

Smodingium dermatitis: the intercellular secretory canals of the aerial axis and their relationship to this toxicity

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ABSTRACT

Smodingium argutum E. Mey. ex Sond., closely related to the American poison-ivy, *Toxicodendron radicans* (L.) Kuntze, is the only known indigenous member of the Anacardiaceae in South Africa causing dermatitis. The sap of the intercellular secretory canals of the stem, petiole and leaf of both plants, is responsible for this toxicity. These secretory canals are described, illustrated and compared for both species, and their formation and the function of the canals and sap, are briefly discussed.

INTRODUCTION

Smodingium argutum E. Mey. ex Sond. is the only known indigenous South African member of the Anacardiaceae that causes dermatitis. Numerous other examples of potentially poisonous members of the family are found throughout the world and include the American poison-ivy, *Toxicodendron radicans* (L.) Kuntze, the poison oak, *Rhus diversiloba*, certain sumacs, the mango, cashew-nut, Japanese lacquer and Indian marking-nut trees (Whiting 1971).

Smodingium argutum, which is confined to South Africa, varies in appearance from a small woody shrub to a small tree or even a creeper. The leaves are trifoliate with dentate margins. The natural distribution of the plant appears to be concentrated in Pondoland and East Griqualand, extending northwards through Natal to Barberton (Findlay 1963). It is now relatively common in parks and gardens in the Transvaal, being readily obtainable from nurseries.

Findlay (1963) suggested that the dermatitis produced by *S. argutum* was of the poison-ivy type—the plants belong to the same family, both have self-melanising sap, the skin reactions are similar to those of poison-ivy and natural and experimental cross reactions take place between sufferers sensitive to the two plants (Whiting 1971). This paper shows further the close relationship between these two poisonous plants from different continents.

Fresh, living material was obtained from plants growing in the National Botanical Gardens, Brummeria, Pretoria, originating from seed collected by Dr L. E. Codd near Port St Johns, Transkei. Poison ivy (*Toxicodendron radicans*) was also collected from these gardens for comparative studies. Leaf, petiole and young stem tissue of both these plants was fixed in glutaraldehyde or FAA, embedded in tissuemat, sectioned at 5 μ and stained in safranin and fast green.

ANATOMY

Intercellular secretory canals in the Anacardiaceae

The outstanding anatomical feature of the axis of all members of the Anacardiaceae is the universal presence of secretory canals or ducts (Metcalf and Chalk 1950). These are present in the roots, stems, leaves, fruit and embryo in the primary phloem (McNair 1918). In addition, in certain representatives of the family, they may be found in the secondary phloem of older roots and stems, while others possess medullary or pith secretory canals.

In accordance with the classification of intercellular spaces (Stern, 1954) these canals are termed intercellular secretory canals to avoid any possible confusion with the term resin canal. This term has

often been used to describe the ducts of the Anacardiaceae, but resin canal is now limited to the canals of the gymnosperms. Gum duct is another alternative term that has been used in place of secretory canals.

Amongst the dicotyledons secretory canals are characteristic of the Compositae and Anacardiaceae only (Fahn 1959). In the Anacardiaceae, various anatomical works (Metcalf and Chalk 1950) show that there are no essential differences in the arrangement and structure of the intercellular secretory canals, and the following description of the canals of *S. argutum* serves further to confirm this.

Intercellular secretory canals of Smodingium argutum

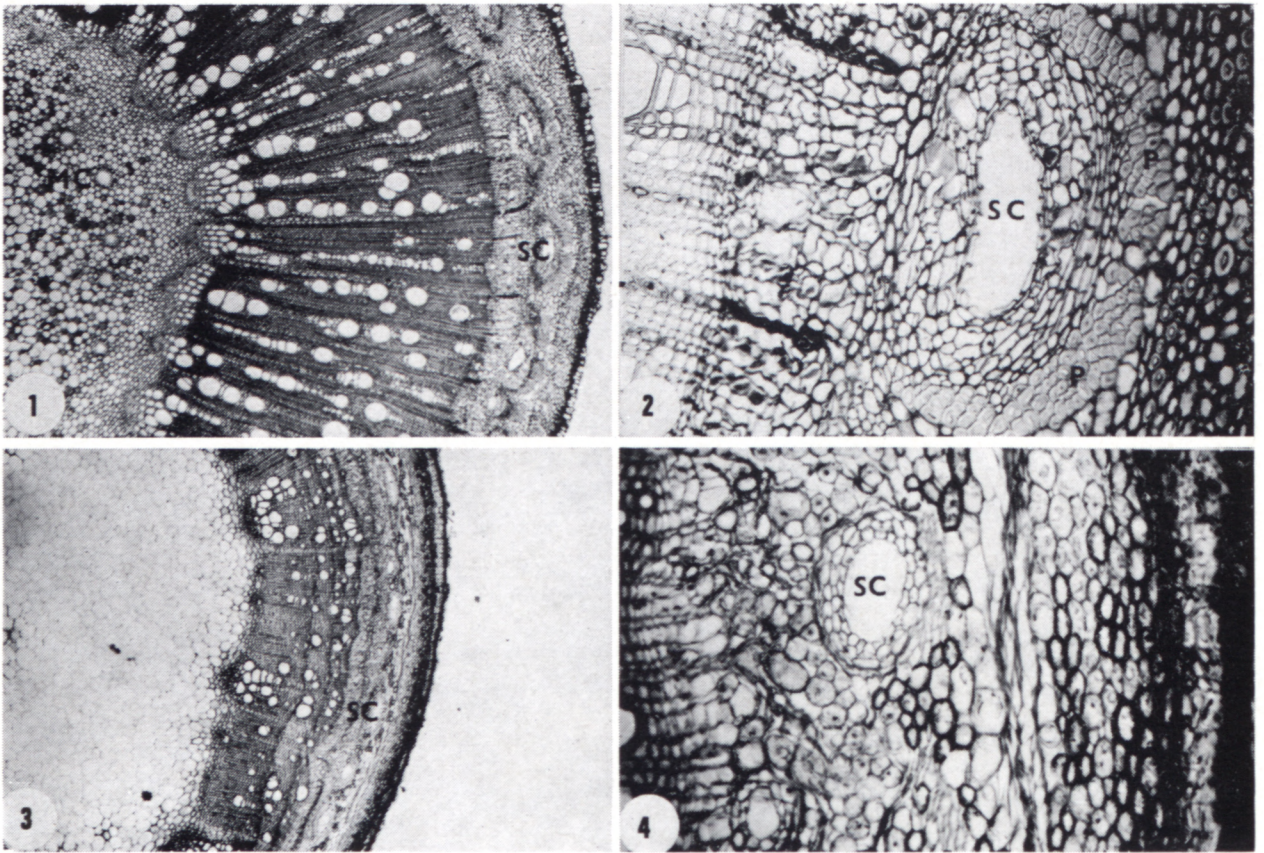
Stem anatomy

The phloem of the primary vascular bundles of *Smodingium* is separated from the parenchymatous outer cortex by a pericycle of isolated, arc-shaped strands of sclerenchymatous fibres, having the convex side towards the exterior (Fig. 1, 2). This fibrous pericycle is absent in *Toxicodendron radicans* (Fig. 3, 4). In older stems of *Smodingium* there is a tendency towards a composite and continuous ring of sclerenchyma with the individual arc-shaped strands not clearly distinguishable. A single, large secretory canal is situated in the primary phloem of each vascular bundle on the inside of each sclerenchymatous arc. Outside the pericycle no canals are found.

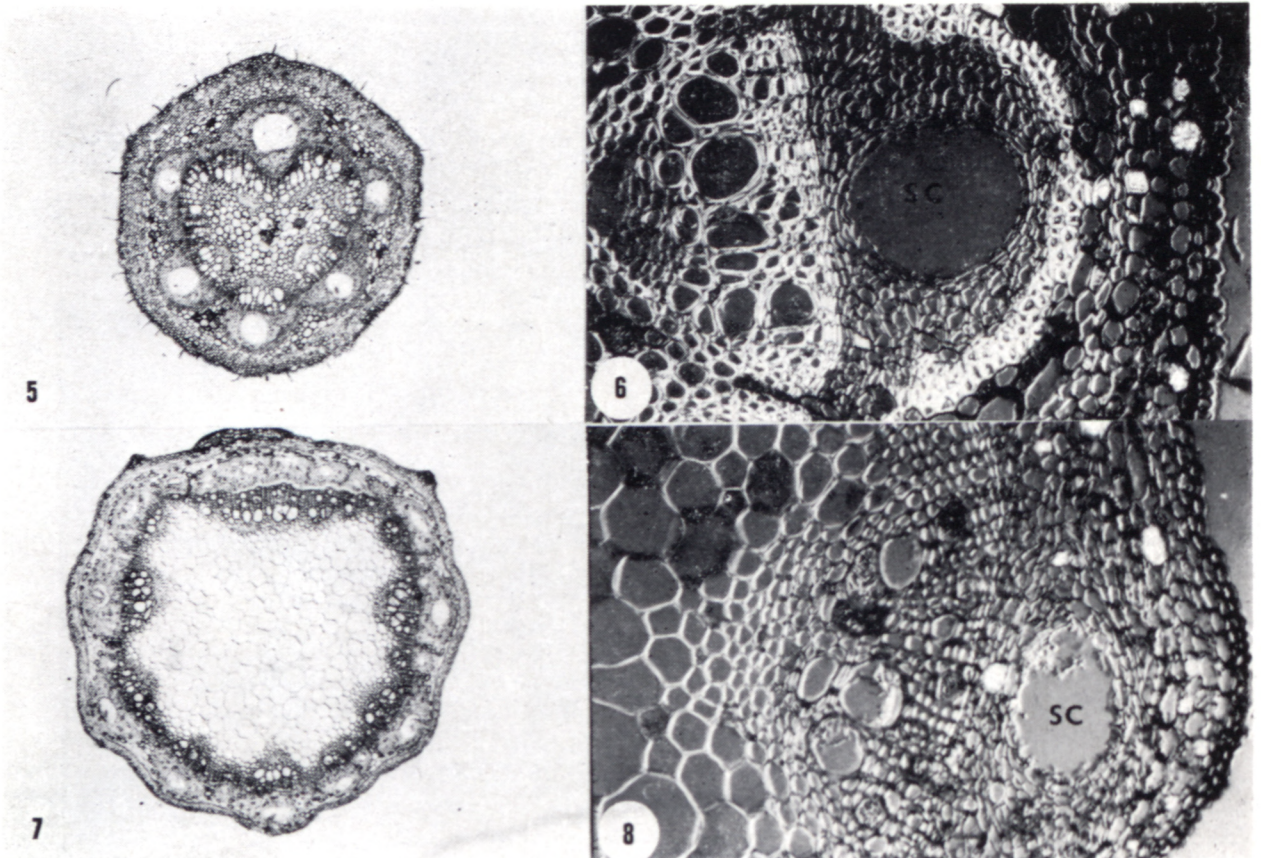
Secretory canals are present in concentric circles in the secondary phloem in most members of the Anacardiaceae (Metcalf and Chalk 1950), and in *Rhus diversiloba* (McNair 1918) these canals anastomose in the internodes forming a complete cylindrical network in the bark. Canals in older bark become displaced and distorted due to the dilatation of the bark when the epithelial cells divide in a plane perpendicular to the duct (Esau 1969). No evidence of canals in the secondary phloem was found in the material studied, but it is not unlikely that this will be the case in older material. Pyrocatechol tannin in the parenchyma and collenchyma of the cortex, as in *R. ovata* (Watkins 1940), was not observed.

A single ring of smaller medullary secretory canals is present interior to the primary xylem in the pith of young stems of *Smodingium argutum* (Fig. 1). Watkins (1940) noted the presence of small secretory canals in the pith of *Rhus laurina* and *R. ovata*, but McNair (1921) comments on their absence in *R. diversiloba* and *R. radicans* (*Toxicodendron radicans*) (Fig. 3). In other members of the Anacardiaceae these medullary canals vary in number in different members of a single genus or even in different internodes of a single plant.

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FIGS. 1-4.—Transverse section of young stem. All bright field. Figs. 1-2, *Smodingium argutum*. Figs. 3-4, *Toxicodendron radicans*. Figs. 1 and 3, $\times 6,25$; Figs. 2 and 4, $\times 40$. SC—secretory canals; MC—medullary secretory canals; P—pericycle fibres.



FIGS. 5-8.—Transverse section of petiole. Figs 5-6, *Smodingium argutum*. Figs. 7-8, *Toxicodendron radicans*. Figs. 5 and 7, $\times 6,25$, bright field; Figs. 6 and 8, $\times 40$, interference contrast. SC—secretory canals.

Petiole anatomy

Metcalf and Chalk (1950) state that secretory canals in the phloem of the petiolar vascular system are presumably present throughout the Anacardiaceae. In *Smodingium* there are six secretory canals arranged in a ring following the outline of the petiole as seen in transverse section. The largest canal is adaxially situated. The canals are exterior to the heart-shaped, cylindrical strand of xylem tissue (Fig. 5). Arc-shaped pericycle caps of thickened fibres are present exterior to the secretory canals which are, therefore, located in the phloem (Fig. 6). The bundles and canals branch upon reaching the leaflets. In *Toxicodendron radicans* there are more numerous canals in the petiole and the pericycle caps are lacking, as in the stem (Fig. 7, 8).

Leaf anatomy

The midrib of *Smodingium argutum* includes a ventral band of three vascular bundles with secretory canals surrounded by pericycle arcs (Fig. 9). The canal arrangement is similar to that of *Rhus diversiloba* (McNair 1918) and *Toxicodendron radicans* (Fig. 11). Dorsally there is a single bundle in *Smodingium* in contrast to *Rhus diversiloba*, which has five to seven bundles arranged in an arc. Scattered throughout the midrib are small irregular secretory canals.

All the lateral veins of the leaves of both *Smodingium argutum* and poison-ivy contain at least one secretory canal on their dorsal sides in the phloem (Fig. 10, 12). Some canals end blindly in the mesophyll and others anastomose in a reticulate manner as do the bundles which they accompany.

Formation of the secretory canals

Secretory spaces, in the form of cavities or canals, are formed by schizogeny or lysigeny or by both phenomena (Esau 1965). Schizogenous canals are lined by secretory cells comprising the epithelium, and lysigenous canals are surrounded by more or less disintegrated cells, the breakdown of which brought about the formation of the canal.

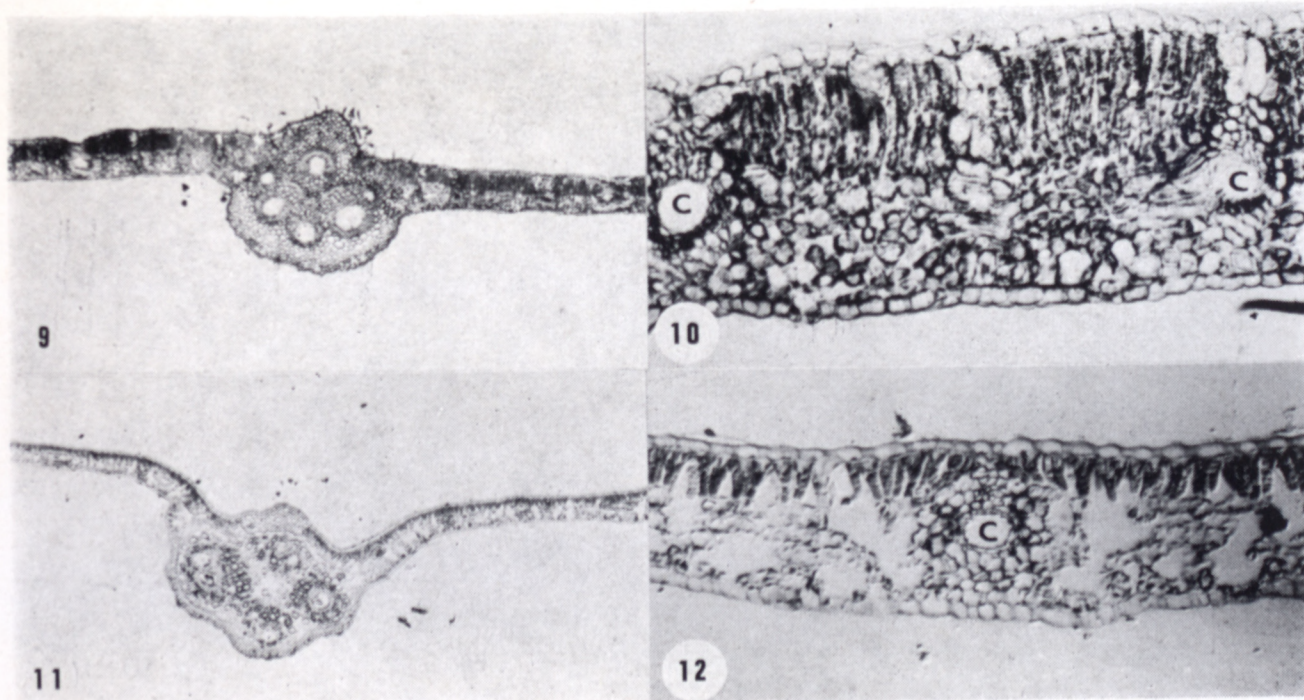
According to Sieck (1895) the canals of the Anacardiaceae are of schizolysigenous origin, but Fahn (1969) states that they are schizogenous and develop between resin-producing parenchyma cells which form the duct epithelium. McNair (1918) found the initial canal development of *Rhus diversiloba* to be clearly schizogenous. In *Smodingium argutum*, the medullary secretory canals are clearly schizogenous but, especially in older stems, petioles and leaves, the epithelial lining of the canals is often disjointed and indistinct (Fig. 2, 6).

Chemical composition of the sap of the secretory canals

The abundant canals of the Anacardiaceae contain a milky sap which turns black on exposure to air. The oleoresin fraction of the sap is often termed urushiol and its antigenetic properties, which are retained long after the plant is dead, are related to the presence of pentadecylcatechols (Whiting 1971). The American poison-ivy oleoresin contains a 1,2-dihydroxy benzene (catechol) with a 15 atom side chain in the third position (Fisher 1967). Proof of the close chemical relationship between the allergens of poison-ivy and *Smodingium* has been obtained (Findlay *et al* 1973, Eggers 1973). These findings suggest that both species manufacture a C_{15} , as well as a C_{17} , side-chain type of catechol, in which the types and degrees of unsaturation varies. Thus, *S. argutum* sap showed large amounts of the C_{17} diolefin, and poison-ivy shows a prominent diolefin at C_{15} , as well as traces of C_{17} side-chain compounds.

Small amounts of fresh sap from these plants, collected from the secretory canals with capillary pipettes, for mass spectrometry, showed similar results. Thus, it is in these secretory canals that the poisonous principles are harboured.

As mentioned, many workers on the Anacardiaceae (Metcalf and Chalk 1950) have shown that there are no essential differences in the arrangement and structure of the intercellular secretory canals in the family. Why some representatives of the family,



FIGS. 9 and 11.—Transverse section of midrib of leaf. FIGS. 10 and 12. Section of leaf lamina. FIGS. 9–10, *Smodingium argutum*. FIGS. 11–12, *Toxicodendron radicans*. FIGS. 9 and 11, $\times 6,25$, bright field; FIGS. 10 and 12, $\times 40$, interference contrast. C—secretory canals.

such as *Smodingium*, and some members of the genus *Rhus*, should be poisonous, or why their poisons should vary, either in physiological action, or chemical composition, cannot be elucidated from their anatomy and remains a mystery.

Function of the secretory canals

Various suggestions have been proposed as to the function of the secretory canals and the resin contained in them. Most of the theories hinge on the characteristic of this sap to harden when in contact with the air. When first expressed from the canals the resinous sap is transparent or light grey in colour, but it rapidly coagulates and hardens into a brown or black varnish-like mass. Microscopically the fresh sap can be seen to be composed of a colourless liquid in part, and in part of minute globules. Soon these globules become dark brown and at the same time oblong, rectangular, colourless crystals separate out.

McNair (1918) suggests that this hardening forms an efficient covering for any wounds the plant may receive. The abundance and relatively large size of these canals, together with their anastomosing, make up an extensive intercommunicating system. Wherever the plant is wounded a protective scab is rapidly formed. The viscosity of the secretory canal contents varies with the seasons. In spring, when the young leaves and twigs are fragile, it is very watery, but later in the summer it is noticeably thicker and slower in exudation.

In autumn, just before the fall of the leaves of *Toxicodendron radicans*, Trecul (1867) noticed the obstruction of the secretory canals at the base of the petiole. This obstruction was effected by an enlargement or increase in the parietal cells of the canals. Trecul (1867) suggests that the development of these tylosoids may have a part to play in the initiation of leaf fall.

Toxicity and the secretory canals

It has been conclusively shown that the freshly exuded, non-volatile, resinous sap is the only part of the plant capable of causing dermatitis in *Rhus diversiloba* (McNair 1916 a) and *Smodingium argutum* (Findlay *et al* 1973). Poisoning can thus occur only as a result of direct contact with the sap of the plant or by contact with this sap on clothing or tools. There is a contradiction in the literature as to whether or not the virulency of the sap from the secretory canals is lost when it hardens into a varnish-like substance. McNair (1917) is of the opinion that the irritating properties of the fresh sap are lost, but Whiting (1971) states that it retains its sensitising potential long after it has adhered to and hardened on objects.

McNair (1921) has shown that the sap retains its toxicity, without much variation in degree of virulency, throughout the year. He correctly points out that the tendency of *Rhus diversiloba* to cause poisoning varies during the course of the year in accordance with the stage of growth of the leaves, stems and flowers. The virulency of the plant is influenced by the virulency of the sap, the turgescence and ease of fracture of the leaves and stems, the conditions of light and humidity and thus turgor and photosynthesis, as well as by the conspicuousness of the plant. McNair (1921) supports this with clinical statistics. These influences on virulency are equally applicable to *Smodingium argutum* in South Africa.

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