irregularly shaped particles arranged in aggregates which often fill the entire cell lumen. These silica bodies are visible in the SEM images recorded by Allott. Prismatic crystals are absent from ray cells.

*Shirakiopsis elliptica* has very long rays occasionally occur in Euphorbiaceae wood – were absent from the charcoal examined. There are small to medium vessels in long radial lines. Charcoal reference material, S JL 88, vessels are narrower than 100 µm, at a frequency of 20–40 vessels per mm², and are arranged in short radial lines of two to four vessels. The silica bodies are non-birefringent and opaque under polarised light. Shape may vary in different materials, from clearly rhombic in the archaeological specimen – which is an interpreted reference for *Spirostachys africana* (NDO in Figure 1d) – to irregular but shiny in the modern wood. Fibres are absent from ray cells. The vessel inclusions are either resin or gum. Resin occurs in the heartwood. Similar comparative images of *Spirostachys africana* have been recorded by Allott, Illic and Kromhout.
Figure 2: Diagnostic characteristics of archaeological charcoal: (a–c) *Spirostachys africana*, (d) *Shirakiopsis elliptica* and (e,f) *Sclerocroton integerrimus*. (a) In *Spirostachys africana*, SPCA B4b 62, there are prismatic crystals (C) in the procumbent ray cells (R), under non-polarised light. (b) These appear shiny under polarised light in radial longitudinal section, matching those of the *Spirostachys africana* SJL 103 reference material. The vessel (V), fibre (F) and ray cell (R) walls are also birefringent under polarised light. (c) In *Spirostachys africana*, SPCA D5c 51, tangential longitudinal section, the ray cell walls are cut away and the crystals underneath are present and shiny, matching those of the *Spirostachys africana* SJL 103 reference material when magnified 500x. (d) In *Shirakiopsis elliptica* archaeological material, MOD C6a 46, silica bodies (S) are present as grains and dots in ray cells and appear opaque under both polarised and non-polarised light. Rays are heterocellular, with mixed upright, square and procumbent cells, in radial longitudinal section. (e) In *Sclerocroton integerrimus* archaeological charcoal, SPCA B4b 66, the silica bodies in the ray cells are spheroidal or irregularly shaped and opaque in non-polarised light in radial longitudinal section and in both polarised (f) and non-polarised light in tangential longitudinal section.
Shirakiopsis elliptica has very few, large to very large vessels in radial lines.\(^1\)\(^{3,4}\) Charcoal reference material, SJL 67, (Figure 1f) vessels are wider than 100 µm, at a frequency of fewer than 10 vessels per mm\(^2\), and are arranged in short radial lines. Silica bodies occur as grains or small dark dots in Asian Sapium species.\(^4\) In our reference material, the silica bodies are inconspicuous, prismatic crystals are absent from ray cells with occasional crystals observed in the parenchyma and tyloses commonly occurring in vessels.\(^1,31\)

Spirostachys and Sclerocroton archaeological charcoal

Spirostachys africana was identified in charcoal from Sibudu from MOD square C6a and from SPC1B squares B4b and D5c. Specimens MOD C6a 39 and SPC1B 62 have as many as 110 vessels per mm\(^2\), small (20–30 µm) to medium (50–100 µm) in size and arranged in radial multiples >4 (long radial lines); rays are uniseriate, frequent and heterocellular, with mixed procumbent, square, upright cells. Prismatic crystals occur in ray cells and shine under polarised light (Figure 2a–c).

Sclerocroton integerrimus charcoal was identified from MOD square E3d and from SPC1B squares B4b, B4c and D5a. Few (30–50 vessels per mm\(^2\)), medium-sized (50–100 µm) vessels occur in radial multiples >4. Silica bodies occur as aggregates which partially fill the ray cell lumina and are opaque under both non-polarised as well as polarised light (SPC1B 66; Figure 2e). Variation was observed in vessel arrangement and ray cell pattern (Table 1).\(^1,3,0\)

Shirakiopsis elliptica charcoal was identified from MOD square C6a. Specimen MOD C6a 46 has many (40 vessels per mm\(^2\)), medium (±50 µm) vessels in radial lines. Specimen SPC1B 4bc 45 has as many as 50 large (100–µm) vessels per mm\(^2\). Occasionally two uniseriate rays meet, forming rays which are jointly longer than 1 mm. Silica bodies in ray cells appear as inconspicuous grains or small, dark dots (MOD C6a 46; Figure 2). The diffuse parenchyma occasionally contains crystals.\(^1\)

**Summary of the characteristic diagnostic features of each species**

The detailed anatomical study of reference material enables the identification of these taxa based on the occurrence of crystals in Spirostachys africana and silica bodies in Sclerocroton integerrimus and Shirakiopsis elliptica ray cells as well as on vessel size classes and frequency of vessels. These diagnostic characteristics are compared in Table 2.

The vessel size of Spirostachys, Sclerocroton and Shirakiopsis increases proportionally as vessel frequency decreases, from Spirostachys africana, with the smallest and most numerous vessels, to Sclerocroton integerrimus, then to Shirakiopsis elliptica with the largest and fewest vessels.

**A comparison of anatomical features**

No clear differentiation in anatomical features among these three taxa under investigation could be found, thus necessitating this study. There is some variation in vessel width and frequency, ray cell type, the absence or presence of tyloses in vessels, of laticifers in rays and of gum or resin deposits in vessels among different published accounts.\(^1,3,0,3,1,3,3,3,3,3,4,9,5,6\)

Relative abundance of crystals may vary. As wood is inherently variable, some features are well defined in some samples, but poorly defined or absent in other samples of the same species.\(^3,6\) There are no quantitative criteria for ‘common’ in the list of the International Association of Wood Anatomists. Comments on relative frequency are therefore added to descriptions.\(^3,1\)

The crystals of calcium oxalate are birefringent under polarised light; however, some cell walls, especially lignified cell walls, are also birefringent (Anonymous reviewer, 2014, personal observation, written communication, July 03). Structures such as xylem vessels with birefringent cell walls have a rainbow sheen in the reference material (SJL 103) and in the inferred reference material (NDO). Birefringent crystals are visible in Spirostachys africana reference material in the

**Table 2:** Comparing the wood anatomy, environment and uses of Spirostachys, Sclerocroton and Shirakiopsis (Euphorbiaceae)

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<th>Spirostachys africana(^1,3,0,5)</th>
<th>Sclerocroton integerrimus(^1,6,0)</th>
<th>Shirakiopsis elliptica(^1,6,0)</th>
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<td>frequency, cell</td>
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<td><strong>Timber</strong></td>
<td></td>
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<tr>
<td></td>
<td>The hard, heavy wood has</td>
<td>The hard, durable wood is used</td>
<td>The tough, soft, light, white</td>
</tr>
<tr>
<td></td>
<td>contrasting light sap wood and</td>
<td>as timber for general purposes, in</td>
<td>wood is used to make instruments,</td>
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<td></td>
<td>dark heartwood, with an</td>
<td>construction and for furniture.(^6)</td>
<td>burnt as firewood and charcoal,</td>
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<td></td>
<td>attractive lustre when polished</td>
<td></td>
<td>but not used as rafters when</td>
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<td></td>
<td>and has therefore been used as</td>
<td></td>
<td>used in construction as it is</td>
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<td></td>
<td>a replacement for sandalwood.</td>
<td></td>
<td>susceptible to insects.(^7)</td>
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<td></td>
<td>It is used in furniture, for</td>
<td></td>
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<td></td>
<td>staves, beads and bangles and in</td>
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<td></td>
<td>construction as rafters. The</td>
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<td></td>
<td>sawdust is poisonous, as is the</td>
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<td></td>
<td>wood if burnt for fuel, causing</td>
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<td></td>
<td>conjunctivitis, nausea and food</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>poisoning.(^1,3,1)</td>
<td></td>
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<tr>
<td><strong>Phytochemistry and</strong></td>
<td>Phorbol esters (terpenoids)</td>
<td>Toxic tetracyclic triterpenic</td>
<td>Tannins and alkaloids have been</td>
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<td><strong>uses</strong></td>
<td>classify latex in bark, wood,</td>
<td>cucurbitacins have been extracted</td>
<td>extracted from the whole plant.</td>
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<td></td>
<td>stems and leaves as an extremely</td>
<td>from root bark of Sclerocroton</td>
<td>Bark extracts have moderate</td>
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<td></td>
<td>hazardous, Class 1a, cellular</td>
<td>cornutus from West and Central</td>
<td>antimicrobial activity against</td>
</tr>
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<td></td>
<td>poison (LD(_{50}) = 5 mg/kg).(^2,5,8,1) Isolated terpenoids have</td>
<td>Africa.(^6)</td>
<td>Campylobacter jejuni which causes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>antibacterial properties.(^8)</td>
<td>food poisoning.(^3,7)</td>
</tr>
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<td></td>
<td>A very drastic purgative, the</td>
<td>Suspected of being poisonous, the</td>
<td>Considered very poisonous and a</td>
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<td></td>
<td>bark and milky latex are used to</td>
<td>clear latex is used as an antiseptic</td>
<td>very drastic purgative and a very</td>
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<td></td>
<td>treat alimentary tract infections.</td>
<td>against toothache and coughs. The</td>
<td>drastic purgative, the clear latex</td>
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<td></td>
<td>Latex is used to treat tooth</td>
<td>fruits were formerly used to make</td>
<td>is added to arrow poison and used</td>
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<td></td>
<td>decay and eye infections. Used</td>
<td>a black ink and are used for</td>
<td>as bird lime.(^7)</td>
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<td></td>
<td>as fish and arrow poison, latex</td>
<td>tanning.(^6)</td>
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<td></td>
<td>causes conjunctivitis, or a</td>
<td></td>
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<tr>
<td></td>
<td>severe contact dermatitis. Bark</td>
<td></td>
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<td></td>
<td>is used for skin ailments, and</td>
<td></td>
<td></td>
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<td></td>
<td>headaches. The fragrant woodblocks</td>
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<tr>
<td></td>
<td>are an insect repellent.(^6)</td>
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<td></td>
<td>Smoke is inhaled for treatment</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>of respiratory infections.(^2,5,1)</td>
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tangential longitudinal section in which the cell walls are cut away. The outline of these crystals is visible, differentiating these crystals from ray cell walls in the radial longitudinal section. Under non-polarised light, the crystals in the inferred reference material match those seen in SJL 103 and those usually seen in wood and charcoal. The crystals seen in archaeological specimens of Spathastrachys africana match those found in reference material SJL 103 ray cells observed in radial and tangential longitudinal sections at high magnification.

The Spathastrachys africana crystals are magnified to 500x the original size and they are clearly visible. In SEM studies of charcoal, energy dispersive x-ray spectrometry analysis capabilities may be used to distinguish between crystals of calcium oxalate and silica, such as the crystals found in Searia undulata (Namaqua kuni-bush). Cassine peragua (spoon-wood) and Gymnosporia buxifolia (spike-thorn) from archaeological charcoal at Diepkoof Rock Shelter.

The variation in anatomical features between the charcoal and fresh wood or between charcoal made from modern wood and archaeological charcoal are because of the natural variation occurring in biological material affected by the sample origin (twig or trunk) or habitat. Quantitative variation may be a result of the shrinkage and distortion which occurs during the formation of charcoal.

We have supplemented the charcoal wood anatomy descriptions with those from fresh woods from the InsideWood database as more detail usually is visible in fresh wood. Comparative sizes rather than measurements are used in anthropology because the anatomy may be distorted by shrinkage, vitrification, diagenesis, and fragmentation and powdering.

**Conclusion**

The charcoal anatomy of Spathastrachys africana, Sclerocrotom integerrimus and Shirakiopsis elliptica enables these species to be distinguished by vessel arrangement, size and frequency, as well as by the presence or absence of crystals or silica bodies in ray cells.

Spathastrachys africana has narrow, frequent vessels; prismatic crystals are present in ray cells. Sclerocrotom integerrimus has wider, less frequent vessels. Of the three species under comparison, Shirakiopsis elliptica has the widest and least frequent vessels. silica bodies are present in ray cells of Sclerocrotom integerrimus and in Shirakiopsis elliptica as small grains and dots while prismatic crystals are absent from ray cells. The silica bodies of Sclerocrotom integerrimus are aggregates of irregularly shaped silicon dioxide particles which often fill the entire cell lumen and appear opaque under polarised light. The silica bodies of Shirakiopsis elliptica appear as grains or small, dark dots.

Spathastrachys africana was identified amongst hearth charcoal of the SPCA layer in squares B4b and D5c, with an age of approximately 58 ka, and in charcoal of the MOD layer in square C6a, with an age of approximately 49 ka. This find confirmed the use of Spathastrachys africana wood at Sibudu rock shelter. Sclerocrotom integerrimus charcoal occurred in SPCA in squares B4b, B4c and D5a and in MOD in square E3d. Shirakiopsis elliptica charcoal was found in SPCA B4c and in MOD in square C6a.

Sclerocrotom integerrimus, Shirakiopsis elliptica and poisonous Spathastrachys africana wood was deliberately burned by people at Sibudu who utilised natural resources. Sclerocrotom integerrimus timber is a hard, heavy, durable wood. Shirakiopsis elliptica timber is soft, light, and suitable for making implements. Spathastrachys africana wood is a hard, durable wood, with poisonous properties. Many of the present day uses of these woods were not applicable during the Middle Stone Age, but these species may have been selected for making wooden implements and for firewood. Spathastrachys africana wood is a skin irritant and it seems unlikely that this wood would have been worked by hand to make implements. Nor does it seem likely that the poisonous wood was used for domestic fires to cook food. It seems more likely that Spathastrachys was deliberately selected for its toxic or insecticidal properties, perhaps so that its smoke would fumigate insects from the camp in Sibudu.

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**Authors’ contributions**

S.J.L. was responsible for the experimental work and wrote the manuscript; M.K.B. supervised the research, helped with charcoal identification and assisted with writing the manuscript.

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