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TROPICAL
FORESTRY
PAPERS

32

Acacia karroo

MONOGRAPH
AND
ANNOTATED BIBLIOGRAPHY



R.D. Barnes, D.L. Filer and S.J. Milton

OXFORD FORESTRY INSTITUTE
DEPARTMENT OF PLANT SCIENCES
UNIVERSITY OF OXFORD
1996

FRP
FORESTRY RESEARCH PROGRAMME

PHOTOGRAPHS

Front cover

Acacia karroo in flower in a sorghum field in the Umguza Valley near Bulawayo, Zimbabwe
(Photograph J.H.W. Bickle)

Back cover

Above: People of Ntabazinduna Communal Area in Zimbabwe nurture and prune the *Acacia karroo* to provide shade and fodder for their livestock

Below: Goats browsing *Acacia karroo* near Queenstown in South Africa where, properly managed, the trees make a valuable contribution to increasing productivity of the range in this environment

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PREFACE

It is one of life's many anomalies that a tree species that now epitomises the concept of multi-purpose trees and shrubs should have been the subject of considerable research on its eradication as a weed. Until the last decade, *Acacia karroo* was considered a major threat to pastures and farmland in southern Africa and little was known of its genetic variation, or of its management and productivity. Largely as a result of work at the Oxford Forestry Institute, and Dr Barnes in particular, we now have a much fuller appreciation of the species as a valuable and manageable resource, offering a wide range of marketable and domestic products as well as a number of characteristics that improve the soil and social environments.

This monograph provides an annotated bibliography of all the relevant literature and a critical monograph on the species, one of the most widespread and important of all the *Acacia* species. The authors have considerable experience in the field, laboratory and library that permit them to produce such an integrative review with excellent field photographs and computer generated maps. The monograph will be of value to rural development specialists, agriculturalists, foresters and extension workers throughout the dry zones of Africa, particularly in the southern half of the continent where the species is indigenous. It will stimulate further research and development of the species for enhanced socioeconomic productivity of the tree itself and of the crops, animals and environments that it supports.

J Burley
Director, Oxford Forestry Institute

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ix
INTRODUCTION	1
NOMENCLATURE AND TAXONOMY	2
The place of <i>Acacia karroo</i> in the genus <i>Acacia</i>	2
Nomenclature	2
Vernacular names	3
Botanical description	3
Representative specimens	6
Related species	10
Natural hybrids	10
GENETIC VARIATION	10
Morphological variation	10
Biochemical variation	13
Sampling variation for genetic evaluation	13
REPRODUCTIVE BIOLOGY	13
Cytology	13
Sporogenesis, embryology and pollination	15
Breeding system	15
Pollinating and seed dispersal agents	15
DISTRIBUTION AND ECOLOGY	16
Natural distribution	16
Ecology	16
Climate	16
Soils	16
Vegetation types and succession	17
Associated fungi	17
Rhizobia	18
GROWTH HABITS	18
Life cycle	18
Growth patterns	19
Flower and fruit phenology	20
PREDATORS, DISEASES AND HARMFUL PHYSICAL AGENCIES	20
Biotic factors	20
Animals	20
Insects	20
Parasitic plants and fungi	21
Abiotic factors	21
Fire	21
Drought	22
Frost	22
PRODUCTS AND USES	22
Wood	22
Anatomy	22
Fuelwood	22
Round and sawn wood	23
Pulp	23
Bark	25
Gum	25
History, specifications and trade	25
Chemistry	26
Collection and marketing	26
Other uses for gum	26
Fodder	27
Medicine and food	29
Soil amelioration	29

ESTABLISHMENT, YIELD AND MANAGEMENT	29
Establishment	30
<i>Seed collection</i>	30
<i>Seed storage</i>	30
<i>Seed pretreatment</i>	30
<i>Nursery</i>	30
<i>Planting</i>	31
Yield and management	31
<i>Wood</i>	31
<i>Browse</i>	34
<i>Control of invasion</i>	36
CONCLUSIONS AND FUTURE RESEARCH	37
ANNOTATED BIBLIOGRAPHY	39
AUTHOR INDEX	75
LIST OF TABLES	
Table 1 Provenances of <i>Acacia karroo</i> collected by the Oxford Forestry Institute for genetic evaluation in the international African <i>Acacia</i> trials network	14
Table 2 <i>Acacia karroo</i> : kraft pulping tests: handsheet properties compared with <i>Eucalyptus grandis</i>	24
Table 3 <i>Acacia karroo</i> : dissolving pulp yields, viscosity, brightness and kappa compared with three Australian acacias	24
Table 4 Proximate nutritional and mineral analyses of <i>Acacia karroo</i> foliage and pods from the Cape Province in South Africa	28
Table 5 An analysis of percentage of leaf nitrogen (%N), nitrogen 15 ratio (¹⁵ N) and carbon 13 ratio (¹³ C) for leaf samples from <i>Acacia karroo</i> compared with <i>Acacia erioloba</i> , <i>A. fleckii</i> , <i>A. nilotica</i> ssp. <i>kraussiana</i> , <i>A. tortilis</i> ssp. <i>heteracantha</i> and <i>Faidherbia albida</i>	28
LIST OF FIGURES	
Figure 1 <i>Acacia karroo</i> . Botanical drawings of branchlets, leaves, stipular spines, pods and glands	4
Figure 2 <i>Acacia karroo</i> . Botanical drawings of branchlets, leaves, pinnules, glands, flowers and pods	5
Figure 3 Leaves from six-month-old seedlings of ten provenances of <i>Acacia karroo</i>	11
Figure 4 <i>Acacia karroo</i> , <i>A. rehmanniana</i> and <i>A. karroo</i> x <i>A. rehmanniana</i> hybrid. Botanical drawings of branchlets, leaves, pinnules, glands and flowers	12
Figure 5 Flowering and fruiting phenology of <i>Acacia karroo</i>	32
Figure 6 Relationship between basal area at breast height and total over-bark volume to 5 cm minimum branch diameter for a stand of <i>Acacia karroo</i>	32
Figure 7 Relationship between basal area at ankle height and total over-bark volume to 5 cm minimum branch diameter for a stand of <i>Acacia karroo</i>	32
Figure 8 Total wood volume production per year in cubic metres and the annual rainfall during the life of a natural stand of <i>Acacia karroo</i>	33
Figure 9 Total cumulative wood volume in cubic metres and the number of stems that contributed to that volume in each year during the life of a natural stand of <i>Acacia karroo</i>	33

LIST OF PLATES

Plate 1 *Acacia karroo*

- A Typical yellow flowers
- B Pale flowers from Bazaruto Island, Mozambique
- C Spines from the coastal dune forests in Zululand
- D Inflated spines from eastern Zimbabwe
- E Unopened pods
- F Dehisced pods with seeds still suspended by the funicle

Plate 2 *Acacia karroo*

- A Bark characteristic of the coastal dune forests
- B Bark characteristic of the main range
- C Putative natural hybrid with *A. rehmanniana*
- D Flowers of *A. karroo* (left), *A. rehmanniana* (right) and the natural hybrid between them (centre)
- E Seedlings of the Bazaruto Island, Mozambique, provenance at six months
- F Seedlings of the Jedibe Island, Botswana, provenance at six months
- G Seedlings of ten provenances at six months from sowing

Plate 3 *Acacia karroo*

- A Distribution plotted from herbarium specimens of precisely known origin
- B Seed collection localities for genetic evaluation trials

Plate 4 *Acacia karroo*

- A Frequency of the peroxidase band M in an electrophoretic study of 63 populations that cover the entire natural range
- B Frequency of the peroxidase band K in an electrophoretic study of 63 populations that cover the entire natural range

Plate 5 *Acacia karroo*

- A In scrub near the coast in the eastern Cape Province of South Africa
- B On the beach on Bazaruto Island in Mozambique
- C In the coastal dune forest of Zululand, South Africa
- D On black vertisols in the Umguza Valley, Matabeleland, Zimbabwe
- E On a salt-encrusted island in the inland Okavango Delta in Botswana
- F In the Bokaap district of Cape Town
- G In the Kalahari Gemsbok National Park in South Africa

Plate 6 *Acacia karroo*

- A Lush perennial *Panicum maximum* pasture beneath the trees
- B The trees follow *A. erioloba* in being among the first to flush at the end of the dry season
- C Foliage and flowers in reach are heavily browsed by domestic and wild animals
- D The species nodulates early and prolifically
- E Intensive root system on a tree uprooted in the coastal sand dunes
- F The parasitic mistletoe, *Viscum* sp., is conspicuous after it has been killed by a heavy frost while the tree has survived
- G Extensive root system exposed of a tree growing near a river in a black vertisol

Plate 7 *Acacia karroo*

- A Gum exudation from the inner bark associated with wood-boring insect activity
- B The larvae of a number of Cerambycid beetles bore in the stems
- C The thin continuous line of marginal parenchyma can be distinguished in transverse section of the wood from the aliform parenchyma associated with the vessels
- D The chambered cells of the marginal parenchyma are crystalliferous
- E Drought and wood boring insects stimulate gum production at the end of the dry season
- F The marginal parenchyma has been shown, by wounding experiments, to be laid down annually during the dry season
- G The crystals in the marginal parenchyma have been identified as calcium oxalate by scanning proton microprobe
- H The fungus *Ravenelia macowaniana* on pods: the galls are inhabited by an assemblage of microlepidoptera

Plate 8 *Acacia karroo*

- A Gum being weighed before purchase at a buyer's factory in Bulawayo, Zimbabwe
- B Tapping gum from the stem for laboratory analysis
- C Gum collectors queuing at the factory door in Bulawayo, Zimbabwe, to sell their loads
- D Pure stands established to rehabilitate coastal dunes after the forest has been removed for the mining of titanium
- E The species is a preferred firewood in all parts of its range
- F A young stand in the Umguza Valley near Bulawayo, Zimbabwe, pruned to let in light for grasses and to give access for domestic stock
- G The only green grass after a drought in what would normally be lush green pasture is under the trees where the shade and soil fertility provide a suitable environment for the more nutritious and deeper-rooted perennial grasses such as *Panicum maximum*

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INTRODUCTION

Woodlands are a crucial component of farming systems in the communal lands of Africa. Increasing population pressure and devastating droughts have brought about deforestation and severe land degradation in the dry zones of the continent. Rural populations in these areas face great hardships and are becoming increasingly vulnerable to climatic change. Improving their quality of life is dependent on increasing yields from cultivated crops, on realizing more of the potential for livestock production and on providing wood for fuel and poles. This can be done most effectively by developing and promoting the use of trees in agrisilvopastoral systems.

The useful species in the original climax tree communities in the savanna woodlands are rapidly disappearing. Even given favourable conditions, they would take many years to re-establish themselves. Attempts to remedy the situation with exotic species have met with limited success. It is among the indigenous pioneers that there is greatest potential now to increase productivity from both arable and non-arable land.

As pioneers, species of the genus *Acacia* are unrivalled by any other group of trees and shrubs in the combined importance of their distribution throughout the seasonally dry to arid regions of the continent, their varied ecologies, their ability to colonize and rehabilitate degraded sites and their relatively fast growth. They are commonly found throughout the continent and are of great ecological and socio-economic importance; they have evolved over the millennia with the larger herbivores for which they provide highly nutritious fodder and which, as a result, disperse the seeds; and, traditionally, rural man and his livestock have exploited these trees for many purposes.

Acacia karroo is foremost among the acacias in southern Africa as regards both range and uses. It occurs in Zimbabwe, Botswana, Swaziland, Lesotho, Namibia, South Africa, Mozambique, Zambia, Malawi and the south of Angola. It varies from a shrub to a tree more than 20 m in height and grows from sea level to 1800 m on soils ranging

from pure unconsolidated sand to heavy clays with an annual rainfall from 1500 mm down to less than 200 mm where ground water is available along drainage lines and around pans and dams. The species fixes nitrogen, provides shade, stabilizes sand dunes and disturbed areas and is resistant to drought, frost, fire and salinity. The leaves, flowers, pods and its parasitic mistletoes are excellent fodder, it yields a high quality clear gum with many uses and it is a good bee tree in that it provides quantities of pollen and nectar and can flower three or four times a year. The wood is an excellent fuel, the bark can be used for tanning, the inner bark makes good cord and the sawn timber can be used for general purposes. *A. karroo* is therefore very much a multipurpose tree with great potential for increasing productivity in agroforestry and silvopastoral systems over a wide range of sites in the dry zones of the tropics and sub-tropics. It has been described as being an asset on any farm.

This Tropical Forestry Paper is based principally on the work done on Project R4526 - *Acacia karroo*: evaluation and assembly of genetic resources at the Oxford Forestry Institute (OFI) in the Department of Plant Sciences, University of Oxford. The project was funded by the Forestry Research Programme (FRP) of the Overseas Development Administration (ODA) of the Government of the United Kingdom. One objective of the project was to supply seed for genetic evaluation of the species across its entire range; this collection has now been completed and the seed is available from the OFI. A second objective was to develop BRAHMS, the Botanical Research And Herbarium Management System; the taxonomic treatment and distribution maps contained in this publication are products of this database. The third major objective was to conduct a literature search on the species and to disseminate all knowledge available. That is accomplished in this monograph and annotated bibliography. The monographic part of the paper summarizes all the information that has been compiled on the species whereas the abstracts in the bibliography provide a path for the reader to focus on specific aspects.

NOMENCLATURE AND TAXONOMY

The place of *Acacia karroo* in the genus *Acacia*

The genus *Acacia* Mill. is the largest in the sub-family *Mimosoideae* and the second largest in the family Leguminosae (= Fabaceae) which also includes the sub-families *Caesalpinioideae* and the *Papilionoideae*. There are five tribes within the *Mimosoideae* of which the Acacieae is one and it currently contains only two genera, *Acacia* and the monospecific *Faidherbia*. The acacias are taxonomically closest to genera in the tribe Ingeae such as *Calliandra* and *Albizia*.

The genus *Acacia* Mill. is pantropical and there are now some 1250 species (840 in Australia; 230 in the New World; 135 in Africa; 18 in India; a few species in Asia; and some island endemics). There has not been a comprehensive revision of the genus since George Bentham's taxonomic study in 1875 when 432 species were recognized and divided into six series (Bentham, 1875). Guinet & Vassal (1978) have since divided *Acacia* Mill. into three subgenera broadly following Bentham's six series: *Heterophyllum* Vassal (series *Phyllodineae* DC., *Botrycephalae* Benth. and *Pulchellae* Benth.), *Aculeiferum* Vassal (series *Vulgares* Benth. and *Filicinae* Benth.) and *Acacia* (series *Gummiferae* Benth.). *Heterophyllum* is virtually restricted to the Australian continent and the majority of species (except series *Botrycephalae* & series *Pulchellae*) have phyllodes (large strap-like foliage) and an absence of thorns. The subgenera *Acacia* Vassal (all bearing thorns) and *Aculeiferum* (some bearing prickles) have bipinnate leaves and occur on all other continents.

Because of its complexity, efforts have been made to split the genus *Acacia*. Pedley (1986) has recently divided the genus into three separate genera *Racosperma*, *Senegalia* and *Acacia*, corresponding to the subgenera of Guinet & Vassal (1978), but these divisions have generally been considered to be problematic. However, more recently there has been a phylogenetic assessment of tribe Acacieae in which it is concluded that *Acacia*, as currently defined, is not a monophyletic group and that tribes Ingeae and Acacieae should be amalgamated (Chappill and Maslin, 1995).

In Africa the acacias belong to two subgenera, *Aculeiferum*, whose species, typified by *Acacia senegal*, are mostly diploid with prickles and spicate inflorescences and *Acacia*, typified by *A. nilotica*, whose species are mostly polyploids with thorns and capitate inflorescences. *A. karroo* belongs in the latter group and is taxonomically closest to *A. tortilis* and *A. nilotica* (Chappill and Maslin, 1995). The polyploid species of *Acacia* occupy a greater range of habitats and are more widely distributed than those of *Aculeiferum*, possibly due to greater genetic plasticity.

Acacia karroo occurs over a diverse range of environments and is therefore extremely variable; and there is evidence that this variation is regional (Ross, 1979). This is supported by various studies in which seedlings from different populations have been raised together and found to differ markedly in morphological traits (Swartz, 1982; Barnes *et al.*, 1995). This has led one researcher to propose a division of the species in six groups each of which would have sub-specific status (Swartz, 1982). However, although the extremes of these variants are distinctive, they are generally linked to the central type by numerous intermediate stages that become progressively less distinct until it becomes impossible to delimit the variant. This has led Ross (1979) to the conclusion that it is preferable "to regard *A. karroo* as an inherently variable polymorphic species in which no formal infraspecific categories are recognized rather than to fragment the species into a number of somewhat arbitrary infraspecific taxa".

[References:- 6, 9, 12, 25, 27, 32, 48, 102, 146, 157, 162, 166, 167, 168, 169, 170, 173, 178, 179, 243, 258]

Nomenclature

Acacia karroo Hayne Arzneyk. Gebr. Gewächse 10: t.33 (1827). Type: South Africa, Cape Province, locality not known, *Herb. Willdenow 19184* fol. 2 (B-Willd., lectotype; PRE photo).

Acacia horrida (L.) Willd. Sp. Pl. 4: 1082 (1806) pro parte quoad syn. *Mimosa leucacantha* Jacq., *non sensu stricto*.

Acacia hirtella E. Mey. Comm. 1:167 (1836). Type: South Africa, Natal, between Umkomaas and Umlazi, *Drege s.n.* (isotypes: K, P).

Acacia natalitia E. Mey. Comm. 1:167 (1836). Syntypes: South Africa, Natal, Durban and Umgeni, *Drege s.n.* (K, P); Transkei, Port St John's District, between Umgazana and Umzimvubu, *Drege s.n.* (P).

Acacia horrida var. *transvaalensis* Burt Davy in Kew Bull. 1908: 158 (1908); *Acacia karroo* var. *transvaalensis* (Burt Davy) Burt Davy in Kew Bull. 1922: 328 (1922). Syntypes: South Africa, Transvaal, Pretoria District, Groenkloof, *Burt Davy 2468* (BOL, FHO, K, PRE); Arcadia, *Burt Davy 2807* (FHO, K, PRE).

Acacia dekindtiana A. Chev. in Revue Bot. appl. Agric. trop. 27:509 (1947). Type: Angola, Huila District, Huila, *Dekindt 431* (Holotype, P).

Acacia inconfagrabilis Gerstner in J. S. Afr. Bot. 14: 24 (1948). Syntypes: South Africa, Natal, Nongoma District, Nongoma, *Gerstner 4562* (K, NBG, NH, PRE); *Gerstner 4635* (NBG, NH, PRE); *Gerstner 4637* (?).

[References:- 27, 87, 174, 179, 208, 240]

Vernacular names

muBayamhondoro (Shona); Butema (Kalanga); Gaba (Kalanga); Mimosa thorn (English); Mooka (Tswana); Mookana (bush) (Tswana); isiNga (Ndebele); Orusu (Herero); Soetdoring (Afrikaans); Sweet thorn (English); muUnga (Shona); umuNga (Zulu). (Timberlake, 1980; Wild *et al.*, 1972).

[References:- 27, 67, 233, 258]

Botanical description (Modified from Ross (1979))

Habit a shrub to 2 m, often several-stemmed, or a tree 25 m high, crown typically somewhat rounded or flattened; sometimes tree very slender, spindle-like and sparsely branched. *Bark* longitudinally fissured, reddish-brown to dark brown or black and rough or pale greyish-white or greyish-brown and smooth, the latter often with scattered persistent spines; smaller branches (<50 mm) roughish, rusty red, sometimes with some grey, discontinuous, peeling striations and persisting thorns; young branchlets bright green, typically glabrous but occasionally densely pubescent, eglandular or with small inconspicuous reddish sessile glands, epidermis flaking off to expose a dark rusty-red non-powdery inner layer or sometimes smooth and persistent. *Stipules* spinescent, in pairs, mostly 0.4-7 (10) cm long but sometimes to 25 cm long and then usually slightly fusiform-inflated and up to c. 1 cm in diameter, remaining distinct to the base and not confluent, straight or slightly curved or deflexed. *Leaves* typically glabrous but occasionally densely pubescent: petiole 0.5-1.8 cm long, adaxial gland usually present; rachis (0) 1-5 (9) cm long, with a gland at the junction of each or some pinnae pairs; pinnae (1) 2-6 (13) pairs; rachillae (1) 1.5-4 (7.2) cm long; leaflets 5-15 (27) pairs per pinna, (2.8) 3.5-8 (12.5) x 1-2.5 (5) mm, linear to obovate-oblong, eglandular, apex rounded to subacute but not spinulose mucronate, usually glabrous sometimes pubescent beneath. *Inflorescences* on the current season's growth, capitate, fascicled or solitary on axillary peduncles, sometimes aggregated into more or less leafless terminal "racemes"; peduncles 0.7-2.4 (4) cm long, usually glabrous; involucrel $\frac{1}{3}$ - $\frac{1}{2}$ way up the peduncle. *Flowers* bright yellow. *Calyx* 1.25-2 mm long, glabrous throughout or apices of lobes pubescent. *Corolla* 2.5-3 mm long, glabrous or almost so. *Pods* brown, (4) 5-10.5 (21) x 0.5-0.7 (1.1) cm, linear, usually more or less falcate, usually \pm constricted between the seeds, often distinctly, mostly glabrous but at times densely tomentellous, sometimes inconspicuously glandular. *Seeds* (3.5) 4.5-6.5 (9) x (2) 3-4 (7) mm, elliptic, lenticular or sometimes \pm quadrate, compressed; areole 3-5.5 (7) x 2-3.5 (4.5) mm. (See Figures 1-4; Plates 1A-F and 2A-B).

Little has been published on the root morphology of *Acacia karroo*. Exposure of root systems has shown that it can vary with site conditions from being extensive in heavy soils as seen on eroded river banks (Plate 6F) (Bayer, 1943) to

being intensive on coastal dunes (Plate 6E). It is among the first trees to flush in the spring at the end of the dry season and it can maintain a luxuriant green crown even when the rains fail which suggests that it can exploit soil moisture reserves at great depth (Plate 6B).

A. karroo occupies a diverse range of habitats and is consequently exceedingly variable. There is evidence that the variation is regional; plants in various parts of the species' geographical range often having a different "look" (Ross, 1971b). "Typical" *A. karroo* grows in the Karoo and in the drier parts of the Cape Province as a shrub (Plate 5A) or tree with dark rough bark, usually 2-3 pinnae pairs per leaf, and 6-12 pairs of leaflets per pinna that are 4.0-8.0 x 1.5-2.5 mm. Apart from the "typical" form, a number of other entities are recognizable within the species. Some of the more important are listed below.

1. The white-barked trees or shrubs with short spines, 4-7 (13) pinnae pairs per leaf and 12-18 (27) pairs of smaller, narrower leaflets per pinna (*Acacia natalitia*) which are found chiefly in the eastern Cape, Natal, Swaziland, the eastern Transvaal, Zimbabwe and Mozambique. *A. hirtella*, described from the Natal coast, is similar but differs in having pubescent young branchlets, leaves, leaflets and peduncles.
2. The small slender shrubs up to 1 m high found in the eastern Cape in the vicinity of the Kei River mouth. A local entity of which Dyer 4502 (K; PRE) is typical.
3. The "fire-resistant" shrubs found in the Nongoma District of Zululand (*Acacia inconflagrabilis*).
4. The slender, sparingly branched trees up to 6 m high found in Zululand, particularly in the Hluhluwe and Umfolozi Game Reserves and in the corridor linking them ("spindle" *Acacia karroo*). A "spindle" growth form also occurs near the Loskop Dam in the Transvaal. Plants typically have bright reddish-brown minutely flaking bark, glaucous foliage, large flattened + discoid petiolar glands and a large gland at the junction of each or most pinnae pairs. Ward 2123 and Codd 9616 are representative.
5. The large trees with greyish-white bark, spines up to 25 cm long and long moniliform pods found along the Zululand coast from the mouth of the Tugela River northwards into Mozambique (Plates 5C and 8D). Plants are confined to a narrow belt and occur on the coastal plain, around the coast dunes, in the mouths of river estuaries and around the shore of the fresh water Lake Sibaya. The plants, which usually form very dense pure stands and are often dominant to the exclusion of other trees, often act as pioneers in stabilising loose sand dunes, especially in disturbed areas and in patches of regenerating dune forest. Unlike in "typical" *A. karroo*, the paired spines often persist on the trunk (Plate 2A). Gerstner 4526 and Strey 4960 are representative.

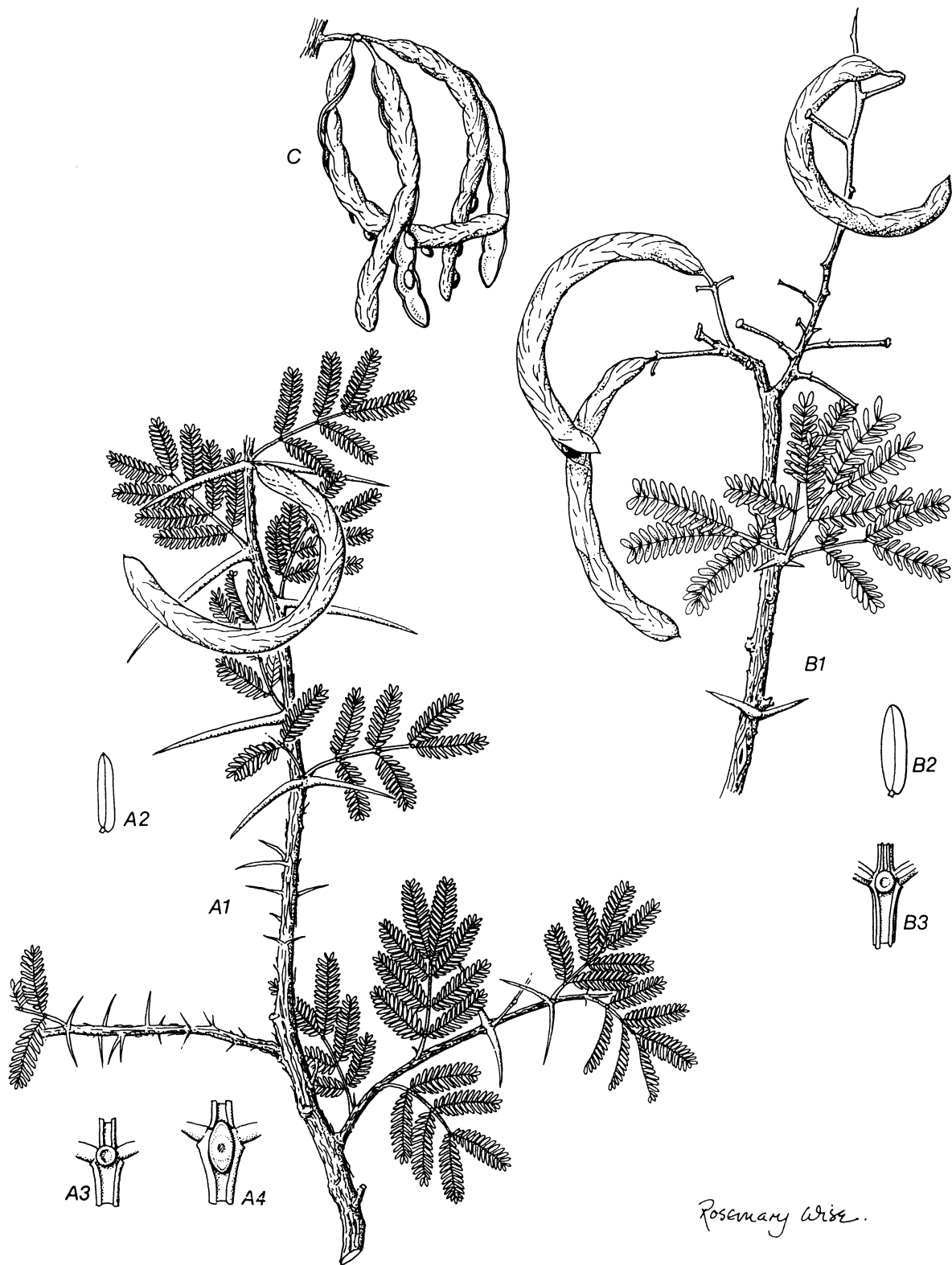


Figure 1 *Acacia karroo*. A1 - Branchlet with leaves, stipular spines and pods (x0.7) Barnes RD 3205; A2 - Pinnule (x3); A3 - Gland (x7); A4 - Gland (x7). B1 - Branchlet with leaves and pods (x0.7) Barnes RD 3208; B2 - Pinnule (x3); B3 - Gland (x7).

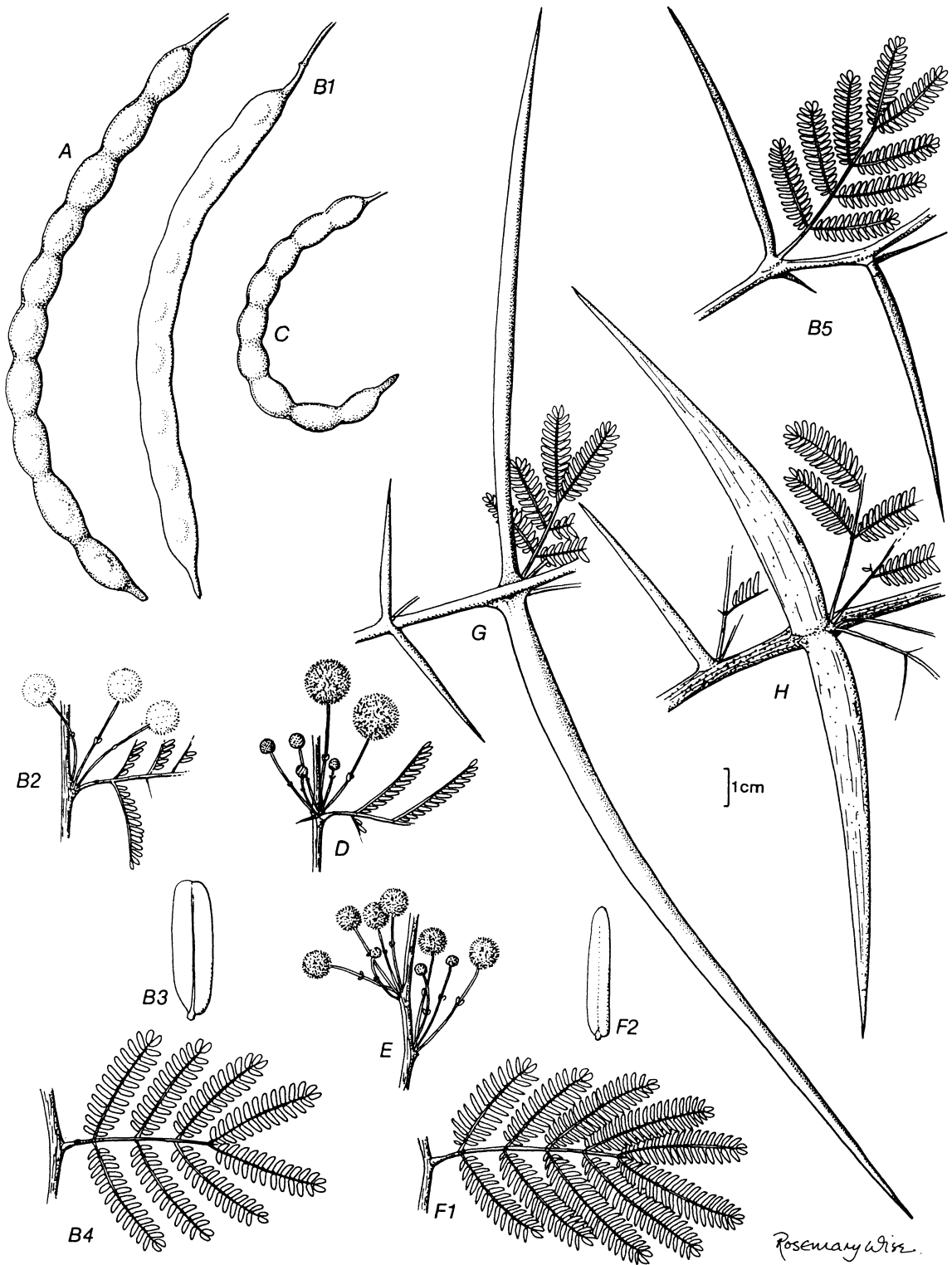


Figure 2 *Acacia karroo*. A - Pod (x0.65) Barnes RD 3183. B1 - Pod (x0.65); B2 - Flowers (x0.65); B3 - Pinnule (x4); B4 - Leaf (x0.65); B5 - Branchlet with leaf and stipular spines (x0.65); Barnes RD 4436. C - Pod (x0.65) Barnes RD 1909. D - Flowers (x0.65) Fagg CW 482. E - Flowers (x0.65) Barnes RD 509. F1 - Leaf (x0.65); F2 - Pinnule (x4); Barnes RD 3183. G - Branchlet with leaf and stipular spines (x0.65) Barnes RD 3151. H - Branchlet with leaf and stipular spines (x0.65) Fagg CW 474.

6. On the Transvaal highveld from Pretoria eastwards there is a local tendency for the production of a sparse indumentum on the young branchlets, leaves, peduncles and pods (*Acacia karroo* var. *transvaalensis*). However, occasionally this tendency is so extreme, for example, at Steelpoort, as to completely alter the general appearance of the plants. Indeed, the latter, for example Codd 6702 and Ross 2089, 2094, bear a strong superficial resemblance to *A. gerrardii*.

7. On the island of Bazaruto in the Bazaruto archipelago in Mozambique, what has been up to now recognized as *Acacia karroo* has pale yellowish bark, rather like that on the Zululand coast, and pale lemon-yellow flowers. Barnes RD 4436 (FHO) is representative. (See Plates 1B and 5B).

The extremes of each of these variants are usually distinctive and attract immediate attention. For example, six well defined intra-specific groups were distinguished in a study of selected natural populations of *Acacia karroo* using numerical taxonomic methods and a combination of 38 traits measured on seedlings raised under controlled conditions (Swartz, 1982). After a discussion of the morphology, distribution and ecological characteristics of the six groups, the author suggested that the groups should have subspecific status. More recently, the taxonomic history of *A. natalitia* was investigated from its description in the early 19th century to its amalgamation with *A. karroo* Hayne (von Breitenbach, 1989). The diffusion of the original *A. karroo* concept by the inclusion of *A. natalitia* and various other clearly differing forms is considered undesirable. It is considered that, with its whitish bark, small thorns, more finely divided leaves, lemon-yellow candle-like inflorescences and longer, more constricted pods, *A. natalitia* at least can be sufficiently well distinguished from *A. karroo* to justify its reinstatement as a separate taxon.

However, as stated by Ross (1979), all these variants appear to be linked to the "central *Acacia karroo* gene-pool" by numerous and varied intermediate stages that become progressively less distinct until it becomes difficult to delimit each variant clearly. Consequently, many specimens are difficult to assign to a particular variant with any degree of certainty. In the absence of more detailed sampling and taxonomic studies, therefore, it remains preferable to regard *A. karroo* as an inherently variable polymorphic species in which no formal infraspecific categories are recognized rather than to fragment the species into a number of somewhat arbitrary infraspecific taxa. Recent molecular studies (Barnes *et al.*, 1994), however, suggest that the island populations of the Bazaruto archipelago may be an exception.

A few flowers often develop in the involucrel on the peduncle in *Acacia karroo* giving the appearance of a smaller secondary capitulum below the main one. These involucrel flowers usually develop before those in the main capitulum. Gordon-Gray and Ward (1974 and 1975),

found a wide range in the number, size and structure of these sterile involucrel flowers and suggested that, opening as they do before the flowers in the main capitulum, "and being both visually and olfactorily attractive", they "may perhaps attract pollinating animals" so that visiting patterns are already established when the bisexual flowers of the capitate head open.

[References:- 27, 43, 55, 67, 93, 94, 174, 179, 194, 233, 243, 258]

Representative specimens

ANGOLA. HUILA: Dec 1859, *WILN?* 1833, (K); **Sa da Bandeira**, 14° 55'S 13° 30'E, 31 Jan 1967, *HENRIQUES C 1070*, (LISC); **Sa da Bandeira, Bata Bbata**, 10 Dec 1961, *SANTOS R 680*, (K); **Tchivinguiro**, 21 Dec 1961, *BARBOSA G 9727*, (K); **Viriambundo**, 27 Feb 1972, *CLARA COUTO 165*, (SRGH).

BOTSWANA. CENTRAL: **Seleka Ranch**, 23° 0'S 27° 50'E, 24 Nov 1977, *HANSEN OJ 3291*, (K, PRE); **NGAMILAND: Nokaneng Flats**, 19° 40'S 22° 12'E, 8 Apr 1975, *ASTLE WL 7396*, (SRGH); **NORTH: Locality?**, 19° 31'S 22° 49'E, 21 Jan 1977, *SMITH PA 1879*, (K, PRE, SRGH); **SOUTH EAST: Gaberones**, 24° 40'S 25° 55'E, 3 Jan 1979, *KREULENAR 516*, (PRE, SRGH); **Gaberones dam**, 24° 44'S 25° 54'E, 26 Dec 1975, *MOTT PJ 854*, (SRGH); **Honye**, 24° 55'S 24° 42'E, 21 Nov 1979, *TIMBERLAKE JR 2047*, (SRGH); **Kanye**, 24° 59'S 25° 19'E, 22 Jan 1979, *TIMBERLAKE JR 1923*, (SRGH); **Mahalapye**, 23° 4'S 26° 50'E, 11 Apr 1962, *YALALA AM 338*, (K, SRGH); **Mmathethe**, 28 Feb 1977, *MOTT PJ 1080*, (SRGH); **Sebele**, 3 Mar 1987, *LONG DG & RAE DAH 20*, (K); **TULI BLOCK: Beers farm**, Sep 1945, *MILLER OB B/375*, (PRE).

LESOTHO. UNKNOWN: **Berea**, *DIETERLENA 185*, (PRE); **Koloni**, Jan 1953, *JACOT-GUILLARM 1496*, (PRE); **Mafeteng dist.**, 29° 49'S 27° 14'E, Dec 1933, *GERSTNER JJ 209*, (PRE).

MALAWI. BLANTYRE: Michiru Mtn, 1 Jul 1980, *MORRIS B 1156*, (MAL); **Michiru Reserve**, 8 Dec 1983, *BANDA CS 18*, (MAL); **Ndirande Plantation**, 15° 45'S 35° 3'E, 12 Mar 1969, *MSINKHU JB 9*, (MAL, SRGH); **Walala**, 7 Nov 1989, *FAGG CW 477*, (FHO, K, MAL); **CHIRADZULU: Chiradzulu Mtn**, 15° 41'S 35° 9'E, 11 May 1980, *BRUMMITT RK & PATEL IH 15618*, (K, MAL); **DEDZA: Dedza**, 14° 24'S 34° 20'E, 22 Apr 1970, *BRUMMITT RK 10035*, (K, MAL, SRGH); **Dedza hills**, 3 Jul 1936, *BURTT-DAVY J 6042*, (K); **Linthipe**, 14° 16'S 34° 15'E, 9 Dec 1988, *FAGG CW 448*, (FHO, K, MAL); **Mpampa**, 1 Dec 1941, *CLEMENTS JB 851*, (MAL); **MULANJE: Fort Lister Gap**, 15° 51'S 35° 0'E, 9 Aug 1958, *CHAPMAN JD 625*, (MAL, SRGH); **NTCHISI: Samson Sonkho**, 15° 15'S 35° 49'E, 9 Sep 1966, *DOWNIE HUTCHESON & LAMB 92*, (MAL); **ZOMBA: Namadzi**, 1900, *CHAPMAN JD & EG 8326*, (K, MO); **Njuli**, 18 Dec 1980, *CHAPMAN JD & PATEL IH 5498*, (K); **Thondwe**, 15° 28'S 35° 15'E, 14 Jan 1981, *SALUBENIA J 2880*, (SRGH).

MOZAMBIQUE. GAZA: 13 Sep 1968, *MYRE M, DUANTEA & ROSE N 4943*, (LISC); **Macia**, 25° 19'S 33° 15'E, 16 Jul 1947, *PEDRO & PEDROGAO 1460*, (K, SRGH); **INHAMBANE: Bazaruto Island**, 21° 32'S 35° 29'E, 20 Oct 1958, *MOGG AOD 28528*, (SRGH); **MANICA ESOFALA: Chimoio**, 19° 0'S 33° 23'E, 2 Mar 1948, *MENDONCA FA 585*, (K); **Macequece**, 18° 58'S 32° 58'E, 25 Mar 1948, *MENDONCA FA 728*, (K); **Serra de Sumba**, 25 Mar 1948, *GARCIA 728*, (EA); **Spungabera**, 20° 29'S 32° 45'E, 15 Nov 1943, *TORRE AR 6202*, (K); **MAPUTO: Bela Vista**, 26° 21'S 32° 40'E, 10 Dec 1962, *LEMOS F & BALSINHAS A 285*, (SRGH); **Bela vista, Ponta de Ouro**, 10 Dec 1961, *DE LEMOS F & BALSINHAS A 285*, (K); **Goba**, 26° 12'S 32° 11'E, 23 Dec 1944, *MENDONCA FA 3481*, (K); **Inhaca Island**, 26° 2'S 32° 58'E, 1 Mar 1963, *MOGG AOD 32000*, (K, SRGH); **Matutuine**, 32° 54'S 26° 45'E, 15 Nov 1979, *JAN DE KONING 7622*, (K); **Mt. Inhaca**, 12 Aug 1980, *JANSEN PCM & DE KONING J 7428*, (K); **Namaacha**, 26° 0'S 33° 10'E, 2 Mar 1948, *TORRE AR 7456*, (K); **Planicies da Polna**, Nov 1940, *HORNBY 996*, (LISC); **Polana**, 12 Mar 1947,

PEDROGAO J 123, (LISC); **Ponta Pondeúni**, 4 Jun 1970, **CORREIA MF & MARQUES A 1635**, (EA); **Ponte do Ouro**, 20 Sep 1968, **MYRE M, DUANTE A & ROSE N 4955**, (LISC); **Santaca**, 26° 26'S 32° 10'E, 12 Jan 1948, **DE FIGUEIREDO GOMES E SOUSA A 3646**, (K); **MACIA: Sul do Sane**, 9 Jul 1947, **PEDRO & PEDROGAO 1393**, (K); **MALEMA**: 5 Feb 1964, **TORRE & PAIVA 10477**, (LISC); **NIASSA**: 5 Feb 1967, **TORRE AR & PAIVA J 10477**, (K); **SULO DO SAVE: Vilanculos**, 22° 1'S 35° 17'E, 27 Mar 1952, **BARBOSA G E BALSINHAS A 5010**, (LISC); **UNKNOWN: Gurue**, 1900, **HORNBY RM 2705**, (K); **Praia**, 23 Feb 1941, **TORRE AR 2611**, (EA); **ZAMBEZIA: Gurue**, 15° 30'S 36° 58'E, 13 Nov 1967, **TORRE AR & CORREIA MF 16074**, (K).

NAMIBIA. CAPRIVI EAST: Shaile, 18° 7'S 24° 7'E, Feb 1923, **DINTER K 4501**, (PRE); **GOBABIS**: 9 Jan 1961, **SEYDEL R 2483**, (LISC); **Okumukaru farm**, 20 Jun 1953, **SCHWERDTFEGER 4105**, (WIND); **Sturmfeld farm**, 2 Jan 1962, **TOLKEN HR 129**, (WIND); **Witvlei**, 22° 22'S 18° 22'E, Jan 1970, **MASON MH 2618**, (PRE); **GROOTFONTEIN: Grootfontein**, 19° 37'S 18° 7'E, Jan 1959, **LE ROUX PJ 240**, (PRE, WIND); **Kumklaus Farm**, 19° 37'S 17° 7'E, Mar 1973, **GISS W 12598**, (PRE, WIND); **HEREROLAND EAST: 21° 0'S 19° 0'E**, Apr 1970, **MACKENZIE J 63**, (PRE); **KARIBIB: Gaub**, 22° 37'S 15° 22'E, Jan 1926, **BORLE J 36**, (PRE, WIND); **KEETMANSHOOP: Sandmodder 73**, Apr 1975, **LENSING JE A10275**, (WIND); **Sandmodder kee 73**, 26° 52'S 18° 52'E, Apr 1975, **MULLER M 102**, (PRE, WIND); **LUDERITZ: 27° 31'S 16° 11'E**, 22 Apr 1988, **WARD CJ & SEELY MK 10245**, (WIND); **Oranjemund**, 28° 32'S 16° 32'E, 26 Apr 1988, **WARD CJ & SEELY MK 10291**, (WIND); **MALTAHOHE: Naukluft Mt. Zebra Park**, 10 Oct 1968, **VAN DER WESTHUYSEN PM 27**, (WIND); **MARIENTAL: Voigtgrund Farm**, 24° 52'S 17° 22'E, Mar 1983, **GERMISHUIZEN G 2788**, (PRE, WIND); **NAMALAND: Asab**, 25° 22'S 17° 52'E, Jan 1975, **WARD WARD 93**, (PRE, WIND); **OKAHANDJA: Okahandja**, 21° 52'S 16° 52'E, May 1888, **MARLOTH RH 1334**, (PRE); **OTJIWARONGO: Omatako**, 27 Nov 1952, **WALTER H ET E 242**, (WIND); **Quickborn**, 21° 7'S 17° 7'E, Nov 1928, **BRADFIELD RD 18**, (PRE); **Waterberg Plateau**, Dec 1935, **BOSS G TM 35006**, (PRE); **REHOBOTH: Nauzerus**, 21 May 1975, **GRIFFIN RE 71**, (WIND); **UNKNOWN: Buispoort**, Dec 1947, **RODIN RJ 2948**, (PRE); **Dassiefontein Farm**, Feb 1974, **DAVIDSE LOXTO 6269**, (PRE); **Hummelshain Farm**, Feb 1955, **DE WINTER B 2422**, (PRE, WIND); **Kuibis**, May 1933, **VAN SON G TM 31818**, (PRE); **Machenie**, Sep 1969, **MACFERREN D 114**, (PRE); **Omuverume**, 20° 37'S 17° 7'E, Dec 1938, **VOLK OH 353**, (PRE); **Waldhausen Farm**, 19 May 1953, **SCHWERDTFEGER 4024**, (WIND); **WINDHOEK: Neudamm Experimental Farm**, 11 Mar 1979, **MULLER M 1458**, (WIND); **Windhoek**, 1 Jan 1963, **SEYDEL R 3208**, (K, SRGH, WIND); **Windhoek**, 20 Nov 1949, **CODD LEW 5798**, (PRE, WIND); **WINHOEK: Otjewarumende**, 22° 0'S 18° 0'E, Jan 1921, **GILLMAN S 103**, (PRE).

SOUTH AFRICA. CAPE: 1838, ECKLON PRE 26909, (PRE); **Addo Olifant Park**, 23° 22'S 25° 52'E, Dec 1976, **BOTHA B 5735**, (PRE); **Albert District**, 30° 37'S 26° 7'E, Dec 1983, **BURROWS HH 2244**, (PRE); **Aluinkrans**, 33° 37'S 26° 7'E, Jan 1984, **JACOT-GUILLARM 9489**, (PRE); **Amherst Siding**, 31° 22'S 26° 22'E, Apr 1974, **ROBBERTSE PJ 955**, (PRE); **Barkley West**, 28° 37'S 24° 37'E, Dec 1944, **BRUECKNER AE 54**, (PRE); **Baviaanskloof**, 33° 37'S 24° 7'E, Jan 1976, **BAYLISS RDA 6164**, (PRE); **Beaufort West**, 31° 22'S 22° 37'E, Jan 1970, **ROSS JH 1**, (PRE); **Beaufort West District**, 32° 7'S 21° 52'E, Dec 1983, **SHEARING D 456**, (PRE); **Bleak House Farm**, 31° 7'S 22° 37'E, Feb 1978, **GIBBS-RUSSELL 185**, (PRE); **Bosluiskloof Pass**, 33° 22'S 21° 37'E, Oct 1966, **EDWARDS D 3365**, (PRE); **Botterkraal**, 33° 7'S 22° 22'E, Apr 1986, **ZIETSMAN ZIET 1631**, (PRE); **Broedersput District**, 26° 52'S 25° 7'E, Jan 1987, **RETIEF E 1709**, (PRE); **Buffelsrivier**, 29° 37'S 17° 7'E, Oct 1971, **CARR DJ 20**, (PRE); **Cango valley**, 33° 22'S 22° 7'E, Feb 1975, **MOFFETT RO 598**, (PRE); **Cape Town Public Gds**, 27 Sep 1937, **HALL N s.n.**, (SRGH); **Coega**, 33° 52'S 25° 37'E, Jan 1935, **LONG FR 1328**, (PRE); **De rust**, 33° 22'S 22° 37'E, Jan 1976, **SWARTZ P 22**, (PRE); **Doornkraal Farm**, 33° 37'S 22° 37'E, Jun 1972, **DAHLSTRAND KA 2253**, (PRE); **Drie Sisters**, 31° 52'S 23° 7'E, 1 Jan 1976, **SWARTZ PP 15**, (PRE, SRGH); **Eastern Cape**, 33° 37'S 26° 52'E, Feb 1971, **STREY RG 10372**, (PRE); **Ecca Pass**, 33° 7'S 26° 37'E, Jan 1976, **SWARTZ P 33**, (PRE); **Echodale Farm**, 31° 52'S 25° 52'E, Jan 1986, **RETIEF GERMIS 377**,

(PRE); **Enkelewilger**, 29° 37'S 22° 37'E, Jun 1965, **PENDERIS I 21**, (PRE); **Enon**, Dec 1930, **THODE A 2645**, (PRE); **Fort Beaufort**, 32° 52'S 26° 37'E, Jan 1976, **SWARTZ P 34**, (PRE); **Gamtoos River**, 33° 52'S 24° 52'E, Feb 1976, **SWARTZ P 29**, (PRE); **Gamtoosvallei**, 33° 52'S 25° 7'E, 21 Jan 1976, **SWARTZ PP 30A**, (PRE, SRGH); **Gouritz River**, 34° 22'S 21° 52'E, Mar 1978, **BOUCHER C 3712**, (PRE); **Graaf Reinet Division**, **MARLOTH RH 9307A**, (PRE); **Grahamstown**, 33° 7'S 26° 37'E, Jan 1976, **SWARTZ P 31**, (PRE); **Grahamstown NR**, 33° 22'S 26° 37'E, Jun 1976, **BOOIA 57**, (PRE); **Groendoom**, Jun 1931, **ORTENDAHL 1337**, (K, PRE); **Groenkloof**, 29° 7'S 17° 7'E, Mar 1984, **CARR DJ 218**, (PRE); **Groot Tafelberg**, Dec 1830, **DREGE PRE 26916**, (PRE); **Hopefield**, 33° 7'S 18° 22'E, Dec 1953, **LETTY CL 340**, (PRE); **Kalahari Gemsbok NP**, 28° 7'S 24° 37'E, Dec 1957, **LEISTNER OA 1047**, (PRE); **Karoo NR**, 32° 0'S 24° 0'E, Jan 1984, **ALLARDICE R 1576**, (PRE); **Kei Mouth**, 31° 37'S 28° 22'E, Apr 1970, **ROBBERTSE PJ 871**, (PRE); **Kei River**, 32° 37'S 28° 7'E, Nov 1945, **DYER RA 4502**, (PRE); **Kentani**, 32° 37'S 28° 22'E, Dec 1979, **VAN WYK AE 3248**, (PRE); **Kentani District**, 1902, **PEGLER A 357**, (PRE); **Kgokgole**, 26° 37'S 23° 52'E, Dec 1977, **PEETERS GERIC 56**, (PRE); **King Williams Town**, 32° 52'S 27° 22'E, 1 Apr 1975, **SWARTZ PP 177**, (PRE, SRGH); **Komga District**, Mar 1890, **FLANAGAN HG 462**, (PRE); **Kowie West**, 33° 37'S 26° 52'E, Jul 1908, **BURTT-DAVY J 7904**, (PRE); **Kuruman**, 27° 22'S 23° 22'E, Feb 1947, **GERSTNER JJ 6280**, (PRE); **Ladismith**, 33° 37'S 21° 22'E, Apr 1975, **BAYLISS RDA 7012**, (PRE); **Loerie**, Feb 1976, **SWARTZ P 30B**, (PRE); **Mbotyi**, 31° 22'S 29° 37'E, 11 May 1969, **STREY RG 8602**, (EA, PRE, SRGH); **Middelburg District**, Jan 1947, **THERON GC 101**, (PRE); **Mkambati NP**, 31° 7'S 30° 7'E, Dec 1986, **NICHOLAS SMOO 2401**, (PRE); **Mountain Zebra NP**, 31° 7'S 25° 7'E, Feb 1972, **PENZHORN B 5916**, (PRE); **Msikaba Drift**, 31° 7'S 29° 37'E, 9 May 1969, **STREY RG 8476**, (EA, PRE, SRGH); **Nelspoort**, 32° 22'S 22° 37'E, Dec 1935, **VON WOLFF NP TM 34935**, (PRE); **Nelspoort**, 32° 7'S 23° 7'E, Dec 1935, **VON WOLFF NP 27607**, (PRE); **Nossob**, 25° 26'S 20° 37'E, 30 Jul 1992, **BARNES RD 3817**, (FHO, SRGH); **Olifantshoek**, 27° 52'S 22° 52'E, Dec 1978, **VAN GREUNING J 464**, (PRE); **Orange River**, 28° 37'S 17° 37'E, Mar 1973, **THOMPSON MF 1565**, (PRE); **Oubergpass**, 33° 37'S 20° 7'E, Mar 1986, **MOFFETT STEEN 4136**, (PRE); **Oudshoorn**, 33° 37'S 22° 7'E, Apr 1976, **SWARTZ P 110A**, (PRE); **Port St Johns**, 31° 37'S 29° 37'E, Apr 1935, **JACOT-GUILLARM GH 4**, (PRE); **Prieska Division**, Feb 1921, **BRYANT EG J 172**, (PRE); **Queenstown**, 31° 52'S 26° 49'E, 16 Jul 1991, **BARNES RD 3208**, (FHO, SRGH); **Queenstown Division**, Jul 1965, **DE WINTER B 8357**, (PRE); **Redhouse**, 33° 52'S 25° 37'E, Dec 1913, **PATERSON F 426**, (PRE); **Riverine Forest**, 28° 37'S 20° 22'E, Mar 1978, **BALSINHAS HAR 3291**, (PRE); **Rolfontein NP**, 30° 7'S 24° 52'E, Nov 1974, **JOOSTE JF 209**, (PRE); **Rozymbosch Farm**, 29° 7'S 20° 52'E, Jun 1973, **LANGE C 3**, (PRE); **Setlagol River**, Feb 1956, **LEISTNER OA 558**, (PRE); **Soetmelks River**, 34° 7'S 21° 22'E, Jan 1969, **THOMPSON MF 706**, (PRE); **Swartberg Pass**, 31° 52'S 21° 52'E, Apr 1975, **ROBBERTSE PJ 988**, (PRE); **Tabankulu**, 30° 52'S 29° 22'E, 1982, **SCHACK W 72**, (PRE); **Thoming**, 27° 37'S 24° 37'E, Jan 1948, **RODIN RJ 3418**, (PRE); **Umzimvubu River**, 30° 52'S 29° 7'E, Feb 1976, **SWARTZ P 41**, (PRE); **Vaal River**, Dec 1885, **MARLOTH RH 808**, (PRE); **Vleikraal**, 31° 37'S 18° 37'E, Feb 1980, **WALTERS I 130**, (PRE); **Vrolijkheid NR**, 33° 52'S 19° 52'E, Apr 1974, **THERON GK 3075**, (PRE); **Vryburg**, 1919, **ROGERS J 99**, (PRE); **Warrenton**, 28° 7'S 24° 52'E, Apr 1917, **POLE EVANS IB PRE 11629**, (PRE); **Wilderness**, 33° 52'S 22° 7'E, Jan 1929, **MOGG AOD 11677**, (PRE); **Worcester Veld Reserve**, Jul 1934, **VAN BREDA NG 22**, (PRE); **NATAL: Amatikulu Estuary**, 29° 7'S 31° 37'E, Mar 1967, **ROSS JH 1674**, (PRE); **Banghazi Fire Tower**, 28° 7'S 31° 37'E, May 1971, **WARD CJ 7003**, (PRE); **Baynes Drift**, 29° 0'S 30° 0'E, Feb 1964, **ROSS JH 572**, (PRE); **Bisley**, Apr 1965, **MOLL EJ 1681**, (PRE); **Charters Creek**, 28° 7'S 32° 22'E, 12 Feb 1957, **WARD CJ 3056**, (PRE, SRGH); **Domba Valley**, 30° 37'S 30° 22'E, Dec 1973, **WARD CJ 8483**, (PRE); **Dukuduku Forest**, Jul 1948, **GERSTNER JJ 6676**, (PRE); **Dundee**, 28° 0'S 30° 0'E, Jan 1964, **ROSS JH 549**, (PRE); **Ehlangeni**, Mar 1914, **DOIDGE EM PRE 10464**, (PRE); **Empangeni**, 28° 37'S 31° 52'E, Apr 1956, **CODD LEW 9642**, (PRE); **Estcourt**, 29° 7'S 29° 52'E, Nov 1944, **ACOCKS JPH 10798**, (PRE); **Estcourt Hill**, 29° 0'S 29° 0'E, Mar 1964, **ROSS JH 745**, (PRE); **Estcourt Pasture Reserve**, Jun 1937, **WEST O 278**, (PRE); **Foxhill**, 29° 37'S 30° 22'E, Jan 1975, **GREEN D 62**, (PRE); **Greytown**, 28° 0'S 30° 0'E, Mar 1964, **ROSS JH 813**, (PRE); **Greytown District**, 28° 52'S 30° 37'E, Feb 1973, **REYNEKE WF 222**, (PRE); **Hamewith**, Nov 1919, **MOGG AOD 5802**, (PRE); **Hlabisa**, 28°

- 7°S 31° 52'E, Oct 1946, *ACOCKS JPH 13077*, (PRE); **Hluhluwe**, 28° 7'S 31° 7'E, Jan 1974, *WARD CJ 8558*, (PRE); **Hluhluwe**, 28° 3'S 32° 3'E, 5 Jul 1991, *BARNES RD 3166*, (FHO, SRGH); **Hluhluwe Game Reserve**, 28° 0'S 31° 0'E, Jan 1968, *BOURQUIN O PRE 52803*, (PRE); **Ingwavuma**, 27° 7'S 31° 7'E, Feb 1979, *VAN WYK AE 2511*, (PRE); **Iyoni**, Apr 1944, *GERSTNER FJ 4526*, (PRE); **Iyoni Beach**, Jan 1944, *GERSTNER FJ 4639*, (PRE); **Itala Nature Reserve**, 27° 22'S 31° 7'E, 16 Jan 1976, *BROWN & SHAPIRO 433*, (PRE, SRGH); **Itala River**, 27° 22'S 31° 7'E, Jan 1976, *BROWN & SHAPIRO 323*, (PRE); **Jaluga River**, 29° 0'S 30° 0'E, Feb 1964, *ROSS JH 622*, (PRE); **Jozini Dam**, 27° 22'S 31° 7'E, Feb 1976, *BRENAN JPM 14238*, (PRE); **Keate's Drift**, 28° 0'S 30° 0'E, Mar 1964, *ROSS JH 825*, (PRE); **Kosi Bay Estuary**, 26° 52'S 32° 52'E, 24 Nov 1967, *STREY & MOLL 3837*, (PRE, SRGH); **Kranskop District**, 28° 0'S 30° 0'E, Mar 1964, *ROSS JH 832*, (PRE); **Ladysmith**, 28° 37'S 29° 52'E, Apr 1966, *ROSS JH 1617*, (PRE); **Lake Nhlabane**, 28° 39'S 32° 16'E, 9 Jul 1991, *BARNES RD 3183*, (FHO, SRGH); **Lake Sibayi**, 27° 22'S 31° 37'E, 1 Mar 1968, *ROSS & MOLL 1845*, (PRE, SRGH); **Lake St Lucia**, 28° 7'S 32° 22'E, Feb 1956, *VINCENT WARD I*, (PRE); **Lebombo Mts.**, 27° 22'S 31° 7'E, Apr 1966, *ROSS JH 1648*, (PRE); **Louwsburg**, 27° 0'S 31° 0'E, May 1964, *ROSS JH 1243*, (PRE); **Louwsburg District**, 27° 22'S 31° 7'E, Jan 1976, *BROWN & SHAPIRO 368*, (PRE); **Lower Umfolozi District**, Mar 1964, *MOLL EJ 804*, (PRE); **Manaba**, 5 Feb 1944, *GERSTNER JJ 4529*, (PRE, SRGH); **Mandeni**, 29° 0'S 31° 0'E, Mar 1964, *ROSS JH 867*, (PRE); **Manzengwenya**, 27° 15'S 32° 46'E, 28 Jun 1991, *BARNES RD 3151*, (FHO, SRGH); **Mapelana**, 28° 22'S 32° 22'E, Nov 1964, *STREYRG 5417*, (PRE); **Matubatuba**, 28° 22'S 31° 7'E, 23 Feb 1968, *ROSS & MOLL 1770*, (EA, PRE); **Mfongosi**, May 1926, *WAIT BRANDWYK 1263*, (PRE); **Mkomas River**, May 1965, *KEYTEL CL 481*, (PRE); **Mkuze Game Reserve**, 27° 0'S 31° 0'E, Feb 1968, *BOURQUIN O 539*, (PRE); **Mooi river**, 29° 0'S 29° 0'E, Mar 1964, *ROSS JH 743*, (PRE); **Mpangazi Lake**, 27° 37'S 32° 37'E, Jan 1964, *STREY RG 4960*, (PRE); **Matubatuba**, 28° 22'S 31° 7'E, Oct 1964, *ROSS JH 1366*, (PRE); **Muden**, 28° 0'S 30° 0'E, Feb 1964, *ROSS JH 640*, (PRE); **Nagle Dam**, 29° 37'S 30° 37'E, Jan 1957, *WELLS MJ 1059*, (PRE); **Ngweni**, Feb 1982, *LAMBINON REEK 82/185*, (PRE); **Nhlange Lake Eastern**, 26° 52'S 31° 52'E, Jan 1974, *WARD CJ 8518*, (PRE); **Nkandladube**, 28° 0'S 31° 0'E, Mar 1968, *DOWNING BH 481*, (PRE); **Nongoma**, 4 Feb 1957, *WARD CJ 3036*, (PRE, SRGH); **Nongoma District**, Mar 1957, *WARD CJ 3036B*, (PRE); **Ntimona**, 28° 37'S 31° 52'E, Apr 1968, *VENTER HJT 4683*, (PRE); **Nyalazi River Valley**, Feb 1956, *WARD CJ 2959*, (PRE); **Palm Ridge Farm**, 28° 22'S 31° 7'E, Nov 1957, *HARRISON ER 284*, (PRE); **Park Rynie**, Dec 1913, *MEDLEY-WOOD J 12533*, (PRE); **Pinetown**, 29° 52'S 30° 52'E, Jan 1972, *WARD CJ 7551*, (PRE); **Pongola Bushveld Far**, 27° 22'S 31° 37'E, Jan 1972, *NEL MDS 124*, (PRE); **Port Edward**, 30° 0'S 30° 0'E, Mar 1964, *ROSS JH 805*, (PRE); **Port Natal**, 29° 52'S 31° 7'E, *GUEINZIUS W 9548*, (PRE); **Port Shepstone**, 13 Feb 1964, *ROSS JH 617*, (LISC); **Reservoir Hills**, Nov 1963, *WARD CJ 4808*, (PRE); **Richards Bay**, 28° 52'S 31° 7'E, Dec 1975, *WARD CJ 8839*, (PRE); **Richmond**, 29° 52'S 30° 7'E, Jan 1980, *HILDYARD CJ 80*, (PRE); **Schoonstrom**, 28° 23'S 31° 17'E, 8 Jul 1991, *BARNES RD 3176*, (FHO, SRGH); **Shongweni Dam**, 28° 7'S 31° 7'E, Feb 1966, *MORRIS JW 812*, (PRE); **Sihangwana Store**, 26° 52'S 31° 37'E, Feb 1968, *ROSS & MOLL 1824*, (PRE); **Somkele**, Nov 1955, *WARD CJ 2706*, (PRE); **Sordwana Bay**, 27° 37'S 31° 37'E, Feb 1973, *REYNEKE WF 232*, (PRE); **St. Lucia**, 28° 22'S 32° 22'E, Feb 1982, *BAMPS P 7106*, (PRE); **St. Lucia Park**, 28° 7'S 31° 22'E, May 1958, *JACOBSEN W 1357*, (PRE); **The Rocks**, 30° 37'S 30° 7'E, Jan 1978, *MANTELL VASSI 90*, (PRE); **Tongaland**, 20 Dec 1964, *BOURQUIN O 372*, (SRGH); **Tugela Ferry**, 15 Mar 1964, *ROSS JH 828*, (LISC); **Umfolozi Game Reserve**, 28° 0'S 31° 0'E, Mar 1964, *ROSS JH 913*, (PRE); **Umgeni Dam**, May 1965, *MOLLEJ 1710*, (PRE); **Umkomaas River**, 29° 0'S 30° 0'E, Feb 1964, *ROSS JH 623*, (PRE); **Umtamvuna FR**, 31° 7'S 30° 7'E, Jul 1970, *STREYRG 9866*, (PRE); **Umtamvuna NR**, 30° 52'S 30° 7'E, Sep 1982, *ABBOTT A 281*, (PRE); **Umvoti District**, 28° 0'S 30° 0'E, Mar 1964, *ROSS JH 822*, (PRE); **Upper Blood River**, May 1962, *EDWARDS D 2836*, (PRE); **Utrecht**, 27° 37'S 30° 22'E, Jan 1916, *WAHLA TM 15533*, (PRE); **Uvongo**, 30° 0'S 30° 0'E, Mar 1964, *ROSS JH 802*, (PRE); **Valley of a Thousand Hills**, 3 Jan 1960, *WATMOUGH R 467*, (PRE, SRGH); **Van Reenens Pass**, 28° 0'S 29° 0'E, Jan 1964, *ROSS JH 535*, (PRE); **Winklespruit**, 29° 52'S 31° 7'E, Jan 1911, *POLE EVANS IB PRE.6553*, (PRE); **Winterton**, 28° 0'S 29° 0'E, Mar 1964, *ROSS JH 756*, (PRE); **ORANGE FREE STATE: Bloemfontein**, 29° 0'S 26° 0'E, Jan 1969, *MULLER DB 451*, (PRE); **Bothaville**, 27° 22'S 26° 37'E, Jan 1933, *GOOSSENS AP 1193*, (PRE); **Bultfontein**, 28° 7'S 26° 7'E, Nov 1972, *WAGENAAR G 3*, (PRE); **Danielsrus**, 28° 7'S 28° 22'E, 16 Jan 1969, *WERGER MJA 170*, (EA, PRE, SRGH); **Doornkop**, 28° 52'S 27° 52'E, Dec 1931, *GOOSSENS AP 737*, (PRE); **Doringspruit**, 28° 52'S 26° 22'E, Apr 1975, *SWARTZ P 183*, (PRE); **Edenville**, 27° 52'S 27° 52'E, Dec 1966, *VAN RENSBURG HJ 24*, (PRE); **Ferrara**, 28° 22'S 27° 22'E, Dec 1931, *GOOSSENS AP 971*, (PRE); **Florisbad**, 28° 52'S 26° 7'E, Feb 1985, *ZIETSMAN ZIET 221*, (PRE); **Garingsdrift**, Jan 1928, *SMITH CA 5278*, (PRE); **Glen Landboukollege**, 28° 52'S 26° 37'E, Dec 1984, *ZIETSMAN ZIET 42*, (PRE); **Kloof**, 26° 22'S 28° 22'E, Jan 1912, *THODE J STEU 3070*, (PRE); **Kroonstad**, 27° 37'S 27° 7'E, Feb 1967, *SCHEEPERS JC 1344*, (PRE); **Luckhoff**, 29° 37'S 24° 52'E, Jan 1928, *SMITH CA 5324*, (PRE); **Mooivlakte Paaas**, 28° 52'S 26° 22'E, Apr 1975, *SWARTZ P 182*, (PRE); **Oppermansdrift Dam**, 27° 37'S 25° 22'E, Dec 1974, *O'CONNOR TG 42*, (PRE); **Petrusburg**, 29° 7'S 25° 22'E, Mar 1980, *REID C 362*, (PRE); **Sasolburg**, 26° 52'S 27° 52'E, Nov 1966, *THERON GK 567*, (PRE); **Willem Pretorius GR**, 28° 22'S 27° 7'E, Nov 1962, *VAN ZINDEREN B 993*, (PRE); **TRANSVAAL: Amersfoort**, 26° 52'S 29° 52'E, Jan 1968, *STREY RG 7881*, (PRE); **Apies River**, 25° 22'S 28° 22'E, Nov 1907, *LEENDERTZ R 3528*, (PRE); **Arcadia**, 22° 22'S 29° 7'E, Dec 1925, *SMITH CA 16944*, (PRE); **Barberspan NR**, 26° 37'S 25° 37'E, Mar 1973, *ZAMBATIS N 41*, (PRE); **Barberton**, 25° 52'S 31° 7'E, Dec 1916, *POTT-LEENDERTZ 5304*, (PRE); **Barberton District**, 25° 0'S 31° 7'E, 1979, *FOURIE SP 250*, (PRE); **Bedford View Hills**, 25 Feb 1950, *MOGG AOD 18848*, (LISC); **Blauwberg**, May 1933, *LEEMAN AC 59*, (PRE); **Bloemhofdam NR**, 27° 0'S 25° 0'E, Jan 1978, *DE WET J 39*, (PRE); **Boskop**, Dec 1939, *LOUW WJ 592*, (PRE); **Boskuil**, 27° 22'S 25° 52'E, May 1929, *SUTTON JD 120*, (PRE); **Botanical Gardens**, 25° 37'S 28° 22'E, Mar 1978, *BALSINHAS AA 3271*, (PRE); **Brak River**, 22° 52'S 29° 7'E, Nov 1974, *ZWANZIGER S 540*, (PRE); **Brits District**, Jan 1911, *JONNES S PRE 6267*, (PRE); **Buffelsdrift**, Dec 1965, *VAHRMEIJER J 1285*, (PRE); **Buffelspoort**, Dec 1934, *TURNER FAS 43*, (PRE); **Bushbuck Ridge**, Nov 1937, *PRITCHARD JA 24*, (PRE); **Carletonville**, 26° 22'S 27° 22'E, Apr 1983, *VAN WYK S 325*, (PRE); **Christiana**, 27° 52'S 25° 7'E, Jun 1970, *OATES LG 318*, (PRE); **Codrington Siding**, 10 May 1966, *MOGG AOD 32734*, (PRE, SRGH); **Crocodile River Poort**, Dec 1918, *ROGERS FA 2225*, (PRE); **Deelkraal**, 26° 22'S 27° 22'E, May 1979, *BOTHA DJ 2535*, (PRE); **Delareyville**, 26° 37'S 25° 22'E, Jan 1987, *RETIEF E 1814*, (PRE); **Derdepoot**, 23° 37'S 28° 7'E, Dec 1965, *GROBBELAAR N 454*, (PRE); **Dieprivier**, 23° 52'S 29° 37'E, 1980, *FOURIE SP 1170*, (PRE); **Dunningkamp**, 25° 52'S 27° 52'E, Nov 1970, *COETZEE BJ 445*, (PRE); **Elim**, 23° 7'S 30° 7'E, Dec 1930, *OVERMEYER AA 939*, (PRE); **Faai Spruit**, 25° 7'S 31° 22'E, Jan 1952, *VAN DER SCHIJF 352*, (PRE); **Faan Meintjies NR**, 26° 52'S 26° 37'E, Feb 1985, *BEZUIDENHOUT H 14*, (PRE); **Faerie Glen**, 25° 37'S 28° 22'E, Nov 1971, *SAGP-SAAB/2 2/19*, (PRE); **Faerie Glen Township**, 25° 52'S 28° 22'E, Nov 1971, *SAGP-SAAB/1 60*, (PRE); **Fanie Botha Reserve**, 23° 52'S 30° 7'E, Apr 1983, *RETIEF IM 54*, (PRE); **Fochville**, 26° 22'S 27° 22'E, Dec 1976, *BOHNEN P 292/1*, (PRE); **Fonteine**, Jan 1905, *LEENDERTZ R 543*, (PRE); **Fountains Valley**, 25° 37'S 28° 7'E, Jun 1928, *VERDOORN IC 409*, (PRE); **Giyani District**, 23° 7'S 30° 7'E, Jul 1977, *LIENGME CA 158*, (PRE); **Gopane**, 25° 22'S 25° 52'E, Jan 1977, *SNYMAN JW 28*, (PRE); **Groblerdal**, 25° 22'S 29° 22'E, 19 Feb 1954, *CODD LEW 8435*, (PRE, SRGH); **Groenkloof**, Apr 1911, *VAN DAM G TM 10294*, (PRE); **Groot Marico**, 25° 37'S 26° 22'E, May 1903, *BURIT-DAVY J 128*, (PRE); **Haenertsburg**, 23° 52'S 30° 52'E, Jan 1955, *PROSSER LN 1911*, (PRE); **Heidelberg District**, Nov 1927, *THODE A1314*, (PRE); **Hendriksrust**, 26° 7'S 26° 7'E, Jan 1968, *MORRIS JW 1151*, (PRE); **Johannesburg**, 26° 7'S 28° 7'E, Mar 1973, *THATCHER F 739*, (PRE); **Kareekloof**, 26° 37'S 28° 22'E, Dec 1971, *BREDENKAMP GJ 360*, (PRE); **Kleinfontein Farm**, 25° 22'S 30° 22'E, Jun 1971, *BURGER GH 12*, (PRE); **Klipvoor NR**, Jan 1977, *MATLHAKU L 166*, (PRE); **Komati River**, 25° 7'S 31° 22'E, Jan 1905, *MOORE A PRE.13*, (PRE); **Kommandodrif**, 27° 22'S 26° 7'E, Jan 1968, *MORRIS JW 1043*, (PRE); **Kratzenstein**, Feb 1931, *HOFFMANN CC 33*, (PRE); **Kromdraai**, 24° 52'S 29° 22'E, Jan 1979, *LESSING P 91*, (PRE); **Kroonhoek**, May 1934, *POLE EVANS IB 4294*, (PRE); **Kruger NP**, 15 Jan 1954, *VAN DE SCHUFTHP 3428*, (SRGH); **Krugersdorp District**, Feb 1961, *WELLS MJ 2424A*, (PRE); **Laersburg**, Dec 1934, *THERON JJ 1041*, (PRE); **Laersdrif**, Apr 1969, *ROSS JH 2089*, (PRE); **Langjan NR**, 22° 52'S 27° 7'E, Jan 1968, *HUNTLEY BJ 1163*, (PRE); **Lebombo Mts.**, Oct 1952, *VAN DER SCHIJF 887*, (PRE); **Lejuma Plateau**, Apr 1966, *SCHLIEBEN HJ 10660*, (PRE); **Lekgalameetse NR**, 24° 7'S 30° 22'E,

- Jun 1984, *STALMANS M 42*, (PRE); *Lekkerluch*, Dec 1939, *LOUW WJ 603*, (PRE); *Lichtenburg*, 26° 7'S 26° 7'E, Feb 1970, *MORRIS ENGELB 1113*, (PRE); *Loskop Dam*, 25° 7'S 29° 22'E, 23 May 1968, *STREY & LEISTNER 8266*, (EA, PRE, SRGH); *Loskop Dam NR*, 25° 22'S 29° 22'E, Mar 1975, *SWARTZ P 190*, (PRE); *Loskop Irrigation dam*, Mar 1944, *MOGG AOD 17293*, (PRE); *Louis Trichardt*, 23° 7'S 29° 52'E, Dec 1945, *GERSTNER JJ 5800*, (PRE); *Lowveld Botanic Garden*, 25° 22'S 30° 52'E, Nov 1970, *BUITENDAG EL 779*, (PRE); *Lydenburg*, 24° 52'S 30° 22'E, Jun 1979, *ARNOLD TH 1263*, (PRE); *Magalakwin River*, 24° 7'S 29° 7'E, Dec 1966, *MOGG AOD 37236*, (PRE); *Magaliesberg*, 25° 37'S 27° 37'E, Dec 1978, *MATTHEWS GC 325*, (PRE); *Magoebas Kloof*, 10 May 1945, *GERSTNER JJ 5417*, (SRGH); *Magoebaskloof*, 23° 52'S 30° 7'E, May 1945, *GERSTNER JJ 5417*, (PRE); *Makapansgat*, 24° 7'S 29° 7'E, Oct 1944, *VERDOORN IC 2257*, (PRE); *Makonde Mission*, 22° 52'S 30° 37'E, Feb 1952, *CODD LEW 6850*, (PRE); *Malaboks Kraal*, Dec 1923, *SMUTS POLE EV 864*, (PRE); *Mandalay*, Jun 1937, *CURSON IRVINE 64*, (PRE); *Manwane*, 25° 22'S 25° 52'E, Feb 1975, *VAN DER MEULEN 67FM*, (PRE); *Mapochs River*, 25° 7'S 29° 52'E, Apr 1969, *ROSS JH 2092*, (PRE); *Mara Pasture St.*, 23° 7'S 29° 37'E, Apr 1971, *STEPHEN JIF 244*, (PRE); *Marico District*, Dec 1926, *VAN DER MERWE 22*, (PRE); *Merensky Dam*, 23° 37'S 30° 7'E, 18 Jan 1961, *SCHEEPERS JC 1095*, (PRE, SRGH); *Middelburg District*, Mar 1933, *BLIGNAUT 4*, (PRE); *Montrose Falls*, 25° 22'S 30° 37'E, 19 Mar 1968, *KILLICK DJB & DE WINTER B 8965*, (PRE, SRGH); *Morone PO*, Apr 1964, *CODD LEW 10483*, (PRE); *Naboomspruit*, 24° 37'S 28° 37'E, Nov 1919, *GALPIN EE M 110*, (PRE); *Nat. bot. Gardens*, 25° 37'S 28° 22'E, Jun 1988, *JOFFE H 518*, (PRE); *Nelspruit*, 25° 22'S 30° 52'E, Oct 1984, *ONDERSTALL J 1137*, (PRE); *Nelspruit District*, Dec 1962, *LEACH LC 11569*, (PRE); *Nelspruit*, 25° 22'S 30° 52'E, May 1984, *PRESTON-MAFHAM 11*, (PRE); *New Agatha District*, Nov 1918, *MACCALLUM I 780*, (PRE); *Nylstroom*, 24° 7'S 28° 7'E, Mar 1987, *WESTFALL RH 2240*, (PRE); *Nylsvley NR*, 24° 37'S 28° 37'E, Apr 1982, *MILTON S 222*, (PRE); *Ohrigstad Dam NR*, 24° 52'S 30° 7'E, Nov 1970, *JACOBSEN NHG 1356*, (PRE); *Oil Fields*, Feb 1930, *GALPIN EE 9781*, (PRE); *Oliemyne*, Dec 1960, *DEVENISH NJ 327*, (PRE); *Onderstepoort*, 25° 37'S 28° 7'E, Apr 1933, *GRAF SMITH I*, (PRE); *Pampoeneek*, 25° 37'S 27° 52'E, Nov 1984, *EKOKONSULT 3034*, (PRE); *Percy Fyfe NR*, 24° 0'S 29° 0'E, 28 Jan 1968, *HUNTLEY BJ 1157*, (PRE, SRGH); *Phalaborwa District*, 24° 7'S 31° 7'E, Dec 1984, *RETIEF IM 290*, (PRE); *Piensaars River*, 25° 0'S 28° 0'E, Oct 1966, *DAHLSTRAND KA 1815*, (PRE); *Piensaars River Rail*, 25° 7'S 28° 22'E, Dec 1966, *MOGG AOD 37197*, (PRE); *Piensaars River St*, May 1952, *CODD LEW 7047*, (PRE); *Pilanesberg*, 25° 22'S 27° 7'E, Jan 1977, *VAN DER WALT 91*, (PRE); *Pilgrims Rest*, 24° 7'S 30° 7'E, 15 Jun 1966, *EDWARDS D 3352*, (EA, SRGH); *Pongola*, 27° 37'S 31° 22'E, Feb 1979, *VAN WYK AE 2485*, (PRE); *Potchefstroom*, 26° 7'S 27° 52'E, Nov 1982, *BEHR CM 143*, (PRE); *Potgietersrust*, 24° 7'S 29° 7'E, Jul 1932, *POLE EVANS IB 3504*, (PRE); *Pretoria*, 25° 0'S 28° 0'E, Mar 1971, *SCHLIEBEN HJ 11964/63*, (PRE); *Pretoria bot garden*, 25° 37'S 28° 7'E, Dec 1941, *VERDOORN IC PRE.26526*, (PRE); *Pretoriuskop*, 25° 7'S 31° 22'E, May 1950, *CODD LEW 6051*, (PRE); *Pretoriuskop District*, Jan 1954, *VAN DER SCHIJF 3428*, (PRE); *Rooikop*, 25° 37'S 28° 7'E, Dec 1932, *SMUTS & GILLET 2107*, (PRE); *Rooiplaat*, Mar 1906, *LEENDERTZ R 779*, (PRE); *Rust der Winter*, 25° 7'S 28° 37'E, Mar 1979, *UECKERMANN A 73*, (PRE); *Rustenburg*, 25° 37'S 27° 22'E, 2 Mar 1972, *COETZEE BJ 1158*, (EA, PRE); *Rustenburg NR*, 25° 37'S 27° 7'E, Mar 1970, *JACOBSEN NHG 9536*, (EA, PRE, SRGH); *Skuinsdrift*, Apr 1927, *LIEBENBERG BAM 549*, (PRE); *South-Eastern District*, 25° 7'S 29° 52'E, Mar 1968, *MORRIS JW 1181*, (PRE); *Spekboom River*, Nov 1933, *YOUNG RGN A 451*, (PRE); *Springbok Flats*, May 1905, *BURTT-DAVY J 4077*, (PRE); *Steelpoort*, 24° 52'S 30° 22'E, 19 Apr 1969, *ROSS JH 2094*, (EA, PRE); *Steelpoort PO*, Mar 1953, *CODD DYER 7713*, (PRE); *Sterkrievierdam*, 24° 22'S 28° 37'E, Feb 1972, *JACOBSEN NHG 1933*, (PRE); *Tate Vondo FR*, 22° 52'S 30° 22'E, Dec 1977, *HEMM G 461*, (PRE); *Tierkopspuit*, 25° 22'S 27° 22'E, Mar 1985, *WELMAN WG 568*, (PRE); *Tshipise*, 22° 37'S 30° 7'E, Jul 1946, *GERSTNER JJ 6225*, (PRE); *Vaal River*, 27° 22'S 26° 7'E, Jan 1968, *MORRIS JW 1048*, (PRE); *Vaalwater District*, 24° 7'S 28° 22'E, Apr 1973, *BURGER GH 223*, (PRE); *Venterskroon*, 26° 52'S 27° 7'E, Nov 1982, *UBBINK B 1124*, (PRE); *Vereeniging*, 26° 37'S 27° 52'E, Nov 1911, *LEENDERTZ R TM 10831*, (PRE); *Warmbaths*, 24° 52'S 28° 22'E, May 1905, *BURTT-DAVY J 4075*, (PRE); *Waterberg District*, Dec 1963, *VAN DER SCHIJF 6554*, (PRE); *Waterkloof*, Dec 1908, *COLLINS M TM 7044*, (PRE); *Waterval Onder*, 25° 37'S 30° 22'E, Feb 1926, *YOUNG RGN TM 26454*, (PRE); *Weigelgen*, 26° 52'S 26° 7'E, Dec 1972, *HANEKOM WJ 2003*, (PRE); *Witbank*, 25° 22'S 29° 7'E, 2 Mar 1968, *MORRIS JW 1168*, (PRE, SRGH); *Witstinkhoutboom*, Jan 1926, *LIEBENBERG BAM 49*, (PRE); *Wolkberg*, Feb 1962, *VAN VUUREN DRJ 1373*, (PRE); *Wolmaransstad District*, Apr 1933, *LANG H TM 31715*, (PRE); *Wolwerand*, 26° 52'S 26° 22'E, Dec 1972, *HANEKOM WJ 2009*, (PRE); *Wonderboom aerodrome*, 25° 37'S 28° 7'E, 15 Feb 1972, *COETZEE BJ 874*, (PRE, SRGH); *Wonderkloof NR*, Jan 1978, *KLUGE JP 1149*, (PRE); *Wyllie's poort PO*, 22° 52'S 29° 52'E, Apr 1972, *BEN-DOVY 100*, (PRE); *Zeerust*, 25° 22'S 26° 37'E, Mar 1983, *BALSINHASAA 3619*, (PRE); *Zoutpansberg*, Jun 1906, *BURTT-DAVY J 5225*, (PRE); *Zoutpansberg District*, Jun 1906, *BURTT-DAVY J 5226*, (PRE);
- SWAZILAND. HHOHO:** *Ezulwini*, Jan 1956, *COMPTON RH 25445*, (PRE); *Mantanga Falls*, 26° 26'S 31° 11'E, 21 Oct 1976, *KEMP ES 390*, (SRGH); *Mbabane*, 26° 7'S 31° 7'E, Aug 1978, *ALEXANDER-PRIO 109*, (PRE); *LUBOMBO: Black Umbeluzi River*, 25° 52'S 31° 37'E, Dec 1969, *BARRETT SCH 402*, (PRE); *Lubombo Mts.*, 26° 22'S 31° 52'E, May 1976, *CULVERWELL J 0027*, (PRE); *Malinda*, 26° 22'S 31° 37'E, Jan 1978, *KEMP ES 1219*, (PRE); *Mhlumeni River*, Jan 1964, *DLAMINI B PRE 52783*, (PRE); *Stegi District*, Jan 1960, *COMPTON RH 29750*, (PRE); *Stegi Hills*, 26° 30'S 32° 0'E, Dec 1957, *COMPTON RH 27325*, (PRE); *MAHUKU: Mhlumeni River*, 26° 19'S 31° 1'E, 22 Jun 1991, *BARNES RD 3135*, UNKNOWN; *Abercorn point*, Apr 1947, *CODD DYER 2860*, (PRE); *Palata*, Oct 1961, *COMPTON RH 30812*, (PRE).
- ZAMBIA. CHIRAMBA:** *Mkuyu*, 2 Mar 1933, *MICHELMORE APG s.n.*, (K); **LUSAKA:** *Lusaka*, 15° 26'S 28° 20'E, 26 Nov 1965, *LAWTON RM 1342*, (K, SRGH); *Lusaka-Kafue*, 1900, *ANGUS A 1442*, (FHO, K); **SOUTHERN:** *Choma*, 16° 51'S 27° 3'E, 16 Mar 1960, *WHITE F 7792*, (K); UNKNOWN: *Chaloshi, chiramba*, 28 Feb 1933, *MICHELMORE APG S.N.*, (K).
- ZIMBABWE. BELINGWE:** *Otto mine*, 20° 48'S 29° 40'E, 17 Mar 1964, *WILD H 6403*, (FHO, K, SRGH); *BUBI: Gwampa FR*, 22 Dec 1957, *BARRETT RL 143/57*, (SRGH); *Gwampa Forest Reserve*, 19° 10'S 28° 30'E, 22 Dec 1957, *BARRETT RL 82836*, (K); *Inyati Mission*, 19° 39'S 28° 54'E, 23 Apr 1947, *KEAY RWJ FH121223*, (FHO, SRGH); **BULAWAYO:** *Umguza Valley Estates*, 19° 58'S 28° 32'E, 28 Mar 1992, *BARNES RD 3650*, (FHO, SRGH); *Umguza Valley Estates*, 19° 58'S 28° 31'E, 1 Jun 1989, *BARNES RD 1909*, (FHO, SRGH); **CHEGUTU:** *Selous*, 18° 13'S 30° 23'E, 1 Jan 1988, *BARNES RD 509*, **CHIMANIMANI:** *Cashel*, 32° 45'S 19° 31'E, 18 Mar 1964, *CORBY HDL 1106*, (K, SRGH); *Nyanyadzi*, 32° 40'S 19° 46'E, 1 Jul 1959, *DAVIES RM 2564*, (SRGH); *Sabi River Valley*, 1 Jun 1932, *JACK RW 5986*, (SRGH); *Skyline Junction*, 19° 53'S 32° 44'E, 28 Nov 1955, *DRUMMOND RB 5044*, (K, SRGH); *CHIPINGE: Chikore*, 32° 31'S 20° 27'E, 16 Feb 1960, *FARRELL JA 141*, (SRGH); *Chirinda*, 20° 24'S 32° 43'E, 6 Feb 1905, *SWYNNERTON CFM 59*, (K); *Chirinda Forest*, 20° 26'S 32° 42'E, 1 Mar 1967, *GOLSMITH B 33/67*, (K, SRGH); *Gungunyama*, 20° 23'S 32° 43'E, 6 Jun 1988, *BARNES RD 512*, (FHO, SRGH); **CHIRUMANZU:** 14 Feb 1951, *MULLIN LJ 35/51*, (FHO, SRGH); **GURUVE:** *Nyamunyeche Estate*, 16° 55'S 30° 46'E, 14 Nov 1978, *NYARIRI P 474*, (SRGH); **GWERU:** *Gwelo*, 19° 27'S 29° 49'E, 12 Nov 1967, *BIEGEL HM 2316*, (SRGH); **HARARE:** *Audley End*, 17° 44'S 30° 36'E, 1 Dec 1970, *GORDON JAD 162*, (SRGH); *Harare*, 1 Nov 1919, *EYLES 1908*, (FHO, K, SRGH); *Seki Reserve*, 17° 43'S 31° 5'E, 13 Jun 1933, *PARDYAA P6633*, (K); **INSIZA: Blackwaters Ranch**, 19° 48'S 29° 10'E, 2 Mar 1991, *BARNES RD 2767*, (FHO, SRGH); **KWEKWE:** *Amatava Farm*, 19° 3'S 29° 52'E, 21 Jul 1965, *BIEGEL HM 144*, (SRGH); *Sable Park*, 18° 3'S 30° 2'E, 13 Jan 1977, *CHIPUNGA L 99*, (SRGH); **MAKONDE:** *Camp Mine*, 5 Dec 1960, *RUTHERFORD-SMITH ROB 390*, (EA, SRGH); *Mtorashanga*, 17° 9'S

30° 40'E, 5 May 1977, CANT P s.n., (EA, SRGH); **Mutorashanga**, 17° 10'S 30° 42'E, 14 Jun 1991, FAGG CW 1, (FHO); **MAKONI: Baddeley**, 18° 20'S 32° 9'E, 28 Feb 1991, BARNES RD 2760, (FHO, SRGH); **Rusape**, 18° 32'S 32° 7'E, 29 Dec 1952, MUNCH R 404, (SRGH); **Rusape**, 18° 32'S 32° 7'E, 10 Dec 1966, CORBY HDL 1689, (SRGH); **MARONDERA**: 21 Dec 1966, CORBY HDL 1701, (K, SRGH); **MASVINGO: Fort Victoria**, 20° 5'S 30° 50'E, 1 Jun 1932, CUTHBERTSON A 5858, (SRGH); **Zimbabwe NP**, 20° 18'S 30° 57'E, 2 Nov 1970, CHIPARAWASHA O 103, (SRGH); **MATOBO: Hope Fountain Mssn**, 20° 16'S 28° 39'E, 21 Apr 1973, NORRGRANN G 342, (SRGH); **MAZOWE: Mazoe Dam**, 17° 37'S 31° 4'E, 24 May 1934, GILLILAND HB 200, (FHO, K); **MUTARE: Odanzi river valley**, 1915, TEAGUE AJ 509, (K); **Old Umtali Mssn**, 18° 51'S 32° 39'E, 29 Dec 1967, BIEGELHM 2461, (SRGH); **Penhalonga**, 18° 53'S 32° 41'E, 20 Jan 1945, HOPKINS 13228, (SRGH); **Penhalonga**, 18° 53'S 32° 41'E, 21 Dec 1964, CORBY HDL 1198, (SRGH); **NDANGA**: Apr 1953, VINCENT V 197, (FHO); **NYAMANDHLOVU**: 19° 40'S 27° 50'E, 1 May 1959, ARMITAGE FB 56/59, (SRGH); **NYANGA: Nyamaropa Reserve**, 18° 0'S 32° 50'E, 25 Jul 1966, CORBY HDL 1626, (SRGH); **Udu Dam**, 18° 17'S 32° 42'E, 17 Jan 1988, BARNES RD 510, SHURUGWI: 1917, WALTERS JAS 2353, (K); **WEDZA: Wedza Mountain**, 18° 45'S 31° 35'E, 22 May 1968, RUSHWORTH JE 1072, (SRGH).

[References:- 27, 179]

Related species

The glandular podded *Acacia* species (*Acacia borleae*, *A. exuvialis*, *A. nebrownii*, *A. permixta*, *A. swazica*, *A. tenuispina* and *A. torrei*) in southern Africa are all related to *A. karroo*. *A. karroo* differs from them all in lacking spinulose-mucronate leaflet apices and glandular pods.

Acacia seyal is also closely related to *A. karroo*, but differs in having powdery bark and the "ant-galls" (when present) confluent and distinctly bilobed basally. The northern limit of distribution of *A. karroo* in Africa corresponds roughly with the southern limit of distribution of *A. seyal*.

[References:- 87, 169, 173, 174, 176, 177, 179, 208, 243]

Natural hybrids

On the Springbok Flats north of Pretoria small shrubby plants occur which can be distinguished from *Acacia tenuispina* only with difficulty. Some of the plants have a similar growth form to *A. tenuispina* but as they lack spinulose-mucronate leaflet apices and glandular pods they are referred to *A. karroo*. Some collectors have suggested that the plants may be hybrids between *A. karroo* and *A. tenuispina*. Burt Davy 4075 and Codd 7040 are representative. (Ross, 1979).

On the Umguza Valley Estates near Bulawayo in Zimbabwe, a tree has been found in a mixed population of *Acacia karroo* and *A. rehmanniana* that has taxonomic characteristics that are intermediate between the two species (Barnes *et al.*, 1994) (Plates 2C-D). The habit is more similar to *A. karroo* but the stem colour is closer to the reddish brown of *A. rehmanniana*; the pubescence of the branchlets, leaf rachis and leaflets is intermediate between

A. karroo (glabrous) and *A. rehmanniana* (densely pubescent); the leaf is glandular (as are the leaves of both *A. karroo* and *A. rehmanniana*) with an average 11 pairs of pinnae (*A. karroo* average 4 and *A. rehmanniana* 30) and 25 pairs of leaflets per pinna (*A. karroo* average 10 and *A. rehmanniana* average 36); the leaflets are closely spaced on the rachis but not overlapping (the leaflets of *A. karroo* are distinctly spaced on the rachis whereas those of *A. rehmanniana* overlap); the flowers are lemon-yellow (*A. karroo* yolk yellow and *A. rehmanniana* creamy-white); the tree bears no pods. Leaf peroxidase analyses of samples from this tree and from neighbouring trees of *A. karroo* and *A. rehmanniana* indicated that the tree could be a hybrid between these two species; *A. nilotica*, also a neighbour, was ruled out as a possible parent by this analysis (Brain, pers. comm.)¹ Barnes RD 3651 (FHO, SRGH) is representative.

[References:- 27, 179]

GENETIC VARIATION

Morphological variation

The extent to which the morphological variation, described under the botanical description above, over the range of *Acacia karroo* is due to genetic differences can be determined only through the establishment of comparative field trials in which the effects of environment can be controlled. The extremes of environment over which the species is indigenous will in itself have a profound effect on the morphology of the tree; but, it would be surprising if these environments themselves have not induced significant genetic adaptive responses in *A. karroo*.

In a numerical taxonomic evaluation of *Acacia karroo* in southern Africa (Swartz, 1982), 38 characters were used in an analysis that distinguished between six well defined intra-specific groups. Seedlings of these groups cultivated under controlled conditions similarly showed morphological variation, indicating that the groups were genetically fixed. In a range-wide study (Barnes *et al.*, 1994), material is now being raised for provenance trials and early results confirm that there is substantial morphological variation in the seedlings and that it is under genetic control (Figure 3; Plates 2E-G). This material is to be used for the establishment of international provenance evaluation trials that will provide information on the genetic control of variation of field characteristics within and between populations. This information will be important for devising optimum strategies for domestication and breeding but it will only provide pointers for the taxonomist. Whether there are grounds for sub-division of the taxon will depend upon

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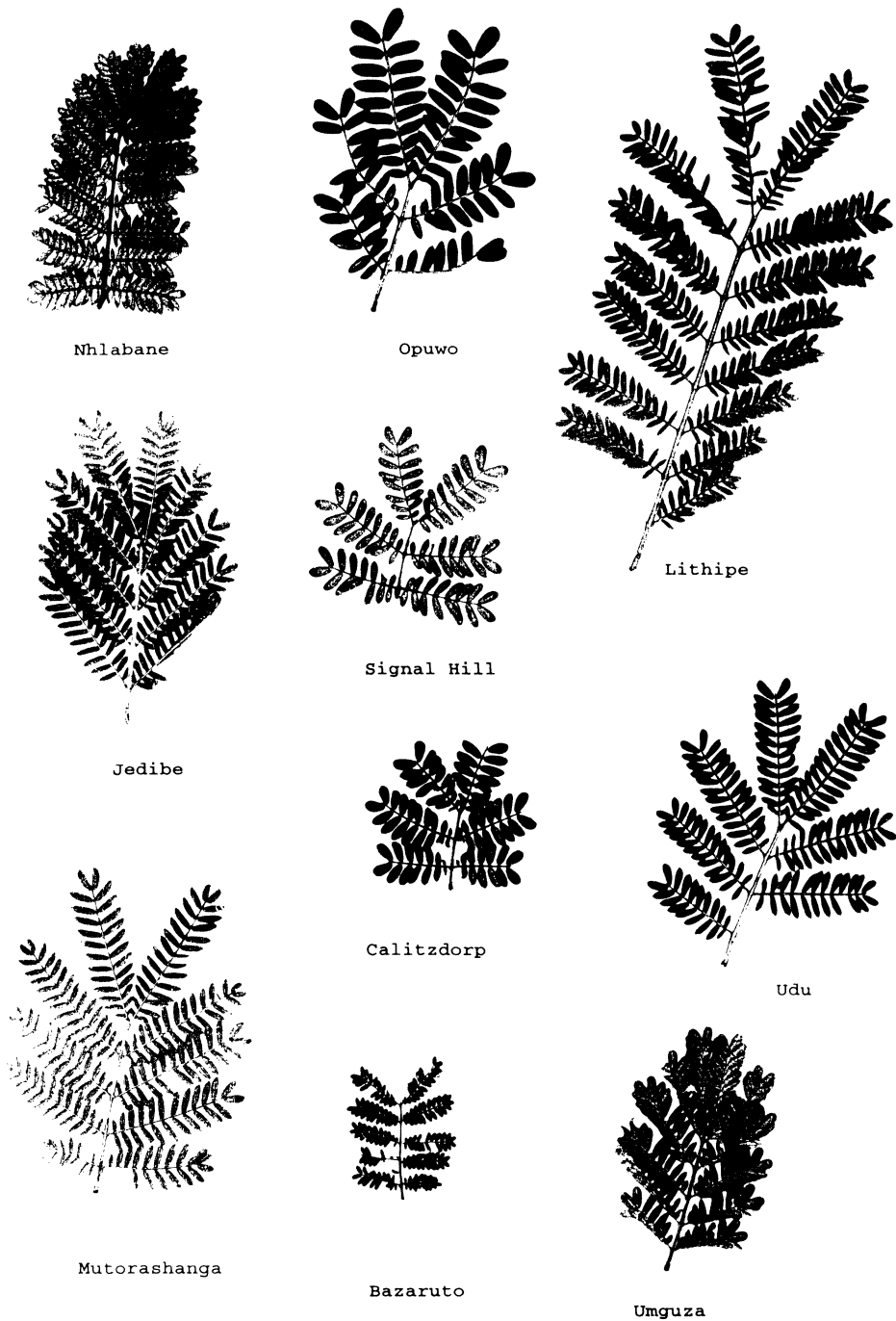


Figure 3 Typical leaves from six-month-old seedlings of ten provenances of *Acacia karroo*, all raised in the same nursery, showing the variation in leaf size, number of pinnae and number, size, shape and density of pinnule. (All x0.7)

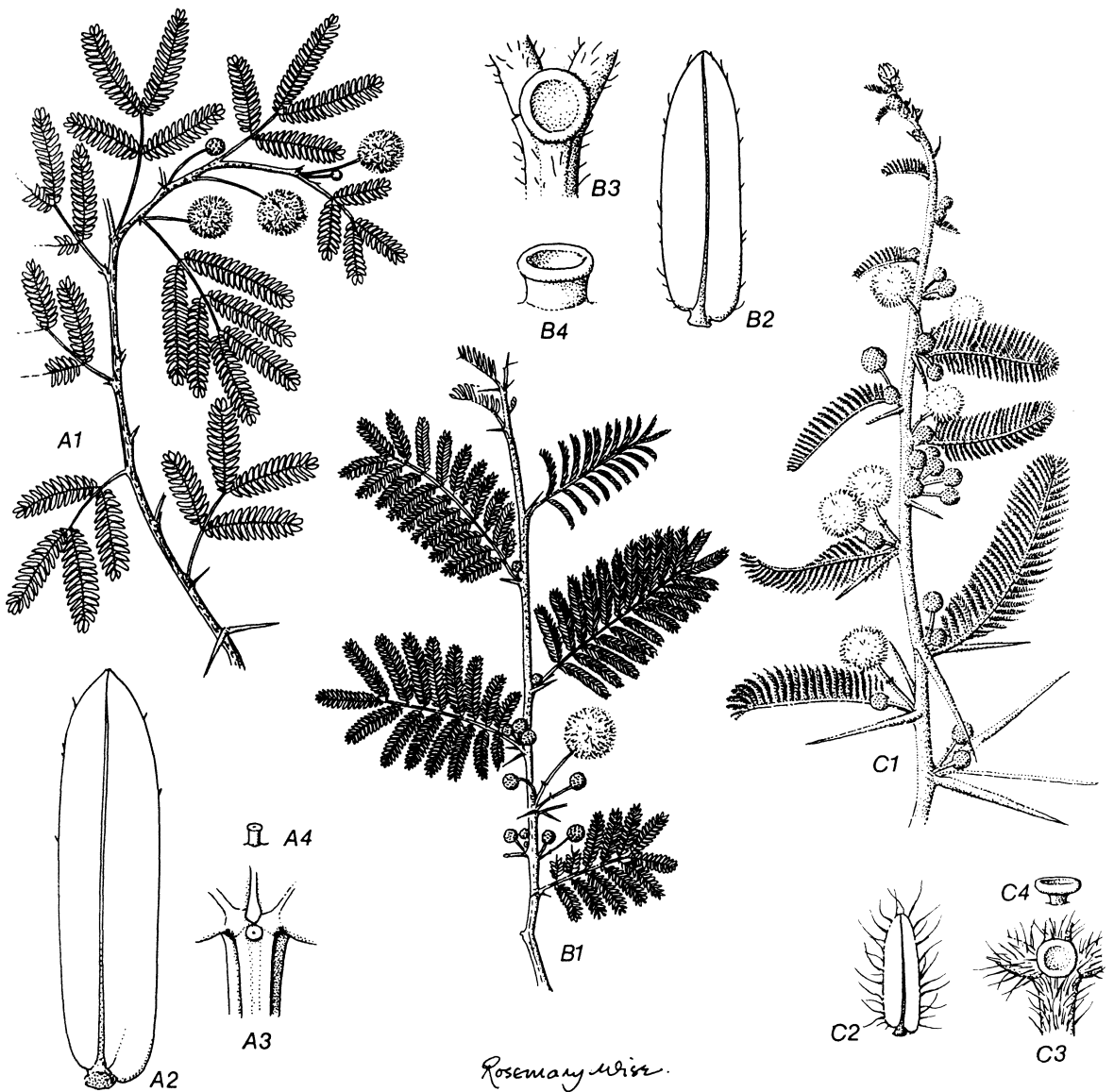


Figure 4 *Acacia karroo*, *A. rehmanniana* and *A. karroo x A. rehmanniana* hybrid. A1 - *A. karroo* - Branchlet with flowers (x0.6); A2 - *A. karroo* - Pinnule (x12); A3 - *A. karroo* - Gland (x25); Barnes RD 3650. B1 - *A. karroo x A. rehmanniana* - Branchlet with flowers (x0.6); B2 - *A. karroo x A. rehmanniana* - Pinnule (x12); B3 and B4 - *A. karroo x A. rehmanniana* - Gland (x25); Barnes RD 3651. C1 - *A. rehmanniana* - Branchlet with flowers (x0.6); C2 - *A. rehmanniana* - Pinnule (x12); C3 and C4 - *A. rehmanniana* - Gland (x25); Barnes RD 3649.

showing that there are discontinuities in the variation and this will require much more intensive sampling in selected parts of the species' range.

[References:- 25, 27, 208]

Biochemical variation

Twelve populations of *Acacia karroo*, covering its entire range, were surveyed for 12 allozyme systems (aspartic aminotransferase, alcohol dehydrogenase, diaphorase, alpha-esterase, beta-esterase, glucose-6 phosphoglucose dehydrogenase, glutamate dehydrogenase, malate dehydrogenase (mdh), malate dehydrogenase (mdhp), menadione reductase, 6-phosphogluconate dehydrogenase and shikimate dehydrogenase) (Oballa, 1993). All expressed a high level of genetic diversity. Ninety-eight percent of the isozyme loci were polymorphic with an average of 3.7 alleles per locus. The total gene diversity was 88%, higher than that reported for most plant species. The mean genetic identity was 90% and the coefficient of gene differentiation was estimated at 5%; this indicated a low divergence between populations. Cluster analysis grouped the populations into three phylogenetic groups, the northern, the southern and the south-central-eastern (Oballa, 1993).

More recently, seed collections have been made from two *Acacia karroo* populations, one on the island of Bazaruto and one on the island of Magaruque, both in the Bazaruto archipelago off the coast of Mozambique. The same 12 allozyme systems were run for this material and they showed these populations to be profoundly different from all others, including those on the island of Inhaca off Maputo and those on the Zululand Coast (Barnes *et al.*, 1994). This makes these populations of great interest both taxonomically and genetically.

In a study of variation of the leaf peroxidases of *Acacia karroo* (Brain 1986 and 1989; Barnes *et al.* 1994; Brain *et al.*, in prep.), two zones of activity, one fast and one slow, were found. The most anodally migrating zone was scored and five bands were found in this region, labelled from the cathode as K, L, M, N, O. Across all populations, the frequencies of the M (.38) and N (.32) bands were much greater than those of bands K (0.1), L (0.1) and O (.10). The analysis of this huge data set, 4,322 individual trees from 63 populations representing the complete range of the species, indicated strong regional concentrations of particular types. The K band has a high frequency in the south (Karoo) but is absent from Zululand and Natal (Plate 4B); band L is more frequent in the western part of the species' range; and there is virtual fixation of the M band in the coastal populations of Zululand and Mozambique (Plate 4A). The latter is one of the most significant findings because M is not fixed in populations just to the west of the dunes with which the *A. karroo* on the dunes could interbreed; therefore it is likely that there is some selective

advantage associated with the M "allele" and, should this prove to be so, it would be one of the first instances where an adaptive trait had been associated with a chemical substance under monogenic control. Cluster analysis suggested the presence of these three groups. Variability appeared to be highest under the most adverse climatic conditions of low temperatures and low rainfall.

[References:- 25, 27, 35, 36, 37a, 37b, 148]

Sampling variation for genetic evaluation

A sampling strategy has been devised to select provenances from which to collect seed for international provenance trials of *Acacia karroo* (Barnes *et al.*, 1994). A combination of geographic, climatic, edaphic, ecological and morphological considerations was used to select provenances together with the evidence from the biochemical studies described above; the latter provided the only hard information on genotypic, as opposed to phenotypic, variation. On the basis of these data, a sampling strategy was devised that was likely to ensure that most of the genetic diversity of *A. karroo* would be contained in the provenance trials. Since the biochemical studies showed that the majority of variation occurred within (80%) rather than between (20%) populations, it was considered appropriate to sample large numbers of trees per population and to restrict the number of populations that were sampled. All the peroxidase alleles and most genotypes could be obtained by sampling very few populations; but if sampling had been restricted to the coastal areas where M is fixed, it would have been possible to miss out entirely on 80% of the genetic variation at this locus.

The map (Plate 3B) shows the localities of the seed collections made for the international provenance trials in relation to the natural distribution of *Acacia karroo* (Plate 3A). Details of the localities are given in Table 1.

[References:- 25, 26, 27, 37b]

REPRODUCTIVE BIOLOGY

Cytology

The chromosome number of *Acacia karroo* was first reported under the species' original name of *A. horrida* as $2n=4x=52$ (Ghimpu, 1929). However, some acacias have variable chromosome numbers and as no cytological survey had been undertaken to determine possible variation with ecotype in this very variable species, a study based on cytological evidence from ten populations was recently undertaken (Oballa, 1993; Oballa and Oling'otie, 1994). *A. karroo* was again found to be a tetraploid consisting of only

Table 1 Provenances of *Acacia karroo* collected under project R.4526 for bulk testing in the OFI acacia trials network

Provenance	Country	Lat./Long.	Alt (m)	MAR (mm)	MAT (°C)
Bazaruto island	Mozambique	21.31S 35.29E	5	1000	24.0
Calitzdorp Spa	S. Africa	33.40S 21.47E	238	201	17.6
Donkerhoek	South Africa	25.48S 28.30E	1700	740	17.2
Dordabis	Namibia	22.56S 17.39E	1500	360	19.0
Fraserberg	S. Africa	32.12S 21.55E	1000	174	12.4
Gungunyana	Zimbabwe	20.25S 32.43E	1075	1470	18.1
Haasties Drift	S. Africa	34.30S 20.06E	67	700	18.4
Hluhluwe	S. Africa	28.03S 32.03E	550	1127	19.9
Inhaca Island	Mozambique	26.00S 33.00E	3	899	22.9
Jedibe island	Botswana	19.02S 22.33E	885	501	22.1
Lake Nhlabane	S. Africa	28.39S 32.16E	10	1054	21.1
Lebombo	Swaziland	26.22S 31.52E	680	865	19.3
Linthipe	Malawi	14.10S 34.08E	1200	905	16.9
Lusaka	Zambia	15.26S 28.20E	1278	804	19.7
Middelstevlei	S. Africa	32.56S 20.59E	900	243	16.8
Mt. Zebra N.P.	S. Africa	32.15S 25.29E	1100	340	16.6
Mutorashanga	Zimbabwe	17.10S 30.42E	1450	873	15.3
Opuwo	Namibia	18.38S 13.43E	1350	95	24.0
Prince Albert	S. Africa	33.14S 22.02E	640	183	14.9
Queenstown	S. Africa	31.52S 26.49E	1075	560	16.8
Signal Hill	S. Africa	33.56S 18.25E	150	630	17.4
Udu	Zimbabwe	18.17S 32.42E	1500	973	16.5
Umfolozu village	S. Africa	28.29S 32.11E	40	1055	21.1
Unguza	Zimbabwe	19.58S 28.30E	1180	541	19.6
Walala	Malawi	15.36S 35.10E	1000	1044	20.6
Worcester	S. Africa	33.55S 19.17E	221	249	17.4



Plate 1 *Acacia karroo* (left to right sequence)

- A Typical yellow flowers
- B Pale flowers from Bazaruto Island, Mozambique
- C Spines from the coastal dune forests in Zululand

- D Inflated spines from eastern Zimbabwe
- E Unopened pods
- F Dehiscent pods with seeds still suspended by the funicle



Plate 2 *Acacia karroo* (left to right sequence)

- A Bark characteristic of the coastal dune forests
- B Bark characteristic of the main range
- C Putative natural hybrid with *A. rehmanniana*
- D Flowers of *A. karroo* (left), *A. rehmanniana* (right) and the natural hybrid between them (centre)
- E Seedlings of the Bazaruto Island, Mozambique, provenance at six months

- F Seedlings of the Jedibe Island, Botswana, provenance at six months
- G Seedlings of (from left) Bazaruto Island (Mozambique), Calitzdorp Spa (Cape, South Africa), Mutorashanga (northern Zimbabwe), Udu Dam (Eastern Zimbabwe), Signal Hill (Cape Town, South Africa), Jedibe Island (Okavango Delta, Botswana), Umguza Valley (western Zimbabwe), Lake Nhlabane (Zululand coast, South Africa) and Linthipe (Malawi)

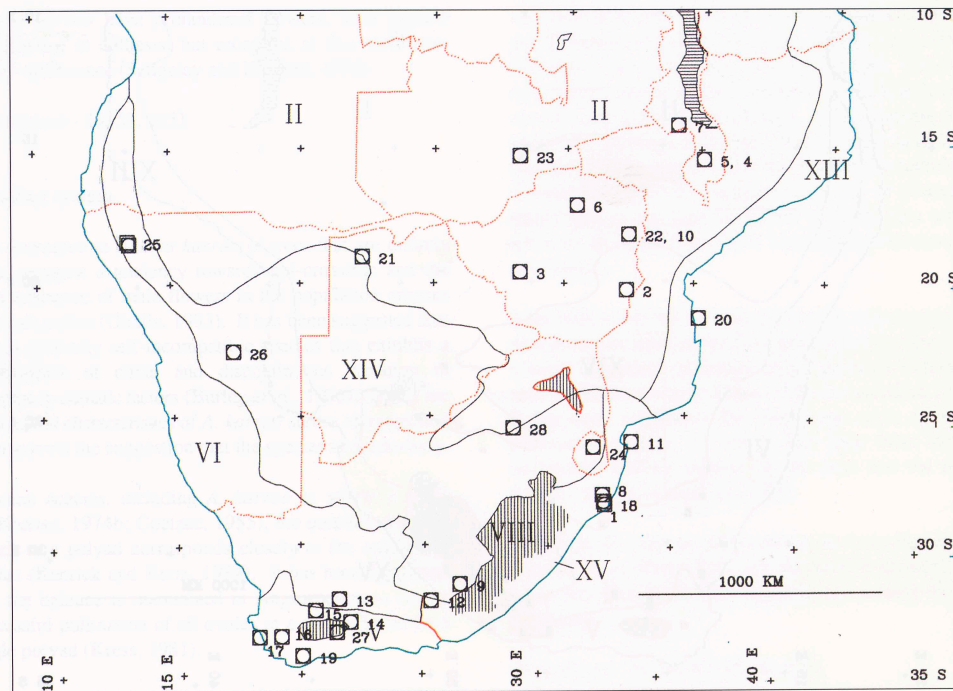
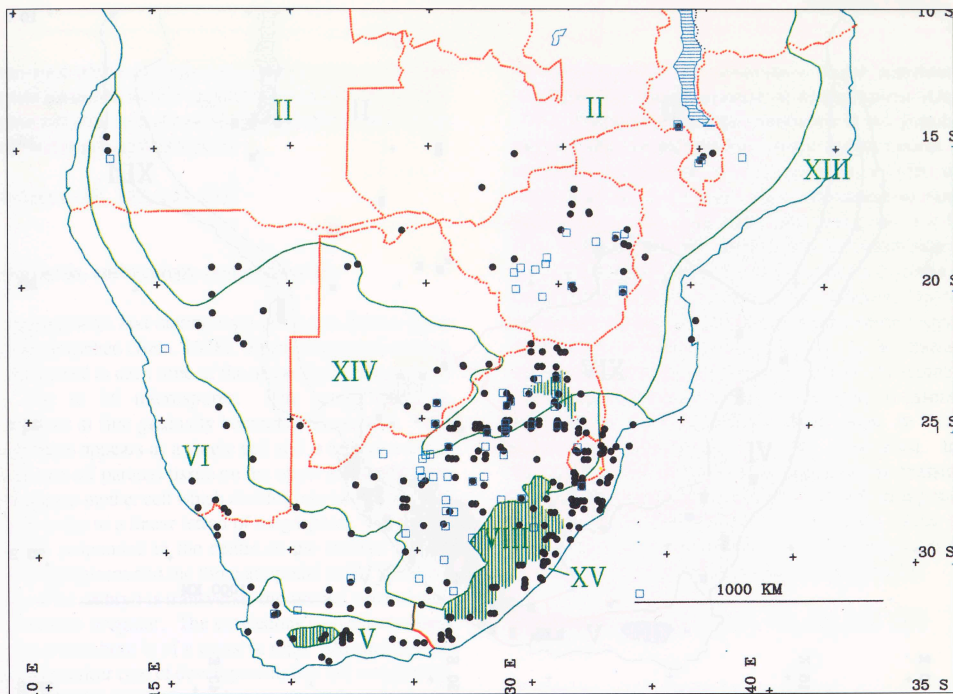


Plate 3 *Acacia karroo* distribution and collection sites

- A** Distribution plotted from herbarium specimens of precisely known origin. Black dots are locations under 1,000 m; blue squares are locations over 1,000 m. Roman numerals and green lines indicate White's phytochoria and their boundaries
- B** Seed collection localities for genetic evaluation trials: 1) Hluhluwe; 2) Gungunyana; 3) Umguzu; 4,5) Walala; 6) Mutorashanga; 7) Linthipe; 8) Lake Nhlabane; 9) Queenstown; 10) Udu; 11) Inhaca Island; 12) Mount Zebra National Park; 13) Fraserberg; 14) Prince Albert; 15) Middelstevlei; 16) Worcester; 17) Signal Hill; 18) Umfolozi village; 19) Haasties Drift; 20) Bazaruto Island; 21) Jedibe Island; 22) Udu; 23) Lusaka; 24) Lebombo; 25) Opuwo; 26) Dordabis; 27) Calitzdorp Spa; 28) Donkerhoek.

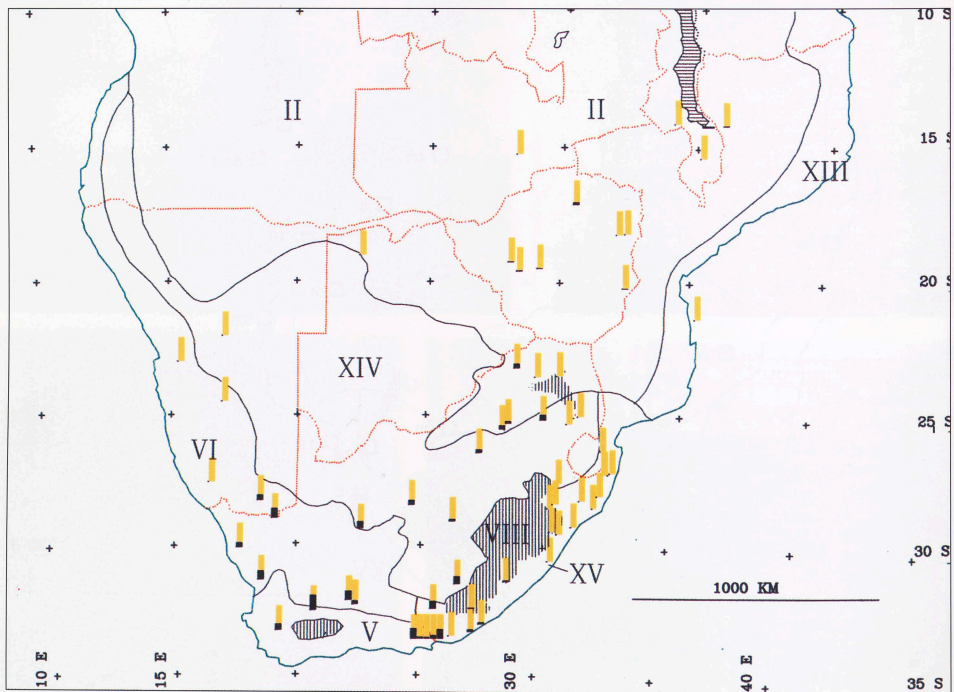
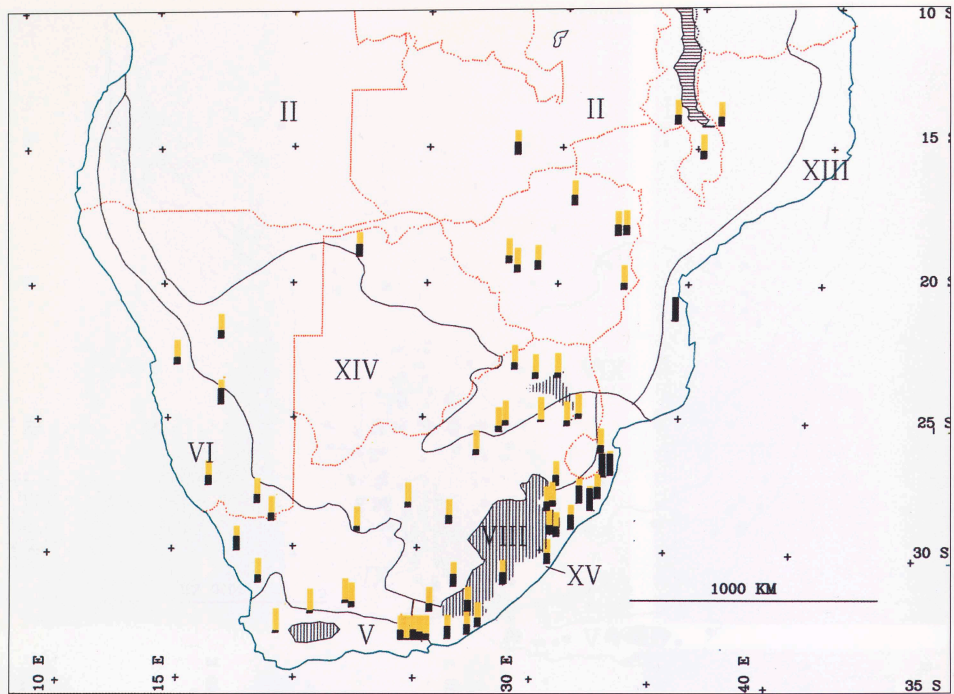


Plate 4 *Acacia karroo* peroxidase distribution

Frequency of the peroxidase bands M (map A above) and K (map B below) in an electrophoretic study of *Acacia karroo* from 63 populations that cover its entire natural range. There are five bands, K, L, M, N and O, in the fast zone of this isozyme system in the species. The black portion of the vertical yellow bar represents the relative proportion of individuals that exhibit the band. Band M is almost fixed in the coastal dune populations of Zululand on the east coast of south Africa and in the coastal populations of Mozambique. The frequency of K is highest in a cluster of populations in the Karoo region of South Africa. (Data from Brain *et al.*, in press)

one cytotype with a chromosome number of $2n = 52$. The tetraploid status was further supported by evidence from the isozyme inheritance patterns which also indicated that the species is a segmental tetraploid.

[References:- 88, 148, 149, 238]

Sporogenesis, embryology and pollination

The sporogenesis and embryology of *Acacia karroo* have been fully described (Bala, 1978). Four microspore mother cells are formed in each lobe of the anther and each of these gives rise to 16 microspores. The young ovule is orthotropous at first gradually becoming anatropous. The archesporium appears as a single cell and is hypodermal in origin; it cuts off parietal tissue on the upper side and forms the megaspore mother cell which divides into two dyad cells which give rise to a linear tetrad of megaspores. Two polar nuclei are suspended in the centre of the embryo sac by means of cytoplasm and the three antipodal cells. The first division of the embryo is transverse, the second vertical and later divisions irregular. The cotyledons are differentiated when the proembryo is of a massive type. The endosperm follows the nuclear type of development; it is not completely reabsorbed by the developing embryo and a little endosperm remains in the mature seed.

Acacia karroo have protandrous flowers, with stigmas unreceptive at anthesis, but receptive at five days after anther dehiscence (Sedgely and Harbard, 1993).

[References:- 23, 58, 165]

Breeding system

The existence in *Acacia karroo* of trees that are entirely male suggests a tendency towards out-crossing; and the preponderance of male flowers in the population ensures abundant pollen (Oballa, 1993). It has been suggested that it is a generally self-incompatible species that exhibits a combination of clinal and discontinuous variation in response to climatic factors (Burley *et al.*, 1986). These are pronounced characteristics of *A. karroo* across its range and this supports the suggestion that the species is outcrossing.

In some acacias, including *A. karroo* in which it is 16 (Robbertse, 1974b; Coetzee, 1955), the number of pollen grains in a polyad corresponds closely to the number of ovules (Kenrick and Knox, 1984). It has been suggested that the balance is maintained in Angiosperms to ensure successful pollination of all ovules in a single flower by a single polyad (Kress, 1981).

An intensive study was undertaken in one population to investigate the breeding system of *Acacia karroo* (Oballa, 1993). Estimates of genetic parameters in this population indicated that the species has a mixed mating system. The multilocus outcrossing rate was estimated at 0.88; single locus outcrossing estimates were heterogeneous ranging from 0.53 to 1.00. The mean outcrossing rate was 0.72. This indicated that the species was predominantly outcrossing in this population but at the same time quite a high level of selfing did occur; however, the estimated biparental inbreeding was higher than actual selfing which suggested the presence of some correlated mating. In the absence of similar studies in other populations and of any estimate of inbreeding depression, it was not possible to assess the likely effect that inbreeding might have in biasing provenance comparisons in the evaluation trials. Nevertheless, the relatively high degree of out-crossing in this population suggests that the effects of inbreeding are not likely to be so profound as to necessitate taking each provenance through a generation of outcrossing to release it from these before genetic evaluation is undertaken.

[References:- 27, 43, 58, 116, 122, 148, 162, 187]

Pollinating and seed dispersal agents

Although eight pollen grains were found per 7 cm² on vaselined slides exposed for 24 hours on a warm, windy day in a flowering community (Coetzee, 1955), *Acacia karroo* is zoomophilous, principally insect-pollinated. This might be expected with the strong colouration of the inflorescence and the heavy pollen grains (Oballa, 1993). Isolated plants often bear no fruits (Gerstner, 1948). Huge numbers of insects of many species visit the flowers throughout the flowering period. No comprehensive list of pollinating insect species has been found but no doubt they include species in the orders Coleoptera, Lepidoptera, Hymenoptera and Diptera.

It has been noted that in the bright yellow inflorescences of *Acacia karroo*, small sterile involuclate flowers develop as a small secondary capitulum on the peduncle before the main fertile flowers open (Ross, 1979; Coe and Coe, 1987). It has been suggested that these may serve to attract pollinating insects, to ensure that they have already established visiting patterns by the time that the fertile flowers open (Coe and Coe, 1987).

Although the pods are dehiscent on the tree, they are not explosively so (Plates E-F) and dispersal is principally by cattle and other herbivores ingesting and voiding through their dung.

[References:- 56, 58, 87, 93, 94, 179]

DISTRIBUTION AND ECOLOGY

Natural distribution

Full details of all botanical specimens of *Acacia karroo* held in all the major herbaria in which the species is likely to be housed, have been logged into the BRAHMS database (Barnes *et al.*, 1994). These herbaria included those in Pretoria (National Herbarium, South Africa), Cape Town (Compton Herbarium, South Africa), Harare (National Herbarium and Botanical Gardens, Zimbabwe), Windhoek (National Herbarium, Namibia), Zomba (National Herbarium, Malawi), Nairobi (National Herbarium, Kenya), Lisbon (The Herbarium, Portugal), Kew (The Herbarium, United Kingdom), Oxford (the Forest Herbarium, United Kingdom), and Paris (Musée National d'Histoire Naturelle, France). The data were used to produce the natural distribution map given on Plate 3A. It is apparent that there are two unexplained gaps in the distribution, one in southern Angola and the other in Mozambique south of the Bazaruto archipelago. It is not clear whether the gaps are due to the species not occurring there or whether they are due to under-collection.

Geographically *Acacia karroo* is the most widespread tree in southern Africa. It occurs in every country of the Southern African Development Community (SADC) region excluding Tanzania where the species is replaced by the taxonomically and ecologically similar *A. seyal*. Within the region, however, there are isolated populations that might be expected to have had the opportunity to diverge genetically. Most notable among these are the island populations off the coast of Mozambique, particularly those on the islands of the Bazaruto archipelago which are the most distant from the mainland. Also isolated are the populations on the islands in the Okavango Delta in Botswana. On a larger scale, the populations of northern Namibia, southern Angola, Zambia, Zimbabwe and Malawi are all separated from the main South African population and each other by arid zones mainly associated with the deep, dry, hot valleys of the major rivers.

[References:- 3, 27, 78, 124, 134, 137, 178, 179, 180, 199]

Ecology

Climate

Acacia karroo occurs naturally over an extraordinary range of climates with rainfall distribution ranging from summer maximum, through evenly distributed, to winter maximum (Plates 5A-G). In each of these zones, mean annual rainfall can vary from 200 to over 1500 mm. Mean annual temperatures are also variable with a high of 24°C on Bazaruto to a low of 12°C in the Karoo; on the Zululand coast the maximum daily temperature may rise to 40°C and

the relative humidity seldom falls below 50% (Venter, 1971). The species survives all but the most severe frosts in southern Africa (c. -12°C in Matabeleland, Zimbabwe) which is one of the factors that explains its ubiquity in the region except at the cold high altitudes in Lesotho, the only country in the world with no land below 1000 m. It also tolerates wind and salt spray from the sea on the coast (Venter, 1971) (Plates 5-B). Timberlake² describes *A. karroo* in Zimbabwe as a catholic species but not ubiquitous and seldom found below 1000 m (at which altitude the mean annual temperature would not exceed about 22°C); it is common on degraded lands in the lower rainfall areas.

[References:- 3, 12, 27, 29, 70, 71, 133, 137, 190, 199, 237, 239]

Soils

The range of soil types on which *Acacia karroo* occurs is no less remarkable than the variability of the climates in which it can thrive. Over much of its inland range it tends to be restricted to the heavier soils and it is one of the very few species that grows on the heavy, black, hydromorphic, cracking vertisols with high pH (Coetzee *et al.*, 1976; Kooij *et al.*, 1991; Plate 5D); but it will thrive on deep alluvial clay-loam soils (du Preez and Venter, 1990) in river valleys, on shales (Roberts, 1966) and even on acid soils (Potts and Tidmarsh, 1937). In Zimbabwe, *A. karroo* forms stands on heavier-textured alluvium and is very common on red clay soils along watercourses and on shallow red clay soils from metasediments and metavolcanics; in high rainfall areas it occurs widely on clay-rich soils; it is generally an indicator of soils that are nutrient-rich (Timberlake *et al.*, 1993). In the more tropical part of its range, *A. karroo* needs somewhat eutrophic, nutrient-rich (particularly calcium-rich) soil conditions for good establishment; consequently it is not found in the miombo woodland except on the more clay-rich soils (Timberlake, pers. comm.)². In arid South Africa, *A. karroo* occurs along drainage lines and round pans (Milton, 1991). At the other extreme, it thrives on the unconsolidated bare drift sands of the coastal dunes in Zululand (Venter, 1971; Mentis and Ellery, 1994; Weisser and Muller, 1983) (Plates 5C and 8D). The species is tolerant of extremely saline conditions and is found growing on the beach below high spring tide level on the island of Bazaruto in Mozambique (Plate 5B) and on salt (probably sodium carbonate) encrusted islands of the Okavango Delta in Botswana (Barnes, 1994). Tolerance of this wide range of edaphic conditions may be in part due to the extremely dense and robust rooting habit (Barnes, 1994) (Plates 6E and 6F). *A. karroo* is intolerant of levels of arsenic of over 10,000 parts per million (Wild, 1974).

[References:- 2, 27, 59, 69, 70, 100, 120, 129, 131, 134, 156, 159, 170, 190, 194, 199, 234, 239, 251, 257, 258]

²J.R. Timberlake, 3 Rue des Fleurs, Fortunes Gate, Bulawayo, Zimbabwe

Vegetation types and succession

Acacia karroo occurs in every one of the nine main phytochoria (White, 1983) in southern Africa (Plate 3A); it is absent only from the Afroalpine zone on the highest mountains in the region. It is also present in all seven of Rutherford and Westfall's (1986) Biomes and it is listed as a typical constituent in five of the seven main veld types of South Africa (Acocks, 1988) particularly in the savanna, karoo and coastal dune forest. It occupies a successional position between the tropical forest and the bushveld (Acocks, 1988; Venter, 1971) but it grows in riverine communities (Dean *et al.*, 1990; Drummond, 1981; Kooij *et al.*, 1991) even into very arid environments provided there is an assured supply of underground water (Acocks, 1988; Carr, 1965). Large specimens of *A. karroo* are reputed to be indicators of underground water (Leistner, 1967). It has been reported as occurring along rivers in 26 of 30 vegetation types sampled in arid and semi arid parts of South Africa (Acocks, 1976) where its comparative tolerance of frost often gives it an advantage over other tree species.

Acacia karroo is an adaptable species that is expanding its range particularly under the disturbed ecological conditions that result from human activity in southern Africa today. In South Africa it is spreading eastward up the valleys into the higher parts of the Karoo and beyond into what has previously been grassveld, and also westward from the valley bushveld of the east coast rivers right up into the surviving temperate forests of the mountains in the eastern Cape Province and the Transkei; it is also invading the open savannas of the Transvaal and Natal (Acocks, 1988). These expansions are usually associated with bad veld grazing management practices although climatic deterioration cannot be ruled out as being at least a contributory factor in its spread.

Acacia karroo is a pioneer with a maximum life of about 40 years (Gourlay and Barnes, 1994). It flowers precociously and produces large quantities of seed. It is well adapted to establishing itself with no shade, shelter or protection from grass fires. However, where *A. karroo* invades following disturbance, the correlation between tree density and pasture condition is not linear; this indicates that there may be a threshold condition below which a dramatic increase in trees is likely (Friedel, 1987). Under undisturbed conditions, many other woody plants germinate beneath the canopy and they and various parasitic mistletoes and root parasites may subsequently kill the pioneer. Marked changes have taken place in dune vegetation near Richards Bay in Zululand that have been due mainly to secondary successions resulting from protection by forest plantation activities. It is estimated that under the existing favourable climatic conditions it takes some dune grassland only 25-60 years to develop into mature *A. karroo* woodland and a further 30-150 years to proceed to secondary dune forest (Weisser and Marques, 1979).

Despite it being a pioneer, there are often environmental conditions that allow *Acacia karroo* stands to regenerate themselves; these may be naturally imposed, for example by local soil or climatic conditions, or they may be the result of human interference, for example through over-grazing or forest clearance. In these circumstances, there is often the development of an understorey of perennial, palatable and nutritious grasses (*e.g. Panicum maximum, Cenchrus ciliaris, Digitaria pentzii, Cynodon incompletus*) that thrive on the environmental benefits that stem from the species' ability to use water and nutrients from depth and to fix nitrogen (Roberts, 1963; Acocks, 1988) (Plate 6A). Shading by the *A. karroo* canopy may also reduce soil surface temperature and evaporation making conditions more suitable for drought susceptible grasses. On the southern coast of the Cape Province, South Africa, where there is year-round rainfall of 725 mm, *A. karroo* is restricted to deep, sandy soils on river banks, the understorey is trampled by antelope seeking shade beneath the trees and the vegetation is consequently dominated by the grass *Cynodon dactylon* (Grobler and Marais, 1967). On alluvial clay-loam soils, understorey shrubs in *A. karroo* woodland near the Vaal River in the Transvaal can include members of the genera *Rhus, Ehretia, Protaspargus, Diospyros, Maytenus, Ziziphus, Lycium* and *Celtis* (Du Preez and Venter, 1990; van der Walt, 1980) among which may be the species that ultimately succeed *A. karroo* (Potts and Tidmarsh, 1937). In the Orange Free state, *A. karroo* occurs in valley bottoms, on riverbanks and in steep ravines where soils tend to be saline. The *A. karroo*-dominated woodland has an understorey of shrubs and grasses but, in the uplands, it occurs on black vertisols associated with rock outcrops, and the understorey is grass (Kooij *et al.*, 1991). In Zimbabwe, *A. karroo* is generally the predominant tree species on heavy black vertisols, derived from calcium-rich basaltic and mafic rocks. The ability of its root system to survive the root-shear associated with the severe cracking of these soils in the dry season ensures its permanent dominance.

[References:- 1, 2, 27, 38, 44, 59, 60, 65, 67, 69, 73, 84, 96, 100, 104, 119, 120, 124, 129, 131, 140, 159, 169, 180, 189, 200, 234, 237, 239, 250, 251]

Associated fungi

Many species of fungi have been isolated from the leaf litter and soil beneath *Acacia karroo* communities. In the Eastern Transvaal, a total of 858 sporulating cultures representing 76 genera and 144 species were recovered from the soil under *A. karroo* communities (Papendorf 1976). The majority were fungi imperfecti, with a limited number of zygomycetes and ascomycetes. No oomycetes or basidiomycetes were recorded. The most abundant genera were *Penicillium* and *Aspergillus* with *Hyalotiella transvaalensis*, *Arxiella terrestris*, *Arthrocladium caudatum*, *Veronaea simplex*, *Exophiala brunnea* and

Melanophoma karroo specifically identified (Papendorf, 1967 and 1969; Papendorf and Du Toit, 1967). The greatest concentration of individuals and species occurred in the surface layers; numbers decreased with increasing depth. The nature of this mycoflora suggests a close correlation with the existing plant cover.

[References:- 89, 127, 128, 151, 152, 153, 154, 159, 207]

Rhizobia

Nodulation in the Mimosoideae is far more common than it is in the Caesalpinioideae but it is by no means universal (Sprent, 1995). Nodulation is very common among the acacias but, even in this genus, it cannot be assumed. There is great diversity in both host and rhizobia symbioses in the acacias. It has been found that the fastest growing acacia rhizobia are those from the most desiccation and salt tolerant isolates. This suggests that there could be considerable scope for improvement through selection.

During the course of a genetic evaluation project on *Acacia karroo* (Barnes *et al.*, 1994), seedlings of six African *Acacia* species (*A. karroo*, *A. tortilis*, *A. senegal*, *A. nilotica*, *A. erioloba* and *Faidherbia (Acacia) albida*) were raised in six nurseries in different environments throughout Zimbabwe and nodules collected for a study on rhizobia technology. The specific objectives of the project were "to isolate, identify and test the effectiveness and competitiveness of *Rhizobium* strains and produce inocula for six Zimbabwean *Acacia* species (Sutherland *et al.*, 1994). Of all six species, *A. karroo* nodulated most freely in the nurseries. The nodules on each species were morphologically different, those on *A. karroo* being typically a slightly pear-shaped cylinder in shape and light to medium brown in colour (Barnes *et al.*, 1994). Only *A. karroo* and *A. tortilis* ssp. *heteracantha* seedlings showed significant increase in dry weight when harvested four months after inoculation (Sutherland *et al.*, 1994); a strategy of applying a mixed inoculum was effective on these species and was recommended. Considerable difficulty was experienced in preventing deterioration of the rhizobia in culture and in achieving nodulation. It is expected that the problems in preventing deterioration will be resolved now that it is realized that tropical tree rhizobia are stressed when grown on a medium developed for temperate field crop rhizobia; while able to survive on this medium, they lose their symbiosis plasmids. The difficulties in effecting nodulation were overcome when it was realized that relatively high light levels are required for effective nodulation in acacias. The prospect, therefore, of cost-effective inoculation of acacias is relatively good for tree establishment in dry areas. Nevertheless, inoculation trials will be costly and imprecise until there is better experimental control of the genetic constitution of the host plants. The future is seen as lying in rhizobia research linked to a tree selection and breeding programme (Sutherland *et al.*, 1994).

During the research being conducted on the genetics and rhizobia of *Acacia karroo*, leaf samples were collected from trees of this species and from five other *Acacia* species growing sympatrically with it for laboratory analysis to compare their efficiency in fixing atmospheric nitrogen and in ground water usage (Barnes *et al.*, 1994). Foliage samples from the six species were collected from Umguza Valley Estates in Zimbabwe and the resultant analysis of the percentage of nitrogen and stable isotope ratios are given in Table 5, page 28. The data suggest that *A. karroo* fixes more atmospheric nitrogen than *A. erioloba* or *A. tortilis* ssp. *heteracantha* but not as much as *A. fleckii*, *A. nilotica* or *Faidherbia albida*. On the other hand, *A. karroo* is less efficient in its water use than all the above species except *A. tortilis* ssp. *heteracantha*.

[References:- 27, 112, 192, 206, 209]

GROWTH HABITS

Life cycle

The pods of *Acacia karroo* ripen between February and June (Figure 5, page 32). They open on the tree and the seeds are suspended by a thin, thread-like funicle which becomes brittle as it dries (Plate 1F). The seeds fall, or are eaten by animals or birds, before the pods drop from the tree two or three months later and are dispersed by wind, water and in the dung of cattle and other mammals (Story, 1952). The heavy, sound, seed falls first very often leaving many lighter, damaged, bruchid-infested seed still suspended from the pods by their funicles after all the sound seed has gone. There is evidence that seed remains viable for up to seven years when buried in the soil (Du Toit, 1972); seeds from herbarium sheets have been found to be viable after 57 years (Story, 1952). The seeds have water impermeable dormancy and can remain damp for 29 months without germinating or rotting; but once the seed coat is penetrated, germination takes place in three or four days. Establishment is prejudiced by desiccation (Du Toit, 1967), severe frost (Carr, 1976), soil compaction (Friedel, 1987), grass competition and browsing animals (Comins, 1962).

Story (1952) found that only about 10% of *Acacia karroo* seed that has not passed through an animal germinates during the first 14 months after sowing. He found that seedlings in cultivated ground had >90% survival rate and reached 42 cm in 18 months, whereas only 5% of seedlings in grassland survived and were only 10 cm high after 18 months. Seedlings were resistant to browsing, but all seedlings <8 weeks old (about 10 cm high) were killed by fire. Twelve month old seedlings (about 35 cm high) died back following a burn but re-sprouted from the base, each giving rise to 3-4 stems (Story, 1952). *A. karroo* seedlings grow faster during their first three months than most other African *Acacia* species (Bryant *et al.*, 1989) and can reach

2 m within the first year on good soils with adequate water (Carr, 1976).

In an investigation into the effects of moisture, temperature and light on the germination and growth of *Acacia karroo* seedlings, it was found that germination is delayed by hard-seededness and a water-soluble inhibitor in the seed coat but that when moisture conditions were favourable, the seeds germinated at temperatures ranging from 10-40°C (Du Toit, 1966). Temperatures that fluctuated between 10 and 20°C were optimum for germination. Optimum temperatures for growth were higher than for germination, and lay between 25 and 33°C.

Acacia karroo has a deep taproot and is independent of surface moisture where underground water is available. The species is drought resistant but cannot withstand desiccation and loss of water from the protoplasm. Light intensities are seldom limiting for *A. karroo* in grassland, but the tree is light-demanding. The seedlings are very sensitive to desiccation because they have a high temperature and moisture requirement for growth. Any factor that causes rapid drying of topsoil or delays root development will be deleterious to *A. karroo* seedlings. The latter may include low diurnal temperatures (Du Toit, 1966).

A natural stand of *Acacia karroo* typically reaches its highest stem diameter growth rate about 20 years after the seedlings have established themselves (Figure 8). Thereafter growth declines rapidly as the crowns become parasitized by mistletoes and collapse at about 30 years (Gourlay *et al.*, in press). Under optimum soil and water conditions the life span may be ten years longer.

[References:- 42, 45, 56, 61, 70, 71, 73, 84, 199]

Growth patterns

Growth in *Acacia karroo* is controlled by current growing conditions. Plants are able to make opportunistic growth at any time in the growing season to take advantage of favourable environmental conditions. By growing in flushes and consolidating after each flush, the tree is able to cope with a variable climate and damage by herbivory. Moisture stress merely slows growth without affecting its pattern (Teague, 1987). In a study at Nylsvly in Transvaal, South Africa (Milton, 1987) it was found that elongating shoots bear only one leaf per node; more leaves appear in whorls as the shoot lignifies. Rapid extension of the shoots starts early in September about six weeks before the rain. Despite the irregular elongation of shoots, peaks were observed in October and December. *A. karroo* was the first to sprout in spring and therefore sustained heavy losses of soft green shoots to browsers.

In field studies in South Africa (Teague, 1988b), *Acacia karroo* showed the seasonal fluctuation in total non-structural carbohydrate (TNC) content that is

characteristic of deciduous species. TNC reserves declined rapidly at bud-burst in spring. TNC reserves also declined during rapid leaf, shoot or reproductive organ growth. TNC reserves were replenished while recently emerged leaves were still small. Water stress did not change the pattern of TNC use and replenishment but did slow down the replenishment process. It was suggested that this slowing down also delays the beginning of the next annual growth event as well as the growth of previously initiated organs. It was also suggested that growth flushes followed by replenishment enable *A. karroo* to withstand harsh environmental conditions and browsing damage.

The growth patterns of *Acacia karroo* at different levels of water stress in different edaphic situations have been described (Teague and Walker, 1988a). Shoots are heterophyllous and formed by free growth. The degree of development of a shoot in the canopy is governed by position. At least six phenological phases were identified in the annual growth cycle. The pattern of growth and the phenological cycle were not changed by water stress. Initiation, emergence and development of shoots and leaves were governed by environmental conditions. If there was little shoot growth early in the season, the plants could partially compensate by producing more leaf/unit of shoot if environmental conditions improved. Leaf and shoot growth at the beginning of the season took place only if there was sufficient moisture available, and if the minimum temperature rose above a threshold value. Soil depth had a marked influence on plant growth, probably due to an increase in nutrients and moisture with increasing depth. Where there was insufficient soil moisture, no growth was observed before rains had fallen. *A. karroo* differs markedly from other broad-leaved African savanna tree species in this ability to respond to growing conditions in the current rather than in the previous season.

In trials near Alice in the Cape Province of South Africa (Teague, 1989c), the response of *Acacia karroo* trees to defoliation of either their upper or lower canopy only was compared with that of plants whose whole canopies had been defoliated at a range of defoliation levels. The plants were very sensitive to defoliation of the upper canopy; 100% defoliation of the upper canopy resulted in the same amount of growth as 100% defoliation of the whole canopy. This was considerably less than the growth of plants defoliated overall, at 25 and 50% leaf removal. In contrast, defoliating the bottom half of the canopy stimulated growth in the whole canopy to the same degree as defoliation of the whole canopy at 25-50%. The increases in growth were largely due to increased growth in the top half of the canopy. Plants were very sensitive to defoliation in the early-flush phenophase. This probably masked the positive effects of the partial defoliations applied at this phenophase.

[References:- 133, 162, 163, 182, 214, 217, 219, 223, 226, 235]

Flower and fruit phenology

Shoot growth, shoot mortality and the abundance of flowers, fruit and leaves were observed on seven *Acacia* species including *A. karroo* for 13 months at Nylsvley, Transvaal, South Africa (Milton, 1987). In this study it was found that *A. karroo* bears flowers only on green extending shoots and flowers throughout the growing season as the new shoots are produced. Flowers are most abundant between December and February. Pods ripen in winter; they are thin-walled and split open while still on the tree when the seeds dangle from the pod on their funicles. In Zimbabwe the flowering period may last from November to late April with individual trees, and sometimes whole populations, flowering three or four times in the year particularly in sunny spells following periods of heavy rain. Flowering is always on the current season's growth (Barnes *et al.*, 1994).

Information on phenological variation between populations of *Acacia karroo* cannot be obtained without making regular observations in many populations over long periods. The extent to which this variation is under genetic control can only be determined from field provenance trials. An attempt has been made to extract as much information as possible on this subject from the herbarium sheet data logged into the Oxford Forestry Institute's database BRAHMS (Barnes *et al.*, 1994). Most of these sheets had been assessed for flowering and fruiting status. Although there was some difficulty in merging different assessor's categories, the overall phenological picture for flowering and fruiting for the species was produced by plotting the number of specimens categorized as "buds and flowers" and "mature fruits" against month as shown in Figure 5, page 32. Because the species covers such a large area, the data was first partitioned into latitudinal bands but this did not indicate that even the most northerly populations within the tropics flowered or fruited at different times from those in the winter rainfall areas of the Cape.

[References:- 27, 124, 131, 133]

PREDATORS, DISEASES AND HARMFUL PHYSICAL AGENCIES

Biotic factors

Animals

Acacia karroo is an important browse tree for many wild and domestic herbivores. The effects of browsing on the subsequent growth and metabolism of the tree are discussed under fodder in the section on yield and management *q.v.*

During drought periods, the foliage of *Acacia karroo* trees is often the only browse available. Drought also promotes gum exudations on the stem. Although severe drought in the

Karoo may reduce flowering, the flowers are more conspicuous in dry periods when they escape storm damage and they then become attractive to herbivores (Plate 6C). Those higher up in the crown are eaten by monkeys and many species of birds; monkeys and galagos (Galagidae) (Anderson and Pinto, 1980) eat the gum.

Peak breeding of birds in *Acacia karroo* woodland near Pietermaritzburg in Natal, South Africa, coincided with the rapid spring increase in insect biomass (Earle, 1981).

[References:- 11, 39, 65, 76, 118, 121, 135, 133, 134, 137, 139, 146, 215, 218, 219]

Insects

There is a great wealth of insect life associated with the African acacias. It has been speculated that no other genus in the semi-arid environments of the continent has as many insects associated with it (Ross, 1975b). The caterpillars of various moths feed on and destroy the leaves, scale insects infest the twigs, the bark and woody tissues are riddled with the holes and tunnels of boring insects while the flowers are visited by numerous species of bees, wasps and flies and beetles voraciously consume the seed.

In a checklist of insects found attacking trees and shrubs growing in South Africa (SAPPRI, 1970), many are listed as attacking *Acacia karroo*. In the order Coleoptera these include species from the families Bostrychidae (larval borers in dry branches and stem), Bruchidae (adults and larvae feed in seed), Cerambycidae (larval borers in the stem, adults ringbark shoots when feeding (Plate 7B)), Lamiinae (adults debark trees, feed in seed pods, feed on leaves and flowers; larvae bore in weak trees), Colydiidae (predate on boring beetles), Curculionidae (leaf feeders) and Scolytidae (bark beetles). In the order Hemiptera (sap-suckers) these include species from the families Asterolecaniidae, Coccidae, Diaspididae, Lacciferidae and Pseudococcidae. In the order Lepidoptera (leaf feeders) these include species from the families Arctiidae, Cossidae, Geometridae (mainly leaf feeders and some wood borers (Plate 7A)), Lasiocampidae, Limacodidae, Lycaenidae, Lymantriidae, Noctuidae, Notodontidae, Psychidae, Pyralidae, Saturniidae and Sphingidae (Taylor, 1949, 1951, 1953 and 1965). In the order Thysanoptera these include species from the Thripidae (sap suckers). In the order Homoptera (foliage feeder) these include species from the Psyllidae (Webb, 1974).

Many species of the family Bruchidae parasitize seeds of the acacias including *Acacia karroo* and since their activity can seriously affect reproduction in the species, an account of the life cycle of a bruchid follows from Southgate (1978). The female beetle lays an egg on a ripening or, more rarely, a ripe pod. The larva bores through the pod wall and burrows into a ripening seed within which it creates a chamber. In its final stages the larva eats away the outer layers of the seed until only a thin shell of testa remains. After pupation, the beetle emerges through the testa. In a

few species the larva leaves the seed and pod, drops to the ground on a silk thread, and pupates in the soil beneath the tree. Early indications from phytochemical investigations indicate that the concentrations of certain amino acids (pipecolic acid and some heteropoly-saccharides) determine if a bruchid larva can survive in a seed (Southgate, 1978). Predation can destroy the viability of up to 90% of the seed.

In a study of the monophagous psyllid *Acizzia russellae* (Homoptera) and its hymenopterous parasites, seasonal patterns in psyllid numbers were found to follow fluctuations in nitrogen levels on individual trees of *Acacia karroo* on which it is the most consistently abundant herbivore; it feeds on the foliage and shows preference for young leaves for oviposition. No effect of stress or leaf hardness was clearly discerned. Cutting of trees altered the characteristics of the subsequent regenerative growth so as to allow massive psyllid infestations to develop, thus showing the critical importance of the host plant quality in determining population levels in this insect (Webb, 1974; Webb and Moran, 1974).

Acacia karroo is often subjected to severe attacks by the psychid wattle bagworm, *Kotochalia junodii* (Ross, 1979). Large trees can be defoliated and killed.

Acacia karroo is resistant to attack by termites throughout its life. It has been suggested that the calcium oxalate crystals in the wood and tissues of tropical trees, including *A. karroo*, make them less palatable to termites (Prior and Cutler, 1992).

A community of small moths is closely associated with the galls caused by the rust fungus *Ravenelia macowaniana* Pазschke on the flowers and fruits of *Acacia karroo* (Chown, 1993) (Plate 7H). Larvae of seven species of these microlepidoptera were found to be associated with *R. macowaniana* near Pretoria and Bloemfontein in South Africa and an additional seven species have been found in the Eastern Cape region of the country (Mcgeoch, 1993). The size and diversity of the larval assemblages in these galls are considered to be potential indicators of habitat quality (Mcgeoch and Kruger, 1994); they will be used to monitor climatic changes due to global warming, and changes in environmental quality caused by pollution and habitat loss. Significant differences have already been observed in highly disturbed as opposed to undisturbed natural areas in the Pretoria region (Chown, 1993).

Gall-like swellings sometimes develop on the stipulate thorns of *Acacia karroo* (Hocking, 1970). An ant, *Cataulacus rugosus*, nests in these hollow spines (Gerstner, 1948).

[References:- 50, 56, 63, 66, 71, 79, 85, 87, 109, 110, 127, 128, 141, 143, 146, 159, 161, 179, 181, 191, 210, 211, 212, 213, 245, 246, 247, 248]

Parasitic plants and fungi

Mistletoe species richness in southern Africa is correlated with host nitrogen levels. Acacias (27 mg g⁻¹ N) support 24 species in this region (Dean *et al.*, 1994). The crowns of *Acacia karroo* trees are characteristically parasitized by various mistletoes particularly during the tree's decline towards the end of its life (Plate 6F). Earlier infestations can occur during drought periods or after severe frosts when the trees are under stress. Species of mistletoe recorded on *A. karroo* include *Loranthus dregei*, *Moquinella rubra*, *Viscum capense*, *V. continuum*, *V. obscurum*, and *V. rotundifolium* (Venter, 1971; van der Walt, 1980; Archer, 1982; Midgeley and Joubert, 1991; Dean *et al.*, 1994).

Root parasites such as *Sarcophyte sanguinea* (Visser, 1981) have been recorded on *Acacia karroo* and may kill the pioneer (Weisser and Marques, 1979; Bews, 1917).

The rust fungus *Ravenelia macowaniana* is specific to *Acacia karroo* (Mcgeoch, 1993). The inflorescences and young pods can be heavily infested causing gall-like growths that inhibit seed production (Potts and Tidmarsh, 1937) (Plate 7H).

[References:- 13, 28, 33, 64, 89, 110, 127, 128, 130, 151, 152, 153, 154, 159, 207, 209, 230, 237, 239, 242, 250]

Abiotic factors

Fire

Acacia karroo is well adapted to establishing itself with no shade, shelter or protection from grass fires (Bews, 1917). However, all seedlings less than eight weeks old, about 10 cm high, can be killed by fire. By twelve months, when the seedlings are 35 cm high, there is die-back following a burn but they re-sprout from the base and each gives rise to 3-4 stems (Story, 1952). Later, *A. karroo* will respond favourably to a very severe burn producing a dense multi stemmed thicket within a season or two (Henderson, 1987; Guilloteau, 1958).

Withholding fire, in combination with overstocking, has been responsible for the marked increase of *Acacia karroo* in various parts of South Africa. Overstocking has eased or removed competitive effects of grass on the tree seedlings and has reduced grass fuel loads and hence fire frequency. This has accelerated succession to a mixed thorn scrub climax (Phillips, 1936). Fire intensity is an important component of the fire regime and its effect on the grass sward and bush were investigated in the Eastern Cape thornveld. Research indicated that fire intensity had no effect on the recovery of grass after a burn. Conversely it had a marked effect on the topkill of bush to a height of 2 m. The results provide valuable guidelines for the use of fire in controlling bush encroachment (Trollope and Tainton, 1986).

[References:- 33, 34, 101, 106, 146, 158, 199, 236]

Drought

Acacia karroo has a deep taproot and is independent of surface moisture where underground water is available. The species is drought resistant but cannot withstand desiccation and loss of water from the protoplasm. The seedlings are sensitive to desiccation because they are fairly slow growing and have a high temperature and moisture requirement for growth. Any factor that causes rapid drying of topsoil or delays root development will be deleterious to the seedlings (Du Toit, 1966). Once established the trees are drought resistant (Cunliff, 1975; Henderson, 1987).

An ecological study has been made of modes of plant adaptation to the extreme conditions of drought, evaporation and temperature that occur in the Natal thornveld. Attention is drawn to the extensive root system of most thornveld trees, including *Acacia karroo*, and to the water relations (specific conductivity, osmotic pressure, transpiration rate, etc.) of woody plants growing in this environment. The transpiration rate of thornveld trees is normally high but is subject to sharp fluctuations. As compared with forest trees, the trees of the thornveld show a much greater latitude of functional response to environmental changes (Bayer, 1943)

[References:- 29, 62, 70, 106, 136, 214, 219, 220]

Frost

Young plants of *Acacia karroo* are said to be frost sensitive (Carr, 1976) but, once established, the trees are moderately resistant (Cunliff, 1975; Henderson, 1987). A frost of -10°C may cause defoliation but does not kill the trees. However, there are occasionally (once in 50 to 100 years) much more severe frosts in its natural range and, on these occasions, whole stands of large trees in frost hollows and river valleys may be completely killed. The extent of frost damage is also likely to be dependent upon the environment and state of growth of the tree. For example, trees planted in the central strip of a dual carriageway in a Johannesburg suburb in the highveld region of South Africa proved to be much more frost-resistant than those in adjacent gardens (Carr, 1977).

Acacia karroo is more resistant to frost than *A. nilotica* (West, 1951) *Faidherbia albida*, *A. galpinii* and *A. tortilis* but not as resistant as *A. erioloba*.

A severe frost (c. -12°C) that occurred in the Umguza Valley in Zimbabwe only defoliated trees of *Acacia karroo* but killed the parasitic *Viscum* sp. mistletoes (Plate 6F).

[References:- 27, 45, 46, 62, 106, 253]

PRODUCTS AND USES

Wood

Anatomy

In end section, growth rings and rays of *Acacia karroo* are well defined, vessels numerous, medium to large, arranged along the growth ring parenchyma (Plate 7C). Clear gum deposits are present (Plate 7A) and parenchyma is aliform-confluent and associated with the vessels (Plate 7C). (Goldsmith and Carter, 1981; Kromhout, 1975). Rays are 1-3 seriate but a significant negative correlation was found between latitude and ray height of *A. karroo* wood specimens collected in different parts of South Africa (Robbertse *et al.*, 1980).

Although early work has suggested that *Acacia karroo* wood showed discontinuous rings and indistinct boundary parenchyma (Lilly, 1977), it has subsequently been shown that marginal parenchyma bands and crystalliferous chains do define growth phases in African *Acacia* species and may therefore be useful for age determination (Gourlay and Kanowski, 1991) (Plates 7D and 7F-G). In a later study on *A. karroo* (Gourlay and Barnes, 1994), seasonal growth rings in the anatomy were confirmed as narrow bands of marginal parenchyma filled with long crystal chains (Plates 7D and 7G) and the number of bands was shown to correspond closely to the known ages of the trees. There was further confirmation that they were annual in that the width of the growth rings was correlated with annual rainfall. The bands were laid down during the dry winter season when stem diameter growth ceased. The crystals were subsequently identified as calcium oxalate through the use of a scanning proton microprobe (Gourlay and Grime, 1994) (Plate 7G). When tree roots take up salty water, excess calcium ions must be removed to maintain its water balance. These are combined with oxalic acid to produce insoluble calcium oxalate which is stored as large prismatic crystals in the wood (Prior and Cutler, 1992).

[References:- 27, 92, 96, 97, 98, 99, 123, 125, 147, 161, 170]

Fuelwood

Acacia karroo is a preferred fuelwood almost everywhere it occurs (e.g. Bembridge and Tarlton, 1990) (Plate 8E). The only exceptions to this are where slow-growing species such as *Colophospermum mopane* and *Combretum imberbe* occur; but where such old-growth species have disappeared and dependence is on fast-growing pioneers, *A. karroo* is unrivalled for its sustained high temperature and clean-burning traits. It burns brightly and evenly with little smoke and no odour. It produces good coals and little ash. It splits easily and, once dried, it does not easily absorb moisture

again even if left out in the rain. Disintegrating heartwood is used as tinder (Archer, 1988).

Eberhard (1990) reports the gross calorific value of *Acacia karroo* sapwood to be 18.69 MJ kg⁻¹, that of the heartwood 18.85 MJ kg⁻¹, the density of the wood to be 890 kg m⁻³ at 10% moisture content and 862 kg m⁻³ dry mass and the calorific value per cubic metre to be 16,185 MJ. Goldsmith and Carter (1981) report its density as 800 kg m⁻³ at 12% moisture content. Wood density can be expected to vary in a species that is morphologically so variable and that grows in such a diverse range of environments. It has, however, been found to be consistently high.

The high quality of *Acacia karroo* fuelwood might be linked to the presence of the calcium oxalate crystals. Prior and Cutler (1992) suggest that when a piece of fuelwood is set alight, it burns rapidly producing carbon monoxide which itself is inflammable and raises the flame temperature. When the temperature rises above 370°C, calcium oxalate breaks down and the released oxygen leads to fuller combustion in the wood. This acts as a flame retardant and promotes a glowing combustion similar to that of banked-down coal. The long-lasting embers are preferable for cooking and heating.

Acacia karroo was included in a study of the potential of some South African woods for use as producer gas generator fuels (Hall, 1939). The analytical tests made on each sample included specific gravity, proximate analysis and low temperature carbonization assay. Specific gravity of the acacias varied from 0.68 to 0.86. In proximate analysis, three of the four acacias, including *A. karroo*, had high ash contents of about 0.9%. The moisture figures were reasonably constant for all the woods ranging between 8.5% and 10.0%; the acacias tended to be driest. In the low temperature carbonization assay the acacias gave 24% charcoal and 13.5-17% tar. Liquor contents were c. 40% and CO₂ c. 10% for all species and gas yields did not differ materially. While from these analyses there did not appear to be any marked difference between the woods, the eucalypts proved to be the most suitable fuels for portable generators followed by the acacias and then the pines.

Acacia karroo is reputed to make an excellent charcoal when grown on the coastal dunes in Zululand even when compared with that made from the casuarinas which are known to produce charcoal of the highest quality.

[References:- 14, 31, 77, 92, 103, 135, 156, 161, 194, 231, 233]

Round and sawn wood

The commercial use of *Acacia karroo* is limited because few trees reach commercial size. The sapwood is very wide and creamy brown while the heartwood is red-brown (Noel, 1982) and often seen as small streaks. It has an even,

medium-textured wood finely wavy in tangential and narrowly striped in radial section. Its mechanical strength and shrinkage properties are unknown but discs cut from the stem are remarkable in that they often do not split radially even when taken from trees of large diameter and articles can be turned from it from unsawn discs on the stem axis. It saws easily, planes to a smooth finish, is moderately durable, glues and varnishes well for furniture. It has to be pre-drilled for nailing. It is liable to twist in seasoning and is susceptible to attack by borers and fungi. Generally it is a tough resilient farm utility timber. (Goldsmith and Carter, 1981).

Acacia karroo is used to make fence poles but is subject to attack by borers (Galpin, 1925) and is not durable. Branchwood is used to make the framework of dwellings and also to make crooks and hooks for use in hunting and livestock management (Archer, 1988).

Dr Peter Brain (pers. comm.)³ recalls:- "I remember in the 1930s some people used the thorns [of *A. karroo*] as gramophone needles and they were even sold commercially for this purpose. In those days fibre needles were commonly used by connoisseurs as they produced less wear on the old 78 rpm records than steel ones did, and one kind of fibre needle was actually a thorn. I also remember reading somewhere that some tribe used such thorns instead of stitches to treat gaping wounds"

[References:- 13, 14, 15, 27, 52, 85, 92, 115, 133, 147, 156, 194, 233]

Pulp

Acacia karroo is a prominent constituent of the natural forest in the kwaMbonambi area of Zululand, South Africa, where there are extensive eucalypt plantations to supply large kraft and dissolving pulp mills. In this area, *A. karroo* is a natural constituent of the dune forests and the main species used to rehabilitate coastal dunes after they have been mined to extract titanium and other minerals from the sands (Barnes *et al.*, 1994). For this reason there has been some interest in its pulping properties.

Kraft pulping tests have been carried out on *Acacia karroo*. It pulped quite easily under standard kraft macro-pulping conditions. The screened yield was 49.74%; rejects 0.13%; total yield 49.9%; kappa No. 22.6; Res. AA 12.76 g l⁻¹; pH 13.09; solids 14.3%; pulp consistency 32.7%. The handsheet properties are compared with the results of a single tree of *Eucalyptus grandis* in Table 2. Yield, kappa number and paper properties were generally inferior to *E. grandis*.

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Table 2 *Acacia karroo*: pulping tests - handsheet properties (Figures in brackets are the results of a macropulping test of a single tree of *Eucalyptus grandis* for comparison.) (Samples collected by P.A. Clegg, tests arranged by C.R.E. Clarke, laboratory evaluation carried out by A. Wessels, all of Sappi Forests, South Africa.)

Test	Unit	Beating revolutions (LPN)			
		0	2250	9000	18000
Wetness	Deg SR	16.0 (19.0)	16.5 (22.0)	23.0 (27.0)	30.0 (34.0)
Freeness	CSF	685 (615)	670 (560)	540 (477)	427 (375)
Grammage (Cond)	gsm	63.5 (63.3)	59.6 (63.6)	59.7 (65.0)	60.2 (65.0)
Grammage (B.D.)	gsm	59.0 (59.0)	55.6 (59.2)	55.4 (60.6)	55.9 (60.5)
Moisture	%	7.17 (6.80)	6.72 (6.83)	7.18 (6.79)	7.01 (7.00)
Bulk Specific	cm ³ g ⁻¹	2.03 (1.50)	1.56 (1.37)	1.62 (1.28)	1.56 (1.22)
Brightness (R457)	%	24.7 (28.3)			
Stretch	%	1.6 (2.3)	2.5 (3.2)	4.0 (4.1)	4.5 (4.9)
Breaking Length (13072)	m	3153 (7133)	4800 (10248)	6929 (12631)	7712
Burst Index	kPa m ² g ⁻¹	1.1 (3.0)	2.2 (5.2)	3.9 (6.7)	4.6 (7.3)
Tear Index	mN m ² g ⁻¹	4.2 (10.0)	7.9 (9.5)	9.3 (9.3)	8.2 (8.8)
T.E.A.	J m ² ⁻¹	17.4 (58.0)	38.7 (111.3)	103.8 (192.8)	133.6 (256.2)
Porosity (10sq cm)	ml min ⁻¹	>12000 (1160)	>12000 (540)	8750 (310)	3500 (80)

Table 3 Dissolving pulp yields, viscosity, brightness and Kappa number for *Acacia karroo* and three Australian acacias grown in southern Africa. (Samples collected by P.A. Clegg, tests arranged by C.R.E. Clarke.)

Species	Yield	Viscosity	Brightness	K number
<i>A. karroo</i>	44.350	43.800	43.200	3.910
<i>A. decurrens</i>	48.822	69.920	55.272	2.315
<i>A. dealbata</i>	46.391	100.67	41.090	4.691
<i>A. mearnsii</i>	49.038	96.113	50.613	2.574

Dissolving pulp tests have also been conducted on *Acacia karroo*. Its pulping properties are inferior to the three Australian acacias with which it is compared in the Table 3; *A. mearnsii* is extensively used for dissolving pulp in South Africa and sets the standard by which *A. karroo* should be judged. In addition, it had more spots and a relatively higher percentage of shives (21%).

[References:- 27]

Bark

Bark from the roots of *Acacia karroo* is used to make twine and rope (Archer, 1988) and bark is used in the construction of the traditional Nama mat house (Archer, 1989a). A dye is extracted from the bark by the Nama people (Archer, 1989b). The bark of the stem contains up to 19% tannin and is used for tanning leather to which it imparts a red colour (Timberlake, 1980). It is also used for making twine (Wehmer, 1935; Watt and Breyer-Brandwijk, 1962).

[References:- 14, 16, 194, 233, 244, 249, 258]

Gum

History, specifications and trade

The historical and present day uses of gum arabic have been comprehensively described (Allison, 1993). It is an ancient article of international commerce and, among other things, it has been used in the mixing of inks and paints, in adhesives, cosmetics, perfumery and in medicine. It is a unique multi-functional food additive for which 80% of the world annual production is used. Its modern day use is principally as an emulsifier, flavouring agent, stabilizer, humectant, surface finishing agent and thickener in the food and pharmaceutical industries. It retards sugar crystallization which is an important property. It also has potential uses in other industries.

The following is an extract from the JECFA (Joint FAO/WHO Expert Committee on Food Additives) 1990 Specifications For Identity and Purity of Food Additives as they refer to gum arabic (syn. acacia gum, arabic gum, INS. No. E414).

"Gum arabic is defined as a dried exudation obtained from the stems and branches of *Acacia senegal* (L) Willd. or closely related species [it is not made clear whether closely related means taxonomically or chemically related]. It consists mainly of high molecular weight polysaccharides and their calcium, magnesium and potassium salts which, on hydrolysis, yield arabinose, galactose, rhamnose and glucuronic acid. The article of commerce may be further specified as to viscosity. Unground gum arabic occurs as white or yellowish white spheroidal tears of varying size or as angular fragments. It is also available commercially in

the form of white to yellowish white flakes, granules, powder or spray-dried."

Specifications have been developed by the Committee to identify the substance that has been toxicologically tested, to ensure that the substance is of the quality required for safe use in foods and to encourage good manufacturing practice.

The increase in the consumption of convenience foods has led to an increase in the use of gum and, at the same time, the concern about a healthy diet has stimulated interest in thickeners of natural origin. Nevertheless, irregularity of supply and fluctuating prices have caused gum arabic to lose out to synthetic substitutes on the world market with the result that annual gum production has dropped from about 70,000 tons in the 1960s to 25,000 tons today. The current (1995) prices are US\$4,200 per ton for ordinary grade, US\$4,650 per ton for hand-picked nodules and US\$5,200 per ton for kibbled ordinary grade ex-Port Sudan from which 85% of the world production is supplied. Gum arabic exports constitute 10-15% of the total foreign currency earnings of Sudan. It is interesting that the value of the soil ameliorating action of the acacia trees on the arable land on which millet crops are grown is estimated to be worth more in terms of grain exported from Sudan than is the gum (Hassan, pers. comm.)⁴. Gum arabic is therefore potentially a valuable product. With improved quality control and a more reliable supply, it could provide a cash income for many more resource-poor farmers in Africa.

Gums from at least ten species of African acacias as well as those from other genera, e.g. *Combretum* and *Albizia*, have been sources of what is marketed as gum arabic. This has given rise to considerable controversy in the trade although it is now widely accepted under the joint WHO/FAO directive, 1989, that the source should be *Acacia senegal* and the 18 species (mostly occurring in Somalia) belonging to the *A. senegal* complex, i.e. those with spicate inflorescences and three prickles at or near the nodes (Allison, 1993). However, because the gum is collected from wild trees by rural people, mixing with gum from species outside this group occurs and cannot be detected although they might be distinguishable pure. On their own, gum from these species would not be acceptable for use in foodstuffs and for pharmaceuticals because it would be held that they were not toxicologically cleared, a process that might be prohibitively expensive for a single species. Even in pure form, the chemical constitution of the gums of *Acacia* species from such widely disparate groups as the Gummiferae and the Vulgares merge at the boundaries indicating that there are some that could be regarded as closely related gums in regulatory terms; this could include species such as *A. seyal* and *A. karroo* (Jurasek *et al.*, 1993). The situation in regard to *A. karroo* is most unsatisfactory in that it is used regionally as a substitute for

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gum arabic in southern Africa yet it cannot be exported to Europe or the USA in labelled form although it might well be introduced undetected in mixture with the gum of *A. senegal*.

Homogeneity of product and continuity of supply are extremely important; Sudan produces gum with the most consistent quality and uniformity at present because most of it comes from one species, *Acacia senegal*, and from planted fallows in which there has probably been some form of selection operating for many years.

[References:- 5, 111, 113]

Chemistry

A comparison between the chemical constituents of the gum of *Acacia karroo* (Anderson and Pinto, 1980) and those of *A. senegal* (Jurasek *et al.*, 1993) shows that the major difference is in the proportion of rhamnose on the presence of which, in chain terminals, "peripheral positions of the globule-shaped molecule and the superior stabilizing powers of gum arabic for oil/water emulsions may depend" (Anderson, 1978). The other main distinguishing features of gums from species in *Vulgares* (compared with those in *Gummiferae*) are the significant negative optical rotations and intermediate molecular weights (for example, -30° and 384×10^3 and $+53^\circ$ and 1860×10^3) respectively for *A. senegal* and *A. karroo* (Anderson, 1978; Anderson and Pinto, 1980). However, the extremes of individual tree values for *A. karroo* reported by these authors (specific rotation $+36^\circ$ to $+67^\circ$; molecular weights, 1500×10^3 to 4800×10^3 , uronic acid 10.3 to 18.1%, rhamnose 4 to 10%) do suggest that, with selection, *A. karroo* could be bred to produce a gum that approached the quality of that of *A. senegal*. Field evaluation trials now being planted will soon provide the opportunity of conducting research that will make it possible to make definitive statements on the total variation and the proportion of it that is under genetic control and therefore susceptible to improvement through selection and breeding.

[References:- 5, 6, 8, 9, 10, 11, 12, 27, 49, 51, 83, 91, 113, 196, 249]

Collection and marketing

The only country in which *Acacia karroo* gum is collected and used as a substitute for gum arabic is Zimbabwe (Plates 8A and 8C). The following account of gum arabic production in that country is based on a visit to a factory in Bulawayo, Zimbabwe (Coppen, pers. comm.)⁵.

Production of gum arabic from *Acacia karroo* in Zimbabwe

started in 1987 to provide a local substitute for imported *A. senegal* gum. Although it does not have quite such good emulsifying properties, it is now used to meet most requirements in the country. Annual production is around 25-30 tonnes.

There is no organized production of gum; it is collected by the rural population in the communal lands and sold to various factories in Bulawayo where it is sorted by hand into lumps, finer material and rejects. Yields of gum are highest during the hot weather at the end of the dry season, August to October, and collectors may bring in 40 to 50 kg at a time. In May to June a collector's sack-load, collected over a period of about one month, will yield, typically, 10-13 kg of gum in lump form and 0.5 to 2.0 kg of sifted material. Gum prices started in the region of Z\$2.00 kg⁻¹ but now may be as high as Z\$12.00 kg⁻¹ for the highest grade clear nodules. However, profit margins on gum arabic are claimed to be small and there has not yet been sufficient incentive to increase or improve production.

Collected gum is principally from natural exudates stimulated by boring insects (Plates 7A and 7E) although a little is now produced by tapping; the latter entails making cuts into the tree with an axe (more in the nature of taking off a sliver of bark than making a deep cut), with no more than three cuts per tree. After one or two days the wet gum is collected and left to dry. Gum samples can be obtained by boring into the stem and setting a bottle in the hole (Plate 8B)

[References:- 5, 13, 15, 57, 156, 194, 258]

Other uses for gum

Because of the limited export potential for the gum of *Acacia karroo* from Zimbabwe, a local supplier has been investigating its potential use in industries other than food; the findings (C. Mandinyanya, pers. comm.)⁶ are summarized below.

Plant industry. Emulsion: the gum could not be used as the industry uses chemicals with specialized properties; wetting/dispersing agent Z: the industry currently uses cellulose derivatives (tylose); the disadvantage of gum is that the viscosity increases very slowly with increase in solids.

Agrochemicals. The industry uses wetting agents for spraying chemicals (molasses and alkylated phenoethylene oxide condensate). While gum cannot replace the oxide, it is currently being tried by the Cotton Research Institute at their Kadoma Research Station, both on its own, and blended with molasses, for cotton spraying. The initial results are encouraging but the yield factor has to be confirmed. The acidic characteristic of gum solution makes it a more suitable carrier as alkaline conditions do not give best environments for the active ingredients.

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Detergents. Surfactants, which are responsible for reducing the surface tension of water, have specific structural features and gum was found unsuitable as a substitute to these products.

Glue industry. Tylose and emulsions are major ingredients; Tylose is used to adjust viscosity. The disadvantage of using gum solution itself is that the glue does not dry quickly.

Stockfeeds industry. Most of the local formulations use molasses and starch (also an ingredient) as binders. Gum solution was rejected by National Foods on cost and because it lacked the molasses flavour.

Printing industry. The printing industry in Zimbabwe is provided with a complete dye carrier which possibly contains gums e.g. Guar. Presentation of gum to such customers was difficult as they always asked for a match to that carrier.

Ink industry. Printing works are already using gum of *Acacia karroo*.

Pharmaceutical industry. This industry is looking for a microbiologically clean and high quality binder. This is difficult to provide until such time as local processors can purify their gum to the desired standard.

Mining industry. Flotation is by hydrophilic and hydrophobic flocculation and these are achieved by specialized chemicals. Thickeners and emulsifiers are used as lubricants during the drilling stage. The main disadvantage of gum solution is the slow increase in viscosity with increase in solids. Guar Gum is used for the flotation of chelite and tungsten; gum acacia could be tried for a range of minerals.

Pottery industry. A number of pottery companies are already using *A. karroo* gum as a glazing agent.

Traditionally, *Acacia karroo* gum is mixed with cattle dung for sealing the floors of dwellings (Archer, 1988).

[References:- 15]

Fodder

The foliage, flowers, green pods and parasitic mistletoes of *Acacia karroo* are important sources of browse for livestock and game in southern Africa (Plate 6C and back cover). When consumption of *A. karroo* browse and grass by goats was measured in woodland in the Eastern Cape Province of South Africa (Teague, 1989a), *A. karroo* was preferred to grass and selected almost exclusively when available at high leaf densities. Grass was consumed in significant amounts only when approximately 50% of the available *A. karroo* leaf had been consumed. Total intake of browse plus grass was lower during the period when the goats changed from consuming mostly *A. karroo* to consuming mostly grass. When a dense stand of *A. karroo* was felled and sheep and goats allowed to browse on regrowth, sheep spent 6% and goats 50% of their foraging time feeding on the *A. karroo* coppice shoots (Plate 6C). Cattle also browse *A. karroo*, particularly when it is the only green forage in woodland at

the end of the dry season, but they do not browse it preferentially as do goats. In the Transvaal, South Africa, *A. karroo* is particularly susceptible to heavy losses of soft green shoots to browsing wild animals in spring (Milton, 1987).

The nutrient and mineral content of *Acacia karroo* browse is known to vary with the population, individual tree, soil, climate, season, age and browsing pressure. A proper understanding of the influence of these factors will not be achieved until experiments are established to control them. The material that will become available from the Oxford Forestry Institute's acacia trials network will provide an opportunity to study their effects. The results of one comprehensive proximate nutritional and mineral analysis of the leaves and pods are given in Table 4.

The green foliage and pods of *Acacia karroo* are protein-rich (14-15% dry weight), well supplied with phosphorus (0.11-0.20% dry weight) (Steenkamp and Hayward, 1979). Nitrogen levels in *A. karroo* foliage are high (23.8 mg g⁻¹ dry matter) in comparison with levels in the foliage of associated plant species growing in river beds in the arid southern Karoo region of South Africa (Dean *et al.*, 1994).

In an investigation into the occurrence of cyanogenic glycosides (Steyn and Rimington, 1935), fresh leaves, flowers and immature pods of *Acacia karroo* and four other *Acacia* species from the northern Transvaal, South Africa, were submitted to the prussic acid test on fresh and wilted material. For *A. karroo* all tests yielded negative results. By comparison, fresh leaves and green pods of *A. erioloba* gave >70 mg of HCN per 100 g dry weight of plant material, *i.e.* they contained dangerously high levels of cyanogenic glycoside. *A. karroo* is therefore more suitable as a stock feed than some other species in this genus. Fresh foliage, flowers and green pods of *A. karroo* sampled at Onderstepoort in the Transvaal, South Africa, were found to contain no cyanogenic glycoside (Steyn, 1943).

In a study of the leaves of the main tree and grass species of a semi-arid savanna in Botswana (Tolsma *et al.*, 1987), it was found that seasonal variation in concentrations of foliar nutrients followed similar trends in all species. Concentrations of N and P were greater in young leaves than in mature leaves, while Ca and Fe accumulated until leaf abscission. Concentrations of Ca and Mg in *Acacia karroo* foliage peaked during the dry winter, whereas N, P and K levels were greatest in new foliage in early summer. It was concluded that P is the most limiting nutrient in this savanna because of the strong translocation from leaves to twigs before leaf abscission. *A. karroo* was the exception among the eight acacias and two other species included in the study in that it was the only tree that was not leafless at the end of the dry season.

There is further evidence of seasonal nutritional variation in the foliage of *Acacia karroo* in a study of the population

Table 4 Proximate nutritional and mineral analyses of *Acacia karroo* foliage and pods from the Cape Province in South Africa. 1 = dry (winter) season; 2 = wet (summer) season; CP = crude protein; CF = crude fibre; EE = ether extract including resins and lipids; NFE = ash and N-free extract including carbohydrates; and Na, K, Ca, P, Mg; all given as % dry mass. Fe, Cu, Mo, Mn and Co are given in parts per million. (From Steenkamp and Hayward, 1979)

	CP	CF	EE	ASH	NFE
1 Foliage	13.7	13.0	3.6	10.6	59.2
2 Foliage	14.7	14.0	4.6	9.8	56.9
2 Pods	15.0	26.3	2.5	6.9	49.3
	NA	K	Ca	P	Mg
1 Foliage	0.12	0.87	2.90	0.11	0.49
2 Foliage	0.10	0.81	2.58	0.14	0.48
2 Pods	0.07	1.31	0.14	0.20	0.32
	Fe	Cu	Mo	Mn	Co
1 Foliage	517	3.4	1.39	34	0.14
2 Foliage	334	3.8	0.99	31	0.13
2 Pods	115	6.1	2.90	17	0.13

Table 5 An analysis of percentage of leaf nitrogen (%N), nitrogen 15 ratio (^{15}N) and carbon 13 ratio (^{13}C) for leaf samples from *Acacia erioloba*, *A. fleckii*, *A. karroo*, *A. nilotica* ssp. *kraussiana*, *A. tortilis* ssp. *heteracantha* and *Faidherbia albida* growing in close proximity (within 2km) to each other on Umguza Valley Estates, Zimbabwe. Figures are an average for six trees for each species except for *A. tortilis* ssp. *heteracantha* for which there were four. The subscripts are the standard errors. Increasing ^{15}N means that a higher proportion of nitrogen comes from the soil or ground water; increasing ^{13}C (i.e. the lower the negative value) indicates greater efficiency in water usage. (Data from Sutherland, pers. comm.)⁷.

Species	%N	^{15}N	^{13}C
<i>A. erioloba</i>	2.36 _{.22}	10.47 _{.58}	-27.80 _{.41}
<i>A. fleckii</i>	2.79 _{.12}	0.77 _{.29}	-27.52 _{.25}
<i>A. karroo</i>	2.45 _{.18}	3.10 _{.34}	-28.00 _{.23}
<i>A. nilotica</i>	2.23 _{.02}	1.35 _{.65}	-26.99 _{.18}
<i>A. tortilis</i>	2.73 _{.39}	7.67 _{1.89}	-28.66 _{.04}
<i>F. albida</i>	4.47 _{.38}	2.13 _{.70}	-27.79 _{.63}

⁷Dr J. Sutherland, University of Dundee, Dundee, U.K.

dynamics of the psyllid *Acizzia russellae* (Webb and Moran, 1978). Population levels of the psyllid were ten times greater on regenerative foliage of pruned *A. karroo* than on normal trees and, during late summer and winter, populations of the psyllid declined more slowly on pruned than on normal trees. It is suggested that the availability of quantities of high quality nutrients in the leaves of pruned *A. karroo* trees may explain the epidemic population levels achieved by the psyllid on pruned plants.

Patterns of browse selection of goats in *Acacia karroo* woodland were studied in the Cape Province, South Africa (Teague, 1989a). The rate of intake of browse was positively related to the leaf mass/unit length of the shoot. Generally, tannin levels and *in vitro* digestibility decreased following browsing. Leaf and shoot intake was negatively related to tannin content and positively related to digestibility, thus influencing patterns of selection for different plant parts and size classes of *A. karroo*.

Viscum and *Loranthus* spp., of the family Loranthaceae are common parasites of *Acacia karroo* throughout the range of *A. karroo*. These are browsed by livestock and, in times of drought, have been lopped from the trees to help sustain the animals. The mistletoes *Moquinella rubra*, *Viscum obscurum* and *V. rotundifolium* on *A. karroo* in the Addo Elephant Park of the Eastern Cape, South Africa, are selectively browsed by elephant (Midgeley and Joubert, 1991). *A. karroo* in the southern limit of its range supports four mistletoe species (Dean *et al.*, 1994).

Bees, *Apis mellifera*, collect pollen and nectar from the flowers of *Acacia karroo* in summer (Timberlake, 1980) and the honey is used by the rural population throughout the species' natural range (see *e.g.* Archer, 1982). The long flowering period of the species makes it a particularly useful bee tree (see *e.g.* Carr, 1976; Timberlake, 1980).

[References:- 13, 17, 18, 19, 20, 45, 52, 64, 68, 117, 118, 130, 133, 138, 145, 156, 195, 197, 198, 221, 224, 233, 235, 247, 249]

Medicine and food

Acacia karroo roots are prescribed as an aphrodisiac in Zimbabwe (infusion taken by mouth) and for pain in the alimentary canal, rheumatism (infusion taken by mouth and ash from burnt root rubbed onto incisions made on painful parts), convulsions (infusion taken by mouth and face washed with infusion), gonorrhoea (infusion taken by mouth), generalized pains (body wash with infusion), syphilis (powder applied on penile sores), and vertigo (infusion or powder taken by mouth) (Gelfand *et al.*, 1993). A decoction of the bark, which contains 19.7% tannin, has been used as an emetic and to treat diarrhoea in humans and "tulp" poisoning in cattle.

The roots are also placed in the fowl run to kill external parasites (Gelfand *et al.*, 1993).

The gum of *Acacia karroo* is widely eaten as confection in southern Africa (Archer, 1982 & 1988; Wild *et al.*, 1972). It is also eaten by animals, particularly vervet monkeys (*Cercopithecus aethiops*) and bushbabies (*Galago* spp.). Children chew the sweet thorns of *A. karroo* in kwaZulu (Milton and Bond, 1986). Seeds have been used as a substitute for coffee (Watt and Breyer-Brandwijk, 1962).

[References:- 13, 14, 24, 86, 133, 146, 155, 244]

Soil amelioration

Once its "skirt" of thorny branches has died and fallen off or been pruned, *Acacia karroo* has only a moderately dense crown that allows enough light through for the development of a grass and shrub understorey. It flushes early in the spring when the temperatures are at their highest and before the rains have come which is when shade is most needed to reduce soil temperatures (Plate 6B).

Acacia karroo is known to nodulate (Barnes *et al.*, 1994) (Plate 6D). Increases in dryland crop yields following clearance of *A. karroo* are well known in the communal areas of Zimbabwe. The benefits are not as marked where crops are planted in mixture with the trees but this is said to be due to shading effects rather than to a reduction of fertility or competition for water.

Cattle farmers recognize the beneficial effects that *Acacia karroo* has on the range through its influence on the species composition of the associated grasses. There is typically development of an understorey of perennial, palatable and nutritious grasses, such as *Panicum maximum* and *Cenchrus ciliaris*, which thrive on the environmental benefits that stem from the species' ability to provide shade, utilize water and nutrients from depth, fix nitrogen, improve soil structure and aid infiltration of rainfall (Roberts, 1963; Felker, 1981; Acocks, 1988). Grasses such as *Panicum maximum* are, in fact, dependent for their existence on the presence of bush (Acocks, 1988). If the trees are cleared away, this grass survives for only one or two years and is then replaced by less valuable species. Results obtained from grazing trials in Zimbabwe leave no doubt that, where the rainfall is sufficient to support perennial grasses, the ideal stage in the succession to maintain is where perennial grasses predominate (West, 1955).

[References:- 2, 25, 27, 80, 169, 254]

ESTABLISHMENT, YIELD AND MANAGEMENT

There is no published record of *Acacia karroo* having been planted and managed on an operational scale. Populations

that have been used for studies of establishment, yield and management have all been naturally regenerated stands (see under life cycle) in the species' indigenous range. Nevertheless, research conducted to establish introduction plots and trials for genetic evaluation have resulted in some knowledge being gained on the technology for the artificial establishment of the species.

In its natural range *Acacia karroo* is reported as being easy to raise from seed (Carr, 1965) and it has been planted widely in experimental plots in South Africa (Browne, 1981) and also in Botswana in test plots for fuelwood production (Tietema and Merkesdal, 1986). It has been reported as one of the fastest growing species planted in the Botanical Gardens in Harare, Zimbabwe (Muller, 1979). It has also been recommended for special sites such as mine dumps (Aylen, 1961) and the central strip in dual carriageways (Carr, 1977).

As an exotic, *Acacia karroo* has been reported as doing well in desert conditions (100-200 mm annual rainfall) in Israel (Gindel, 1946; Kaplan, 1957) and in the Rajasthan Desert, India (1980). It is threatening to become naturalized in Western Australia (Scott, 1991). It has even been suggested as a suitable subject for bonsai (Ormond, 1968).

[References:- 41, 44, 46, 114, 140, 142, 150, 184, 232]

Establishment

Seed collection

The pods of *Acacia karroo* dehisce on the tree. If they are collected before they open, the viability of the seed is severely prejudiced. Therefore collection must be during the period when the sound seed is still suspended from the pod on the thread-like funicle (Plate 1F). The funicle is brittle at this stage and any shaking of the pods will result in the seed falling to the ground where it is unrecoverable unless a ground sheet is laid beneath the canopy. The seed is therefore most effectively collected by breaking off the whole bunch of pods direct into a cloth or polythene bag and separating seed from pods later by crushing and winnowing. A high proportion of the seed is often already damaged by bruchids when the pods open and, as this seed is light, it remains suspended by the funicle for a much longer period than the heavier sound seed. It is therefore critical to make sure that the seed is collected before the sound seed has fallen otherwise viability in the seed collected can be so low that it is virtually useless.

[References:- 25, 45]

Seed storage

Provided the seed is sound, ripe and hard when collected, it is robust and can remain viable for 50 years or more in dry

conditions in ambient temperatures (Story, 1952). It is thought that if the seed is subjected to freezing down to -15°C for 48 hours, remaining bruchid eggs and larvae are killed (Nixons pers. comm.)⁸

[References:- 73, 199]

Seed pretreatment

As with most *Acacia* species, the seeds of *Acacia karroo* have water impermeable dormancy (Du Toit, 1966) and this must be broken before the seed can germinate. In nature this is either accomplished through the erosion of time in moist soil or, more rapidly, by passage through the digestive tract of a browsing animal. Artificially any of the techniques used to break or soften the seed coat can be used. These include boiling in water (Story, 1952), hot wire scarification, abrasion of the seed coat (Carr, 1976) and nicking the coat with a pair of nail cutters. The most effective way of ensuring rapid and uniform germination is to nick the seed coat at the micropylar end, soak in water for 12 hours, pre-germinate in a controlled temperature cabinet at a constant temperature of 35°C and sow the seed in the nursery when the radicle appears which is usually in two to three days.

[References:- 26, 40, 45, 60, 62, 70, 164, 199]

Nursery

The seed of *Acacia karroo* must be sown directly into pots, tubes or "speedling" polystyrene trays. Pretreated seed germinates within three or four days of sowing. If nicking is used, damaged seed can be recognized during the nicking process and discarded; this can ensure 90-100% germination (Barnes *et al.*, 1995).

It is amenable to being raised in a container with a medium volume of as little as 100 cm³ and will tolerate repeated pruning of the taproot by shearing or by desiccation through placing the container off the ground or on an impervious substrate (Nixon, pers. comm.)⁸.

Sterilization of nursery soil kills the rhizobia and probably delays the development of nodules on the roots until after planting out in the field. Inoculation with rhizobia of plants growing in soil that has been sterilized does not appear to bring about as good a response as inoculation of plants growing in unsterilized soil; this has been tentatively attributed to the mycorrhizae also being killed by the sterilization (Sutherland *et al.*, 1994). Low soil fertility and small container size in which the nutrient reserves are rapidly depleted stimulates the development of nodules on the roots. Although there is some indication that performance can be enhanced through inoculation in the

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nursery and field, much more work needs to be done to show which strains of rhizobia are most effective and whether these effects have practical significance.

The seedlings grow rapidly and, depending on provenance, container size, soil fertility and temperature can reach heights of over 40 cm in six months (Barnes *et al.*, 1995) (Plates 2E-G). They can be hardened off by reducing water in the weeks preceding planting. They are more drought tolerant than the Australian acacias commonly used as exotics in southern Africa if water is withheld (Nixon, pers. comm.⁹).

Acacia karroo has been rooted successfully (Dick, pers. comm.)¹⁰

[References:- 26, 41, 45, 62, 206]

Planting

Provided that care is taken not to expose or damage the root system at planting, survival in the field is good when there is sufficient soil moisture. If dry conditions follow planting, there may be losses but, under drought conditions, the seedlings may lose all their leaves and then sprout from the base again after rain. Like most of the African acacias, *Acacia karroo* is resistant to termites.

Under the right conditions, direct sowing into the field should be possible with *Acacia karroo* although it could be difficult to prevent heavy losses soon after germination from insects and small mammals which can be controlled much more easily in the nursery. Another possibility would be to feed the seed to goats or cattle at an opportune time when the conditions were suitable for seedling establishment in the range on which livestock were put out to browse and graze.

[References:- 22, 25, 41, 44, 45, 46, 47, 62, 90, 112, 114, 140, 142, 150, 160, 232]

Yield and management

Wood

Because of the difficulties of determining the age of tropical tree species, there have been no estimates of wood production in *Acacia karroo*. However, recently there have been two studies on this subject, one based on a knowledge of the year in which the stand is likely to have been established and the other based on a new ageing technique.

In an evaluation of eucalypt woodlots and acacia woodland management practices in a dry part of Zimbabwe where the mean annual rainfall is in the region of 500 mm, it was found that many of the small community woodlots of *Eucalyptus camaldulensis* completely failed and the very best showed a mean annual increment of only 2.09 m³ ha⁻¹ yr⁻¹ (1.72 fresh t ha⁻¹ yr⁻¹). These productivity levels were insufficient to cover establishment costs at current pole and fuelwood prices. By comparison, wood production in four to thirty-year-old natural *Acacia karroo* stands in which the regrowth was protected and managed was found to range between 0.7 and 3.2 fresh t ha⁻¹ yr⁻¹ (Clarke and Crockford, in press).

In another study in a similar environment in Zimbabwe, the recently developed ageing technique (Gourlay and Barnes, 1994) was used to estimate wood productivity over the life of a natural stand of *Acacia karroo* (Gourlay *et al.*, in press). Total overbark volume down to a branch diameter of 5 cm was measured in a number of felled sample trees covering the range of tree sizes found in the stand. Basal area at breast height (1.3 m) was found to be a good predictor of total tree volume (Figure 6). The relationship between basal area at ankle height (0.1 m) and total tree volume was also investigated because it had been chosen as a precise indicator of tree volume in a study in Botswana (Tietema, 1993). In the Botswana study, the regression formulae for estimating individual tree fresh biomass (B) in kg from ankle height basal area (BA) in cm² for *A. karroo* were $B=0.2865 \times BA^{1.2082}$ ($R^2=0.96$), when BA was plotted on a logarithmic scale, and $B=0.7558 \times BA$ ($R^2=0.93$) when BA was plotted untransformed. In the second Zimbabwean study, ankle height and breast height basal areas were found to be equally precise predictors (Figures 6 and 7). Increment cores were taken at breast height from every tree in the stand, ring widths counted and measured and yearly and cumulative volume estimated back in time to when the first tree reached a measurable breast height diameter. The annual increment curve in Figure 8 confirms the suspected c. 25-year life-span of *A. karroo* and suggests that growth rate peaks at about 20 years, thereafter falling off rapidly. At its peak, this stand could be expected to produce about 2.8 m³ ha⁻¹ yr⁻¹ of wood unless there were adverse environmental factors. Total volume at about 25 years was about 33 m³ ha⁻¹ suggesting an mean annual increment over the rotation of 1.32 m³ ha⁻¹ yr⁻¹ (Figure 9). On the other hand, individual trees in this stand that had unrestricted growing space produce 1 m³ of wood in 25 years. The crowns of these trees occupied about 95 m² of growing space suggesting that, under uniform spacing and growing conditions, total stand volume after 25 years could be 100 m³, a mean annual increment of 4 m³ ha⁻¹ yr⁻¹. These figures nicely bracket Clarke and Crockford's (in press) estimate.

[References:- 25, 53, 96, 99, 231]

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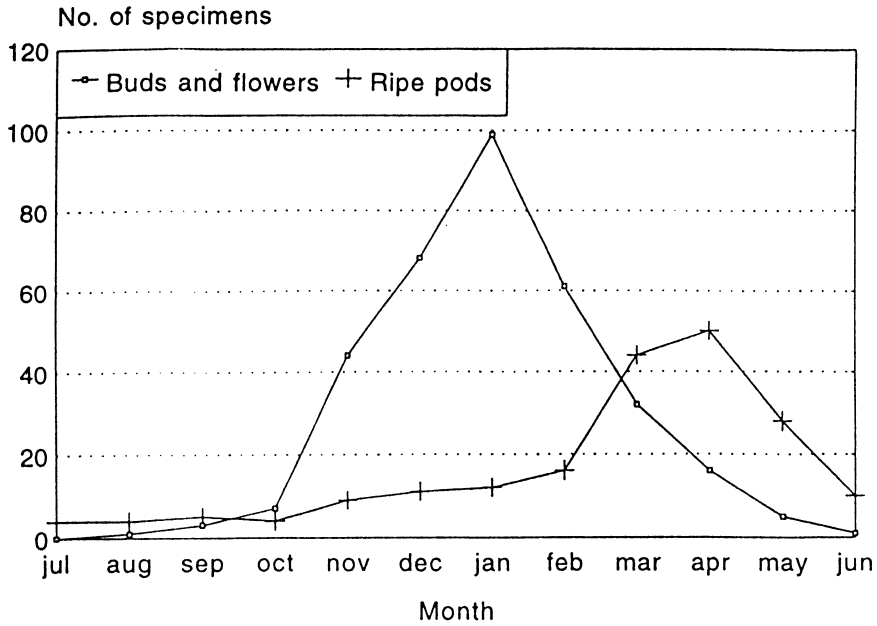


Figure 5 Flowering and fruiting phenology of *Acacia karroo*. This chart was constructed using the flowering and fruiting status entered for the herbarium specimen held in the BRAHMS database. The total numbers in the "buds and flowers" and the "mature fruit" categories are plotted against month of collection.

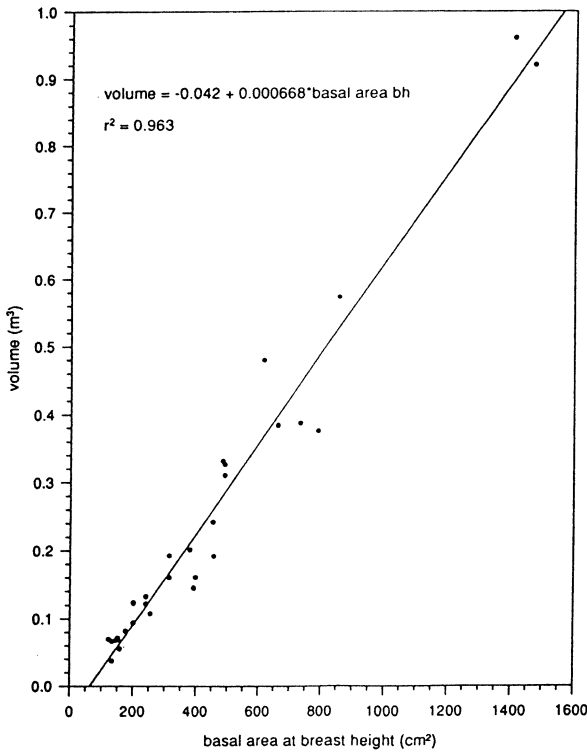


Figure 6 Relationship between basal area at breast height (1.3 m) and total over-bark volume to 5 cm minimum branch diameter for a stand of *Acacia karroo* on Umguza Valley Estates in Zimbabwe. (From Gourlay *et al.*, in press).

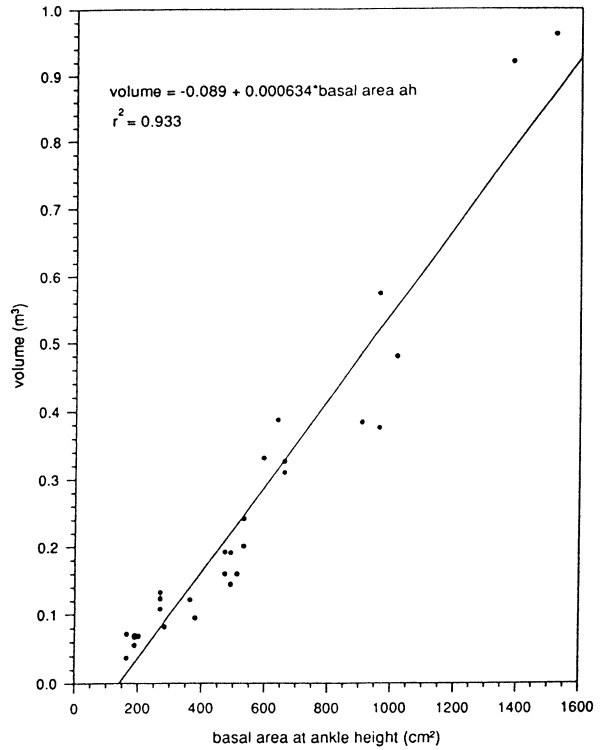


Figure 7 Relationship between basal area at ankle height (0.1 m) and total over-bark volume to 5 cm minimum branch diameter for a stand of *Acacia karroo* on Umguza Valley Estates in Zimbabwe. (From Gourlay *et al.*, in press).

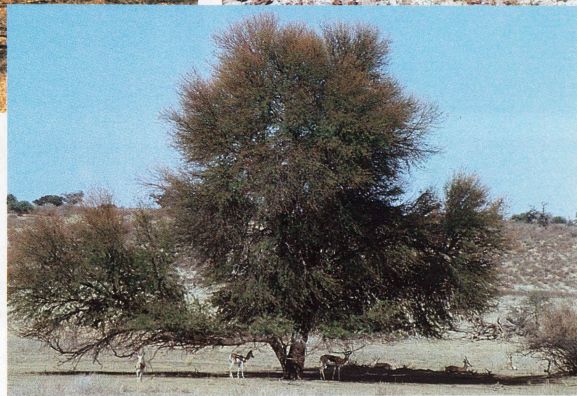


Plate 5 *Acacia karroo* (left to right sequence)

- A In scrub near the coast in the eastern Cape Province of South Africa
- B On the beach on Bazaruto Island in Mozambique
- C In the coastal dune forest of Zululand, South Africa
- D On black vertisols in the Umuza Valley, Matabeleland, Zimbabwe
- E On a salt-encrusted (sodium carbonate) island in the inland Okavango Delta in Botswana
- F In the Bokaap district of Cape Town
- G In the Kalahari Gemsbok National Park in South Africa

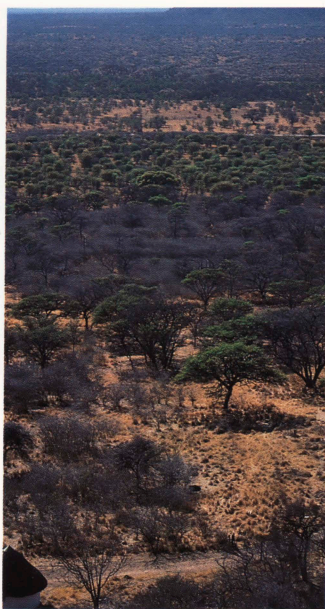
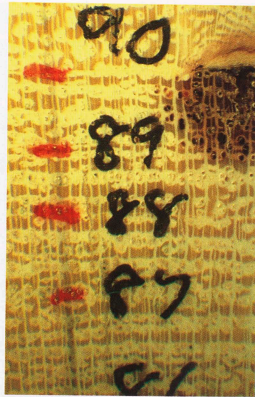
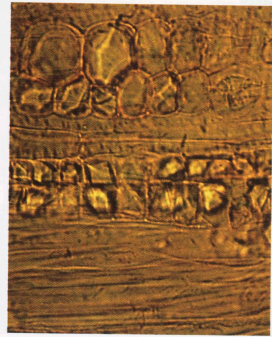
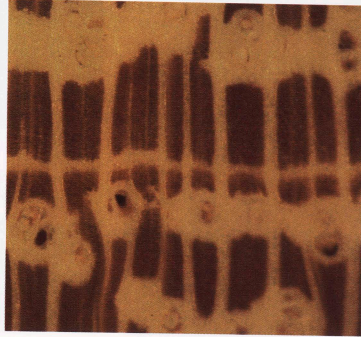


Plate 6 *Acaci karroo* (left to right sequence)

- A Lush perennial *Panicum maximum* pasture beneath the trees
- B The trees follow *A. erioloba* in being among the first to flush at the end of the dry season
- C Foliage and flowers in reach are heavily browsed by domestic and wild animals
- D The species nodulates early and prolifically
- E Intensive root system on a tree uprooted in the coastal sand dunes
- F The parasitic mistletoe, *Viscum* sp., is conspicuous after it has been killed by a heavy frost while the tree has survived
- G Extensive root system exposed of a tree growing near a river in a black vertisol



CA: PIXE H: 432 C: 12%

RUN 147089 25-SEP-91 (250um)

OPS39: Acacia Kr



Plate 7 *Acacia karroo* (left to right sequence)

- A Gum exudation from the inner bark associated with wood-boring insect activity – probably a cossid moth in this case
- B The larvae of a number of Cerambycid beetles bore in the stems
- C The thin continuous line of marginal parenchyma in the wood can be distinguished in transverse section from the aliform parenchyma associated with the vessels (Photo I.D. Gourlay)
- D The chambered cells of the marginal parenchyma are crystalliferous (Photo I.D. Gourlay)
- E Drought and wood borers stimulate gum production at the end of the dry season
- F The marginal parenchyma has been shown, by wounding experiments, to be laid down annually during the dry season (Photo I.D. Gourlay)
- G The crystals in the marginal parenchyma have been found to be calcium oxalate by scanning proton microprobe (Photo I.D. Gourlay)
- H The fungus *Ravenelia macowaniana* on pods: the galls are inhabited by an assemblage of microlepidoptera

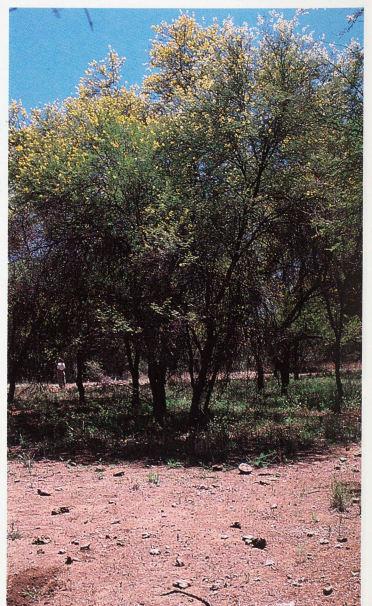


Plate 8 *Acacia karroo* (left to right sequence)

- A Gum being weighed before purchase at a buyer's factory in Bulawayo, Zimbabwe
- B Tapping gum from the stem for laboratory analysis
- C Gum collectors queuing at the factory door in Bulawayo, Zimbabwe, to sell their loads
- D Pure stands established to rehabilitate coastal dunes after the forest has been removed for the mining of titanium
- E The species is a preferred firewood in all parts of its range
- F A young stand in the Umguza Valley near Bulawayo, Zimbabwe, pruned to let in light for grasses and to give access for domestic stock
- G The only green grass after a drought in what would normally be lush green pasture is under the trees where the shade and soil fertility provide a suitable environment for the more nutritious and deeper-rooted perennial grasses such as *Panicum maximum*

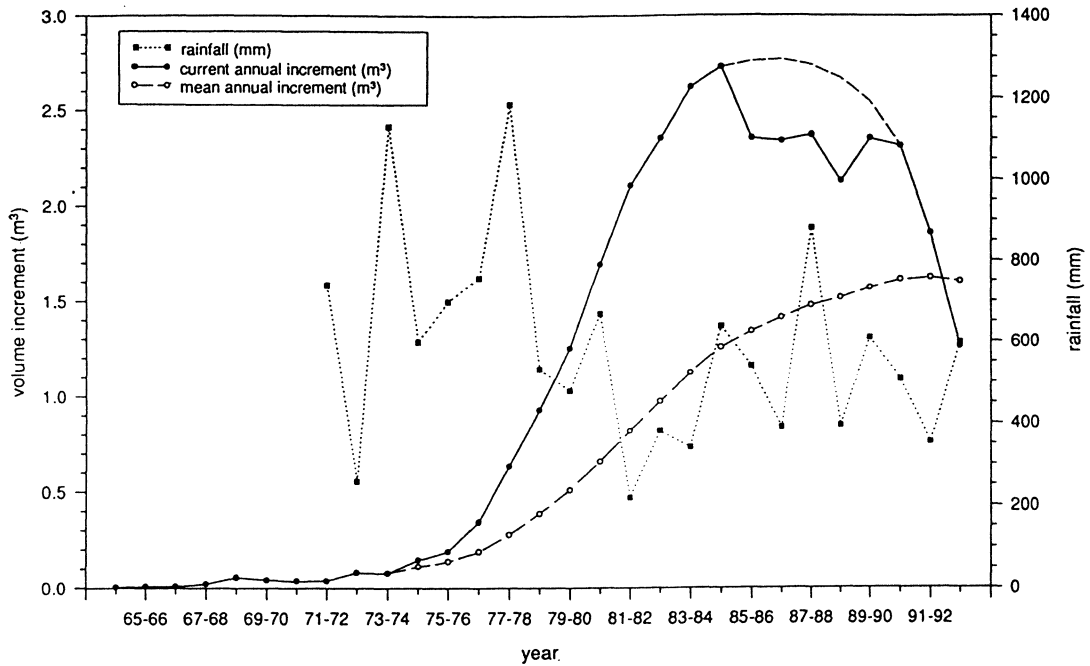


Figure 8 Estimated total wood volume (overbark to a minimum diameter of 5 cm) production per year in cubic metres and the annual rainfall during the life of a natural stand of *Acacia karroo* on Umguza Valley Estates in Zimbabwe. There were 140 trees in this stand and they occupied one hectare of growing space. (From Gourlay *et. al.*, in press).

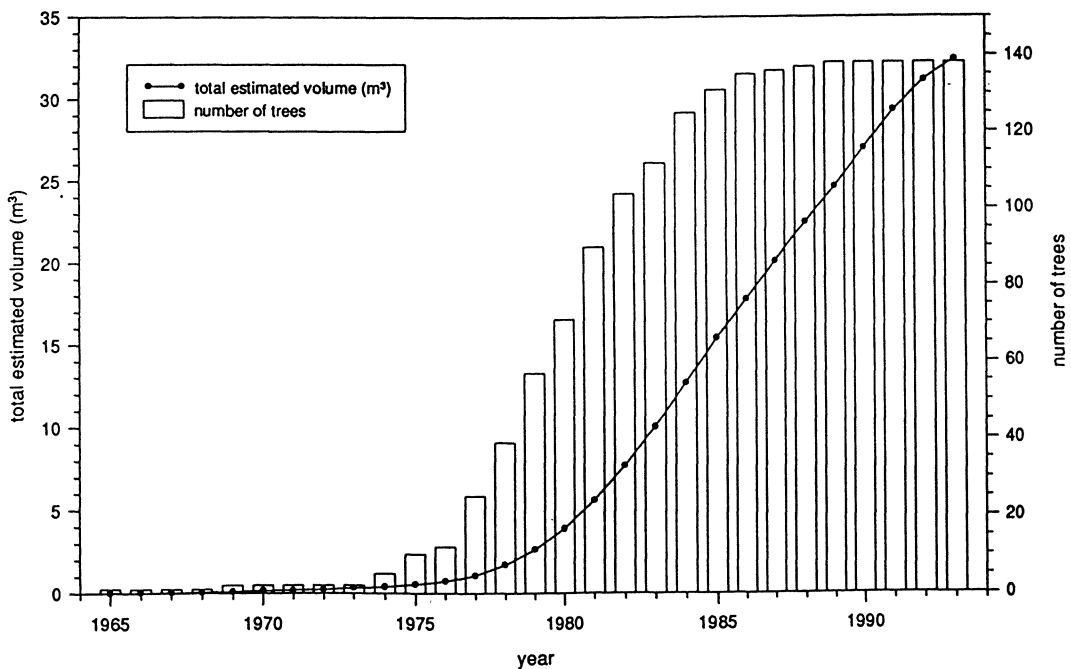


Figure 9 Estimated total cumulative wood volume (overbark to a minimum diameter of 5 cm) in cubic metres and the number of stems that contributed to that volume in each year during the life of a natural stand of *Acacia karroo* on Umguza Valley Estate in Zimbabwe. There were 140 trees in this stand and they occupied one hectare of growing space. (From Gourlay *et. al.*, in press).

Browse

In southern Africa, livestock is produced mainly in the Karoo, grassland and savanna biomes (Bosch and Tainton, 1988). The grasslands lie on a gradient from the more arid south-west area where the vegetation retains its nutritional value throughout the year, to sour grasslands and savannas in the more eastern parts of the region where the rainfall is higher, the soils more leached and acid, and the herbage less acceptable to livestock in winter. In grassland and grassland/savanna that receives a mean annual rainfall of 500-800 mm, unsound livestock management practices and abandonment of worked-out arable lands have led to encroachment by shrubs and trees that prejudice the production of grass. Foremost among these bush encroaching trees are a number of the *Acacia* species, the natural pioneers on disturbed and degraded land. *A. karroo* is prominent in this role over large parts of the Karoo and grassland biomes of South Africa as it is on the heavier soils, particularly in vleis and along rivers, in the open savanna woodlands that fall into this environmental category in other parts of southern Africa. Often, both grazing (cattle, sheep) and browsing (goats) animals are farmed in these areas where they compete for forage and further influence the competitive balance between herbaceous and woody plants (Stuart-Hill, 1985).

A great deal of attention and research has been focused on devising methods to eradicate encroaching *Acacia karroo*. In the Eastern Cape, removal of thickets has been attempted by using goats to browse the bush, by ringbarking and by poisoning with arsenite of soda, diesel and oil waste. When there is continuous, heavy grazing by cattle, sheep and goats, the ground can become colonized by *Cynodon dactylon*, a rhizomatous grass, and under such conditions, seedlings of *A. karroo* are grazed down and cannot establish themselves (Comins, 1962). Continuous grazing by goats causes higher mortality of trees than does rotational grazing (du Toit, 1972b). However, there has been little success in eradicating the tree from rangeland and recently there has been much more effort directed towards conducting research to understand its ecology and quantify its potential with a view to managing it to increase productivity of non-arable land, particularly in the farming systems of the Eastern Cape Province of South Africa where the species occurs in almost pure stands over very large areas.

Most studies in rangeland dominated by *Acacia karroo* have been directed towards identifying and understanding the influence of factors affecting the relative amounts of grass and browse produced off the veld and being able to quantify these. In the course of this work there has been considerable development of the methodology to evaluate browse management systems and strategies.

In a model to simulate browse production and response of *Acacia karroo* to defoliation (Teague *et al.*, 1990), sensitivity analyses indicated that five parameters had a very strong influence on the output of the model. These were

moisture, soil depth, the magnitude and duration of growth stimulation following defoliation, how soon growth was initialized and how favourable growing conditions were in spring; plant size and the carry-over of growth stimulation from one year to the next had a moderate influence.

Indices of potential competition with grass and browse productivity of single-stemmed *Acacia karroo* trees can be predicted within c. 25% error using maximum tree height, maximum canopy radius and height of the canopy bottom as basic measurements (Hobson and de Ridder, 1991).

Various quantitative descriptive units for woody plant communities have been proposed (Smit, 1989). These are the Evapotranspiration Tree Equivalent (ETTE), Browse Tree Equivalent (BTE) and Canopied Subhabitat Index (CSI), which describe the status of a woody community in terms of potential moisture use, value of the trees as food for browsers and subhabitat suitability for grass-tree associations, respectively. A Quantitative Description Index (QDI) for woody plant communities, containing descriptive unit-values, is proposed. Regression equations were developed from harvested *Acacia karroo* trees.

In a study to compare the response of *Acacia karroo* plants to defoliation by hand compared to defoliation by goats (Teague, 1988a), leaf growth on plants 50% defoliated by goats was approximately three-fold that on plants 50% defoliated by hand but, at the same time, leaf growth on hand-defoliated plants was approximately twice that of undefoliated plants. This suggests that the browsing animals themselves should be used in any defoliation studies.

In a study in semi-arid savanna in South Africa (Stuart-Hill and Tainton, 1989b), experimentally isolated *Acacia karroo* showed that trees suppressed grass growth up to 9 m away, depending upon their height, but that tree removal also reduced grass growth. Grass growth was reduced when trees were frequently defoliated, probably because of the stimulatory effect of defoliation on the competitiveness of *A. karroo*. Tree production increased in response to sward removal but was unaffected by sward harvesting, except if trees were defoliated frequently when production of browse increased in response to frequent grass harvesting. It is argued that residual soil moisture levels remain relatively high when grass growth is poor, so that water penetrates to greater depths after rain than when grass growth is vigorous and this favours the deep rooted trees (Stuart-Hill and Tainton, 1988).

In the same region, research to investigate the competition between *Acacia karroo* and grass for water (Stuart-Hill, 1985), showed that the trees thrived only where water penetrated regularly to some depth. Stemflow did not appear to be important in supplying water to the deeper soil layers. Most of the water penetrating to deep soil did so by moving through the uninterrupted soil profile. The process was enhanced where boulders were embedded in the soil. Dense grass rapidly depleted soil water to a depth of 60 cm.

In the absence of dense grass, evaporative losses were low and water was retained in the profile. Rainfall on an area with low grass biomass resulted in penetration of the wetting front to a depth that permitted vigorous tree growth.

Generally, trees can have both a beneficial and a detrimental influence on the herbaceous layer. Grass benefits from the shade and leaf litter supplied by the trees but suffers from the reduced amount of moisture available (Stuart-Hill, 1985) (Plates 6A and 8G).

A study was conducted in the Eastern Cape Province of South Africa to explore the response of *Acacia karroo* plants to defoliation by goats in a farming situation (Teague, 1987). Growth in *A. karroo* was dominated by current growing conditions. Plants were able to make opportunistic growth at any time to take advantage of favourable environmental conditions. By growing in flushes and consolidating after each flush, these plants are able to cope with a variable climate and damage from herbivory. Moisture stress merely slows growth, with the pattern of growth being unaffected.

In a study on the effect of intensity and phenophase of defoliation and water stress on the rate of photosynthesis and the recovery of carbohydrate reserves in *Acacia karroo* (Teague, 1988b and 1988c), the rate of photosynthesis of fully expanded leaves increased markedly following defoliation. Light defoliation increased photosynthetic rate the most. Total non-structural carbohydrate levels dropped significantly after defoliation. The magnitude of decrease was directly related to the intensity of defoliation. Recovery of carbohydrate levels was much faster after heavy than after light defoliation. Rates of recovery were also faster following defoliation in the second half of the growing season than in the first half, but the plants that had been heavily defoliated in the second half of the growing season had not fully recovered carbohydrate levels before leaf fall in late autumn. Moisture stress has very little effect on carbohydrate levels in comparison with the defoliation treatments.

Another study to determine the effect of browsing (Teague, 1986), showed that leaf production in *Acacia karroo* was increased two- to three-fold at an optimum browsing intensity that varied with the phenophase of the tree. Trees were most sensitive to defoliation at the early flush, when carbohydrate levels are at their lowest, and at the reproductive phase and it is recommended that, for maximum production, they be defoliated by 25-50%, followed by a rest period of 3-6 months, depending on the phenophase. (See also Teague and Walker, 1988a and 1988b; Aucamp, 1976.). The more frequently plants are defoliated, the more carbohydrate reserves drop but plants do adjust to cope with very frequent defoliations (Teague, 1989b). Trees are more sensitive to defoliation in the upper than in the lower canopy (Teague, 1989c).

Acacia karroo occurs in the semi-arid Eastern Cape

Province of South Africa in almost pure stands in an open to dense tree savanna. It has a deleterious effect on grass production and its increase cannot be prevented by burning, resting or judicious grazing management with cattle. However, it has been found to be possible to control the species with browsing goats and, at the same time, to increase meat production per unit area without adversely affecting grass production (Teague, 1986).

A model was developed to simulate the response of *Acacia karroo* to a wide range of different climatic patterns and defoliation regimes (Teague *et al.*, 1990). Increases in *A. karroo* harvests can be achieved with different management strategies such as increasing the number of camps, varying the length of stay in each and varying the rest period before the next occupation at different stocking rates. But the most important predictions of the model were that large increases in productivity could be expected by sparing use early in the growing season and that even if it were possible to reduce stock in times of drought, it would be of very little benefit.

It has been recommended that *Acacia karroo* should be utilized by browsers and converted into saleable animals rather than removed to keep grazing animals (Aucamp and Barnard, 1980). This recommendation has been supported by a study (Aucamp and Danckwerts, 1986) which showed that grass production did not decrease linearly with increasing tree density and that maximum red meat production and profitability occurred when *A. karroo* density approached 1600 tree equivalent/ha and goats and cattle were stocked together. In another study (Hobson and de Ridder, 1993), *A. karroo* browse production was found to be negatively related to tree density at the beginning of the growing season but stabilized by the middle of the summer resulting in a positive relationship between browse production and tree density. Grass production varied more between seasons than *A. karroo* production and was inversely related to tree density. Maximum forage production (grass and browse) occurred at moderate densities of *A. karroo*. A production model has been devised (Stuart-Hill, 1985) that predicts that maximum forage production, livemass production and profit will be achieved at 1220, 1320 and 1000 tree equivalents per hectare respectively. It was recommended that where trees exceeded densities of 1320/ha they should be removed in order of decreasing height. Browse yields do not increase as trees grow taller than 1.8 m (Stuart-Hill and Tainton, 1988).

A parklike *Acacia karroo* woodland with large trees scattered in grassland occurs in some areas of the eastern Cape and is ideal for grazing; the trees also serve as foci for development of clumps of fruiting shrubs (Comins, 1962). Overgrazing in such parkland leads to the establishment of thickets of *A. karroo* with little grazing beneath them.

In Zimbabwe it has been found effective to prune selected stems in dense stands of *Acacia karroo*. This allows access for domestic stock to graze and browse, the increased light encourages grass growth and the pruned trees develop large

crowns which prevent further thicket growth (Plate 8F and back cover).

[References:- 17, 18, 19, 20, 21, 25, 34, 52, 61, 72, 74, 81, 82, 107, 108, 121, 145, 188, 199, 200, 201, 202, 203, 204, 205, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 235, 254]

Control of invasion

Acacia karroo is included in the National Weed List in South Africa as having the undesirable characteristics of being competitive for space, light, water and nutrients and of replacing the preferred grass vegetation with thorny plants that prevent access. The species is legislated as a declared invader and is subject to herbicide registration (New, 1984; Wells *et al.*, 1986; Henderson, 1987). *A. karroo*, in common with other thornveld trees, shows a great latitude of functional response to environmental conditions and, with its extensive root system, can tolerate extreme conditions of drought and temperature (Bayer, 1943). Attention has been drawn to the presence of a localized population of *A. karroo* in western Australia and there is concern that it could become established in pastoral areas over most of south and parts of south east Australia. Eradication in Australia was strongly recommended, given the species' potential to become a serious weed (Scott, 1991) and attempts were in progress to eradicate it in 1992 (Scott, 1992).

Many methods have been tried to control invasion by *Acacia karroo* in its natural range in southern Africa. These include the use of browsing animals, fire, ringbarking, physical removal and arboricides (Scott, 1967). In the eastern Cape Province of South Africa, dense stands of *A. karroo* were felled at 30 cm above ground level then controlled by running goats with cattle at high densities in small camps on a rotational basis (Fourie, 1981). In the same region, Teague (1986) reports that goats are simultaneously able to control *A. karroo* and increase total red meat production per unit area by browsing, without adversely affecting grass production. Also in the eastern Cape, it was found that fire intensity had no effect on the recovery of grass after a burn whereas it had a marked effect on the topkill of various bush encroachment species, including *A. karroo*, to a height of two metres. The results provide guidelines for the use of fire in controlling bush encroachment (Trollope and Tainton, 1986). Ringbarking is reputed not to be an effective means of controlling the species (Cleghorn *et al.*, 1958). Cutting young trees, and fire when it is incorrectly used, can bring a response of thicket formation from the coppicing stools (Henderson, 1987) although older trees tend not to coppice when they are felled. Complete stumping would be effective but prohibitive in cost.

Acacia karroo was much less susceptible to arboricides

than most indigenous trees in trials conducted in Zimbabwe, the best kill being only 15% (Cleghorn *et al.*, 1958). Ring barking, blazing and applying NH₄ sulphamate or 2,4,5-T in water to blazes had little effect on the trees. The arboricide 2,4,5-T in diesel, or diesel oil alone, applied to blazes, were more effective. This was confirmed later when control of thornveld dominated by *A. karroo* on a cattle ranch in Zimbabwe was achieved in trials by frilling stems of >5 cm diameter at 1.3 m and brushing with 2,4,5-T at 1:200 dilution in diesel oil (Bembridge, 1966). A burn twelve months later controlled all new regeneration. Use of old motor oil was cheaper than and almost as effective as diesel oil as the diluent. Treatment resulted in twice as much dry-matter production of grass as on control plots two years later. In South Africa, paraffin and diesel solutions of 2,4,5-T (90 g amyl ester in 9 l of solvent) gave satisfactory control of *A. karroo* (Naude, 1956). Three proprietary herbicides are registered for the chemical control of *A. karroo* in South African rangeland; these are bromacil, ethidimuron and tebuthiuron (Vermeulen and Grobler, 1986).

In most circumstances it is very doubtful that any of the above methods of controlling invasion by *Acacia karroo* could be economic except for containment through browsing animals. If invasion is to be avoided, the range must be managed to avoid conditions developing that are suitable for mass seedling establishment. Once there has been a mass germination of *A. karroo*, fire is a possible means of control provided it is used in the first year or two after establishment and provided that enough grass is left to generate the heat needed to kill the seedlings. Once the cohort of seedlings has suppressed the grass, the most economic approach may well be to let it develop and to manage it, by judicious pruning and thinning, to create an open parkland in which the trees provide their multiple benefits of shade, browse, fuelwood and palatable grasses in a range of increased and sustainable fertility (Barnes and Fagg, 1995).

In contrast to its registration as a weed, *Acacia karroo* has been classified as a framework barrier plant and recommended in all regions of South Africa for replacing alien species that have become aggressive invaders with less aggressive species, preferably indigenous. In this respect, it is described as a very valuable species (Henderson, 1987).

A crucial area for future research will be an investigation into the conditions that cause *Acacia karroo* to adopt its invasive mode and whether sterility can be induced into the species either directly or through species hybrids so that its multifarious attributes can be used without the risk of invasion. (Barnes *et al.*, 1994)

[References:- 17, 25, 27, 29, 30, 34, 54, 61, 72, 74, 75, 81, 82, 84, 106, 126, 144, 146, 169, 170, 183, 184, 185, 186, 193, 216, 225, 236, 241, 252]

CONCLUSIONS AND FUTURE RESEARCH

Acacia karroo is a species full of contradictions.

1. Morphologically, it is so variable at its extremes that taxonomists repeatedly propose that it should be divided into as many as six different taxa; yet none of these proposals has ever matured because the variants are generally linked to the central type by so many intermediate forms.
2. Ecologically, it is essentially a pioneer; yet there are environments, both man-made and natural, in which it perpetuates itself as the dominant, and often virtually the only tree species in the plant community.
3. Economically, it is described as a species with an almost unlimited number of uses but, at the same time, most of the research done is on its eradication. It is accused of invading grassland and reducing productivity; yet it has been shown that it should be maintained at a very high stocking in the range for maximum red meat production.
4. Nutritionally, it is a preferred browse for livestock; yet it has a high tannin content that appears to prejudice the retention of proteins. The gum has for many years been widely used in the food and pharmaceutical industries locally; yet it is not accepted in international trade as it has not been proven to be non-toxic.

A. karroo is, however, accepted universally as a rehabilitator of degraded sites and dunes, as providing the environment for sustained production of nutritious perennial grasses and as a very high quality fuelwood.

The research and review on *Acacia karroo* reported in this monograph highlight five areas of recent findings.

1. The molecular studies and the first field trials have indicated that there is significant genetic variation in *A. karroo* across environments, particularly between the coastal and the inland provenances, and the species' tolerance of a wide range of climates and soils may be due to genetic diversity rather than to a versatility of genotype.
2. The discovery of an anatomical feature in the wood of *A. karroo* that corresponds with annual growth now means that the productivity and dynamics of natural stands can be quantified and modelled. Further, the strongly linear correlation that has been found between basal area and volume suggests that the simple and economic mean tree method of stand volume estimation can legitimately be used.
3. The application of the dendrochronological techniques has shown *A. karroo* to be short-lived but much more highly productive than was previously thought.
4. Review of the literature from the eastern Cape Province of South Africa on browse production has drawn attention to the large amount of information that is now available on the inter-relationship of *A. karroo* and grass production and the value of the species for goats.
5. It has been found that *A. karroo* crosses naturally with other acacias, which reveals that there is the potential to complement its desirable attributes in hybrid combination with those of other *Acacia* species.

In the light of these findings, where do we go from here? What more do we need to know about *Acacia karroo* before we can start managing the natural stands, planting degraded land and bringing in the goats? The following are put forward as the most important areas for research.

1. A rangewide ecological assessment of the vegetation types that include *A. karroo* is required to determine the common factors that govern its occurrence. How important is it ecologically? What determines whether it is secondary with disturbance or whether it is part of the climax? Does karroo modify its environment to suit itself? To what extent is its expansion in abundance and range primarily attributable to the increase and enclosure of domestic livestock? What are the precise conditions that are required for episodic invasion?
2. Field evaluation trials are needed over a wide range of sites to establish the degree and mode of genetic control of the adaptational, morphological, physiological and chemical traits of interest in *A. karroo*. The extremes of environment over which the species is indigenous will in itself have a profound effect on the morphology of the tree but these environments will certainly have induced significant genetic responses, an understanding of which is essential for effective domestication and use of the species. These trials should also provide the opportunity to resolve some of the species' intractable taxonomic problems.
3. The isozyme studies of *A. karroo* are unusual in that they suggest that there may be some link between a chemical product at the level of the gene and an adaptive trait. Further research is needed to establish this; and if it is found to be so, there may be a unique opportunity to use early molecular screening in selection for economically important traits.

4. The potential benefits from species hybrids are such that controlled pollinations should be made between *A. karroo* and a number of other species selected for the complementarity of their attributes. Quite apart from the heterosis that could emerge from testing these crosses, the hybrids might also be sterile which would eliminate the invasive problems in the range.
5. There is an urgent need to quantify the benefits that stem from *A. karroo* in terms of both soil fertility and the species composition, mass and nutritional value of the grasses that are dependent upon it to counter the traditional denigration of the species as an unwelcome invader.
6. The new dendrochronological techniques should be used in studies of stand dynamics and productivity in representative stands of *A. karroo* to quantify its economic worth throughout its range.
7. The acceptability of the gum of *A. karroo* for international trade in the food and pharmaceutical industries needs to be investigated with a view to the

development of exports from the countries where it is indigenous.

8. Research is needed to determine the precise nature of the tannins in the foliage of *A. karroo* and their effect on the accessibility of proteins in livestock rumens.
9. Management systems must be devised to exploit the potential of natural stands of *A. karroo*, to introduce it into agricultural systems and to integrate genetically superior material into agroforestry situations where an indigenous variant already exists.

The diversity and ubiquity of *Acacia karroo* evokes this rich response of research to exploit its undoubted potential to increase productivity from non-arable land in semi-arid lands in some of the most problematical and poorest regions of the world. Although the work recommended is selected for its immediate downstream developmental value, there is little doubt that it will also lead to the understanding of much more basic issues that have an application far beyond the domestication of *A. karroo* itself.

ANNOTATED BIBLIOGRAPHY

This bibliography is arranged in alphabetical order of authorship. Subject groupings can be accessed by reference to the publication numbers at the end of each section in the main text of the monograph. There is also an author index at the end of the bibliography in which the publication numbers are given for each author.

Both the published and the grey literature on *Acacia karroo* have been searched for this bibliography. Many references were found in which the species has been noted to occur in particular vegetation types or in certain areas during visits and travels by various individuals and groups; these have not been included in the bibliography unless there is information in them that is additional to a note of their occurrence. In some abstracts, information is given on other species where this serves to place *A. karroo* in context in the subject being discussed.

Not all the publications cited were available to the authors and CAB International abstracts have been used in a number of instances and acknowledged. Where a publication was judged to be of significance from its title but neither the paper nor an abstract was available, it has, nevertheless, been included without annotation.

In the monographic section, reference has been made to a number of works that do not specifically mention *A. karroo* but which are pertinent to the discussion of the particular topic. For ease of reference, these are included, without annotation, in this bibliography rather than in a separate section.

1 ACOCKS, J.P.H. **Riverine vegetation of the semi and arid regions of South Africa.** *Journal of the South African Biological Society* (1976) **17**, 21-35 [En]

Acacia karroo occurs along rivers in 26 of 30 vegetation types sampled in arid and semi arid parts of South Africa.

2 ACOCKS, J.P.H. **Veld Types of South Africa.** 3rd edition *Botanical Survey of South Africa Memoirs* (1988) No. 40, 128 pp. [En, 20 ref.]

South African vegetation types are comprehensively examined with vegetation maps and separate veld type map given. *Acacia karroo* is an important constituent of the following south African vegetation types: savanna, karoo (semi-desert) along river courses, coastal dune forest. It occurs in regions receiving between 170 and 900 mm p.a. in winter, and summer rainfall regions. Associated plant species are listed and reports given on the western movement of *A. karroo* which is already a very widespread species throughout the region. A map is included to show this movement.

3 ACOCKS, J.P.H. **Acock's notes: key grasses of South Africa.** Zacharias, P.J.K. (compiler) *Grassland Society of southern Africa*, P.O. Box 750, Howick 3290, South Africa. (1990) 82pp. [En]

4 ADAMSON, R.S. **Notes on the vegetation of the Kamiesberg.** *Botanical Survey of South Africa Memoirs* (1938) No. 18, 24 pp. [En]

Acacia karroo is restricted to water courses on the plains surrounding the Kamiesberg mountain in

Namaqualand, Cape, South Africa. This region receives an annual rainfall of 200-300 mm.

5 ALLISON, G.E. **Gum arabic: an ancient trade in decline?** M.Sc. Thesis, Oxford Forestry Institute, Department of Plant Sciences, University of Oxford (1993) 165 pp [En]

The approach in this work is basically historical. Sources of gum arabic are first described together with production techniques. The development of the gum arabic trade is traced from the earliest times to the present. Factors affecting supply to the world market are identified and there is discussion on how demand has changed over the years. The future of the trade is discussed in the context of current developments and the findings of the study. Although there is only brief mention of *Acacia karroo* being used in Zimbabwe and South Africa, this work constitutes a comprehensive account of the subject that is highly relevant to the acceptance of the species as a source of gum arabic on the world market.

6 ANDERSON, D.M.W.; **Chemotaxonomic aspects of the chemistry of *Acacia* gum exudates.** *Kew bulletin* (1978) **32** 529-536 [En]

7 ANDERSON, D.M.W.; CREE, G.M. **Studies on uronic acid materials Part XXVI. The aldobiouronic acids in gums from *Acacia* species.** *Carbohydrate Research* (1968a) **6** 214-219 [En, 15 ref.]

Reports on a number of studies, the results of which indicate that the methoxyl content in an *Acacia* gum polysaccharide is associated with the uronic acid residues,

but is not present as methyl ester. Of the species studied to date, those having positive specific rotations contain the four aldobiouronic acids (A-D); the exceptions were *A. karroo* and *A. nubica* gums which have low methoxyl contents and consequently small proportions (if any) of the 4-O-methyl acids C and D. [CABI abstract]

8 ANDERSON, D.M.W.; CREE, G.M. **Studies on uronic acid materials Part XXVII* The structure of the gum from *Acacia nubica* Benth.** *Carbohydrate Research* (1968b) **6** 385-403 [En, 17 ref.]

A study of the polysaccharide exuded by *Acacia nubica* trees was made. The disaccharide, 3-O- α -D-galactopyranosyl-L-arabinose, found in *A. senegal*, *A. cyanophylla* and *A. karroo*, was not detected. [CABI abstract]

9 ANDERSON, D.M.W.; DEA, I.C.M. **Review Article Chemotaxonomic aspects of the chemistry of *Acacia* gum exudates.** *Phytochemistry* (1969) **8** 167-176 [En, 89 ref.]

The results of chemical studies of the gum exudates from thirty *Acacia* species are reviewed, and their taxonomic significance is discussed with respect to Bentham's divisions of the genus. According to Bentham's classification of gum exudates *A. karroo* belongs to the Gummiferae series sub-series Medibracteatae. [CABI abstract]

10 ANDERSON, D.M.W.; KARAMALLA, K.A. **Studies on uronic acid materials Part XVI¹. Inter-nodule variation and the acidic components in *Acacia nilotica* gum.** *Carbohydrate Research* (1966) **2** 403-410 [En, 11 ref.]

A study of the inter-nodule variation and acidic components in *Acacia nilotica* gum was made. Prior to this investigation only *A. karroo* and *A. senegal* were reported to contain two aldobiouronic acids; on reexamination, those species previously reported to contain only 6-O-(β -D-glucopyranosyluronic acid)-D-galactose may be found to be more complex. [Author's summary]

11 ANDERSON, D.M.W.; PINTO, G. **Variations in the composition and properties of the gum exuded by *Acacia karroo* Hayne in different African locations.** *Botanical Journal of the Linnean Society* (1980) **80** (1) 85-89 [En, 13 ref.]

The variation in chemical composition of 15 specimens of the gum exudate from *Acacia karroo* Hayne, obtained from four different African locations, was investigated. The range of analytical values found (e.g., specific rotation +36° to +67°; uronic acid 10.3 to 18.1%; rhamnose 4 to 10%) reflect the well known variability of this species. The major analytical difference concerns the unusually wide range of molecular weights observed, i.e., 1.5×10^5 to 48×10^3 . The

material of highest molecular weight, from trees infested with Cerambycid beetle, is consumed by bush-babies (Galagidae). [CABI abstract]

12 ANDERSON, D.M.W.; BRIDGEMAN, M.M.E.; DE PINTO, G. ***Acacia* gum exudates from species of the series Gummiferae.** *Phytochemistry* (1984) **23** (3) 575-57 [En, 19 ref.]

Data are reported from gum polysaccharide analyses of specimens from the African species *Acacia ehrenbergiana*, *A. xanthophloea*, *A. hockii* and *A. sieberana* [*A. sieberiana*] var. *villosa*, and the Australian species *A. calcigera*. Comparisons are made with published data for *A. sieberana* var. *sieberana* and *A. karroo* and taxonomic implications discussed. [CABI abstract]

13 ARCHER, F.M. **[A preliminary study on edible plants of the Kamiesberg]** 'n Voorstudie in verband met die eetbare plante van die Kamiesberge. *Journal of South African Botany* (1982) **48** (4) 433-449 [Af]

The Nama herders of the Kamiesberg area of the northwestern Cape, South Africa (29°S 18°E) eat *Acacia karroo* gum as a confection. Bees (*Apis mellifera*) collect nectar from the flowers of *A. karroo* in summer and the honey is used by the herders. The people also eat the fruits of the mistletoes *Moquinella rubra* that grows on *A. karroo*. Pods and foliage are browsed by livestock and green branches are used to build the framework of traditional Nama dwellings.

14 ARCHER, F.M. **Customary plant use in Namaqualand: *Acacia karroo* Hayne - A tree with many uses.** *Veld & Flora* (1988) **74** (3) 111-112 [En]

Gum exuding from injuries to the bark of *Acacia karroo* is eaten or mixed with cattle dung for sealing the floors of dwellings. Extracts from the bark are used as a colic remedy and as a dye for leather. Bark from the roots is used to make twine and rope. Tall, young branches are used to make the framework of dwellings and are also bent to make crooks and hooks used in hunting and livestock management. The rotten heartwood is used as tinder and the most important use of sound wood is as fuel. A bracket fungus that grows on green and dead wood is pounded and used as talcum powder.

15 ARCHER, F.M. **[Construction of a typical Nama mat house]** Die konstruksie van 'n tradisionele Nama matjieshuis. *Sagittarius* (1989a) **4**, 20-22 [Af]

Use of *Acacia karroo* poles and bark in construction of traditional Nama dwellings in Leliesfontein, Namaqualand, Cape, South Africa.

16 ARCHER, F.M. **[Plant utilization by the Nama-speaking KhoiKhoi of Namaqualand]**

Plantegebruik in die tradisionele vel verwerking van die Nama-sprekende KhoiKhoi van Namaqualand. *Sagittarius* (1989b) **4**, 23-24 [Af]

Use of dye and fibre from *Acacia karroo* bark and roots by Nama people in Leliesfontein, Namaqualand, Cape, South Africa.

17 AUCAMP, A.J. **The role of the browser in the bushveld of the eastern Cape.** *Proceedings of the Grassland Society of southern Africa* (1976) **11** 135-138 [En]

Goats reduce *Acacia karroo* cover as well as providing meat from farmland with high densities of scrubby *A. karroo* trees.

18 AUCAMP, A.J.; BARNARD, H.H. [An investigation of the stock production potential of the dry grass-bush community of the eastern Cape] Die ontplooiing van die veekuddepotensiaal van die droë gras-bosgemeenskappe in die Oos-Kaap. *Proceedings of the Grassland Society of southern Africa* (1980) **15** 137-140 [Af]

In semi-arid rangeland a plant should not be removed unless it can be replaced by something better and plants (such as *Acacia karroo*) that can be converted into saleable animals should be utilized by browsers rather than being removed so as to keep grazing animals.

19 AUCAMP, A.J.; DANCKWERTS, J.E. **Browse as a forage source in semi-arid south savannah rangelands: a resource under siege.** *Proceedings of the 2nd International Rangeland Congress*, Adelaide, Australia, 13-18 May 1984. Canberra, Australia; Australian Academy of Science (1986) 403-404 [En]

Five treatments were replicated twice:- 1) complete removal of woody plants; 2) partial clearing to a density of five hundred *Acacia karroo* plants/ha; 3) partial clearing to one hundred *A. karroo*/ha; 4) partial clearing to 1500 *A. karroo*/ha; 5) no removal of woody plants. Grass production did not decrease linearly with increasing tree density. Maximum red meat production and maximum profitability occurred when *A. karroo* density approached 1600 tree equivalents/ha and goats are run in conjunction with cattle.

20 AUCAMP, A.J.; DANCKWERTS, J.E.; TEAGUE, W.R.; VENTER, J.J. **The role of *Acacia karroo* in the False Thornveld of the Eastern Cape.** *Proceedings of the Grassland Society of Southern Africa* (1983) **18** 151-154 [En]

Grass production did not decrease linearly with increasing densities of *Acacia karroo*. Grass production was not affected up to a density of 297 tree equivalents per hectare but decreased rapidly when tree density exceeded 1000 units/ha. Maximum feed production (grass plus bush) was achieved at 847 tree equivalents per ha. Maximum

profit would be obtained by using cattle and goats together (112 cattle and 500 goats/1000 ha) where *A. karroo* was at a density of 1600 trees/ha. Total clearing of bush cannot be justified in terms of meat production.

21 AUCAMP, A.J.; DANCKWERTS, J.E.; VENTER, J.J. **The production potential of an *Acacia karroo* community utilized by cattle and goats.** *Journal of the Grassland Society of Southern Africa* (1984) **1** (1) 29-32 [En, af, 15 ref.]

In studies on the relationships between bush density and animal production and profitability/ha, Boer goat farming was more profitable in the short term than beef ranching. The best long-term strategy was a combination of goats and cattle in an integrated animal production system. Such an integrated system was approximately three times as profitable as a pure beef production system. A prerequisite for implementing such a system is that stocking rates of cattle must be set according to the condition of the herbaceous vegetation and stocking rates of goats must be set according to the condition of the woody vegetation.

22 AYLEN, D. **Vegetation growing in unlikely conditions: Rhodesia Trees in South Africa** (1961) **13** (3) 58-61 [En]

Observations are made on natural or planted vegetation succeeding under unlikely conditions; trees as yet form only a minor part of that vegetation. On mine dumps a number of species have been found including *Acacia karroo*.

23 BALA, B.B. **A comparative study of sporogenesis and embryogeny in *Acacia karroo* and *Acacia caffra*.** M.Sc. Thesis (1978) Faculty of Science, Fort Hare, South Africa. 73 pp. [En, 61 ref.]

In *Acacia karroo*, four microspore mother cells are formed in each lobe of the anther and each of these gives rise to 16 microspores. The young ovule is orthotropous at first gradually becoming anatropous. The archesporium appears as a single cell and is hypodermal in origin; it cuts off parietal tissue on the upper side and forms the megaspore mother cell which divides into two dyad cells which give rise to a linear tetrad of megaspores. The chalazal megaspore forms an embryo sac while the micropylar megaspores degenerate. The primordia of integuments appear at the megaspore mother cell stage; the micropyle is formed by the outer integument alone. Two polar nuclei are suspended in the centre of the embryo sac by means of cytoplasm and the three antipodal cells. The first division of the embryo is transverse, the second vertical and later divisions irregular. The cotyledons are differentiated when the proembryo is of a massive type. The endosperm follows the nuclear type of development. It is not completely reabsorbed by the developing embryo and a little endosperm remains in the mature seed.

24 BARNARD, A. **The Cape Journals of Lady Anne Barnard**. Eds. Robinson, Lenta, M., and Driver, D. van Riebeck Society, Cape Town (1994) p 345 [En]

On *Acacia karroo*:- "I pluck'd from the great thorn trees some of their prickles of which I send you a few...they exactly resemble the horns of the Cattle, I hear the plant has found its way to Kew Gardens and is there called the "Cuckold Tree" it is certainly no scandal to give it that name, for richly does it deserve it from the quantity of horns it bears, and all being white, at a distance looks as if the Tree was covered with snow. They are excellent toothpicks and in case of necessity might do very well for pins the points are so sharp and the wood so tough."

25 BARNES, R.D.; FAGG, C.W. **The potential of African acacias in agricultural systems in the dryland tropics**. Paper at Inter-Divisional Session 4, *Tropical and sub-tropical dry forests*, IUFRO XX World Congress (1995), Tampere, Finland, 6-12 August, 1995. 12 pp. [En]

Acacia species dominate the dry zones of Africa. They provide the rural people of the continent with multiple products including fuelwood, fodder, food, fibre and gums. Their role is becoming more prominent because of their ability to use deep sources of water and nutrients, fix nitrogen and colonize and rehabilitate the increasing amount of degraded land. Genetic variation and their range of ecologies give them the potential of being more formally used to ameliorate soils and climate and to increase productivity throughout dryland Africa. Their most likely use is in improving animal production by enriching the range in silvopastoral systems, in restoring fertility in bush-fallows, in inter-cropping with grain crops and in woodlots dedicated to fuelwood or gum production. Research into genetic variation of six important species including *A. karroo*, is providing the information and materials necessary for breeding. Research is also needed into their ecology to help integrate this superior material into operational agricultural systems. A knowledge of the environmental conditions that are required for the periodic mass regeneration events and an understanding of the competition and allelopathic relationships must be acquired to provide a basis for the development of management techniques to establish and control the improved germplasm in the new environments.

26 BARNES, R.D.; CHIMBALANGA, J.; MARUNDA, C. **Project R5653: genetic evaluation of African *Acacia* species: phase I**. First year report, Oxford Forestry Institute (1995) 38 pp. [En. 10 figs.]

This report describes the work of a project to establish genetic evaluation trials of 70 provenances of six species of African acacias, including 10 provenances of *Acacia karroo*, over a number of sites near Bulawayo, Zimbabwe. Differences between seedlings from various provenances of *A. karroo* are illustrated. The eight sites selected for screening trials cover a range of climatic and edaphic conditions with mean annual rainfall varying of 300-650

mm and soils derived from granitic, basaltic and meta-volcanic parent materials and wind-blown sands.

27 BARNES, R.D.; FILER, D.L.; LOCKHART, L.A.; GOURLAY, I.D. ***Acacia karroo*: evaluation and assembly of genetic resources**. Unpublished Final Report of ODA Forestry Research Scheme R.4526. Oxford Forestry Institute (1994) 157 pp [En, 17 tables, 30 figs, 275 ref.]

This final report describes the work completed under a three-year (plus one-year extension) Research Scheme (No. R.4526, 1 January 1989 to 31 December, 1993) conducted by the Oxford Forestry Institute and funded by the Overseas Development Administration of the United Kingdom Government. It also describes uncompleted studies, started with non-project scientists and agencies, which also constituted important accomplishments of project. The development of the database BRAHMS (Botanical Research And Herbarium Management System) and the production of a systems manual was a major output from the project. BRAHMS is an information system for storing and processing botanical data. It is a tool that has been developed to assist with botanical research, both monographic and floristic, and to provide curatorial support in the herbarium. It was an invaluable asset in the study of the taxonomy, natural distribution and phenology of *Acacia karroo* and details of 800 specimens from all the main herbaria for the species were logged into the system. BRAHMS is also now being used by a broad range of ODA and other projects in Europe, Africa, Latin America and Asia. The second major achievement of the project was the seed collections that were made to represent the full geographic, climatic, edaphic, ecological and morphological range of the species as indicated by the data accumulated in BRAHMS and by observations made on field trips. These 26 seed collections are being used in evaluation of genetic variation both in the laboratory and in the field. The third achievement concerned two isozyme studies of *A. karroo*, one an extension of Brain's (1989) leaf peroxidase study to cover the species' whole range and the other a study of 12 isozyme systems over 12 populations selected to cover the species natural distribution. The results indicated that, although the majority of genetic variation is within populations, there are important regional groupings. This information was used to improve the precision of the sampling strategy for seed collection. One of the most significant findings was that a particular allele in one of the leaf peroxidase loci becomes fixed in the east coast dune populations. Another significant finding was that the populations of *A. karroo* on the islands of the Bazaruto archipelago in Mozambique are genetically distinct from all other populations studied for these allozyme systems. The fourth achievement was the development of an ageing technique for *A. karroo* through counting the crystalliferous terminal parenchyma bands from stem discs or cores, and the use of this technique to make the first assessment of growth rate and productivity of a natural stand of the species. The fifth major achievement was the production of plans for the field trials, including selection of sites and

cooperators and deciding on the composition and design. These trials of *A. karroo* will provide the structured material needed for future research not only into genetic variation, but also into its silviculture and use in agricultural systems. The objectives of the trials include studies to clarify the taxonomy and reproductive biology of the species as well as studies of variation and its control in adaptability, productivity, phenology and ability to ameliorate site. A crucial area for future research will be an investigation into the conditions that cause the species to adopt its invasive mode and whether sterility can be induced into the species either directly or through species hybrids so that its multifarious attributes can be used without the risk of invasion.

28 BAXTER, B.; YEATON, R.I. **Partitioning of an environmental resource between the sexes of a dioecious hemiparasite.** *South African Association of Botanists 17th Annual Congress Abstracts*, University of Natal, Pietermaritzburg (1991) 152 pp. [En]

In the Weenen Nature Reserve the major host of *Viscum verrucosum* (Harv.), a dioecious hemiparasite, is *Acacia karroo*. The broad pattern of distribution of *A. karroo* follows water courses. Over an environmental gradient at right angles to the water course, *A. karroo* experiences increasing water stress. The distribution of *V. verrucosum* on *A. karroo* is governed by water stress and not host availability. The distribution of the hemiparasite is far narrower than that of its host. At the dry extremes of the gradient both the hemiparasite and its host are more stressed than at the wet extreme. The *V. verrucosum* exhibits sexual segregation along the moisture gradient, the sex ratio being female biased in the wet sites and male biased in the dry sites. Fruit diameters were significantly greater in wet sites.

29 BAYER, A.W. **The Thornveld tree: a note on plant adaptation.** *South African Journal of Science* (1943) **39**, 44-55 [En]

An ecological study of the vegetation of the Natal thornveld, with particular reference to modes of plant adaptation to the extreme conditions of drought, evaporation and temperature which occur in this habitat at certain seasons of the year. The dominant trees which have invaded these former grasslands seldom exceed 12-15 ft. in height and are usually rather widely spaced (20-60 or more yards apart). The most common dominants are certain *Acacia* species (e.g. *A. karroo*, *A. arabica*, *A. caffra* and *A. robusta*) and a few leafless succulent species of *Euphorbia*. Species of *Gymnosporia*, *Cassine*, *Dovyalis* and *Zizyphus* are also common. The author discusses different types of plant adaptation as exemplified in succulent and non-succulent species. Attention is drawn to the extensive root system of most thornveld trees, to the production by many species of thorns and axillary leaf fascicles, and to the water relations (specific conductivity, osmotic pressure, transpiration rate, etc.) of woody plants growing in this

environment. The transpiration rate of thornveld trees is normally high but is subject to sharp fluctuations. As compared with forest trees, the trees of the thornveld show a much greater latitude of functional response to environmental changes. [CABI abstract]

30 BEMBRIDGE, T.J. **Eradication of thorn trees.** *Rhodesian Agricultural Journal* (1966) **63** (4), 86-88 [En, 2 ref.]

Control of thornveld dominated by *Acacia karroo* and *A. nilotica* on a cattle ranch in Rhodesia was achieved in trials (at a cost of 25 S./1000 trees) by frill-cutting all trees > 2 in. d.b.h. and brushing with 2,4,5-T at 1: 200 dilution in diesel oil. A burn twelve months later controlled all new regeneration. Use of old motor oil was cheaper than and almost as effective as diesel oil for the diluent. Treatment resulted in twice as much dry-matter production of grass as on control plots two years later.

31 BEMBRIDGE, T.J.; TARLTON, J.E. **Woodfuel in Ciskei: a headload study.** *South African Forestry Journal* (1990) **154** 88-93 [En, 29 ref.]

The results are presented of a study of the use of fuelwood in one region in the Ciskei, South Africa. Data were provided by respondents on the number of headloads per week and the time taken in collecting wood. The amount, sizes and types of wood collected were recorded. On average, rural women spend over two hours per day collecting fuelwood headloads of 24 kg air-dry mass, comprising approximately twenty eight pieces of 2.40 m length with a diameter of 44 mm and a mass of 862 g. The number of headloads averaged over five per week and average per capita consumption of fuelwood was 1.14 t. Women have a good local knowledge of tree species collected for fuelwood. *Acacia karroo* was the most favoured species. The open fire is used for cooking two to three meals per day. Paraffin was the most favoured alternative fuel but was used mainly for lighting. Patterns of fuelwood usage are location specific and vary widely. Research is needed into the multiple use of woody vegetation, as well as appropriate means of conserving fuelwood. [CABI abstract]

32 BENTHAM, G. **Revision of the sub-order Mimoseae.** *Trans. Linn Soc. Lond.* (1875) **30** 335-664

33 BEWS, J.W. **Plant succession in the thorn veld.** *South African Journal of Science* (1917) **14** (4) 153-172 [En]

Acacia horrida (*A. karroo*) and *A. arabica* (*A. nilotica*) are the chief pioneer species establishing on bare ground in the Pietermaritzburg area, Natal, South Africa. They are well adapted to establishing with no shade, shelter or protection from grass fires. Many other woody plants germinate beneath the these thorn trees and may

subsequently kill the pioneer.

34 BOSCH, O.J.H.; TANTON, N.M. **Ecological principles and their application to rangeland management in South Africa.** In *Vegetation science applications for rangeland analysis and management* [edited by Tueller, P.T.]. Dordrecht, Netherlands; Kluwer Academic Publishers ISBN 90-6193-195-9 (1988) 363-397 [En, 87 ref.]

In South Africa, livestock is produced mainly in the Karoo, Grassland and Savanna biomes. The grasslands, strongly dominated by hemicryptophytes of the Poaceae, follow a soil gradient from the more arid area in the west whose vegetation retains its nutritional value throughout the year to sour grasslands in the more eastern fringe whose herbage is acceptable to livestock only in the summer growing season and in whose structure fire has played a large part. In grasslands receiving rainfall of 500-800 mm per annum, overgrazing leads to encroachment by shrubs and trees, particularly *Acacia karroo*. The savannas have shrub components, including *A. karroo*, whose management includes the use of goats to browse shrubs not consumed by cattle and sheep. Ecological studies over the last six decades have provided useful principles with regard to limitations inherent in rangeland production and are being used to define sound management practices.

35 BRAIN, P. **Leaf peroxidase types in *Acacia karroo*. Geographical distribution and influence of the environment.** *South African Journal of Botany* (1986) 52 (1) 48-52 [En]

Leaf peroxidase types were examined by starch gel electrophoresis in 1 662 individuals of *Acacia karroo* Hayne from twenty localities in southern Africa. The patterns show a zone of slow anodic migration with relatively little variation, and a fast zone under independent genetic control which is highly polymorphic. Most individuals have either one or two fast bands, but a proportion (5% overall; 0-20% at individual localities) has three or four. Multiple banding is more frequent in colder localities. Fast zone phenotypes vary both geographically and with climate, and phenotypic diversity is strongly correlated with low temperature and low rainfall.

36 BRAIN, P. **Immunology and phylogeny: a preliminary study of *Acacia*.** *South African Journal of Science* (1987) 83 (7) 422-427 [En, 16 ref.]

The seed proteins of thirty seven species of the cosmopolitan genus *Acacia* were investigated serologically by double diffusion and immunoelectrophoresis, using rabbit antisera to separate *A. karroo*, *A. ataxacantha*, and *A. mearnsii*. Identity and absorption tests showed remarkable homogeneity in the series Gummiferae; all the African species, except *A. albida*, reacted identically, as did the Australian *A. bidwillii*. The two American species (*A. caven* and *A. farnesiana*) were identical to them in three of the four bands observed on immunoelectrophoresis. *A. albida*

reacted atypically with all the antisera, and is probably not an *Acacia*. The four African species with spicate inflorescences, classified in the series Vulgares, also form a tight group, but the series Phyllodineae originating from Australia is very variable, only one of the 17 species examined absorbing all activity from the anti-mearnsii serum. The Australian Phyllodineae and Botryocephalae appear serologically closer to the African Vulgares than to the Gummiferae, confirming hypothesis of a separate origin for the latter group. These findings are considered in the light of phylogeny and plate tectonics.

37a BRAIN, P. **Genetic races in a ring species, *Acacia karroo*.** *South African Journal of Science* (1989) 85 (3) 181-185 [En, 9 ref.]

In a study of 3080 *Acacia karroo* trees from forty two sites in South Africa and Namibia, electrophoresis of leaf extracts and staining for peroxidase revealed a polymorphism. Cluster analysis differentiated three genetic races: a western or Karoo race with highest frequencies of the slower K and L bands; an intermediate or Eastern Cape race with highest frequency of the central M band; and an eastern or Natal-Lowveld race lacking K and with highest frequencies of the fastest N and O bands. The species encircles the Drakensberg massif, with no latitudinal gene flow. The Natal-Lowveld race meets a race of higher K frequency at two places: near the Natal-Transkei border on the east coast, where there is a gradual reduction in K going north; and at the northern end of the ring west of Pietersburg, where there is a very sudden west to east fall in K frequency, from 29% to 3%, in the course of a few kilometres. [CABI abstract]

37b BRAIN, P.; HARRIS, S.A.; BARNES, R.D. **Leaf peroxidase types in *Acacia karroo* Hayne (Acaciaeae, Leguminosae): a range-wide study.** (in prep.)

Peroxidase variation has been assessed in 63 populations (4322 individuals) of *Acacia karroo* Hayne (Acaciaeae: Mimosoideae) from across its entire southern Africa range. Twenty-seven different phenotypes were identified with between two and 22 phenotypes found per population. Shannon's measure of phenotypic diversity varied from 0.15 to 4.11 (mean 2.71), whilst apportionment of the diversity showed that 74% of the diversity occurred within populations. Six coastal dune populations of *A. karroo* from Zululand and Mozambique clustered together and had a low phenotypic diversity. Band M is common throughout the range of the species but it is virtually fixed to the exclusion of other bands in the coastal dune populations. Band K, on the other hand, is restricted to the Karoo region of the Cape Province of South Africa with lower frequencies in the adjacent Highveld region of the central and western Transvaal province to the north. It is completely absent to the east of the Drakensburg Mountains and very rare in the west and north of its range. The implications of these data for seed sampling strategies in *A. karroo* are considered. [Authors' summary]

38 BREDEKAMP, G.J.; BEZUIDENHOUT, H. **The phytosociology of the Faan Meintjies Nature Reserve in the western Transvaal grassland, South Africa.** *South African Journal of Botany* (1990) **56** (1) 54-64 [En, 1 map, 23 ref.]

Near Klerksdorp, Transvaal, South Africa, *Acacia karroo* woodland occurs on the lower slopes of lava and quartzite hills. *A. karroo* was the dominant tree, 5-6 m in height with a canopy cover of 22%. Understorey has a canopy cover of about 9% and is made up of low shrubs, particularly *Grewia flava*, *Protasparagus suaveolens*, and *Zizyphus zeyheriana*.

39 BROOKE, R.K. **The bird community of Tamarix-clad drainages, northwestern karoo, Cape Province.** *Ostrich* (1992) **62** (1) 42-43 [En]

Lists twenty eight species of birds found in *Acacia karroo* dominated drainage lines in arid parts of the Cape Province, South Africa, and compares them with the twenty species of birds found in *Tamarix usneoides* dominated drainage lines in the same region.

40 BROWN, N.A.C. **A study of seed-coat impermeability, seed germination and seedling growth in certain *Acacia* species.** M.Sc thesis in Department of Pasture Science, Faculty of Agriculture, University of Natal, Pietermaritzburg, South Africa (1965) [En]

In this investigation, a detailed study was made of the morphology of the seed and the anatomy of the seed coat of *Acacia nilotica* ssp. *kraussiana* and *A. tortilis* ssp. *heteracantha* and some observations were made on *A. karroo*.

41 BROWNE, C.W. **Sowing tree seeds *in situ*.** *Trees in South Africa* (1981) **32** (4) 95-98 [En]

Reports on experimental planting at fifty sites with the seeds of various indigenous and exotic trees. The seeds of *Acacia karroo* were among those that germinated successfully.]

42 BRYANT, J.P.; KUROPAT, P.J.; COOPER, S.M.; FRISBY, K.; OWEN-SMITH, N. **Resource availability hypothesis of plant antiherbivore defence tested in a South African savanna ecosystem.** *Nature* (1989) **340** 227-229 [En]

Acacia karroo seedlings grow faster during their first three months than three other sympatric acacia species grown in green house experiments.

43 BURLEY, J.; HUGHES, C.E.; AND STYLES, B.T. **Genetic systems of tree species for arid and semi-arid lands.** *Forest Ecology and Management* (1986) **16** 317-344 [En]

44 CARR, J.D. **The propagation of indigenous trees.** *Trees in South Africa* (1965) **17** (2) 30-40 [En]

It is suggested that one positive step to preserving native flora would be to engage actively in the propagation of those species that will enhance a garden. Amongst the highveld species *Acacia karroo* is suggested as a species that could be raised from seed.

45 CARR, J.D. **The South African acacias.** Johannesburg, South Africa; Conservation Press (Pty.) Ltd. (1976) 68-77 [En]

Detailed descriptions are given of all the forms of *Acacia karroo* that occur in South Africa. For cultivation from seed, seeds should be sanded on one edge, scalded with boiling water and left to soak for 24 hours. Seedlings take from 5-13 days to emerge. Saplings can reach 2 m within their first year on good soils with adequate water. Early pruning may be necessary to produce a straight stem. Vigorously-growing plants should be staked. Young plants are frost sensitive.

46 CARR, J.D. **Indigenous trees as street subjects in Sandton.** *Trees in South Africa* (1977) **28** (4) 110-112 [En, 1 pl.]

Trees planted in the central strip of a dual carriageway in a Johannesburg suburb in the highveld region of South Africa proved to be much more frost-resistant than in adjacent gardens. Promising species (including *Acacia karroo*, *Dombeya rotundifolia*) and unpromising species are listed. The protective effect of being in the central strip could not be completely explained.

47 CARR, J.D. **Indigenous Trees on the Median Strip.** *Trees in South Africa* (1981) **33** (2) 48-52 [En]

Reports on the success of planting various species on the median strip of dual carriageways in detail; other species involved in the experiment are listed, including *Acacia karroo* [both "Typical" and "Lydenburg" forms].

48 CHAPPILL, J.A.; MASLIN, B.R. **A phylogenetic assessment of tribe Acacieae.** In: Crisp, M., and Doyle, J.J. (editors) *Advances in legume systematics 7: Phylogeny* (1995) Royal Botanic Gardens, Kew, p. 77-99 [En]

49 CHARLSON, A.J.; NUNN, J.R.; STEPHEN, A.M. **The composition of *Acacia karroo* gum.** *Journal of the Chemistry Society*, University of Cape Town (1955) 1428-1431 [En]

Acid hydrolysis of *Acacia karroo* gum furnishes L-rhamnose (2%), L-Arabopyranosyl-L-arabopyranose, 4-O-alpha-D-glucuronosyl-D-galactose, and 6-O-beta-D-glucuronosyl-D-galactose have been isolated from the products of partial hydrolysis. The gum differs markedly in

structure from other *Acacia* gums so far examined.

50 CHOWN, S. **Moths for monitoring.** *Our Living World* (1993) South African Nature Foundation [En]

A community of small moths is closely associated with the fungus galls growing on the widespread tree species *Acacia karroo* in southern Africa. They will be used to monitor climatic changes due to global warming, and changes in environmental quality caused by pollution and habitat loss. Significant differences have already been observed in highly disturbed as opposed to undisturbed natural areas in the Pretoria region.

51 CHURMS, S.C.; STEPHEN, A.M.; STEYN, C.B. **Analytical comparison of gums from *Acacia hebeclada* and other Gummiferae species.** *Phytochemistry* (1986) **25** (12) 2807-2809 [En, 25 ref.]

Analyses are reported of arabinogalactan-proteins from *Acacia hebeclada* and comparisons made with analyses and published data on *A. tortilis* ssp. *heteracantha*, *A. karroo*, *A. erioloba* and *A. robusta* var. *clavigera*. [CABI abstract]

52 CLARKE, J. **Building on indigenous natural resource management: Forestry practices in Zimbabwe's communal lands.** Forestry Commission, Harare, Zimbabwe (1994) 55 pp. [En]

This book marks a step in the search for a new approach to development forestry in Zimbabwe. It builds on the experience of the Forestry Commission in promoting a new approach to working with rural communities. Attitudes of foresters have had to be changed from one of being "gurus" of development forestry to one of being catalytic agents. To do this they have had to build on indigenous knowledge, promote participation, develop local-level capacity, demonstrate tangible benefits of sound resource management and devolve control. Descriptions of 14 diverse case studies by local farmers are contained in a matrix of two chapters, one on recognition of existing forestry practices and one on building on these practices. *Acacia karroo* figures significantly in the study of village-based woodland management in Ntabazinduna. This communal area was deforested as a result of fuelwood cutting for the nearby city of Bulawayo. One resident started protecting the *A. karroo* near his home and the practice of pruning and thinning rather than cutting is now spreading on its own. The pruned branches are spread on the ground to reduce run-off and to promote grass establishment. None of the area is fenced and stock graze and browse beneath the pruned trees. The trees provide poles, fuelwood, fodder and protection from wind.

53 CLARKE, J.M.; CROCKFORD, K.J. **An evaluation of eucalypt woodlots and acacia woodland management practices in Ntabazinduna Communal Land, Zimbabwe** (in press.) *Commonwealth Forestry Review* [En, 31 ref.]

The promotion of eucalypt woodlots and management of *Acacia* woodlands in Ntabazinduna, a low rainfall communal land in Zimbabwe, are evaluated. With the exception of the council plantation which has shown good yields, many of the small community woodlots of *Eucalyptus camaldulensis* have completely failed and the very best showed an MAI of only 2.09 m³ ha⁻¹ yr⁻¹. Innovative self help initiatives in woodland management have been concentrated on protecting and managing the *Acacia* regrowth near homes. Six woodland groves, predominantly *A. karroo*, aged between 4 and 30 years were examined and productivity was found to range between 0.7 and 3.2 t ha⁻¹ yr⁻¹. The local communities list a wide range of products and values being derived from the *Acacia* woodland including fuelwood, poles, gum, shade for livestock, windbreaks, improved grazing, browse and fodder.

54 CLEGHORN, W.B.; MCKAY, A.D.; CRONIN, C.H. **Results of preliminary arboricide and herbicide trails on a number of species limiting livestock carrying capacity of veld in Southern Rhodesia.** *Proceedings of the 1st African Weed Control Conference, Victoria Falls* (1958) **39** pp. From abstract in *Weed Abstract* **7** (12), (1958) 2215 [En, 10 ref.]

Reports on the effectiveness of various arboricides on *Brachystegia spiciformis*, *Isobertinia globiflora*, *Terminalia sericea*, *A. heteracantha*, *Combretum apiculatum* and *Dichopetalum cymosum* and a number of *Acacia* species. Monuron and diuron up to 120 lb/acre had little effect on *Acacia* species generally. Na arsenite (50%) at 1.5 oz/stump killed 93% of *Acacia subalata*; paraffin as a basal bark treatment was less effective. *A. karroo* was much less susceptible, the best kill being only 15%. Preliminary observations showed that ring barking, blazing or applying NH₄ sulphamate or 2,4,5-T in water to blazes had little effect on *A. karroo*, *A. subalata*, *A. gerrardii*, *A. nigrescens* or *A. rehmanniana*; 2,4,5-T in dieselene, or diesel oil alone, applied to blazes, were promising. *A. rehmanniana* reacted similarly.

55 COATES-PALGRAVE, K.E. **Trees of Southern Africa.** Cape Town; Struik (1977) 240 pp. [En]

The book describes and illustrates all the indigenous and many of the naturalised non-indigenous species of trees at present known to occur in South Africa, Zimbabwe, South West Africa, Botswana, Lesotho, Swaziland and Mozambique. The distribution map for *Acacia karroo* shows it to be the most widespread acacia if not one of the most widespread trees in the region. It describes the species as a tree to 15 m occurring over a wide range of altitudes from coastal scrub to woodland, wooded grassland, often along rivers and streams. Its presence is considered to be an indication of sweet veld and its uses described as almost unlimited making it an asset on any farm. It is a good tree, a good fodder and the gum can be used for confectionary and adhesive purposes. The bark can be used to make rope and the timber, although susceptible to borers, is suitable for

making furniture. It is a very adaptable tree, frost- and drought-resistant and fast-growing. It provides shade, fuel and very effective fences made from the thorny branches. It is a protected tree in the northern Cape Province and the Jacobsdal district of the Orange Free State in South Africa.

56 COE, M.; COE, C.E. **Large herbivores, acacia trees and bruchid beetles.** *South African Journal of Science* (1987) **83** (10) 624-635 [En, 85 ref.]

The African acacias comprise 128 of the 1200 species throughout the world. These are variously defended by spines or hooks. Eleven per cent of the African species develop "pseudo-galls" which are occupied by predatory *Crematogaster* ant species. *Acacia* pods may be classified into dehiscent and indehiscent forms, the latter being favoured by large browsing herbivores which disperse the seeds. Seeds from indehiscent pods are thick and robust, and resist the shearing forces of the molar teeth of large herbivores much better than dehiscent seeds. *Acacia* pods reach their full size before the seeds swell, thus conserving their nutrients. The activities of ants and the rapid mobilization of chemical defences may explain why specialist browsers feed only in short bursts. The larvae of bruchid beetles are important predators of acacia seeds. The larger bruchids are more likely to attack indehiscent than dehiscent seeds. Virtually all seeds may be colonized by these beetles on occasion, though 10% is more common. X-ray studies show that up to 16% of acacia seeds are digested in their passage through the gut of large herbivores. Consumption by these mammals not only aids in the dispersal of seeds but also reduces bruchid attack. It has been demonstrated that in the bright yellow flowers of *A. karroo* and some other species, small sterile involuclate flowers develop as a small secondary capitulum before the main fertile flowers open. It has been suggested that these may serve to attract insects, to ensure that they are already present in large numbers before the fertile flowers open. *A. karroo* has dehiscent seeds. [CABI abstract]

57 COE, M.; BEENTJE, H.E. **A Field guide to the Acacias of Kenya.** Oxford University Press (1991) **3** [En]

This work describes 43 *Acacia* species in Kenya. Notes the increased commercial use of gum from *A. karroo* in the confectionery industry.

58 COETZEE, J.A.E. **The morphology of *Acacia* pollen.** *South African Journal of Science* (1955) **52** 23-27 [En, 1 ill., 14 ref.]

A study was made of 28 South African and 31 Australian species of *Acacia*. In this insect-pollinated genus, only eight large pollen grains are produced per anther. On vaselined slides exposed for twenty four hours on a warm, windy day in a flowering *A. horrida* (*A. karroo* community, no more than 8 pollen grains were found per 7 cm². An illustration show the germination of *A. karroo* pollen grains.

59 COETZEE, B.J.; VAN DER MEULEN, F.; ZWANZIGER, S.; GONSALVES, P.; WEISSER, P.J.E. **A phytosociological classification of the Nylsvley Nature Reserve.** *Bothalia* (1976) **12** (1) 137-160 [En, fr, af, 27 ref., 1 map, 3 tab.]

This work classifies the vegetation in the Nylsvley Nature Reserve in the Transvaal mixed bushland hierarchically by the Braun-Blanquet method. There are four major groups of plant communities in the seasonal grassland and deciduous savannas of which the third, grassland and thorn savanna on calcareous self-mulching vertisols, is dominated by *A. karroo*.

60 COHEN, C.E. ***Stoebe vulgaris*. A study of an ecological problem.** *Journal of South African Botany* (1940) **6** (2) [En]

Seeds of *Acacia karroo* were kept on the soil surface at air temperature and watered daily, but no germination occurred in sixty two days.

61 COMINS, D.M.E. **The vegetation of the districts of East London and King William's Town, Cape Province.** *Botanical Survey of South Africa Memoirs* (1962) No. 33, 1-32 [En, 1 detailed vegetation map, photos, 38 ref.]

A parklike *Acacia karroo* woodland with large trees scattered in grassland occurs in some areas of the eastern Cape and is ideal for grazing. Scattered *A. karroo* trees serve as foci for development of clumps of fruiting shrubs. Thickets of small *A. karroo* trees with little grazing beneath them develop on parkland overgrazed by cattle and on abandoned ploughed fields. Removal of thickets was attempted using goats to browse the thickets, ringbarking and poisoning with arsenite of soda, dieseline and oil waste. When there is continuous, heavy grazing by cattle, sheep and goats, the ground is covered by a rhizomatous grass (*Cynodon dactylon*). Under such conditions, seedlings of *A. karroo* are grazed down and cannot establish.

62 CUNLIFF, K.M.E. **Trees for tomorrow (*Acacia karroo*).** *Trees in South Africa* (1975) **27** (2) 50-51 [En, 3 photos of flowers, thorns, pods]

Acacia karroo is the most widespread *Acacia* in southern Africa. This hardy, deciduous tree is armed with paired, white stipular spines varying in length from 2-10 cm. Flowers are bright yellow, sweet scented and are usually produced in early to mid summer (November-December). The pods, which are 50-120 mm long and 6-10 mm wide, split when ripe to release several seeds measuring about 6 by 4 mm. The hard-coated seeds should be soaked in water, initially hot, for a day or two before sowing. It does not grow well in acid soil. Transplanting should be done early so as not to damage the long tap root that develops soon after germination. Once established the trees are frost and drought resistant.

63 DAMIANO, A.E. *Casama innodata*, a lymantriid injurious to *Acacia karroo* in Tripolitania. *Riv. Agric. subtrop. trop.*, Firenze (1965) **59** (4/6) 143-148 [It. it. e.f. span, 5 ph.]

Describes the morphology, life history, distribution and natural enemies of this insect, apparently a newcomer to Tripolitania, where it can completely defoliate and sometimes kill *Acacia karroo*, which is a species of vital importance for soil conservation. [CABI abstract]

64 DEAN, W.R.J.; MIDGELEY, J.J.; STOCK, W.D. The distribution of mistletoes in South Africa: patterns of species richness and host choice. *Journal of Biogeography* (1994) **21** 503-510 [En]

The distribution records of mistletoes (Loranthaceae and Viscaceae) in South Africa were analyzed in terms of host taxa and geographic patterns. Few species were found in the nutrient-poor Cape shrublands or in the southern evergreen forests on nutrient-poor sands. The most species-rich areas are the nutrient-rich mesic savannas. Mistletoe species richness is significantly correlated with the average nitrogen levels of the woody plants in any biome. The analysis of host-choice of mistletoes also indicates a non-random distribution; 33 genera in 22 plant families host from 3 to 24 different mistletoe species suggesting that parasitism is not related to phylogenetic position. The most important host genera are *Acacia* (hosting 24 mistletoe species) followed by *Combretum* (14), *Maytenus* (13) and *Rhus* (12). The species richness and number of mistletoes are significantly correlated with mean host N. In this study, *A. karroo* had the highest number of mistletoes and the highest number of mistletoe species associated with it of any of the host plants studied.

65 DEAN, W.R.J.; MILTON, S.J.; SIEGFRIED, W.R. Dispersal of seeds as nest material by birds in semi-arid Karoo shrubland. *Ecology* (1990) **71** (4) 1299-1306 [En]

Acacia karroo trees are common along dry water courses and rivers in the southern Karoo near Prince Albert, South Africa, but are absent from the intervening plains and hillsides. The spiny trees are favoured by birds as nest sites.

66 DICKSON, C.G.C.; KROON, D.M. Pennington's butterflies of southern Africa. Johannesburg, South Africa; A.D. Donker (Pty) Ltd. (1978) 670 pp. [En]

Acacia karroo is listed as a food plant for larvae of the following butterfly species: Lycaenidae: *Anthene amarah*, *A. definita*, *A. otacilia*, *A. talboti* (flowers and leaves), *Azanus moriqua* (flowers and buds), *A. natalensis* (flowers and buds), *A. ubaldus*, *Cruderia leroma* (young shoots and thorns), Charaxidae: *Charaxes zoolina*.

67 DRUMMOND, R.B. Common trees of the central watershed woodlands of Zimbabwe. Causeway, Zimbabwe; Natural Resources Board (1981) 46-47 [En, 1

map]

Common names in Zimbabwe are sweet thorn; muunga, mubayamhondoro (Shangaan); isinga (Ndebele). *Acacia karroo* is normally found in wooded grassland and on vlei margins.

68 DUBE, J.S. Nutritive value of four species of browse preferred by indigenous goats in a redsoil thornveld in southern Zimbabwe. M.Phil. thesis, Department of Animal Science, Faculty of Agriculture, University of Zimbabwe (1993). [En 93 ref. 93 pp.]

The nutritional value of *Acacia karroo*, *A. nilotica*, *Securinega virosa* and *Ziziphus mucronata* were investigated by laboratory analysis, the nylon bag technique and feeding trials. All species contained high nitrogen (19, 25, 34 and 26 g kg⁻¹ of DM respectively), low fibre (337, 314, 305 and 336 g NDF kg⁻¹ of DM respectively and variable condensed tannin (243, 67, 15 and 46 g kg⁻¹ of DM respectively). The four species were allocated to four rumen-fistulated goats in a 4x4 latin square design. Ten nylon bags containing samples of each species were placed in the rumen and withdrawn in pairs after 3, 6, 12, 24 and 48 hours in each period. *S. virosus* degraded fastest (degradation constant c when $p=a+b(1-e^{-ct}) = 0.1528$), followed by *A. nilotica* (c=0.0922), *Z. mucronata* (c=0.0679) and *A. karroo* (c=0.0266). Hand-clipped browse was offered with hay to 16 Matabele goats in metabolism crates. The goats were randomly allocated to diets. The intake of browse (g kg⁻¹ W^{0.75} d⁻¹) was highest for *S. virosa* (34), followed by *Z. mucronata* (32), *A. nilotica*, (27) and *A. karroo* (26). Browse intake was unrelated to tannin content or hay intake. Digestibility of the browse/hay mix was significantly (p<0.05) and negatively related to vanillin-HCl tannins or the butanol-HCl tannins. Animals on *A. karroo* produced high faecal N (average 7.4 g d⁻¹) and low N retention (average 1.1 g d⁻¹).

69 DU PREEZ, P.J.; VENTER, H.J.T. The phytosociology of the woody vegetation in the southern part of the Vredefort Dome Area, Part I: communities of the plains, riverbanks and islands. *South African Journal of Botany* (1990) **56** (6) 631-636 [En, 1 map, 17 ref.]

Along the banks of the Vaal river, South Africa, and at the base of a granite massive (Vredefort Dome), *Acacia karroo* dominates the woodland on alluvial clay-loam soils (pH 6.1-6.5). Understorey shrubs include members of the following shrub genera *Rhus*, *Ehretia*, *Protasparagus*, *Diospyros*, *Maytenus*, *Ziziphus*, *Celtis* and annual grasses.

70 DU TOIT, P.F. [An autecological study of the *Acacia karroo* seedling] Outekologiese studie van die *Acacia karroo* saailing. M.Sc. thesis, University of Pretoria, South Africa (1966) [Af]

The study investigated the effects of moisture, temperature and light on the germination and growth of

Acacia karroo seedlings. Delayed germination is caused by hard-seededness and a water soluble inhibitor in the seed coat. When moisture conditions are favourable the seeds can germinate at temperatures ranging from 10-40°C. Temperatures that fluctuated between 10 and 20°C were optimum for germination. Optimum temperatures for growth were higher than for germination, and lay between 25 and 33°C. The species has a deep taproot and is independent of surface moisture where underground water is available. The species is drought resistant but cannot withstand desiccation and loss of water from the protoplasm. Light intensities are seldom limiting for *A. karroo* in grassland, but the tree is light-demanding. The seedlings are very sensitive to desiccation because they are fairly slow growing and have a high temperature and moisture requirement for growth. Any factor that causes rapid drying of topsoil or delays root development will be deleterious to *A. karroo* seedlings. The latter may include low diurnal temperatures.

71 DU TOIT, P.F. **Bush encroachment with specific reference to *Acacia karroo* encroachment.** *Proceedings of the Grassland Society of Southern Africa* (1967) **2** 119-126 [En]

Acacia karroo seedlings are sensitive to desiccation and temperature changes. *A. karroo* is the African acacia most susceptible to attack by psychid moths *Kotachalia junodi* (bagworm).

72 DU TOIT, P.F. **A preliminary report on the effect of *Acacia karroo* competition on the composition and yield of sweet grassveld.** *Proceedings of the Grassland Society of Southern Africa* (1968) **3**, 147-149 [En]

A dense stand of *Acacia karroo* was killed by basal bark application of 2,4,5-T in paraffin. Cleared paddocks yielded more grass. Encroachment of *A. karroo* into grassy areas is a symptom rather than the cause of rangeland deterioration.

73 DU TOIT, P.F. ***Acacia karroo* intrusion: the effect of burning and sparing.** *Proceedings of the Grassland Society of southern Africa* (1972a) **7** 23-27 [En]

There is evidence that buried *Acacia karroo* seed remains viable for up to seven years. Burning and grazing treatments do not prevent *A. karroo* seedling establishment. At high densities *A. karroo* reduces grass production.

74 DU TOIT, P.F. **The goat in a bush-grass community.** *Proceedings of the Grassland Society of southern Africa* (1972b) **7** 44-50 [En]

A dense stand of *Acacia karroo* was cleared by felling all the trees. Sheep and goats were permitted to browse on regrowth rotationally or continuously. Sheep spent 6%, and goats 50% of their foraging time feeding on *A. karroo* coppice shoots. Continuous grazing by goats caused higher

mortality of trees than did rotational grazing.

75 DU TOIT, P.F.; NEL, L.O. **Chemical control of *Acacia karroo*.** *Proceedings of the Grassland Society of Southern Africa* (1973) **8** 29-34 [Af, en, 6 ref.]

Reports trials in 1967-72 in eastern Cape Province, where large areas of productive grassland have been invaded by *Acacia karroo* and other species.

76 EARLÉ, R.A. **Factors governing avian breeding in *Acacia savanna*, Pietermaritzburg, Parts 1, 2, 3.** *Ostrich* (1981) **52** 65-73, 74-83, 235-243 [En]

Factors governing breeding of birds in savanna dominated by *Acacia karroo*, *Erhetia rigida*, *Grewia occidentalis* and *Maytenus* sp. were studied near Pietermaritzburg, Natal, South Africa. Over two breeding seasons, 421 nests of 49 birds species were found in an areas of 1.4 km². Peak breeding coincided with the rapid spring increase in insect biomass.

77 EBERHARD, A.A. **Fuelwood calorific values in South Africa.** *South African Forestry Journal* (1990) **152** 17-22 [En, 5 ref.]

The gross calorific value of *Acacia karroo* sapwood is 18.69 MJ kg⁻¹ and of heartwood is 18.85 MJ kg⁻¹. The density of the wood is 890 kg m⁻³ at 10% moisture content and 862 kg m⁻³ dry mass. The calorific value per cubic metre is 16 185 MJ.

78 EDWARDS, D. **A Plant Ecology Survey of the Tugela River Basin, Natal.** *Botanical Survey of South Africa Memoirs* (1967) No. 36, 285 pp. [En, many ref.]

The catchment system of the Tugela River is considered to be an area with considerable economic and industrial potential. The Natal Town and Regional Planning Commission has undertaken a comprehensive study of the region. In order to provide information for agricultural development and other aspects. One project was a study of the plant ecology. *Acacia karroo* is included in a species list collected and recorded during the survey of the Tugela Basin. The list may be regarded as comprehensive for trees and shrubs. [CABI abstract]

79 ERNST, W.H.O.; DECELLE, J.E.; TOLSMA, D.J. **Predispersal seed predation in native leguminous shrubs and trees in savannas of Southern Botswana.** *African Journal of Ecology* (1990) **28** (1) 45-54 [En]

Seed predation by insects in the seed crop of nine *Acacia* species including *A. karroo* was examined in various tree savannas in Botswana. The degree of infestation varied strongly between and within species from 0% to more than 80%. Whereas in all *Acacia* species only one phytophagous hymenopteran (*Oedaule* sp.) was present, the number of

bruchid species varied between one and eight species. The life history of *B. sahlbergi* was studied in detail and lasted at least 100 days from egg to adult beetle. The life-span of adult beetles may extend to a further 57 seven days. [author's summary]

80 FELKER, P. **Uses of tree legumes in semi-arid regions.** *Economic Botany* (1981) **35** 174-186.

81 FOURIE, C. **Small camps really pay.** *Farmers Weekly*, April 15th (1981) 62-65 [En]

In the eastern Cape, dense stands of *Acacia karroo* were felled at 30 cm above ground level then controlled by running goats with cattle at high densities in small camps on a rotational basis.

82 FOURIE, O. **Beat bush with boer goats.** *Farmers Weekly*, June 18th 1982, 35-37 [En]

In the eastern Cape, South Africa, *Acacia karroo* has increased greatly in density over the past 50 years on rangeland. Some ranchers fell the trees then use goats to reduce regrowth.

83 FREEMAN, B.H.; STEPHEN, A.M.; WOOLARD, G.R. **The G.L.C. (gas-liquid chromatographic) analysis of methylated polysaccharides using derivatives of alditol methyl ethers.** *Journal of South African Chemistry Institute* (1973) **26** (3) 106-110 [En]

Mixtures of methylated sugars, obtained by hydrolysis of complex methylated polysaccharides, have been reduced and converted to their acetates and to their trimethylsilyl ethers. The relative proportions of these derivatives have been estimated by g.l.c., and the relative merits of the two methods of analysis are compared. Analytical results for eight methylated *Acacia* gums are presented, including the African species *A. giraffae* and *A. karroo*, and 6 Australian species alien to South Africa. Major components of *A. karroo* gum were 2,3,5-Ara, 2,3-Ara and 2,4-Gal. The relationship obtained between end groups and branch points was poor in this species. [CABI abstract]

84 FRIEDEL, M.H. **A preliminary investigation of woody plant increases in the western Transvaal and implications for veld assessment.** *Journal of the Grassland Society of Southern Africa* (1987) **4** (1) 25-30 [En]

The relationships between tree density and indices of pasture and soil condition were examined in western Transvaal grasslands where *Acacia karroo* had increased following disturbance. The correlation between tree density and pasture condition was not linear, indicating a threshold in condition below which dramatic increase in trees is likely. Some evidence is presented for a second threshold where soil compaction inhibits seedling establishment and tree

density declines. The necessity for assessing tree and soil status in addition to pasture condition is discussed and a variety of possible indicators of pasture, woody plant and soil status is considered.

85 GALPIN, E.E. **Native timber trees of the Springbok Flats, Transvaal.** *Botanical Survey of Africa Memoirs* (1925) No. 7, 26 pp. [En]

Acacia karroo wood is hard, tough and pale and the grain is often twisted. It is used to make fence poles but is subject to attack by borers.

86 GELFAND, M.; MAVI, S.; DRUMMOND, R.B.; NDEMERA, E.B. **The traditional medical practitioner in Zimbabwe.** Mambo Press, Gweru, Zimbabwe. (1993) 411 pp. [En, 49 ref., 23 tables, 62 plates]

This book consists of two parts, the first a general survey of the practice of the n'anga (traditional medical practitioner) and the second a survey of the plants used in the remedies of the n'anga. *Acacia karroo* (roots) is among the plants prescribed as an aphrodisiac (infusion taken by mouth) and for pain in the alimentary canal, rheumatism (infusion taken by mouth and ash from burnt root rubbed onto incisions made on painful parts), convulsions (infusion taken by mouth and face washed with infusion), gonorrhoea (infusion taken by mouth), generalized pains (body wash with infusion), syphilis (powder applied on penile sores), and vertigo (infusion or powder taken by mouth). The roots are also placed in the fowl run to kill external parasites.

87 GERSTNER, J. **Three closely related Acacias of southern Africa.** *Journal of South African Botany* (1948) **14** 19-27 [En, 1 ill.]

This author proposed that *Acacia karroo* Hayne (Zulu "umuNga"), *A. natalita* E. Mey (Zulu "umSama") and *A. conflagrabilis* Gerstner (Zulu "isiKhombe") were three distinct species. All have stipules modified to form paired white spines which are sometimes enlarge and inflated. An ant *Cataulacus rugosus* nests in these hollow spines. All three species are insect pollinated and isolated plants often bear no fruits. Cattle and other herbivores disperse the seed. A table summarises differences in bark colour and texture, inflorescence development and pinnule size and shape for the three forms.

88 GHIMPU, V. **Contribution á L'étude chromosomique des Acacia.** *Comptes-Rendus Acad. Sciences Paris* (1929) **188** 1429-1431 [Fr]

Reports *Acacia karroo* as being a polyploid with a chromosome number of $2n=4x=52$.

89 GIBSON, I.A.S. (COMPILER) **Diseases of forest trees widely planted as exotics in the tropics and Southern Hemisphere. Part I. Important members of the**

Myrtaceae, Leguminosae, Verbenaceae and Meliaceae. Surrey, UK; Commonwealth Mycological Institute, and Oxford, UK; Commonwealth Forestry Institute (1975) 51 pp. [En, many ref.]

Lists the diseases according to the circumstances of their occurrence and gives descriptions of the symptoms and information on control methods. *Acacia karroo* may be attacked by *Ravanelia inornata* which forms leaf pustules or by *R. macowaniana* Patzschke which forms cup shaped lesions on pods and pustules on young branches and leaves.

90 GINDEL, G.F. **Afforestation of semi-arid and arid areas in Palestine.** *Empire Forestry Review* (1946) **25** (2) 213-21 [En, plates]

Afforestation work in Palestine, carried out during the previous two decades, penetrates already into areas with 100 mm of yearly rainfall. Initial success could be observed with a number of species including *Acacia karroo*. The prerequisites for successful afforestation of such arid areas are: (1) the preparation of suitable stock for planting. (2) choosing the most suitable season for planting and raising plants in receptacles rather than in beds; (3) hoeing and weeding the soil of newly established plantations; (4) choice of species with regard to exposure and slope.

91 GMELIN, R.; KJAER, A.; OLESEN-LARSEN, P. **N-acetyl-L-djenkolic acid, a novel amino acid isolated from *Acacia farnesiana* Willd.** *Phytochemistry*. Oxford (1963) **2** (4) 233-6 [En, 14 ref.]

A paper-chromatographic analysis of a seed extract is described. The new substance is an S-containing amino acid and it is present in seed extracts of *Acacia horrida*, *A. karroo*, and *Mimosa acanthocarpa*.

92 GOLDSMITH, B; CARTER, D.T. **The indigenous timbers of Zimbabwe.** *The Zimbabwe Bulletin of Forest Research*, No. 9. Zimbabwe Forestry Commission (1981) 406 pp. [En]

Includes *Acacia karroo* for which a general description of the tree is given followed by an account of the features and working properties of the wood. Its commercial use is limited due to few trees being of commercial size. The sapwood is very wide, creamy brown, the heartwood red-brown and often seen as small streaks. It has an even medium-textured wood finely wavy in tangential and narrowly striped in radial section. In end section: growth rings and rays are well defined; vessels numerous, medium to large, arranged along the growth ring parenchyma; clear gum deposits present; and parenchyma aliform-confluent and associated with the vessels. Its mechanical strength and shrinkage properties are unknown but its weight at 12% moisture content is 800 gm³-1. It saws easily, planes to a smooth finish, is moderately durable, glues and varnishes well but has to be pre-drilled for nailing. It is liable to twist in seasoning and is susceptible to attack by borers and fungi. Generally it is a tough resilient farm utility timber.

93 GORDON-GRAY, K.D.; WARD, C.J. **Floral variation in *Acacia karroo* in eastern south Africa.** *Abstracts of papers presented in Geneva. International Group for the study of Mimosoideae Bulletin* (1974) No. 2, 12-13 [En]

Acacia karroo Hayne is the most widespread and the most variable of South African *Acacia* species. The range of variation in the florets of the head and the involucre, for plants of *A. karroo* from eastern South Africa, particularly Natal, is described and illustrated. Parameters giving the ratio of hermaphrodite to male flowers in the capitata heads are also given. Attention is drawn to other South American species in which florets have been observed either within the involucre or along the peduncle.

94 GORDON-GRAY, K.D.; WARD, C.J. **A contribution to the knowledge of floral variation in *Acacia karroo* in eastern South Africa.** *Boissiera* (1975) **24** 279-284 [En]

Floral variation for plants of *Acacia karroo* from eastern South Africa was studied. Ordinary capitata, and involuclate florets borne on the peduncles were examined, and attention is drawn to other South African species bearing involuclate florets.

95 GOURLAY, I.D. **Growth ring characteristics of some African *Acacia* species.** *Journal of Tropical Ecology* (1995) **11** 121-140 [En]

The age of most temperate tree species can be estimated accurately by counting the annual rings revealed by concentric changes in their wood anatomy. In the tropics and sub-tropics, this growth periodicity is seldom clearly and unambiguously defined. This research investigates whether a wood anatomical feature is present that delimits annual periods in one of the most widely distributed genera in the semi-arid and arid areas of Africa, *Acacia*, including *A. karroo*. Most research on this topic has been based on sample trees from natural stands, often the largest and putatively oldest trees. In contrast, the trees sampled for this study were actively sought from material of known age, particularly those for which the history of management was known. Several African *Acacia* species were examined for growth rings. These were apparent in most species as narrow bands of marginal parenchyma filled with long crystal chains. The crystals were subsequently identified as calcium oxalate through the use of a scanning proton microprobe. The number of bands formed annually corresponded to the number of peaks in the annual rainfall distribution. Ring widths were highly correlated with total annual rainfall.

96 GOURLAY, I.D.; BARNES, R.D. **Seasonal growth zones in the wood of *Acacia karroo* Hayne: their definition and implications.** *Commonwealth Forestry Review* (1994) **73** 121-127 [En]

The age of tropical and sub-tropical tree species is

seldom clearly and unambiguously defined. This study investigates whether any anatomical feature in the wood delimits annual periods of growth in *Acacia karroo* Hayne, one of the most widely distributed tree species in southern Africa. Samples from 36 trees from four African countries, covering over 14 degrees of latitude were included in the study. Complete stem cross sections were examined from these trees, the majority of which were selected for their supporting data on planting dates. In addition a sub-set was wounded at documented time intervals to produce a callus which could be located and related to anatomical variation and phenological events. Seasonal growth rings in the anatomy were apparent as narrow bands of marginal parenchyma filled with long crystal chains of calcium oxalate. The number of bands was shown to correspond closely to the known ages of the trees. There was further confirmation that they were annual in that the width of the growth rings was correlated with annual rainfall. The bands were laid down during the dry winter season when stem diameter growth ceased.

97 GOURLAY, I.D.; GRIME, G.W. **Calcium oxalate crystals in African *Acacia* species and their analysis by scanning proton microprobe (SPM).** *IAWA Journal* (1994) **15** (2) 137-148 [En]

The radial and cross-sections of wood samples from individual trees of known age of a number of African *Acacia* species including *A. karroo* were examined for growth rings. These were apparent in most species as narrow bands of marginal parenchyma filled with long crystal chains. The crystals were subsequently identified as calcium oxalate through the use of a scanning proton microprobe. Several other chemical elements were concentrated around this zone. The number of bands formed annually corresponded to the number of peaks in the annual rainfall distribution. These results suggest that the presence of marginal parenchyma bands and crystalliferous chains define growth phases in African *Acacia* species, and can be used for age determination.

98 GOURLAY, I.D.; KANOWSKI, P.J. **Marginal parenchyma bands and crystalliferous chains as indicators of age in African *Acacia* species.** *IAWA Bulletin n.s.* (1991) **12** (2) 187-194 [En, 28 ref.]

The radial cross sections of wood samples from individuals of known age in six African *Acacia* species were examined for growth rings, which were apparent in most species as narrow bands of marginal parenchyma filled with long crystal chains. The number of bands formed annually corresponded to the number of peaks in rainfall distribution. The results suggested that marginal parenchyma bands and crystalliferous chains define growth phases in African *Acacia* species, and may therefore be useful for age determination. Two samples of *A. karroo* (Hayne) trees self-sown in 1975/76 on abandoned hay fields (black cotton soil) in a region of Zimbabwe with unimodal summer rainfall and felled in 1989 had mean diameter of 15.5 cm

and 12.0 cm, and mean ring widths of 8.61 mm and 7.50 mm. One sample had 9 rings and the other had 8 rings. Both had very clear, fine, marginal parenchyma bands, and crystal chains were present in the marginal bands.

99 GOURLAY, I.D.; SMITH, J.P.; BARNES, R.D. **Estimation of wood production in a natural stand of *Acacia karroo* using growth ring analysis.** *Forest Ecology and Management* (in press) [En]

Trees are important components of agricultural systems in the dry tropics of Africa. The assumption that exotic species are more productive than the indigenous woodland in these situations is not supported by quantitative data because of the difficulty of assessing yield in natural stands. In this study a new technique of recognizing annual growth rings from the bands of marginal parenchyma has been used to model growth in a natural population of *Acacia karroo* Hayne, one of the most widespread and useful trees in the savanna woodlands of southern Africa. The study showed both basal area at breast height and basal area at ankle height to be good predictors of total tree volume. Stands may yield from about 1 to about 4 m³ ha⁻¹ yr⁻¹ depending upon the regularity of spacing and uniformity of site; individual trees produced up to 1 m³ of wood in 26 years. Maximum current annual increment was reached about 14 years after the trees were established and then they declined until they became moribund at about 26 years. The economic rotation for wood production was close to the lifespan of the tree.

100 GROBLER, P.J.; MARAIS, J. **Die plantegroei van die Nasionale Bontebok Park, Swellendam.** *Koedoe* (1967) **10**, 132-146 [Af, 1 map]

The park lies on the southern Coast of the Cape Province, South Africa and receives year round rainfall (725 mm). *Acacia karroo* is restricted to deep, sandy soils on the banks of the Breë River. The understorey is trampled by antelope seeking shade beneath the trees and is therefore dominated by the grass *Cynodon dactylon*.

101 GUILLOTEAU, J. **The problem of bush fires and burns in land development and soil conservation in Africa south of the Sahara.** *Sols Africains* (1958) **4** 64-102 [En, fr]

Southern African *Acacia* species including *A. karroo* and *A. stolonifera* withstand fire and coppice after being burned.

102 GUINET, P.; VASSAL, J. **Hypotheses on the differentiation of the major groups in the genus *Acacia* (Leguminosae).** *Kew Bulletin* (1978) **32** 509-527

103 HALL, P.E. **Notes on the analyses of certain South African woods with special reference to their use as a producer gas generator fuels.** *Journal of the*

Chemical, Metallurgical and Mining Society of South Africa (1939-1940) **40**, 350-2 [En]

This investigation was carried out jointly by the Forest Products Institute and the Fuel Research Institute. Three groups of species were tested, pines, eucalypts and acacias; the latter included *Acacia karroo*. The analytical tests made on each sample included: (1) specific gravity, (2) proximate analysis, and (3) low temperature carbonization assay. Among the *Acacia* woods, specific gravity varied from 0.68 to 0.86. The ash contents of the acacias were high (0.9%) in the proximate analysis. The moisture figures were reasonably constant (8.5% to 10.0%); the acacias were drier than the others. The calorific values lay between 7,410 and 7,820 B.T.U's/lb. In the low temperature carbonization assay, the acacias gave approximately 24% of charcoal, 13.5-17% tar, 40% of liquor and 10% of CO₂. While from these analyses there did not appear to be any marked difference between the woods tested, the acacias proved reasonably satisfactory, the charcoal yield being fair, the specific gravity being medium and the tar yield being fairly low.

104 HARDY, M.B.; HOBSON, F.O. **Evaluation of belt transect sampling to determine tree density in a semiarid *Acacia karroo* savanna.** *Proceedings of the First Natal Bushveld Symposium*. Scottsville, South Africa; Grassland Society of Southern Africa (1992) 33-35 [En]

Belt transects 2 m wide are frequently used to sample the densities of trees *Acacia karroo* savanna with 400-2000 trees/ha. A minimum of 20-60 transects 2 m x 30 m would be required in order to reduce the coefficient of variation to < 10%.

105 HELLINGE, A. [**Trees producing gum arabic**] Arabische gom leverende gewassen. Rapp. Bosbouwproefsta. *Buitenzorg* (1949) No. 21, 5 pp. [Dutch, Javanese, En]

Experiments on the growth of gum-producing *Acacia* species in Indonesia show that *A. senegal*, *A. arabica*, *A. karroo* and *A. stenocarpa* give good results. Their cultivation by the native population in the east of the archipelago is recommended, with the use of the timber for fuel and construction, the bark for textiles and tanning, and the leaves and fruit as fodder, in addition to the Collection of the gum arabic. [CABI abstract]

106 HENDERSON, L. **Barrier plants of Southern Africa.** *Botanical Survey of South Africa Memoirs* (1987) No. 55, 97 pp. [En]

Presents information on 504 species of which 220 are indigenous and 96 of these are being suggested for use as barrier plants for the first time. Of the 408 species known as barrier plants in southern Africa, and which have been used as security hedges, garden hedges and windbreaks, 284 are aliens. Attention is drawn to the need to replace alien species which have become aggressive invaders, with less

aggressive species, preferably indigenous. Security hedge plants are illustrated by 47 photographs. The indigenous species are described and recommended for the four major climatic regions of southern Africa. The advantages of combination plantings of two or more species with different characteristics are emphasized. Alien species are listed with the climatic regions in which they have been grown in southern Africa or to which they are suited. Weedy and aggressive species are indicated. It is noted that *Acacia karroo* will respond favourably to a very severe cut or burn producing a dense multi stemmed thicket within a season or two. Notes are given on *A. karroo* as follows: produces an outstanding display of flowers which have a strong and sweet fragrance. A good source of honey. Thorns could be a disadvantage in a garden hedge. One of the most widespread woody species in southern Africa. A very valuable species. Dense multi-stemmed shrubby growth can be obtained by cutting or clipping. Often thicket forming and difficult to eradicate from agricultural land; it is a declared invader plant in South Africa. It is categorized as a "framework" barrier plant; found in climatic zones: hot and moist, hot and dry, cold and moist, and cold and dry. It is moderately frost hardy and is drought hardy. It is found in all regions of southern Africa. [CABI abstract]

107 HOBSON, F.O.; DE RIDDER, C.H. **Quantifying indices of potential competitiveness and browse productivity of single stemmed *Acacia karroo* trees in south-eastern Africa.** *Journal of the Grassland Society of Southern Africa* (1991) **8** (1) 1-8 [En, 17 ref.]

The prediction of indices of potential competition with grass and browse productivity of single-stemmed *Acacia karroo* trees, using various trunk and canopy parameters, was evaluated on the basis of the variance accounted for by each of four operators and the repeatability for all operators. Potential competitiveness and browse productivity was measured as total dry weight of leaf-bearing twig and that occurring below a height of 1.5 m, respectively. While trunk measurements and measurements based on canopy volume and twig densities accounted for the greatest variance in competitiveness, trunk circumference and maximum tree height produced the highest levels of repeatability, with maximum errors of c. 7 and c. 17% respectively. The variance in browse productivity accounted for and the repeatability of predictions of browse productivity were lower than those for potential competitiveness. Browsing units calculated from partial spherical canopy volumes gave predictions of browse productivity with the lowest error (c. 25%). Indices of competitiveness and browse productivity of single-stemmed *A. karroo* trees can be predicted within c. 25% error using maximum tree height, maximum canopy radius and height of the canopy bottom as basic measurements. [Author's summary]

108 HOBSON, F.O.; DE RIDDER, C.H. **Grass and browse production under different tree densities in a humid *Acacia karroo* savanna in south-eastern Africa.**

Bulletin of the Grassland Society of southern Africa (1993) **4** (1) 19 [En]

Acacia karroo browse production was negatively related to tree density at the beginning of the growing season but stabilized by the middle of the summer resulting in a positive relationship between browse production and tree density. Grass production varied more between seasons than *A. karroo* production and was inversely related to tree density. Maximum forage production (grass and browse) occurred at moderate densities of *A. karroo*.

109 HOCKING, B. **Insect associations with swollen thorn acacias.** *Transactions of the Royal Entomological Society of London* (1970) **122** (7) 211-255 [En, many ref.]

Gives dimensions of the gall-like swellings in some of the stipulate thorns of acacia species including *Acacia karroo*.

110 HOFFMANN, J.H.; MORAN, V.C.; WEBB, J.W. **The influence of the host plant and saturation deficit on the temperature tolerance of a psyllid (Homoptera).** *Entomologia Experimentalis et Applicata* (1975) **18** 55-67 [En]

In the laboratory, *Acizzia russelae* survived higher temperatures when sitting on its host plant, *Acacia karroo*, than when isolated from it. When the moisture saturation deficit was very low (and hence leaf transpiration also low) and when it was very high (causing rapid desiccation despite high plant transpiration) mortality of the psyllid was higher than at moderate moisture saturation deficits. In the field, high temperatures cause a reduction of populations.

111 HOWES, F.N. **Vegetable gums and resins.** Chronica Botanica Co., Waltham, Massachusetcs [En]

Historical export of *Acacia karroo* gum from the Cape, South African and Namibia to Europe.

112 IBPGR (International Board for Plant Genetic Resources). **Forage and browse plants for arid and semi-arid Africa.** Food and Agricultural Organization of the United Nations, Rome (1984) [En, 5 ref.]

Acacia karroo occurs naturally in Mozambique, Malawi, Zambia, Zimbabwe, Angola, Namibia, Botswana, South Africa; but is introduced in North Africa and India. It can easily be grown from seed or root suckers and is reportedly nodulated.

113 JURACEK, P.; KOSIK, M.; PHILLIPS, G.O. **A chemometric study of the Acacia (gum-arabic) and related natural gums.** *Food hydrocolloids* (1993) **7** (1) 73-85 [En]

114 KAPLAN, J. **The arboretum at Gilat [N. Negev].** *La-Yaaran* (1957) **7** (3/4) 9-12, 40-39 [Hebrew, En, 1

photo]

More than 150 species were established to determine suitable species for planting on a large area of loess with 200 mm annual rainfall. Plantings have been made since 1951 in groups of 15, spaced 2 x 4 m, with 5-6 irrigations in the first two seasons. *Acacia karroo* was among those that showed promise.

115 KARSTEN, M.C. **Carl Peter Thunberg: an early investigator of Cape Botany.** *Journal of South African Botany* (1939) **5**, 87-155 [En]

Extracts from Thunberg's notes on his travels into the Karoo, Cape South Africa. In the Robertson Karoo he found that livestock were enclosed in circular *kraals* made of the thorny branches of *Mimosa nilotica* (*Acacia karroo*) and *Carissa* sp.

116 KENRICK, J.; KNOX, R.B. **Quantitative analysis of self-incompatibility in trees of seven species of Acacia.** *Journal of Heredity* (1989) **80** 240-245 [En]

117 KERLEY, G.I.H.; ERASMUS, T. **Chemical attributes of seeds of some economically important Karoo plants.** *South African Journal of Wildlife Research* (1991) **21** (1) 19-22 [En]

The chemical composition of *Acacia karroo* seeds collected in the eastern Karoo (33°S 24°E) are given. Free water was 5.6%. Other components expressed as a proportion of oven-dry mass were cell walls 53.5%, cell contents, crude protein 24.2%, ether extract 4.8%, ash 4.7%, silica 0.47%, soluble carbohydrates 13.3% and polyphenols 0.41%.

118 KERLEY, G.I.H.; ERASMUS, T. **What do mice select for in seeds?** *Oecologia* (1992) **86**, 261-267 [En]

Acacia karroo seeds are eaten by the rodents *Gerbillurus paeba*, *Mastomys natalensis* and *Mus minutoides*. However the rodents took >3 minutes to consume one 0.052 ± 0.012 g seed. Although *A. karroo* seeds contained more energy (20.47 kJ g⁻¹ intact seed) than 10 other Karoo plant species investigated, they were among the seed species least preferred by mice. Low preference for *A. karroo* seed was thought to be related to handling time.

119 KOOLJ, M.S.; BREDEKAMP, G.J.; THERON, G.K. **The plant communities of the hills and ridges in the north western Orange Free State, South Africa.** *Botanical Bulletin of Academia Sinica* (1990) **31** (4) 295-304 [En, Ch, 28 ref.]

A phytosociological analysis of the vegetation of the hills and ridges in the northwest Orange Free State is presented. Relevés were compiled in only 15 sample plots due to the restricted area occupied by hills and ridges. A TWINSPAN-classification refined by Braun-Blanquet

procedures revealed the following major communities: *Maytenus heterophylla*-*Celtis africana* shrubby thorn veld; *Ehretia rigida*-*Rhus magalismsontanum* shrub veld; *Heteropogon contortus* - *Eragrostis racemosa*; *Panicum coloratum* - *Eragrostis curvula* bottomland grassland; and *Acacia karroo* - *Protasparagus suaveolens* river thorn veld. All communities are related to specific environmental conditions. Descriptions of the communities are given. [CABI abstract]

120 KOOLJ, M.S.; SCHEEPERS, J.C.; BRENDENKAMP, G.J.; THERON, G.K. **The vegetation of the Kroonstad area, Orange Free State I: vlei and bottomland communities.** *South African Journal of Botany* (1991) **57** (4) 213-219 [En, 1 map, 17 ref.]

At 27°S 27°E, South Africa, *Acacia karroo* occurs in valley bottoms, on riverbanks and in steep ravines. Soils tend to be saline. The *A. karroo* dominated woodland has an understorey of shrubs and grasses. On uplands, *A. karroo* occurs on black vertisols associated with rock outcrops, and the understorey is grassy.

121 KOTZE, D.C.; ZACHARIAS, P.J.K. **Browsing of woody plants by black rhino in the western Itala game reserve.** *Proceedings of the First Natal Bushveld Symposium*, Scottsville, South Africa; Grassland Society of Southern Africa (1992) 9-11 [En]

Acacia nilotica contributed 18% and *A. karroo* 11% to the diets of black rhino (*Diceros bicornis*) foraging in woodlands of the Itala Nature Reserve in northern Natal. Rhino preferred open acacia woodland with small trees to tall and closed woodland.

122 KRESS, W.J.; **Sibling competition and evolution of pollen unit, ovule number and pollen vector in Angiosperms.** *Systematic Botany* (1981) **6** 101-112 [En]

123 KROMHOUT, C.P. **'n Sleutel vir die mikroskopiese uitkenning van die vernaamste inheemse houtsoorte van Suid-Afrika.** Pretoria, South Africa; Department of Forestry (1975) Bulletin No. 50, 1-140 [Af, many ref., microphotographs]

Describes the microscopic structure of the wood of 12 species of *Acacia* including *A. karroo*. Illustrated with black and white photographs of cross sections of wood.

124 LEISTNER, O.A. **The Plant Ecology of the Southern Kalahari.** *Botanical Survey of South Africa Memoirs* (1967) No. 38, 172 pp. [En, many ref., photos]

Reports on the plant ecology of the Southern Kalahari. The research project had four main aims: 1. the compilation of a vegetation map of the region; 2. the description of the vegetation of the main habitats; 3. the study of plants in

relation to climate, soil and animals; 4. the compilation of a check list. In the section on Physiography it was noted that the occurrence of large specimens of *Acacia karroo* indicate the presence of underground water in the Aranos area. It was also noted that *A. karroo* was one of the few shrubs and trees that only flowers in the hottest months of the year - December to February. *A. karroo* is largely restricted to the upper reaches of the river. [CABI abstract]

125 LILLY, M.A. **An assessment of the dendrochronological potential of indigenous tree species in South Africa.** *Occasional Paper, University of the Witwatersrand*, Johannesburg, South Africa; Department of Geography (1977) No. 18, 80 pp. [En, many ref.]

Acacia karroo woods showed discontinuous rings and indistinct boundary parenchyma. Photographs show *A. karroo* wood cross-sections.

126 MARCHANT, N.G.; WHEELER, J.R.; RYE, B.L.; BENNETT, E.M.; LANDER, N.S.; MACFARLANE, D.T. **Flora of the Perth region, Part 1. Western Australian Herbarium** (1987) [En]

Acacia karroo was first collected in Australia in 1963 from the banks of the Swan River, Midland. Specimens are housed in the Western Australian Herbarium.

127 MCGEOCH, M.A. **The microlepidoptera associated with a fungus gall on *Acacia karroo* Hayne in South Africa.** *African Entomology* (1993) **1** (1) 49-56 [En]

The rust fungus *Ravenelia macowaniana* is specific to *Acacia karroo*. Larvae of seven species of Lepidoptera were associated with *R. macowaniana* near Pretoria, Transvaal and near Bloemfontein, OFS. The three most frequent species were *Getulina* nr. *semifuscella* (Pyralidae), *Pardasena* nr. *virgulana* (Noctuidae) and *Ascalenia pulverata* (Cosmopterigidae). Less common species were *Anarsia nimbosa* (Gelechiidae) and three Tortricidae: *Cryptophlebia peltastica* and *Cydia* (2 spp). An additional 7 species (2 Cospopterigidae, 1 Tortricidae, 1 Gelechiidae, 1 Tineidae, 1 Oecophoridae, 1 Gracillariidae) were collected at Ashton Bay in the eastern Cape. Galls from Pretoria contained a mean of 3.3 individuals/gall compared with a mean of 9.6 microlepidoptera from galls of the fungus *Uromycladium tepperianum* on *Acacia decurrens* near Melbourne, Australia.

128 MCGEOCH, M.A.; KRUGER, M. **Identification and diagnosis of Lepidoptera larvae inhabiting galls induced by *Ravenelia macowaniana* Pазschke on *Acacia karroo* Hayne in South Africa.** *African Entomology* (1994) **2** (1) 37-43 [En, 4 ref.]

Diagnoses, illustrations and head capsule widths are given of the five dominant Lepidoptera species that inhabit galls induced by *Ravenelia macowaniana* Pазschke

(Uredinales:Pucciniaceae) on *Acacia karroo* Hayne in South Africa are presented. These five species constitute approximately 90% of all the individuals. A key to the larvae inhabiting the galls is provided. This larval assemblage is a potential indicator of climate and habitat quality.

129 MENTIS, M.T.; ELLERY, W.N. **Post-mining rehabilitation of dunes on the north-east coast of South Africa.** *South African Journal of Science* (1994) **90** (2) 69-74 [En, 19 ref.]

The article examines a claim by environmentalists that miners revegetate but do not restore natural communities on coastal dunes subject to opencast mining. A test of the claim was conducted under the paradigm of ecological succession. It was supposed that restoring natural communities required reinstatement of community process, and succession in particular. Thirty sample plots were located on unmined areas and thirty seven on mined areas. Time-associated changes in community composition occurred on both unmined but disturbed, and mined areas. Euclidean distance of disturbed stands from an average mature or climax stand decreased over time. There was no significant difference in this convergence on the climax state between mined and unmined areas. Plant species richness increased with time since disturbance, again with no significant difference between mined and unmined areas. *Acacia karroo* was the dominant woody pioneer in both natural disturbances and post-mining succession. It was concluded that succession was occurring on mined areas, and that this succession did not differ materially from that on unmined areas.

130 MIDGELEY, J.J.; JOUBERT, D. **Mistletoes, their host plants and the effects of browsing by large mammals in Addo Elephant National Park.** *Koedoe* (1991) **34** (2) 149-152 [En, 11 ref.]

Moquinella rubra (Loranthaceae) was common and *Viscum obscurum* and *V. rotundifolium* (Viscaceae) were rare on *Acacia karroo* in the Addo Elephant Park, eastern Cape, South Africa. These species were more common on *A. karroo* outside the park, and it was concluded that they were selectively browsed by elephant in the park.

131 MILLER, O.B. **The Woody Plants of the Bechuanaland Protectorate.** *Journal of South African Botany* (1952) **18**, 22 [En]

This paper describes the area, the species and their occurrence. Forty-four acacias are included. *Acacia karroo* grows to 10 m on deep black turf soils. It flowers in December-February but is also seen flowering in March near Lake Ngami, central Botswana. Local names are "mooka", "mookana", "mokha".

132 MILTON, S.J. **Phenology of seven *Acacia* species in South Africa.** *South African Journal of Wildlife Research* (1987) **17** (1) 1-6 [En, af, 25 ref.]

Shoot growth, shoot mortality and the abundance of flowers, fruit and leaves on marked shoots of *Acacia burkei*, *A. caffra* and *A. mellifera* (hook-thorn), *A. karroo* and *A. nilotica* (straight-thorn) and *A. leuderitzii* and *A. tortilis* (mixed-thorn) were recorded for 13 months at Nylsvley, Transvaal, South Africa. All seven species began to grow or flower before the end of the dry season, but other aspects of the phenology and seasonal use of the plants by browsers differed at the species and superspecies level. Although the reproductive phenology of every species was unique, there were similarities between members of a superspecies group. Phenology of the vegetative organs, at least in the case of *A. tortilis*, appears to be more flexible than reproductive phenology, and the timing and extent of leaf fall and shoot growth can be modified by environmental factors. *A. karroo* bears flowers only on green extending shoots and flowers throughout the growing season as the new shoots are produced. Flowers are most abundant between December and February. Pods ripen in winter; they are thin-walled and split open while still on the tree when the seeds dangle from the pod on their funicles. Elongating shoots bear only one leaf per node; more leaves appear in whorls as the shoot lignifies. Rapid extension of the shoots starts early in September about six weeks before the rain. Despite the irregular elongation of shoots, peaks were observed in October and December. *A. karroo* was the first to sprout in spring and therefore sustained heavy losses of soft green shoots to browsers in spring. *A. caffra* saplings were browsed towards the end of the growing season and giraffes took much new growth from the crowns of taller trees. *A. tortilis* was heavily browsed in June and July. [CABI abstract]

133 MILTON, S.J. **The effects of pruning on shoot production and basal increment of *Acacia tortilis*.** *South African Journal of Botany* (1988) **54** (2) 109-117 [En, 36 ref.]

The shoot production of pruned, felled and undamaged *Acacia tortilis* trees on an old land site in the northern Transvaal was compared over two growing seasons. Trees were tolerant of damage and continued to increase in size when all current season's shoots were removed. Basal increment of treated pruned trees was less than controls. Shoot production, relative to basal area, increased after winter pruning and decreased after summer pruning. Shoot production and basal increment were positively correlated with rainfall and were indicators of soil moisture. Replacement shoots of pruned trees had a higher moisture content and leaf mass in the dry season and were more thorny than shoots of undamaged trees. Repeated harvesting, continuous browsing or felling followed by browsing reduce shoot production in *A. karroo* and water stress inhibits its growth.

134 MILTON, S.J. **Plant spinescence in arid southern Africa: does moisture mediate selection by mammals?** *Oecologia* (1991) **87**, 279-287 [En, 73 ref.]

The prediction that spinescence in plants increases with aridity, soil fertility and mammalian herbivory was examined at regional and local scales in southern Africa. Spinescence tended to increase with aridity. Within arid areas, vegetation of moist, nutrient-rich habitats was more spinescent than that of the surrounding dry plains. Spinescence in plants of drainage lines and pans in arid southern Africa occurs in a wide range of genera and appears to have been selected by the effect of large mammals which concentrate on these moist patches. It is concluded that spinescence may be selected by breakage as well as herbivory, and that in arid areas moisture may be important in mediating mammalian selection of spinescence. *Acacia karroo* was recorded as a deciduous, phanerophyte species of drainage line and pan habitat.

135 MILTON, S.J.; BOND, C. **Thorn trees and the quality of life in Msinga.** *Social Dynamics* (1986) **12** (2) 64-76 [En]

Acacia species and *Dichrostachys* provide the people of Msinga, a dry and rugged district of kwaZulu, with browse, fuel, building and fencing materials. These products are currently worth about R425 per year to a rural family. Employment of rural people in agroforestry projects aimed at the rational management of existing plant resources could improve the quality of life for the people of Msinga. *A. karroo* was found to be used for fencing, and children chew the sweet thorns of *A. karroo*.

136 MILTON, S.J.; MACDONALD, I.A.W. **Tree deaths near tar roads in the northern Transvaal.** *South African Journal of Science* (1988) **84** (3) 164-165 [En, 4 ref.]

This is a study of the mortality of large and small trees of a number of indigenous species, including *Acacia karroo*, recorded on verges of tar and gravel roads.

137 MILTON, S.J.; SIEGFRIED, W.R.; DEAN, R.J. **The distribution of epizoochoric plant species: a clue to the prehistoric use of arid Karoo rangelands by large herbivores.** *Journal of Biogeography* (1990) **17** 25-34 [En, 53 ref.]

Adhesive dispersal mechanisms are rare in the flora of the plains of the arid south western Karoo, South Africa, and most plants lack the long or hooked thorns normally associated with defence against browsing mammals on nutrient rich soils. The flora of drainage lines (often dominated by *Acacia karroo*), differs from that of the surrounding flats in that many of its species are thorny, bear pods or succulent fruits palatable to mammals, and more species have adhesive propagules. Before the advent of livestock ranching, large browsing mammals were probably restricted to the taller vegetation of drainage lines. The

grassier northern and eastern Karoo, with its thorny trees and shrubs and barb-fruited grasses, probably provided permanent forage for herds of large ungulates which occasionally extended their ranges southwestwards, after relatively high rainfall periods had promoted improved forage in the arid Karoo. [Author's summary]

138 MITCHELL WATT, J. **An ABC of trees in South Africa.** *Trees in South Africa* (1957) **9** (3) 50-61 [En, 29 ref.]

Acacia karroo failed to give any indication of the presence of hydrocyanic acid and so is not thought to cause poisoning and death in stock.

139 MOGG, A.O.D. **Fruits of the woody plants of the Witwatersrand region.** *Trees of South Africa* (1963) **15** (3) 56-60 [En]

Listing of fruits arranged according to succulence and colour at maturity and in accordance with Ridley's colour attractiveness to birds. *Acacia karroo* is classified as having an inert mechanism of distribution.

140 MULLER, T.H. **Acacia species cultivated in the National Botanic Garden, Salisbury, Rhodesia.** *International Group for the Study of Mimosoideae Bulletin No. 7* (1979) 36-39 [En]

Acacia karroo was found to be one of the fastest growing species in the systematic section that has been devoted to the genus.

141 MUNTING, J. **New and little known armoured scales (Homoptera: Diaspididae) from South Africa - 2.** *Journal of the Entomological Society of South Africa* (1965) **28** (2) 179-216 [En]

The scale *Andaspis bulba* (Munting) was collected on *Acacia karroo* at Hammanskraal, Transvaal.

142 MUTHANA, K.D.; GYAN CHAND; ARORA, G.D. **Silvicultural studies on indigenous and exotic tree species in Rajasthan Desert.** *Arid Zone Research and Development*. Edited by Mann, H.S., Jodhpur, India; Scientific Publishers (1980) 339-343 [En, 3 ref.]

Between 1958 and 1976, 112 species of *Eucalyptus*, 65 species of *Acacia* and 82 miscellaneous species from both indigenous and exotic sources were investigated in trials at Jodhpur and Pali, India. The most promising species are listed and some of their characteristics briefly described. The *Acacia* species that gave the most favourable results were, in order of performance: *A. tortilis* [*A. tortilis* ssp. *tortilis*, *A. tortilis* ssp. *raddiana*, *A. senegal*, *A. planifrons*, *A. ciliata*, *A. aneura*, *A. karroo*, *A. leucophloia* [*leucophloea*], *A. saligna*, *A. nilotica* and *A. catechu*. [CAB abstract]

143 NAUDE, T.J. **Research into the control of insect pests.** *Farming in South Africa* (1949) **24** (275) 105-13 [En, 25 ref.]

Contains a short section on forest insect pests in South Africa. Extensive dying-out of *Acacia karroo* is not directly traceable to insects, but large numbers of cerambycid beetles (*Zographus oculato* and *Ceroplesis thunbergi*) have been found ovipositing heavily on moribund trees and hastening defoliation by ringbarking the shoots in feeding. The ecological study of the wattle bagworm has enabled reliable predictions of outbreaks to be made. An oil-based aerial spray, which should be partially rain-proof, is being investigated. [CABI abstract]

144 NAUDE, C.P. **Eradication of Lantana and Thorn trees.** *Farming in South Africa* (1956) **31** (360) 209-210 [En, 4 ref., 2 photos]

Acacia karroo was controlled with paraffin and diesel solutions of 2,4,5-T (3 1/6 oz. amyl ester in 2 gal. solvent).

145 NCUBE, S; DUBE, J.S.; HOVE, L. **Value of browse, wild fruits as livestock feed.** *The Farmer* (Zimbabwe) (1992) **60** (18) 7-8 [En]

Natural veld is the major source of feed for ruminant livestock of Zimbabwe. The seasonal fluctuation of both the quantity and the quality of the veld are countered with protein supplement. With increasing costs farmers are encouraged to use more economical sources such as pods from wild trees. Chemical composition of browse was assessed for *Acacia karroo* and three other preferred indigenous species. *A. karroo* had 12% crude protein, 14% crude fibre, and 24% tannin; all three other species had higher crude protein and lower tannin, *Securinega virosa* being best at 21% and 2% respectively. The crude protein and seed:pod ratio were also assessed for *A. karroo* and compared with those of four other indigenous species. Crude protein was 16.1% for the whole fruit, 24.3% for the seed and 4.1% for the seed alone; the seed pod ratio was 45:55. The most significant difference from the pods of other species assessed was the low protein content of the pods of *A. karroo*. The authors conclude that trees in the range can be a critical resource as the trees are affected less than the grass in times of drought.

146 NEW, T.R. **A Biology of Acacias.** Melbourne, Australia; Oxford University Press (1984), 153 pp. [En, 28 pp. of ref.]

Chapters of this book deal with classification and phylogeny, ecology, and utilization of acacias by man, arthropods and other organisms. Information on *Acacia karroo* includes references to its chemistry, phylogeny, invasiveness, factors influencing seedling survival, fire tolerance, medicinal use, insects (psyllids, bagworm), and animals feeding on the gum.

147 NOEL, A.R.A. **The Heart of the Matter.** *Trees in South Africa* (1982) **33** (4) 92-96 [En]

Acacia karroo has a distinct differentiation between the sapwood which is a pale yellow and the heartwood which is red-brown.

148 OBALLA, P.O. **Genetic variation within *Acacia karroo*** Hayne. D.Phil. thesis, University of Oxford (1993) 224 pp. [En, 388 refs., 17 tables, 24 figs]

This isozyme study was based on material sampled across the natural range of *Acacia karroo*. Interpretation of allozyme data requires a knowledge of the ploidy level in a species. An understanding of cytotype distribution within the population under study is crucial to interpret the complex electrophoretic patterns that arise with increasing ploidy level. The chromosome number of *A. karroo* was reported as $2n = 52$ under its original name *A. horrida* (Grimpu, 1929) and confirmed later under *A. karroo* (Vassal, 1974). However, there had been no survey to determine the distribution of cytotypes among the ecotypes of the species. A cytological investigation of *A. karroo* was therefore undertaken. The survey revealed that all the populations of *A. karroo* that were studied had only one cytotype with $2n = 52$ chromosomes. Despite its morphological variation, therefore, the species has retained a single genome. However, the possibility of isolated occurrences of other cytotypes cannot be excluded given that naturally sterile trees have been documented previously in *A. karroo*. The tetraploid status was further supported by evidence from the isozyme inheritance patterns which also indicated that the species is a segmental tetraploid. Twelve populations of *A. karroo* were surveyed for 12 allozyme systems (aspartic aminotransferase, alcohol dehydrogenase, diaphorase, alpha-esterase, beta-esterase, glucose-6 phosphoglucose dehydrogenase, glutamate dehydrogenase, malate dehydrogenase (mdh), malate dehydrogenase (mdhp), menadione reductase, 6-phosphogluconate dehydrogenase and shikimate dehydrogenase). All expressed a high level of genetic diversity. Ninety-eight percent of the isozyme loci were polymorphic with an average of 3.7 alleles per locus. The total gene diversity was 88%, higher than that reported for most plant species. The mean genetic identity was 90% and the coefficient of gene differentiation was estimated at 5%; this indicated a low divergence between populations. Cluster analysis grouped the populations into three phylogenetic groups, the northern, the southern and the south-central-eastern. The distribution of some common alleles at the shikimate dehydrogenase and alcohol dehydrogenase loci were significantly correlated with some geographical factors, viz., latitude, longitude and rainfall. Estimates of mating system parameters in one population indicated that the species has a mixed mating system. Multilocus outcrossing rate was estimated at 0.88; single locus outcrossing rates were heterogeneous, ranging from 0.53 to ≥ 1.00 , confirming the variable characteristics of the loci. The mean outcrossing rate, estimated using fixation indices for all 12 populations, was 0.72; the gene flow rate (Nm) was estimated at 4.47, consistent with the

entomophilous pollination mechanism reported for other tree species. Gene distribution within the population studied showed no specific spacial pattern.

149 OBALLA, P.O.; OLNQ'OTIE, P.A.S. **Chromosome numbers in two African *Acacia* species.** *Kew Bulletin* (1994) **49** (1) 107-113 [En, 28 ref.]

Chromosome numbers were surveyed in populations of *Acacia karroo* Hayne and *A. tortilis* (Forssk.) Hayne sampled across their wide geographical range. Seeds used in this analysis were collected from plantations maintained by the Oxford Forestry Institute. *A. karroo* plantations were in South Africa, Malawi, Zambia and Zimbabwe, and *A. tortilis* plantations were in Botswana, Israel, Kenya, Niger, Senegal and Zimbabwe. Only one cytotype, with a chromosome number $2n = 52$, was found in populations of *A. karroo* and *A. tortilis* subspecies *tortilis*, *spirocarpa* and *heteracantha*. Both $2n = 52$ and $2n = 104$ were found in populations of *A. tortilis* ssp *raddiana*. It was concluded that most common varieties of *A. karroo* and *A. tortilis* subspecies *tortilis*, *spirocarpa* and *heteracantha* are tetraploids, but the possibility of isolated cases of other cytotypes cannot be excluded given that naturally sterile trees have been documented previously in *A. karroo*. The cytotypes of *A. tortilis* are more variable. Clarification will require more detailed analysis.

150 ORMOND, B. **Indigenous Bonsai - A Plea for Experiment.** *Trees in South Africa* (1968) **20** (3) 71-74 [En]

Acacia karroo is suggested as a suitable indigenous species for bonsai culture.

151 PAPENDORF, M.C. **Two new genera of soil fungi from South Africa.** *Transactions of the British Mycological Society* (1967) **50** (1) 69-75 [En, 8 ref. 1 plate]

The fungi, isolated from leaf-litter and soil of an *Acacia karroo* community, are *Hyalotiella transvaalensis* and *Arxiella terrestris*.

152 PAPENDORF, M.C. **New South African soil fungi.** *Transactions of the British Mycological Society* (1969) **52** (3) 483-489 [En, 4 ref., 3 fig.]

Three new fungi are described, isolated from soil and litter of a mixed *Acacia karroo* community in the Transvaal: *Arthrocladium caudatum* gen. et sp. nov., *Veronaea simplex* sp. nov., and *Exophiala brunnea* sp. nov. [CABI abstract]

153 PAPENDORF, M.C. **The soil mycoflora of an *Acacia karroo* community in the western Transvaal.** *Bothalia* (1976) **12** (1) 123-127 [En, fr, af, 56 ref.]

A total of 858 sporulating cultures representing 76 genera and 144 species were recovered from the soil under a community of *Acacia karroo*. The majority were fungi imperfecti, with a limited number of zygomycetes and ascomycetes. No oomycetes or basidiomycetes were recorded. The most abundant genera were *Penicillium* and *Aspergillus*. The greatest concentration of individuals and species occurred in the surface layers; numbers decreased with increasing depth. The nature of this mycoflora suggests a close correlation with the existing plant cover. [CAB abstract]

154 PAPENDORF, M.C.; DU TOIT, J.W. ***Melanophoma*: a new genus of the Sphaeropsidales.** *Transactions of the British Mycological Society* (1967) **50** (3) 503-506 [2 ref., 1 set of diagrams, 1 pl.]

Melanophoma karroo, the type species, is described. It was found associated with the litter and surface soil of a mixed *Acacia karroo* community in Potchefstroom, South Africa. [CABI abstract]

155 PAPPE, L. **Florae Capensis Medicae Prodromus.** 2nd ed., Cape Town (1857) [La]

Historical medicinal use of *Acacia karroo* in the Cape Province, South Africa.

156 PARDY, A.A. **Notes on indigenous trees and shrubs of Southern Rhodesia.** *The Rhodesia Agricultural Journal* (1952) **49** (6) 316-317 [En]

This note includes descriptions of *Ricinodendron rautanenii* and *Acacia karroo*. The latter is described morphologically and noted as a tree to 9 m with bright green foliage and frequent exudations of gum. It is a common and widely distributed tree on a variety of sites but particularly common on black turf soils. It is often regarded as an indicator of good soils for agricultural crops. The timber is said to be useful only for fuel but goats and other livestock relish its foliage in spring when grazing is poor. The branches are used for fencing, the bark for tanning and the gum can be used as an adhesive.

157 PEDLEY, L. **Derivation and dispersal of *Acacia* (Leguminosae), with particular reference to Australia, and the recognition of *Senegalia* and *Racosperma*.** *Bot. J. Linn. Soc.* (1986) **92** 219-254

158 PHILLIPS, J. **Fire in vegetation: a bad master, a good servant, and a national problem.** *Journal of South African Botany* (1936) **2** 35-45 [En, 4 ref.]

Withholding fire, in combination with overstocking, has been responsible for the marked increase of acacias including *Acacia karroo*, *A. caffra*, *A. robusta* and *A. tortilis* in various parts of South Africa. Overstocking has

eased or removed competition between grass and acacias and has reduced grass fuel loads and hence fire frequency. This has accelerated succession to a mixed thorn scrub climax.

159 POTTS, G.; TIDMARSH, C.E. **An ecological study of a piece of Karroo-like vegetation near Bloemfontein.** *Journal of South African Botany* (1937) **3** 51-92 [En]

In the Orange Free State near Bloemfontein, South Africa, *Acacia karroo* occurred in the mouths of river valleys on soils up to 1.5 m deep. Soils were acid although *A. karroo* is normally found on alkaline soil. *A. karroo* saplings were scarce and old trees were apparently being replaced by dense stands of *Celtis*, *Rhus*, *Ziziphus* and *Diospyros*. The inflorescences and young pods of *A. karroo* were heavily infested by the rust-fungus *Ravenalia macowaniana* which caused gall-like growths, inhibiting seed production. A large percentage of the older trees were severely attacked by a borer larva *Macrotoma palmata*.

160 POYTON, R.J. **Characteristics and uses of selected trees and shrubs cultivated in South Africa.** *South African Directorate of Forestry, Pretoria; Department of Environment Affairs Bulletin* (1984) No. 39, pp. 22, 66, 93 [En]

This bulletin includes tables on characteristics and uses of species and recommended silvicultural zones for each including *Acacia karroo*.

161 PRIOR, J.; CUTLER, D. **Trees to fuel Africa's fires.** *New Scientist* (1992) 29 August 35-39 [En]

The paper emphasizes the need for trees to provide fuel for rural people to cook their staple foods. Exotic species cannot withstand the severe droughts or provide fuelwoods with the burning properties of the indigenous species. The potential lies in the species of the African savannas which occupy 65% of the continent's land area but which are themselves under threat because their fragile ecologies are under pressure from human need. In 1989, a three-year international research programme was set up in Zimbabwe for a detailed study of the structure, functioning and productivity of four popular indigenous firewood species one of which was *Acacia karroo*. In determining wood quality, a key factor is given as the presence in the wood of these species of large crystals of calcium oxalate which are deposited in the tree when the salts in the water taken up by the roots are combined with oxalic acid to maintain its overall water balance. Oxygen-bearing calcium oxalate affects the wood density and how quickly it burns. Wood tends to burn rapidly at first, producing carbon monoxide which is itself flammable and raises the flame temperature. As the temperature rises above 370°C, calcium oxalate breaks down and the released oxygen leads to fuller combustion of the carbon in the wood. This produces carbon dioxide which acts as a flame retardant and promotes a

glowing combustion similar to that of banked down coal. Test results confirmed the flame retarding properties of calcium oxalate. It is also stated that calcium oxalate makes tropical trees less palatable to termites.

162 ROBBERTSE, P.J. [Nastic movements in leaves of South African *Acacia* species] Slaapbewegings by die blare van die Suid-afrikaanse *Acacia* spesies. *Koedoe* (1972) **15**, 83-89 [Af]

Leaves of all 39 *Acacia* species investigated, including *A. karroo*, underwent nocturnal movements. The mechanism and its application to taxonomy is discussed.

163 ROBBERTSE, P.J. [The genus *Acacia* in South Africa III with special reference to the morphology of the seed] Die genus *Acacia* in Suid-Afrika III met spesiale verwysing na die morfologie van die saad. *Tydskrif vir Natuurwetenskap* (1973) **13** (2) 72-95 [Af]

Describes the ontogeny of the seeds of *Acacia karroo* and the morphology and anatomy of this and other southern African acacias.

164 ROBBERTSE, P.J. [Germination of thorn tree seed] Ontkieming van doringboomsaad. *Journal of South African Botany* (1974a) **40** (4) 269-273 [Af]

Piercing the testa of *Acacia karroo* and *A. robusta* seeds increased germination on moist filter paper from 3% (6/200 control seeds) to 99% and 93% respectively.

165 ROBBERTSE, P.J. A scanning electron microscope investigation of the pollen of South African *Acacia* species. *Journal of South African Botany* (1974b) **40** 91-99 [En]

166 ROBBERTSE, P.J. **The genus *Acacia* Miller in South Africa. I. Stipules and spines.** *Bothalia* (1975a) **11** (4) 473-479 [En]

A large number of seedlings and young twigs of South African *Acacia* species was sectioned and the vascularization of the nodes and internodes studied. The nodes of all the species examined are trilacunate and the vascular tissue of the stipules originates from the lateral leaf traces. The Gummiferae species, including *Acacia karroo*, all have spinescent stipules, while the stipules of the Vulgares species are membranous. Prickles containing no vascular tissue are found on the nodes and in some species also on the internodes of the Vulgares species. These prickles always occur on the ridges formed on the stem by leaf traces.

167 ROBBERTSE, P.J. **The genus *Acacia* in South Africa. IV. The morphology of the mature pod.** *Bothalia* (1975b) **11** (4) 481-489 [En]

The external morphology and the anatomy of the pods of all the South African *Acacia* species are discussed. It was found that the South African *Acacia* species can be grouped into a number of distinct categories on the basis of the anatomy of their pods. There is a marked difference in the anatomy of the pod between the series *Vulgares* and series *Gummiferae*. According to the classification based on the anatomy of the pod *A. karroo* belongs to the sub species *Gummiferae* having no stone cells and having a fibre stratum with longitudinal fibres only.

168 ROBBERTSE, P.J. **The genus *Acacia* Miller in South Africa- VI. The morphology of the leaf.** *Boissiera* (1975c) **24** 263-270 [En, fr]

In a study of the morphology and anatomy of the heterophyllous (proximal and distal) leaves of south African *Acacia* species, *A. karroo* was found to be member of the *Gummiferae* based on the anatomy of the petiole.

169 ROBBERTSE, P.J.; SWARTZ, P.; KOK, P.D.F. **Variations of *Acacia karroo*.** *Bulletin of the International Group for Study of Mimosoideae* (1981) **9** 69 [En]

Acacia karroo is the most widely distributed of all south African acacias. Phenetic variations occur and some of these have been regarded as distinct species. Two main variations can be distinguished, namely a variation with narrow pinnules and a variation with broad pinnules with a very wide distribution. Within each of these variations smaller subdivisions are found. [CABI abstract]

170 ROBBERTSE, P.J.; VENTER G.; VAN RENSBURG, H.J. **The wood anatomy of the South African acacias.** *IAWA-Bulletin* (1980) **1** (3) 93-103 [En, 19 ref., 2 pl.]

Wood specimens of 37 different *Acacia* species were studied. Of the many wood characters investigated, only nine were found useful for principal component analysis to differentiate between the different species. Width and, to a lesser extent, height of the rays gave the best results. The rays in the wood of the subgenus *Acacia* are 1-3 seriate, while those of the subgenus *Aculeiferum* are multiseriate. A significant negative correlation was found between latitude and ray height of *A. karroo* wood specimens collected in different parts of south Africa. [CABI abstract]

171 ROBERTS, B.R. **A contribution to the ecology of Cathcart and environs with special reference to slope exposure and soil pH.** (1963) **19**, 153-162 [En, 1 map]

The Black Kei River Valley (32°S 27°E; alt. 1000 m; rain 435 mm) is characterised by dominance of *Acacia karroo*. This species causes encroachment problems on most farms in the valley. Associated grasses include *Panicum maximum*, *Rhynchelytrum repens*, *Cenchrus ciliaris* and *Cynodon incompletus*.

172 ROBERTS, B.R. **Observations on the temperate affinities of the vegetation of Hangklip mountain near Queenstown, Cape.** *Journal of South African Botany* (1966) **32** 243-260 [En]

Near Queenstown, South Africa (31°S 26°E; annual rainfall 533 mm, mostly in summer; alt. 1000-1500 m), overgrazing has resulted in severe erosion on shale soils. Injudicious chopping of *Acacia karroo* for firewood has led to replacement of open stands of large trees by dense thickets of smaller trees of this species.

173 ROSS, J.H. **The *Acacia* species with glandular glutinous pods in Southern Africa.** *Bothalia* (1971a) **10** (2) 351-354 [En]

This work gives a map of the distribution of a complex of seven *Acacia* species, endemic to southern Africa, that have glandular glutinous pods. A key to the identification of these species has been constructed and the distinguishing features of *A. karroo* given.

174 ROSS, J.H. ***Acacia karroo* in southern Africa.** *Bothalia* (1971b) **10** (2) 385-401 [En, many ref. in text]

Gives a broad description of this extremely variable species, with an account of nomenclature and synonymy, a distribution map, and notes on its relationship to *Acacia seyal*, *A. hockii*, and the glandular-podded species. The range of variation in *A. karroo*, especially in Natal, is considered and it is concluded that no infraspecific taxa should be recognized. [CABI abstract]

175 ROSS, J.H. **A Variant of *Acacia karroo* from Sekukuniland (Eastern Transvaal).** *Bothalia* (1971c) **10** (3) 427-430 [En]

Discusses and maps the distribution of densely pubescent plants referred to *Acacia karroo* without formal taxonomic recognition. *A. karroo* var. *transvaalensis* is not upheld.

176 ROSS, J.H. **Notes on *Acacia* species in southern Africa. III.** *Bothalia* (1973) **11** (½) 127-131 [En, many ref. in text]

Miscellaneous information is given on *Acacia caffra*, *A. davyi*, *A. karroo*, *A. pervillei* and *A. tristis*. The synonymy of *A. petersiana* with *A. tortilis* ssp. *spirocarpa* is confirmed, and a review is given of *A. sieberiana*, with a key to its varieties and a sketchmap showing their distribution.

177 ROSS, J.H. **Notes on African *Acacia* species.** *Bothalia* (1975a) **11** (4) 443-447 [En, many ref. in text]

Acacia dekindtiana and *A. hirtella* var. *inermis* are reduced to synonymy under *A. karroo*. Notes are also included on some taxa of *Acacia* originally described under the genus *Mimosa*.

178 ROSS, J.H. **An analysis of the African *Acacia* species: their distribution, possible origins and relationships.** *Bothalia* (1975b) **13** (3 & 4) 389-413 [En, 92 ref.]

The three subgenera recognized within the genus *Acacia* are outlined and the global distribution of each is indicated. The differences between the subgenera and the degree of relationship and levels of specialization are discussed briefly. It is suggested that the ancestral members of the genus were climbers or lianes. Past geological events considered likely to have influenced the distribution of the *Acacia* species in Africa are outlined. The number of species recorded from each African country is tabulated and the distribution and concentration of species within the genus *Acacia* as a whole and within each subgenus in Africa are illustrated. The highest concentrations of species within each subgenus occur in tropical east and southeast Africa. The distribution of species within some of the individual African countries and possible affinities are discussed and attention is drawn to the main centres of endemism. The distribution of the African species is correlated with the major phytogeographical regions recognized on the continent. The relationships between the African and the American, Madagascan, Indian and Australian *Acacia* species are discussed briefly. *A. karroo* and *A. caffra* are noted as being the most widespread species in the Cape Region. *A. karroo*, *A. erioloba*, *A. hereroensis*, *A. tortilis* and *A. mellifera* are characteristic of the Karroo-Namib Region, which consists of the interior of the Cape Province, the western portion of south west Africa and extends into south western Angola. [CABI abstract]

179 ROSS, J.H. **A conspectus of the African *Acacia* species.** *Botanical Survey of South Africa Memoirs* (1979) No. 44, 93 pp. [En]

A conspectus is presented of the *Acacia* species (Fabaceae) which occur indigenously in the continent of Africa west of Suez. The characters traditionally employed to divide the African species into two main groups are reviewed and the advantages of using these characters are discussed. The findings of workers in a number of diverse fields such as pollen, seedling and chromosome morphology, phytochemistry and amino acid content of seeds is correlated with general morphology to provide a more comprehensive overall picture, and the infrageneric classification of the African species down to rank of section is provided. Brief notes are given on pollen morphology and pollination, seed production, predation and dispersal, hybridization, and the origin and distribution of the African species. The morphological characters employed in the keys to the identification are outlined and keys to the identification of the African species are provided. A brief description of each species is given together with synonymy, bibliographic references and a selection of representative specimens, and most species are illustrated with a simple line drawing. Attention is drawn specifically to deficiencies in our knowledge and to species where taxonomic problems exist. For *Acacia karroo*, 17 synonyms are given. Taxonomic

confusion results from the regional variability of this species. It occupies many different habitats, and plants in various parts of the geographical range look different.

180 RUTHERFORD, M.C.; WESTFALL, R.H. **Biomes of southern Africa: an objective categorization.** *Memoirs of the Botanical Survey of Southern Africa* (1986) **0** (54) I-VI 1-98 [En, afr.]

181 SAPPRI (South African Plant Protection Research Institute). **Checklist of insects on forest trees and shrubs in South Africa.** Department of Agricultural Technical Services, Pretoria, South Africa; *Entomology memoir* (1970) No. 21, 81 pp. [En, 17 ref.]

This is a checklist of insects recorded as attacking trees and shrubs growing in South Africa. The following insects are listed as attacking *Acacia karroo* Hayne (Mimosaceae):-
 Order COLEOPTERA: Family Bostrychidae, *Sinoxylon ruficorne* (borer in dry branches and stems); Family Bruchidae, *Bruchus petechialis* (adults and larvae feed in seeds); Family Cerambycidae: Subfamily Cerambycinae, *Chlorophorus capensis*, *Hypoeshrus strigosus* (larval borers), *Ossibia fasciata* (reared from felled trees), *Phyllocnema latipes* (larval borer), *Xystrocera erosa*, *Zamium bimaculatum* (reared from felled tree); Subfamily Lamiinae: *Ceroplesis ferrugator*, *Ceroplesis thunbergi* (adults debark trees, larvae bore in weak and unhealthy trees), *Enaretta acaciarum* (beetles feed in seed pods), *Nitocris nigricornis* (beetles feed on flowers, larvae bore in cut logs), *Zographus oculator* (adults defoliate, larvae bore in weak trees); Subfamily Prioninae, *Acanthophorus capensis* (adults feed on leaves); Family Colydiidae, *Microdiidae* (reared from felled tree, predator of borer beetles); Family Curculionidae: *Deredus schonherri*; Family Scolytidae: *Xykebirys aemulus* (reared from felled tree);
 Order HEMIPTERA: Superfamily Coccoidea: Family Asterolecaniidae, *Lecaniodiaspis mimosae*; Family Coccidae, *Gascardia mimosae*, *Parafairmairia patellaeformis*; Family Diaspididae, *Abrallaspis furcillae*, *Clavaspis pectinata*, *Melanaspis phenax*, *Pseudotargionia glandulosa*, *Pudaspis newsteadi*; Family Lacciferidae, *Tachardina africana*, *Tachardina albida*; Family Pseudococcidae, *Allococcus quaesitus*.
 Order LEPIDOPTERA: Family Arctiidae: Subfamily Arctiinae, *Dionychopus amasis*; Family Cossidae, *Brachylia terebroides* (larval borer in stems and branches); Family Geometridae: Subfamily Geometrinae, *Heterostegane indularia*, *Omphaluca maturnaria*, *Oemiothisa brongusaria*, *Semiothisa observata*, *Semiothisa proci data*, *Semiothisa streniata*, *Semiothisa umbrata*, *Tephрина deerraria*, *Tephрина spissata*, *Zamarada metallicata*, *Zamarada opposita*, *Zamarada pulverosa* (the larvae of these moths are leaf feeders); Subfamily Hemiteiinae, *Omphacodes delicata*, *Prasinocyma scissaria*; Subfamily Sterrhinae, *Chlorerythra rubriplaga*, *Traminda ocellata*; Family Lasiocampidae, *Anadiasa puctifascia*, *Anadiasa swierstrae*, *Beralada fumosa*, *Beralada perobliqua*,

Beralada prompta, *Braura truncata*, *Gonometa postica*, *Odontocheilopteryx myxa*, *Pachypasa capensis*, *Philotherma rosa*: Family Limacodidae, *Coenobasis amoena*: Family Lycaenidae, *Anthene amarah*: Family Lymantriidae, *Dasychira municipalis*, *Euproctis fasciata*, *Laelia* sp., *Porthesia aethiopica*: Family Noctuidae: Subfamily Catocalinae, *Achaea lienardi*, *Pericymna scandulata*: Subfamily Noctuinae, *Polydesma quenavadi*, *Sphingomorpha chlorea*: Subfamily Westermanniinae, *Earia biplaga*: Family Pyralidae: Subfamily Phycitinae, *Myeloides ceratoniae*, *Trachypteryx magella*: Family Saturniidae: Subfamily Saturniinae, *Gonimbrasia tyrreha*, *Gyanisa maia*: Family Sphingidae, Subfamily Choerocampinae, *Hippotion celerio*: Order THYSANOPTERA: Family Thripidae: *Scirtothrips aurantii*.

182 SCHILDKNECHT, H. **Turgorins - new chemical messengers for plant behaviour.** *Endeavour* (1984) **8** (3) 113-117 [En, 3 ref.]

The identification of turgorins (chemical messengers for seismonasty, nyctinasty and photonasty) and their occurrence in a range of species including *Acacia karroo*, *Robinia pseudacacia*, *Oxalis stricta* and soybeans is described. It is concluded that turgorins are a new class of growth regulators that are active in concentrations as low as 10^{-9} - 10^{-7} M and show structural-activity relationships and exhibit activity over a range of species. [CABI abstract]

183 SCOTT, J.D. **Bush encroachment in South Africa.** *South African Journal of Science* (1967) **63**, 311-314 [En]

Bush encroachment is more serious every year in the Molopo area of the northwestern Cape, the Transvaal, Natal and the eastern Cape Province of South Africa. The most important species are *Acacia karroo*, *A. nilotica*, *A. tortilis*, *A. mellifera*, and *Dichrostachys cinerea*. Methods for prevention and eradication are reviewed. They include the keeping of browsing animals as well as grazers, mechanical removal (felling, ringbarking, bull-dozing and the use of a winch or mechanical chisel) and chemical treatment (paraffin, diesel oil, arsenic pentoxide, 2,4,5-T).

184 SCOTT, J.K. ***Acacia karroo* Hayne (Mimosaceae), a potentially serious weed in Australia.** *Plant Protection Quarterly* (1991) **6** (1) 16-18 [En, 22 ref., 1 map, 2 photos]

Attention is drawn to the presence of a localized population of *Acacia karroo* in western Australia. This spiny, small tree is an important invader of natural pasture in its region of origin, south Africa, where it is subjected to weed control legislation. The plant has a wide climatic tolerance, and could become established in pastoral areas over most of south Australia and be a threat to parts of south east Australia. Eradication of this plant in Australia is

strongly recommended, given its potential to become a serious weed. [CABI abstract]

185 SCOTT, J.K. **Southern African plants naturalized in Australia: a review of weed status and biological control potential.** *Plant Protection Quarterly* (1992) **7** (2) 70-80 [En]

Attempts to eradicate *Acacia karroo* populations in western Australia were in progress in 1992.

186 SCOTT, J.K.; PANETTA, F.D. **Predicting the weed status of southern African plants.** *Journal of Biogeography* (1993) **20** 87-93 [En, 27 ref.]

Possible weed status of southern African plants in Australia was associated with being geographically widespread in southern Africa, being described as a weed or targeted by herbicides in southern Africa, and with weediness in regions other than southern Africa. *Acacia karroo*, although only recently introduced to Australia, has naturalized and is predicted to become a weed.

187 SEDGELEY, M.; HARBARD, J. **Pollen storage and breeding systems in relation to controlled pollination of four species of *Acacia*.** *Australian Journal of Botany* (1993) **41** 601-609

Successful plant breeding depends on the hybridization of superior individuals with the characters required for commercial production. Such superior individuals often do not flower at the same time, and may be growing in different locations. In an ACIAR project on the hybridization of acacias, techniques for pollen storage were developed. Pollen of *Acacia auriculiformis*, *A. iteaphylla*, *A. karroo* and *A. mangium* was stored at 25, 5, -18 and -196°C, for up to three years, and its viability tested by pollen staining, *in vivo* pollen tube growth or by pod set one month after hand pollination. The effectiveness of staining methods using 2,3,5-triphenyltetrazolium chloride (TTC), 5-bromo-4-chloro-3-indole- β -galactoside (X-Gal) and fluorescein diacetate (FDA) to predict pollen viability was investigated. All of the staining methods gave variable results, but the TTC and X-Gel tests were found to be particularly unreliable. FDA staining of pollen gave the best indication of its ability to germinate on the stigma and penetrate ovules. Pollen stored for up to three days at 25°C retained the ability to penetrate ovules following hand pollination, and of that stored for three years at 5°C, 19% of the grains fluoresced with FDA. Pollen stored at -18°C for one year retained the ability to penetrate ovules and produce pod set, and of that stored for three years, 23% of the grains fluoresced with FDA. Pollen stored at -196°C for one year retained the ability to penetrate ovules and produce pod set, but thawing and refreezing of the pollen reduced viability to zero. It was concluded that the most successful and convenient method of pollen storage was vacuum drying followed by storage at -18°C. *A. karroo* had protandrous flowers, with stigmas unreceptive at anthesis, but receptive at five days after

anther dehiscence. Deposition of self pollen on the stigma prior to attainment of receptivity rendered hand pollination of this species unreliable. [Abstracted from summary in ACIAR Forestry Newsletter No. 17]

188 SMIT, G.N. **Quantitative description of woody plant communities: Part 1, an approach.** *Journal of the Grassland Society of Southern Africa* (1989) **6** (4) 186-191 [En, af, 11 ref.]

Various descriptive units for woody plant communities are proposed. These are the Evapotranspiration Tree Equivalent (ETTE), Browse Tree Equivalent (BTE) and Canopied Subhabitat Index (CSI), which describe the status of a woody community in terms of potential moisture use, value of the trees as food for browsers and subhabitat suitability for grass-tree associations, respectively. A Quantitative Description Index (QDI) for woody plant communities, containing descriptive unit-values, is proposed. The calculation of the various unit values, excluding the CSI, rests upon the relationship between spatial volume of a tree crown and its true leaf volume and true leaf DM, taking into account differences in leaf densities. These relationships and the factors that influence the estimation of leaf densities are discussed. Regression equations were developed from harvested *Acacia karroo* trees. Their applicability to other woody species was confirmed, as predicted values differed non significantly from true values for two other species.

189 SMITH, T.M.; WALKER, B.H. **The role of competition in the spacing of savanna trees.** *Proceedings of the Grassland Society of southern Africa* (1983) **18** 159-164 [En, 27 ref.]

Acacia karroo and *A. tortilis* trees at Pilansberg Game Reserve, Boputhatswana were found to be regularly dispersed. Distances between *Acacia* trees increased linearly with the combined canopy cover of pairs of trees. The regular spacing is believed to be brought about by competition between *Acacia* trees. The dispersion of all trees (*Acacias* and non-*Acacias*) in the site was random, possibly because some of the other tree species were shade tolerant, generally occurring beneath canopies of *Acacia* trees.

190 SMITTER, Y.H. **Plants as indicators of ground water in southern Africa.** *Trees in South Africa* (1955) **7** (3) 6-10 [En]

Acacia karroo is among the phreatophytes that occur in the xerophytic vegetation on fracture lines over groundwater at 21 and 32 feet.

191 SOUTHGATE, B.J. **Variation in the susceptibility of African *Acacia* (Leguminosae) to seed beetle attack.** *Kew Bulletin* (1978) **32** (3) 541-544 [En]

Many species of the family Bruchidae parasitize seeds

of members of the Leguminosae. The female beetle lays an egg on a ripening or, more rarely, a dehisced ripened pod. The larva bores through the pod wall and burrows into a ripening seed within which it creates a chamber. In its final stages the larva eats away the outer layers of the seed until only a thin circular 'window' of testa remains. After pupation, the beetle emerges through the 'window'. In a few species the larva leaves the seed and pod, drops to the ground on a silk thread, and pupates in the soil beneath the tree. Fourteen of the 61 *Acacia* species recorded in East Africa are known to be the hosts of one or more species of bruchid. Examples of the very high rates of seed infestation that can occur in markedly different habitats are given by data relating to *A. tortilis*: ssp. *spirocarpa* (Tanzania) 90-95%; ssp. *raddiana* (Israel) 72%; and ssp. *tortilis* (Israel) 99%. Moreover, species with very different seed pods may be parasitized by the same bruchid, e.g. that which parasitizes the *A. tortilis* complex also infests seed of *A. malacocephala* and probably *A. abyssinica* ssp. *calophylla* in Tanzania, *A. erioloba* in Botswana, *A. karroo* in Natal and *A. hockii* in Ethiopia. Early indications from phytochemical investigations indicate that the concentrations of certain amino acids (pipercolic acid and some heteropoly-saccharides) determine if a bruchid larva can survive in a seed. A method for collecting and storing seed pods to preserve beetles emerging from them is described, and attention is drawn to the importance of international cooperation to gain further knowledge of the bruchid/host relationship. [CABI abstract]

192 SPRENT, J.I. **Legume trees and shrubs in the tropics: N₂ fixation in perspective.** *Soil Biol. Biochem.* 1995 **27** (4/5) 401-407 [En]

193 STAPLES, R.R.; HUDSON, W.K. **An ecological survey of the mountain area of Basutoland.** U.K.; Lechworth Garden City Press (1938) 1-68 [En]

Overgrazing between 1910 and 1938 led to the replacement of much of the original grassland of the Drakensburg mountain catchment area by *Acacia karroo* scrub. Carrying capacity for cattle was reduced by 50%.

194 STEADMAN, E.C. **A description of some trees and shrubs and lianes of Southern Rhodesia.** The Argus Printing and Publishing Co. Ltd, Bulawayo (1933) 191 pp. [En]

A brief taxonomic description and uses of *Acacia karroo* is included in this work. On good sites it grows into a handsome tree and its presence denotes good soil. The wood is good for fuel and polo mallets. Goats relish the young leaves, shoots and fruits, the thorns are used as needles and the bark for tanning. The gum is used in the manufacture of sweets and is exported for use as an adhesive.

195 STEENKAMP, C.W.P; HAYWARD, F.C. **[Chemical composition of common plants in the south-central section of the Great Escarpment]** Chemiese samestelling van die vernaamste plantspesies in die suid-sentrale sektor van die Groot Eskarpment. Department of Agriculture, Pretoria, South Africa; *Technical Report No. 149* (1979) 1-20 [Af]

Acacia karroo was one of 100 species collected for forage analysis in the districts of Craddock, Somerset East, Graaff-Reinet, Aberdeen and Middelburg of the Cape Province South Africa. Dry season (winter) foliage, wet season (summer) foliage and pods proximate and mineral analyses are given respectively for each element in the nutrient and mineral analysis below. The Weende system of proximate nutritional analysis results were, on a % dry mass basis, crude protein (13.7, 14.7, 15.0), crude fibre (13.0, 14.0, 26.3), ether extract including resins and lipids (3.6, 4.6, 2.5), ash (10.6, 9.8, 6.9) and N-free extract including carbohydrates (59.2, 56.9, 49.3). Minerals, as % dry mass, were respectively Na (0.12, 0.10, 0.07), K (0.87, 0.81, 1.31), Ca (2.90, 2.58, 1.23), P (0.11, 0.14, 0.20), Mg (0.49, 0.48, 0.32) and as parts per million Fe (517, 334, 115), Cu (3.4, 3.8, 6.1), Mo (1.39, 0.99, 2.90), Mn (34, 31, 17) and Co (0.14, 0.13, 0.13).

196 STEPHEN, A.M.; VOGT, D.C. **Application of gas-liquid chromatography to the structural investigation of polysaccharides. III. The gum of *Acacia karroo* Hayne.** *Tetrahedron*, Oxford (1967) **23** (3) 1473-1478 [En 16 ref. 1 table]

197 STEYN, D.G. **Camel-thorn pods as stockfeed.** *Farming in South Africa* (1943) **18** 313-318 [En]

Fresh foliage, flowers and green pods of *Acacia karroo* sampled at Onderstepoort in the Transvaal, South Africa were repeatedly tested but found to contain no cyanogenic glycoside (prussic acid).

198 STEYN, D.G.; RIMINGTON, C. **The occurrence of cyanogenic glycosides in South African species of *Acacia*. I. Onderstepoort** *Journal of Veterinary Science and Animal Industry*, Pretoria (1935) **4** (1) 51- 63 [En, 5 ref.]

Fresh leaves, flowers and immature pods of *Acacia karroo* Hayne and four other southern African species of *Acacia* were collected in the northern Transvaal and submitted to the prussic acid test (sodium picrate paper). Tests were performed on plant material alone or with chloroform or in an acid environment (pH 6.0). Tests were also run on wilted foliage. For *A. karroo* all these tests for prussic acid yielded negative results. By comparison fresh leaves and green pods of *A. erioloba* gave positive results (>70 mg HCN/100 g dry weight of plant material) containing dangerously high levels of cyanogenic glycoside. *A. karroo* is therefore more suitable as a stock feed than

some other species in this genus.

199 STORY, R. **A botanical survey of the Keiskammahoek District.** *Botanical Survey of South Africa Memoirs* (1952) No. 27, 184 pp. [En, 85 photos, many ref.]

Describes the climate and vegetation of the eastern Cape Province, South Africa. Aspects of the ecology, utilization and management of *Acacia karroo* are discussed in some detail. The density of *A. karroo* increased when the grass cover was reduced by grazing cattle. The tree is a source of gum, of firewood and of thorn branches for making animal enclosures. Distribution of *A. karroo* in the Cape appears to be limited by excess moisture, dryness and low temperatures. A sketch map shows how distribution is related to altitude and temperature. Flower and seed crops vary between years: data are presented. Seeds appear to be dispersed by wind, water and in the dung of cattle and other mammals. In some years many seeds contain bruchid beetles. Germination varies from 8-95%. Seeds have water impermeable dormancy and can remain damp for 29 months without germinating or rotting. Piercing the seed coat results in germination within four days. Seeds from herbarium sheets were viable after 28 and 57 years. 6-11% of untreated seeds germinated over 423 days in field trials, but 17% of seeds scalded with boiling water germinated within eight weeks. Seedlings in cultivated ground had >90% survival rate and reached 18 in. in 18 months, whereas only 5% of seedlings in grassland survived and were only 4 in. high after 18 months. Seedlings were resistant to browsing, but all seedlings <8 weeks old (4 in.) were killed by fire. Older seedlings (12 months, 14 in.) died back following a burn but resprouted from the base, each giving rise to 3-4 stems.

200 STUART-HILL, G.C. **Competitive interactions between *Acacia karroo* and the grass sward in the false thornveld of the eastern Cape.** M.Sc. thesis, University of Natal, Pietermaritzburg, South Africa (1985) [En, many ref.]

In semi-arid savanna of the Eastern Cape, South Africa, both grazing (cattle, sheep) and browsing (goats) animals are ranched. These animals compete for forage, influencing the competitive balance between herbaceous and woody plants. This research investigated the competition between trees and grass, particularly for water. Trees (*Acacia karroo*) thrived only where water penetrated regularly to some depth. Stem low did not appear to be important in supplying water to the deeper soil layers. Most of the water penetrating to deep soil did so by moving through the uninterrupted soil profile. The process was enhanced where boulders were embedded in the soil. Dense grass rapidly depleted soil water to a depth of 60 cm. In the absence of dense grass, evaporative losses are low and water is retained in the profile. Rainfall on an area with low grass biomass results in penetration of the wetting front to a depth which permits vigorous tree growth. Trees had both a beneficial and detrimental influence on the herbaceous layer. Grass

benefitted from shade and leaf litter supplied by the trees, but these reduced the amount of moisture available for the grass. The trees were stimulated by moderate to light defoliation, and this increased their competitiveness. Using the data generated from this programme, a previously developed production model for the community was revised. This model predicts that maximum forage production, livemass production and profit will be achieved at 1220, 1320 and 1000 tree equivalents respectively per hectare. An algorithm is presented as a guide to the estimation of long-term stocking rates of grazers and browsers. It was recommended that where trees exceeded densities of 1320/ha trees should be removed in order of decreasing height.

201 STUART-HILL, G.C. **Refinement of a model describing forage production, animal production and profitability as a function of bush density in the false thornveld of the eastern Cape.** *Journal of the Grassland Society of southern Africa* (1987) **4** (1) 18-24 [En]

The model describing the influence of *Acacia karroo* density on forage production, animal production and profitability (Aucamp et al 1983) over-estimated the potential for livestock production by 51% and presented an over-optimistic view of the potential of bush utilization.

202 STUART-HILL, G.C.; TANTON, N.M. **Browse and herbage production in the Eastern Cape thornveld in response to tree size and defoliation frequency.** *Journal of the Grassland Society of Southern Africa* (1988) **5** (1) 42-47 [En, af, 12 ref.]

Grass yields in the semi-arid savanna declined as the size of *Acacia karroo* increased. Browse yields did not increase as trees grew taller than 1.8 m. Simulated browsing of *A. karroo* trees stimulated browse production, provided it was not too intense. As a consequence, the competitive ability of the trees increased and grass yields were adversely affected. Conversely, simulated grazing reduced the competitiveness of the grass and thereby resulted in an increase in browse production. It is argued that residual soil moisture levels remain relatively high when grass growth is poor, so that water penetrates to greater depths after rain than when grass growth is vigorous and this favours the deep rooted trees.

203 STUART-HILL, G.C.; TANTON, N.M. **Water utilization patterns around isolated *Acacia karroo* trees in the False Thornveld of the eastern Cape.** *Journal of the Grassland Society of Southern Africa* (1989a) **6** (4) 195-204 [En, af, 21 ref.]

The effect of various vegetation treatments on two soil moisture regimes (*i.e.* the proportion of the experimental period when the soil had sufficient water for growth and to keep the plants turgid in the vicinity of experimentally isolated *Acacia karroo* trees) was monitored over a two-year period. Removal of all vegetation had the greatest

effect on soil moisture, increasing the moisture regime by around 200%. Grass removal had the next most significant effect, increasing moisture regimes within 9 m of the tree by around 100%. Removal of the tree had the smallest significant effect, increasing the moisture regime by < 20%. There was no difference in the moisture regime surrounding trees with heights ranging between 1.4 and 2.5 m, or where various combinations of tree and/or grass defoliations were implemented. It was concluded that water supply to the trees was enhanced when soil water extraction was reduced *e.g.* during winter or when the sward was harmed. It was suggested that this may be a mechanism of accelerating bush encroachment in semi-arid savannas.

204 STUART-HILL, G.C.; TANTON, N.M. **The competitive interaction between *Acacia karroo* and the herbaceous layer and how this is influenced by defoliation.** *Journal of Applied Ecology* (1989b) **26** (1) 285-298 [En, 35 ref.]

A study in semi-arid savanna in South Africa of experimentally isolated *Acacia karroo* trees (all other trees and shrubs had been cleared from the sites). Three treatments were given in plots of 9 m radius: with a central tree surrounded by grass; with all grass removed; with central tree removed. Grass/foilage was harvested 1, 2 or 3 times a year for three years to simulate grazing and/or browsing. Trees suppressed grass growth up to 9 m away, tall trees more so than short trees, and tree removal also reduced grass growth. Grass growth was reduced when trees were frequently defoliated (attributed to the stimulatory effect of defoliation on competitiveness of *A. karroo*). Tree production increased in response to sward removal but was unaffected by sward harvesting, except when trees were defoliated frequently, when production of browse increased in response to frequent grass harvesting. [CABI abstract]

205 STUART-HILL, G.C.; TANTON, N.M.; BARNARD, H.J. **The influence of an *Acacia karroo* tree on grass production in its vicinity.** *Journal of the Grassland Society of Southern Africa* (1987) **4** (3) 83-88 [En, af, 37 ref.]

It was established that a consistent pattern of grass production (*Digitaria eriantha*, *Sporobolus fimbriatus*, *Cymbopogon plurinodis*) occurred around isolated *Acacia karroo* trees. This was characterized by high yields under and immediately south of the tree canopy, and low yields immediately to the north of the canopy. The former was attributed to favourable influences by the tree (*e.g.* shade and tree leaf litter), whereas the latter was probably a result of reduced water input associated with physical redistribution of rainfall by the tree and competition from the tree for soil water. It is argued that the net effect of the favourable or unfavourable influences of *A. karroo* on grass production was dependent on tree density. This explains why grass production was greater where there were a few *A. karroo* trees than where there were no trees and why grass production declined as tree density increased beyond a critical level.

206 SUTHERLAND, J.; MCINROY, S.G.; ODEE, D.W.; STANFORTH, A. **African acacia rhizobial technology and ecology: ODA Project R. 4714**. Final report (1994). Department of Biological Sciences, University of Dundee, United Kingdom. 88 pp.

The principal conclusion of this research was that one mixed medium could be used in unsterilized soil for the successful inoculation of all seven *Acacia* species tested (*A. arenaria*, *A. karroo*, *A. nilotica*, *A. senegal*, *A. tortilis* ssp. *heteracantha*, *A. tortilis* ssp. *spirocarpa*, *Faidherbia albida*) resulting in increases in both nitrogen fixation and dry weight. Effective means of strain identification were achieved with capillary electrophoresis of whole cell proteins and methods were developed that use no volatile toxic chemicals, unlike the more commonly used gel electrophoresis. Successful conclusion of these identification investigations were prevented by loss of effectiveness of the inoculated rhizobium strains. The authors conclude that the future of acacia research must lie in designer trees selected and bred for particular purposes in consultation with local users and that rhizobia research would be most cost effective if linked to tree breeding programmes.

207 SWART, H.J. **Fungi and Trees Part III: Some Fungi found on leaves and branches. Trees in South Africa** (1963) **15** (2) 34-36 [En]

Includes diagram of the distorted inflorescence of *Acacia karroo* caused by the fungus *Ravenelia*.

208 SWARTZ, P.P. [A numerical taxonomic evaluation of the taxon *Acacia karroo* Hayne in southern Africa] Numeries-taksonomiese evaluering van die takson *Acacia karroo* Hayne in suidelike Afrika. M.Sc. thesis, University of Pretoria, Pretoria, South Africa (1982) [Af](ex Webb) [En]

Using numerical taxonomic methods and a combination of 38 characters for *Acacia karroo* from southern African populations, six well defined intra-specific groups were distinguished. Seedlings of these groups cultivated under controlled conditions similarly showed phenotypic variation, indicating that the groupings are genetically fixed. The morphology, distribution and ecological characteristics of members of the six groups are described in detail in this thesis. The author suggests that the groups should have subspecies status, suggests new name combinations, and provides a key to the groups.

209 TALBOT, P.H.B. **New and interesting records of South African fungi. Bothalia** (1957) **6**, 183-204 [En, 1 ill.]

A specimen of the Discomycete fungus *Patellaria atrata* (Hedw.), found on dead wood in Pretoria, South Africa, is housed in the Mycological Herbarium, Department of Agriculture, Pretoria. A specimen from the living bark of *Acacia karroo* is housed in the South African

Museum, Cape Town (SA Mus No. 33426, MacOwan 1058).

210 TAYLOR, J.D. **Notes on Lepidoptera in the eastern Cape Province -1. Journal of the Entomological Society of Southern Africa** (1949) **12**, 78-95 [En, 6 ref.]

Larvae of the following families and species of lepidoptera were reported feeding on *Acacia karroo* in the Districts of Albany and Fort Beaufort, South Africa: Noctuidae: *Sphingomorpha chlorea*, *Polydesma quenavadi*; Lymantriidae: *Euproctis fasciata*; Sphingidae: *Chaerocampa celerio*; Notodontidae: *Braura truncata*; Geometridae: *Semiothisa brongusaria*, *S. observata*, *Traminda ocellata*, *Zamarada opposita*, *Z. metallica*; Saturniidae: *Gynanisa maia* Lasiocampidae: *Anadiasa punctifascia*, *Beralada prompta*, *B. fumosa*, *Gonometela postica*. Text gives descriptions and notes on behaviour and seasonality.

211 TAYLOR, J.D. **Notes on Lepidoptera in the eastern Cape Province - 2. Journal of the Entomological Society of Southern Africa** (1951) **14** (2) 94-125 [En, 9 ref.]

Larvae of the following families and species of lepidoptera were reported feeding on *Acacia karroo* in the Districts of Albany, East London, Fort Beaufort and Kei Road, South Africa: Noctuidae: *Earias biplaga*, *Pericyma scandulata*, *Sphingomorpha chlorea*; Lymantriidae: *Dasychira municipalis*, *Porthesis aethiopica*; Geometridae: *Chlorerythra rubiplaga*, *Omphalucha maturnaria*, *Semiothisa streniata*, *S. proci data*, *Zamarada pulverosa*; Lasiocampidae, *Pachypasa capensis*; Limacodidae: *Coenobasis amoena*; Pyralidae: *Myelois ceratoniae*. Text gives descriptions and notes on behaviour and seasonality.

212 TAYLOR, J.D. **Notes on Lepidoptera in the eastern Cape Province - 3. Journal of the Entomological Society of Southern Africa** (1953) **16** (2) 143-167 [En, 12 ref.]

Larvae of the following families and species of lepidoptera were reported feeding on *Acacia karroo* in the Districts of Albany, East London, Fort Beaufort and Kei Road, South Africa: Noctuidae: *Pericyma scandulata*; Geometridae: *Prasinocyma scissaria*, *Tephrina spissata*, *P. decraria*, *Semiothisa streniata*, *S. umbrata*, *S. proci data*, *Heterostegane indularia*; Lasiocampidae: *Anadiasa sweirstrae*, *Braura truncata*, *Odontocheilopterix myxa*, *Beralada prompta*, *B. perobliqua*. Text gives descriptions and notes on behaviour and seasonality.

213 TAYLOR, J.D. **Notes on Lepidoptera in the eastern Cape Province - 5. Journal of the Entomological Society of Southern Africa** (1965) **28** (2) 137-154 [En]

Larvae of the following families and species of

Lepidoptera were reported feeding on *Acacia karroo* near Port Elizabeth, South Africa: Lymantriidae: *Laelia* cf. *clarki* Geometridae: *Tephрина spissata*. The larva and pupa of *L. cf. clarki* is described in detail.

214 TEAGUE, W.R. **The expected response of *Acacia karroo* Hayne to moisture stress and defoliation.** *Proceedings of the Grassland Society of southern Africa* (1983) **18** 147-150 [En]

The ontogeny and annual growth cycles of *Acacia karroo* are given and possible responses to water stress and defoliation are discussed.

215 TEAGUE, W.R. **Leaf growth of *Acacia karroo* trees in response to frequency and intensity of defoliation.** In *Ecology and management of the world's savannas, International Savanna Symposium* (edited by Tothill, J.C.; Mott, J.C.). (1984) pp. 220-222.

Depending on the frequency, *Acacia karroo* plants defoliated by goats showed some activation of growth. This led to a similar amount of leaf accumulation of plants under a 75% defoliation regime when defoliated at two-weekly, four-weekly and twelve-weekly intervals.

216 TEAGUE, W.R. **Response of *Acacia karroo* trees to intensity of defoliation at different phenophases in a South African savanna.** In *Rangelands, a resource under siege. Proceedings of the 2nd International Rangeland Congress, Adelaide, Australia, 13-18 May 1984* (edited by Joss, P.J.) Canberra; Australian Academy of Science (1986) 466-467 [En]

In the semi-arid eastern Cape area of South Africa, *Acacia karroo* occurs in almost pure stands over large areas as the woody component in an open to dense, dwarf tree savanna. It has a deleterious effect on grass production and its increase cannot be prevented by burning, resting and/or judicious grazing management with cattle. However, goats are simultaneously able to control *A. karroo* and increase total red meat production per unit area by browsing, without adversely affecting grass production. In order to define the potential of the species as a fodder source for goats, its response to defoliation was studied. Leaf growth was measured in trees in which the entire canopy had been defoliated by goats at intensities of 25, 50, 75 and 95%. The defoliation was arranged at each of 5 phenophases: early flush, pre-reproductive, reproductive, post-reproductive and late season. In all phenophases leaf production at the opt. defoliation intensity was 2-3 X that in control trees; trees were most sensitive to defoliation at the early flush and reproductive phases. In order to achieve max. leaf growth, it is recommended that they be defoliated by 25-50%, followed by a rest period of 3-6 months, depending on the phenophase. [CABI abstract]

217 TEAGUE, W.R. **Defoliation and browse production of *Acacia karroo* Hayne in the eastern Cape, South Africa.** Ph.D. thesis, University of the Witwatersrand, Johannesburg, South Africa (1987) [En, many ref.]

This thesis explores the response of *Acacia karroo* plants to defoliation by goats in a farming situation. Field experimentation at the individual plant level was conducted to examine the growth pattern and response of these plants to the abiotic environment and to defoliation by goats. At the plant community level the pattern and rates of consumption in a representative community were examined. A simulation model collates the data generated and considers the implications for management. Growth in *A. karroo* is dominated by current growing conditions. Plants are able to make opportunistic growth at any time, to take advantage of favourable environmental conditions. By growing in flushes and consolidating after each flush, these plants are able to cope with a variable climate and damage by herbivory. Moisture stress merely slows growth, with the pattern of growth being unaffected. The model predicts that increasing the number of camps increases the total amount of *A. karroo* harvested that can be expected with different management strategies, particularly sparing or very light use during early in the growing season. Even if it is possible to reduce stock in times of drought, this was shown to be probably of very little benefit.

218 TEAGUE, W.R. **The response of *Acacia karroo* plants to defoliation by hand compared to defoliation by goats.** *Journal of the Grassland Society Southern Africa* (1988a) **5** (3) 122-124 [En, af, 19 ref.]

Acacia karroo plants were 50% or 100% defoliated, with or without shoot-tip removal, by hand or by goats. Leaf and shoot production did not differ between plants where leaves only or leaves and shoot tips were removed. Leaf growth on plants 50% defoliated by goats was approx. 3-fold of that on plants 50% hand-defoliated. Leaf growth on hand-defoliated plants was approximately twice that of undefoliated plants. Heavy defoliation by hand or goat gave approximately half the leaf growth of moderately defoliated plants. Shoot production was greatest under goat defoliation and least with no defoliation.

219 TEAGUE, W.R. **Growth patterns and annual growth cycle of *Acacia karroo* Hayne in relation to water stress. II. The annual use and replenishment of non-structural carbohydrates in relation to phenological development** *Journal of the Grassland Society of South Africa* (1988b) **5** (3) 169-173 [En, af, 25 ref.]

In field studies at 3 sites in South Africa, *Acacia karroo* showed the seasonal fluctuation in total non-structural carbohydrate (TNC) content characteristic of deciduous species. TNC reserves declined rapidly and substantially at bud-burst in spring. TNC reserves also declined during

rapid leaf, shoot or reproductive organ growth. TNC reserves were replenished while recently emerged leaves were still small. Water stress did not change the pattern of TNC use and replenishment but did slow down the replenishment process. It was suggested that this slowing down also slows down the beginning of the next annual growth event as well as the growth of previously initiated organs. It was also suggested that growth flushes followed by replenishment enable *A. karroo* to withstand harsh environmental conditions and damage by herbivory.

220 TEAGUE, W.R. **Effect of intensity and phenophase of defoliation and water stress on the rate of photosynthesis and the recovery of carbohydrate reserves in *Acacia karroo* Hayne.** *Journal of the Grassland Society of Southern Africa* (1988c) 5 (4) 223-226 [En]

A field study was conducted with *Acacia karroo* plants to determine changes in relative photosynthetic rates, the extent of carbohydrate reserve depletion, and the rate reserves take to recover following defoliation by goats at different intensities and phenophases, at a wet and a dry site. The rate of photosynthesis of fully expanded leaves increased markedly following defoliation. Light defoliation increased photosynthetic rate the most. Total non-structural carbohydrate levels dropped significantly after defoliation. The magnitude of decrease was directly related to the intensity of defoliation. Following heavy defoliations, recovery of carbohydrate levels was much faster than after the light defoliations. Rates of recovery were also faster following defoliation in the second half of the growing season, than in the first half. However, the plants that had been heavily defoliated in the second half of the growing season had not fully recovered carbohydrate levels before leaf fall in late autumn. Moisture stress has very little effect on carbohydrate levels in comparison with the defoliation treatments.

221 TEAGUE, W.R. **The rate of consumption of bush and grass by goats in a representative *Acacia karroo* savanna community in the Eastern Cape.** *Journal of the Grassland Society of Southern Africa* (1989a) 6 (1) 8-13 [En, af, 30 ref.]

Consumption of browse and grass by goats in a representative *Acacia karroo* savanna community was measured. *A. karroo* was preferred to grass. It was selected almost exclusively when available at high leaf densities. Grass was consumed in significant amounts only when approximately 50% of the available *A. karroo* leaf had been consumed. Maximum daily intake was 78 g kg⁻¹ W 0.75 per day and decreased with decreasing amount of browse on offer. When approximately 90% of the available *A. karroo* leaf had been removed, the goats had consumed only 30% of the available grass. Total intake of browse plus grass was lower during the period when the goats changed from consuming mostly *A. karroo* to consuming mostly grass. Goats did not appear to select a diet according to their

nutritional needs, as judged by feeding tables, when this was possible. This may be due to protein indigestibility caused by tannin complexing by *A. karroo*, luxury consumption of *A. karroo* as a favoured food, an adaptation by goats to use browse more efficiently than grass, or differences in palatability between *A. karroo* and grass.

222 TEAGUE, W.R. **Effect of intensity and frequency of defoliation on aerial growth and carbohydrate reserve levels in *Acacia karroo* plants.** *Journal of the Grassland Society of Southern Africa* (1989b) 6 (3) 132-138 [En, af, 24 ref.]

Acacia karroo trees near Alice, Ciskei, were defoliated by goats at two intensities at 2, 4, 8 and 12-week intervals. Leaf accumulation and carbohydrate reserve levels were compared with a non-defoliated control, and to plants (defoliation control) which were defoliated for the first time that season each time a frequency treatment was defoliated. These plants are activated by defoliation in such a manner that successive defoliations can result in this activation being additive. There is clearly a defoliation level below which they are not activated. Activation appeared to be negated to a degree by defoliations at 2- and 4-week frequencies, relative to the 8-week defoliation frequency. The 12-week frequency at heavy defoliation produced less than the same defoliation at 8-week frequency. The 2-week frequency treatments produced as much leaf as the 4- and 12-week defoliations at the same defoliation intensity. The more frequently plants were defoliated, the more carbohydrate reserves dropped. Plants adjusted to cope with very frequent defoliations. There was no connection between leaf accumulation and carbohydrate reserve levels following the different frequencies and intensities of defoliation.

223 TEAGUE, W.R. **The response of *Acacia karroo* plants to defoliation of the upper or lower canopy.** *Journal of the Grassland Society of Southern Africa* (1989c) 6 (4) 225-229 [En, af, 17 ref.]

In trials near Alice, Cape Province, the response of *Acacia karroo* trees to defoliation of either the upper or lower canopy only was compared with that of plants whose whole canopies had been defoliated at a range of defoliation levels. These plants were very sensitive to defoliation of the upper canopy; 100% defoliation of the upper canopy resulted in the same amount of growth as 100% defoliation of the whole canopy. This was considerably less than the growth of plants defoliated overall, at 25% and 50% leaf removal. In contrast, defoliating the bottom half of the canopy stimulated growth in the whole canopy to the same degree as defoliation of the whole canopy at 25-50%. The increases in growth were largely due to increased growth in the top half of the canopy. Plants were very sensitive to defoliation in the early-flush phenophase. This probably masked the positive effects of the partial defoliations applied at this phenophase.

224 TEAGUE, W.R. **Patterns of selection of *Acacia karroo* by goats and changes in tannin levels and in vitro digestibility following defoliation.** *Journal of the Grassland Society of Southern Africa* (1989d) 6 (4) 230-235 [En, af, 23 ref.]

In trials near Alice, Cape Province, patterns of browse selection of Boer goats in a representative *Acacia karroo* community were studied. The rate of intake of browse was positively related to the leaf mass/unit length of the shoot. The ease of harvesting leaf material, as determined by the height above ground, modified the rate of intake. Generally, following browsing, tannin levels increased and in vitro digestibility decreased. These changes in tannin content and digestibility differed in magnitude according to plant size and age of the shoot and leaf. Generally, leaf and shoot intake was negatively related to tannin content and positively related to digestibility, thus influencing patterns of selection for different plant parts and size classes of *A. karroo*. However, some of the results were contradictory.

225 TEAGUE, W.R.; KILLILIA, D.M. **The application of various picloram formulations to cut stumps of *Brachystegia spiciformis* Benth., *Julbernardia globulifera* (Benth.) Troupin, *Terminalia sericea* Burch. ex DC. and *Acacia karroo* Hayne trees.** *Journal of the Grassland Society of Southern Africa* (1990) 7 (2) 125-132 [En]

The application rates of picloram/2,4-D amine or picloram/2,4,5-T amine (expressed as grams acid equivalent picloram per mm girth) required to kill 80% of *Acacia karroo* trees was 0.012-0.016 g/mm.

226 TEAGUE, W.R.; WALKER, B.H. **Growth patterns and annual growth cycle of *Acacia karroo* Hayne in relation to water stress. I. Leaf and shoot growth.** *Journal of the Grassland Society of Southern Africa* (1988a) 5 (2) 85-95 [En, af, 26 ref.]

The growth patterns of *Acacia karroo* at different levels of water stress in different edaphic situations are described. Shoots are heterophyllous and are formed by free growth. The degree of development of a shoot, relative to others in the canopy, is governed by branch and position in the canopy. At least six phenological phases were identified in the annual growth cycle. The pattern of growth and the phenological cycle were not changed by water stress. Initiation, emergence and development of shoots and leaves were governed by environmental conditions. If there was little shoot growth early in the season, the plants could partially compensate by producing more leaf/unit of shoot if environmental conditions improved. Leaf and shoot growth at the beginning of the season took place only if there was sufficient moisture available, and if the minimum temperature rose above a threshold value. Where there was insufficient soil moisture, no growth was observed before rains had fallen. The growth strategy of *A. karroo* differed markedly from that of broad-leaved African savanna tree species. Growth in *A. karroo* was dominated by current growing conditions, rather than those of the previous season,

and it was able to make opportunistic growth at any time. Soil depth had a marked influence on plant growth, presumably due to a larger available nutrient and moisture pool.

227 TEAGUE, W.R.; WALKER, B.H. **Effect of defoliation by goats at different phenophases on leaf and shoot growth of *Acacia karroo* Hayne.** *Journal of the Grassland Society of Southern Africa* (1988b) 5 (4) 197-206 [En, af]

Defoliation by goats (leaves plus shoots) during growing phases resulted in considerable stimulation of leaf and shoot growth relative to non-defoliated plants. The response differed depending on the intensity and phenophase of defoliation. Plants were most susceptible to defoliation and young shoot removal during the spring flush when carbohydrate levels were at their lowest. During the rest of the growing season, carbohydrate levels were high. At these times moderate to heavy (50%-75%) leaf removal resulted in the greatest leaf and shoot growth.

228 TEAGUE, W.R.; WALKER, B.H. **Simulating browse production and response of *Acacia karroo* to defoliation II. Evaluation of browse management systems and strategies.** *Journal of the Grassland Society of Southern Africa* (1990) 7 (4) 243-248 [En, 13 ref.]

To assess management implications, a model was used to simulate the response of *Acacia karroo* to a wide range of different climatic patterns and defoliation regimes. The model predicts that if poor growing conditions initiate growth later in spring than normal, total season growth and harvest is significantly reduced. In comparison, cooler overall temperatures throughout the season reduce the season less markedly. Results indicate that increasing the number of camps in a pastoral system increases the total amount of *A. karroo* that can be harvested. The model illustrates, in general terms, the limits and constraints of increasing the number of camps, varying the length of stay in each and varying the length of the rest period before the next occupation at different stocking rates. It also indicates the increases in *A. karroo* harvests that can be expected with different management strategies. The most important prediction of the model was the large increase in productivity that could be expected by sparing or very light use early in the growing season. Even if it is possible to reduce stock in times of drought, this was shown to be of very little benefit. [Author's summary]

229 TEAGUE, W.R.; TEAGUE, R.C.; WALKER, B.H. **Simulating browse production and response of *Acacia karroo* to defoliation I. Model description and sensitivity analyses.** *Journal of the Grassland Society of Southern Africa* (1990) 7 (1) 1-10 [En, 18 ref.]

The model is aimed at synthesizing existing data to enhance the understanding of this data and explore the consequences of possible browse management strategies. It

gives a good reproduction of the shoot and leaf growth responses used to develop it and a reasonable prediction of leaf growth when tested against independent data. The prediction of shoot growth against independent data was poor. Sensitivity analyses indicate that five parameters have a very strong influence on the output of the model. These are moisture, soil depth, the magnitude and duration of growth stimulation following defoliation, how soon growth is initialized and how favourable growing conditions are in spring. Plant size and the carry-over of growth stimulation from one year to the next had a moderate influence. [Author's summary]

230 THODAY, D. **Modes of union and interaction between parasite and host in the Loranthaceae. V. Some South African Loranthoideae.** *Proceedings of the Royal Society, London* (1960) 152B, 143-62 [En, 17 ref.]

Describes with illustrations the haustorial structure and behaviour of *Loranthus elegans* on *Acacia karroo* and *Carissa arduina*, *L. prunifolius* on *Rhoicissus cuneifolia*, *L. glaucus* on *Lycium* spp. and *L. dregei* on *Zizyphus mucronata*.

231 TIETEMA, T. **Biomass determination of fuelwood trees and bushes of Botswana, Southern Africa.** *Forest Ecology and management* (1993) 60 257-269 [En, 21 ref.]

Samples of 14 tree species indigenous to Botswana, including *Acacia karroo*, were measured, cut and weighed to establish the relationship between tree fresh biomass and tree dimensions. The relationship best suited to the indirect estimation of total fresh weight was the regression between tree fresh weight and stem basal area at ankle height (5-10 cm above ground level). The research showed that there was a sufficient similarity between the regression lines of a range of trees in Botswana to allow the determination of tree biomass in a normal diverse forest or woodland with the replacement of the regression lines of the individual tree species by one combi-line. The regression formulae for estimating individual tree fresh biomass (B) in kg from ankle height basal area (BA) in cm² for 36 trees of *A. karroo* growing at Dikeletsane in Botswana were $B=0.2865 \times BA^{1.2082}$ ($R^2=0.96$), when BA was plotted on a logarithmic scale, and $B=0.7558 \times BA$ ($R^2=0.93$) when BA was plotted untransformed. The R^2 value for *A. karroo* fit to the combi-line was 0.89. The regression formula for the combi-line for 512 trees of 14 species was $B=0.1936 \times BA^{1.654}$ ($R^2=0.92$).

232 TIETEMA, T.; MERKESDAL, E. **An establishment trial with *Acacia tortilis*, *A. karroo*, *A. erubescens* and *A. erioloba* at Morwa Forestry. The situation after one year.** *Journal of the Forestry Association of Botswana* (1986/87), 47-52 [En, 5 ref.]

Eucalypt plantations in Botswana have failed to produce more wood than indigenous natural woodland. Therefore,

seedlings of four indigenous *Acacia* species were planted in an establishment trial at Morwa Forestry, Kgatleng District, Botswana, in January 1986. About one year after planting, *A. tortilis* had a survival of 85%; survival of the other three species ranged from 25.6% to 41%; these low figures were caused mainly by a high incidence of death in early summer. Increased watering is recommended to increase survival rates of the three poorly performing species.

233 TIMBERLAKE, J. **Handbook of Botswana acacias.** Ministry of Agriculture (1980) Gaborone, Botswana. 120 pp. [En]

This field guide to the 32 *Acacia* species of Botswana includes a dichotomous key for identification and some general notes about the taxonomy, ecology and uses of the genus. For each species, including *A. karroo*, a taxonomic description is given followed by notes on the distribution and habitat, uses and culture. The species is described as very variable in form and habitat; and it is useful, although it can encroach on badly-managed rangelands. The wood is hard and heavy and has many uses but is not durable. It makes good firewood and charcoal, the bark is used for tanning, the flowers are valuable sources of pollen and nectar, the foliage, flowers and pods are valuable browse and the gum is edible.

234 TIMBERLAKE, J.R.; NOBANDA, N.; MAPAURE, I. **Vegetation survey of the communal lands - north and west Zimbabwe.** *Kirkia* (1993) 14 (2) 171-270 [En, 93 ref. 1 Map]

The survey was carried out using a phytosociological approach with initial stratification based on air photos followed by field sampling. The survey concentrated on the floristic composition of the various ecological units. Thirty seven vegetation types are described and these are grouped into eight vegetation classes. *Acacia karroo* is described as a tree of 4-10 m that forms stands on heavier-textured alluvium and is very common on red clay soils along watercourses and at the base of the Great Dyke. In high rainfall areas it occurs widely on clay-rich soils. Generally, it is an indicator of nutrient-rich soils.

235 TOLSMA, D.J.; ERNST, W.H.O.; VERWEIJ, R.A.; VOOIJIS, R.T.I. **Seasonal variation of nutrient concentrations in a semi-arid savanna ecosystem in Botswana.** *Journal of Ecology* (1987) 75 (3) 755-770 [En, 39 ref.]

Presents data for seasonal changes of nutrient concentrations in the leaves of the main tree and grass species of a semi-arid savanna in Botswana. Leaves, flowers and fruits (if present) were collected at 3-4 week intervals during September 1982 - December 1983 from the trees *Acacia burkei*, *A. erubescens*, *A. fleckii*, *A. karroo*, *A. mellifera* ssp. *detinens*, *A. nilotica* ssp. *kraussiana*, *A. robusta*, *A. tortilis* ssp. *heteracantha* and *Terminalia sericea*, the shrub *Dichrostachys cinerea* and the grasses

Eragrostis rigidior and *Panicum maximum* in the cattle-free zone of Gaborone. All plant material was analyzed to determine contents of N, P, K, Ca, Mg, Fe, Na, Zn and Mn and results for most elements are shown in graphs. With the exception of *A. karroo*, most tree species were leafless at the end of the dry season. Seasonal variation in concentrations of foliar nutrients followed similar trends in all species. Concentrations of N and P were greater in young leaves than in mature leaves, while Ca and Fe accumulated until leaf abscission. Concentrations of Ca and Mg in *A. karroo* foliage peaked during the dry winter whereas N, P and K levels were greatest in new foliage in early summer. Variations in foliar nutrients in flowering and non-flowering trees and total nutrients in flowers and fruits of trees are also described. It is concluded that P is the most limiting nutrient in this savanna because of the strong translocation from leaves to twigs before leaf abscission.

236 TROLLOPE, W.S.W.; TAINTON, N.M. **Effect of fire intensity on the grass and bush components of the Eastern Cape Thornveld.** *Journal of the Grassland Society of Southern Africa* (1986) **3** (2) 37-42 [En, 8 ref.]

Fire intensity is an important component of the fire regime and its effect on the grass sward and bush were investigated in the Eastern Cape thornveld. Research indicated that fire intensity had no effect on the recovery of grass after a burn. Conversely it had a marked effect on the topkill of bush to a height of 2 m. The results provide valuable guidelines for the use of fire in controlling bush encroachment. The species studied included *Acacia karroo*, *Rhus lucida*, *Ehretia rigida*, and *Grewia occidentalis*.

237 VAN DER WALT, P.T. **A phytosociological reconnaissance of the Mountain Zebra National Park.** *Koedoe* (1980) **23** (1) 1-32 [En, 38 ref., 4 maps]

Acacia karroo is the dominant tree in xeric riparian bush in the Mountain Zebra Park, Cape, South Africa. Rainfall averages around 400 mm yr⁻¹ and 70% falls in summer months. The *A. karroo* trees are 6-9 m in height and are associated with shade-loving shrubs (*Lycium*, *Diospyros*), climbers (*Protasparagus*), forbs and grasses. The parasite *Viscum capense* is common on *A. karroo* at this site.

238 VASSAL, J.; LESCANNE, N. [Cytology and taxonomy in the genus *Acacia*.] Cytologie et taxonomie dans le genre *Acacia*. *Bulletin de la Société d'Histoire Naturelle de Toulouse* (1976) **112** (1-2) 101-110 [Fr, en, 14 ref.]

This work presents the main results of morphological investigations on chromosomes of the genus *Acacia*. Chromosome numbers and chromatin and chromosome lengths are given for the different sub-genus groups and the relationships between the different subgenera *Aculeiferum* Vas., *Heterophyllum* Vas. and *Acacia* Vas. are discussed.

239 VENTER, H.J.T. [Ecology of the vegetation of Richards Bay] Ekologie van die plantegroei van Richardsbaai. *South African Journal of Science* (1971) **67** (2) 52-55 [Af]

Rainfall at Richard's Bay (northern coast of Natal, South Africa) averages 1300 mm p.a., summer temperatures exceed 40°C and relative humidity seldom falls below 50%. Winds and salt spray also influence and occasionally damage the coastal vegetation. *Acacia karroo* colonizes grassland in this area and is also found on bare drift sand. Large areas to the north and south of the Richards Bay lagoon are covered in *A. karroo* woodland which forms a zone between dune forest and grassland. The species grows exceptionally large here (15 m high, 1.4 m stem circumference). The mistletoe *Loranthus dregei* kills old *A. karroo* trees in the dune forest, often breaking their branches with its weight.

240 VERDOORN, I.C. **The nomenclature of the Cape Acacia.** *Bothalia* (1954) **6** (2) 409-413 [En, several ref. in text, 2 photos]

Acacia karroo is the correct name for the Cape *Acacia* which occurs within about c. 100 km of Cape Town.

241 VERMEULEN, J.B; GROBLER, H. **A guide to the use of herbicides, 9th ed.** Department of Agriculture, Pretoria (1986) 112 pp. [En]

Three herbicides are registered for the chemical control of *Acacia karroo* in South African rangeland: bromacil, ethidimuron and tebuthiuron.

242 VISSER, J. **South African parasitic flowering plants.** Juta, Cape Town (1981) 177 pp. [En]

Acacia karroo is listed as a host of the root parasite *Sarcophyte sanguinea* (Balanophoraceae). A colour photograph shows attachment of the parasite to the roots of an *A. karroo* sapling. The parasite, known from the eastern Cape, Natal and the eastern Transvaal, South Africa, has also been found on other species of *Acacia*.

243 VON BREITENBACH, F. **The lost Natal Thorn: For a reinstatement of *Acacia natalitia* E. Mey.** *Journal of Dendrology* (1989) **12** 1-10 [En, 23 ref.]

The taxonomic history of *Acacia natalitia* E. Mey. is investigated from its description in the early 19th century to its recent amalgamation with *A. karroo* Hayne. The diffusion of the original *A. karroo* concept by the inclusion of *A. natalitia* and various other clearly differing forms is considered undesirable, but to isolate the true *A. karroo* by separating from it all definable divergent forms, is preferred. With its whitish bark, small thorns, more finely divided leaves, lemon-yellow candle-like inflorescences and longer, more constricted pods, *A. natalitia* can be sufficiently well distinguished from *A. karroo* to justify its reinstatement as a separate taxon.

244 WATT, J.M.; BREYER-BRANDWIJK, M.G. **The medicinal and poisonous plants of Southern and Eastern Africa.** Edinburgh and London; E & S Livingstone Ltd. (1962) 543-544 [En, many ref., 1 ill.]

A decoction of the bark of *Acacia karroo* which contains 19.7% tannin has been used as an emetic and to treat diarrhoea in humans and "tulip" poisoning in cattle. The bark is also used for tanning and for making twine. Pods and foliage give negative tests for hydrocyanic acid and are eaten by goats and other livestock. Seeds have been used as a coffee substitute. Branches are used in basket making and for supporting thatched roofs of traditional African buildings. Wood is used as fuel. The gum (Cape gum) is of the arabinose-galactose type and has been analyzed.

245 WEBB, J.W. **The population dynamics of an indigenous psyllid *Acizzia russellae* (Homoptera: Psyllidae) with special reference to the host plant *Acacia karroo*.** Ph.D. thesis, Rhodes University, Grahamstown, South Africa (1974) [En]

The study includes a taxonomic description of the psyllid, an account of its general biology, monitoring of the seasonal fluctuations in numbers of the psyllid and its hymenopterous parasites, a study of various aspects of the host plant (*Acacia karroo*) including nitrogen levels, water stress, leaf hardness, and the effect of cutting in relation to spatial and temporal differences in insect population numbers. Seasonal patterns in psyllid numbers followed fluctuations in nitrogen levels on individual trees. No effect of stress or leaf hardness was clearly discerned. Cutting of trees altered the characteristics of the subsequent regenerative growth so as to allow massive psyllid infestations to develop, thus showing the tremendous importance of the host plant in determining population levels in this insect. Preliminary investigations of the nature and mechanism of this effect were conducted, and its significance is discussed. The relevance of these findings to modern concepts of regulation in insect populations and to principles of pest management is discussed.

246 WEBB, J.W. **The life history and population dynamics of *Acizzia russellae* (Homoptera: Psyllidae).** *Journal of the Entomological Society of Southern Africa* (1977) **40** (1) 37-46 [En, 27 ref.]

The life cycle of the psyllid was studied under laboratory conditions and the population dynamics were studied in the eastern Cape, South Africa over three years. There was a single peak of high abundance each spring. Dispersal was important because psyllids were influenced by the physiological condition of their host plant *Acacia karroo*.

247 WEBB, J.W.; MORAN, V.C. **New species of *Acizzia* (Homoptera: Psyllidae) from *Acacia karroo* in southern Africa.** *Journal of the Entomological Society of Southern Africa* (1974) **37** (1) 118-124 [En]

Describes *Acizzia russellae* collected on *Acacia karroo* near Grahamstown, Cape Province, South Africa.

248 WEBB, J.W.; MORAN, V.C. **The influence of the host plant on the population dynamics of *Acizzia russellae* (Homoptera: Psyllidae).** *Ecological Entomology* (1978) **3** 313-321 [En, 26 ref.]

Population levels of the psyllid were ten times greater on regenerative foliage of pruned *Acacia karroo* trees than on normal trees. During late summer and winter, populations declined more slowly on pruned than on normal trees. Laboratory measurements of several chemical and physical characteristics of the foliage of pruned and normal trees did not reveal any differences which could account for the observed effects. It is suggested that the availability of quantities of suitable high quality nutrients in the leaves of pruned *A. karroo* trees explains the epidemic population levels achieved by the psyllid on pruned plants.

249 WEHMER, C. **Die Pflanzstoffe, 2nd ed.** Fischer, Jena (1935 supplement to 2nd ed. 1929) [Ge]

Gives the tannin contents of bark and fruit, analysis of gum of *Acacia karroo*.

250 WEISSER, P.J.; MARQUES, F. **Gross vegetation changes in the dune area between Richards Bay and the Mfolozi River, 1937-1974.** *Bothalia* (1979) **12** (4) 711-721 [En, fr, af, 11 ref., 7 pl.]

Marked changes in dune vegetation in this region of Natal, as shown on air photos taken in 1937 and 1974, are described and quantified. About 55% of the study area had changed from one mapping unit to another during the period, the changes being mainly due to secondary successions resulting from protection by the Department of Forestry, which is also responsible for extensive afforestation. It is estimated that under the existing favourable climatic conditions it takes some dune grassland only 25-60 yr to develop to mature *Acacia karroo* woodland and a further 30-150 yr to proceed to secondary dune forest. [CABI abstract]

251 WEISSER, P.J.; MULLER, R. **Dune vegetation dynamics from 1937-1976 in Mlalazi - Richard's Bay of Natal, South Africa.** *Bothalia* (1983) **14** (3/4) 661-667 [En]

Dune vegetation changes were studied qualitatively with the aid of air photos taken in 1937, 1957 and 1976. Results were transferred to 1:10 000 scale maps. In 1937 roughly 80% of the dune forest habitat was occupied by planted fields and post cultivation seral stages such as Secondary Grasslands and Dwarf Shrubland, Secondary Scrub and *Acacia karroo* Woodland. In three areas, the vegetation cover had been completely destroyed and drift sands had formed. In the 1950's the trend of vegetation degradation was changed by the implementation of an afforestation programme by the Department of Forestry. The 1976 air

photos indicate that the post cultivation seral stages of 1937 had been largely replaced by forest plantations. In secondary, unafforested areas the vegetation is evolving rapidly towards a Secondary Dune Forest. [Author's summary]

252 WELLS, M.J.; BALSINHAS, A.A.; JOFFEE, H.; ENGELBRECHT, V.M.; HARDING, S.; STIRTON, C.H. **A catalogue of problem plants in Southern Africa, incorporating the National Weed List of South Africa.** *Botanical Survey of South Africa Memoirs* (1986) No. 53, 43 [En]

Information listed on 1653 taxa, including 711 naturalized exotics, which have been shown to be weedy in certain situations in southern Africa. Forty five *Acacia* taxa (mostly indigenous) are described, including *A. karroo* Hayne. It is included in the National Weed list having the undesirable characteristics of being competitive (for space, light, water, nutrient), replacing the preferred vegetation (grass), thorny (plant) and obstructive (access). It is cultivated as an ornamental or barrier crop. It is legislated as a declared invader and is subject to herbicide registration. [CABI abstract]

253 WEST, O. **The vegetation of Weenen county, Natal.** *Botanical Survey of South Africa Memoirs* (1951) No. 23, 183 pp. [En, many refs]

254 WEST, O. **Veld management in the dry, summer-rainfall bushveld.** In: *The grasses and pastures of South Africa*. (1955) (Meredith, D., Ed.). Cape Times Limited, Parow, C.P. 771 pp. [En]

The *Acacia arabica* (*A. nilotica*) belt occurs in the driest parts of the valley, usually half way up the sides. Further down the valley with improving moisture conditions, are the *A. caffra* and *A. karroo* zones. *Acacia karroo* forms the lowest zone, also occurring along river valleys. *A. caffra* and *A. karroo* are more tolerant to frost and less tolerant to drought than *A. nilotica*.

255 WHITE, F. **Forest flora of Northern Rhodesia.** London, Oxford University Press (1962) 76-85 [En]

This comprehensive account of the woody plants of Northern Rhodesia gives a brief description of each tree species classified by family, including *Acacia karroo*.

256 WHITE, F. **The vegetation of Africa.** Natural Resources Research, UNESCO (1983) 356 pp. [En]

257 WILD, H. **Arsenic tolerant plant species established on arsenical mine dumps in Rhodesia. Geobotanical anomalies in Rhodesia. 4. The vegetation of arsenical soils.** *Kirkia* (1974) 9 (2) 265-278 [En, 2 ref.]

Describes the vegetation of 15 spoil mounds at gold mines, mainly deposits from slimes, and lists 77 indigenous and exotic plant species with their frequency and tolerated range of soil As contents (up to 30 000 p.p.m.). Some indigenous species were not recorded from natural As sites, notably *Acacia karroo* (up to 10 000 p.p.m. As); most of these species were associated with metalliferous sites. Plantations of *Euphorbia tirucalli* have succeeded in some instances at <5 000 p.p.m. As. [CABI abstract]

258 WILD, H.; BIEGEL, H.M.; MAVI, S. **A Rhodesian botanical dictionary of African and English names.** Government Printer, Salisbury, Rhodesia. (1972) 281 pp. [En, 42 ref., 2 fig.]

The dictionary includes *Acacia karroo* for which a brief botanical description is given. It is described as probably the commonest and most wide-spread *Acacia* in Zimbabwe found at most altitudes on fertile black clay soils and along water-courses. Uses include bark for rope, dye and tannin, and gum which is chewed and used as an adhesive.

AUTHOR INDEX

- ACOCKS, J.P.H. 1, 2, 3
 ADAMSON, R.S. 4
 ALLISON, G.E. 5
 ANDERSON, D.M.W. 6, 7, 8, 9, 10, 11, 12
 ARCHER, F.M. 13, 14, 15, 16
 ARORA, G.D. 142
 AUCAMP, A.J. 17, 18, 19, 20, 21
 AYLEN, D. 22
 BALA, B.B. 23
 BALSINHAS, A.A. 252
 BARNARD, A. 24
 BARNARD, H.H. 18
 BARNARD, H.J. 205
 BARNES, R.D. 25, 26, 27, 37b, 96, 99
 BAXTER, B. 28
 BAYER, A.W. 29
 BEENTJE, H.E. 57
 BEMBRIDGE, T.J. 30, 31
 BENNETT, E.M. 126
 BENTHAM, G. 32
 BEWS, J.W. 33
 BEZUIDENHOUT, H. 38
 BIEGEL, H.M. 258
 BOND, C. 135
 BOSCH, O.J.H. 34
 BRAIN, P. 35, 36, 37a, 37b
 BREDEKAMP, G.J. 38, 119, 120
 BREYER-BRANDWIJK, M.G. 244
 BRIDGEMAN, M.M.E. 12
 BROOKE, R.K. 39
 BROWN, N.A.C. 40
 BROWNE, C.W. 41
 BRYANT, J.P. 42
 BURLEY, J. 43
 CARR, J.D. 44, 45, 46, 47
 CARTER, D.T. 92
 CHAPPILL, J.A. 48
 CHARLSON, A.J. 49
 CHIMBALANGA, J. 26
 CHOWN, S. 50
 CHURMS, S.C. 51
 CLARKE, J.M. 52, 53
 CLEGHORN, W.B. 54
 COATES-PALGRAVE, K.E. 55
 COE, C.E. 56
 COE, M. 56, 57
 COETZEE, B.J. 59
 COETZEE, J.A.E. 58
 COHEN, C.E. 60
 COMINS, D.M.E. 61
 COOPER, S.M. 42
 CREE, G.M. 7, 8
 CROCKFORD, K.J. 53
 CRONIN, C.H. 54
 CUNLIFF, K.M.E. 62
 CUTLER, D. 161
 DAMIANO, A.E. 63
 DANCKWERTS, J.E. 19, 20, 21
 DE PINTO, G. 12
 DE RIDDER, C.H. 107, 108
 DEA, I.C.M. 9
 DEAN, R.J. 137
 DEAN, W.R.J. 64, 65
 DECELLE, J.E. 79
 DICKSON, C.G.C. 66
 DRUMMOND, R.B. 67, 86
 DUBE, J.S. 68, 145
 DU PREEZ, P.J. 69
 DU TOIT, J.W. 154
 DU TOIT, P.F. 70, 71, 72, 73, 74, 75
 EARLÉ, R.A. 76
 EBERHARD, A.A. 77
 EDWARDS, D. 78
 ELLERY, W.N. 129
 ENGELBRECHT, V.M. 252
 ERASMUS, T. 117, 118
 ERNST, W.H.O. 79, 235
 FAGG, C.W. 25
 FELKER, P. 80
 FILER, D.L. 27
 FOURIE, C. 81
 FOURIE, O. 82
 FREEMAN, B.H. 83
 FRIEDEL, M.H. 84
 FRISBY, K. 42
 GALPIN, E.E. 85
 GELFAND, M. 86
 GERSTNER, J. 87
 GHIMPU, V. 88
 GIBSON, I.A.S. 89
 GINDEL, G.F. 90
 GMELIN, R. 91
 GOLDSMITH, B. 92
 GONSALVES, P. 59
 GORDON-GRAY, K.D. 93, 94
 GOURLAY, I.D. 27, 95, 96, 97, 98, 99
 GRIME, G.W. 97
 GROBLER, H. 241
 GROBLER, P.J. 100
 GUILLOTEAU, J. 101
 GUINET, P. 102
 GYAN CHAND 142
 HALL, P.E. 103
 HARBARD, J. 187
 HARDING, S. 252
 HARDY, M.B. 104
 HARRIS, S.A. 37b
 HAYWARD, F.C. 195

- HELLINGE, A. 105
HENDERSON, L. 106
HOBSON, F.O. 104, 107, 108
HOCKING, B. 109
HOFFMANN, J.H. 110
HOVE, L. 145
HOWES, F.N. 111
HUDSON, W.K. 193
HUGHES, C.E. 43
IBPGR 112
JOFFEE, H. 252
JOUBERT, D. 130
JURACEK, P. 113
KANOWSKI, P.J. 98
KAPLAN, J. 114
KARAMALLA, K.A. 10
KARSTEN, M.C. 115
KENRICK, J. 116
KERLEY, G.I.H. 117, 118
KILLILIA, D.M. 225
KJAER, A. 91
KNOX, R.B. 116
KOK, P.D.F. 169
KOOIJ, M.S. 119, 120
KOSIK, M. 113
KOTZE, D.C. 121
KRESS, W.J. 122
KROMHOUT, C.P. 123
KROON, D.M. 66
KRUGER, M. 128
KUROPAT, P.J. 42
LANDER, N.S. 126
LEISTNER, O.A. 124
LESCANNE, N. 238
LILLY, M.A. 125
LOCKHART, L.A. 27
MACDONALD, I.A.W. 136
MACFARLANE, D.T. 126
MAPAURE, I. 234
MARAIS, J. 100
MARCHANT, N.G. 126
MARQUES, F. 250
MARUNDA, C. 26
MASLIN, B.R. 48
MAVI, S. 86, 258
MCGEOCH, M.A. 127, 128
MCINROY, S.G. 206
McKAY, A.D. 54
MENTIS, M.T. 129
MERKESDAL, E. 232
MIDGELEY, J.J. 64, 130
MILLER, O.B. 131
MILTON, S.J. 65, 132, 133, 134, 135, 136, 137
MITCHELL WATT, J. 138
MOGG, A.O.D. 139
MORAN, V.C. 110, 247, 248
MULLER, R. 251
MULLER, T.H. 140
MUNTING, J. 141
MUTHANA, K.D. 142
NAUDE, C.P. 144
NAUDE, T.J. 143
NCUBE, S. 145
NDEMERA, E.B. 86
NEL, L.O. 75
NEW, T.R. 146
NOBANDA, N. 234
NOEL, A.R.A. 147
NUNN, J.R. 49
OBALLA, P.O. 148, 149
ODEE, D.W. 206
OLESEN-LARSEN, P. 91
OLNG'OTIE, P.A.S. 149
ORMOND, B. 150
OWEN-SMITH, N. 42
PANETTA, F.D. 186
PAPENDORF, M.C. 151, 152, 153, 154
PAPPE, L. 155
PARDY, A.A. 156
PEDLEY, L. 157
PHILLIPS, G.O. 113
PHILLIPS, J. 158
PINTO, G. 11
POTTS, G. 159
POYTON, R.J. 160
PRIOR, J. 161
RIMINGTON, C. 198
ROBBERTSE, P.J. 162, 163, 164, 165, 166, 167, 168, 169, 170
ROBERTS, B.R. 171, 172
ROSS, J.H. 173, 174, 175, 176, 177, 178, 179
RUTHERFORD, M.C. 180
RYE, B.L. 126
SAPPRI 181
SCHEEPERS, J.C. 120
SCHILDKNECHT, H. 182
SCOTT, J.D. 183
SCOTT, J.K. 184, 185, 186
SEdgeLEY, M. 187
SIEGFRIED, W.R. 65, 137
SMIT, G.N. 188
SMITH, J.P. 99
SMITH, T.M. 189
SMITTER, Y.H. 190
SOUTHGATE, B.J. 191
SPRENT, J.I. 192
STANFORTH, A. 206
STAPLES, R.R. 193
STEADMAN, E.C. 194
STEENKAMP, C.W.P. 195
STEPHEN, A.M. 49, 51, 83, 196
STEYN, C.B. 51
STEYN, D.G. 197, 198
STIRTON, C.H. 252
STOCK, W.D. 64
STORY, R. 199
STUART-HILL, G.C. 200, 201, 202, 203, 204, 205
STYLES, B.T. 43
SUTHERLAND, J. 206
SWART, H.J. 207

-
- SWARTZ, P.P. 169, 208
TAINTON, N.M. 34, 202, 203, 204, 205, 236
TALBOT, P.H.B. 209
TARLTON, J.E. 31
TAYLOR, J.D. 210, 211, 212, 213
TEAGUE, R.C. 229
TEAGUE, W.R. 20, 214, 215, 216, 217, 218, 219, 220,
221, 222, 223, 224, 225, 226, 227, 228, 229
THERON, G.K. 119, 120
THODAY, D. 230
TIDMARSH, C.E. 159
TIETEMA, T. 231, 232
TIMBERLAKE, J. 233, 234
TOLSMA, D.J. 79, 235
TROLLOPE, W.S.W. 236
VAN DER MEULEN, F. 59
VAN DER WALT, P.T. 237
VAN RENSBURG, H.J. 170
VASSAL, J. 102, 238
VENTER G. 170
VENTER, H.J.T. 69, 239
VENTER, J.J. 20, 21
VERDOORN, I.C. 240
VERMEULEN, J.B. 241
VERWEIJ, R.A. 235
VISSER, J. 242
VOGT, D.C. 196
VON BREITENBACH, F. 243
VOOIJIS, R.T.I. 235
WALKER, B.H. 189, 226, 227, 228, 229
WARD, C.J. 93, 94
WATT, J.M. 244
WEBB, J.W. 110, 245, 246, 247, 248
WEHMER, C. 249
WEISSER, P.J.E. 59, 250, 251
WELLS, M.J. 252
WEST, O. 253, 254
WESTFALL, R.H. 180
WHEELER, J.R. 126
WHITE, F. 255, 256
WILD, H. 257, 258
WOOLARD, G.R. 83
YEATON, R.I. 28
ZACHARIAS, P.J.K. 121
ZWANZIGER, S. 59

