A MONOGRAPHIC STUDY OF THE GENUS *WIDDRINGTONIA* ENDL.

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by

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CHAPTER 1

INTRODUCTION

There are six indigenous genera of the Gymnosperms in Southern Africa. _Encephalartos_ and _Stangeria_ represent the Cycadinae and _Podocarpus_, _Widdringtonia_ and _Juniperus_ the Coniferae. The sixth genus, _Welwitschia_ of the Gnetinae is found in South West Africa and Angola.

Widdringtonia, the "African cypress" or "Sederboom", is our only indigenous member of the Cupressaceae. It occurs mainly along the southern and eastern mountain ranges of Southern Africa extending as far north as Malawi (Nyasaland) (Fig. 1.1).

After having been twice renamed, the genus was finally named by Endlicher in 1842 after Captain Samuel Edward Widdrington (né Cook), a British botanist and Captain of the Royal Navy, who travelled in Spain from 1829-32. He changed his name from Cook to Widdrington in 1840. He published two books, one on European Pines (1843) and another on the vegetation of Spain (1847). Captain Widdrington died on the 11th of January 1846 (Gordon 1858; Britten and Boulger 1893).

The last revision of the genus was undertaken by Stapf in 1933 when six species were recognised. However, insufficient material was at the time available to establish the great variation existing in each population. The result is that many botanists through the years have criticized this revision of the taxon. A reviewer (W.T. Saxton) in Journ. Bot. Soc. S.A. xix 26 (1933) stated shortly after Stapf's work was published:

" The characters used in the clavis to separate the

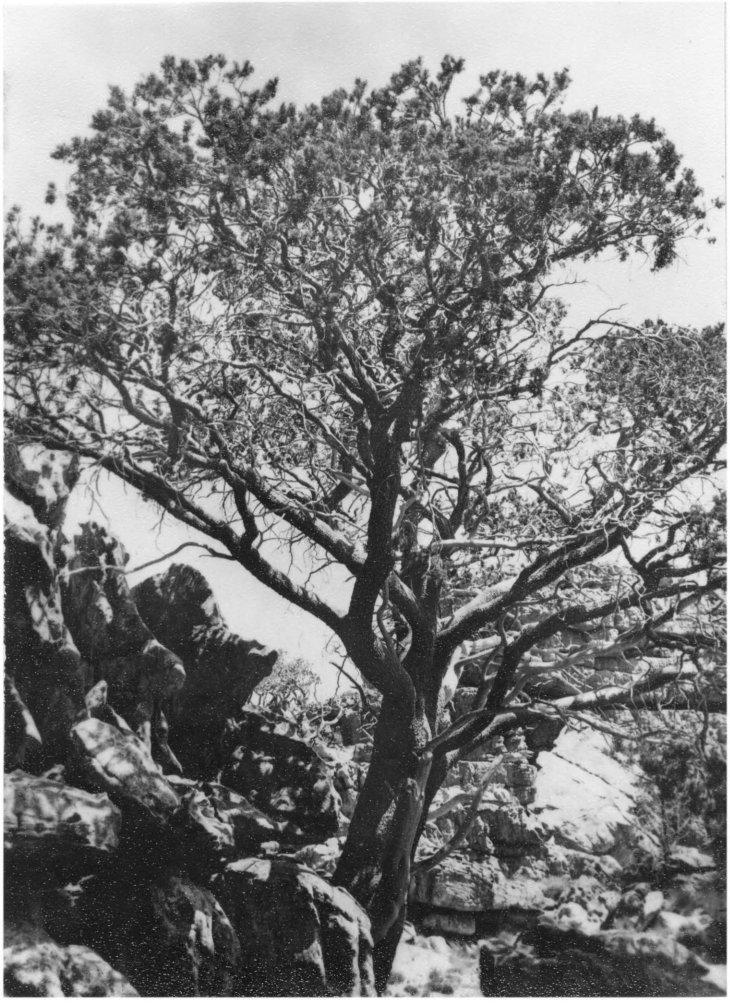

Fig. 1.1. - Habit study of Widdringtonia cedarbergensis.
(Clanwilliam District, Cedarberg Mts.)
(Photograph; Department of Forestry).

species are hardly constant enough for this purpose; the number of mature seeds in a cone is decidedly variable!"

This critic also correctly points out a discrepancy with regard to Stapf's description of the number of pollen sacs per microsporophyll.

The author however, for reasons mentioned in the text, has come to the conclusion that only three species can be upheld.

CHAPTER 2

AN HISTORICAL ACCOUNT OF THE GENUS *WIDDRINGTONIA* ENDL.

The first known reference to a South African *Widdringtonia* is that made in 1689 by Jacobus Breyne, a Danzig merchant, in his Prodromi Fasciculi Rariorum Plantarum. He named a plant of unknown origin *Cupressus Aethiopica coronata*. It then being the fashion to collect Cape plants, *Widdringtonia* attracted considerable interest particularly amongst the horticulturists.

Plukenet (1691) figures in his Phytographia, a sterile branch of a young plant of *Juniperifoliis Frutex Africanus* which he saw at Hampton Court, England.

In 1769, he mentioned *Cupressus nana compressis Taxi longioribus et tenuioribus foliis Africana* together with the afore-mentioned name in his Almagestrum Botanicum Mantissae. Neither of these plants can be identified with certainty but it is considered that they probably represent *W. cupressoides* (L.) Endl.

The same tentative identification applies to the Burmann plant named *Cupressus Africana, Lini folio, Larix Conifera* in his Catalogi Duo Plantarum Africanum (1737), which is a catalogue of the plants collected by Hermann, Oldenland and Hartog at the Cape.

Cupressus juniperoides, described by Linnaeus in 1763, and *Cupressus africana* by Miller in 1768, most probably represent the same taxon, since Linnaeus and Miller were acquainted and may thus have based their descriptions on material raised from seed obtained from the same source.

In the British Natural History Museum, there is an

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Oldenland specimen labelled *Cupressus africana* author?, which was later determined as *Cupressus juniperoides* L. This plant, however, is definitely *W. cupressoides* (L.) Endl., as is the Burmann specimen in the Conservatoire Botaniques, Geneva, which is also labelled *Cupressus juniperoides* L.

The second but valid description by Linnaeus of *Widdringtonia* material is that of *Thuja cupressoides* in his Mantissae Plantarum (1767). In this description a plate depicting *Thuja aphylla* Shaw is cited from Shaw's Catalogus Plantarum quas in variis Africa et Asiae (1738), but this reference is preceded by a question mark indicating uncertainty on the part of Linnaeus. Linnaeus' doubts have proved correct, as Shaw's taxon has since been found to be conspecific with the North African *Tetraclinis articulata* (Vahl) Mast. Unfortunately the types of the Linnaean taxa *Cupressus juniperoides* and *Thuja cupressoides* are not represented in the Linnaean Herbarium.

In 1768, Nicolaas Burmann, in his Prodromus Flora Capensis, mentions *Thuja aphylla* Shaw, which has since been considered to be a synonym of *W. cupressoides* (L.) Endl. However, *Thuja aphylla* Shaw was a misinterpretation on Burmann's part, since this taxon is synonymous with *Tetraclinis articulata* (Vahl) Mast., mentioned previously. Thus *Thuja aphylla* Shaw is synonymous with *Tetraclinis articulata* (Vahl) Mast., whereas *Thuja aphylla* sensu Burmann non Shaw must be considered a synonym of *Widdringtonia cupressoides* (L.) Endl.

Lamarck in his Encyclopédie Methodique (1786) describes *Juniperus capensis*, which cannot be identified with certainty as the description is based on young, sterile material taken from a plant cultivated in the Jardin du Roi, Paris. The original seed was obtained from the Kew gardener Aiton, who is reputed to have obtained it from the Cape,

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possibly from Masson. However, as this *J. capensis* Lamarck has been considered by Carriere (1855) to be synonymous with the Clanwilliam plant, previously known as *W. juniperoides* (L.) Endl., which has now been described as *W. cedarbergensis* Marsh (see chapter on taxonomy) Masson's routes were investigated to see whether he could have collected from the Cedarberg where this plant is found. It does not appear likely that Masson ever collected there (Smith, 1955; Karsten, 1958; van der Merwe, 1963). However, the only Masson specimen seen by the author was one in the British Natural History Museum which is *W. cupressoides* (L.) Endl. Therefore it is safe to assume that *Juniperus capensis* Lamarck is probably *W. cupressoides* (L.) Endl. (if a *Widdringtonia* at all).

The name *Thuja cupressoides* L. was upheld by Thunberg, one of Linnaeus' pupils, in his Prodromus Plantarum Capensium of 1800. Linnaeus' description of *T. cupressoides* is repeated by Willdenow in Species Plantarum ed. 5, 1805. (In this edition he incorrectly cites *T. aphylla* Burmann as one of the synonyms for this plant.)

Thunberg, in his Flora Capensis (1823), was the first person to give detailed localities in the Cape for *T. cupressoides* L. He too, did not collect in the Cedarberg (Smith, 1955; van der Merwe, 1963).

The next reference to what is now *Widdringtonia* is by Sprengel in Linnaei Systema Vegetabilium (1826), where the name *Cupressus juniperoides* is changed illegitimately to *Schubertia capensis* Spreng. Harvey, in his Genera of South African Plants (1838), admits that he does not know this Cape group and is not therefore able to judge the validity of Sprengel's change, but he emphasizes that the genus *Schubertia* is based on a large, North American tree with deciduous leaves. This is sufficient to question not

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only the authenticity of Sprengel's material but also the validity of what appears to be an unjustified name change.

In 1833 Brongniart in Annules Sciences Naturelles was the first to place Thuja cupressoides L. and Cupressus juniperoides L. under one genus, which he calls Pachylepis. Together with these two species, he describes the new taxon P. commersonii, based on material said to have been cultivated at Reduit, Mauritius. The type specimen is housed in the Paris Herbarium and definitely represents W. cupressoides (L.) Endl. Enquiries as to whether Widdringtonia could possibly be indigenous there and whether Commerson actually did collect this specimen on Mauritius, gave negative results (Vaughan, 1964).

Endlicher (Genera Plantarum, 1840) upheld Pachylepis Brongn., not realising at the time that this name was a later homonym of Pachylepis Lessing (1832), a member of the Compositae. He tried to rectify this error by using the name Parolinia (Suppl. 1, Genera Plantarum, 1841) to replace that of Pachylepis Brongn., only to realise later that Parolinia Endl. was also a later homonym of Parolinia Webb (1840), a member of the Cruciferae. He therefore renamed the genus Widdringtonia (Suppl. 2, Genera Plantarum, 1842) in honour of Capt. Widdrington (Chapman, 1961).

In Endlicher's Catalogus Horti Academici Vindobonensis (1842), the genus is referred to but not described. However, this work contains the first valid combination of the species W. cupressoides (L.) Endl.

Endlicher published his Synopsis Coniferarum in 1847, upholding the three species of Brongniart but under the new generic name viz. Widdringtonia juniperoides (L.) Endl.; W. cupressoides (L.) Endl. and W. commersonii (Brongn.) Endl. W. natalensis Endl. and W. wallichii Endl. are cited as 'species inquirenda'. The latter is a synonym of

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W. cedarbergensis Marsh as described in chapter 7 of this work while the former, a synonym of W. cupressoides (L.) Endl., is inadequately described from material reputed to have been collected by Krauss and Gueinzius at Port Natal. According to Stapf (1933), the Drakensberg Mountains in Natal were botanically unknown at that time (1839-1843). It is unlikely that Krauss collected Widdringtonia specimens in Natal because, his routes being well known today, do not coincide with areas in which this plant is indigenous. However, Krauss definitely collected W. cupressoides (L.) Endl. in the Cape (Outeniqua Mountains), of which there are specimens in both the Botanische Staatssammlung, Munich, and the Universitatis Florentinae.

Attempts at tracing the Endlicher material were most unsuccessful, as both Prof. K. Rechinger of Vienna and Dr. E. Potztal of Berlin-Dahlem communicated that all this Widdringtonia material was destroyed during the War.

Drege in Zwei Pflanzengeographische Documente (1843) was the first to mention localities for the Clanwilliam Cedar which he called Callitris arborea Schrad. (nom. nud.).

More information concerning the plant is given by Pappe in his Flora Capensium Medicae Prodromus (1850) under the name of Callitris ecklonii Schrad. (a nomen subnudum). In 1854 he published Silva Capensis, where he discusses the uses of the timber of the Clanwilliam Cedar.

The Pinetum by Gordon (1858) being merely a translation of Endlicher's Synopsis Coniferarum (1847), does not merit further consideration.

Berg (1860) in Bonplandia described a new species, Widdringtonia caffra, which, in the present author's opinion is a form of W. cupressoides (L.) Endl. The reputed differences between the cones of his species and W. cupressoides (L.) Endl. are not constant when compared with a wide range of material of the latter. Berg, also for the first time,

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described the form and appearance of the resin gland in the centre of the female cone, not realising that although varying greatly in form and size, its presence is common to the genus. This synonym, overlooked to date except in Kew Index Suppl. 9 (1938), is thus placed under W. cupressoides (L.) Endl.

In 1855 Carriere published his Traité Général des Conifères, a work similar to that of Gordon's but offering additional information on the cultivation of Widdringtonia under glass.

An historical account of the genus complete with descriptions of the subordinate taxa is published by von Schlechtendal in Linnaea (1864).

In 1868, Parlatore in de Candolle's Prodromus, gives a synopsis of the taxon Widdringtonia together with synonyms and their authors. According to von Schlechtendal (l.c.), Parlatore worked at Florence. Since this Herbarium has not often been visited by subsequent workers on the genus, this may account for the 'loss' of certain specimens cited by Parlatore e.g. Commerson, 1472. This specimen was located in the Herbarium of the University of Florence, Italy, by the present author.

In the Genera Plantarum (Benth. and Hook., 1880), the genus Widdringtonia, reconsidered by Bentham, is lowered in rank to that of Sectio Pachylepis of the genus Callitris Vent.

The first authentic record of the occurrence of Widdringtonia in Natal is that by Fourcade in the Report on the Natal Forests (1889).

In 1895 Masters in the Journal of the Linnaean Society resusicates Widdringtonia to occupy a position generically distinct from Callitris.

In the following years, descriptions of a number of

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additional taxa of Widdringtonia and Callitris from Southern Africa make their sporadic appearance in literature.

The first taxon W. whytei, described by Rendle in The Transactions of the Linnaean Society (1894), is named after the collector, A. Whyte. The second taxon, Callitris schwarzii, the Willowmore Cedar, described by Marloth in 1905 (Engl. Bot. Jahrb.), is named after E. Schwarz who first drew Marloth's attention to this plant. This taxon, however, was transferred by Masters to the genus Widdringtonia, thus bearing the binome Widdringtonia schwarzii (Marl.) Mast.

Stapf described the species W. dracomontana from Natal (Kew Bulletin, 1918) and the species W. stipitata from the Transvaal (Hooker's Icones Plantarum, 1930).

Apart from the above-mentioned literature, the following publications contain synopses of the genus, but they do not throw additional light on the taxonomy of the genus:

i) Durand and Schinz (1894) in Conspectus Florae Africae (taxa under the genus Callitris).

(ii) Masters (1905) in the Journal of the Linnean Society, vol. 37. (It contains a description of W. mahoni, later placed in synonymy).

(iii) Sim (1907) in The Forests and Forest Flora of the Cape Colony.

(iv) Marloth (1913) in The Flora of South Africa.

(v) Chalk (1932) in Some East African Coniferae and Leguminosae.

(vi) Stapf (1933) in Flora Capensis vol. 5, 2, suppl.

(vii) Dallimore and Jackson (1948) in A Handbook of Coniferae.

(viii) Chapman (1961) in Kirkia 1.

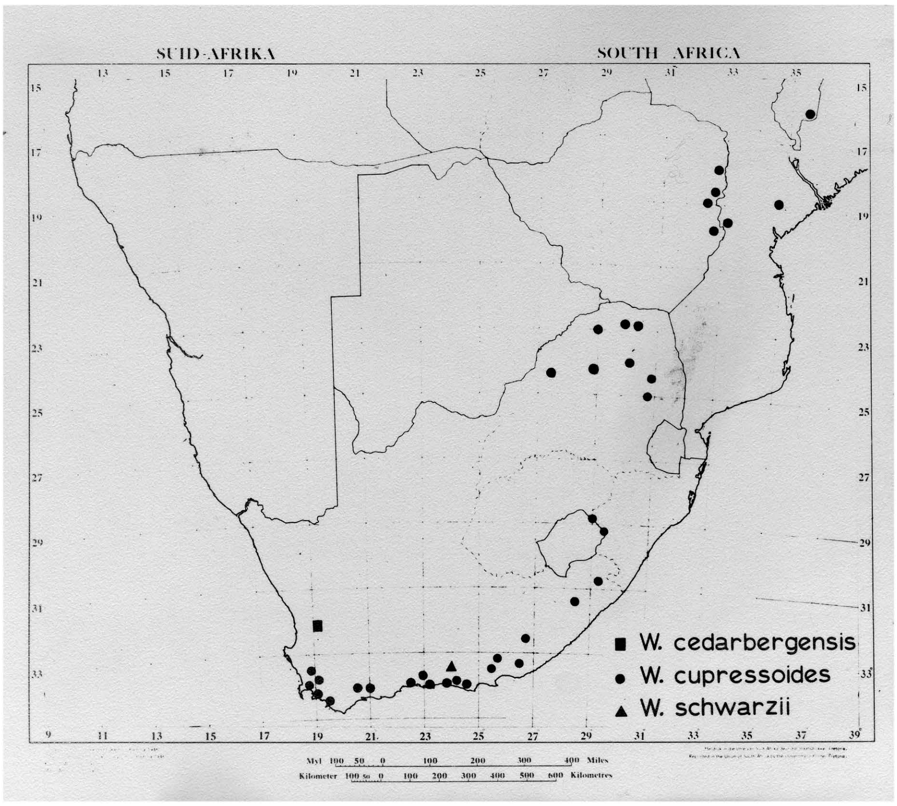

Fig. 3.1. - The distribution of Widdringtonia Endl.

CHAPTER 3

SOME ASPECTS OF THE ECOLOGY OF WIDDRINGTONIA ENDL.

Widdringtonia generally occurs on eastern mountain ranges and their subsidiary mountain chains running from Malawi down Africa to the eastern Cape Province and thence on southern and western coastal ranges to the Cedarberg in the western Cape Province (Fig. 3.1).

At present the majority of plants are restricted to inaccessible ravines, rocky outcrops, ledges and cliffs while in the past, they appear to have been more widely distributed (Dallimore, 1913). According to McClounie (1896), and Chapman (1961), charred stumps and a number of roots are found in grassland areas a considerable distance from the nearest existing forest.

3.1 WIDDRINGTONIA CUPRESSOIDES (L.) ENDL. OF THE NATAL DRAKENSBERG

W. dracomontana Stapf is regarded as synonymous with W. cupressoides (L.) Endl. Reasons for this conclusion are given in Chapter 6 of this work.

A number of publications on the ecology of Widdringtonia have appeared over the years, but, as there is no detailed account of the associates of Widdringtonia in the Natal Drakensberg, the following observations are reported.

W. cupressoides in the Natal Drakensberg is a pioneer of the macchia or 'fynbos' community and occurs together with Passerina, other representatives of the family Thymelaeaceae, Leucosidea, Erica and Pteridium aquilinum. Where the soil is too shallow to support high forest, Widdringtonia is dominant, while in areas suitable for high forest, species of *Podocarpus*, *Curtisia*, *Olea* and *Halleria* are dominant, as the young plants of *Widdringtonia* are unable to compete.

3.2 GENERAL REQUIREMENTS OF *WIDDRINGTONIA*

It appears that *Widdringtonia* prefers the following conditions:-

(a) *Temperature*

In any one locality the range in altitude over which *Widdringtonias* are found is very limited. At the most it is 330 m (1000 feet) and it is very often 150 m (500 feet) or less. This limited altitudinal range appears to indicate that the genus can adapt itself to only a limited range of temperatures.

Unfortunately, very few temperature readings have been taken in *Widdringtonia* habitats. Consequently some means of estimating temperatures at the altitudes at which *Widdringtonias* occur from the temperatures recorded at the nearest available stations has to be adopted in order to test this hypothesis. These temperature figures however, can only be regarded as approximations.

In order to determine the variation in mean annual temperature with altitude, areas in which a number of temperature readings have been made over a long period at neighbouring stations of different altitude were examined. One such area was selected at the southern end of the range of the genus and the other in the Northern Transvaal.

The former is comprised of the following series of meteorological stations in the Cape Peninsula:-

Royal Observatory (12 m or 40 feet above mean sea level),
Wingfield (19m or 57 feet),
Wynberg (81 m or 243 feet),

Kirstenbosch (93 m or 293 feet),
Devils Peak (478 m or 1433 feet),
Table Mountain (846 m or 2537 feet), and
Cableway (1186 m or 3557 feet).

When the mean annual temperature of these stations is plotted against their altitudes on graph paper, it is found that the mean temperature falls by 1.5°C on the average for every 300 m (1000 feet) rise in altitude.

The other series consists of the following meteorological stations in the Tzaneen - Leydsdorp area:-

Dusseldorf (540 m or 1800 feet),
Leydsdorp (615 m or 2050 feet),
Ofcolaco (675 m or 2250 feet),
Pusella (738 m or 2460 feet),
Belvedere (960 m or 3200 feet),
Mamathola (1032 m or 3440 feet),
New Agatha (1080 m or 3600 feet),
Weltevreden (1230 m or 4100 feet),
Pigeon Hole (1242 m or 4140 feet), and
Woodbush (1500 m or 5000 feet).

By similar graphical means, the mean annual temperature in this area is found to decrease by 1.75°C for every 300 m (1000 feet) increase in altitude.

Since there is so little difference between changes in mean annual temperature with altitude at two such widely separated points, the average of them, i.e. - 1.6°C per 300 m (1000 feet) increase in altitude, has been used to calculate the mean annual temperature of the known *Widdringtonia* habitats included in Table 3.1. In this table the name and mean altitude of the *Widdringtonia* habitat, the name and altitude of the nearest temperature or climatic station, the mean annual temperature of the latter, the difference in altitude between the habitat and the climatic

Table 3.1 Estimated mean annual temperature of some *Widdringtonia* localities.

Locality (a)	Mean altitude of locality in meters	Nearest climatic station (b)	Altitude of climatic station in meters	Mean annual temp. of station.	Difference between altitudes of a and b	Correction in mean annual temperature	Estimated mean annual temp. for *Widdringtonia* locality.
Jonkershoek	330	Jonkershoek	274	16.4	56	-0.3	16.1
Kirstenbosch	240	Kirstenbosch	88	16.2	152	-0.8	15.4
Rivier Sonder Ent	390	Caledon	244	16.1	146	-0.8	15.3
Knysna	120	Knysna	9	16.9	111	-0.5	16.4
Prince Albert Pass	1200	Uniondale	762	16.2	438	-2.3	13.9
Storms River	510	Storms River	241	15.8	269	-1.4	14.4
Zuurberge	750	Dunbrody	122	18.6	628	-3.3	15.3
Howiesonspoort	750	Grahamstown	539	16.4	211	-1.1	15.3
Evelyn Valley	1200	Evelyn Valley	1219	13.7	19	0	13.7
Katberg Mts.	1500	Bedford	747	16.9	753	-4.0	12.9
Tabankulu	1200	Tabankulu	1128	16.2	72	-0.4	15.8
Cathedral Peak	1800	Cathedral Peak	1800	13.9	0	0	13.9
Mariepskop	1800	Bosbokrand	853	19.9	947	-5.1	14.9
Wolkberg	1560	Woodbush	1528	15.0	32	-0.2	14.8
Zoutpansberge	1500	Alaska	1231	17.2	269	-1.1	16.1
			W. cupressoides				
Baviaanskloof	1050	Willowmore	826	15.8	224	-1.1	16.1
			W. schwarzii				
Cedarberg Mts.	1200	Clanwilliam	76	19.7	1124	-5.9	13.8
			W. cedarbergensis				

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station, the equivalent correction in mean annual temperature, and the estimated mean annual temperature of the habitat is given. It will be seen from this table that the mean annual temperature of all these habitats is closely comparable, but that W. cupressoides is probably slightly more tolerant as regards temperature than the other two species which have a more restricted distribution. A mean estimated annual temperature range of 12.9° C to 16.4°C covers the whole series of habitats and this must be considered to be an important factor in limiting the distribution of the distribution of the genus.

(b) Rainfall

Except in the case of W. schwarzii (Marl.) Mast., a minimum mean annual rainfall of 25 inches is experienced in Widdringtonia habitats. W. schwarzii (Marl.) Mast occurs in areas with a rainfall of 15 inches, but according to Lückhoff (1963) this species only attains its maximum height on sites where it can draw moisture from neighbouring streams.

The highest mean annual rainfall recorded in Widdringtonia habitats in South Africa is in the neighbourhood of 70 inches at Woodbush, North Transvaal.

The leaf form of the Cupressaceae, according to Kerfoot (1964), is most effective in condensing small droplets from cloud and fog. The influence of this extra water on the general water economy of the plant might be of more importance than is generally realised. As mists are prevalent in Widdringtonia habitats, they may be an important source of supplementary moisture.

(c) Geology

Except for some forms of W. cupressoides (L.) Endl. found on Mount Mlanje (Malawi) where the acidic soils are

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derived from igneous syenite, the genus generally occurs on sandy, acidic soils derived from sandstone or quartzite.

In the Cape Province all three species occur on Table Mountain Sandstone, while W. cupressoides (L.) Endl. in Natal is found on Cave Sandstone of the Karoo System and in the Transvaal on sandstone of the Waterberg and Transvaal Systems.

In Southern Rhodesia it is found on sandstone of the Umkondo System which is regarded as equivalent to the Waterberg System (Du Toit, 1956).

(d) Altitude

Widdringtonia does not usually occur in coastal areas. The only species found near the coast is W. cupressoides (L.) Endl. at approximately 130 m (400 feet) above sea level. However, Sim (1921) states that W. cupressoides (L.) Endl. was used at one time in the afforestation of drifting sands in the Western Province, but its absence from such sites today (Marsh, E.K., 1964) throws doubt on its efficacy for this purpose.

W. schwarzii (Marl.) Mast and W. cedarbergensis Marsh are generally found at an altitude between 990 - 1660 m (3000 - 4000 feet) while the altitudinal range for W. cupressoides (L.) Endl. is much wider i.e. 130 - 2000 m altitude, as is to be expected from the wide range of latitude over which it occurs.

(e) Aspect

Cool, shady, southern and south-eastern cliffs, rocky ledges and ravines are usually favoured by Widdringtonia, but trees may be found on a variety of aspects if other conditions are suitable.

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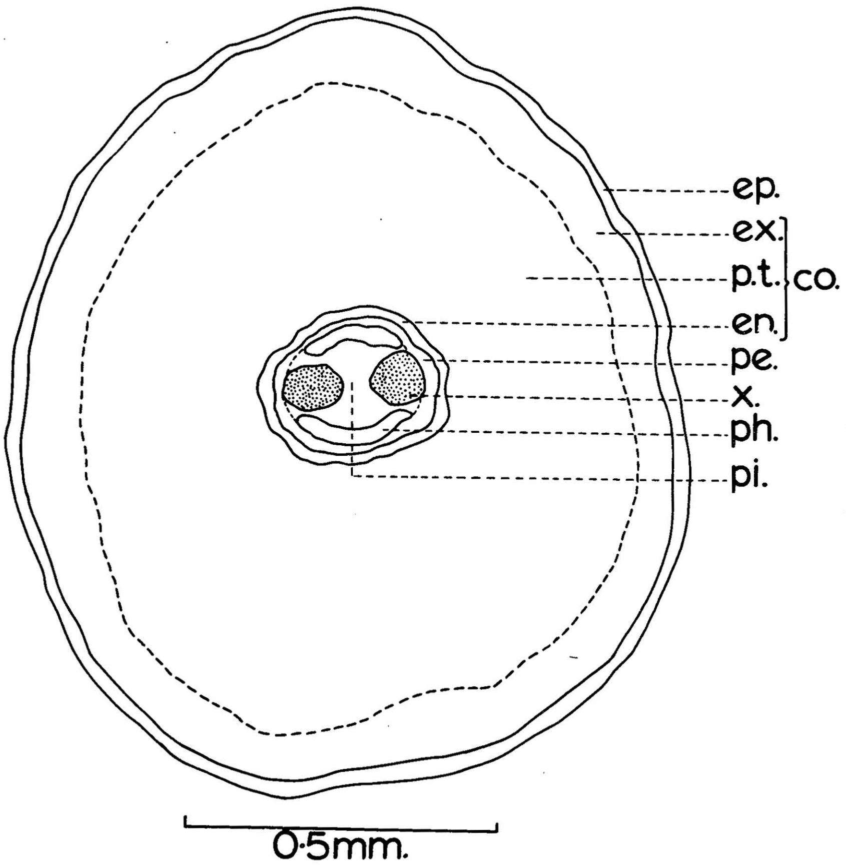

Fig. 4.1. - Diagram of transverse section of the root of W. cupressoides (L.) Endl.

CHAPTER 4

MORPHOLOGY

A study of the internal and external morphology of the root, stem and leaf as well as a study of the cones and seeds was undertaken. This study reveals striking similarities as well as some differences of taxonomic importanc in the various taxa.

4.1 THE ROOT

Widdringtonia possesses a tap root system. Handsections of the primary roots taken from seedlings of all the species, show the presence of a diarch stele with a central axial pith (Fig. 4.1). No conspicuous differences between the taxa were observed in the root.

The roots are very sensitive to heat and the plants grow well in rocky areas where they are able to penetrate the cracks between the rocks (Lückhoff, 1963). This type of habitat also affords protection from fire. In most instances a light scorching is sufficient to kill the plant because it has an exceptionally thin bark and the wood contains inflammable essential oils. Hubbard (1937) observes that a tree of W. cedarbergensis Marsh, 1.2 m in diameter, has a bark of only 13-16 mm thick, while the bark of smalle trees is correspondingly thinner.

4.2 THE STEM

A. Growth form and regeneration

Young trees of all species are usually conical in shape. Sometimes this pyramidal form is retained throughou the life of the tree. This is true of W. schwarzii (Marl.) Mast. (Lückhoff, 1963) and of cultivated specimens of

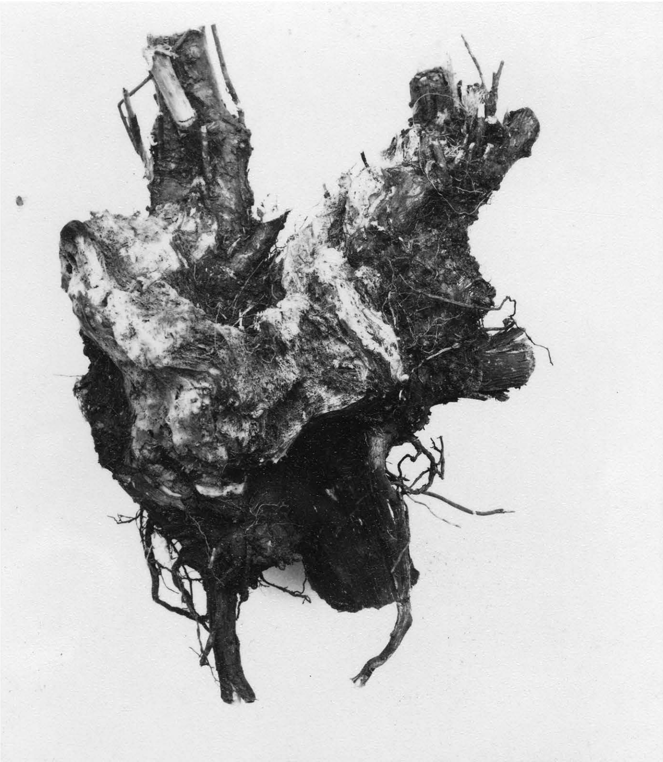

Fig. 4.2 - Root-stock of W. cupressoides (L.) Endl. showing new stems formed during coppicing after fire (Katberg Mountains, Cape Province).

Photo: Department of Forestry.

W. cedarbergensis Marsh when not crowded (Hubbard, 1937) and W. cupressoides (L.) Endl. (Fourcade as quoted by Stapf, 1933).

This conical shape, according to Hubbard (1937) usually endures in W. cedarbergensis Marsh for 40 years or more before the lower branches commence to die. With increasing age, the foliage in the flattened crown becomes thinner, and the branches more or less horizontally spreading. Dwarfed or gnarled and stunted forms of W. schwarzii (Marl.) Mast. (Lückhoff, 1963) and the other W. taxa are often met with where the soil is shallow, especially on ledges or cliffs, while tall trees are found on pockets of deep soil (Dixey, 1927).

In some taxa after damage by fire, renewed growth takes place in the basal, usually subterranean and undamaged portion of the stem. The plants coppice and eventually assume a shrubby habit.

Fig. 4.2 shows a stem base of W. cupressoides (L.) Endl. from the Katberg Mountains, Cape Province. A number of stems have arisen successively from the undamaged portion of the original stem, while a portion of this has decayed. The root system appears to be unaffected. Sections through the thickest root show the presence of 18 annual rings whereas those of the two stems reveal five and eight annual rings respectively.

As far as is known, coppicing does not take place in specimens having single boles viz. most plants of W. schwarzii (Marl.) Mast. and W. cedarbergensis Marsh.

B. Anatomy

A detailed anatomical study of the plant was not undertaken as the aim was solely to find distinctive characteristics for the various taxa. The structure of stem, like that of the root, was found to be similar for the three species.

Handsections stained with Reactive Genevois, were made from the stems of young seedlings. The stem is generally four lobed, occasionally five (Fig. 4.3). Resin ducts are only present in the cortex and occur singly in the centre of each lobe.

However, resin cells are a constant feature of the wood of the Cupressaceae (Esau, 1953).

The collateral vascular bundles embedded in ground tissue are arranged in two more or less concentric circles. Each of the small bundles forming the outer circle (and representing the leaf traces) lie directly opposite a resin canal.

The four bundles of the inner circle occasionally merge laterally so that their absolute boundaries are not always distinguishable.

C. Xylotomy

According to Greguss (1955), five of the six taxa recognised by Stapf can best be separated xylotomically by the number of cells per ray as seen in tangetial sections of secondary wood. The rays are relatively 'high' in the wood of *W. schwarzii* (Marl.) Mast. (33 superposed cell rows), considerably 'lower' in the wood of *W. juniperoides* (L.) Endl. and *W. cupressoides* (L.) Endl. (16 cell rows per ray) and the 'lowest' in the wood of *W. dracomontana* Stapf (15 rows per ray).

Since Greguss examined a limited amount of material and his key therefore is regarded as unsatisfactory, it was decided to reinvestigate this aspect briefly.

The rays in young and mature wood of these taxa were examined and compared with a view to determining the existence of substantial differences in the number of superposed cell rows per ray.

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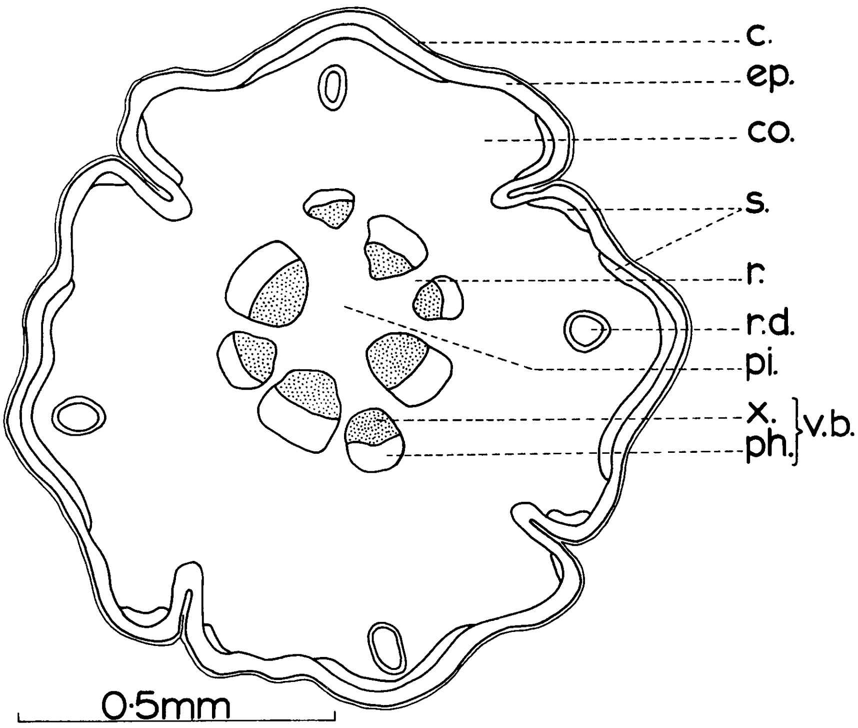

Fig. 4.3 - Diagram of transverse section of a young stem of *W. cedarbergensis* Marsh.

Slides of both young and mature wood were made. For slides of young wood, material was taken from twigs or stems up to half an inch thick, while those of mature wood were taken from the outer portion of the thickest stems available. All these slides were prepared by the Department of Forestry, Republic of South Africa.

(i) Statistical analyses of the mean number of cells per ray

Random counts were made of the number of cell rows per ray in tangential sections of the mature wood of each of the five taxa. By throwing a dice, ten fields on each slide were chosen at random and all cell rows within complete rays in each field were then counted. These results were statistically analysed by the Kruskal-Wallis one-way analysis of variance and the Mann-Whitney-Wilcoxon U-test (Siegel, 1956).

(ii) Results (Tables 4.1 - 4.6)

Analysis of the data presented in Tables 4.1 - 4.6 gives the following results:

(a) By means of the Mann-Whitney-Wilcoxon U-test ($p \gg 0.001$) it is found that there is a highly significant difference between the values for young and mature wood of the same species. As age is so important it is obviously useless to compare annual rings of unknown age (Tables 4.5 and 4.6).

(b) It would appear from this investigation (Tables 4.1 and 4.5) that the five taxa fall into two distinct categories, i.e. those with a low number of cells per ray (*W. cupressoides* (L.) Endl. and *W. dracomontana* Stapf), and those with a higher number of cells (*W. whytei* Rendle,

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TABLE 4.1. - Mature wood of W. cupressoides (L.) Endl.

Fields	1	2	3	4	5	6	7	8	9	10	Total
Total number of rays	69	58	65	68	77	72	73	62	70	66	680
Total number of cell counted	134	118	128	126	163	144	154	121	140	149	1377
Mean no. of cells per ray	1.9	2.0	1.9	1.8	2.1	2.0	2.1	1.9	2.0	2.2	2.0

TABLE 4.2. - Mature wood of W. dracomontana Stapf

Fields	1	2	3	4	5	6	7	8	9	10	Total
Total number of rays	55	67	76	62	68	71	80	77	78	58	676
Total number of cell counted	162	190	203	186	181	178	210	204	204	176	1894
Mean no. of cells per ray	2.9	2.8	2.6	3.0	2.9	2.6	2.9	2.5	2.6	3.0	2.8

TABLE 4.3. - Mature wood of W. whytei Rendle

Fields	1	2	3	4	5	6	7	8	9	10	Total
Total number of rays	36	31	31	28	36	38	24	29	36	33	322
Total number of cell counted	256	255	243	203	242	254	170	239	230	246	2338
Mean no. of cells per ray	7.1	7.5	7.8	7.2	6.7	6.6	7.0	8.2	6.3	7.4	7.2

TABLE 4.4. - Mature wood of W. juniperoides (L.) Endl.

Fields	1	2	3	4	5	6	7	8	9	10	Total
Total number of rays	37	30	32	28	34	33	30	27	41	35	327
Total no. of cell counted	219	206	216	175	242	195	184	204	221	319	2181
Mean no. cell per ray	5.9	6.8	6.7	6.2	7.1	5.9	6.1	7.5	5.3	9.1	6.6

TABLE 4.5. - Mature wood of *W. schwarzii* (Marl.) Mast

Fields	1	2	3	4	5	6	7	8	9	10	Total
Total number of rays	36	23	35	27	26	25	32	33	27	25	289
Total number of cells counted	217	164	200	190	153	144	203	210	193	148	1822
Mean no. of cells per ray	6.0	7.1	5.7	7.0	5.8	5.7	6.3	6.3	7.1	5.9	6.3

TABLE 4.6. - Immature wood of *W. schwarzii* (Marl.) Mast

Fields	1	2	3	4	5	6	7	8	9	10	Total
Total number of rays	50	54	55	80	102	90	79	86	66	59	721
Total number of cells counted	139	133	155	202	257	202	183	209	188	154	1822
Mean no. of cells per ray	2.7	2.4	2.8	2.5	2.5	2.2	2.3	2.4	2.8	2.6	2.5

W. juniperoides (L.) Endl. and W. schwarzii (Marl.) Mast.) Even such a grouping of the species should be rejected, however, because it probably results from the fact that wood of comparable age is not available for examination in the case of W. dracomontana Stapf and W. cupressoides (L.) Endl., in which the aerial portion of the stem is relatively short-lived (refer Fig. 4.2) and therefore strictly comparable with immature wood such as that evaluated in Table 4.6.

Thus it will be seen from the results of this investigation that the conclusions drawn by Greguss (1955) cannot be supported.

4.3 THE LEAF

Widdringtonia is an evergreen and two leaf-types are met with:

A. Juvenile leaf

In seedlings and young plants the leaves are needle-like. According to Chamberlain (1957), young shoots formed where the stem is wounded, also possess needle-like leaves and occasionally individuals of a species which has appressed leaves revert more or less to this juvenile leaf type. It has been observed that innovation shoots of mature trees (at least in cultivation), also possess this type of leaf and such shoots sometimes even bear male cones alone.

There are a number of historically very old specimens in overseas herbaria of young plants of W. cedarbergensis Marsh (W. juniperoides (L.) Endl. and W. cupressoides (L). Endl.). As there is much confusion regarding the typification of these specimens, a study of the juvenile leaf was made in the hopes of finding distinguishing and thus taxonomically important characteristics. Identification of the two taxa in the juvenile state would then be possible as the seedlings and young plants of W. cupressoides (L.)

Endl. often possess soft juvenile leaves about 13-16 mm long, separated by long internodes; while those of W. cedarbergensis Marsh are stiff and short (7-8 mm long).

Examination of many seedlings of the two taxa concerned showed however, that the juvenile leaves of W. cupressoides (L.) Endl. vary so greatly in length and texture (thus approaching those of W. cedarbergensis Marsh), that it is not possible to distinguish the taxa on basis of these characteristics.

Anatomically the juvenile leaves of the various species are indistinguishable. It will thus suffice if the anatomy of W. cupressoides (L.) Endl. alone be discussed. Anatomical works published to date on the juvenile leaf are on W. cupressoides (L.) Endl. and W. cedarbergensis Marsh by Rendle (1894) and Masters (1905). The diagrams of the latter are very diagrammatic and unsatisfactory. As a result of independent investigations, the writer observed the following (Fig. 4.4):

The outer walls of the epidermis are covered by a greatly thickened cuticle. Stomata of the type found in Sequoia (Esau, 1953, p.148, fig.7.4F) occur mainly in the abaxial epidermis. Along the two lateral flanks of the leaf, a single layer of hypodermal sclerenchyma is present. This also occurs above the main vein adjoining the adaxial epidermis and occasionally occupying a corresponding position abaxially.

The mesophyll consists of palisade tissue occurring mainly adaxially and spongy tissue predominantly abaxially. The cells of the mesophyll all contain an abundance of chloroplasts.

There is no distinctly differentiated and continuous endodermis. However, a vaguely defined parenchymatous sheath interrupted laterally by transfusion tissue is

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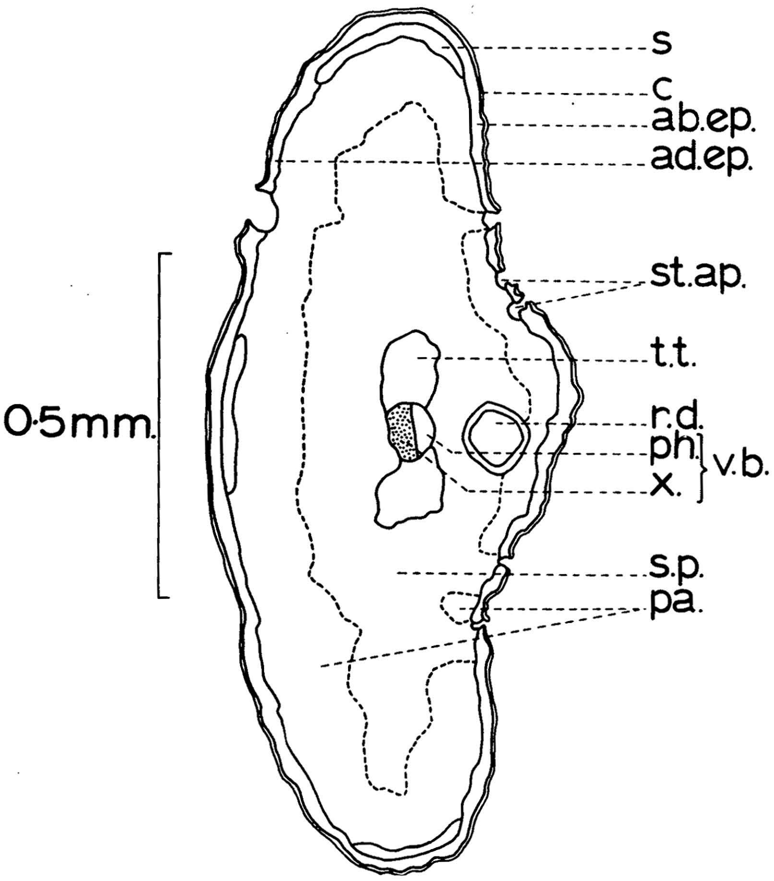

Fig. 4.4 - Diagram of transverse section of the juvenile leaf of W. cupressoides (L.) Endl.

present. It is apparently this layer that Masters misinterpreted as the endodermis. He was unaware of the presence of the transfusion tissue or he would have noted that his 'endodermis' was laterally interrupted by it. The transfusion tissue is a lateral continuation of the vascular bundle (Worsdell, 1897) and according to Esau (1953), the endodermis is a continuous sheath that envelopes both the transfusion tissue and the vascular bundle. This sheath also consists of relatively thick-walled cells with no or few intercellular spaces. Masters' 'endodermis' fulfils none of these conditions as his cells are thin-walled, have large intercellular spaces and the lateral interruption caused by the transfusion tissue passed unobserved therefore not meeting the requirements of an endodermis.

Both juvenile and adult leaves possess a single, axial, longitudinal vein which is of the collateral type typical of the Coniferae. Worsdell (1897) correctly states that the transfusion tissue of Widdringtonia consists of tracheids of various shapes, some small and rounded and others very large and polyhedral. The walls of these are spirally thickened and show the presence of bordered pits.

B. Mature or adult scale-like leaf

Two main forms of mature, scale-like leaves can be distinguished (Fig. 4.5):-

1. The leaf of W. cupressoides (L.) Endl., W. dracomontana Stapf and W. whytei Rendle, is generally narrowly oblong, adnate at the base, its free and adnate portions often equally long.

2. The leaves of W. cedarbergensis Marsh and W. schwarzii (Marl.) Mast, in comparison with the former, are generally ovate and the free portion is usually much shorter

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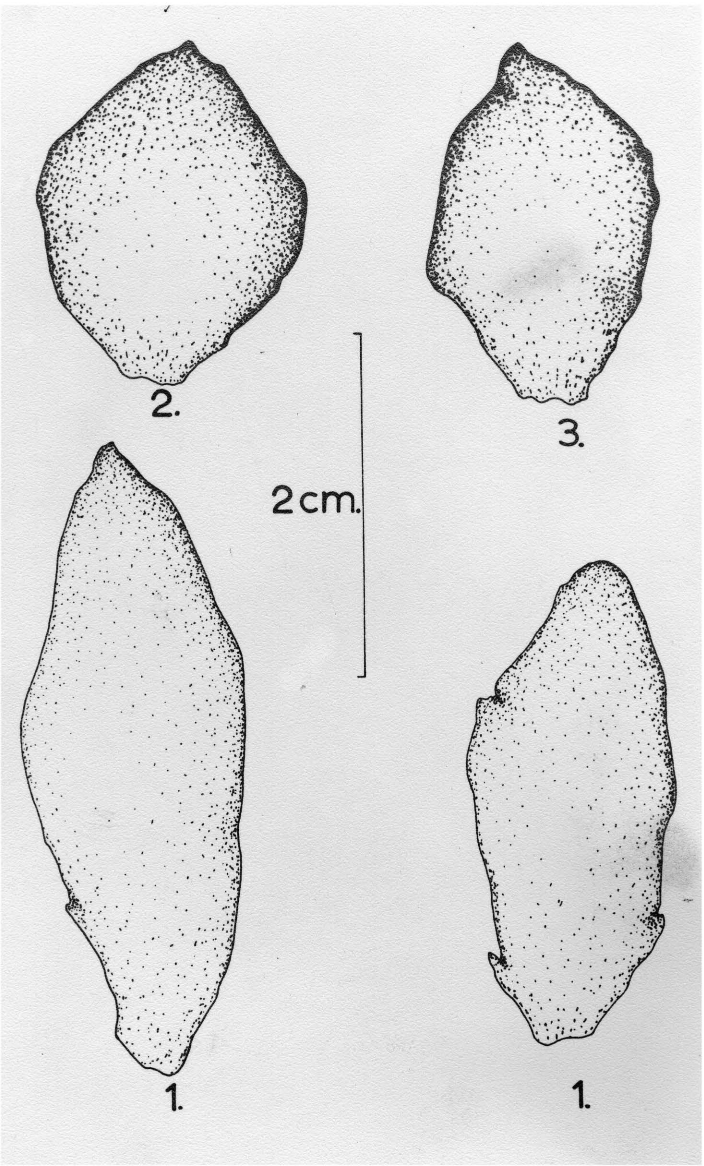

Fig. 4.5- Leaf forms of mature scale-like leaves (abaxial view) of Widdringtonis Endl.

1. W. cupressoides (L.) Endl.
2. W. cedarbergensis Marsh.
3. W. schwarzii (Marl.) Mast.

than the adnate portion.

The mature leaves on ultimate branchlets in all three species appear to be mostly opposite and decussate. However, microtome sections of some of these branchlets seem to indicate that the leaves of W. cupressoides (L.) Endl. are not strictly decussate but are spirally arranged while those of W. schwarzii (Marl.) Mast. and W. cedarbergensis Marsh are usually strictly decussate. The author's own observations are supported also by those of Henry (1930) who observed specimens of W. cupressoides (L.) Endl. (= W. dracomontana Stapf) with a phyllotaxis of 5/13.

Anatomy

Basically the anatomy of the adult leaf is similar to that of the juvenile leaf. Sections through the stem with its appressed leaves show that they are adnate for at least half their length (Fig. 4.6, 4.7 and 4.8).

The leaves of W. cedarbergensis Marsh and W. schwarzii (Marl.) Mast. are usually semi circular in transverse section of the upper adnate portion, while those of W. cupressoides (L.) Endl. are more often semi-triangular with a sinuate margin.

Although a single resin duct usually traverses the leaf longitudinally, three to five such ducts may be present. Viewed in transverse section, the more strongly developed 'carinal' duct is flanked symmetrically by two to four less conspicuous ducts.

4.4 THE CONES

Normally the genus Widdringtonia is monoecious. However, as far as was observed, during a particular season young trees often bear male cones only, whereas both male and female cones appear during subsequent seasons, thus creating an erroneous impression of being dioecious.

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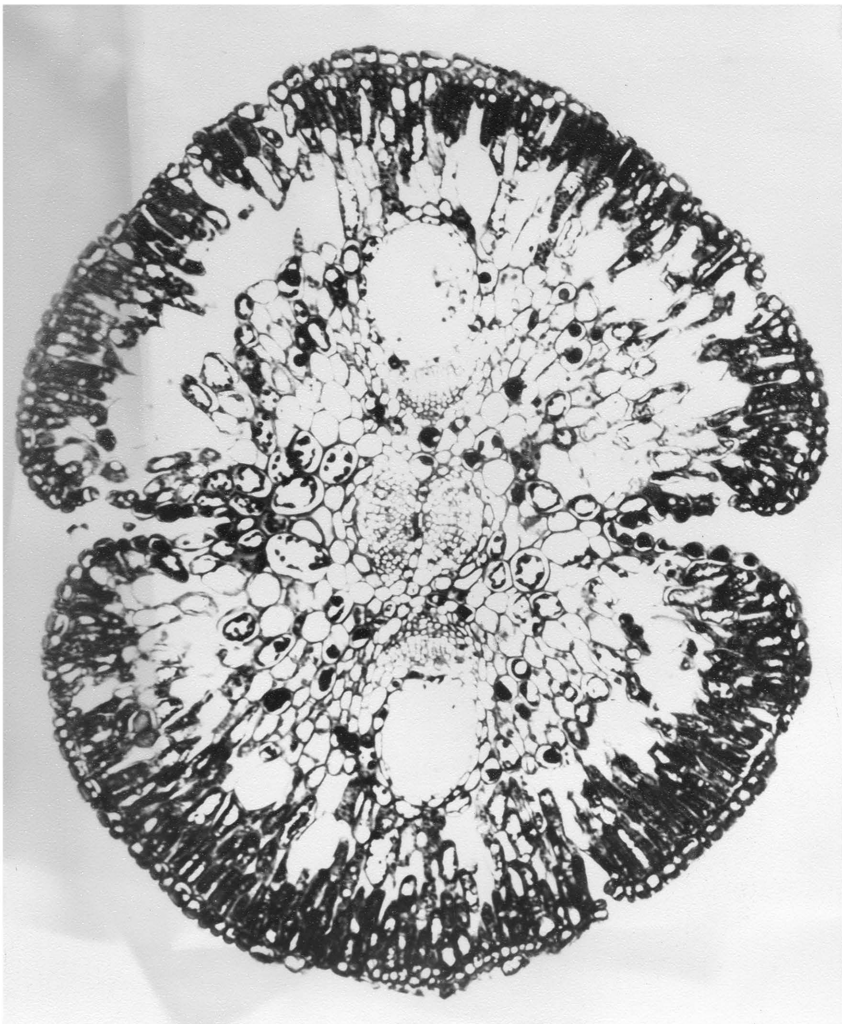

Fig. 4.6 - Transverse section through the basal portion of the decussate adult leaves and the stem of W. schwarzii (Marl.) Mast.

Photograph: Department of General Botany.

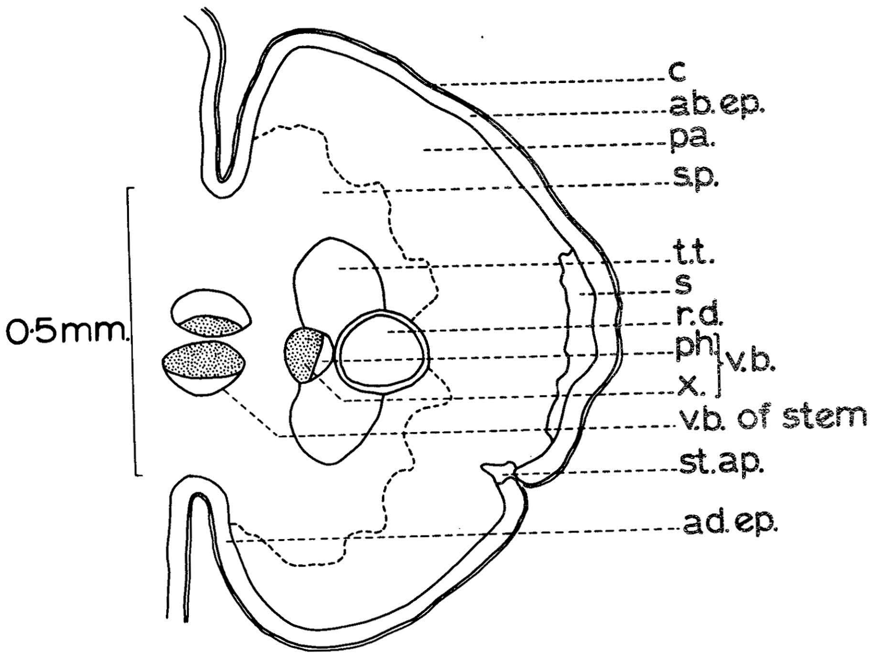

Fig. 4.7 - Diagram of transverse section of the stem and adult leaf of W. schwarzii (Marl.) Mast.

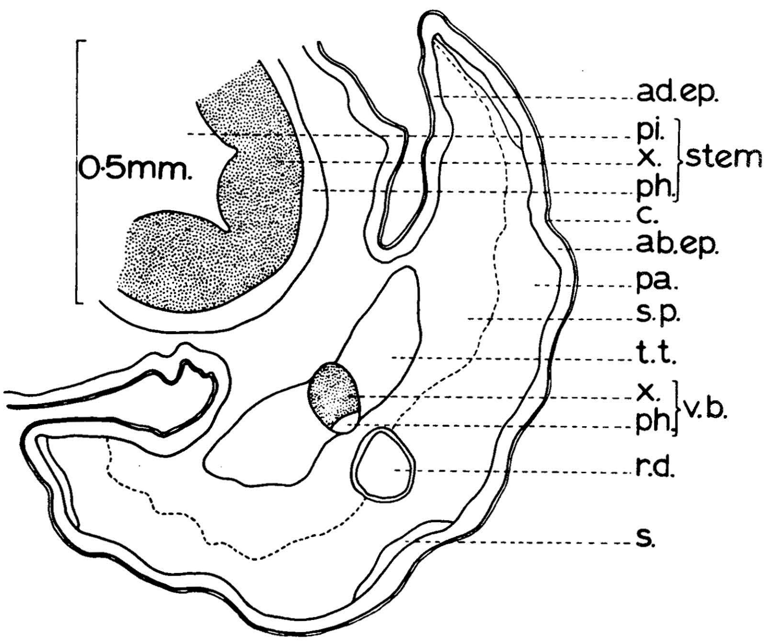

Fig. 4.8 - Diagram of transverse section of the stem and adult leaf of W. cupressoides (L.) Endl.

A. The male cone

The male cone is small (2-4 mm long) and occurs terminally on the short, lateral branchlets. There are 5-7 pairs of sub peltate microsporophylls per cone. However, this number is not constant.

The sporophylls are decussate, each scale bearing four, basal pollen sacs. The pollen, typical of the Cupressaceae, is wingless (Wodehouse, 1935).

The male cones appear to ripen at definite seasons while young female cones appear throughout the year. Judging by dates of collection of herbarium specimens, most male cones of W. cupressoides (L.) Endl. in the Humansdorp-Kynsna area and W. schwarzii (Marl.) Mast. are in anthesis during August. As Widdringtonia is wind pollinated, this might be of some ecological or genetical importance since August is at least in summer-rainfall areas regarded as being one of the windiest months of the year.

Material of W. cedarbergensis Marsh with male cones was collected in April by the South African Department of Forestry, during June by Leipoldt, and during September by Weintroub. The main flowering season is apparently during April, as the greatest profusion of male cones is found on specimens collected then and also the majority of specimens collected over the years at this time bear mature male cones.

With regards to W. cupressoides (L.) Endl., Kerfoot (1963) maintains that in the Stellenbosch area the male cones mature in April, a fact supported by more recent collections in this area. Even Ecklon and Zeyher's specimens collected during April in the Albany district bear male cones. However, some specimens from the Cape Peninsula collected during September and November show the presence of male cones. Although this species flowers mainly during April in the Transvaal, a few odd cones are often met with as late as July. Thus it is not possible to specify a clearly defined flowering season for this taxon.

When mature, the pollen sacs protrude beyond the scales of the male cones of all the species. Therefore this character, as used by Stapf (1933), is not reliable from a diagnostic point of view.

Nor is it possible to distinguish the species on the basis of the sporophylls as their number and size vary greatly.

B. The female cone

The young female cones are axillary, about two millimeters in diameter and are arranged singly or in clusters on elongated shoots.

(i) Flowering time

According to Levyns (1929) female cones of *W. cupressoides* (L.) Endl. in the Cape Peninsula appear from January to May. However, Kerfoot (1963) has observed young unpollinated 'flowers' or cones throughout the year. This is certainly true of cultivated specimens of the same species growing at the University of Pretoria. Dates on herbarium labels also reveal that the appearance of young female cones is not restricted to any specific season.

These young female cones are sub-sessile and consist of two pairs of decussate, coriaceous scales. A number of ovules are found at the base of each of the divaricate scales, which, after pollination, as a result of further growth and development, intergrow. The cone thus closes and becomes woody. The ovules often exude macroscopically visible, glistening, viscous pollination drops.

(ii) The number of ovules, seeds and seed scars per cone

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The number of ovules per scale, to which Stapf (1933) attached some taxonomic importance, varies considerably and is therefore a characteristic of little value. In addition, it is not a practical means of identification because of the technical difficulties encountered when dissecting such a minute, round and tough object. It is not always possible to sever the scales without damaging or removing ovules belonging to the adjoining scales.

Thus it is considered more practical to count the number of ovules per cone and not per scale. The same result is achieved by a less laborious method, whereby the number of seeds (abortive and fertile in fairly large, closed cones) or the number of seed scars found on an open female cone (abortive ovules included) are counted. Abortive ovules or their minute scars must also be counted to arrive at a correct result.

Except for W. stipitata Stapf random counts of the number of seed scars per cone were made for each species recognised by Stapf (1933). W. stipitata Stapf is regarded as synonymous with W. whytei Rendle and as no cones were available, the number of seed scars of this species was not counted. The standard deviation and 95 per cent confidence interval for the true mean value of the species was calculated. The following results were obtained (Table 4.7).

TABLE 4.7 - The number of seed scars per cone

Species	Mean number of seed scars per cone	Standard deviation	95% confidence interval
W. juniperoides (L.) Endl.	11.2	4.0	7.2 - 15.2
W. schwarzii (Marl.) Mast.	15.3	4.4	10.9 - 19.7
W. cupressoides (L.) Endl.	25.2	8.0	17.2 - 33.2
W. dracomontana Stapf	13.9	5.7	8.2 - 19.6
W. whytei Rendle	22.7	6.9	15.8 - 29.6

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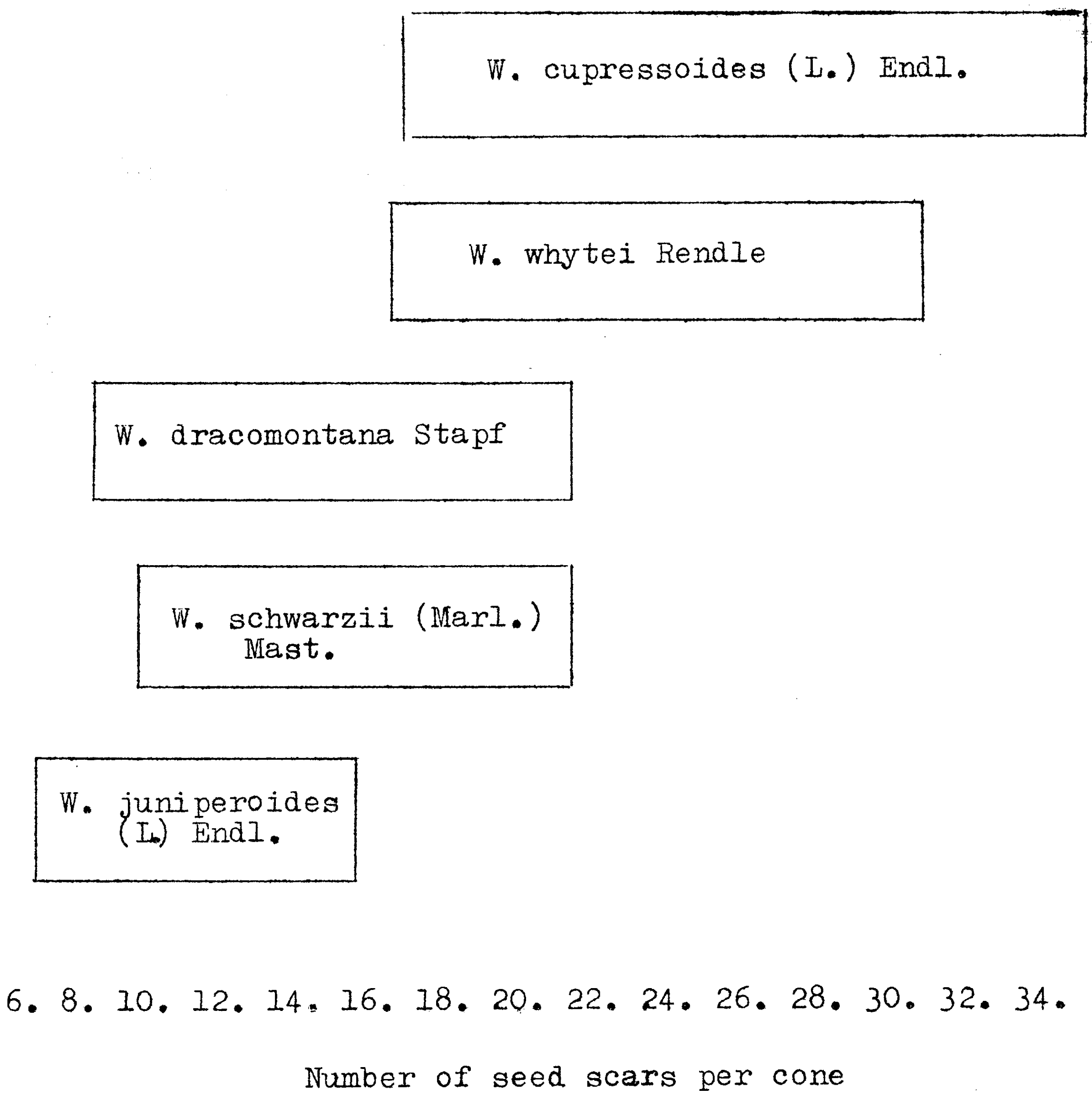

Fig. 4.9 Diagrammatic representation of the number of seed scars per cone of the five species recognised by Stapf (1933).

The formula used to obtain the 95 per cent confidence interval for the true mean value of the species is

$\bar{x} \pm 1.960s$; where s = standard deviation
$\bar{x}$ = mean number of seed scars per cone

When the results are represented in a diagram (Fig. 4.9), it will be seen that four of the five species overlap in the region of 17-20 seeds per cone so that identification on this basis will be of limited use, except towards the two extremities of the diagram.

(iii) Valve or scale sculpture

Even in relatively young, developing cones, two main sculpture patterns may already be distinguished on the dorsal surface of the scales (Fig. 4.10). Each scale in the female cone of *W. schwarzii* (Marl.) Mast. and *W. cedarbergensis* Marsh is regularly sculptured along its outer margin with striations radiating from a centrally placed dorsal spur. The marginal pattern is caused by verrucae of resiniferous tissue, while striations are due to the presence of resin canals clearly visible on the young cones of both species. According to Stapf (1933), the spur on each scale is its morphological apex. In very young cones, this apex before terminating its growth, may at times reach the length of the scale.

The scales of *W. cupressoides* (L.) Endl., may however, be smooth, wrinkled or irregularly verrucose. If present, the verrucae are irregularly distributed, resulting in an incoherant, diffuse and hence not characteristic pattern. Furthermore, although the spurred scales are more finely and thus less conspicuously striated, the striations appear

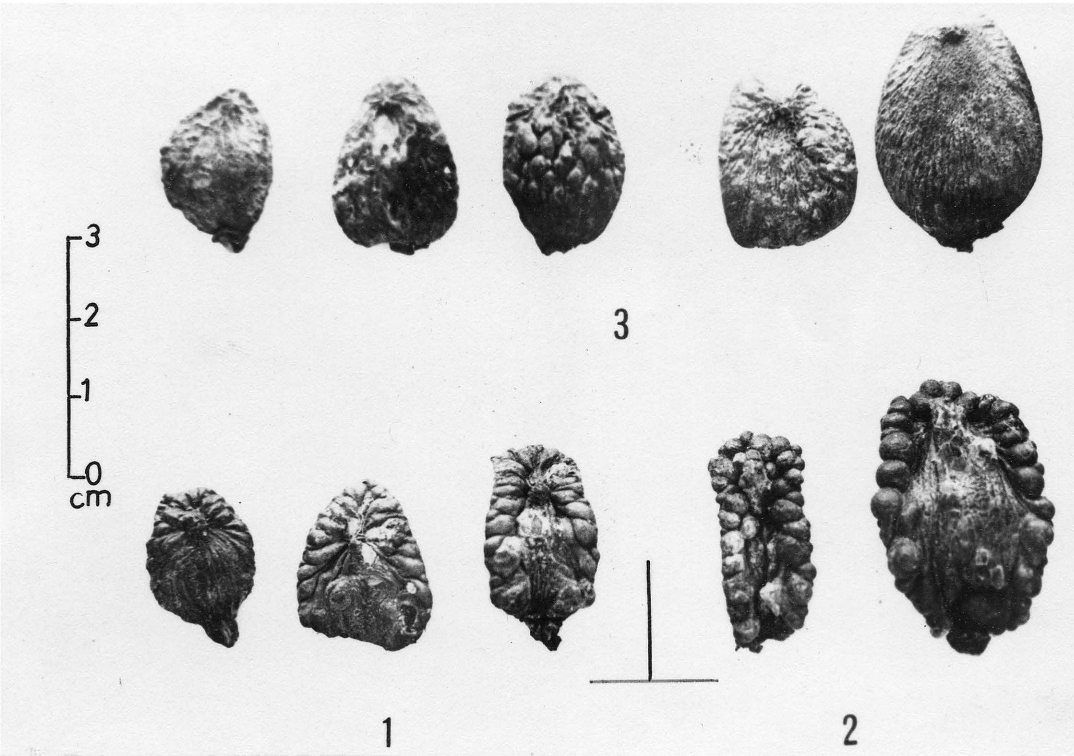

Fig. 4.10 - Variations of value or scale sculpture of the female cones. 1. W. schwarzii (Marl.) Mast. 2. W. cedarbergensis Marsh. 3. W. cupressoides (L.) Endl.

to be less obliterated by verrucae.

4.5 THE SEED, GERMINATION AND THE SEEDLING

The mature seeds of all three species are winged and with the exception of those of W. cedarbergensis Marsh are fairly light and flattened and are thus easily dispersed by wind (Fig. 4.11).

The seeds of W. cedarbergensis Marsh are trigonous and heavy with a very narrow wing along two angles and over the tip of the seed. They are twice the size and volume of those of the remaining species on account of an exceptionally thick testa, a large endosperm and cotyledons. The seed has a large and often whitish basal, somewhat oblique, scar of dehiscence corresponding ventrally to a similar scar at the base of the scale.

The seeds of W. schwarzii (Marl.) Mast. and W. cupressoides (L.) Endl. are ovoid and oblong - obovate in outline including the conspicuous wing. It was previously thought that the seeds of W. dracomontana Stapf could be distinguished by its rounded wings. However, after a large quantity of material, especially from the two extremities of its distribution range was examined, the wing characteristic was found to be unreliable. It merges with the characteristics of the seeds of W. cupressoides (L.) Endl. to the south and with that of W. whytei Rendle to the north (Fig. 4.12).

The seed of all three species germinates readily within a fortnight in moist sand or vermiculite.

The embryo of Widdringtonia normally has two cotyledons but occasionally embryos with three occur. Germination is epigeous with the cotyledons bright green colour on emergence. The cotyledons possess a single median vascular bundle and may attain a length of 25 mm and width

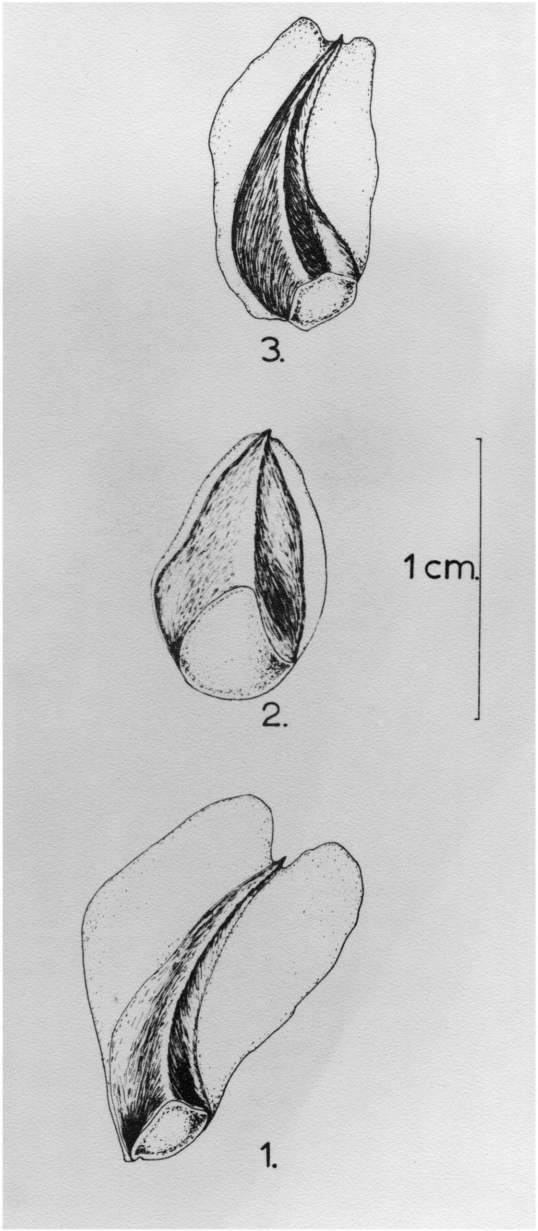

Fig. 4.11 - Seed types of *Widdringtonia* Endl.
1. *W. cupressoides* (L.) Endl. 2. *W. cedarbergensis* Marsh. 3. *W. schwarzii* (Marl.) Mast.

Fig. 4.12 - Variations in seed form of Widdringtonia Endl. 1. W. cupressoides (L.) Endl. 2. W. cedarbergensis Marsh. 3. W. schwarzii (Marl.) Mast.

of 4-5 mm in W. cedarbergensis Marsh while in the remaining species the width may vary from 2-3 mm.

Seedlings and young trees have sub-spirally arranged needle-like leaves.

In conclusion it may be said that it is possible to separate the species distinguished by Stapf (1933) into two groups on the basis of leaf form, sculpturing of the exterior scale surface of female cones, seed shape and in the width of the cotledonary leaves. These groups are

1. W. cupressoides (L.) Endl.
2. W. cedarbergensis Marsh and
   W. schwarzii (Marl.) Mast.

4.6 LIST OF THE ABREVIATIONS USED IN THE DIAGRAMS

ab.ep.	abaxial epidermis
ad.ep.	adaxial epidermis
c	cuticle
co	cortex
en	endodermis
ep	epidermis
ex	exodermis
hd	hypodermis
pa	palisade tissue
pe	pericycle
ph	phloem
pi	pith
p.t.	parenchymatous tissue
r	ray
r.d.	resin duct
s	sclerenchyma
s.p.	spongy parenchyma
st.ap.	stomatal apparatus
t.t.	transfusion tissue
v.b.	vascular bundle
x	xylem

CHAPTER 5

PHYTOCHEMICAL AND CYTOLOGICAL DATA

5.1 PHYTOCHEMISTRY

Chemical characteristics often demonstrate further relationships between taxa but the intangibility and difficulty of detecting and defining them have restricted their use considerably. In addition a thorough knowledge of chemistry is necessary to evaluate and assess the importance and value of these characteristics. For this reason it is difficult to draw conclusionsfrom the results obtained from the chemical analyses of the heartwood of Widdringtonia by Creighton, Gibbs and Hubbert (1944); Enzell and Erdtman (1958) and Erdtman and Thomas (1958). Gibbs (1945) and Hegnauer (1962) also discuss the importance of these results.

The presence of a particular compound (according to Benson, 1962) in one taxon and its absence from a related one is likely to be connected with the evolutionary processes which brought about the original segregation of the groups of organisms. This difference may thus be fundamental to classification.

An example of the significance of chemical characteristics is the protection against natural enemies e.g. fungi, insects and bacteria afforded to the plant by some chemical substances. The presence of these substances may often prevent extinction of the species. The wood of Widdringtonia is resistant to decay by fungi e.g. species of Coniophora, Lentinus and Poria (Erdtman and Thomas, 1958) and termites. This property of the wood makes it much sought after for fencing poles (Lückhoff, 1963).

Erdtman (1958) states that his study of Widdringtonia reveals that the genus constitutes a rather homogenous but distinctly separate group of general Cupressales characters sharing eudesmol with some southern hemisphere genera and widdrene, cedrol and widdrol with some northern genera. The latter has recently also been found in Chaemaccyparis thyroides.

He found that W. whytei Rendle (=W. cupressoides (L.) Endl.), W. juniperoides (L.) Endl. (= W. cedarbergensis Marsh) and W. schwarzii (Marl.) Mast. all contain cedrol, widdrene and widdrol, while these three substances together with eudesmol were found in W. dracomontana Stapf (= W. cupressoides (L.) Endl.), but only eudesmol in the S.E. Cape plant, W. cupressoides (L.) Endl., apparently a chemically closely related species to W. dracomontana Stapf. However, he had insufficient oil for a detailed examination of W. cupressoides (L.) Endl.

Erdtman further maintains that although it was not isolated in W. schwarzii (Marl.) Mast., W. juniperoides (L.) Endl. and W. whytei Rendle the presence of eudesmol in these species cannot be ruled out.

The occurence of both cedrol, which is characteristic of northern genera, and eudesmol, which is characteristic of southern genera, in at least W. dracomontana Stapf, is interesting, as the biosynthesis of these two substances proceeds along different routes.

From the results obtained by Erdtman and Thomas (1958), it appears that the species could be separated into two main groups, viz. those containing eudesmol (W. cupressoides (L.) Endl. and W. dracomontana Stapf) and those in which eudesmol has not yet been found (W. whytei Rendle, W. cedarbergensis Marsh and W. schwarzii (Marl.) Mast.). However, this division does not correspond with the author's

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concept of the species and is in accordance with Benson's (1962) statement that chemical characteristics are not necessary consistent with other features of the species and that further subdivision of species groups on such characteristics is rarely possible.

5.2 CYTOLOGICAL STUDY

A knowledge of cytogenetics, particularly with regard to the chromosome number and their morphology, can be an additional aid to the systematist when determining the boundaries between taxa. Thus all five species recognised by Stapf (1933) were investigated to ascertain the basic chromosome number for the genus and the diploid chromosome number for each species.

Some botanists would like the Mlanje cedar to be a separate species because it reaches tremendous dimensions in comparison with the smaller, more universally distributed form which occurs alongside the giant form on Mount Mlanje (Malawi). However, a cytological investigation revealed that the giant form has the same chromosome number as the stunted form. The difference in size appears therefore to be caused by a difference in the genes and not in the number of chromosomes, thus making the giant plant in the absence of other distinctions a mere race and not a separate species from W. cupressoides (L.) Endl.

A. Material and method

The material was obtained from the root tips of seedlings germinated in vermiculite. From these root tips fixed in Carnoy, squashes were made and stained with aceto carmine (Darlington and La Cour, 1962).

B. Results

The chromosomes of Widdringtonia are small, stain fairly well, but do not spread easily, with the result that visibility of the individual chromosomes is poor and the counts therefore probably inaccurate. As far as was possible to ascertain from about a hundred counts, the diploid number of chromosomes for *Widdringtonia* is 16, but according to Darlington and Wylie (1955), counts of other genera of the Cupressaceae have indicated 22 or more chromosomes.

As far as the author was able to observe, all the species of *Widdringtonia* have the same number of chromosomes but this genus require further investigation by an experienced cytologist.

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CHAPTER 6

TAXONOMIC AND PHYLOGENETIC OBSERVATIONS

6.1 TAXONOMIC OBSERVATIONS

On examining the results obtained from morphological, cytological and chemical studies of the genus, it is felt that the six species recognised by Stapf (1933) cannot be upheld, and it is proposed to combine these taxa into three species.

W. schwarzii (Marl.) Mast. is still upheld, likewise the concept of W. juniperoides (L.) Endl. (now W. cedarbergensis Marsh). These two species are very closely related as they are xylotomically, anatomically, chemically and to a great extent also morphologically similar. However, as the seed shape and size are so very different and they are geographically isolated, it was decided to maintain each as a separate species.

W. cupressoides (L.) Endl. now comprises Stapf's concepts and interpretations of W. cupressoides (L.) Endl., W. dracomontana Stapf, W. whytei Rendle and W. stipitata Stapf. Examination of a wide range of material comprising a large number of specimens, both in the living and dried state, showed much gradation between and a partial overlapping of these taxa. Furthermore, even within the population of one and the same taxon great variation was observed.

W. stipitata Stapf was described from cultivated material from Piet Retief, Transvaal. The orginal seed from which tree was grown is reputed to have come from Hansen's farm 'Rossbach' (fide his son, 1965) or 'Hillside' (fide Stapf, 1933) in the Zoutpansberg. All subsequent specimens from this area,however, have proved to be *W. whytei* Rendle, now *W. cupressoides* (L.) Endl.

The single specimen on which this species is based, is probably a sport and thus does not warrant taxonomic rank, even though the female cones are distinctly stipitate while those of *W. cupressoides* (L.) Endl. are sub sessile.

Attempts at establishing the where-abouts of the actual tree from which the type material was originally taken, have so far proved to be abortive.

According to Hansen filius (1964-1965) the tree is still growing in his late father's garden at Piet Retief. Unfortunately/at present only vegetative and male flowering material has been obtained from this plant. This material gave the author the impression of not being a *Widdringtonia*. Until such time as complete flowering and fruiting material becomes available, the identity of the tree in question must remain doubtful.

Batches of female cones, comprising 60 individuals each from various populations representing the five species upheld by Stapf, were examined with regard to seed shape and sculpture pattern of the scales. In this respect no reliable and consistent differences could be detected between *W. cupressoides* (L.) Endl., *W. dracomontana* Stapf and *W. whytei* Rendle. Hence *W. dracomontana* Stapf and *W. whytei* Rendle are regarded as being conspecific with *W. cupressoides* (L.) Endl.

6.2 PHYLOGENETIC APSPECTS

When the various results are collectively evaluated, some interesting surmises on the phylogeny of the genus can be made.

Many workers on the Coniferae have speculated on the origin and relationships of *Widdringtonia*. Some believe it

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to be a close ally of the Australian taxon, Callitris (Bentham and Hooker, 1880; Durand and Schinz, 1894; Engler, 1908; Hutchinson, 1924; Engler and Prantl, 1926; Moseley, 1943); others consider it to be closely related to the northern genera i.e. Cupressus and/or Thuja (Wilson, 1929; Erdtman, 1962).

The latter view appears to be more acceptable, if phytochemical evidence, distribution, and certain vegetative similarities are taken into consideration.

With regards to the phytochemical evidence, Erdtman and Thomas (1958) studied the heartwood constituents of Widdringtonia. They found that the genus constitutes a rather homogenous, but distinctly separate group of general Cupressales character, sharing with some northern genera, the chemical compounds widdrene, cedrol and widdrol, but eudesmol with some southern genera. Widdrene, which was at that time a newly isolated substance, has since been encountered in Thuya orientalis and Chamaecyparis, both of which are northern genera. Thus Erdtman considers Widdringtonia to be related to northern genera.

Distribution of both fossil and living material of the genus indicate that it may have originated in the northern rather than the southern hemisphere. According to Schimper and Schenk (1890), fossil material of Widdringtonia occurs over great areas of the Tertiary polar regions, the proof being cone-bearing twigs.

Knowlton (fide Phillips, 1927) records three species from the upper Cretaceous and Miocene in Colorado, while Berry (1916) states that Widdringtonia was frequent in the Cenozoic of Europe. Other known fossils of the genus have been found near Knysna in South Africa (Phillips, J.F., 1927). If all these fossils have been correctly identified (which Florin, 1963, doubts), Widdringtonia was previously very widely distributed.

As no reference to fossilized pollen or wood of the genus occurring in any other continent previously connected with Gondwanaland could be traced, the genus most likely originated in the northern hemisphere and thence migrated southward.

According to Kerfoot (1964), Widdringtonia should have been able to span the gaps between the highland areas in Africa, as it was present in South Africa before the final phase of the Rift Valley volcanism culminated, when many of the present gaps and intervals were established. At present Widdringtonia is still found on some mountain ranges down the east of Africa e.g. Mount Mlanje (Malawi), Gorongosa Mountains (Portuguese East Africa); Chimanimani Mountains (Southern Rhodesia); the Drakensberg Mountains and many mountain ranges of the Cape Province (Republic of South Africa).

With regards to the distribution of Widdringtonia within the Republic of South Africa, the majority of species occur in the east and the north. Levyns (1952) therefore does not consider it to be a member of the Cape Flora, the components of which are generally assumed to be southern in origin showing a west-south distribution pattern.

Being a member of the Temperate Forest Flora, which is assumed to be northern in origin, the alliance of Widdringtonia with the Cape Flora may rather be a question of available water than one of mutual origin (Levyns, 1952).

However, some authors favour the theory that Widdringtonia originated in the southern hemisphere, thus being closely related to the southern genus Callitris (Australian). Support in favour of this is the occurence in Widdringtonia of eudesmol, a chemical substance only present in southern genera.

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Here it could be added that *Tetraclinis*, a North African conifer, is not chemically related to *Widdringtonia* (Erdtman and Thomas, 1958), as was believed by some who favoured a northern origin for the genus. However, Erdtman states that *Tetraclinis* shows definite affinities with the northern genera as does *Widdringtonia*, although these two genera are not chemically related (Erdtman, personal communication with Kerfoot, 1962).

CHAPTER 7

TAXONOMY

Specimens have been examined from the following herbaria who kindly either sent specimens on loan, or permitted the very generous use of their herbarium and library facilities.

Only specimens seen by the author are cited. The herbaria as far as is possible, are cited according to the internationally accepted 'Index Herbariorum' ed. 3 (1956). However, a list is given below of the abbreviations used in this chapter for those to whom this index is not available.

B Berlin-Dahlem, Botanisches Museum.

BM British Natural History Museum.

BOL Bolus Herbarium, Capetown.

BR Brussels, Jardin Botanique de l'État.

E Edinburgh, Royal Botanic Garden.

FI Florence, Herbarium Universitatis Florentiae.

F.D.HERB. Forest Department Herbarium, Pretoria.

G Geneva, Conservatoire et Jardin Botaniques.

GRA Grahamstown, Herbarium of the Albany Museum.

K Kew, Royal Botanic Gardens.

L Leiden, Rijksherbarium.

LD Lund, Botanical Museum and Herbarium.

M Munich, Botanische Staatssamlung.

MO Missouri Botanical Garden, St. Louis.

NBG National Botanical Gardens, Kirstenbosch.

NH Natal Herbarium, Durban.

P Paris, Muséum National d'Histoire Naturelle.

PRE Pretoria, Botanical Research Institute.

RUH Rhodes University Herbarium, Grahamstown.

S Stockholm, Naturhistoriska Riksmuseum.

STEL Stellenbosch, Botanic Station Herbarium

UPR University of Pretoria Herbarium, Pretoria.

W Vienna, Naturhistorisches Museum.

Z Zürich, Botanischer Garten und Museum.

7.1 THE GENUS WIDDRINGTONIA

Widdringtonia Endl., Gen. Pl. Suppl. 2:25 (1842); Endl., Cat.Hort.Vondob. 1:209 (1842); Endl., Syn. Conif. 31 (1847); Lindley & Gord. in JournHort.Soc.Lond. 5:203 (1850); Knight and Perry, Syn. Conif. Pl. 13 (1850); Gordon, Pinet. ed. 1:333 (1858), ed. 2:416 (1875); Carr., Trait. Conif. ed. 1:63 (1855), ed. 2:57 (1867); von Schlechtend. in Linnaea 23:339 (1864-5); Henkel and Hochst., Syn.Nadelhölzer 292 (1865); Parlatore in DC., Prodr. 16,2:442 (1868); Harvey, Gen.S.Afr. Pl. ed. 2:353 (1868); Masters in Journ. Linn. Soc. Bot. 30:16 (1895); Masters in Journ. Linn. Soc. Bot. 37:207 (1905); Sim, For. Fl. Cape Col. 336 (1907); Thonner, Blütenpflz. Afr. 76 (1908); Stapf in Fl. Trop. Afr. 6,2:334 (1917); Sim, Native Timb. S.Afr. 130 (1921); Hutchinson in Kew Bull. 2:49 (1924); Pilg. in Engl. and Prantl. Nat. Pflzf. ed. 2,13:382 (1926); Burtt Davy, Man. Flow. Pl. and Ferns Tvl. 1:102 (1926); Levyns, A Guide to Fl. Cape Penins. 20 (1929); Chalk et al., Some E. Afr. Conif. and Legum. 16 (1932); Stapf in Fl. Cap. 5,2 (suppl.) :15 (1933); Dallimore and Jackson, Handb. Conif. ed. 3:654 (1948); Adamson and Salter, Fl. Cape Penins. 33 (1950); Phill., Gen. ed. 2:51 (1951); Lewis in Exell and Wild, Fl. Zamb. 1, 1:86 (1960); Chapman in Kirkia 1:139 (1961); White, For. Fl. N. Rhod. 8 (1962).

Type species W. cupressoides (L.) Endl.

Pachylepis Brongn. in Ann. Sc. Nat. ser. 1, 30:190 (1833) non Lessing (1832); Endl., Gen. Pl. 259 (1837); Hook.f.

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in Lond. Journ. Bot. 4:141 (1845).

Parolinia Endl., Gen.Pl. Suppl. 1:1372 (1841), non Webb (1840).

Callitris sect. Pachylepsis (Grongn.) Benth. in Benth. and Hook. f., Gen. Pl. 3, 1:424 (1880).

Callitris sensu Eichler in Engl. and Prantl., Nat. Pflzf. ed. 1, 2:94 (1889); Durand and Schinz, Consp. Fl. Afr. 5:951 (1894); Engl., Pflzw. Afr. 2:88 (1908).

Description

Monoecious, evergreen trees or shrubs; wood fragrant, easily worked, containing oil and resin. Leaves of two types, in juvenile form needle-like and subspirally arranged, in adult form scale-like and appressed, decussate or alternate but not in whorls of 3 or 4. Male cones small, c. 4 mm, terminal, mostly on short lateral branchlets; scales 5-7 pairs (usually 6), decussate, coriaceous, peltate, with normally 4 pollen sacs at the base of each scale. Female cones small, axillary on elongated shoots, single or clustered; scales normally 4 of equal size and arranged in one whorl, rarely 5 or 6 scales, corky - coriaceous, apiculate, divaricate at time of pollination, then closing; ovules several at the base of each scale; mature cones woody, 1.3 - 2.5 cm in diameter, opening at the apex, with 4 very thick, woody valves often each with a prominent dorsal cusp; exterior of valves smooth to warty. Seeds ovoid or trigonous, winged; testa crustaceous. Cotyledons after germination 2 rarely 3, green, needle-like.

A small genus occurring mainly along the southern and eastern mountain ranges of Southern Africa extending as far north as Malawi (Nyasaland). Three species recognised, all of which occur in the Republic of South Africa.

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Genus named after Captain S.E. Widdrington (né Cook) who travelled in Spain from 1829-32 and who published a book on European Pines (1843).

7.2 KEY TO THE SPECIES

Valves of female cone on the exterior surface, smooth to wrinkled, not verrucose along margin, if warty then irregularly so; adult leaves on ultimate branchlets narrowly oblong, subtriangular in transverse section.

.... W. CUPRESSOIDES 1.

Valves of female cone on the exterior surface, rough, with regular verrucae along margin; adult leaves on ultimate branchlets ovate, semi-circular in transverse section.

Seeds ovoid, triquetrous, obscurely winged, scar 4.5 x 6 mm; recorded from Clanwilliam district

.... W. CEDARBERGENSIS 2.

Seeds somewhat flattened, conspicuously winged, scar 1.5 x 2.5 mm; recorded from Willowmore district

.... W. SCHWARZII 3.

1. W. cupressoides (L.) Endl., Cat. Hort. Vindob. 1:209 (1842); Endl., Syn. Conif. 33 (1847); Knight and Perry, Syn. Conif. Pl. 13 (1850); Lindley and Gord. in Journ. Hort. Soc. Lond. 5:203 (1850); Pappe, Silva Cap. ed. 1:31 (1854); Carr., Trait. Conif. ed. 1:66 (1855), ed. 2:59 (1867); Gordon, Pinet. ed. 1:333 (1858), ed. 2:417 (1875); Henkel and Hochst., Syn Nadelhölzer 293 (1865); von Schlechtend. in Linnaea 23:358 (1864-5); Parlatore in DC., Prodr. 16, 2:443 (1868); Harvey, Gen. S.Afr. Pl. ed. 2:353 (1868); Sperk (fide Stapf, 1933) in Mém. Acad. Sc. St. Petersb. ser. 7, 13, 6: fig. 132-135 (1869); Masters in Journ. Linn. Soc.

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Bot. 37:270 (1905); Marloth, Fl. S.Afr. 1:101 (1913); Sim, Native Timb. S.Afr. 131 (1921); Pilg. in Engl. and. Prantl, Nat. Pflzf. ed. 2, 13:383 (1926); Levyns, A guide to Fl. Cape Penins. 20 (1929); Chalk et al., Some E. Afr. Conif. and Legum. 15 (1932); Stapf in Fl. Cap. 5, 2:18 (1933); Dallimore and Jackson, Handb. Conif. ed. 3:654 (1948); Adamson and Salter, Fl. Cape Penins. 33 (1950); Chapman in Kirkia 1:138 (1961).

Thuja cupressoides Linn., Mant. Pl. 125 (1767); Linn. Mant. Pl. Alt. 518 (1771); Tunb., Prodr. Pl. 2:110 (1800); Barrow, Travels in S.Afr. 1:298 (1801); Willd., Sp. Pl. ed. 5, 4:510 (1805); Ait. f., Hort. Kew. ed. 2,5:322: (1813); Thunb., Fl. Cape. ed. Schult, 500 (1823); Harvey, Gen. S. Afr. Pl. ed. 1:311 (1838); Loudon, Arboret and Frut. Brit. 4:2460, fig. 2310 (1838).

Type: No specimen in LINN; the description is adequate.

Thuja quadrangularis Vent.ex Duhamel, Trait. des Arbr. 3: 16 (1806). Type: 'Ile de France', Commerson in Herb. de Jussieu 17177 (P, holo.!).

Cupressus capensis Breon in Cat. Pl. Jard. Bot. et Nat. Bourb. (1825). Type: 'Ile de Bourbon' Breon s.n. (P; holo.!).

Pachylepis cupressoides Brongn. in Ann. Sc. Nat. ser.1, 30:190 (1833); Krauss, Fl. Kap.u. Natal 1:152 (1846). Type: 'Ile de France', Commerson s.n. (P; holo.!).

Pachylepis commersonii Brongn. in Ann. Sc. Nat. ser. 1, 30:190 (1833). Type: 'Ile de France', Commerson s.n. (P; holo.!).

Callitris cupressoides (L.) Schrad. ex Drege (E.Mey.) Zwei Pflageogr. Doc. 115, 126 (1843) nom. nud.; Durand and

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Schinz, Consp. Fl. Afr. 5:950 (1894); Engl. in Notizbl. Bot. Gart. Berlin App. 11:28 (?); Wood in Trans. S.Afr. Phil. Soc. 18:22 (1907); Wood, Handb. Fl. Natal 122 (1907); Engl., Pflzw. Afr. 2:88 (1908); Marloth, Kapland 116, 196, 199 (1908); Dallimore and Jackson, Handb. Conif. ed. 3:654 (1948).

Widdringtonia commersonii (Brongn.) Endl., Syn. Conif. 34 (1847); Lindley and Gord. in Journ. Hort. Soc. Lond. 5: 203 (1850); Carr., Trait. des Conif. 67 (1855); Gordon, Pinet. ed. 1:322 (1858), ed. 2:417 (1875); Henkel and Hochst., Syn. Nadelhölzer 294 (1865); Parlatore in DC., Prod. 16, 2:443 (1868).

Widdringtonia natalensis Endl., Syn. Conif. 34 (1847); Carr., Trait. des Conif. ed. 1:67 (1855), ed. 2:62 (1867); Gord., Pinet. 334 (1858); Henkel and Hochst., Syn. Nadelhölzer 294 (1865); Parlatore in DC., Prodr. 16, 2:443 (1868); Durand and Schinz, Consp. Fl. Afr. 5:951 (1894); Sim, For. Fl. Cape Col. 337 (1907). Type: reputed to be a Krauss or Guienzius specimen from Port Natal.

Widdringtonia caffra Berg in Bonplandia 8:190 (1860). Type: No specimen cited.

Callitris natalensis Endl. ex Fourcade in Rep. Natal For. 121 (1889), nom. nud.

Callitris commersonii (Brongn.) Durand and Schinz, Consp. Fl. Afr. 5:951 (1894).

Widdringtonia whytei Rendle in Trans. Linn. Soc. Bot. 4:60 (1894); Whyte in Kew Bull. 121 (1892); Britten in Trans. Linn. Soc. Bot. ser. 2, 4:60 (1894); Masters in Gard. Chron. 15:746 (1894), 16:190 (1894); McClounie in Kew Bull. 216 (1896); Burkill ex Johnston, Brit. Centr. Afr. Bot. App. 11:233 (1897); Masters in Journ. Linn. Soc. Bot.

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37:270 (1905); Sim, Tree Plant. Natal 234 (1905); Sim, For. Fl. Portug. E. Afr. 109 (1909); Purvis, Some Notes on Tree Plant. Shire Highlands 1910; Rendle in Journ. Linn. Soc. Bot. 40:235 (1912); Stapf ex Fl. Trop. Afr. 6, 2:334 (1917); Burtt Davy, Man. Flow. Pl. and Ferns Tvl. 1:102 (1926); Pilg. in Engl. and Prantl, Nat. Pflzf. ed. 2, 13:383 (1926); Dixey in Geogr. Rev. 17:611 (1927); Henkel in Proc. Rhod. Sc. Ass. 30:12 (1931); Chalk et al. in Brit. Emp. 1:12 (1932); Stapf in Fl. Cap. 5, 2:17 (1933); Dallimore and Jackson, Handb. Conif. ed. 3:654 (1948); Brass in Mem. N. York Bot. Gard. 48, 3:175 (1953); Lewis in Fl. Zamb. 1, 1:86 (1960); Chapman in Kirkia 1:138 (1961); White, For. Fl. N.Rhod. 8 (1962); Chapman, Veg. Mlanje Mts., Nyas. (1962).

Type: Malawi ; Mt. Mlanje, Whyte s.n. (BM; holo.!).

Widdringtonia mahoni Masters in Journ. Linn. Soc. Bot. 37:271 (1905); Sim, For. Fl. Portug. E. Afr. 109 (1909); Stapf in Fl. Trop. Afr. 6, 2:334 (1917).

Type: Melsetter, Mahon, alt. 4500 - 7000 ft. (K carp. coll. ?).

Callitris whytei (Rendle) Engl. in Pflzw. Afr. 2:89 (1908); Eyles in Trans. R. Soc. S.Afr. 5, 4:292 (1916).

Callitris mahoni (Mast.) Engl. in Pflzw. Afr. 2:88 (1908).

Widdringtonia dracomontana Stapf in Kew Bull. 206 (1918); Pilg. in Engl. and Prantl, Nat. Pflzf. ed. 2, 13: 383 (1926); Chalk et al., Some E. Afr. Conif. and Legum. 15 (1932); Stapf in Fl. Cap. 5, 2(suppl.):21 (1933); Dallimore and Jackson, Handb. Conif. ed. 3:653 (1948); Chapman in Kirkia 1:138 (1961).

Type: Drakensberg Mts., Sanderson 2011 (K; holo.! S!).

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Widdringtonia stipitata Stapf in Hook. Ic. Plant. 32: 3126 (1930); Stapf in Fl. Cap. 5, 2 (suppl.):16 (1933); Chapman in Kirkia 1:140 (1961).

Type: Piet Retief; Hansen garden, Kotze sub num. 7048 (F.D. Herb.; holo.!).

Description

Shrub or small tree up to 9 m high or, in the tropics, attaining a height of about 50 m, with a stem diameter up to 2 m, crown pyramidal when young, spreading with age; bark on young trees reddish grey, thin, fibrous, flaking off.

Leaves of two types; juvenile leaves on seedlings and young trees needle-like, spreading, 1-2 cms long and up to 2 mm broad; adult leaves scale-like, appressed, narrowly oblong, often not strictly decussate, subtriangular in transverse section, adnate at the base, free and adnate portions often equally long. Male cones mostly on short lateral branchlets; scales usually 6 pairs, decussate, coriaceous, peltate, broadly ovate with 4 pollen sacs at the base of each scale. Mature female cones consisting of usually 4 woody valves; valves smooth to wrinkled, not verrucose along margin, if warty then irregularly so. Seeds ovoid, conspicuously winged, somewhat flattened, seed scar about 1.5 x 2.5 mm, outline including wings oblong-obovate, wing retuse at apex. Cotyledonary leaves 20-25 mm long and about 2 mm broad.

Found on mountain ranges of the south eastern and eastern Cape, Natal, Transvaal extending into Southern Rhodesia, Portuguese East Africa and Malawi (Nyasaland).

CAPE - Peninsula: Table Mt., Roxburgh (G), Burchell 771 (K) Stellenbosch: Jonkershoek, Galpin 12787 (K), Meeuse 4407 (L; S). Caledon: Hermanus, Smuts 1222 (PRE) Swellendam: Tygerberg nr. Rivier Zonderend, Codd 10140

(PRE). George: Outeniqua Mts., Krauss 1140 (FI; M). Humansdorp: Goukama, Burchell 5588 (K; L; M; P). Port Elizabeth: Otterford Reserve, Rodin 1123 (K; MO; S). Grahamstown: Howiesonspoort, Zeyher 3885 (P), Governor's kop, Rogers 27668 (Z). Stockenstrom: Katberg, Mt. Didema, Fraser s.n. (E). Umtata: Baziya, Sim 1473 (GRA; PRE). Mt. Ayliff: Tonti, Kriel 3004 (F.D. herb.)

NATAL - Escourt: Giant's Castle, Sanderson 2011 (K; S), Cathkin Peak, Meebold 13144 (M). Bergville: Cathedral Peak, Killick 1745 (NH; PRE).

TRANSVAAL - Pilgrimsrest: Mariepskop, van der Schijff 4477 (K; PRE; UPR). Waterberg: Groothoek, Codd 3976 (K; PRE). Pietersburg: Wolkberg, Labourer 5293 (F.D. Herb.), Blaauwberg, Schweickerdt 1821 (BM; K; L). Zoutpansberg: Hanglip, Rodin 4050 (K; MO; PRE; S).

PORTUGUESE EAST AFRICA - Manica, Barbosa 1653 (BR). Gorongosa Mts., Gomes e Sousa 4310 (K).

SOUTHERN RHODESIA - Melsetter: Chimanimani Mts., Swynnerton 1963 (BM; K; Z). Umtali: Engwa, Exell, Mendonca and Wild 78 (BM). Inyanga: Inyanga Mts., Chase 2872 (BM; BR; MO).

NYASALAND - Mlanje: Mt. Mlanje, Whyte s.n. (BM), McClounie s.n. (K).

CAPUT BONAE SPEI - without precise localities; Masson (BM) Kiggelaer (BM), Mace (P), Thunberg (LD; S), Oldenland (BM), Burmann collect. (G).

Commerson's specimens from Mauritius of W. commersonii (Brongn.) Endl. were examined and found to be W. cupressoides (L.) Endl. Vaughan (1961) states that no reference to these specimens is to be found in Commerson's manuscript and no species of Widdringtonia is indigenous to the island. Therefore the Commerson specimens were either obtained from a cultivated plant (which is unlikely), or were collected at the Cape and were accidentally included with the Commerson collection when it was shipped to France after Commerson's death.

W. stipitata Stapf is nothing more than a form of W. cupressoides (L.) Endl. with longer pedicels. As this characteristic is not constant, this species is placed in synonymy.

Although an impression is gained that subspecies can be recognised in W. cupressoides (L.) Endl. (sens. lat.), the variation in such characteristics as leaf shape, seed form and cone morphology observed in W. dracomontana Stapf, W. whytei Rendle and W. cupressoides (L.) Endl. are such that no reliable distinguishing characteristic can be suggested on which to separate these three sub species.

However, on Mountain Mlanje a race is found which attains a much greater stature than the other forms of this species. This makes it a more desirable race to use for forestry purposes, but it is botanically indistinguishable from the other races of W. cupressoides (L.) Endl.

2. W. cedarbergensis Marsh, sp. nov., W. schwarzii (Marl.) Mast. affinis, sed seminibus minoribus angustissimis alatis et cicatriculis minoribus differt.

Arbor vel frutex 5-20 m altus. Folia adulta, squamiformia, appressa, decussata, ovata. Coni masculi parvi, 4 mm longi; squamae c. 12, peltatae, late ovatae, decussatae. Coni feminei globosci; valvae 4, lignae, rugosae, verrucis ad margines regulariter dispositis. Semina ovoidea, obscure alata, trigona; seminis cicatricula c. 4.5 mm lata, 6 mm longa. Cotyledones post germinationem 35 mm longae, 5 mm latae. Type: Clanwilliam, Cedarberg Mountains, Lückhoff s.n. (PRE; holo.!).

Callitris arborea Schrad. ex Drege, (E. Mey.). Zwei Pflzgeogr. Doc. 73 (1843) nom. nud., Hutchins (fide Stapf 1933) in Report Conserv. For. Cape Col. 48, 49 (1895); Hutchins in Trans. S.Afr. Phill. Soc. 11:62 (1902); Hutchins in Agric. Journ. Cape G. Hope 26:661 (1905); Storr Lister, (fide Stapf, 1933) in Rep. Chief Conserv. For. Cape G. Hope 2 (?); Dallimore in Kew Bull. 35:224 (1913).

W. wallichii Endl., Syn. Conif. 34 (1847); nom. nud.; Lindley and Gord. in Journ. Hort. Soc. Lond. 5:203 (1850); Carr., Trait. des Conif. ed. 1:68 (1855), ed. 2:62 (1867); Gordon, Pinet. ed. 1:335 (1858), ed. 2:419 (1875); von Schlectend. in Linnaea 23:359 (1864-65); Henkel and Hochst., Syn. Nadelhölzer 295 (1865); Parlatore in DC., Prodr. 16, 2:443 (1868); Masters in Journ. Linn. Soc. Bot. 37: 271-274 (1905).

W. juniperoides sensu Endl., Syn. Conif. 32 (1847); Knight and Perry, Syn. Conif. Pl. 13 (1850); Lindley and Gord. in Journ. Hort. Soc. Lond. 5:203 (1850); Pappe, Silva Cap. ed. 1:30 (1854); Pappe, Fl. Cap. Med. Prodr. ed. 2:36 (1857); Carr., Trait. des Conif. ed. 1:64 (1855), ed. 2:58 (1867); Gordon, Pinet ed. 1:334 (1855), ed. 2:418 (1875); Henkel and Hochst., Syn. Nadelhölzer 292 (1865); von Schlectend. in Linnaea 23:357 (1864-5); Parlatore in DC., Prodr. 16, 2:442 (1868); Harvey, Gen. S. A fr. Pl. ed. 2:353 (1868); Rehmann in Bot. Centralbl. 1:1120 (1880); Masters in Journ. Linn. Soc. 37:268 (1905); Sim, Tree Plant. Natal 234 (1905); Sim, For. Fl. Ca pe Col., 8-26, 53-74, 337-338 (1907); Marloth, Fl. S.Afr. 1:101 (1913); Sim, Nat. Timb. S.Afr. 131 (1921); Pilg. in Engl. and Prantl,

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Nat. Pflzf. ed. 2, 13:382 (1926); Wilson, Plant Hunt. 1:27 (1927); Wilson in Journ. Arnold Arboret. 10:1 (1929); Chalk et al. in Brit. Emp. 1:15 (1932); Stapf in Fl. Cap. 5, 2:23 (1933); Hubbard in S.Afr. Journ. Sc. 33:572 (1937); Dallimore and Jackson, Handb. Conif. ed. 3:654 (1948); Smith in Journ. S.Afr. For. Ass. 25 (1955); Chapman in Kirkia 1:138 (1961).

Callitris ecklonii Schrad. ex Pappe, Fl. Cap. Med. Prodr. ed. 1:25 (1850), nom. subnud.

W. wallichiana Gordon, Pinet. suppl. 107 (1875), nom. nud.

Callitris juniperoides sensu Durand et Schinz, Consp. Fl. Afr. 5:951 (1894); Engl., Pflzw. Afr. 2:89 (1908); Marloth, Kapland 167 (1908).

Description

Tree normally 5-7 m high, occasionally attaining a height of about 20 m with stem diameter up to 2 m; crown pyramidal when young, spreading with age; bark on young trees reddish grey, thin, fibrous, flaking off. Leaves of two types; juvenile leaves on seedlings and young trees needle-like, spreading, 1-2 cms long and up to 2 mm broad; adult leaves scale-like, appressed, ovate, usually strictly decussate, semi-circular in transverse section, adnate at the base, free portion often much shorter than adnate portion. Male cones mostly on short lateral branchlets; scales usually 6 pairs, decussate, coriaceous, peltate, broadly ovate acuminate with 4 pollen sacs at the base of each scale. Mature female cones consisting of usually 4, woody valves; valves rough, with regular verrucae along the margin. Seeds ovoid, obscurely winged, trigonous; seed scar about 4.5 by 6 mm. Cotyledonary leaves about 35 mm long by about

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5 mm broad.

Found on the Cedarberg Mountains, near Clanwilliam in the Cape province; occurs singly or scattered over some 30 miles on rocky outcrops between 3,000 and 5,000 feet.

Reasons why it was found necessary to rename and describe this species can be found in Bothalia, vol 9 (1966) and note under Cupressus juniperoides L., nom. dub. P.53.

CAPE – Clanwilliam: Cedarberg mts., Compton 12776 (NBG), Drege 74.3 (E;G); Galpin s.n. (PRE); Leipoldt 1649 (BM; G; K; P; Z); MacOwan in Herb. Bol. sub numero 27689 (BOL); Marloth 3086 (PRE); Mogg 2010 (PRE), Pocock 522 (STE); Wallich s.n. (BM; K); Ecklon and Zeyher 74.3 (GRA; L; MO; W; Z); Gordon s.n. (K) cult.

3. W. schwarzii (Marl.) Mast. in Journ. Linn. Soc. Bot. 37:269 (1905); Sim, For. Fl. Cape Col. 337 (1907); Marloth, Fl. S.Afr. 1: plate 17D (1913); Sim, Native Timb. S.Afr. 131 (1921); Pilg. in Endl. and Prantl, Nat. Pflzf. ed. 2:383 (1926); Chalk et al. in Brit. Emp. 1:15 (1932); Stapf in Fl. Cap. 5, 2(suppl.):22 (1933); Dallimore and Jackson, Handb. Conif. ed. 3:654 (1948); Ward in Journ. S.Afr. For. Ass. 31 (1958); Chapman in Kirkia 1:143 (1961) Lückhoff in Bosbou S.Afr. 3:1 (1963).

Type: Hb. Marloth 3614 (PRE; holo.!).

Callitris schwarzii Marloth in Engl. Bot. Jahrb. 36: 206 (1905); Marloth, Kapland 134 (1908).

Type: Hb. Marloth 3614 (PRE; holo.!).

Description

Tree normally 17-26 m high, occasionally attaining a height of about 40 m with stem diameter up to 5 m; crown pyramidal, usually not spreading with age; bark on young trees reddish grey, thin, fibrous, flaking off. Leaves of two types; juvenile leaves on seedlings and young trees needle-like, 1-2 cm long and up to 2 mm broad; adult leaves scale-like, appressed, ovate, usually strictly decussate, semi-circular in transverse section, adnate at the base, free portion often much shorter than adnate portion. Male cones mostly on short lateral branchlets, scales usually 6 pairs, decussate, coriaceous, peltate, oblong, acuminate with 4 pollen sacs at the base of each scale. Mature female cones consisting of usually 4 woody valves; valves rough, with regular verrucae along the margin. Seeds ovoid, conspicuously winged, somewhat flattened, seed scar about 1.5 by 2.5 mm, outline including wings oblong-obovate, wing retuse at apex. Cotyledonary leaves 20-25 mm long and about 2 mm broad.

Found in rocky ravines of the Baviaanskloof and Kouga Mountains, Willowmore district, Cape Province.

CAPE - Willowmore : Civil Commissioner s.n. (F.D. Herb.; K); Baviaanskloof Mts., Forest Officer sub numero 7157 (F.D. Herb.); Kouga Mts., Burton 4019 (F.D. Herb.), Gov. Forester 2 (GL; MO; PRE; S; UPR), 4 (UPR), Sim 2920 (BOL; F.D. Herb.). Cult.: Kirstenbosch, Fourcade s.n. (K; NBG), Pretoria, Marsh, J.A. 1(PRE).

7.4 PRE-LINNAEAN NAMES

Cupressus aethiopica coronata Breyn., Prodr. Fasc. Rar.

Plant. ed. 2:59 (1689). As the Cedarberg and Baviaanskloof Mountains were botanically unknown at that time, it can safely be assumed that this plant (if a *Widdringtonia* at all) is *W. cupressoides* (L.) Endl.

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Cupressus africana Burmann, Cat. Pl. Afr. Herm. in Thesaur. Zeylan. 8 (1737), another pre-Linnaean name which also for reasons above is probably W. cupressoides (L.) Endl.

7.5 DOUBTFUL AND EXCLUDED NAMES

Cupressus juniperoides L., Sp. Pl. ed. 2:1422 (1763) was based on young seedlings grown from seed said to have come from 'Caput Bonae Spei'. There is no record that any subsequent author saw a specimen and no specimen is present in the Linnaean Herbarium.

Brongniart (1833) was the first botanist to interpret Cupressus juniperoides L. as being the Cedarberg plant. However, the Cedarberg Mountains were botanically unknown at the time Linnaeus described this plant i.e. 1763 (Stapf 1933, van der Merwe 1963) (See also note under Pachylepis juniperoides (L.) Brongn. P.53).

Judging from specimens seen in the British Museum and Geneva, the name was applied by botanists before 1800 to the S.W. Cape plant described by Linnaeus as Thuja cupressoides in 1767. From the description it is impossible to identify the original plants, which may even have belonged to a genus other than Widdringtonia. It is therefore considered advisable to reject the name as a nomen dubium.

The following five names, based on the Linnaean epithet, must also be rejected for the same reasons.

Schubertia capensis Spreng., Syst. Veg. 3:890 (1826), nom. illegit., based on Cupressus juniperoides L.

Pacylepis juniperoides (L.) Brongn. in Ann, Sc. Nat. 30: 190 (1833), nomen dubium, based on Cupressus juniperoides L. (q.v.). Brongniart was dealing with a specimen labelled Cupressus juniperoides in Herb. Burmann.

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The author has seen a specimen in the Herb. Burmann, Geneva which proves to be W. cupressoides (L.) Endl. and is possibly the plant studied by Brongniart.

Widdringtonia juniperoides (L.) Endl., Syn. Conif. 32 (1847) nomen dubium, based on Cupressus juniperoides L. (q.v.).

Parolinia juniperoides (L.) Endl. ex Gord., Pinet. ed. 2: 418 (1875), nomen dubium, based on Cupressus juniperoides L. (q.v.)

Callitris juniperoides (L.) Dur. and Schinz, Consp. Fl. Afr. 5: 951 (1894), nomen dubium, is also based on Cupressus juniperoides L. (q.v.)

Cupressus africana Mill., Gard. Dict. ed. 8 (1768), nomen dubium which is presumably W. cupressoides (L.) Endl. from the Cape Peninsula.

Juniperus capensis Lam., Encycl. Meth. 2:626 (1786), nomen dubium. The type, which was examined in the Herbarium of the Muséum National d'Histoire Naturelle, Paris, consists of sterile, juvenile branches which could not be identified with any degree of certainty.

Widdringtonia equisetiformis Mast. in Journ. Linn. Soc. Bot. 37: 271 (1905) was based on a cultivated specimen from Tokai Forest Station, Cape Peninsula. However, it was placed as a synonym of Callitris robusta by Masters himself in Journ. Linn. Soc. Bot. 37:332 (1905)

7.6 NOMINA NUDA

The following nomina nuda or subnuda are not able to be identified with certainty.

Callitris stricta Schlect. ex Hook. in Lond. Journ. Bot. 4:141 (1845).

Widdringtonia ericoides Knight in Syn. Conif.Pl. 13 (1850).

Callitris capensis Schrad. ex Gord., Pinet. 333 (1858).

Widdringtonia glauca Carr., Trait. Conif. ed. 2:61 (1867).

7.7 INDEX OF COLLECTORS

A. Widdringtonia cupressoides (L.) Endl.

Acocks 4001 (S); Adamson 443 (E; K; P); Adamson s.n. (BM); Alston 15306 (BM).

Banks in F.D. Herb. sub numeris 12818 (F.D. Herb.; PRE; OPR) et 12819 (F.D. Herb.); Barbosa 1653 (BR); Barnes, P. in F.D. Herb. sub numero 2960 (F.D. Herb.); Barnes, R.D. in F.D. Herb. sub numeris 13041 (F.D. Herb) et 13042 (F.D. Herb.); Barnes in Hb. Sim sub numero 19258 (PRE); Barnett 72 (K; PRE); Barlett s.n. (K); Bayer 1222 (PRE); Beckhuis 6328 (UPR); B.E.J. 15138 (L); Bews 1041 (STE); Bews s.n. (PRE); Black s.n. (K); Bolus 4067 (BOL); Bolus s.n. (BOL; BR); Botha 4415 (F.D. Herb.); Brain 9320 (MO; PRE); Brass 16513 (MO), 16514 (K; MO), 16668 (BM, BR, K, L, MO), 16718 (BR; K; MO), 16719 (MO; PRE), 16744 (BR; K; MO; PRE) et 16838 (K; MO); Bremekamp & Schweickerdt 449 (PRE; UPR); Brent in F.D. Herb. sub numero 11214 (F.D. Herb.; PRE); Brisley in F.D. Herb. sub numeris 12985 (F.D. Herb.) et 12986 (F.D. Herb.; LD; MO; S); Britten 1086 (GRA; STE; PRE), 5099 (GRA) et 5781 (GRA); Brunt in F.D. Herb. sub numero 4078 (F.D. Herb.); Burchell

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771 (K), 4688 (BM; K; L), 5588 (K; L; M; P) et 5979 (K); Burmann s.n. (G); Burton in F.D. Herb. sub numero 4020 (F.D. Herb.); Buse s.n. (L).

Chapman 307 (BR) et 328 (BR; K); Chase 2872 (BM; BR; MO; PRE), 4907 (BM; MO; PRE) et s.n. (BM); Clarke s.n. (E); Clements 110 (K), 272 (K) et s.n. (BR); Codd 3976 (K; PRE); 8760 (K; PRE) et 10140 (PRE); Codd and Dyer 9093 (PRE); Commerson 1472 (FI); Commerson in Hb. de Jussieu sub numero 17177 (FI; P) et s.n. (P); Compton 5160 (BOL), 8080 (NBG), 10105 (NBG; PRE), 18052 (NBG), et 18099 (NBG); Coombes s.n. (K); Coppen s.n. (PRE); Cosson 18 (P) et s.n. (P); Craib s.n. (K).

Davis 63523 (NBG); Davy, E.W. s.n. (K); Davy, O.M. in Hb. K. sub numeris 54, 55 et 56 (K); Desevès s.n. (P); Drege 56.6 (G; FI; MO), 74.3 (FI), 3885 F.I., IV A 10 (S), IV, C.c.2. (S), s.n. (G; L; P) et s.n. (K); Dümmer 1141 (E); Duthie 693 (BOL; GRA) et 16430 (STE); Dyer 5317 (K; PRE).

Ecklon 801 (S) et s.n. (M; S); Ecklon and Zeyher 74.3 (GRA; L; MO; W; Z) et s.n. (L; P); Edwards 2125 (PRE); Esterhuysen, E 655 (NBG), 7951 (BOL), 21525 (BOL) et s.n. (BOL); Esterhuysen, J.W. s.n. (PRE); Exell, Mendonca and Wild 78 (BM).

Fisher, B.S. 1260 (NH; PRE); Fisher D.K. 23 (NBG); Forest Dept. P.E. 215 (GRA); Forester in F.D. Herb. sub numeris 3009 (F.D. Herb.), 7297(F.D. Herb.; K), 7298 (F.D. Herb.; K), 7886 (F.D. Herb.); 7887 (F.D. Herb.), 12820 (F.D. Herb.; LD; PRE), 12821 (F.D. Herb.; S; UPR), 12822 (BR; F.D. Herb.); Forester, Hanglip 13/2/64 s.n. (BR; G; M; MO; Z) et 24/3/64 s.n. (BOL); Fourcade, H.J. 290 (GRA), 2205 (BOL); in F.D. Herb. sub. numero 5425 (F.D. Herb.) F.D. Herb.); Fourcade, H.G. 2293 (BOL; K); Fraser s.n. (E); Friede s.n. (PRE); Fries, Norlindth, Weimarck 1135 (LD), 3078 (LD), 3617 (LD), 4462 (LD); F.R.O. Kromhout, Cathedral Peak 1. (F.D. Herb.: GRA; M; NBG) et 5 (F.D. Herb.; L; LD); Funuer 87 (E).

Galpin 11698 (BOL; K; PRE), 12789 (K: PRE), 14225 (BOL; K; NH; PRE; S), 14952 (BOL; K: PRE); Gamble 22013 (K), 30235 (K) et 30650 (K); Game Conservator in F.D. Herb. sub numero 2989 (F.D. Herb.,; K); Garside 1287 (K) et 1382 (K); Geertsema s.n. (F.D. Herb.); Germishuizen in F.D. Herb. sub numero 12171); Gerstner 5783 (NBG; PRE); Gilliland 766 (BM), 766 B (PRE), 918 (BM: PRE) et 2082 (BM); Godfrey s.n. (GRA); Gomes e Sousa 4316 (K); Goodier 179 (K; PRE); Gordon s.n. (K); Gov. Forester, Jonkershoek s.n. (M); Gov. Forester, Klaserie 1 (M), 3(BR) et 4(Z); Gov. Forester, Longmore (PRE); Gov. Forester, Mariepskop, 15/2/64 s.n. (NH), 17/3/64 s.n. (PRE; UPR), 27/3/64 s.n. (GRA); Greathead and Seagrief 13357 (RUH); Greenway 2304 (K), 6323 (K) et s.n. (K); Grobler 74 (PRE).

Hafström s.n. (S); Haig in F.D. Herb. sub numero 12999 (F.D. Herb.); Hansen 7120 (F.D. Herb.), 7313 (F.D. Herb.; K); Hansen and sons 10962 (F.D. Herb.), Hansen s.n. (PRE, UPR); s.n. (PRE); Harvey 417 (E); Henry s.n. (K); Holland 293 (GRA); Holtzkampf 4348 (F.D. Herb.); Humbert 9662 (PRE) et 20841 (P); Hutchins in F.D. Herb. sub numero 1112 (F.D. Herb.); Hutchins, D.E. s.n. (K); Hutchinson 1380 (K) et 1498 (BOL); Hutchinson and Gillet 4410 (BM; K); Hyéres 397 (BM).

Jackson 300 (K), 2177 (BM), 2183 (BM) et 2186 (BM); Jacot-Guillarmod 4601 (RUH); Jarvis 1077 (F.D. Herb.); Jeppe 10964 (F.D. Herb.).

Kapp 92 (PRE); Kappler 9625 (F.D. Herb.); Keet 542 (F.D. Herb.; GRA; STE), in F.D. Herb. sub numeris 1041 (GRA; PRE), 1122 (STE) et 12522 (STE); Kerfoot April 1964 s.n. (BOI; BRU; G; GRA; L; LD; M; MO; NBG; NH; PRE; S; UPR; Z); Kerfoot 3.3.1964 s.n. (BR; G; LD; MO; S); Kies s.n. (PRE); Kiggelaer s.n. (BM); Killick 1745 (NH; PRE); Killick and Strey 2403 (K; PRE); Kinnard s.n. (BM); Kotze in F.D. Herb. sub numeris 2507 (F.D. Herb.), 4945 (F.D. Herb.) et 7084 (F.D. Herb.; K; PRE); Krause 9013 (STE) ; Krauss 1140 (FI; M); Kremafi 108 (K); Kriel in F.D. Herb. sub numero 3004 (F.D. Herb.; PRE); Kromhout 1 (PRE; UPR); Kuntze s.n. (K).

Labourer (native watcher) in F.D. Herb. sub numero 5293 (F.D. Herb.); Lam and Meeuse 4407 (L; S); Laughton in F.D. Herb. sub numero 7254 (F.D. Herb.; S); Lear 31 (PRE); Leemann 104 (PRE); Lewis and Baragwanath 3597 (BOL. /col. HB. 3184/ F.D. Herb.; PRE); Lewis in col. Herb. sub numero 4310 (K); Lewis s.n. (P); Lindeberg s.n. (S); Long, F.R. 1266 (GRA; K; PRE; RUH); Long, W.R. 84 (STE); Lückhoff in F.D. Herb. sub numero 12126 (F.D. Herb.).

Macé s.n. (P); MacOwan 1303 (BOL) et 24334 (NBG); Mader 1874 (GRA); Maguire 1443 (NBG); Marloth 11102 (PRE), 11109 (PRE), 11252 (PRE) et 13816 (STE); Marisse 57 (PRE), E.K. s.n. (PRE; UPR); Marsh, J.A. s.n. (Z); Martin 8133 (RUH); Masson s.n. (BM); Master Collection in K. Herb. sub numeris 50 (K), 51

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(K) et s.n. (BM; K); McClounie in K. Herb. sub numero 38 (K); Meebold 108 (M) et 13144 (M); Meerseveen in Sloan Hb. sub numero 30 H.S. 77, 78 (BM); Meeuse 9970 (PRE, S); Mentzel in F.D. Herb. sub numero 7372 (F.D. Herb.); Michelmore 258 (K); Mitchell 272 (BM; BOL; PRE); Monro s.n. (Z); Morkel s.n. (K); Moss 2099 (BM); Muir 318 (PRE) et 5338 (PRE); Müller s.n. (BOL; BR; F.D. Herb.; G; MO; NH; PRE; S; UPR); Mundt s.n. (K: S).

Nänni s.n. Blaauwberg (PRE; S; UPR), Wolkberg s.n. (G; PRE; UPR), et in F.D. Herb. sub numero 11131 (F.D. Herb.); Newman and Whitmore 39 (BM), 250 (BM) et 692 (BM); Nienholt s.n. (BM); Noeb 1211 (RUH); Norman 325 (BM).

Obermeyer 2314 (PRE); Ogilvie in J.M. Wood herb. sub numero 8629 (NH); Oldenland 203 in Hort. Siccus (BM); Oranje 340 (F.D. Herb.).

Pappe in NBG Herb. sub numero 24335 (NBG); Pardy 5096 (BM); Phillips 1356 (NBG); Pole Evans and Smuts 928 (K; PRE); Pole-Evans in K. herb. sub numero 15 (K; S); Poynton in F.D. Herb. sub numeris 12170 (F.D. Herb.), 12186 (F.D. Herb.), 12191 (F.D. Herb.), 12192 (F.D. Herb.); 12933 (F.D. Herb.), 12934 (F.D. Herb.), 12939 (F.D. Herb.), 12940 (F.D. Herb.), 12941 (F.D. Herb.), 12942 (F.D. Herb.), 12944 (F.D. Herb.), 12948 (F.D. Herb.) et 12949 (F.D. Herb.); Prior s.n. Genadendal (K) et s.n. Table Mt. (K).

Rehm s.n. (M); Rehmann 216 (BM; Z); Repton 5221 (PRE); Research officer in F.D. Herb. sub numeris 12824 (F.D. Herb.), 12825 (F.D. Herb.) et 12826

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(F.D. Herb.); Ritchie s.n. (K); Robertson in F.D. Herb. sub numeris 1567 (F.D. Herb.), 3007 a, b, c (F.D. Herb.; PRE), 3008(F.D. Herb.; PRE), 3009 (F.D. Herb.; PRE), 7365 (F.D. Herb.); Rodin 1123 (BOL; K; MO; PRE; S), 3170 (BOL; K), 3289 (BOL; K), et 4050 (K; MO; PRE; S); Rogers 21901 (BOL; GRA; NH; PRE; Z) et 27668 (Z); Roxburgh s.n. (G).

Sanderson 2011 (K; S); Schelpé 3794 (BM) et 4018 (BM); Schlecter s.n. (PRE); Schmidt 36 (M); Schumann s.n. (P); Schweickerdt 1545 (UPR), 6121 (UPR), 1821 (BM; K; L; UPR) et 1988 (UPR); Sclater s.n. (BM; K) et s.n. (K); Scott Elliot s.n. (E); Seagrief in RUH sub numero 12753 (RUH); Sim 1473 (GRA; PRE), in F.D. Herb. sub numero 1044 (F.D. Herb.; K(/13-14/) et 1889 s.n. (PRE); Smith in K. Herb. sub numero 49 (K); Smuts 1222 (PRE); Soleman 7660 (K); Staples s.n. (PRE); Stayner 102 (BOL; F.D. Herb.; GRA; PRE); Stebbins 145 (BR; MO); Strey and Schlieben 8540 (K; PRE); Swynnerton 1963 (BM; K; Z), 1964 (K) et 1965 (BM); Symons 15823 (PRE).

Tapham 940 (BR; K); Taylor 3225 (NBG); Terblanche 11168 (F.D. Herb.); Theron 1691 (K; PRE) et 1830 (GRA; K; PRE); Thode A 1015 (K; NH;PRE), A2391 (NH; PRE), A 2575 (NH; PRE), 4714 (STE), 5898 (STE), 9198 (STE) et 9202 (STE); Thom s.n. (K); Thorne 45758 (NBG); Thouarg s.n. (P); Thouin 148 (M) et 256 (M); Thunberg s.n. (LD; S); Topper 64 (NBG).

Van der Merwe 1201 (PRE; STE), 1299 (PRE, STE), et 2410 (PRE; STE); van der Schijff 4477 (K; PRE; UPR), 4894 (K; PRE), 5842 (UPR), 6356 (UPR), 6356 a

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(UPR), et 6644 (UPR); van Rensburg 467 (STE), 2105 (K; PRE), et 10457 (F.D. Herb.); Verdcourt and Pudden 1141 (K); Verdoorn 2229 (PRE); Vincent s.n. (BM).

Walsh in F.D. Herb. 12533 (F.D. Herb.); W.B. s.n. (E); Werdermann and Oberdick 417 (PRE); West s.n. (PRE); Whellan 437 (MO); Whyte 1 (K), s.n. (BM) et s.n. (K); Wild 1407 (BR; K; P; PRE); Wilms 3634 (K) et 3639 (BM); Wilson 84 (S) et s.n. (S); Wolley-Dod 2679 (BOL).

Zeyher 225 (NBG); 3885 (BOL; NBG; P; PRE) et s.n. (BOL).

Collectors unknown

In F.D. Herb. sub numeris 1075 (F.D. Herb.), 1110 (F.D. Herb.), 1111 (F.D. Herb.), 1113 (F.D. Herb.), 1320 (F.D. Herb.), 1372 (PRE), 1373 (F.D. Herb., PRE), 1374 (F.D. Herb.; PRE), 1375 (F.D. Herb.), 4119 (F.D. Herb.) et 10637 (F.D. Herb.); in K Herb. sub numero 1498 (K); In PRE Herb. sub numeris 779 (PRE) et 4162 (PRE).

B. Widdringtonia cedarbergensis Marsh

Coetzee s.n. (PRE); Compton 12776 (NBG).

Drege 74.3 (E; G), in K. Herb. sub numero 26 (K); et s.n. (BM; G; L; P; S).

Forester Bath 5535 (F.D. Herb.; S); Forester, Cedarberg s.n. (L; PRE);

Galpin s.n. (PRE); Gordon s.n. (K).

Kappler 9626 (F.D. Herb.).

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Leipoldt 1649 (BM; G; K; P; Z) et 1061 (BOL).

MacOwan inHerb. Bol sub numero 27689 (BOL) et 3034 (NBG; PRE); Marloth 3086 (PRE); M.B.G.H. in Herb. MO sub numero 1798091 (MO); Mogg 2010 (PRE).

Norman 341 (BM; MO); 342 (BM; MO).

Parlatore s.n. (FI); Pocock 522 (STE), 716 (STE) et 725 (STE).

Saayman in F.D. Herb. sub numeris 12828 (M; PRE; STE; Z), 12853 (BOL; LD; NH; S; Z), 12854 (F.D. Herb.; G; GRA; L; NBG; S); 4 (NH; PRE), 5 (PRE), 6 (BR; G; MO; PRE) et s.n. (NBG); S.G. s.n. (E); Sim 2578 (NH) et s.n. (PRE); Suessenguth 82 (M).

Wallich s.n. (BM; K) et s.n. (BM); Wallich and Hartmann s.n. (S); Walsh in F.D. Herb. sub numero 12534 (F.D. Herb.) et 12827 (F.D. Herb.; PRE); Weintroub 19656 (BM).

Zeyher 50 (NBG); Zèyher s.n. (MO).

<u>Collectors unknown</u>

In Herb. Berol. sub numero 358 (B; S); In F.D. Herb. sub numeris 1027 (F.D. Herb.), 1028 (F.D. Herb.), 1029 (F.D. Herb.) et 1318 (F.D. Herb.); In Herb. K. sub numero 25 (K); In F.D. Herb. sub numero Herb. Stapf 1030; In FI Herb. s.n. (FI) cult.

C. <u>Widdringtonia</u> <u>schwarzii</u> (Marl.) Mast.

Burton 4019 (F.D. Herb.).

Civil Commissioner in F.D. Herb. sub numero 1107 (F.D. Herb.; K).

Forest Officer in F.D. Herb. sub numero 7157 (F.D. Herb.); Fourcade s.n. (K; NBG).

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Gov. Forester, 3/10/64 1 (BR), 2 (G; L; MO; PRE; S; UPR), 3 (PRE), 4 (UPR), 6 (LD; NBG), 7 (M), 11 (Z); Gov. Forester in F.D. Herb. sub. numero 12884 (F.D. Herb.; PRE); Gov. Forester, Aug. 1964 1-4 (PRE).

Kappler s.n. (F.D. Herb.).

Legner s.n. (K; PRE).

Marloth 3614 (GRA; NBG; PRE); Marsh, J.A. 1 (PRE) cult.

Selling s.n. (S) cult.; Sim 2920 (BOL; F.D. Herb.); Simmons 7157 (F.D. Herb.; S).

Versfeld 57377 (NBG).

SUMMARY

The Gymnosperms in the Republic of South Africa are represented by five indigenous genera, one of which is Widdringtonia Endl.

Widdringtonia generally occurs on eastern mountain ranges and their subsidiary mountain chains running from Malawi down Africa to the eastern Cape Province and thence on southern and western coastal ranges to the Cedarberg in the Western Cape Province.

As the previous key to the genus compiled by Stapf and the delimitations of the taxa are unsatisfactory and little was known of the anatomy and cytology, the genus has been revised.

An historical account of the existing literature on Widdringtonia is given.

The genus is fairly uniform in its environmental requirements and its distribution appears to be limited by mean annual temperature, rainfall and soil.

A morphological study of the root, stem, leaf, cones, seed and seedling was undertaken. Identification of the various taxa is not possible on the basis of transverse sections through the primary root, stem and juvenile leaf.

Regeneration of the stem has been observed to take place in the shrubby growth-forms of W. cupressoides (L.) Endl. sens. lat.

Permanent slides for a xylotomical study of the wood of all the taxa were obtained and examined. These results were compared with those of Greguss,1956. Contary to his findings, no means of distinguishing between the wood of the various species was found.

Two types of mature adult scale-like leaves can be recognised.

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Since the number of ovules per scale (or per cone) varies greatly in all taxa, this characteristic formerly used by Stapf, 1933, is of little taxonomic value.

Chemical relationships and distribution of fossils indicate that Widdringtonia may have originated in the northern hemisphere and that the genus is not closely related to Callitris, generally considered to be southern in origin.

The chromosomes of Widdringtonia are small, few in number and stain well. They are however, difficult to count as the chromosomes do not spread easily. Thus the diploid number of 16 chromosomes for Widdringtonia is tentatively suggested but may be inaccurate.

W. caffra Berg, previously overlooked, is considered synonymous with W. cupressoides (L.) Endl.

The nomen dubium W. juniperoides (L.) Endl. is replaced by W. cedarbergensis Marsh.

A critical study of a wide range of both living and dried material of Widdringtonia Endl. resulted in the recognition of three species only: W. cedarbergensis Marsh, W. cupressoides (L.) Endl. and W. schwarzii (Marl.) Mast. The six species recognised by Stapf, 1933, cannot be upheld, since the species W. dracomontana Stapf, W. whytei Rendle, and W. stipitata Stapf are all regarded as synonymous with W. cupressoides (L.) Endl.

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REFERENCES

A. References cited.

ADAMSON, R.S. & SALTER, T.M. (1950). Flora of the Cape Peninsula. Cape Town: Juta and Co.

AITON, W. (1789). Hortus Kewensis, 3, 373.

AITON, W.T. (1813). Hortus Kewensis, 5, 322-323.

BARROW, J. (1806). Travels in Southern Africa. Vol. 1. London: T. Cadell and W. Davies.

BENTHAM, G. & HOOKER, J.D. (1880). Genera Plantarum. Vol. 3. London: L. Reeve and Co.

BENSON, L. (1962). Plant Taxonomy. New York: The Ronald Press Co.

BERG, O. (1860). Beschreibung einer neuen Drogum vom Cap. Bonplandia 8: 190.

BERRY, E.W. (1916). The Geological History of Gymnosperms Plant World 19: 27-40.

BEWS, J.W. (1919). The Plant Ecology of the Drakensberg Range. Annals of Natal Museum 3: 549.

BRASS, L.J. (1953). Vegetation of Nyasaland. Mem. N. York Bot. Gard. 48, pt.3.

BRÉON, N. (1825). Catalogue des Plantes Cultivées aux Jardins Botanique et de Naturalisation de L'ile Bourbon. Ile Bourbon: de L'imprimerie du Gouvernement.

BREYNIUS, J.P. (1689). Prodromi Fasciculi Rariorum Plantarum. Danzig: T.J. Schreiberi.

BRITTEN, J. & BOULGER, G.S. (1893). A Biographical Index of British and Irish Botanists. London.

BRONGNIART, M.A. (1833). Annules Science Naturelles ser. 30, 190.

68/.......

BURKILL, I.H. (1898) & JOHNSTON, H.H. British Central Africa Bot. App. 11. 233-284. London.

BURMANN, J. (1737). Catalogi duo Plantarum Africanarum in Thesaurus Zeylanicus. Amstelaedami.

BURMANN, N.L. (1768). Prodromus Flora Capensis. Lugduni.

BURTT DAVY, J. (1926). The Flowering Plants and Ferns of the Transvaal and Swaziland. London: Longmans Green.

CARRIÈRE, E.A. (1855). Traité Général des Coniféres. Ed. 1. Paris. (1867). Ed. 2.

CHALK, L., BURTT DAVY, J. & DESCH, H.E. (1932). Some East African Coniferae and Leguminosae. Oxford: Clarendon Press.

CHAMBERLAIN, C.J. Gymnosperms. New York: Johnson Reprint Corporation.

CHAPMAN, J.D. (1961). Some Notes on the Taxonomy, Distribution, Ecology and Economic importance of Widdringtonia, with particular reference to W. whytei. Kirkia 1:138.

CREIGHTON, R.H.J., GIBBS, R.D. & HIBBERT, H. (1944). Studies on lignins and related compounds LXXXV. Alkaline Nitrobenzene oxidation of plant materials and application to taxonomic classification. J. Americ. Chem. Soc. 66:32-37.

DALLIMORE, W. (1913). Cedar Woods. Kew Bull. 35: 222.

DALLIMORE, W. & JACKSON, J.B. (1948). A Handbook of Coniferae ed. 3. London: Arnold.

DARLINGTON, C.D. & LA COUR, L.F. (1962). The Handling of Chromosomes. London: George Allen & Unwin Ltd.

DARLINGTON, C.D. & WYLIE, A.P. (1955). Chromosome Atlas of Flowering Plants. London: G. Allen & Unwin Ltd.

DIXEY, F. (1927). The Mlanje Mountain of Nyasaland. Geogr. Review 17:611-626.

DREGE, J.F. (1843). Zwei Pflanzengeographische Documente. Regensburg.

69/.......

DURAND, T. & SCHINZ, H. (1895). Conspectus Florae Africae. Paris: Klincksieck.

DU TOIT, A.L. (1956). The Geology of South Africa. Edinburgh: Oliver & Boyd.

ENDLICHER, S.L. (1837). Genera Plantarum. Vindobonae.
(184[illegible]) Supplement.
(1842) Supplement.

ENDLICHER, S.L. (1842). Catalogus Horti Academici Vindobonensis. Vol. 1. Vindobonae.

ENDLICHER, S.L. (1847). Synopsis Coniferarum. Sangali.

ENGLER, A. (1903). Notizbl. Bot. Gart. Berlin App. II:28

ENGLER, A. (1908). Die Pflanzenwelt Afrikas. Vol. 2. Leipzig.

ENGLER, A. & PRANTL, K. (1926). Die Natürlichen Pflanzenfamilien ed. 2. Vol. 13. Leipzig: Engelmann.

ENZELL, C. & ERDTMAN, H. (1958). Tetrahedron 4, 361.

ERDTMAN, H. & THOMAS, B.R. (1958). The Chemistry of the Constituents of the Genus Widdringtonia. Acta Chem. Scand. 12, 1:267-273.

ERDTMAN, H. (1962). Personal communication with Kerfoot.

ESAU, K. (1953). Plant Anatomy. New York: John Wiley & Sons.

ESAU, K. (1962). Anatomy of Seed Plants. New York: John Wiley & Sons.

EYLES, F. (1916). A Record of Plants Collected in S. Rhodesia. Trans. R. Soc. S.Afr. 5, pt. 4:292.

EXELL, A.W. & WILD, H. Flora Zambesiaca 1, 1:86 (1960).

FLORIN, R. (1963). The Distribution of Conifer and Taxad Genera in Time and Space. Acta Horti Bergiani 20, 4:275.

FOURCADE, H.G. (1889). Report on the Forests. Natal: W.M. Watson.

FRANCO, J.D.A. (1951). Notas Sombre A Flora Lenhosa Da Mata do Bucaco. Bot. Soc. Brot. ser. 2, 25:219.

70/.......

GIBBS, R.D. (1945). Comparative Chemistry as an Aid to the Solution of Problems in Systematic Botany. Trans. R. Soc. Canadaser. 3, 5, 39:71-103.

GORDON, G. (1858). The Pinetum ed. 1. London: H.G. Bohn.

GORDON, G. (1875). The Pinetum ed. 2.

GREGUSS, P. (1955). Identification of Living Gymnosperms on the Basis of Xylotomy. Budapest: Akademici Kiado.

HANSEN, W. (1965) Personal communication with author

HARVEY, W.H. (1838). Genera of South African Plants. ed. 1. Cape Town.

HARVEY, W.H. (1868). Genera of South African Plants. ed. 2. London.

HEGNAUER, R. (1962). Spezieller Teil Cupressaceae. Chemotaxonomie der Pflanzen 1:366.

HENKEL, J.S. (1931) Proc. Rhod. Sci. Ass. 30:12.

HENRY, A. (1930). Dublin, Eire. Personal communication with Kotze (Dept. of Forestry, Pretoria).

HOOKER, J.D. (1845). On the Huon Pine and on Microcachrys a new genus of Coniferae from Tasmania; together with remarks upon the geographical distribution of that order in the Southern Hemisphere. London. J. Bot. 4: 141-142.

HUBBARD, C.S. (1937). Observations on the Distribution and Rate of Growth of the Clanwilliam Cedar Widdringtonia juniperoides Endl. S.Afr. J.Sci. 33:572-586.

HUNT, D.R. (1962). Typification of Thuja aphylla L. Kew Bull. 16:481-482.

HUTCHINS, D.E. (1902). Cape National Forests. Trans. S. Afr. Phil. Soc. 11:62

HUTCHINS, D.E. (1905). Extra-tropical Forestry. Agric. J. Cape of Good Hope 26:661-662.

HUTCHINSON, J. (1924). Contribution towards a phylogenetic classification of Flowering plants. III. The Genera of Gymnosperms. Bull. Miscellaneous Inform. 2:49.

HUTCHINSON, J. (1946). A Botanist in Southern Africa. London: P.R. Gawthorn Ltd.

KARSTEN, M.C. (1958). Francis Masson, A Gardener-Botanist who collected at the Cape. J.S.Afr. Botan.24:203-218.

71/.......

KERFOOT, O. (1963-64). Personal communication with author.

KERFOOT, O. (1964). The Distribution and Ecology of Juniperus procera Endl. in East Central Africa, and its relationship to the Genus Widdringtonia Endl. Kirkia 4. 75-89.

KNIGHT,& PERRY (1850). A Synopsis of the Coniferous Plants grown in Great Britain. London: Longman, Brown, Green and Longmans.

KNOWLTON, F.H. Catalogue of the Cretaceous and Tertiary Plants of North America.

KRAUSS, F. (1846). Flora des Kap und Natallandes. Regensburg.

LAMARCK, J.B.A.P.M. (1786). Encyclopédie Méthodique 2:626. Paris

LEVYNS, M.R. (1929). A Guide to the Flora of the Cape Peninsula. Cape Town: Juta & Co. Ltd.

LEVYNS, M.R. (1952). Clues to the Past in the Cape Flora of Today. S.Afr. J.Sci. 49:155.

LEWIS, J. (1960). Flora Zambesiaca. 1, 1:86-88. London.

LINDLEY, J. & GORDON, G. (1850). A Catalogue of Coniferous Plants with their synonyms. J. Hort. Soc. Lond. 5:203.

LINNAEUS, C. (1763). Species Plantarum ed. 2. Stockholm.

LINNAEUS, C. (1767). Mantissa Plantarum. Stockholm.

LINNAEUS, C. (1771). Mantissa Plantarum Altera. Stockholm.

LOUDON, J.C. (1838). Arboretum et Fruticetum Britannicum 4:2460. London. Longman, Orme, Brown, Green & Longmans.

LUCKHOFF, H.A. (1963). Die Baviaanskloof - of Willowmore - Seder (Widdringtonia schwarzii (Marl.) Mast.). Bosbou in S.Afr. 3:1-13.

MARLOTH, R. (1905). Engler's Botanische Jahrbücher 37:206.

MARLOTH, R. (1908). Das Kapland. Jena.

MARLOTH, R. (1913). The Flora of South Africa. Vol. 1. Cape Town: Darter Bros & Co.

72/.......

MARSH, E.K. (1963-65). Personal communication.

MASTERS, M.T. (1894). New or Noteworthy Plants. Gard. Chron. 15:746.

MASTERS, M.T. (1894). Widdringtonia whytei. Gard. Chron. 16:190.

MAs

MASTERS, M.T. (1905). J. Linn. Soc. Botan. 37:268-274.

McCLOUNIE, J. (1896). Cedar Tree of Mt. Mlanje. Kew Bull. 216-217.

MILLER, P. (1768). Gardeners' Dictionary ed. 8. Vol. 6.

MOSELEY, M.F. (1943). Contributions to the Life History, Morphology and Phylogeny of W. cupressoides. Lloydia 6, 2:109-132.

PAPPE, K.W.L. (1850). Flora Capensis Medicae Prodromus. ed. 1. Cape Town.

PAPPE, K.W.L. (1857). Flora Capensis Medicae Prodromus. ed. 2. Cape Town: W. Britain.

PAPPE, K.W.L. (1854). Silva Capensis. ed. 1. Cape Town: van de Sandt de Villiers & Co.

PARLATORE, P. (1868) in De Candolle Prodromus 16, 2:442-443. Paris.

PHILLIPS, J.F. (1927). Fossil Widdringtonia in Lignite of the Knysna series, with a note on fossil leaves of several other species. S.Afr. J.Sci. 24:188-197.

PLUKENET, L. (1691). Phytographia Vol. 4. London.

PLUKENET, L. (1769). Almagestrum Botanicum. London.

POTZTAL, E. (1964). Communication with Dr. Codd (Bot. Research Instit.)

REHMANN, A. (1880) in Bot. Centralbl. 1:1120

RECHLINGER, K.H. (1964). Nat. Hist. Mus. Vienna. Communication with Dr. Codd (Bot. Research Instit.).

RENDLE, A.B. (1894). The Plants of Mlanje, Nyasaland, collected by Mr. A. Whyte. Trans. Linn. Soc. Botan. 4:60.

RENDLE, A.B. (1912). A contribution to our knowledge of the flora of Gazaland. Gymnosperms. J. Linn. Soc. Botan. 40:235.

SALE, G.N. (1935). Exotics in Mauritius. Brit. Emp. For. Confer. S.Afr.

SAXTON, W.T. (1933). J. Bot. Soc. S. Afr. 19:26.

SCHIMPER, W.P. & SCHENK, A. (1890). in Zittel's Handbuch der Palaeontologie, Palaeophytologie. Vol. 1.

SHAW (1738). Catalogus Plantarum quas in variis Africae et Asiae Partibus.

SIEGEL, S. (1956). Nonparametric Statistics.

SIM, T.R. (1905). Tree Planting in Natal. Pietermaritzburg: Natal Witness.

SIM, T.R. (1907). The Forests and Forest Flora of the Colony of the Cape of Good Hope. Aberdeen: Taylor & Henderson.

SIM, T.R. (1909). Forest Flora and Forestry Resources of Portuguese East Africa. Aberdeen: Taylor & Henderson.

SIM, T.R. (1921). Native Timbers of South Africa. Pretoria: Govt. Printer.

SMITH, C.A. (1955). Early Nineteenth Century records of the Clanwilliam Cedar. J. S.Afr. For. Ass. 25.

SPACH, M.E. (1842). Histoire Naturelle Vegiétaux 11:346.

SPERK, G. (1869). Die Lehre von der Gymnospermie im Pflanzenreiche. Mémoires de l'Académie Impériale des Sciences de St. Petersbourg. ser. 7, 13, num. 6: 132-135.

SPRENGEL, C. (1826). Linnaei Systema Vegetabile 3:890.

STAPF, O. (1917) in Flora of Tropical Africa 6, 2:334. London: Lovell Reeve & Co. Ltd.

STAPF, O. (1918). Diagnoses Africanae LXXI. Kew Bull.

STAPF, O. (1930). Hookers Icones Plantarum 32:3126.

STAPF, O. (1933) in Flora Capensis 5, sect. 2(suppl.): 14-24. London: L. Reeve & Co. Ltd.

74/.......

THUNBERG, C.P. (1800). Prodromus Plantarum Capensium.

THUNBERG, C.P. (1823). Flora Capensis ed. Schult.

VAN DER MERWE, P.J. (1963). History Dept. (Stellenbosch). Personal communication with Prof. v.d. Schijff (Botany Dept., Pretoria University).

VAUGHAN, R.E. (1964). Mauritius. Personal communication with Dr. Codd (Bot. Research Instit.).

VENTENAT, E.P. (1806). Traité des Arbres et Arbustes. Vol. 3. Paris: E. Michel.

VON SCHLECHTENDAL, D.F.L. (1864-65). Beiträge zur Kenntniss . Coniferen. _Linnaea_ 33: 339-361.

WARD, J.H. (1958). Notes on the Cedar of Willowmore. _J. S.Afr. For. Ass._ 31.

WHITE, F. (1962). Forest Flora of N. Rhodesia. Oxford: Oxford Univ. Press.

WHYTE, A. (1892). _Kew Bull._ 121-124.

WILLDENOW, C.L. (1805). Caroli a Linné Species Plantarum ed. 5. 4:510.

WILSON, E.H. (1929). _W. Juniperoides._ _J. Arnold Arboret._ 10: 1-2.

WODEHOUSE, R.P. (1935). Pollen Grains. New York: McGraw Hill.

WOOD, J.M. (1907). _Trans. S.Afr. Phil. Soc._ 18:122-124.

WORSDELL, W.C. (1897). On Transfusion tissue. _Trans. Linn. Soc. Lond. Bot._ 5:301-319.

B. _References consulted but not cited._

ACOCKS, J.P.H. (1964). Personal communication.

ALEXANDER, J. (1838). An Expedition of Discovery into the Interior of Africa. Vol. 1.

ANONYMOUS (1886). Cape of Good Hope. Official Handbook. Cape Town: Saul Solomon & Co.

ANONYMOUS (1899). _Cape Illustrated Magazine._

75/.......

ANONYMOUS (1934). Wood and Oil of Widdringtonia whytei. Bull. Imp. Inst. 32. 2:240-250.

ANONYMOUS (1940). A standard Nomenclature for S.Afr. Grown Timber. J. of S.Afr. For. Ass. 5:79.

BAILEY, L.H. (1923). Cultivated Evergreens. London: Mac Millan & Co.

BOLUS & WOLLEY DOD (1903). Flora of the Cape Peninsula. Trans S.Afr. Phil. Soc. 14:320.

CARRIERE, E.A. (1857). Manuel genéral des Plantes, Arbres. Vol. 4.

CHAMBERLAIN, C.J. (1957). Gymnosperms. New York: Johnson Reprint Corporation.

CHAPMAN, J.D. (1962). The vegetation of the Mlanje Mounts, Nyasaland. Zomba: Gov. Printer.

DALLA TORRE ET HARMS (1958). Genera Siphonogamarum. Weinheim: H.R. Engelmann (J. Cramer).

DAUBENMIRE, R.F. (1959). Plants and Environments. New York: John Wiley & Sons.

DESFONTAINES, I. (1809). Histoire des Arbores et Arbrisseaux. Vol. 2. Paris: J.A. Brosson.

EAMES, A.J. & MacDANIELS, L.M. (1925). Introduction to Plant Anatomy.

ENGLER, A. (1903). Über die Frühlingsflora des Tafelberges bei Kapstadt. Notizblatt des Konigl. Botan. Gartens und Museums zu Berlin. Ap. 11. Leipzig. Preis.

GODEE MOLSBERGEN, E.C. (1916, 1922, (1932). Reizen in Zuid-Afrika in de Hollandse tijd. Vols. 11, 12, 20, 34. Gravenhage: M. Nijhoff.

GOUWS, J.B. (1964). Somatic Chromosomes of three species of Haemanthus. J. S.Afr. Botan. 30:147.

HAUPT, A.W. (1953). Plant Morphology. New York: McGraw-Hill

HENKEL, J.B. & HOCHSTETTER, W. (1865). Synopsis der Nadelhölzer. Stuttgart: J.G. Coltaschen Buchhandlung.

76/.......

HENKEL, J.S. (1931). Types of vegetation in S. Rhodesia. Proc. Rhod. Sci. Ass. 30:12.

HENKEL, J.S. (1934). The Woody Plants of Natal and Zululand. Durban: Robinson & Co.

HILL, T.G. & DE FRAINE, E. (1908). On the Seedling Structure of Gymnosperms. I. Ann. Bot. 22:88.

HORN, L.W. (1962). Karyotype Analysis in Protea L. J.S.Afr. Bot. 28, 4.

HUTCHINS, D.E. (1902). Cape National Forests. Trans. S.Afr. Phil. Soc. 11:62.

JESSOP, J.P. (1964). Itinerary of Rudolf Schlechter's Collecting Trips in S.A. J. S.Afr. Botan. 30, 3:129-146.

JOUBERT, D.M. (1962). Handleiding vir die skrywe van seminare en verhandelinge. Pretoria: Dept. Landboutegniese Dienste.

JUEL, H.O. (1918). Plantae Thunbergiana. Upsala: A-B Akademiska Bokhandeln.

KARSTEN, M.C. (1951). The Old Company's Garden. Cape Town: Maskew Miller Ltd.

KIDD, M.M. (1950). Wild Flowers of the Cape Peninsula. Capetown: Oxford Univ. Press.

KING, N.L. (1941). The Exploitation of the Indigenous Forests of S.A. J. S.Afr. For. Ass. 6:26-48.

LINNAEUS (1759). Flora Capensis. Upsaliae.

MASTERS, M.T. (1895). J. Linn. Soc. 30:16.

MORRIS, H.S. (1910). Notes on an Abnormal Seedling of Widdringtonia cupressoides, and a brief account of the Vascular System of the Normal Seedling. Trans. Act. Roy. Soc. S.Afr. 1. part 2:411.

PALMER, E. & PITMAN, N. (1961). Trees of South Africa. Amsterdam: A.A. Balkema.

PHILLIPS, E.P. (1951). The Genera of South African Flowering Plants. Pretoria: Govt. Printers.

RAY (1682). Abores Coniferae Resiniferae.

77/.......

REHMANN, A. (1880). Geo-botanische Verhältnisse von Süd-Afrika. Bot. Centralblatt. 1:1120-22.

RENAULT, M.B. (1885). Coniféres Cours de Botanique Fossile. Vol. 4. Paris: G. Masson.

SAXTON, W.T. (1909). Preliminary Account of the Development of the Ovule, Gametophyte and Embryo of W. cupressoides Bot. Gaz. 48: 161-178.

SAXTON, W.T. (1910). Contributions to the Life History of Callitris. Ann. Bot. 24:557-69.

SAXTON, W.T. (1910). Contributions to the Life History of Widdringtonia cupressoides. Bot. Gaz. 50:30-48.

SAXTON, W.T. (1910). Notes on the anatomy of Widdringtonia and Callitris. S.Afr. J.Sci. 7:282-286.

SAXTON, W.T. (1913). Contribution to the life history of Tetraclinis articulata Mast. with notes on the phylogeny of the Cupressoideae and Callitroideae. Ann. Bot. 27: 577-605.

SAXTON, W.T. (1934). Notes on conifers. 9. The ovule and embryogeny of Widdringtonia. Ann. Bot. 48:429-31.

SCLATER, B.L. (1893). Routes and Distances in S. Nyasaland. Geograph. J. 2:416.

SCOTT, M.H. (1927). Notes on the Characteristics and Minute Structure of thirty woods indigenous to South Africa. S.Afr. J.Sci. 24:298-316.

S COTT, M.H. (1935). Weights of S.A. Grown Timbers. Dept. Agric. and Forestry. Series 1. Pretoria: Govt. Printer.

SPILHAUS, M.W. (1950). Indigenous Trees of the Cape Peninsula, Capetown: Juta & Co.

STAPF, O. (1931). Index Londinensis. Oxford.

THONNER, F. (1908). Die Blütenpflanzen Afrikas. Berlin: R. Friedländer & Sohn.

VAN DER MERWE, C.R. (1941). Soil groups and sub-groups of South Africa. Pretoria: Govt. Printer.

78/.......

VAN DER SCHIJFF, H.P. (1963). A Preliminary Account of the Vegetation of the Mariepskop Complex. Fauna and Flora 14:42-53.

VON MEYER, W. (1843). Reisen in Süd Afrika während der Jahre 1840 und 1841. Hamburg.

WATT, J.M. & BREYER-BRANDWYK, M.G. (1962). The Medicinal and Poisonous Plants of Southern and Eastern Africa. London: E. & S. Livingstone Ltd.

WATT, W.E. (1935). Forest Protection from Fire in S.A. 4th. Brit. Emp. For. Confer. S.A.

WHYTE, A. (1895). Botanical Enterprise in Brit. Central Africa. Kew Bull. 189.

WICHT, C.L. (1940). Afrikaanse Bosboomname. Tydskrif van S.Afr. Bosbouvereniging 5. Okt.

WILLAN, R.G. (1953). Timber Extraction in Nyasaland by Wyssen Skyline Crane. Emp. For. Rev. 32.

WILSON, E.H. (1927). Plant Hunting. Vol. 1. Boston: The Stratford Comp.

C. References not seen.

ANONYMOUS (1943). Abstracts in Trop. Woods 76:54.

CLEMENTS, J.B. A Working plan for the Widdringtonia Forests in the Mlanje Mt. and Mchese Forest Reserve for the period 1940-1950 (M.S.).

HUTCHINS (1895). Report Conserv. For. Cape Col. 48-49.

NEWMAN, E.I. & WHITMORE, T.C. (1957). Vegetation of Mt. Mlanje, in a paper. Cambridge Jan.

PURVIS, J.M. (1910). Some Notes on Tree Planting in Plantings in the Shire Highlands. Zomba: Govt. Printer.

STORR LISTER. Rep. Chief Conserv. For. Cape Good Hope figs on P.2.