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Species Diversity and Fodder Values of Native Trees and Shrubs in the Traditional Silvopastoral System of Adamawa State, Nigeria

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Abstract

The study was carried out to assess the diversity and fodder values of native tree and shrub species in the traditional silvopastoral system of Adamawa, State, Nigeria. Transects of 1100m in length with a distance of 500m between them were used in the study site. Sample plots of 25m x 25m in dimension were laid in alternate positions along each transect at 250m interval. All the trees/shrub encountered in each of the sample plots were identified by their botanical names and species with potential for fodder were classified based on farmer's citation on palatability to Ruminant Livestock. Biodiversity indices were estimated using appropriate formula. The results of floristic diversity showed that the two sites were rich in tree and shrub species diversity. This was supported by the value obtained for Shannon-Weinner diversity indices (3.00, 2.70), Marlalef index of species richness (6.51, 4.58), Species evenness (0.40, 0.32), Simpson's index (0.86, 0.96) and Minhinck's index (1.16, 0.57) in Nyibango and Gongoshi forest grazing reserves respectively. Fifty four percent (54%) of the species were classified as shrubs, while forty six percent (46%) were trees based on their growth characteristics. The species were rated according to their fodder value as high (19%), medium (34%) and low (27%) based on farmer's perception of palatability to ruminant livestock. A relatively small percentage (19%) was rated to be of no fodder value. The study revealed that native tree and shrub species contribute substantially to availability of feed for livestock in the traditional silvopastoral system of Adamawa State.

Key Words: Diversity, Potentials, Fodder value, Silvopastoral system, Traditional

Introduction

Agroforestry comprises a set of practices that combine trees and crops and/or animals within the same area. It is a dynamic system that diversifies and sustains production with social, economic and environmental benefits for land users at all levels. In particular, silvopastoralism is one of the oldest practices of agroforestry, a deliberate growing of woody perennials on the same unit of land as livestock in interacting combinations for multiple products or benefits from the same management unit (Nair, 1993). The 'Silvopastoral systems' is defined as managed unit of three main components within a particular edapho-climatic context: (1) tree, (2) pasture and (3) animals (Mosquera-Losada *et al*., 2001).

Trees and shrubs are particularly important in pastoral production systems. According to Babayemi and Bamikole, (2006) fodder trees and shrubs are important components of ruminant diet and they have been found to play an important role in the nutrition of grazing animals in areas where few or no alternatives are available (Van *et al.,* 2005). In a study conducted by Osemeobo, (2006) it is observed that fodder trees consumed in the livestock industry and the savanna areas account for about 10-15% livestock food in the dry seasons. These parts of the country have less rainfall and low biomass production but support over 90% of livestock. Fodder trees and shrubs were noted to support livestock such as cattle, sheep, goats, donkey and camel in the dry season.

As a major source of animal feeds in Africa, fodder trees and shrubs are highly valued by farmers. Browses have multiple roles such as feed, fire wood and as human and veterinary medicines (Luseba and Van der Merwe, 2006) in farming systems. These forage species contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry seasons and dry periods. They have

deep root systems enabling the extraction of water and nutrients from deep in the soil profile (Teferi and Lisanework, 2008). Most browse plants have high crude protein content, ranging from 10 to more than 25% on a dry matter basis (Moleele, 1998). This reliable protein resource can be used to develop a sustainable feeding system and increase livestock productivity.

According to Aganga and Tshwenyane, (2003) the parts of trees that are commonly used as feed include leaves, tender shoots or twigs, fruits, pods and seeds. In general, leaves are higher in crude protein (almost twice) than twigs, indicating that livestock have access to nutritious feed. Leaves also contain more crude protein on average than pods but the latter were found with higher organic matter and digestibility.

Oke and Jamala (2013) noted that traditionally farmers grow crops under scattered trees and shrubs of different species and also incorporate animal production with no special technique, species type or density per unit area. The development and sustainable management of these resources, therefore, is the way to ensure present and future supply of these valuable natural resources. So far, very little work has been done on the identification, prioritization and characterization of native fodder trees and shrubs in the savanna areas of Adamawa State. Reliable information in terms of species composition and fodder value are very crucial for management purposes as well as for further researches. This study was conducted to identify the most appreciated and utilized native trees/shrubs as browse species in the savanna areas of Adamawa State, Nigeria.

Materials and Methods

The Study site

The study area is Adamawa State (Figure 1) located at the North Eastern part of Nigeria. It lies between latitude 7^{o} and 11^{o}N and Longitude 11^{o} and 14^{o}E. It shares boundary with Taraba State in the south and west, Gombe State in its north-west and Borno State to the north. The State has an international boundary with the Cameroon Republic along its eastern side. It has a land area of about 38,741 km^2 (Adebayo, 1999). The State is divided into 21 Local Government Areas LGAs). Adamawa State has a tropical wet and dry climate. Dry season lasts for a minimum of five months (November-March) while the wet season spans April to October. Mean annual rainfall in the State ranges from 700mm in the North-west, to 1600mm in the extreme southern part of the State. The State is naturally divided into two ecological zones; the guinea and sudan savanna zones. In general, the distribution of vegetation reflects the combined control of rainfall, topography and to a lesser extent, that of soils. Agriculture is the mainstay of about 80% of the inhabitants of the State. The ecological condition of the State permits cultivation of root crops, cereals and rearing of livestock in large numbers.

Major livestock species are cattle, sheep and goats with poultry species reared all over the State (Tukur and Ardo, 1999). The dominant system of livestock management is nomadic herding. The ruminants' population of the State stands at 8.7 million consisting of 3.2 million cattle, 2.5 million sheep and 3.0 million goats (Tukur and Ardo, 1999).

The field studies were carried out at the Nyibango which lies between latitude 8^0 48′ and 8^0 75′ N and longitude 12^0 17′ and 12^0 38′ E in Jada LGA and Gongoshi which lies between latitude 9^0 3′ and 9^0 27′ N and longitude 12^0 3′ and 12^0 18′ E in Mayo-Belwa LGA. It has a land area of about 2291.42km^2 and a population of 164,087 (NPC, 2007). The mean annual temperature of the study area is 26.7^{o}C while the mean annual rainfall ranges between 1100 mm and 1600 mm with a distinct dry season which begins in November and ends in April and the wet season begins in April and ends in October or sometimes in November.

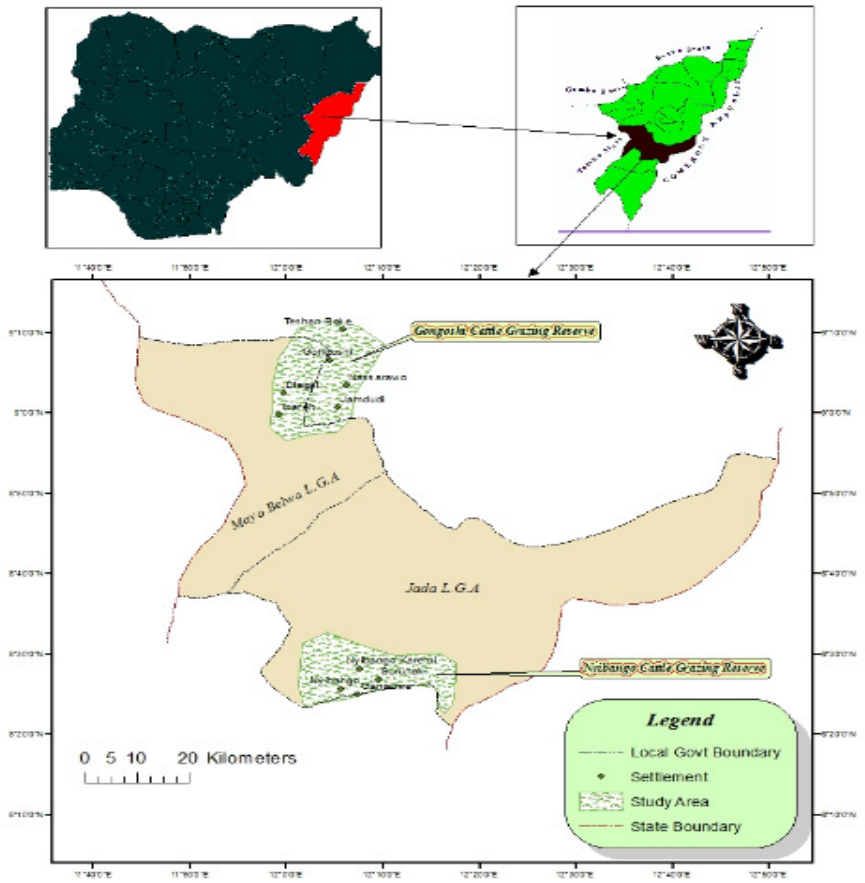

Fig. 1: Map of the study area

Experimental Procedures

Enumeration of fodder trees/shrubs in the grazing reserves

A reconnaissance survey of the grazing reserves was carried to locate the boundaries of the reserves and get acquainted with the general conditions. With the assistance of the forest officers and livestock superintendents in the reserves, the sample plots were marked. Systematic line transect was employed in laying out the plots. Two transects of 1100m in length with a distance of at least 500m between the two parallel transects were used in the study site. Sample plots of 25m × 25m in dimension were laid in alternate positions along each transect at 250m interval.

Trees Species Identification

All the trees/shrub encountered in each of the sample plots were identified by their botanical names. With the aid of existing literatures and farmer's indigenous knowledge, all tree/shrub species with potential for fodder were identified.

Tree/shrub species classification and diversity indices

All trees/shrubs were assigned to families and number of species in each family was obtained for tree species diversity classification. Frequency of occurrence was obtained for species abundance/richness. This was repeated for the entire trees encountered in the entire sample plots for the study area. Biodiversity indices were used to obtain tree

species richness and evenness within the grazing reserve.

Species relative density (RD): Was obtained by using the formula given by Oduwaiye *et al*., (2002):

$$R = \left[\frac{ni}{N}\right] X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

RD = Relative density

n_i = Number of individual species i

N = Total number of individual in the entire population

Relative frequency (RF): was obtained using the formula given by Oduwaiye et al. (2002):

$$RF = \frac{\sum Ft\ X\ 100}{Fn} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

RF = Relative frequency

Fi = Number of plot where species I was found

Fn = Total frequency of all species

The community diversity was obtained by using a mathematical formula that took into account the species richness and abundance of each species in the ecological community. The equation that was used is given as:

Shannon-Wiener diversity index given by Price (1997):

$$H^1 = \sum_{=1}^{s} Pi\ LnPi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

H^1 =Shannon diversity index

S= total number of species in the community

Pi= proportion of a species to the total number of plant in the community

Ln= natural logarithm

Menhinick's diversity index:

$$D_{mn} = \frac{S}{\sqrt{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where N = the total number of individuals in the sample and S = the number of species recorded

Species eveness in each community was determined using Shannon's equitability (E^H):

$$E_H = \frac{H}{Hmax} = \frac{\sum_{i=1}^{S} pi \ln(pi)}{\ln(S)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Mangalef's index was calculated using the equation below:

$$D = \frac{S-1}{\ln N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where:

D = Mangalef's index

S = Number of species

N = Number of individual

Simpson's index

$$D = \frac{\sum ni(ni-1)}{N(N-1)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where:

D = Simpson's index

n_i = number of individual species i

N = total number of all tree species in the entire community

Results and Discussion

Results

Table 1 shows the density and diversity of trees and shrubs in the 1.75 ha of Nyibango forest grazing reserve surveyed. Seven thousand and eighty four (7,084) individual plants belonging to 50 species and 28 families were encountered. The number of individual trees/shrubs per hectare was 4,048. The richest family was combretaceae which had six species. Family fabaceae and leguminoceae had five species each while rubiaceae had four species. Family anacardiaceae and meliaceae also had three species each. The predominant species were *Combretum glutinosum, Anogeissus leiocarpus, Annona senegalense, Detarium microcarpum, Pteleopsis habeensis, Piliostigma thonningii, Combretum fragrans, Vitellaria paradoxa, Pseudocedrela kotschyi* and *Bridelia ferruginea* which accounted for 69.45% of the total woody plant population in the grazing reserve.

Table 2 shows the diversity of trees and shrubs in the 1.75 ha of Gongoshi forest grazing reserve surveyed. Four thousand nine hundred and eighty one (4,981) individual plants belonging to 40 species and 20 families were identified. The number of individual trees/shrubs per hectare was 2,846. The richest family was combretaceae which had six species. Family leguminoceae had five species while rubiaceae

and fabaceae had four species. Family anacardiaceae had three species each while family meliaceae had two. The predominant species were *Combretum glutinosum, Anogeissus leiocarpus, Annona senegalense, Detarium microcarpum, Pteleopsis habeensis, Piliostigma thonningii, Combretum fragrans, Bridelia ferruginea, Vitellaria paradoxa* and *Terminalia glauscens* which accounted for 78.34% of the total woody plant population.

The summary of tree/shrub species distribution and diversity in the study area is presented in Table 3. The table shows that a total 50 tree species were encountered in Nyibango forest grazing reserve and these were distributed in 28 families. The Shannon-Weinner diversity index for the site was 3.00 while Species evenness was 0.40. Simpson's index, Marlalef index and Minhinck's index had the values of 0.86, 6.51 and 1.16 respectively. Shannon's maximum diversity index for the site was 7.56. Forty (40) tree species were encountered in Gongoshi forest grazing reserve and these were distributed in 20 families. The Shannon-Weinner diversity index for the site was 2.70 while Species evenness was 0.32. Simpson's index, Marlalef index and Minhinck's index had the values of 0.96, 4.58 and 0.57 respectively. Shannon's maximum diversity index for the site was 8.51.

Table 4 presents the lists of encountered woody species, their life forms and fodder values as indicated by farmers in Nyibango grazing reserve. The results indicate that 56% of the species were classified as shrubs, while 44% were trees. Eighteen percent (18%) of the encountered species were rated to be of high fodder value, 36% were rated to be of medium fodder while 28% were rated to be of low fodder value based on farmer's perception of palatability to ruminant livestock. The remaining 18% were rated to be of no fodder value. The lists of encountered woody species, their life forms and fodder values as indicated by farmers in Gongoshi grazing reserve is presented in Table 5. Over fifty two percent (52.5%) of the species were classified as shrubs, while 47.5% were trees. Twenty percent (20%) of the encountered species were rated to be of high fodder value, 32.5% were rated to be of medium fodder while 27.5% were rated to be of low fodder value based on farmer's perception of palatability to ruminant livestock. The remaining 20% were rated to be of no fodder value.

Table 1: Density and diversity of tree and shrubs in the 1.75 ha of Nyibango forest grazing reserve

Species	Family	Freq.	Density (No Ha^{-1})	R. D.	pi*ln(pi)
Combretum glutinosum Perr. ex. DC.	Combretaceae	990	565.7	13.98	-0.2696
Anogeissus leiocarpus (DC.) Guill. & Perr.	Combretaceae	970	554.3	13.69	-0.26684
Annona senegalense Pers	Annonaceae	686	392.0	9.68	-0.22095
Detarium microcarpum Guill. & Perr	Caesalpiniaceae	630	360.0	8.89	-0.21019
Pteleopsis habeensis Aubrév. ex Keay	Combretaceae	382	218.3	5.39	-0.15337
Piliostigma thonningii (Schumach.)	Fabaceae	336	192.0	4.74	-0.14075
Combretum fragrans F. Hoffm.	Combretaceae	260	148.6	3.67	-0.11795
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	227	129.7	3.20	-0.10716
Pseudocedrela kotschyi (Schweinf.) Harms	Meliaceae	220	125.7	3.11	-0.10479
Bridelia ferruginea Benth.	Euphorbiaceae	219	125.1	3.09	-0.10445
Terminalia glaucescens Planch. ex. Benth.	Combretaceae	216	123.4	3.05	-0.10342
Lannea schimperi Hochst. ex. A. Rich	Anacardiaceae	211	120.6	2.98	-0.1017
Entada africana Guill. & Perr.	Mimosoideae	188	107.4	2.65	-0.09356
Prosopis africana (Guill., Perrott. and Rich.) Taub.	Leguminosae	136	77.7	1.92	-0.07365
Crossopteryx febrifuga (Afzel.) Benth.	Rubiaceae	134	76.6	1.89	-0.07284
Burkea africana Hook. var.	Fabaceae	118	67.4	1.67	-0.06618
Cochlospermum tinctorium Perr. ex A. Rich.	Cochlospermaceae	90	51.4	1.27	-0.05424
Cochlospermum planchonii Hook. Ef. x Planch	Cochlospermaceae	90	51.4	1.27	-0.05378
Ficus sycomorus L.	Moraceae	84	48.0	1.19	-0.05098
Grewia venusta Fresen.	Tiliaceae	57	32.6	0.80	-0.03759
Acacia nigricans (Labill.) R. Br.	Fabaceae	57	32.6	0.80	-0.03759
Daniella oliveri (Rolfe) Hutch. & Dalziel	Fabaceae – Caesalpinioideae	47	26.9	0.66	-0.03223
Terminalia macroptera Guill. & Perr	Combretaceae	47	26.9	0.66	-0.03223
Balanites aegyptiaca (Linn.) Del.	Balanitaceae	45	25.7	0.64	-0.03112
Lannea acida A. Rich	Anacardiaceae	41	23.4	0.58	-0.02887
Ziziphus mauritiana Lam.	Rhamnaceae	40	22.9	0.56	-0.0283
Ziziphus abyssinica Hochst.	Rhamnaceae	40	22.9	0.56	-0.00579
Securidaca longepedunculata Fresen.	Polygalaceae	39	22.3	0.55	-0.02773
Maytenus senegalensis (Lam.) Exell	Celastraceae	39	22.3	0.55	-0.02773
Vitex simplicifolia Oliv.	Lamiaceae	36	20.6	0.51	-0.02599
Acacia polyacantha Willd.	Leguminosae	35	20.0	0.49	-0.0254
Strychnos spinosa	Loganiaceae.	34	19.4	0.48	-0.02481
Khaya senegalensis A. Juss	Meliaceae	31	17.7	0.44	-0.02301
Pterocarpus erinaceus Poir.	Fabaceae-Papilionoideae	31	17.7	0.44	-0.01992
Cussonia barteri Seem.	Araliaceae	28	16.0	0.40	-0.02117
Vitex doniana (Sweet)	Verbenaceae	28	16.0	0.40	-0.02117
Gardenia aqualla Stapf & Hutch.	Rubiaceae	28	16.0	0.40	-0.02117
Nauclea latifolia Smith	Rubiaceae	28	16.0	0.40	-0.02117
Acacia arenaria Schinz	Fabaceae	23	13.1	0.32	-0.018
Gardenia sokotensis Hutch.	Rubiaceae	22	12.6	0.31	-0.01735
Hymenocardia acida Tul.	Euphorbiaceae	21	12.0	0.30	-0.01669
Ximenia americana Linn.	Olacaceae	19	10.9	0.27	-0.01536
Bombax costatum Pellegr. & Vuillet	Bombacaceae	18	10.3	0.25	-0.01469
Strychnos innocua Del.	Loganiaceae	16	9.1	0.23	-0.01331
Azadirachta indica A. Juss.	Meliaceae	14	8.0	0.20	-0.0119
Acacia gourmaensis A. Chev.	Leguminosae	8	4.6	0.11	-0.00741
Haematostaphis barteri Hook. F.	Anacardiaceae	7	4.0	0.10	-0.00661
Acacia hockii De Wild.	Leguminosae	7	4.0	0.10	-0.00661
Parkia biglobosa (Jacq.) Benth.	Leguminosae	6	3.4	0.08	-0.00579
Sterculia setigera Del.	Sterculiaceae	5	2.9	0.07	-0.00495
		7084	4048.0	**H'**	**3.00**

Table 2: Density and diversity of trees in the 1.75 ha of Gongoshi forest grazing reserve

Species	Family	Freq.	Density (No Ha^{-1})	R.D.	pi*ln(pi)
Combretum glutinosum Perr. ex. DC.	Combretaceae	893	510.3	17.93	-0.300
Anogeissus leiocarpus (DC.) Guill. & Perr.	Combretaceae	867	495.4	17.41	-0.296
Annona senegalense Pers	Annonaceae	560	320.0	11.24	-0.238
Detarium microcarpum Guill. & Perr	Caesalpiniaceae	353	201.7	7.09	-0.181
Pteleopsis habeensis Aubrév. ex Keay	Combretaceae	270	154.3	5.42	-0.152
Piliostigma thonningii (Schumach.)	Fabaceae	254	145.1	5.10	-0.146
Combretum fragrans F. Hoffm.	Combretaceae	191	109.1	3.83	-0.120
Bridelia ferruginea Benth.	Euphorbiaceae	179	102.3	3.59	-0.115
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	175	100.0	3.51	-0.113
Terminalia glaucescens Planch. ex. Benth.	Combretaceae	160	91.4	3.21	-0.106
Lannea schimperi Hochst. ex. A. Rich	Anacardiaceae	155	88.6	3.11	-0.103
Entada africana Guill. & Perr.	Mimosoideae	149	85.1	2.99	-0.101
Crossopteryx febrifuga (Afzel.) Benth.	Rubiaceae	85	48.6	1.71	-0.066
Burkea africana Hook. var.	Fabaceae	85	48.6	1.71	-0.066
Prosopis africana (Guill., Perrott. and Rich.) Taub.	Leguminosae	83	47.4	1.67	-0.065
Ficus sycomorus L.	Moraceae	49	28.0	0.98	-0.043
Terminalia macroptera Guill. & Perr	Combretaceae	47	26.9	0.94	-0.042
Daniella oliveri (Rolfe) Hutch. & Dalziel	Fabaceae – Caesalpinioideae	45	25.7	0.90	-0.041
Vitex simplicifolia Oliv.	Lamiaceae	35	20.0	0.70	-0.033
Khaya senegalensis A. Juss	Meliaceae	31	17.7	0.62	-0.030
Strychnos spinosa	Loganiaceae.	30	17.1	0.60	-0.029
Pterocarpus erinaceus Poir.	Fabaceae-Papilionoideae	26	14.9	0.52	-0.026
Grewia venusta Fresen.	Tiliaceae	25	14.3	0.50	-0.025
Acacia polyacantha Willd.	Leguminosae	25	14.3	0.50	-0.025
Cussonia barteri Seem.	Araliaceae	24	13.7	0.48	-0.024
Lannea acida A. Rich	Anacardiaceae	22	12.6	0.44	-0.023
Hymenocardia acida Tul.	Euphorbiaceae	21	12.0	0.42	-0.022
Nauclea latifolia Smith	Rubiaceae	20	11.4	0.40	-0.021
Bombax costatum Pellegr. & Vuillet	Bombacaceae	18	10.3	0.36	-0.019
Ximenia americana Linn.	Olacaceae	17	9.7	0.34	-0.018
Strychnos innocua Del.	Loganiaceae	16	9.1	0.32	-0.018
Azadirachta indica A. Juss.	Meliaceae	13	7.4	0.26	-0.015
Gardenia aqualla Stapf & Hutch.	Rubiaceae	12	6.9	0.24	-0.019
Gardenia sokotensis Hutch.	Rubiaceae	12	6.9	0.24	-0.014
Acacia gourmaensis A. Chev.	Leguminosae	8	4.6	0.16	-0.010
Haematostaphis barteri Hook. F.	Anacardiaceae	7	4.0	0.14	-0.009
Acacia hockii De Wild.	Leguminosae	7	4.0	0.14	-0.009
Sterculia setigera Del.	Sterculiaceae	5	2.9	0.10	-0.007
Parkia biglobosa (Jacq.) Benth.	Leguminosae	5	2.9	0.10	-0.007
Ziziphus abyssinica Hochst.	Rhamnaceae	2	1.1	0.04	-0.003
		4,981	2846.3	**H'**	**2.70**

Table 3: Summary of tree species diversity and distribution in the study area

Site	No of species	No of families	H'	H/Hmax	D	S-D/lnM	S/√M	Hmax
Nyibango	50	28	3.00	0.40	0.86	6.51	1.16	7.53
Gongoshi	40	20	2.70	0.32	0.96	4.58	0.57	8.51

H'=Shannon-Weinner diversity index, H/Hmax=Species evenness, D=Simpson's index, S-D/lnM=Marlalef index, S/√M =Minhinck's index and Hmax= Shannon's maximum diversity index

Table 4: Life forms and fodder values of encountered woody species in Nyibango grazing reserve

Species	Life form	*Fodder value	Livestock species
Acacia arenaria Schinz	Shrub	Medium	Goats and Sheep
Acacia gourmaensis A. Chev.	Tree	Medium	Cattle, Goats and Sheep
Acacia hockii De Wild.	Shrub	Medium	Cattle, Goats and Sheep
Acacia nigricans (Labill.) R. Br.	Shrub	Medium	Goats and Sheep
Acacia polyacantha Willd.	Tree	None	
Annona senegalensis Pers	Shrub	High	Goats
Anogeissus leiocarpus (DC.) Guill. & Perr.	Tree	High	Cattle, Goats and Sheep
Azadirachta indica A. Juss.	Tree	Low	Cattle and Goat
Balanites aegyptiaca (Linn.) Del.	Shrub	Medium	Goat
Bombax costatum Pellegr. & Vuillet	Tree	Low	Goat and Sheep
Bridelia ferruginea Benth.	Tree	Low	Cattle, Goats and Sheep
Burkea africana Hook. var.	Tree	None	
Cochlospermum planchonii Hook. Ef. x Planch	Shrub	Medium	Cattle
Cochlospermum tinctorium Perr. ex A. Rich.	Shrub	None	
Combretum fragrans F. Hoffm.	Tree	None	
Combretum glutinosum Perr. ex. DC.	Tree	Medium	Cattle, Goats and Sheep
Crossopteryx febrifuga (Afzel.) Benth.	Shrub	Low	Cattle, Goats and Sheep
Cussonia barteri Seem.	Tree	Low	Cattle, Goats and Sheep
Daniella oliveri (Rolfe) Hutch. & Dalziel	Tree	High	Cattle and Goats
Detarium microcarpum Guill. & Perr	Tree	Medium	Cattle, Goats and Sheep
Entada africana Guill. & Perr.	Shrub	Medium	Cattle, Goats and Sheep
Ficus sycomorus L.	Tree	High	Cattle, Goats and Sheep
Gardenia aqualla Stapf & Hutch.	Shrub	High	Goats
Gardenia sokotensis Hutch.	Shrub	Medium	Cattle, Goats and Sheep
Grewia venusta Fresen.	Shrub	None	
Haematostaphis barteri Hook. F.	Tree	None	
Hymenocardia acida Tul.	Shrub	None	
Khaya senegalensis A. Juss	Tree	High	Cattle and Goats
Lannea acida A. Rich	Shrub	Low	Cattle, Goats and Sheep
Lannea schimperi Hochst. ex. A. Rich	Shrub	Medium	Goat
Maytenus senegalensis (Lam.) Exell	Shrub	Low	Cattle, Goat and Sheep
Nauclea latifolia Smith	Shrub	Medium	Goats and Sheep
Parkia biglobosa (Jacq.) Benth.	Tree	Medium	Cattle, Goats and Sheep
Piliostigma thonningii (Schumach.)	Shrub	Medium	Goats and Cattle
Prosopis africana (Guill., Perrott. and Rich.) Taub.	Tree	High	Cattle, Goats and Sheep
Pseudocedrela kotschyi (Schweinf.) Harms	Shrub	Low	Cattle
Pteleopsis habeensis Aubrév. ex Keay	Shrub	None	
Pterocarpus erinaceus Poir.	Shrub	Leaves	Goat and Sheep
Securidaca longepedunculata Fresen.	Shrub	Low	Goat and Sheep
Sterculia setigera Del.		None	
Strychonos innocua Del.	Shrub	Low	Cattle, Goats and Sheep
Strychonos spinosa	Tree	High	Cattle, Goats and Sheep
Terminalia glaucescens Planch. ex. Benth.	Tree	Medium	Cattle, Goats and Sheep
Terminalia macroptera Guill. & Perr	Tree	Medium	Cattle, Goats and Sheep
Vitellaria paradoxa C.F. Gaertn.	Tree	Medium	Cattle, Goats and Sheep
Vitex doniana (Sweet)	Tree	Medium	Goat and Cattle
Vitex simplicifolia Oliv.	Shrub	Low	Goat and Cattle
Ximenia americana Linn.	Shrub	Low	Cattle, Goats and Sheep
Ziziphus abyssinica Hochst.	Shrub	Low	Cattle, Goats and Sheep
Ziziphus mauritiana Lam.	Shrub	High	Goat and Sheep

* Fodder value based on farmer's citation on palatability to Ruminant Livestock only

Table 5: Life forms and fodder values of encountered woody species in Gongoshi grazing reserve

Woody Species	Life form	*Fodder value	Livestock species
Acacia gourmaensis A. Chev.	Tree	Medium	Cattle, Goats and Sheep
Acacia hockii De Wild.	Shrub	Medium	Cattle, Goats and Sheep
Acacia polyacantha Willd.	Tree	None	
Annona senegalense Pers	Shrub	High	Goats
Anogeissus leiocarpus (DC.) Guill. & Perr.	Tree	High	Cattle, Goats and Sheep
Azadirachta indica A. Juss.	Tree	Low	Cattle and Goat
Bombax costatum Pellegr. & Vuillet	Tree	Low	Goat and Sheep
Bridelia ferruginea Benth.	Tree	Low	Cattle, Goats and Sheep
Burkea africana Hook. var.	Tree	None	
Combretum fragrans F. Hoffm.	Tree	None	
Combretum glutinosum Perr. ex. DC.	Tree	Medium	Cattle, Goats and Sheep
Crossopteryx febrifuga (Afzel.) Benth.	Shrub	Low	Cattle, Goats and Sheep
Cussonia barteri Seem.	Shrub	Low	Cattle, Goats and Sheep
Daniella oliveri (Rolfe) Hutch. & Dalziel	Tree	High	Cattle and Goats
Detarium microcarpum Guill. & Perr	Tree	Medium	Cattle, Goats and Sheep
Entada africana Guill. & Perr.	Shrub	Medium	Cattle, Goats and Sheep
Ficus sycomorus L.	Tree	High	Cattle, Goats and Sheep
Gardenia aqualla Stapf & Hutch.	Shrub	High	Goats
Gardenia sokotensis Hutch.	Shrub	Medium	Cattle, Goats and Sheep
Grewia venusta Fresen.	Shrub	None	
Haematostaphis barteri Hook. F.	Tree	None	
Hymenocardia acida Tul.	Shrub	None	
Khaya senegalensis A. Juss	Tree	High	Cattle and Goats
Lannea acida A. Rich	Shrub	Low	Cattle, Goats and Sheep
Lannea schimperi Hochst. ex. A. Rich	Shrub	Medium	Goat
Nauclea latifolia Smith	Shrub	Medium	Goats and Sheep
Parkia biglobosa (Jacq.) Benth.	Tree	Medium	Cattle, Goats and Sheep
Piliostigma thonningii (Schumach.)	Shrub	Medium	Goats and Cattle
Prosopis africana (Guill., Perrott. and Rich.) Taub.	Tree	High	Cattle, Goats and Sheep
Pteleopsis habeensis Aubrév. ex Keay	Shrub	None	
Pterocarpus erinaceus Poir.	Shrub	Leaves	Goat and Sheep
Sterculia setigera Del.		None	
Strychonos innocua Del.	Shrub	Low	Cattle, Goats and Sheep
Strychonos spinosa	Tree	High	Cattle, Goats and Sheep
Terminalia glaucescens Planch. ex. Benth.	Tree	Medium	Cattle, Goats and Sheep
Terminalia macroptera Guill. & Perr	Tree	Medium	Cattle, Goats and Sheep
Vitellaria paradoxa C.F. Gaertn.	Tree	Medium	Cattle, Goats and Sheep
Vitex simplicifolia Oliv.	Shrub	Low	Goat and Cattle
Ximenia americana Linn.	Shrub	Low	Cattle, Goats and Sheep
Ziziphus abyssinica Hochst.	Shrub	Low	Cattle, Goats and Sheep

* Fodder value based on farmer's citation on palatability to Ruminant Livestock only

Discussion

Diversity of trees and shrubs in the grazing reserves

In biological communities, Shannon-Wiener diversity index varies from 0 to 5, according to this index, values less than 1 characterize heavily disturbed condition, and values in the range of 1 to 2 are characteristics of moderate disturbed condition while the value above 3 signifies stable environmental conditions (Mason, 1988). Typically, the Shannon index in real ecosystems ranges between 1.5 and 3.5 (MacDonald, 2003). In the present study, Shannon Wiener index of 2.70 was computed for Gongoshi forest grazing reserve while 3.00 was computed for Nyibango forest grazing reserve. Evenness index, however, varied from 0.13 Gongoshi forest grazing reserve to 0.14 at Nyibango forest grazing reserve.

Generally, Simpson index ranges from 0 to 1. Mature and stable communities have high diversity value (0.6 to 0.9), while the communities under stress conditions, exhibiting low diversity, usually show close to zero value (Dash, 2003). Simpson diversity index is always higher where the community is dominated by less number of species and when the dominance is shared by large number of species (Whittaker, 1965). In this study, Simpson index was 0.998 at Gongoshi forest grazing reserve and 0.860 at Nyibango forest grazing reserve and as such Nyibango forest grazing reserve experienced larger anthropogenic pressures.

Margalef index has no limit value and it shows a variation depending upon the number of species, thus, it is used for comparison of the sites (Kocatas 1992) and takes only one component of diversity (species richness) into consideration reflecting sensitivity to sample size. The only advantage of this index is that we can compare the richness of different study sites over the Simpson index and that the values extend beyond 1 which is unlike the Simpson index where the values range from 0 to 1. In the present assessment, the values of Margalef diversity index were between 4.58 Gongoshi forest grazing reserve and 6.51 at Nyibango forest grazing reserve. Menhinick index, like Margalef's index, attempts to estimate species richness but at the same time it is independent on the sample size. In this study, it ranged from 0.57 for Gongoshi forest grazing reserve to 1.16 for Nyibango forest grazing reserve. The lower diversity associated with Gongoshi forest grazing reserve, as ascribed by the Shannon, Margalef and Menhinick indices may be attributed to lesser number of species and environmental degradation due to anthropogenic pressures, besides other biotic factors (Ravera, 2001).

Availability of the native trees/shrubs

The relative density of trees and shrubs species associated with flora diversity in the two forest grazing reserves studied reflects their availability in the area. The inventory of these reserves showed a difference in trees and shrubs species diversity according to their locations. These differences could be explained by varied ecological conditions such as edaphic factors, gradient of humidity, and soil depth. However, human activities could also have some influences. The density recorded in the two reserves was much higher than the overall density (298 trees ha^{-1}) reported by Couteron and Kokou (1997) in the semi-arid savanna of Burkina Faso. Higher trees/shrubs density was recorded in Nyibango forest grazing reserve (4, 048 trees/shrubs ha^{-1}) and (2, 846 trees/shrubs ha^{-1}) in Gongoshi forest grazing reserve respectively. This may however be attributed to the fact that both tree and shrub species were enumerated and there was no limit to the diameter of trees counted as is usually the case in many tree enumeration studies. Hiernaux and Gerard, (1999) reported a flora diversity of (8 to 9 species) and this was below the value obtained

in this study (50 species) in Nyibango forest grazing reserve and (40 species) in Gongoshi forest grazing reserve. Lamprey *et al.* (1980), Le Houérou (1980) and Walker (1980), reported about 124 fodder trees and shrub species in 39 families.

Fodder trees and shrubs in the grazing reserves

Sustainable livestock production usually involves efficient utilization of locally available resources. Of all savanna species, those used as pasture are a critical component in Livestock rearing, an occupation and source of income for the majority of resource-poor farmers in the area. According to Aganga and Tshwenyane (2003) trees and shrubs form part of the complex interactions between plants, animals and crops. Devendra, (1994) maintained that they help to balance a plant-animal-soil ecosystem and from which there is a sustainable source of feeds.

Fifty six percent (56%) of the species were classified as shrubs, while forty four percent (44%) were trees based on their growth characteristics in Nyibango grazing reserve. The species were rated according to their fodder value as high (18%), medium (36%) and low (26%) based on farmer's perception of palatability to ruminant livestock. This showed that eighty two percent (82%) of the species had high to low potentials for ruminant livestock production. A relatively small percentage (18%) was rated to be of no fodder value. The Gongoshi grazing reserve accounted for over fifty two percent (52.5%) of the species as shrubs and over forty seven percent (47.5%) as trees. The species fodder value revealed that twenty percent (20%) of the species were rated to be of high fodder value, over thirty two percent (32.5%) medium and twenty seven percent (27.5%) were rated to be of low fodder value, based on farmer's perception of palatability to ruminant livestock. Twenty percent (20%) were rated to be of no fodder value for ruminant livestock. This results corroborate the findings of other authors (Tabuti and Lye, 2009; Neba, 2010; Speedy and Pugliese, 2011; Ghosh, 2012; Konsala *et al*., 2013; Oke and Jamala, 2013; Holmstrom, 2013) who observed species such as *Ficus sycomorus, Annona senegalense, Gardenia aqualla, Piliostigma thonningii, Anogeissus leiocarpus, Detarium microcarpum, Vitellaria paradoxa, Azadirachta indica, Acacia hockii, Daniella oliveri, Prosopis africana,* and *Terminalia glaucescens*, as tree and shrub species used in the farming systems (as fallow species) and in livestock production. They are also cited as species of the silvopastoral systems and woody species used as fodders to ruminants within agroforestry systems in tropical humid Africa.

The results showed that the grazing reserves were characterized by more shrub species compared to tree species, indicating that the reserves offer complementary browse plant resources beneficial to ruminant production. Eighty two percent (82%) and eighty percent (80%) of the species in both reserves were rated as high to low fodder value for ruminant livestock production. Lucha and Chuyong (2016) conducted ethnobotanical Survey of Fodder/Forage Plant Species and maintained that majority of plants used as fodder were herbs, followed by shrubs, which is closely followed by trees. This revealed that a higher percentage of woody species have potentials for fodder that can be use as diet for ruminant livestock which constitute good sources of proteins, minerals and vitamins. Aregheore (2001) and Bamikole, *et al*. (2004) pointed out that fodder trees and shrubs form an integral part of ruminant production and as a fraction of total fodder intake during the dry season, browse can contribute as much as 30% of cattle's and 60% of goats' fodder. The higher percentage of these woody species in the grazing reserves may not be unconnected with their

attribute as pioneer species which grows well in an open savanna forest. The number of plant species browsed by ruminants is high and varies depending on the country. In Nigeria, Okoli (2003) found 163 species which were utilized for ruminant feeding. In Burkina Faso, many species have been reported to be less to highly browsed by ruminants (Zoungrana, 1991; Sawadogo, 1996). Ouédraogo-Koné *et al.* (2006) reported 17 to 24 species. This species diversity has been found to play an important role in the diet selection of grazing animals.

Conclusion

The information obtained in this study clearly indicates the diversity and availability of native trees/shrubs species in the traditional silvopastoral system of Adamawa State, Nigeria. A very high proportion of the trees/shrubs in the study area were found to have potentials for fodder although the fodder values of the species varies from low to high.

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