PARAMETER ANALYSIS OF RANGE PLANT RESOURCES IN THE SAVANNA ECOSYSTEM OF ADAMAWA STATE, NIGERIA

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ABSTRACT

Studies were carried out on Adamawa State range sites to determine the pattern of distribution of both herbaceous and woody plant resources of the range sites. Whittaker plot was used to generate data for the study. Results obtained indicated eight species with Correspondence Analysis CA score between 1.601 and 3.978 are important to Guyaku are those which lie furtherest to the right of Axis 1; Axonepus compressus, Brachiaria falcifera, Celosia leptostachya, Eragrostis tenuebabis, E. tremula, Mitracarpus villosus, Spermacoce octodon and Sporobolus pyramidalis. Looking at the individual woody plants species CA variable scores, species which are important in Chekelek range site are those which lie furtherest to the left of Axis 1; Combretum collinum, C. fragrans and Tamarindus indica with CA scores of -0.273, Acacia erythrocalyx and Isoberlinia tomentosa with CA scores of -0.973 and 1.898.Gongoshi range site which lies southward of the guinea savanna showed higher similarity to Chekelek in the sudan savanna in herbaceous plant composition than to Guyaku which lies in the same zone (guinea savanna). In this study, the dominant woody plant species are those with Importance Value Indices (IVI) scores of 20 and above. Adequate policy and institutional arrangements should be put in place for proper management and conservation of Adamawa rangeland is recommended.

Keywords: Correspondence analysis, distribution pattern, importance value indices, savanna ecosystem.

INTRODUCTION

A range is a broad, wide and unfenced area on which animals graze and roam. They comprise the low rainfall and variable climate, arid and semi-arid areas and, north of the Tropic of Capricorn and some seasonally high rainfall areas. The main ecosystem types are shrublands, grasslands and woodlands.

Rangelands are ecologically important for their high species diversity and ecological and geo-morphological integrity (Coupland, 1993).The economic importance of rangelands world-wide is extremely variable according to the socio-economic system in which they are found. In developed economies, such as Australia and America, rangelands are essentially marginal terrain suitable for low-intensity stock-rearing and hunting. In Africa and Central Asia, rangelands are essential to the subsistence of pastoralists and farmers (Blench and Sommer, 1999). Rangelands are also of socio-cultural importance to both indigenous and non-indigenous people, particularly in the provision of forage, source of wood products, food, fodder, medicines, construction materials and as well as a source of income.

Changes in rangeland ecosystems in most cases are as a result of some climatic and anthropogenic factors which could improve or destroy them. Barbier *et al.* (1994) reported minimum temperature, Plant Available Moisture (PAM), Plant Available Nutrients (PAN), fire, and herbivores as determinants of natural rangeland vegetation. The combination of these factors prevents the establishment and growth of trees and other woody plants in high densities, although their significance varies in different parts of the world.

The key factors in determining floristic diversity are thus likely to be the morphology of grazing impact, the density of micro-habitats and the degree of habitat conversion. Changes in the pattern of grazing, for example through the introduction of domestic stock, can affect rangeland bio-diversity both directly through pressure on plants, and indirectly, by trampling from large hoofed animals. Heavy grazing tends to cause palatable species to decline and the subsequent dominance by other, less palatable, herbaceous plants or bushes (De Haan *et al*., 1997; Adams, 1996; James *et al.*, 1998). In arid and semi-arid rangelands, extensive vegetation change can be a cyclical process responding to climatic variability. The extent of vegetation change that can be attributed to livestock versus climate is debatable (De Queiroz, 1993; Doughill and Cox, 1995; Homewood and Rogers, 1987; Perevolotsky, 1995; West, 1993).

Groombridge (1992) observed significant pressures on biodiversity on rangelands; depressed net incomes, land use conversion, fire suppression, invasion by woody and alien species, grazing pressure by domestic livestock, residential and industrial developments, urbanisation, agriculture, mining, industrialisation,, linear developments such as roads and pipelines as well as climate change, and these threats are for practical purposes, irreversible. The overall impacts are reduction and fragmentation, and impaired natural ecosystem functions.

MATERIALS AND METHODS

Study Location

Adamawa State is located at the North eastern part of Nigeria. It lies between latitude 7º and 11ºN of the equator and between longitude 11º and 14ºE of the Greenwich Meridian. It shares common boundary with Taraba State in the south and west, Gombe State in its North West and Borno to the North. Adamawa State has an international boundary with Cameroun Republic along its eastern boarder (Fig. 1). The State covers a land area of about 39,741km^2 (Adebayo, 1999).The major vegetation formations in the State are the Guinea and the Sudan savanna. Within each formation is an interspersion of thickets, tree savanna, open grass savanna and fringing forests in the river valley (Akosim *et al*., 1999).

Gongoshi range site is located in Mayo-Belwa Local Government area of Adamawa State in the northeastern part of Nigeria. The local government covers a land area of about 1,768km^2 while the range site covers a land area of about 8,000ha. It lies between latitude 9º3'N and longitude 12º3'E. Guyaku range site is located in Gombi Local Government area of Adamawa State in the northeastern part of Nigeria. The local government covers a land area of 1,101km^2 while the range site covers a land area of about 6,250ha. It lies between latitude 10º30'N and longitude 12º30'E. Chekelek range site located in Madagali local government area of northeastern Nigeria covers a land area of about 5,750 ha. It lies between latitude 11ºN and longitude 13ºE (Adebayo, 1999).

Study Design

The two ecological zones in Adamawa State (Guinea and Sudan savanna) were delineated. Rangeland sites representative of each zone were selected. In view of the relative size of Guinea savanna to sudan savanna in the State, two range sites were purposively selected in the Guinea savanna and one in the Sudan savanna. The area of each site

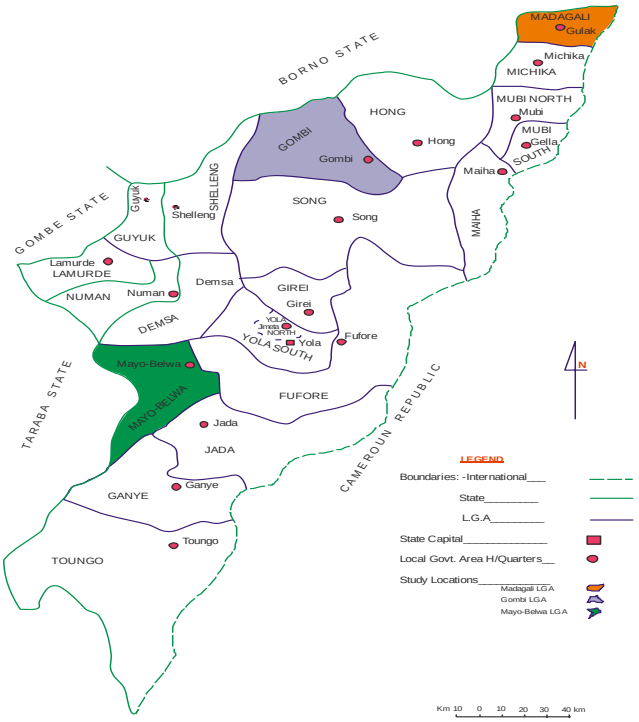

Fig. 1: Map of Adamawa State Showing the Study Locations
Source: Adebayo (1999).

was determined and all the ecological investigations carried out on the selected rangeland sites.

Data Collection

The collection of data for the parameter (correspondence and importance value indices) analysis, involved the use of the Whittaker Plot method (Comiskey *et al*., 1999). The Whittaker plot consisted of a 0.1ha plot that measured 20 by 50m. The locations of these plots were chosen randomly. The largest sub-plot (C) was 20 by 5m and was in the centre of the plot. Two smaller sub-plots (B_1 and B_2) measuring were 2m by 5m and located in two opposite corners of the plot. Finally, there were ten small sub-plots (A_1 – A_{10}) of 2 by 0.5m placed just inside the periphery of the plot. Relative density, diversity and distribution pattern of plant resources were examined using the 2 by 0.5m plots. All the herbaceous plant species in the plots were counted and identified. The list of all the herbaceous plant species was made from all the plots and their relative density, frequency distribution and diversity were determined. The diameter at breast height was measured at 1.3m above ground level. Woody plant resources ≥ 1cm diameter at breast height (dbh) were identified and enumerated in 5m by 2m plots; those ≥ 5cm were identified in 20 by 5m plots; the ones ≥ 10cm were identified in the entire 0.1ha plot. The dbh of the species were also measured and recorded (Fig. 2).

Data analysis

(i) Relative frequency = N/T x 100/1
(N=No. of occurrence of individual species; T = Total number all individuals in the study)

(ii) Relative density = A/B x 100/1
(A = Number of individual species; B = Number of individual of all the species)

(iii) Relative dominance =R/D x 100/1
(R=Total basal area of individual species; D=Total basal area of all species in the study)

(iv) Importance Value Index = (RF+RDo+RD)/3(Shukla and Chandel, 2006) (RF = relative frequency; RDo = Relativedominance; RD = Relative density)

(v) The multivariate analysis technique of the Correspondence Analysis (CA) was performed using Statistical Analysis System (SAS) (2000) to determine the pattern of distribution of herbaceous plant species in the rangeland sites.

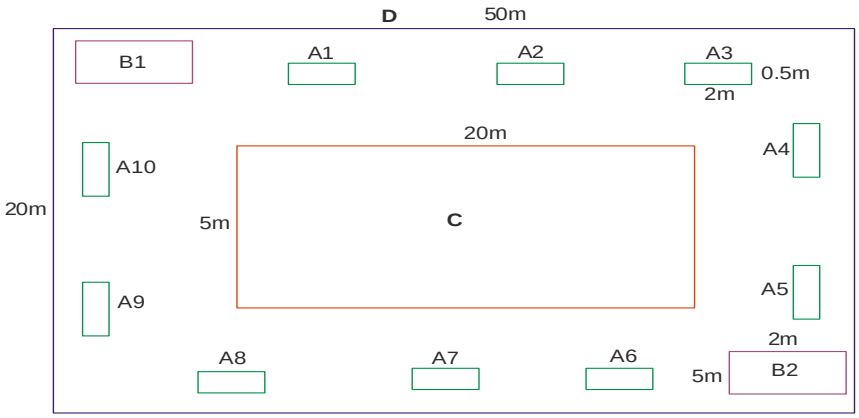

Fig. 2: Layout of the Whittaker and its Sub-Plots (Comiskey *et al*., 1999).
Note: A = 2m x 0.5m; B = 2m x 5m; C = 20m x 5m and D = 20m x 50m (0.1ha)

RESULTS

Correspondence Analysis of Herbaceous Plant Species

The eigenvalues showed that Axis 1 of the Correspondence Analysis (CA) explained 93.868% of the variation in herbaceous plant species frequency. Axis 2, unlike Axis 1, explained 98.709% of the variation in herbaceous plant species frequency. This means that Axis 1 separated the sites better according to herbaceous species frequency. Looking at the individual herbaceous species CA variable scores, species which are important in Guyaku are those which lie furtherest to right of Axis 1 (Fig.3). These comprise the 8 species with CA score between 1.601 and 3.978; *Axonepus compressus*, *Brachiaria falcifera*, *Celosia leptostachya*, *Eragrostis tenuebabis*, *E. tremula*, *Mitracarpus villosus*, *Spermacoce octodon*and *Sporobolus pyramidalis*. In contrast, the species which lie further along to the left of the Axis 1 are the *Chloris pilosa* with a CA score of 1.464, and *Senna obtusifolia* with a CA score of 1.431. In addition, *Loudetia simplex* has by far the highest CA score on Axis 2 (3.327) (Table 1).

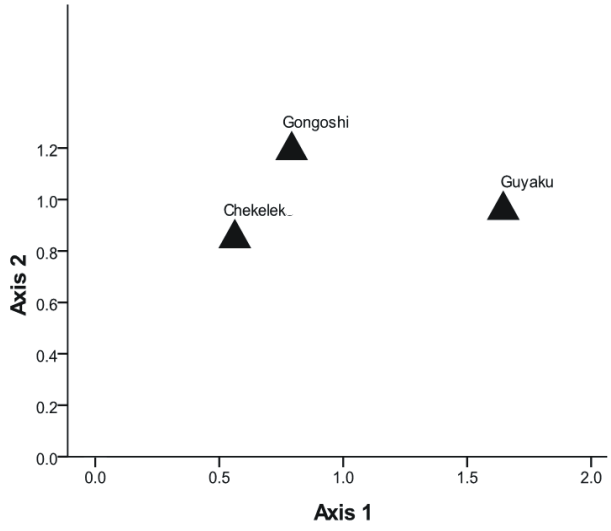

Fig. 3: Correspondence analysis based on the frequency of herbaceous plant species Axis 1 and Axis 2 indicated the dispersion among range sites.

Correspondence Analysis of Woody Plant Species

The differences in the distribution of woody plant species among the range sites was also illustrated using correspondence analysis. The eigenvalues showed that Axis 1 the CA explained 50.84% of the variation in woody plant species frequency. Axis 2, unlike Axis 1, explained 71.31% of the variation in woody plant species frequency. This means that Axis 1 separates out well the sites according to woody plant species frequency. Looking at the individual woody plants species CA variable scores, species which are important in Chekelek range site are those which lie furtherest to the left of Axis 1 (Fig. 2). These comprise the three species (*Combretum collinum*, *Combretum fragrans* and *Tamarindus indica*) with CA scores of -0.273, *Acacia erythrocalyx and Isoberlinia tomentosa* with CA scores of-0.973 and 1.898 respectively (Appendix 2). These are all woody plant mostly found in Guyaku range site. In contrast, the species which lie further along to the right of Axis 1 are the three (3) species (*Daniellia oliveri*, *Hexalobus monopetalus* and *Prosopis africana*) with CA score of 3.282 and *Terminalia laxiflora* with CA score of 0.533. In addition, four species (*C. collinum*, *C. fragrans*, *Ficus sycomorus* and *Tamarindus indica*) had by far the highest CA score on Axis 2 (3.292) (Table 2).

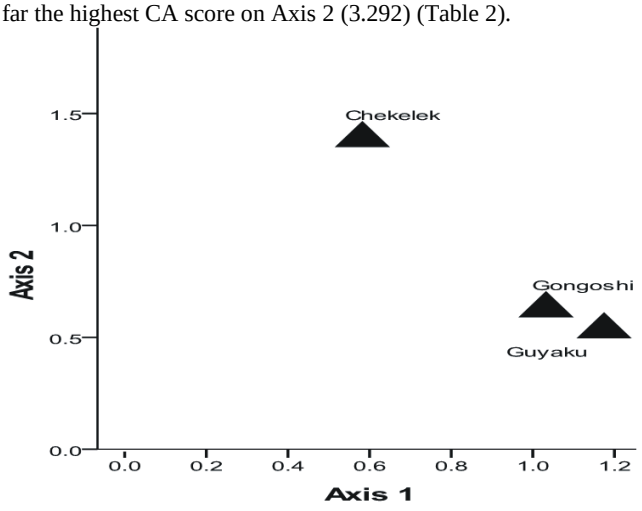

Fig. 4: Correspondence analysis based on the frequency of woody plant species Axis 1 and Axis 2 indicated the dispersion among range sites.

Table 1: Object Scores of Herbaceous Plant Species at the Range Sites

Plant spp. (Scientific Name)	Observation	Axis 1	2
Acalypha fimbriata	1	.003	-.065
Acanthospermum hispidum	2	.002	-.096
Acroceros zizanioides	3	.003	-.065
Aeschynomene indica	4	.009	-.103
Ageratum conyzoides	5	.005	-.096
Amaranthus spinosus	6	.004	-.097
Andropogon gayanus	7	-.003	-.089
Aspilia bussei	8	.004	-.084
Axonepus compressus	9	2.305	-3.146
Borreria verticellata	10	.009	-.101
Brachiaria deflexa	11	-.060	1.272
Brachiaria falcifera	12	3.978	-.158
Brachiaria lata	13	-1.872	1.195
Celosia leptostachya	14	2.305	-3.146
Cenchrus biflorus	15	.005	-.095
Cenchrus ciliaris	16	.003	-.125
Chamecrista mimosoides	17	.002	-.082
Chloris gayana	18	.639	-2.810
Chloris pilosa	19	1.464	-3.379
Chrysanthelium indicum	20	.004	-.092
Chrysopogon aciculatus	21	.000	-.106
Cleome viscosa	22	-.003	-.089
Commelina benghalensis	23	.011	-.105
Commelina nudiflora	24	.003	-.101
Crotalaria macrocalyx	25	.002	-.093
Crotalaria retusa	26	.013	-.107
Ctenium newtonni	27	-1.825	1.891
Cymbopogon giganteus	28	.003	-.084
Cynodon dactylon	29	.004	.104
Cyperus esculentus	30	.003	-.101
Cyperus iria	31	.002	-.026
Cyperus rotundus	32	-.508	-.058
Dactyloctenium aegyptium	33	.515	-1.077
Desmodium scopiurus	34	.000	-.103
Desmodium tortusom	35	.002	-.087
Digitaria gayana	36	-1.135	.886
Digitaria horizontalis	37	1.544	2.801
Digitaria tanata	38	.006	-.528
Echinochloa colona	39	.014	-.106
Eleusine indica	40	.005	-2.583
Eragrostis atrovirens	41	.004	-.097
Eragrostis ciliaris	42	-3.102	-1.459
Eragrostis megaphylla	43	-10.045	-2.035
Eragrostis tenella	44	.002	-.105
Eragrostis tenuebabis	45	1.601	-1.176
Eragrostis tremula	46	1.743	2.152
Eriosema psoraleiodes	47	.004	-.101
Euphorbia hirta	48	.003	-.102
Euphorbia hyssopifolia	49	.004	-.092
Evolvulu salsioides	50	.003	-.065
Fimbristylis littoralis	51	.003	-.092
Gomphrena celosioides	52	.006	-.104
Hackelochloa granularis	53	.003	-.065
Heliotropium ovalifolium	54	.003	-.065
Hibiscus asper	55	.003	-.085
Hyparrhenia involucrata	56	.017	-.108
Hyparrhenia rufa	57	.007	-.101
Hyperthelia dissoluta	58	.013	-.106
Hypoestes cancellata	59	-.003	-.089
Hyptis lanceolata	60	.001	-.088
Hyptis spicigera	61	.001	-.103
Hyptis suaveolens	62	.006	-.102

Imperata cylindrica	63	.002	-.089
Kyllinga erecta	64	.003	-.021
Kyllinga squamulata	65	.012	-.105
Laggera aurita	66	.003	-.084
Leptochloa caerulescens	67	.002	-.103
Leucas martinicensis	68	-1.571	2.634
Loudetia annua	69	1.544	2.801
Loudetia arundinaceum	70	.004	-.097
Loudetia simplex	71	-.706	3.327
Mitracarpus villosus	72	3.362	2.817
Monechma ciliatum	73	.007	-.102
Oldenlandia herbacea	74	.004	-.110
Panicum maximum	75	.003	-.081
Panicum repens	76	.004	-.101
Paspalum conjugatum	77	-.003	-.089
Paspalum scrobiculatum	78	.004	-.098
Pennisetum pedicellatum	79	.030	3.054
Pennisetum polystachion	80	.004	-.096
Pennisetum violaceum	81	.003	-.091
Perotis indica	82	-.303	-1.125
Platostoma africanum	83	.000	-.105
Polycarpaea corymbosa	84	.004	-.079
Rhynchelytrum repens	85	-.508	-.058
Sclerocarpus africanus	86	.004	-.092
Senna obtusifolia	87	1.431	-.125
Senna occidentalis	88	.002	-.091
Setaria barbata	89	.007	.314
Setaria longiseta	90	.005	.239
Setaria megaphylla	91	-3.935	-.391
Setaria pumila	92	.680	-2.353
Sidaacuta	93	.023	-.114
Sidacordifolia	94	.009	-.101
Sidarhombifolia	95	.005	-.096
Sorghum bipennatum	96	.003	-.065
Spermacoce octodon	97	2.305	-3.146
Spermacoce verticellata	98	-.003	-.089
Sporobolus pyramidalis	99	1.640	2.402
Striga hermonthica	100	.006	-.103
Striga senegalensis	101	.006	-.097
Tephrosia linearis	102	-.217	.732
Tephrosia pedicellata	103	.335	1.153
Trianthema postulacastrum	104	.002	-.092
Tridax procumbens	105	.005	-.096
Triumfetta cordifolia	106	.004	-.092
Triumfetta rhomboidea	107	.002	-.090
Vernonia cinerea	108	.002	-.088
Waltheria indica	109	.000	-.108
Zornia latifolia	110	.000	-.102

Where, observations 1 – 110 represents the 110 herbaceous species studies (Appendix 1)
Note: Positive Sign (-) represents species which are more important in a given range site while the Negative (-) indicates species which are less important in a given range site

Table 2: Object Scores of Woody Plant Species at Gongoshi, Guyaku and Chekelek Range Sites

Observation	Axis	
	1	2
1.	-1.053	-.885
2.	-.299	.166
3.	-.973	-.963
4.	- .1.225	-.974
5.	-.386	.067
6.	-.386	.067
7.	-.759	-.369
8.	-.386	.067
9.	-1.146	-1.514
10.	-1.263	-1.066
11.	-1.132	-.806
12.	-1.393	-1.326
13.	-.273	3.292
14.	-.273	3.292
15.	-.759	-.369
16.	3.282	-1.477
17.	-1.263	-1.066
18.	-.386	.067

19.	.461	1.395
20.	-.273	3.292
21.	2.590	-.818
22.	3.282	-1.477
23.	.166	2.775
24.	1.898	-.160
25.	-1.132	-.806
26.	-1.132	-.806
27.	3.282	-1.477
28.	-1.053	-.885
29.	2.590	-.818
30.	-.386	.067
31.	-.273	3.292
32.	.756	-.046
33.	.988	1.164
34.	.533	1.826
35.	.461	1.395
36.	-1.263	-1.066
37.	-.597	.851

Where, observations 1 – 37 represents the 37 woody species studies (Table 2)
Note: Positive Sign (-) represents species which are more important in a given range site while the Negative (-) sign indicates species which are less important in a given range site

Importance Value Indices of Woody Plant Species

The Importance Value Indices (IVI) of the woody plant resources identified in the study areas are shown in Table 3. In Gongoshi range site, the IVI of woody plant species in the range site ranged between 38.942 and 4.256 with *Balanites aegyptiaca* having 38.942 while *Acacia erhenbergiana* had 4.255. In Guyaku range site, the IVI ranged from 40.401 to 6.48 with *Balanites aegyptiaca* having 40.401 and *Acacia nilotica* having the least IVI of 6.477. While in Chekelek range site, the IVI ranged from 32.193 to 8.997 with *Acacia nilotica* having the highest IVI of 32.193 and *Combretum collinum* having the least IVI of 8.997.

DISCUSSION

Correspondence analysis of the herbaceous plant species on the three range sites indicated a deviation from the normal trend. This is because Gongoshi range site which lies southward of the guinea savanna showed higher similarity to Chekelek in the sudansavanna in herbaceous plant composition than to Guyaku which lies in the same zone (guinea savanna). This deviation can be explained by Groombridge's (1992) finding that factors such as plant available moisture, plant available nutrient, temperature, occurrence of fire and the influence of herbivores could result in local variations irrespective of geographical region.Besides, Baruch *et al.* (1996) reported that species differentiation may be more marked in high-stress ecosystems and more subtle in resource-rich and low-stress ecosystems. The high-stress at Gongoshi range site which has turned the site into an almost sudan type may not be unconnected with the anthropogenic activities such as overgrazing due to high population of livestock, farming, high incidence of wildfire and over-exploitation of woody plant resources. However, the correspondence analysis of woody plant species indicated that Gongoshi and Guyaku range sites, both in guinea savanna had higher similarity in the distribution pattern of woody plant species. The analysis indicated a clear distinction between Chekelek in the sudansavanna and any of the two (Gongoshi and Guyaku) range sites.

Analysis of the vegetation of the sites to show the Importance Value Indices (IVI) of the woody plant species is a means of providing information on the dominant woody plant species in the area. Result of this study indicates that dominant woody species are those with IVI scores of 20 and above. It implies that these species are adapted to the range sites more than others and can survive agents of decimation more than other woody plant species. Their relevance in terms of cover, food for both animals and man and wood, adds value to the ecosystem. Therefore, the availability of a minimum of four (4) woody plant species as dominant species on each site is an indication of high conservation and economic value of the sites.

Table 3: Importance Value Indices of Woody Plant species at the Range Sites

S/N	Scientific Name	Range Site		
		Gongoshi	Guyaku	Chekelek
1.	*Acacia dudgeon*	-	6.0374	20.3650
2.	*Acacia erhenbergiana*	4.2558	19.0755	22.2903
3.	*Acacia erythrocalyx*	-	-	22.1204
4.	*Acacia nilotica*	-	6.4773	32.1931
5.	*Acacia senegalensis*	4.2816	-	-
6.	*Afzelia Africana*	6.0813	-	-
7.	*Albizia zygia*	6.1585	9.5774	-
8.	*Anogeissus leiocarpus*	6.3384	-	-
9.	*Balanites aegyptiaca*	38.9418	40.4009	22.2336
10.	*Bombax costatum*	19.5295	9.8125	-
11.	*Boswellia dalzieli*	-	8.7395	-
12.	*Burkeaafricana*	18.8996	-	-
13.	*Combretum collinum*	-	-	8.9968
14.	*Combretum fragrans*	-	-	11.3184
15.	*Combretum molle*	6.1327	9.4936	-
16.	*Daniellia oliverii*	12.0598	18.4007	-
17.	*Detarium microcarpum*	18.8610	9.0747	-
18.	*Diospyros mespiliformis*	6.4413	-	-
19.	*Ficus exaperata*	-	27.6972	-
20.	*Ficus sycomorus*	-	-	10.1859
21.	*Guiera senegalensis*	11.9827	-	22.2405

CONCLUSION AND RECOMMENDATIONS

Result of Importance Value Index (IVI) of woody plant species showed that *Balanites aegyptiaca* and *Terminalia glaucescens* maintained consistent high IVI in the three rangeland sites. Distribution pattern of plant species among the three range sites showed that floristic composition is not determined by geographical location but by ecological requirements. Important Value Index (IVI) of the woody plant species indicated that most of the dominant species are not of economic value. Adequate policy and institutional arrangements should be put in place for proper management and conservation of Adamawa rangeland; Proper grazing plan that should take into consideration the carrying capacity of the range sites should be developed and functional laws and effective surveillance should be put in place.

22.	*Hexalobus monopetalus*	9.2959	-	-
23.	*Isoberlinia doka*	23.8880	-	8.4305
24.	*Isoberlinia tomentosa*	-	-	15.1123
25.	*Khaya senegalensis*	-	9.2003	-
26.	*Parkia biglobosa*	-	9.8288	-
27.	*Prosopis Africana*	-	18.0236	-
28.	*Ptericarpus lucens*	-	6.6029	21.3848
29.	*Sclerocarya birrea*	-	18.5683	19.7490
30.	*Sterculia setigera*	6.8784	-	-
31.	*Tamarindusindica*	-	-	12.8473
32.	*Terminaliaavicennioides*	5.9013	-	19.2960
33.	*Terminaliaglaucescens*	25.3535	28.4806	19.5791
34.	*Terminalialaxiflora*	24.9936	27.8103	-
35.	*Terminaliamollis*	19.0153	-	-
36.	*Vittelariaparadoxum*	5.9013	9.5355	-
37.	*Vitex doniana*	18.8096	7.0638	11.6582

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