ECOLOGICAL AND NUTRITIVE ASSESSMENT OF INDIGENOUS BROWSE SPECIES AS FEED FOR RUMINANT ANIMALS IN GRAZING AREAS OF CHOMA (SOUTHERN PROVINCE OF ZAMBIA)

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By

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A RESEARCH PROJECT REPORT

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DEDICATION

I dedicate this thesis to my parents, grandparents, siblings and to the University of Zambia's Animal science graduates, class of 2013.

DECLARATION

This Bachelor's of Science in Agricultural Sciences (BSc. Agric. Sciences) thesis represents my own work and it has not been previously submitted for a degree at this or any other university. All the sources of information have been acknowledged by citation and references.

Name.................................. Date..19/09/13...

ACKNOWLEDGEMENTS

I am deeply grateful to the following people, without whose support this thesis could have not been completed.

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ABBREVIATIONS

ADF	:	Acid Detergent Fibre
AOAC	:	Association of Official Analytical Chemists
CF	:	Crude Fibre
CP	:	Crude Protein
IVDMD	:	*In Vitro* Dry Matter Digestibility
NDF	:	Neutral Detergent Fibre

ABSTRACT

An ecological and nutritive assessment of five indigenous browse tree species was carried out to determine the usefulness of their leaves as dry season feed for ruminants in Choma District in Southern Zambia. Vegetative assessment was done to measure the specie's frequency and density using the quadrant method. Proximate analysis and *in vitro* dry matter digestibility test was used to assess the nutritive value of the leaves of the browse species. The four trees with the exception of *Parinari curatellifolia* were dominant in the grazing lands of Choma. *Julbernardia globiflora* had the highest density of 6 %, followed by *Brachystegia spiciformis* with 31%, *Dichrostachys cinerea* with 3%, *Piliostigma thonningii* with 3% and *Parinari curatellifolia* with 2%. Crude protein were similar for *Julbernadia globiflora* and *Brachystegia spiciformis* with 11.70±0.14 and 11.42±0.31 respectively but were higher than for *Dichrostachys cinerea* and *Piliostigma thonningii* ($p<0.05$). Crude fibre was found to be lowest in *Dichrostachys cinerea* with 18.16±0.16% which also contained the highest amount of tannins with 4.10±0.06% ($p<0.05$). *Piliostigma thonningii* had the highest levels of calcium of 1.76±0.03% and *Dichrostachys cinerea* had the least amount with 1.35±0.18% ($p<0.05$). The leaves of *Brachystegia spiciformis* had the highest digestibility of 67.95±0.85%, followed by *Dichrostachys cinerea* with 66.03±1.95%, *Julbernadia globiflora* with 49.47±1.06%, and *Piliostigma thonningii* with 24.82±2.62% ($p<0.05$). Overall, the browse species assessed are abundant and have a good potential to supply nutritious and fairly digestible feeds suitable for ruminant feeding in the dry season.

Key words: Crude fibre, *in vitro* dry matter digestibility, specie's density, tannins

CHAPTER 1

1.0 INTRODUCTION

Livestock production is a key element of socioeconomic development in many countries in the tropics (FAO, 2005) and also contributes to nutritional and food security and plays an important role in cultural events (Nianogo and Thomas, 2004).

Ruminant livestock production, in many areas of Africa, has long been of major importance to the rural population. It has served many purposes: in the direct production of food, providing traction for transportation, as a cash reserve for emergency investments and long term saving, and in the fulfillment of social obligations. Another important input is the use of draught animals as a source of power in agriculture (FAO, 2007). Draught cattle are used for ploughing, weeding, harvesting and transportation. With draught cattle, smallholder farmers can double or triple the cultivated area, thereby increasing crop output at low cost.

However, ruminant production across most of these areas is constrained by the poor quality of the consumed feed. The alternating relatively long-dry and short-rainy seasons, as one moves from the south to the north of tropical areas, has a major influence on the productivity and quality of rangeland. Sustainability of these production systems has been facing a lot of challenges in Africa especially with reference to availability of adequate animal feed resources (Chibinga et al, 2012).

Zambia is endowed with a ruminant population of approximately 2.6 million cattle, 580 000 goats and 65 000 sheep (Simbaya, 1998). More than 85% of ruminants in Zambia are found in the traditional smallholder sector and their production is limited by inadequate nutrition during the dry-season. This is because these animals depend on fibrous crop-residues and natural pasture which are usually in short supply and of low nutritive value. Inadequate nutrition in the dry season often results in reduced productive and reproductive performance of livestock which culminate in substantial economic losses to the farmers (Simbaya, 1998). One of the strategies to overcome this challenge is the use of browse feed in the dry periods of the year.

Information on vegetation of grazing lands is critical to our understanding of livestock production and our ability to manage both animal and plant resources to optimize the productivity of grazing lands. In a FAO's report (1995), it was mentioned that livestock use 3.3

billion hectares of grazing lands such as rangelands (i.e. grasslands, shrublands, savannas, tundra and open forest lands), pasturelands and grazed forests. To most effectively manage vegetation and grazing animals for livestock production with care to avoid overuse and destruction of natural resources, we need information concerning vegetation ecology and an understanding of plant-animal interactions. Measurements or estimations of vegetation characteristics, such as weight, cover, density, and nutritional value and of foraging behaviour are vital to achieve this knowledge. (Ben Salem et al. 2005).

Browse tree species are plants that are palatable to animals. They include a wide range of low-growing species that have palatable leaves, flowers, fruits, small stems and twigs. They remain green during the dry season when most natural grasses have dried up. Generally, their nutritive values are higher than those of natural grasses. (Chileshe, 2002)

Browse trees benefit soils by protecting them from erosion and may increase soil fertility. They also benefit crops and animals with shade, and provide people with fuel, medicines and building materials. (Woodward and Reed, 1989)

However, a few problems are associated with using fodder trees and shrubs: Some may be mildly toxic. Accessibility may be difficult, as animals cannot feed above two metres, and some plants are thorny. Some browsable plants have an unpleasant odour, which makes them unacceptable to cattle. They have so-called antinutritional substances, which make them unsuitable as the only feed. They are still valuable as a complement of the diet, and as dry season and drought feeding. (Chileshe, 2002)

Twenty one (21) different species of browse have been identified by the agro-pastoralists as being important for ruminant feed in the dry season, in Choma district in Southern Province. However, there exists little information about the ecological and nutritional assessment of these browse species hence the need to carry out this research. (Chibinga et al, 2012).

1.1 RESEARCH OBJECTIVES

The main objective of this research was to determine the distribution and abundance of the browse species and to estimate their chemical composition as well as digestibility to ascertain their usefulness as feed for ruminants in the dry season.

The specific objectives were

- To assess the species density (number of browse tree species per given unit area), and their frequency;
- To estimate the chemical composition of the leaves of the browse tree species by carrying out proximate analysis;
- To determine the digestibility of the browse leaves with the use of the *in vitro* dry matter digestibility (IVDMD) test.

CHAPTER 2

2.0 LITERATURE REVIEW

Herders are facing new challenges to secure their livelihoods, and, in this context, fodder trees and shrubs are emerging as key resources, allowing herds to subsist up to the end of the dry season (Gautier et al, 2005 Ouédraogo-Koné *et al., 2006).*

Many browse species remain in full leaf and are green even during the driest period of the year. They are in general deep-rooted, resistant to drought, have a long life, act as windbreaks, have low demands on maintenance and can conserve soil moisture (Humphreys, 1994*).*

In the past years several new techniques of estimations of vegetation characteristics have been developed or old techniques have been modified, the problem concerning what is the best technique in terms of accuracy and precision stays open. Terms such as biomass, frequency of browse, cover and density are used to describe the ecological condition of grazing land and its ability to contribute nutrients to a grazing animal. Biomass is one of the most important characteristics of grazing land vegetation and it is defined as the total amount of living plants and animals above and below ground in an area at a given time (Range Term Glossary Committee, 1989). According to the same source, browse is "that part of leaf and twig growth of shrubs, woody vines and trees available for animal consumption". Cover is "the plants or plant parts, living or dead, on the surface of the ground or the area of ground cover by plants of one or more species", while density is "the number of individuals per unit of area". (Ben Salem et al. 2005). It is obvious that the estimation of the above vegetation parameters, especially forage production, are very useful to project stocking rates and feed requirements for specific time periods (i.e. annually, grazing season, rotation cycle, etc.). In addition, the degree to which forage meets the nutritional requirements of a specific kind and class of animal (i.e. forage quality; Allen and Segarra, 2001) is always important to be taken into account (Ben Salem et al. 2005).

Density determinations are useful when one is more interested in the number of individuals rather than cover or biomass, such as in evaluations of seedlings. Density can be determined by the use of quadrants or distance techniques (Cook and Stubbendieck, 1986).

Weight (biomass yield) is the most important expression of herbage production. Clipping is probably the most common method for determining herbage weight for pasturelands and grasslands where the vegetation is primarily herbaceous and is stratified into relatively homogeneous types. The herbage weight is determined in representative small plots (quadrants), which can be varied in size and shape (e.g. rectangular, quadrangular, and circular; Cook and Stubbendieck, 1986). Herbage weight from such quadrants is multiplied by a given factor to obtain kg/ha (Ben Salem et al. 2005).

Cover (area occupied) has often been used as a primary attribute of vegetation in ecological or rangeland studies. Cover can be used as a basis for comparison among plants of differing life forms and is a non-destructive measurement. Permanent sampling units can be established and repeated measurements taken. Basal cover has often been used to evaluate herbs while canopy or aerial cover has commonly been used for woody plants. (Ben Salem et al. 2005).

Browse production and availability is influenced by many environmental factors such as climatic, edaphic and topographic conditions and management background involving exploitation by animals, lopping and burning forested areas. Browse productivity (production per unit area) has been found to be linked to habitat and soil texture. For instance, in a study carried out by Cisse and Wilson (1984) at Niono in Mali, the number of *Pterocarpus lucens* trees found on clay, loamy-clay and sandy soils was 845, 100 and 94 per hectare, respectively. The corresponding foliage production was 3.5, 0.9 and 0.4 tons DM/ha. In the same zone, and open woodland with *Sclerocarya birrea* and *Guiera senegalensis* produced only 0.02 ton DM/ha (Ben Salem et al. 2005).

Trees and shrubs survive harsh climatic conditions such as drought and are an important source of browse feed in the arid and semi-arid savannas of Africa. However, although tree leaves have high protein content, tannins and other secondary compounds may bind this protein, thus rendering it unavailable to the animal. Indeed, tannins and related polyphenolics may have negative effects on palatability and digestibility, and many are also poisonous. Increasing browse cannot therefore be viewed as a simple substitute for declining grass cover. Certainly in grazing areas browse can provide feed in dry seasons to cattle and other domestic stock when the grasses have a low nutritional value, or have all but disappeared. Along the Boteti *Acacia erioloba* pods, dry *Terminalia* leaves and browse were found in the dung deposits of wildebeest

(DHV, 1980) suggesting th protein boost provided by such browse when graze values are low or negligible, may be critica

The main features of brows plants are their high crude protein (CP) and mineral contents. The concentration of CP in the eaves and fruit of the majority of fodder trees and shrubs is above 10% even in the dry season. Generally, calcium and potassium contents are higher than those of other minerals. The role of ees and shrubs in the supply of vitamins is indirectly demonstrated in dry tropical Africa by e fact that browsers such as goats and camels seldom contract photophobia or eye inflamm ation which many cattle are prone to during the dry season.

The dry matter digestibility which is related to nutrient composition, varies widely among tree and shrub species. A range om 38 to 78% was given by Skarpe and Bergstrom (1986) working in Botswana with Kalahar woody species. Similar findings were reported by McKay and Frandsen (1969) and Walk r (1980). However, digestibility alone gives a poor assessment of the nutritive value of fodd r trees and shrubs. This is because there is often no relationship between digestibility and in ake.

Low intake and digestibil ty of browse may have some connection with the deleterious substances that it may cont in. For instance, some browse species contain substances such as cyanogenic glucosides, flu roacetate or tannins which may considerably reduce their nutritive value or even be toxic to nimal. However, toxicity depends upon the concentration of the deleterious compound in th fodder and the rate at which the forage is eaten. "An amount of the plant eaten quickly, say in ne hour, could be fatal, whereas the same amount of plant material eaten slowly over, for exan ple, a five hour period, would be harmless" (Storrs, 1982). On the range, the chances of an mals getting poisoned are remote because they actually eat a combination of species and browse slowly, particularly when the plant is armed with defensive structures such as hairs and horns.

A research by Chibinga et al (2012), investigating the chemical composition and in vitro dry matter digestibility in the eaves of *Julbernardia globiflora* at four different post sprouting stages was conducted to de ermine the usefulness of the browse as dry season feed and it was found that the leaves of *Julbernardia globiflora* have a good potential to supply highly digestible feeds suitable fo ruminants in the dry season. There was a general decrease in the crude protein with increase in maturation of the leaves. This decrease in crude protein as the leaves mature could make nitrogen a limiting factor to intake and digestibility. However, the protein range is still above the adequate range (10-13%) for maintenance and growth for cattle, sheep and goats (kearl, 198[illegible]).

For most of the fodder trees and shrubs identified in dry tropical Africa, knowledge of browse production and chemical composition is still insufficient. Overcoming this constraint would ensure maximization of the use of this fodder by livestock.

CHAPTER 3

3.0 METHODOLOGY

3.1 Study area

The study was conducted in grazing lands of Choma District (Mochipapa area) in Southern Province, Zambia. Choma is situated at 16.82° South latitude, 26.98° East longitude and 1325 meters elevation above sea level (map data© 2013 Google). It covers an area of about 7, 296 square kilometers of land. It is found on high ground with typical climate of southern Zambia of temperatures of between 14 °C and 28°C. The rainfall pattern is from October-November to March-April with mean annual rainfall about 800mm of which 369mm falls between January and February. Agriculture is the main economic activity with approximately 180 commercial farmers, 150 emergent farmers and approximately 23, 206 small scale farmers who are involved in production of cash crops or rearing of livestock (Choma municipal council, 2013).

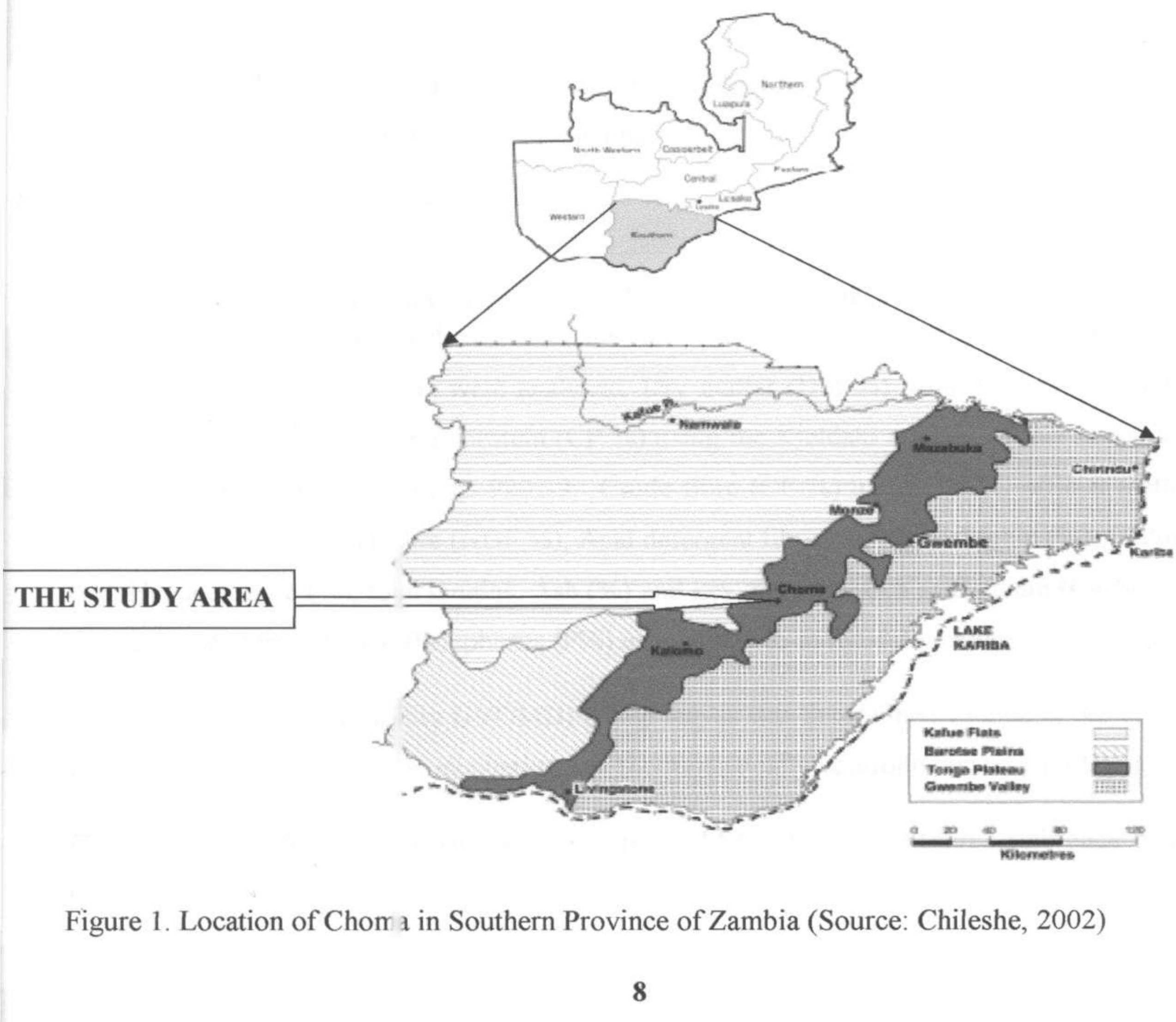

Figure 1. Location of Choma in Southern Province of Zambia (Source: Chileshe, 2002)

3.2 Vegetative Sampling design

Vegetative field sampling was done at plot levels. 10 x 10meters fifty (50) plots were established at 1 km intervals to quantify species density and frequecy. The density was estimated as described by Cook and Stubbendiek (1986). Species Frequency was estimated as applied by Abercombie *et al.* (1980) based on percentage of occurrence of individual plant species in relation to the total number of observation points. Accordingly, the abundance status of each plant genera or family will be categorized as dominant (frequency of occurrence of ≥15%), common (frequency of occurrence of 6-14%), less common (frequency of occurrence of 4-5%) and uncommon or scarce (frequency of occurrence of <4%).

Table 1. List of vegetation metrics that were assessed in this study and their definitions.

Metric	Definition
Density	Number of individual browse trees per unit area
Frequency	The ratio of the number of sample units that contain a particular species to the total number of sample units.

3.3 Chemical and in vitro dry matter digestibility tests of the leaves

The chemical composition of the leaves collected was determined by use of proximate analysis were the following parameters were analyzed: Dry matter (DM %) using Official Methods of Analysis, AOAC (1990); crude protein (CP %) using the Kjeldahl method; Ether Extract (EE %) using AOAC official methods 920.39; Crude fibre (CF %) using AOAC official methods 962.09; Neutral Detergent fibre (NDF %), Acid detergent fibre (ADF %), Lignin (%), Cellulose (%), Hemicellulose (%), total tannins, Ash (%) and key minerals such as Calcium (Ca %) using permanganate method; and Phosphorus (P%) using Vanodo-molybdate method.

In vitro dry matter digestibility (IVDMD) of the leaves was determined following the methods of Tilley and Terry (1963), by incubating in a thermostatically controlled water circulating bath.

The data was subjected to Analysis of Variance (ANOVA) using Minitab reference manual version 16.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

Table 2. Browse species from Mochipapa area of Choma assessed;

	Local name in Tonga	English name	Scientific name
1	Mweeye	Sickle bush	*Dichrostachys cinerea*
2	Muumba	-	*Julbernardia globiflora*
3	Musekese	Monkey bread, camel's foot	*Piliostigma thonningii*
4	Musiwe	Bean pod tree	*Brachystegia spiciformis*
5	Mubula	Hissing tree, fever tree	*Parinari curatellifolia*

Figure 2. Dichrostachys cinerea (Source; Author)

Taxonomy

Species: *Dichrostachys cinerea*

Family: *Fabaceae*

Local name (Tonga): Mweeye

The specie is a thorny and bushy semi-deciduous tree, 1-8m in height and is found throughout Zambia on most soils. Widely used for fodder (pods, young twigs and leaves), firewood, timber and medicine.

Figure 3. *Julbernardia globiflora* (Source; Author)

Taxonomy

Species: *Julbernardia globiflora*

Family: *Leguminosae*

Local name (Tonga): Muumba

The tree is a well-branched, deciduous, rounded tree, growing up to 15m in height. It occurs in mixed deciduous woodland co-dominant with *Brachystegia spiciformis*, it is ecologically important, growing over large areas of the escarpment and the Tonga plateau. Its tender leaves are fodder for livestock. Other uses are timber is used for canoes.

Figure 4. *Piliostigma thonningii* (Source; Author)

Taxonomy

Species: *Piliostigma thonningii*

Family: *Fabaceae*

Local name (Tonga): Musekese

It is a semi-deciduous tree, usually 3 to 5 m in height, reaching 10 m under ideal conditions. Branches are often twisted. The tree is found in all parts of Southern Province, especially in wooded grasslands at medium to low altitudes. Its presence is an indicator of high water levels. Pods and shoots are eaten by cattle; in Choma, pods are crushed and fed to pigs. The major constraint is that the trees are few and scattered.

Figure 5. *Brachystegia spiciformis* (Source; Author)

Taxonomy

Species: *Brachystegia spiciformis*

Family: *Fabaceae*

Local name (Tonga): Musiwe

A medium to large semi-evergreen tree growing 8 to 15 m high but can grow to 30 m in favorable conditions. The branches are heavy, growing upwards and outwards, often twisting and curving. It is a widespread tree over large areas of range. The young leaves **provide animal** feed, tannin from the bark is used in tanning hides, and the tree is widely used for fuel, both wood and charcoal

The following information on the five browse species under study was obtained from a personal conversation with Mr. Jerem ah M. Mapepula (Senior Agricultural Research officer, Zambia Agricultural Research Instit ıte, Choma). The ruminants prefer feeding on the fruits of *Dichrostachys cinerea* than o ı its leaves. There is abundance of these species in the upper land region of the study area than :owards the dumbo areas. This means that *Dichrostachys cinerea* thrives well in drier areas. *Jı lbernardia globiflora* and *Brachystegia spiciformis* are the most prominent species on upper l. nd. The two species though may seem to be similar differ in that the leaves of *Julbernardia globiflora* have tips which almost rounded whilst those of *Brachystegia spiciformis* hav ; tips which are pointed. The leaves of *Brachystegia spiciformis* also have a smooth texture ar 1 have a darker shade of green compared to those of *Julbernardia globiflora.* The other differen :e is that the bark of *Brachystegia spiciformis* tree is darker (Dark grey) compared to the bar : of *Julbernardia globiflora.* According to the local people, *Julbernardia globiflora* has higher fibre quality compared to *Brachystegia spiciformis.* *Piliostigma thonningii* is not frequently found around Mochipapa area. This could be because it is not genetically aggressive to survive around that area. The same is the case for *Parinari curatellifolia* which is liked b / the ruminant animals for its fruits

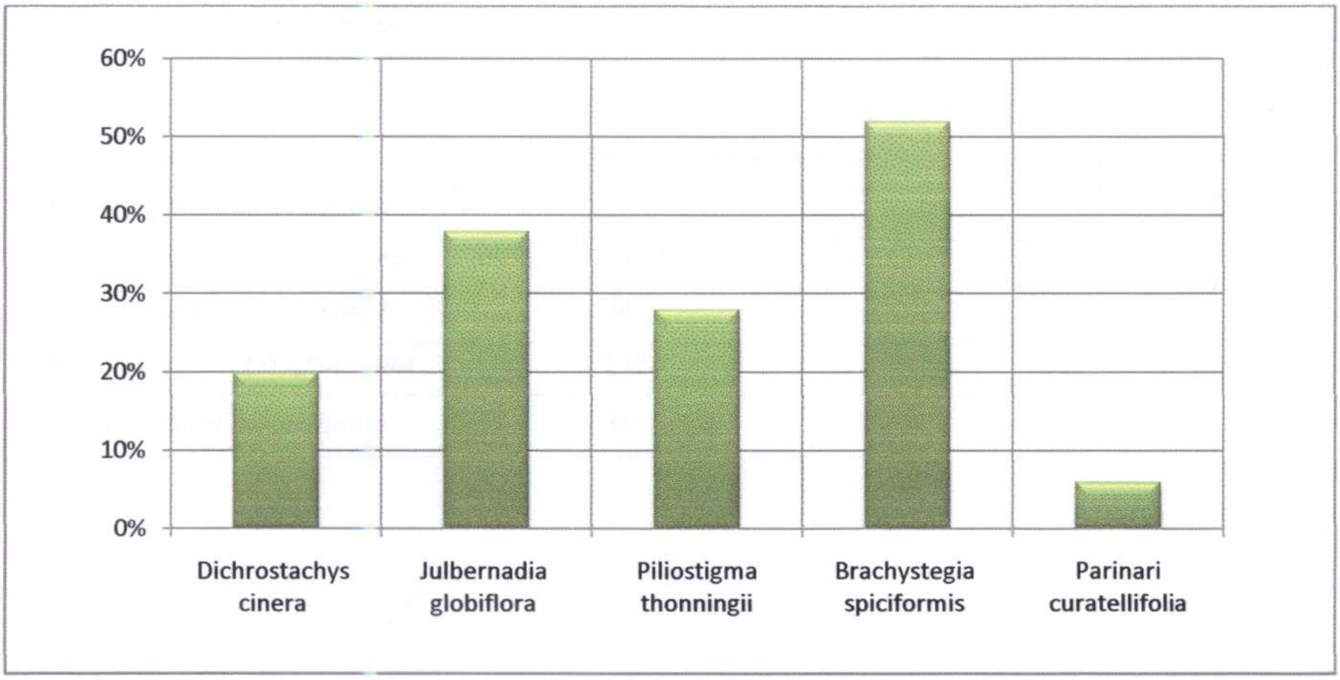

Figure 6. Frequency distribution

Table 3. Classification of the species frequency

	Species	Abundance
1	*Dichrostachys cinerea*	Dominant
2	*Julbernardia globiflora*	Dominant
3	*Piliostigma thonningii*	Dominant
4	*Brachystegia spiciformis*	Dominant
5	*Parinari curatellifolia*	Less common

Key (Abercombie *et al.* 1980)

>15% - dominant

6 – 14% - common

4 – 5% - less common

<4% - uncommon or scarce

Table 4. Density of the species

	Species	Density (trees/ha)
1	*Dichrostachys cinerea*	52
2	*Julbernardia globiflora*	1,056
3	*Piliostigma thonningii*	44
4	*Brachystegia spiciformis*	542
5	*Parinari curatellifolia*	34

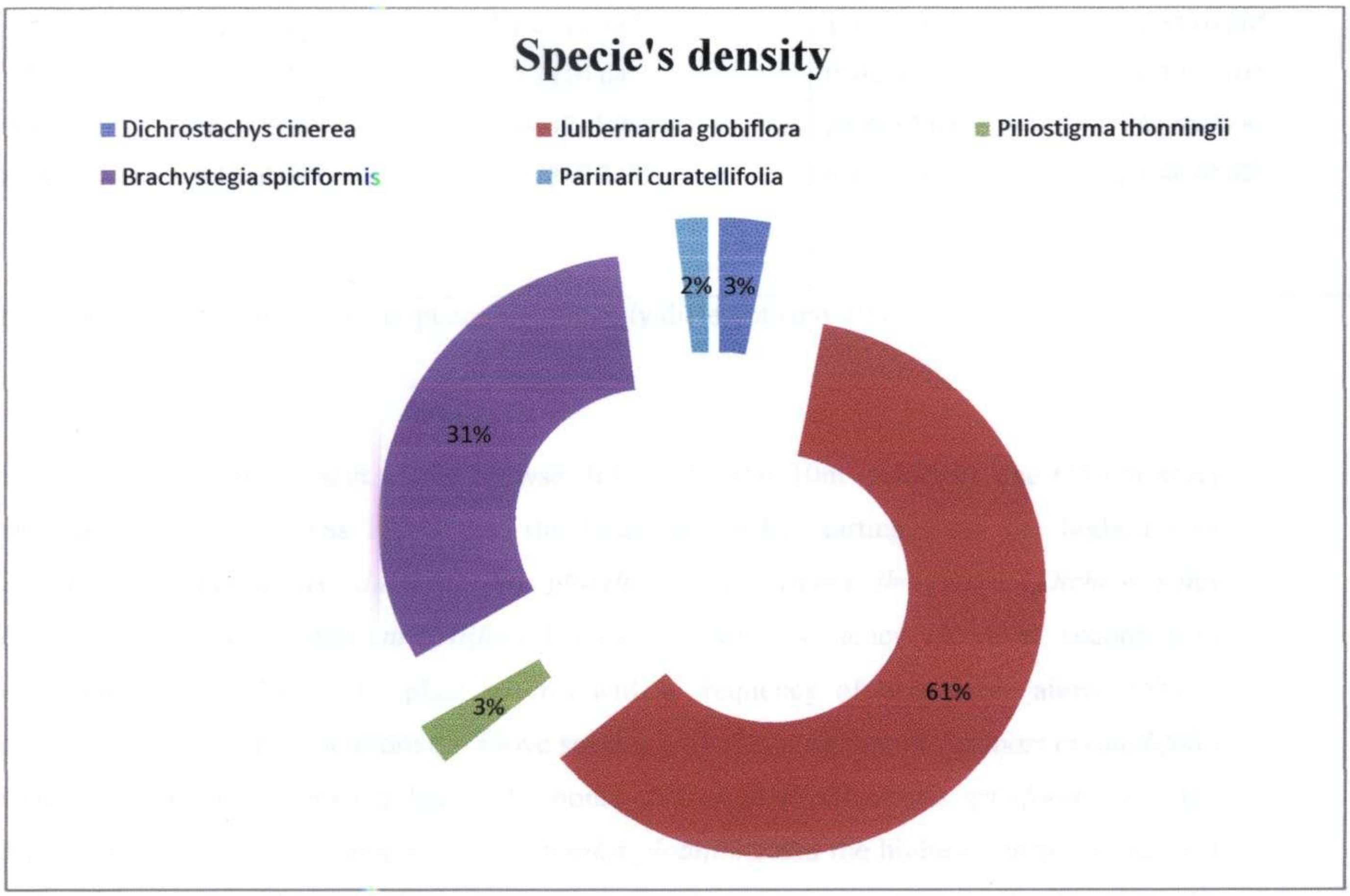

Figure 7. Density

Table 5. Chemical compositio ı (%) and in-vitro digestibility of browse tree leaves

Parameter (%)	*Dichrostachys cinera*	*Julbernadia globiflora*	*Piliostigma thonningii*	*Brachystegia spiciformis*
Dry matter	93.36±0.12[c]	94.52±0.18[a]	93.25±0.04[c]	93.77±0.01[b]
Crude protein	7.63±0.77[b]	11.70±0.14[a]	8.58±0.07[b]	11.42±0.31[a]
Ether extract	2.92±0.68	5.05±1.48	5.05±0.92	4.88±0.53
Crude fibre	18.16±0.16[d]	33.24±0.04[a]	28.03±0.07[b]	27.56±0.14[c]
ADF	20.30±2.91[a]	22.31±3.66[a]	17.06±4.31[b]	15.33±3.45[b]
NDF	33.74±2.66	32.38±5.39	40.64±8.66	28.27±1.78
Lignin	18.19±2.68[a]	14.94±1.69[a]	12.93±3.34[b]	9.42±2.47[b]
Hemicellulose	17.48±4.65[b]	17.43±1.84[b]	23.58±4.36[a]	12.93±2.64[b]
Cellulose	2.11±1.68[c]	7.37±1.97[a]	4.14±1.24[b]	5.91±2.87[b]
Ash	6.66±0.20[a]	4.63±0.10[c]	5.93±0.09[b]	4.43±0.11[c]
Calcium	1.35±0.18[b]	1.47±0.14[ab]	1.76±0.03[a]	1.53±0.06[ab]
Phosphorus	0.15±0.03[bc]	0.24±0.04[a]	0.19±0.02[ab]	0.12±0.01[c]
IVDMD	66.03±1.95[a]	49.47±1.06[d]	24.82±2.62[c]	67.95±0.85[a]
Tannins	4.10±0.06[a]	2.28±0.11[b]	0.11±0.06[c]	1.46±0.02[b]

Figures with a different super cript are significantly different ($p<0.05$)

In the ecological assessment of the browse, fifty (50) 10mx10m quadrants one (1) km apart were assessed and it was f ɔund that the frequency order starting from the highest was *Brachystegia spiciformis, J ılbernardia globiflora, Piliostigma thonningii, Dichrostachys cinerea* and finally *Parinari curatellifolia* having the lowest frequency. However, according to Abercombie *et al.* 1980, an plant species with a frequency of occurrence above 15% is classified as dominant. There ɔre the above species with the exception of *Parinari curatellifolia* were dominant in the grazir lands of Choma. Although *Brachystegia spiciformis* was the browse with the highest freqı ency, *Julbernardia globiflora* had the highest density (twice that of Brachystegia spiciformis). The implication is that there is more fodder availability from the species *Julbernadia globiflor* and *Brachystegia spiciformis* as they were both dominant and had a very high density compa ed to the rest of the species assessed.

Since browse production anc availability is influenced by a combination of environmental factor and management back round involving exploitation by animals, lopping and burning forested areas, it is therefore p ssible the above ecological assessment results of the distribution and abundance of the browse pecies were found in those numbers because of the above factors of the areas assessed.

The chemical composition an lysis data indicated that only ether extract and NDF of the four trees were not significantly di ferent from each other. The rest of the parameters analyzed were significantly different from ea h other (at $p<0.05$).

Crude protein was found to b in the same range for *Julbernadia globiflora* and *Brachystegia spiciformis* (11.70±0.14 and 1.42±0.31 respectively at $p<0.05$). These values fall within the crude protein requirements f ruminants which ranges from 10% - 13% (kearl, 1982). *Dichrostachys cinerea* and *P iostigma thonningii* had lower crude protein levels of the four species (7.63±0.77 and 8.58± .07 respectively at $p<0.05$) however; these crude protein levels are still higher than those of dried grass (has about 4-6% CP) and hay (2% CP) which is normally available in the dry season and therefore still important supplementary feed. It was also noted that generally dige tibility of the leaves was increasing as the crude protein content was increasing. This is shown elow:

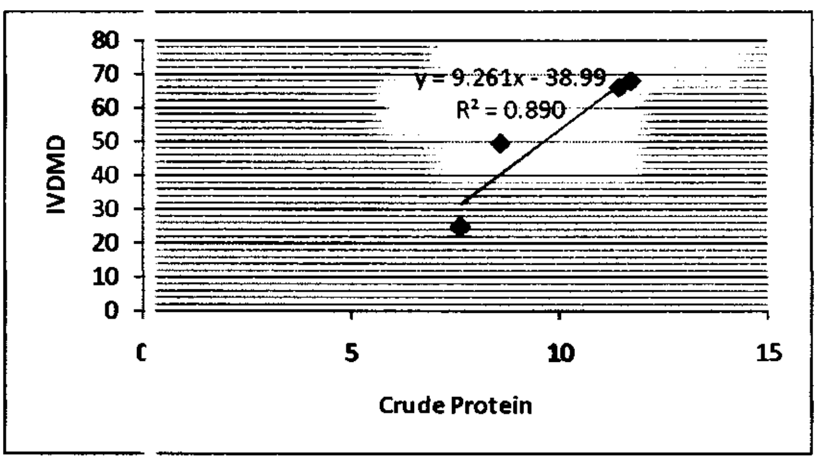

Figure 8. IVDMD vs. (rude Protein

Both NDF and ADF had a negative correlation to the digestibility

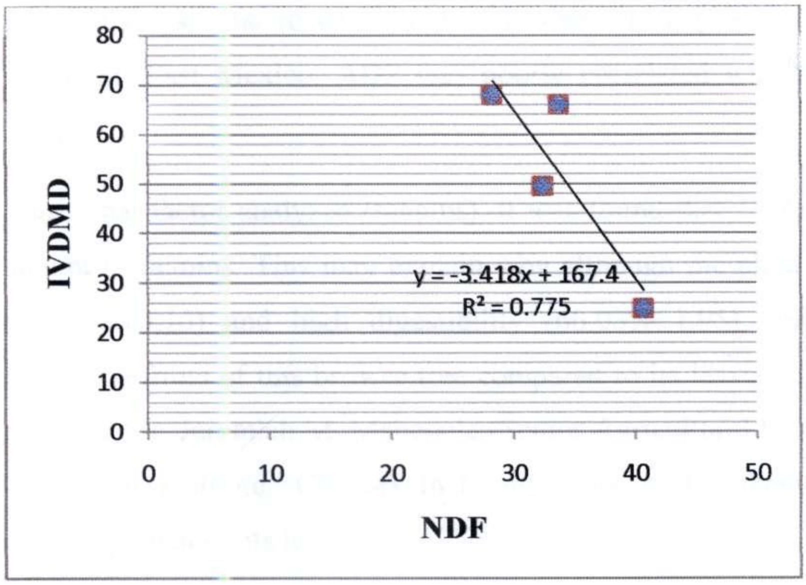

Figure 9. IVDMD vs. NDF

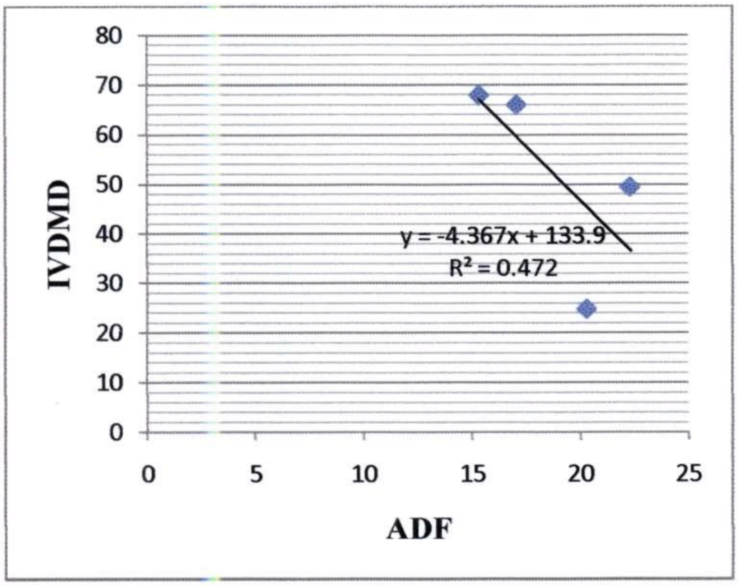

Figure 10. IVDMD vs. ADF

The increase in NDF and ADF are the major determinants of forage quality. The NDF content ranged from 28.27±1.78-40.64±8.66% whilst that of ADF ranged from 15.33±3.45-22.31±3.66%. NDF was also negatively correlated with IVDMD (R^2 = -0.775, $p<0.05$) (Fig. 9). This is similar to what Solorio-Sanchez *et al.* (2000) found in the leaves of fodder trees in South East Mexico. ADF was poorly correlated with IVDMD (R^2 = -0.47, $p<0.05$) (Fig. 10).

For the anti-nutritional factor analyzed (tannins), it was found that *Dichrostachys cinerea* had the highest amount of tannins. This may explain why although the plant had the lowest crude fibre content (18.16±0.16) and high digestibility (66.03%±1.95), animals prefer to feed relatively more on the fruits of this browse tree compared to its leaves. This is agrees with the information given by Mr. Jeremiah M. Mabepula (Senior Agricultural Research officer, Zambia Agricultural Research Institute, Choma) that ruminants prefer feeding on the fruits of *Dichrostachys cinerea* than on its leaves.

Brachystegia spiciformis showed to be the most digestible of the four species having a digestibility of 67.95±0.85%

CHAPTER 5

5.0 CONCLUSION

All the browse species under study, with the exception *Parinari curatellifolia* were dominant though with varying frequencies and densities.

Of the browse species assessed in this research, *Brachystegia spiciformis* and *Julbernardia globiflora* were the most dominant and abundant species. *Brachystegia spiciformis* and *Julbernardia globiflora* also contained crude protein levels which fall in the range of the crude protein requirements of ruminant animals. *Dichrostachys cinerea* had the highest amount of total tannins and therefore less nutritious of the four species. However, overall, the browse species assessed are abundant and have a good potential to supply nutritious and fairly digestible feeds suitable for ruminant feeding in the dry season.

5.1 RECOMMENDATIONS

1. Further studies be carried out to estimate these species' biomass production, their average heights and canopy cover which will give better estimations of the productivity of these browse trees and on how to promote and increase their productivity.

2. There is also need for more research on how to reduce tannin levels in the leaves to ensure better utilization by the ruminant animals

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APPENDIX

One-way ANOVA: *Dichrostachys cinerea, Julbernardia globiflora, Piliostigma thonningii, Brachystegia spiciformis*

Crude Protein

Source	DF	SS	MS	F	P
Factor	3	37.188	12.396	34.66	0.000
Error	8	2.861	0.358		
Total	11	40.049			

S = 0.5980 R-Sq = 92.86% R-Sq (adj) = 90.18%

Individual 95% CIs for Mean Based on Pooled St. Dev

```
Level                     N  Mean    St. Dev  ----+---------+---------+---------+-----
Piliostigma thonningii    3   8.583  0.095           (----*-----)
Julbernardia globiflora   3  11.697  0.196                              (----*----)
Brachystegia spiciformis  3  11.417  0.438                            (----*----)
Dichrostachys cinerea     3   7.630  1.091      (----*----)
                                              ----+---------+---------+---------+-----
                                                 7.5       9.0      10.5      12.0
```

Pooled St. Dev = 0.598

Grouping Information Using Fisher Method

	N	Mean	Grouping
Julbernardia globiflora	3	11.6967	A
Brachystegia spiciformis	3	11.4167	A
Piliostigma thonningii	3	8.5833	B
Dichrostachys cinerea	3	7.6300	B

Means that do not share a letter are significantly different.

Crude Fibre

Source	DF	SS	MS	F	P
Factor	3	354.4782	118.1594	4701.30	0.000
Error	8	0.2011	0.0251		
Total	11	354.6793			

S = 0.1585 R-Sq = 99.94% R-Sq (adj) = 99.92%

```
                                        Individual 95% CIs for Mean Based on Pooled St. Dev
Level                        N   Mean    St. Dev  -----+---------+---------+---------+----
Piliostigma thonningii       3   28.030  0.101                          *)
Julbernardia globiflora      3   33.237  0.055                                      *)
Brachystegia spiciformis     3   27.560  0.201                        (*
Dichrostachys cinerea        3   18.160  0.217    *)
                                                  -----+---------+---------+---------+----
                                                     20.0      24.0      28.0      32.0
```

Pooled St. Dev = 0.159

Grouping Information Using Fisher Method

	N	Mean	Grouping
Julbernardia globiflora	3	33.237	A
Piliostigma thonningii	3	28.030	B
Brachystegia spiciformis	3	27.560	C
Dichrostachys cinerea	3	18.160	D

Means that do not share a letter are significantly different.

Calcium

Source	DF	SS	MS	F	P
Factor	3	0.2715	0.0905	3.22	0.083
Error	8	0.2248	0.0281		
Total	11	0.4963			

S = 0.1676 R-Sq = 54.70% R-Sq (adj) = 37.71%

Individual 95% CIs for Mean Based on Pooled St. Dev

Level	N	Mean	St. Dev	-----+---------+---------+---------+----
Piliostigma thonningii	3	1.7600	0.0400	(--------*--------)
Julbernardia globiflora	3	1.4667	0.2013	(--------*--------)
Brachystegia spiciformis	3	1.5333	0.0757	(--------*--------)
Dichrostachys cinerea	3	1.3467	0.2540	(--------*--------)
				-----+---------+---------+---------+----
				1.25 1.50 1.75 2.00

Pooled St. Dev = 0.1676

Grouping Information Using Fisher Method

	N	Mean	Grouping
Piliostigma thonningii	3	1.7600	A
Brachystegia spiciformis	3	1.5333	A B
Julbernardia globiflora	3	1.4667	A B
Dichrostachys cinerea	3	1.3467	B

Means that do not share a letter are significantly different.

IVDMD

Source	DF	SS	MS	F	P
Factor	3	3313.76	1104.59	159.37	0.000
Error	7	48.52	6.93		
Total	10	3362.28			

S = 2.633   R-Sq = 98.56%   R-Sq (adj) = 97.94%

```
                                                  Individual 95% CIs for Mean Based on Pooled St. Dev
Level                       N   Mean    St. Dev   ------+---------+---------+---------+---
Piliostigma thonningii      3   24.823  3.697     (--*-)
Julbernardia globiflora     3   49.467  1.504                (-*-)
Brachystegia spiciformis    2   67.950  1.202                          (--*--)
Dichrostachys cinerea       3   66.033  2.757                          (-*-)
                                                  ------+---------+---------+---------+---
                                                        30        45        60        75
```

Pooled St. Dev = 2.633

Grouping Information Using Fisher Method

	N	Mean	Grouping
Brachystegia spiciformis	2	67.950	A
Dichrostachys cinerea	3	66.033	A
Julbernardia globiflora	3	49.467	B
Piliostigma thonningii	3	24.823	C

Means that do not share a letter are significantly different.