Natural Resources Institute

Use of Trees by Livestock

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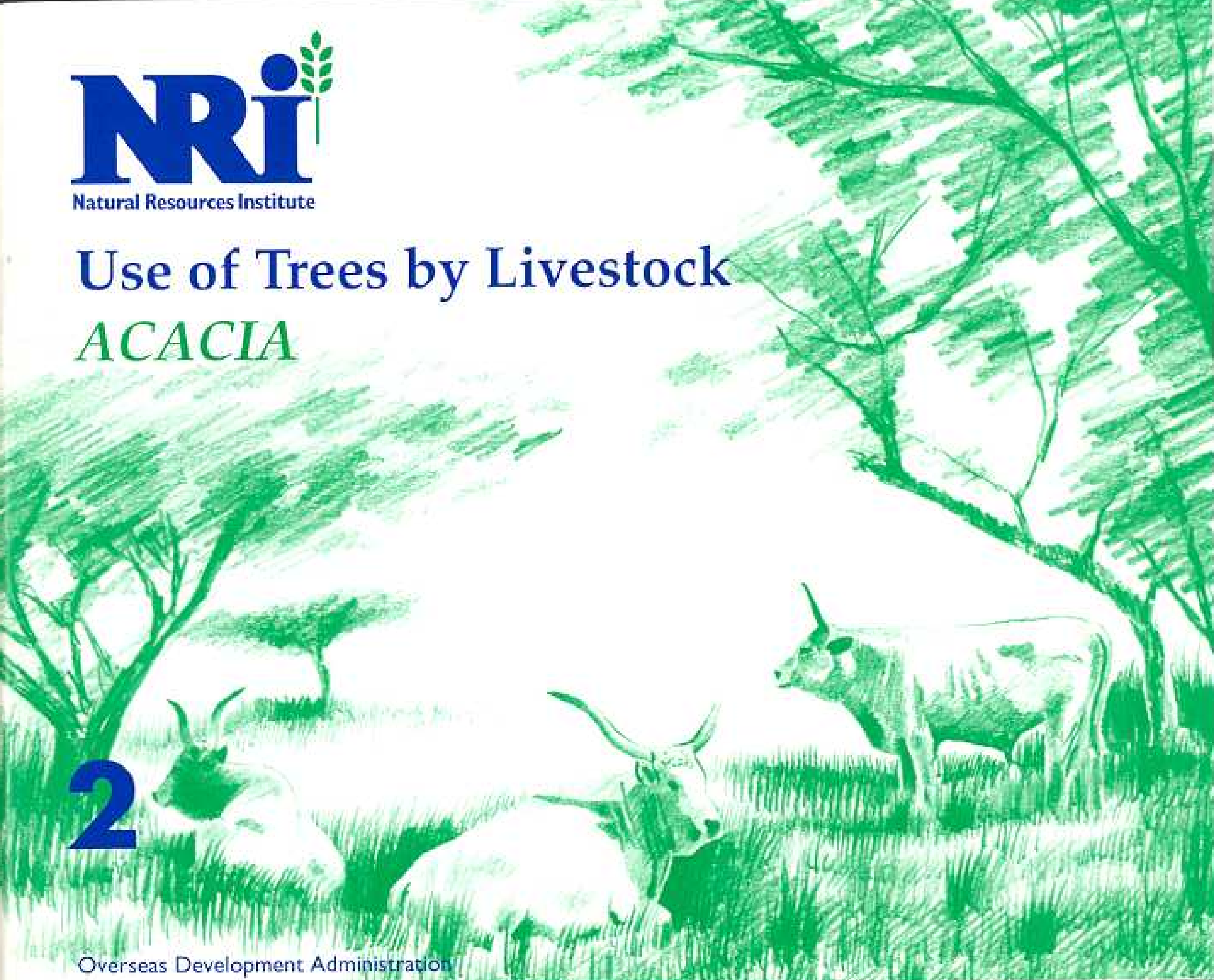

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Overseas Development Administration

ACACIA

Use of Trees by Livestock
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J.J. Bennison and R.T. Paterson

Natural Resources Institute

The scientific arm of the
Overseas Development Administration

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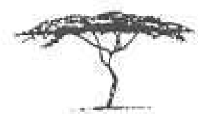

Foreword

The importance of trees and shrubs in the feeding of animals in the tropics and sub-tropics has long been recognized by livestock owners. In arid areas where the growth of herbaceous plants is limited by lack of moisture, leaves and edible twigs of trees and shrubs can constitute well over 50% of the biomass production of rangeland. At high altitudes, tree foliage may provide over 50% of the feed available to ruminants in the dry season, branches being harvested and carried to the animals. Even in regions of higher rainfall where grass supplies the major proportion of the dry matter eaten by ruminants, tree leaves and fruits can form an important constituent of the diet, particularly for small ruminants.

In the last two decades interest in the planting of trees as a source of feed for livestock has been encouraged by workers in research and development, but in contrast to the hundreds of indigenous species which are used as fodder, attention has focussed on a limited number of introduced species. Thus there are many publications reporting the chemical composition of *Leucaena leucocephala* leaves and suggesting management strategies for utilization of the tree for fodder, but it is more difficult to find information on alternative genera which might be equally, or more, appropriate.

The aim of this series of publications is to bring together published information on selected genera of trees which have the potential to increase the supply of fodder for ruminants. Each booklet summarizes published information on the fodder characteristics and nutritive value of one genus, with recommendations on management strategies, where available. Further, since the leaves of woody species frequently contain secondary compounds which may have an anti-nutritional, or toxic, effect, a separate booklet summarizes the effects of a number of these compounds. It is hoped that the booklets will provide useful resource material for students, research and extension workers, interested in promoting the use of trees as a source of fodder for ruminants

Further copies of this booklet or others in the series can be obtained by writing to the Publications Section at the Natural Resources Institute.

Margaret Gill
Livestock Production Programme

Genus *Acacia*

Family LEGUMINOSAE
Subfamily MIMOSOIDEAE
Tribe ACACIEAE

Principal phyllodenous species

Acacia aneura
Acacia combagei
Acacia coriacea
Acacia cyanophylla
Acacia dealbata
Acacia decurrens
Acacia holosericea
Acacia mearnsii
Acacia nilotica
Acacia pendula
Acacia salicina
Acacia tortilis
Acacia trachycarpa (syn. *A.* aff. *linarioides*)
Acacia tumida

Principal bipinnate species

Faidherbia albida (syn. *Acacia albida*)
Acacia brevispica
Acacia cornigera
Acacia drepanolobium
Acacia farnesiana
Acacia haematoxylon (syn. *A. giraffae*)
Acacia hebeclada subsp. *hebeclada* (syn. *A. stolonifera*)
Acacia lasiopetala
Acacia leucophloea
Acacia mearnsii (syn. *Racosperma mearnsii*)
Acacia mellifera
Acacia mellifera subsp. *detinens*
Acacia nilotica
Acacia oerfota (syn. *A. nubica*)
Acacia robusta
Acacia senegal
Acacia seyal
Acacia sieberiana
Acacia tortilis
Acacia tortilis subsp. *heteracantha* (syn. *A. likatunensis*)

Summary

With the African *Acacia* spp. the fruit is probably more valuable as a feed than the foliage, because with the exception of *F. albida*, they tend to shed their leaves at the time of greatest feed scarcity during the dry season. Australian species however, retain their leaves and therefore show greater potential as fodder trees.

The productivity responses of animals reflect both the total intake, and the availability, of nutrients in the diet. Proximate and fibre analyses are unreliable indicators of nutritional value because of the presence of both cyanogenic glycosides and polyphenolics. A cautious approach should be adopted when feeding both *A. leucophloea* and some of the Australian species.

In some areas of Africa, *Acacia* spp. are the dominant browse trees within the natural ecosystem. Often there is no choice but to utilize the available feeds even if they do contain anti-nutritive compounds. Consumed as part of a wider diet, the effect of anti-nutritive factors is diluted. They only become serious in periods of extreme feed scarcity or in situations where the opportunity for feed selection is reduced, such as in stall feeding and cut-and-carry systems.

Acacia is a huge genus with pantropical distribution and a notable ability to survive in harsh environments. It has potential for use in environmental protection and for production of fodder, fuelwood, gums, and tannins.

Description and distribution

Acacia is a pantropical and subtropical genus with species abundant throughout Australia, Asia, Africa and the Americas. They thrive in a diverse range of habitats and environments. Many species are well adapted to the semi-arid and savannah regions but equally others survive in moist forest and riverine areas, tolerating both high pH and waterlogged soils. With such diversity, *Acacia* has considerable potential in a range of livestock and agroforestry systems. In Africa and Australia, some naturally occuring species are important in traditional pastoral and agropastoral systems, while imported species have become commercially accepted. Trees provide fodder and shade for livestock, improve soil fertility through nitrogen fixation and the production of leaf litter and stabilize soils. *Acacia* species provide edible fruits and seeds, gum arabic and timber for fuel, construction and fencing.

In a large genus of 800-900 species (Allen and Allen, 1981), classification and nomenclature can be complex, particularly as there have been a number of revisions and attempts to subdivide the genus. Pedley (1986; 1987) advocated that it be divided into three separate genera, namely *Acacia*, with 200 species best represented in Africa and South America, *Senegalia*, with about 150 species with the same geographical distribution, and *Racosperma*, with about 850 species virtually confined to Australia. While the suggestion may have merit, it has not yet been generally accepted. This text uses the traditional nomenclature adopted by standard flora. Where a name has been changed as a result of a generally accepted revision, the name used in the original reference is listed as a synonym. The names of the African species are those included in the check-list produced by Lock (1989) as part of the programme of the International Legume Database and Information Service (ILDIS).

One widely accepted recent change is the reclassification of *Acacia albida* as *Faidherbia albida*, although Coe and Beentje (1991) stated that the justification for the change was primarily phytochemical. In this publication, for purposes of discussion and comparison, the name *F. albida* is accepted but it is considered as though it had remained within the genus *Acacia*, since it shares many agronomic characteristics with species that have not been reclassified.

Various workers have divided the genus into divisions, series and subseries (Bentham, 1864) or sections (Taubert, 1894) but for ease of description and an understanding of the fodder potential, it is simplest to describe *Acacia* spp. as being either phyllodenous (principally Australian in origin) or bipinnate (mainly from Africa and Asia).

Phyllodenous *Acacia* species

The majority of Australian *Acacia* spp. lack true leaves. Instead, they exhibit a characteristic known as phyllodony where the petiole is expanded and flattened. The phyllode has the ability to photosynthesize and for all practical purposes, it is the equivalent of a leaf. The Australian exceptions are from the Section *Botrycephalae*, which maintain bipinnate foliage until maturity and do not develop phyllodes.

Vercoe (1987) noted that species of *Acacia* and other genera from the dry tropics of Australia had potential in the semi-arid zones of Africa for fuelwood and erosion control. If their usefulness as fodder could also be established, this would enhance their overall value. Certainly the value of trees such as *A. aneura* as drought reserve feed is well established and recognized by pastoralists in Australia. Unfortunately, success in establishing *A. aneura* in Africa has been limited. However, a number of other species appear to show potential, notably *A. holosericea*, *A. trachycarpa* and *A. coriacea*. Other species that have been studied include *A. salicina* and *A. cyanophylla*, although the phyllodes of the latter contain high tannin levels (Vercoe, 1987; Goodchild and McMeniman, 1987; Reed *et al.*, 1990), which can reduce both the palatability and the feeding value. Unlike African and Asian species, Australian *Acacia* spp. are evergreen and unarmed.

Bipinnate *Acacia* species

There are about 200 bipinnate *Acacia* species in the New World and a further 150 species in Africa and Asia. All 129 African species possess bipinnate leaves. There are other physical and physiological characteristics which separate them from their Australian relatives, the *Botrycephalae*. This group, the best known of which is *A. mearnsii* (black wattle), grown throughout the subtropical world for the extraction of tannin, is confined to the cooler and moister parts of south eastern Australia. They are not noted as valuable fodder trees (Boland, 1987). Most bipinnate *Acacia* spp. are armed with thorns of various shapes and sizes, some of which are modified stipules at the base of the leaves. Many exhibit transient periods of defoliation in the dry season and have been described as deciduous. Before the start of the rains, there is a often a flush of new growth of leaves. Although the stimulus for this activity is uncertain, it may be due to temperature.

Fodder characteristics

Fodder yield

Information on leaf yield of African bipinnate *Acacia* spp. is limited, and comparative data with introduced Australian species, even more so. The work of Cossalter (1986) compared species from the two regions, when grown in Senegal at uniform spacings of 3 x 3 m (Table 1). The results, as means of 20, or 25 individual trees aged between 18-23 months, demonstrated the fodder potential of the Australian *Acacia* species when compared with African ones. *A. holosericea* is perhaps the most frequently planted Australian *Acacia* in development projects because of its superior yield and because it retains a large phyllode biomass during the dry season, while African species shed their leaves during this period (Cossalter, 1986). There is some uncertainty about the palatability of *A. holosericea*: early trials indicate that only dry phyllodes are accepted. The fresh phyllodes of *A. trachycarpa* and *A. tumida*, however, were readily eaten by both cattle and sheep (Hamel, 1980).

Table 1 Total biomass production (phyllodes, leaves and wood) of *Acacia* spp.

Origin	Species	Dry leaves, phyllodes (g/tree)	Wood (kg/tree)
Australia	*A. holosericea*	2660	12.03
Australia	*A. trachycarpa*	1993	10.65
Australia	*A. tumida*	2600	8.69
Australia	*A. trachycarpa*	1700	3.73
Africa	*A. senegal*	60	9.92
Africa	*A. seyal*	208	9.39
Africa	*A. tortilis*	130	5.89

Source: Cossalter (1986)

When assessing the fodder value of African *Acacia* spp., the importance of the fruit and pods cannot be ignored. This fraction may be of more value than the foliage in some cases. A major problem in estimating the yield of fruit is the variation in individual trees between years. Trees may bear a heavy crop one year and little the next. The fruits of *F. albida* are relished by game, cattle and small ruminants and NAS (1979) suggests that yields of 125-135 kg are possible from a single tree. When ripe, the fruit can be harvested and stored for future use, although there is a tendency for the pods to shatter and disintegrate.

The bark of *A. seyal* is particularly valuable as a fodder, although complete removal will result in the death of the tree. Skerman *et al.*, (1988) suggested that the bark, which is extensively used for feeding cattle and small ruminants in the dry season, was the most valuable part of the plant. Cattle could consume up to 5.5 kg bark/day, sufficient for maintenance and the production of 4.5 litres of milk.

Nutritive value

In Table 2, the mean proximate and fibre analyses of leaves, phyllodes and fruits of *Acacia* spp. are summarized from data of individual species (Appendix 1). Absolute values should be treated with caution since there is considerable variation in the literature. For example, the mean crude protein (CP) level of *Acacia* leaves is 18.9% of dry matter (DM), with a reported range of 6.5-42.8 %. However, the data provide an indication of the nutritive value and in general both leaves and fruits of all species are valuable sources of protein, particularly when compared with mature grasses, where CP levels in forage dry matter (DM) during the dry season can fall to 3-4% or less, well below the 7% CP which is suggested as a lower limit for fibre digestion in cattle (Van Soest, 1982).

While the crude fibre (CF) levels of *Acacia* are relatively high (15-40%) compared with other fodder tree species such as *Leucaena leucocephala* and *Gliricidia sepium*, they are still markedly lower than for tropical grasses and common crop residues. Even the fruit, consisting of the dry dehiscent pod and the seeds contained in it, are a valuable feed source, with moderate CF (25%) and high CP levels (15%). The phyllodenous *Acacia* spp. tend to have marginally higher CF and lower CP levels than bipinnate species (Appendix 2) though the available data consist of

Table 2 Mean proximate and fibre analyses of *Acacia* leaves, phyllodes, fruits and seeds

	Crude protein	Crude fibre	Ash	Ether extract	NFE	NDF	ADF
	(% of dry matter)						
Acacia LEAVES							
No. of data	41	41	40	39	38		
Mean	**18.9**	**21.0**	**7.6**	**3.3**	**48.6**		
Range	(7-43)	(8-46)	(5-12)	(2-13)	(32-66)		
Acacia PHYLLODES							
No. of data	6	6	6	6	6		
Mean	**12.2**	**27.6**	**7.0**	**2.9**	**48.7**		
Range	(9-13)	(16-33)	(5-11)	(1-5)	(38-55)		
Acacia FRUIT							
No. of data	33	29	33	28	28	4	4
Mean	**14.5**	**24.7**	**5.8**	**1.7**	**51.9**	**34.6**	**25.7**
Range	(8-22)	(12-41)	(3-14)	(1-3)	(31-67)	(32-37)	(23-28)
Acacia SEEDS							
No. of data	8	4	8	4	4	4	4
Mean	**28.2**	**15.9**	**5.2**	**6.0**	**38.8**	**35.3**	**24.4**
Range	(19-40)	(11-21)	(4-7)	(2-10)	(26-55)	(28-40)	(19-29)

Sources: Gohl, (1981); Goodchild and McMeniman, (1987); Skerman *et al.*, (1988); Tanner *et al.*, (1990)
Notes: NFE - Nitrogen-free extract; NDF - Neutral detergent fibre; ADF - Acid detergent fibre.

fewer observations. The lower nutritive value is offset by both the higher biomass yield and the retention of the phyllodes throughout the dry season, when bipinnate species tend to shed their leaves.

Information on the digestibility of DM and organic matter (OM) of *Acacia* leaves and phyllodes is limited but the available data indicate that, with sheep, they are relatively low and in the range of 40-60% respectively (Table 3). The digestibility of phyllodes appears to be lower than that of bipinnate leaves. Goodchild and McMeniman, (1987) suggested that the low fibre digestibility could be associated with the high lignin content of the cell wall, since fibre digestibility is inversely related to the lignin content of the fibre fraction.

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While the digestibility of the whole fruit (seed and pod) is higher than that of the leaves and phyllodes, it can be adversely affected by the proportion of seeds that pass undigested through the gut of the animal. Tanner *et al.*, (1990) reported that 46% of *A. tortilis* seeds were voided in the faeces of sheep. Similarly, Goodchild and McMeniman (1987) noted that when feeding yearling cattle with seeds of *A. tortilis* subsp. *spirocarpa*, 12% passed unchanged through the gut. Legume seeds are physically hard and notoriously resistant to digestive juices, although the small size of *Acacia* seed may be a contributory factor in their passage through the gut (Tanner *et al.*, 1990).

The digestibility of the leaf and fruit fraction can also be depressed by the presence of polyphenolic compounds, including tannins.

Anti-nutritive factors

Acacia spp. have acquired a variety of physical and chemical defence mechanisms aimed at reducing the palatability and nutritive value of the plant to

Table 3 *In vivo* digestibility (%) of *Acacia* forage

	Organic matter	Dry matter	Neutral detergent fibre	Nitrogen	Crude protein	Source
LEAVES						
A. farnesiana	60 *				19.8	1
F. albida	53				17.8	1
A. sieberiana	54		37	27	16.9	3
A. seyal	54		42	28	18.2	3
PHYLLODES						
A. aneura	47	32*			12.2	1/4
A. combagei	44 *					1
A. pendula	43					1
A. holosericea		32*				4
A. cyanophylla	41		29	10	6.3	3
FRUIT (pods and seeds)						
A. tortilis	61	58	51	30	14.5	2
F. albida	57	55	45	29		2
F. albida	58	1			11.0	1
A. nilotica	61	59	49	32		2
A. nilotica	66	1			11.3	
A. sieberiana	55	53	39	29	18.1	2

Notes: * *in vitro* determinations.

Sources: 1 Goodchild and McMeniman (1987); 2 Tanner *et al.* (1990); 3 Reed *et al.* (1990); 4 Vercoe, (1987).

predators including both insects and animals.

Perhaps the most obvious physical characteristic is the spiny armature of the African species, which evolved as a defence against large herbivores. *A. mellifera* subsp. *detinens* derived its common name (wait-a-bit tree) from the pairs of small hooks on the branches. *A. tortilis* is protected by two types of thorns, long white stipular spines and small curved hooks, a formidable protection against animals. Coe and Beentje (1991) suggested that as thorns restrict the availability of forage, a critical level is reached below which the herbivore no longer finds it nutritionally efficient to seek shoots between the spines, since this invariably involves movement between each bite. There is also evidence that in *A. drepanolobium*, thorns on branches which are regularly browsed by animals are significantly longer than those on undefoliated branches (Young, 1987).

Tree size is a form of physical protection that can be harnessed as a desirable characteristic in certain agroforestry systems. Domestic animals are unable to browse tall trees which then maintain a standing reserve of foliage which can be made available by strategic lopping at critical periods when other feed is scarce.

A fascinating defence mechanism of the genus is the symbiotic relationship with ants known as myrmecophily, where the plant lives in association with an ant colony. In the tropical American species *A. cornigera*, association with ants from the genus *Pseudomyrmex* is a notable example of myrmecophily. The trees have modified, swollen spines or galls, which provide shelter for the ants, and extrafloral nectaries and modified leaflet tips which provide food. The ants, in return, protect the trees from insects and other predators by swarming to attack them when the tree is disturbed (Janzen, 1966). In Africa, *A. drepanolobium* is commonly known as the 'whistling thorn', a name derived from the noise of the wind blowing into the holes of the galls that have been occupied by ants.

Many *Acacia* spp. produce a range of potentially toxic compounds which prevent herbivores from eating the foliage, although it is thought that the chemicals originally evolved as defence mechanisms against insect and fungal attack. Some members contain specific anti-nutritive factors, for example, *A. georginae* has been implicated in heavy stock losses in Australia due to its content of fluoracetic acid (D'Mello, 1992). In general terms the genus contains two major groups of anti-nutritive factors, cyanogenic glycosides and polyphenolic compounds.

Cyanogenic glycosides

When cyanogenic substrates are broken down under the action of a hydrolyzing enzyme, hydrogen cyanide (HCN) is formed. Plants that contain both cyanogenic glycosides and an endogenous, hydrolytic enzyme are the most dangerous but broad-spectrum enzymes may be present in other fractions of the diet. Symptoms of HCN poisoning include respiratory dyspnoea, intense red conjunctiva, frothing at the mouth, bloat, a staggering gait, convulsions and violent death. On post-mortem examination, a characteristic almond smell is often noted in the contents of the gut.

In Asia, there are a number of reports of HCN poisoning of livestock when fed on the pods and leaves of *A. leucophloea* (Gupta and Naurival, 1966; Prasad *et al.*, 1977; Vihan and Panwar, 1987). In South Africa, Steyn and Rimington (1935) reported the presence of cyanogenic glycosides in *A. haematoxilon*, *A. lasiopetala*, *A. tortilis* subsp. *heteracantha*, *A. robusta* and *A. hebeclada* subsp. *hebeclada*. They found higher concentrations of HCN from leaves and immature pods than from mature pods. In *A. robusta*, the glycoside was present without the corresponding hydrolytic enzyme. They isolated the cyanogenic compound acacipetalin from *A. lasiopetala* and *A. hebeclada*. Siegler *et al.*, (1975) isolated a further compound, dihydroacipetalin, from the leaves and shoots of *A. sieberiana* var. *woodii*.

Toxicity appears only in sporadic outbreaks, being dependant on a number of factors, including the species and variety of *Acacia*, the rate of ingestion by the animal and the availability of alternative feeds. It is more likely to occur during periods of drought or feed scarcity when hungry animals consume large quantities of feed in a short period of time. Access to cold water during feeding appears to promote the release of HCN from the substrates. Practical measures can be taken to reduce the risk of poisoning such as restricting the intake, particularly of leaves and immature pods, separating the time or place of feeding and watering, and feeding dangerous material with molasses or sulphur. These substances combine with HCN to form harmless cyanhydrin and sulphocyanides respectively (Steyn and Rimington, 1935).

Phenolic compounds

There are numerous reports of the presence of polyphenolic compounds in the various components of plants of the genus *Acacia*. From the standpoint of nutrition, the most important of these are the tannins, compounds with molecular weights in excess of 500, which are able to form complexes with, and to precipitate proteins (McLeod, 1974; Mangan, 1988). Hydrolyzable tannins are readily broken down by acids, bases and enzymes to form sugars and phenolic carboxylic acid and are therefore easily degraded in the gut. In contrast, condensed tannins are not degraded and so are available to form complexes with proteins, resulting in reduced feed intake and digestibility. McNaughton (1987) suggested that at levels above about 5%, increasing the tannin content in a diet reduced its palatability.

Reed *et al*., (1990) assessed the effects of polyphenolics on intake, growth, digestibility and nitrogen utilization by sheep. Three *Acacia* forages, (phyllodes of *A. cyanophylla*, leaves of *A. seyal*, and fruit of *A. sieberiana*), all containing high levels of polyphenolics, were compared with three protein supplements and another fodder tree *Sesbania sesban* which is low in polyphenolics. All diets were fed in combination with teff straw (*Eragrostis abyssinica*). The diets containing *Acacia* led to the highest levels of feed refusal by the sheep their and lowest intake of teff straw. Fibre digestibility was lower for these diets and the tannins complexed with proteins, resulting in higher levels of faecal nitrogen.

A complementary study by Tanner *et al*., (1990) reported significant differences in the growth rates of sheep supplemented with fruits from four different *Acacia* spp. (*A. tortilis, F. albida, A. nilotica* and *A. sieberiana*) even though there were no significant differences in total nitrogen intake. The tannin-rich fruits, particularly of *A. sieberiana* and *A. nilotica*, reduced feed intake and the efficiency of nitrogen utilization by forming complexes with proteins which again resulted in a shift of nitrogen excretion from urine to faeces. The growth rates of sheep fed the diets low in polyphenolics (*F. albida* and *A. tortilis*), were not significantly different from sheep supplemented with noug meal (*Guizotia abyssinica*), indicating their suitability as dietary supplements.

The literature abounds with conflicting reports on the suitability of *Acacia* spp. for livestock feed.

Dumancic and Le Houerou (1981) considered the phyllodes of *A. cyanophylla* to be sufficient to meet the protein maintenance requirements of sheep, while Reed *et al.*, (1990) reported a negative nitrogen balance for animals fed on this legume. Predictions of the productive responses of livestock are problematical and uncertain. There are a number of possible explanations for the conflicting reports:

- the chemistry of tannins is complex and analytical results do not always correlate with biological effects, e.g. nitrogen digestibility;
- a single feed may contain more than one anti-nutritive factor. *A. nilotica* is known to have both tannins and catechin gallates (Mueller-Harvey *et al.*, 1987);
- the concentration and type of phenolic compound both vary with season and in response to stimuli such as defoliation;
- there is much variation between both species and provenance in tannin content, the effect being both genetic and environmental.

Management

Where the principal use of *Acacia* spp. is for browsing by livestock, little is done to manage the resource, except through some measure of defoliation control by herding the animals. High branches are lopped during times of feed shortage, particularly in the dry season. At other times of the year, the trees are subjected to uncontrolled browsing, often by both wild and domestic animals.

Many legumes produce seed which has a hard, impermeable seed coat. Such seed will not germinate until moisture is able to penetrate it. This characteristic, known as 'hard seededness', prevents the simultaneous germination of the entire stock of seed in the soil at the start of the wet season. This adaptation favours the long-term survival of the population where rainfall is unpredictable. It is, however, a disadvantage when attempting to establish new stands from seed, particularly in areas with a short growing season. *Acacia* shows extreme variability in the degree of hard seededness, both between and within species; the proportion of hard seed in a sample depends on the environmental conditions during plant growth, the maturity of the seed at harvest and the length of time it has spent in storage. In general, Australian species respond to seed scarification. Recommended treatments (Doran and Gunn, 1987) include:

- manual nicking of the seed coat. Because of the amount of labour involved, this is suitable only for seed for germination tests, or for valuable research lots;

- placing the seed in boiling water for one minute. This is recommended for many hard-coated seed lots;

- placing the seed in hot water (80-90°C) for one minute. This is recommended where sensitivity to boiling water is suspected.

In Central Australia where annual rainfall is about 300 mm, native *Acacia* spp. naturally regenerate after exceptionally high rainfall at populations of some 5000 stems/ha, and many species produce multiple stems. Subsequent fires and drought will thin the stand to 100-400 stems/ha. Under these conditions, the optimum stocking level for planted stands may be in the region of 1000 seedlings/ha, followed by thinning as the stand matures. Alternatively, where thinning is not practical, an initial stand of about 400 trees/ha would be appropriate (Kube, 1987). The seed is scarified in hot water (80°C) and germinated in trays. Seedlings are transplanted after a few days into individual tubes 5 cm in diameter by 15 cm deep, filled with a potting mixture of equal parts of coarse sand, fine sand or sandy loam and peat moss. Treatment with fungicide is usually necessary and the seedlings are grown in decreasing shade for about three months before planting out. Supplementary irrigation is applied for 6-12 months, depending upon rainfall. Growth is often rapid, many species attaining heights of 2 m in about two years.

In Tanzania, *A. mearnsii* plantations have been established for fuelwood, charcoal and building poles by direct seeding scarified seed at rates of 1.2-2.4 kg/ha in rows 1.8 m apart in fully cultivated soil (Kessy, 1987). The major problem with this species has been its susceptibility to competition from weeds. Harvesting has been on an 8-12 year cycle and natural regeneration has taken place after the original stand has been clear felled and burned.

Alternative uses

While *Acacia* is the largest of the mimosoid genera and the second largest of all the legume family, only about 75 members have economic value, and of these only about 50 are actually cultivated. Nevertheless, they are used in various ways, as described by Allen and Allen, (1981) and Boland, (1987).

Many *Acacia* spp. form spiny, slow-growing scrub which provides protection against soil erosion caused by wind and rain. Their tolerance of harsh conditions makes them valuable for stabilization and revegetation of difficult sites. *A. armata*, *A. glaucescens*, *A. pycnantha* and *A. suaveolens* tolerate salt spray and so can be used to stabilize coastal sand dunes. *A. decurrens* is planted along roadsides in Australia and on denuded hills in Rwanda. *A. mearnsii* and *A. dealbata* are used to control gulley and hillside erosion in New Zealand.

Acacia is an important source of fuelwood or charcoal in arid regions. *A. mearnsii* is used for both domestic fuel and tobacco curing in Indonesia (NAS, 1980). It also provides poles for mining and agriculture in many parts of the world.

As timber, *Acacia* wood is extremely durable and although it is hard to work, it finishes well. Smaller species provide wood which is used to make implement handles, pipes and furniture, while larger species are used for paneling, boats and musical instruments. Hawaian mahogany (*A. koa*) was once prized for making surfboards, canoes and bowls while *A. segal* and *A. tortilis* were the principal trees of the Arabian Desert region. *A. glaucescens* and *A. melanoxylon* are major timber trees today. *A. dealbata* and *A. mearnsii* are used for pulping in Australia and Japan, while the latter species is used in the production of rayon in South Africa and India.

A. mearnsii is the world's most important source of vegetable tannin, 35-40% of the air-dry weight of bark is extracted for leather manufacture. Yields in excess of 15% are also obtainable from other species such as *A. albida* and *A. cyanophylla*. Wood adhesives and polyurethane foams can be prepared from bark extracts of *A. mearnsii*, and used as substitutes for petroleum products .

Gum arabic, an important emulsifier, protective colloid, adhesive and binder, is produced in commercially exploitable quantities by *A. arabica*, the principal historical source, and more recently by *A. senegal* and some 20 other species of *Acacia*. It is used in foods, pharmaceuticals, cosmetics, adhesives, paints, polishes and inks and in lithography, photography, textile-sizing and other processes.

Species such as *A. dealbata*, known as mimosa by florists, *A. albida* and *A. tortilis*, are valued as ornamentals while *A. farnesiana* and *A. dealbata* are used in the production of base oils for perfumes. In Australia, several species are valuable sources of pollen in apiculture.

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Appendix 1

Proximate and fibre analyses of bipinnate *Acacia* spp.

	Dry matter %	Crude protein	Crude fibre	Ash	Ether extract	NFE	NDF	ADF
			(% of dry matter)					
Faidherbia albida LEAVES								
No. of data	1	4	4	4	3	2	0	0
Low	36.3	17.1	12.4	6.4	1.6	51.9		
High	36.3	19.7	19.6	8.4	3.7	59.8		
Mean	**36.3**	**18.1**	**16.8**	**7.4**	**2.5**	**55.8**		
Faidherbia albida FRUIT								
No. of data	0	6	5	6	4	4	1	1
Low		8.8	21.4	2.7	0.7	42.6	37.4	27.9
High		14.3	40.7	6.3	1.5	61.7	37.4	27.9
Mean		**12.0**	**27.8**	**4.0**	**1.1**	**53.6**	**37.4**	**27.9**
Faidherbia albida PODS								
No. of data	0	1	0	1	0	0	1	1
Low		7.8		3.8			44.3	31.9
High		7.8		3.8			44.3	31.9
Mean		**7.8**		**3.8**			**44.3**	**31.9**
Faidherbia albida SEEDS								
No. of data	0	1	0	1	0	0	1	1
Mean		**27.9**		**4.9**			**29.7**	**18.2**

Continued

	Dry matter %	Crude protein	Crude fibre	Ash	Ether extract	NFE	NDF	ADF
			(% of dry matter)					
Acacia brevispica LEAVES								
No. of data	0	5	5	5	5	5	0	0
Low		17.1	18.0	5.6	2.0	41.5		
High		26.0	29.9	8.2	5.7	51.0		
Mean		**19.6**	**23.5**	**6.6**	**3.7**	**46.7**		
Acacia drepanolobium LEAVES								
No of data	0	1	1	1	1	1	0	0
Mean		**15.4**	**29.8**	**5.5**	**2.3**	**47.0**		
Acacia farnesiana LEAVES								
No. of data	1	1	1	1	1	1	0	0
Mean	**40.0**	**17.2**	**17.9**	**5.2**	**2.1**	**57.1**		
Acacia farnesiana FRUIT								
No. of data	0	1	1	1	1	1	0	0
Mean		**17.2**	**19.4**	**4.1**	**1.6**	**57.7**		
Acacia farnesiana SEEDS								
No. of data	0	1	1	1	1	1	0	0
Mean		**20.9**	**18.3**	**3.8**	**2.3**	**54.7**		

Continued

	Dry matter %	Crude protein	Crude fibre	Ash	Ether extract	NFE	NDF	ADF
			(% of dry matter)					
Acacia mellifera LEAVES								
No. of data	1	4	4	4	4	4	0	0
Low	34.1	8.0	14.1	6.2	1.8	32.2		
High	34.1	42.8	45.8	10.2	2.6	53.4		
Mean	**34.1**	**28.7**	**23.1**	**7.8**	**2.4**	**38.0**		
Acacia nilotica LEAVES								
No. of data	0	3	3	3	3	3	0	0
Low		11.9	11.3	5.5	2.0	42.9		
High		16.2	31.6	7.3	12.6	59.1		
Mean		**13.7**	**21.4**	**6.4**	**5.6**	**52.9**		
Acacia nilotica FRUIT								
No. of data	1	7	6	7	6	6	1	1
Low	90.1	10.4	12.3	4.7	0.8	51.2	31.6	22.5
High	90.1	13.1	28.5	13.8	3.0	68.6	31.6	22.5
Mean	**90.1**	**12.0**	**17.0**	**6.6**	**2.0**	**62.3**	**31.6**	**22.5**
Acacia nilotica PODS								
No. of data	0	1	0	1	0	0	1	1
Mean		**9.7**		**6.5**			**29.8**	**22.8**

Continued

	Dry matter %	Crude protein	Crude fibre	Ash (% of dry matter)	Ether extract	NFE	NDF	ADF
Acacia nilotica SEEDS								
No. of data	0	1	0	1	0	0	1	1
Mean		**21.1**		**6.9**			**39.8**	**29.3**
Acacia oerfota LEAVES								
No. of data	0	2	2	2	2	2	0	0
Low		32.4	15.8	8.8	1.7	41.2		
High		32.5	15.8	8.9	1.7	41.3		
Mean		**32.5**	**15.8**	**8.8**	**1.7**	**41.3**		
Acacia senegal LEAVES								
No. of data	1	4	4	4	4	4	0	0
Low	88.4	18.2	11.2	6.8	2.2	41.3		
High	88.4	20.5	27.7	8.4	6.7	55.5		
Mean	**88.4**	**19.8**	**23.6**	**7.7**	**3.5**	**45.3**		
Acacia senegal FRUIT								
No. of data	0	2	2	2	2	2	0	0
Low		19.6	19.0	5.3	1.0	30.9		
High		22.0	29.6	7.1	2.1	43.3		
Mean		**20.8**	**24.3**	**6.2**	**1.6**	**37.1**		

Continued

	Dry matter %	Crude protein	Crude fibre	Ash	Ether extract	NFE	NDF	ADF
			(% of dry matter)					
Acacia senegal SEEDS								
No. of data	1	2	2	2	2	2	0	0
Low	86.7	38.9	13.7	5.0	5.8	25.5		
High	86.7	40.1	20.6	5.9	10.0	35.4		
Mean	**86.7**	**39.5**	**17.1**	**5.4**	**7.9**	**30.5**		
Acacia seyal FRUIT								
No. of data	1	2	2	2	2	2	0	0
Low	95.3	20.9	20.2	5.6	1.4	43.7		
High	95.3	21.9	27.4	9.3	1.9	47.7		
Mean	**95.3**	**21.4**	**23.8**	**7.4**	**1.6**	**45.7**		
Acacia sieberiana LEAVES								
No. of data	1	1	1	1	1	1	0	0
Mean	**48.8**	**15.8**	**23.6**	**11.6**	**6.3**	**42.7**		
Acacia sieberiana FRUIT								
No. of data	2	4	3	4	3	3	1	1
Low	89.8	8.4	20.2	4.0	1.3	42.7	37.0	28.2
High	94.5	12.8	40.2	9.0	1.9	57.9	37.0	28.2
Mean	**92.2**	**11.4**	**28.5**	**6.2**	**1.5**	**52.4**	**37.0**	**28.2**

Continued

	Dry matter %	Crude protein	Crude fibre	Ash	Ether extract	NFE	NDF	ADF
		(% of dry matter)						
Acacia sieberiana PODS								
No. of data	0	1	0	1	0	0	1	1
Mean		**9.8**		**6.8**			**40.5**	**32.7**
Acacia sieberiana SEEDS								
No. of data	0	1	0	1	0	0	1	1
Mean		**19.6**		**4.8**			**39.3**	**26.3**
Acacia tortilis LEAVES								
No. of data	1	3	3	3	3	3	0	0
Low	90.9	6.5	9.4	8.7	2.8	47.8		
High	90.9	19.2	34.1	9.6	8.3	59.4		
Mean	**90.9**	**13.0**	**18.4**	**9.0**	**5.7**	**53.9**		
Acacia tortilis FRUIT								
No. of data	0	5	4	5	4	4	1	1
Low		12.3	17.5	4.7	1.7	49.1	32.4	24.2
High		17.8	24.8	8.4	3.1	57.9	32.4	24.2
Mean		**15.8**	**20.5**	**6.5**	**2.1**	**54.1**	**32.4**	**24.2**
Acacia tortilis PODS								
No. of data	0	1	0	1	0	0	1	1
Mean		**7.8**		**6.9**			**39.4**	**26.4**

Continued

	Dry matter %	Crude protein	Crude fibre	Ash (% of dry matter)	Ether extract	NFE	NDF	ADF
Acacia tortilis SEEDS								
No. of data	0	2	1	2	1	1	1	1
Low		19.1	10.9	4.6	6.0	39.7	33.7	23.9
High		37.8	10.9	5.9	6.0	39.7	33.7	23.0
Mean		**28.5**	**10.9**	**5.2**	**6.0**	**39.7**	**33.7**	**23.9**

Sources: Tanner *et al.*, (1990); Le Houerou, (1980); Goodchild and McMeniman, (1987); Gohl, (1981) Skerman *et al.*, (1988).

Notes:
NFE - nitrogen free extract
NDF - neutral detergent fibre
ADF - acid detergent fibre

Appendix 2

Proximate analyses of *Acacia* phyllodes

	Crude protein	Crude fibre	Ash	Ether extract	NFE
Acacia aneura					
No. of data	4	4	4	4	4
Low	9.2	27.9	5.0	1.1	47.2
High	13.2	32.9	6.9	4.6	51.5
Mean	**11.7**	**30.0**	**5.9**	**2.7**	**49.7**
Acacia cambagei					
No. of data	1	1	1	1	1
Mean	**13.3**	**15.9**	**11.0**	**3.1**	**55.2**
Acacia holosericea					
No. of data	2	2	2	2	2
Low	7.8	38.6	6.0	4.0	32.3
High	14.1	38.9	6.3	8.7	43.3
Mean	**11.0**	**38.8**	**6.2**	**6.3**	**37.8**
Acacia salicina					
No. of data	1	1	1	1	1
Mean	**18.1**	**23.8**	**14.7**	**6.0**	**37.4**
Acacia trachycarpa					
No. of data	1	1	1	1	1
Mean	**14.6**	**32.6**	**7.2**	**5.0**	**40.0**
Acacia tumida					
No. of data	1	1	1	1	1
Mean	**15.7**	**30.2**	**7.2**	**6.7**	**40.2**

Sources: Skerman et al. (1988); Gohl (1980); Hamel (1981).

Notes: NFE - nitrogen free extract.