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An Investigation into the Herbaceous Plant Formations of Yankari Game Reserve Bauchi, Nigeria

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Abstract: The diversity of herbaceous plant species of YGR was investigated using the point centred quarter method. Five permanent transects (sites) established earlier on were systematically sampled and plant communities encountered reported. About 45 species belonging to 5 families and 8 genera were identified. The strength of the family wise distribution of the species is Poaceae; 31 (68.8%), Cyperaceae; 9 (20%), Poligonaceae; 3 (6.7%) Ceasalpinnaceae and Malvaceae; 1 (2.2%) each. All associations and similarity values were negative except those between sites III and IV and IV and V. The relationship between Sites I and V was significant ($p>0.05$) indicating strong heterogeneity. The species encountered belonged to *Polygonum salicifolium*, *Pycreus lanceolatus* and *Digitaria gayana* community. In addition, all the species were distributed mainly in the three lower Constancy Classes (CC) of 0-20, 21-40 and 41-60. One species, *Digitaria gayana* was found in the CC4. Therefore, majority of the species encountered were infrequent as high values where obtained in lower constancy classes whereas low values were obtained in higher constancy classes. Thus, it is possible to conclude that there exists a high degree of floristic heterogeneity in Yankari Game Reserve.

Key words: Diversity, importance value, constancy, communities, priority, genera

INTRODUCTION

Plants are universally recognized as vital part of the world's biological diversity and an essential resource for human well-being (Kumar, 1997). Besides the crop plants that provide the basic food and fibres, many thousands of wild plants have great economic, aesthetic and cultural values and potential, providing food, medicine, fuel, clothing and shelter for vast numbers of people throughout the world. Plants also play a key role in maintaining basic ecosystem support services and functions in the provisioning of goods and services and provide an important component of the habitats for the world's animal life (McNeely, 1994). At present, a complete inventory of the plants of the world has not been assembled but it is estimated that the total number of vascular plant species may be of the order of 300,000 (FAO, 2006). Of particular concern is the fact that many are in danger of extinction, threatened by habitat transformation, over-exploitation, alien invasive species, pollution and climate change (World Conservation Monitoring Centre, 1992; Sanusi and Daura, 1997). The disappearance of such vital and large amounts of biodiversity sets one of the greatest challenges for the world community: to halt the destruction of the plant diversity that is so essential to meet the present and future needs of humankind (FAO, 2006). The herbaceous flora of the YGR is among the most diverse of all savanna landscapes (Green and Amanche, 1987). This diversity derives in part from site's moist-warm climate and also from its geological and topographic diversity (Keay, 1962; Geerling, 1973; Green and Amanche, 1987; Abdullahi, 2001). Besides its intrinsic value, the diverse array of herbaceous species including the woody elements play a significant role in the overall ecology of the area and it is a key element for nearly all of the ecosystem services they provide (Abdullahi and Sanusi, 2006; Abdullahi *et al*., 2009). Herbs provide critical habitat for a diverse array of animals and are the base for complex food webs. They stabilize soil and retain water, thereby maintaining water quality, moderating water flows and preventing erosion. Thus, herbs are especially important to watershed health (McNeely, 1994). The herbaceous flora of this region also provides direct economic value to communities (Abdullahi *et al*., 2007).

They contribute significantly to the aesthetic beauty of the reserve. Many of the reserves herb species have economic value in their own right for example *Hyparrhenia* and *Andropogon* sp. are widely harvested and used in making thatched roofs. Several herbs, most notably *Digitaria gayana*, *Cyperus exaltaltus* and *Cynodon dactylon* (Abdullahi *et al*., 2010) are prized for their medicinal value. Thus the significance of the vegetation of the area need not be overemphasized. Therefore the need for such a study is not only necessary but urgent. Here, we report on the status and potential future of the herbaceous flora of the YGR for possible exploitation and management.

MATERIALS AND METHODS

Description of the study site: Yankari Game Reserve lies in the Southern part of the Sudan Savanna. It is composed of savanna grassland with well-developed patches of woodland. It is also a region of rolling hills, mostly between 200 and 400 m above sea level. It falls within the latitudes 9°50'N and 10°30'E lying in the South-Central area of Bauchi state. The vegetation is composed mainly of combretaceous trees and shrubs, Afzelia, Anogeissus and Detarium savanna woodlands. Annual rainfall in the park is between 900 and 1,000 mm. The rainy season is from May to September. Temperatures range between 18 and 38°C throughout the season. During the dry season, the harmattan wind blows from the Sahara, often bringing dusty skies and night temperatures fall as low as 12°C. The hottest period falls in March and April when temperatures can rise above 40°C in the day (Geerling, 1973).

The selection of sites was done to satisfy and provide for reasonable sampling of the main floristic types in the area. The number of vegetation types and subtypes identified and sampled for the study follows Green and Amanche (1987).

Site I: Situated on latitude 09°87'N and longitude 10°39'E and altitude of 328 m laying along Coulthard way (about a km East of Ahmadu Bello way) in shrub savanna derived from tree savanna by dying off of most trees which corresponds with Transect No. 1.

Site II: Situated on latitude 09°46'N, longitude 10°32'E and an altitude of 352 m, laying along Shaaman track (about 3 km West of Kalban hill, near Afzelia tree savanna junction) which corresponds with Transect No. 2.

Site III: Situated on latitude 09°88'N, longitude 10°39'E and an altitude of 430 m, laying about 3 km Northeast of Wikki camp in combretaceous tree savanna which correspond with Transect No. 3.

Site IV: This is situated on latitude 09°77'N, longitude 10°25'E and an altitude of 341 m, about 2.5 km, South of Familian Guturu track in Combretaceous shrub savanna which corresponds with Transect No. 4.

Site V: Situated on latitude 09°88'N, longitude 10°34'E and an altitude of 467 m, laying on Yalo track about 2.5 km East of Kariyo hill in Afzelia tree savanna which corresponds with Transect No. 5.

Study procedure: The vegetation study using the Point Centered Quarter (PCQ) Method was undertaken in 2005. About 50 sampling points along five habitats (transects) each were enumerated and recorded. The quantitative account of vegetation such as density and frequency were recorded using plotless sampling technique of Cottam and Curtis (1956). Importance Value Index (IVI) was obtained for each species that was calculated by adding relative density and relative frequency (Misra, 1968). On the basis of highest IVI, sampled vegetation was delineated into different plant communities based on the three leading dominant species per site (Qadir *et al*., 1966; Misra, 1968; Qureshi and Bhatti, 2006). Plants were identified with the help of floristic literature (Hutchinson and Dalziel, 1963).

Constancy was calculated based on the number of occurrences of species within the sites (Misra, 1968). The number of site of occurrence of a species was divided by the total number of sites sampled and multiplied by 100 (Misra, 1968). The result was expressed in the following scale: 1-20% (CC1), 21-40% (CC2), 41-60% (CC3), 61-80% (CC4) and 81-100% (CC5). The interpretation for this is that if there is a combination of several species with a high constancy percentage, the species belong to one association (Misra, 1968). The 2×2 contingency table was also used for calculating Chi-square and correlation coefficients and consequently the statistical test was employed on the Chi-square. The Chi-square statistic compares the tallies or counts of categorical responses between two (or more) independent groups (Causton, 1988). Chi-square as used here was a measure of the magnitude of association between two sites for either positive or negative associations, the higher the value of Chi-square, the higher the degree of association (Chapman, 1976; Causton, 1988; Kinako, 1988). Chi-square was also used to test the significance of associations and in this case, calculated value of Chi-square was compared with the tabulated value for the relevant degrees of freedom (one in this case) and the selected probability level. The correlation coefficient (r) is a perfectly good measure of correlation between sites whatever the statistical distribution of the data might be (Causton, 1988). The sign of this is the same as that of (ad-bc) from the equation. For both x^2 and r if the product ad>bc, a positive association was indicated and conversely if ad<bc the association is negatively correlated (Causton, 1988; Kinako, 1988; Kent and Coker, 1992).

RESULTS AND DISCUSSION

Floristic composition: Important Value Index (IVI) is a good index for summarizing vegetation characteristics, sranking species for management purposes and conservation practices. It reflects the degree of dominancy and abundance of a given species in relation to the other species in the area (Kent and Coker, 1992).

Table 1: The importance value index of the herbaceous species of Yankari Game Reserve

Species	I	II	III	IV	V	Importance Values mean	max
Acroceras amplectans	-	-	-		14.0	14.00	14.0
Andropogon ascinoides	-	-		10.5	-	10.50	10.5
Andropogon gayanus	-	-	-		6.5	6.50	6.5
Brachiaria deflexa	-	12.0	-	-	-	12.00	12.0
Ctenium newtoni	-	-	9.0	-	-	9.00	9.0
Cymbopogan gigantum	-	10.5	15.0	-	-	12.60	15.0
Cynodon dactylon	-	15.0	-	-	-	15.00	15.0
Cyperus difformis	12.5	-	-	-	-	12.50	12.5
Cyperus exaltaltus	12.0	9.5	-	-	-	10.80	12.0
Digitaria exilis	10.0	-	-	-	-	10.00	10.0
Digitaria gayana	-	11.5	15.0	15.5	13.0	13.80	15.5
Digitaria horizontalis	-	5.5	7.0	-	6.5	6.30	7.0
Echinochloa pyramidalis	-	-	10.0	11.5	8.5	10.00	11.5
Echinochloa stagnina	-	-	-	-	7.5	7.50	7.5
Eleusine indica	-	9.0	-	-	-	9.00	9.0
Eragrostis tenella	-	-	6.5	11.5	3.0	7.00	11.5
Fimbistylis exilis	-	-	-	-	10.5	10.50	10.5
Fimbristylis ferruginea	10.5	5.0	-	-	-	7.75	10.5
Fuirena ciliaris	-	-	9.0	-	-	9.00	9.0
Fuirena umbellate	12.5	-	-	-	-	12.50	12.5
Hyparrhenia cyanensis	9.5	-	-	-	-	9.50	9.5
Hyparrhenia rufa	9.5	-	-	-	-	9.50	9.5
Imperata cylindrical	-	-	-	-	10.5	10.50	10.5
Leersia hexandra	11.0	15.0	-	10.0	-	12.00	15.0
Loudetia annua	4.0	10.0	-	-	-	7.00	10.0
Oryza barthii	9.5	-	-	-	-	9.50	9.5
Oryza longistaminata	-	-	9.0	-	-	9.00	9.0
Panicum subalbidum	-	9.0	-	-	-	9.00	9.0
Pennisetum polystachion	-	11.0	-	-	-	11.00	11.0
Pharagmites karka	-	-	-	-	8.0	8.00	8.0
Poligonum lanigerium	13.5	-	15.0	-	-	14.30	15.0
Polygonum palcrum	-	-	10.5	-	-	10.50	10.5
Polygonum salicifolium	-	4.0	17.5	-	-	10.80	17.5
Pycreus lanceolatus	-	16	-	-	-	16.00	16.0
Rotboellia exaltata	-	-	-	-	10.5	10.50	10.5
Rynchospora corymbosa	12.5	-	8.0	-	-	10.25	12.5
Sacciolepis africana	-	-	10.0	14.0	15.0	13.00	15.0
Senna mimosoides	-	-	-	-	7.0	7.00	7.0
Setaria anceps	-	-	13.5	-	-	13.50	13.5
Setaria barbata	-	-	-	8.5	-	8.50	8.5
Setaria pumila	-	-	9.0	-	-	9.00	9.0
Sorghum arundinaceum	-	-	-	-	10.5	10.50	10.5
Sporobulus pyramidalis	-	-	-	8.5	13.5	11.00	13.5
Urena lobota	-	-	-	10.5	-	10.50	10.5
Vetiveria nigritana	14.5	-	9.0	-	-	11.80	14.5

The result of IVI is shown in Table 1. The number of sites in which a species occurred during the period of the survey, the mean and maximum IVI values of the species based on the rankings of the importance values was also shown for the respective sites. Three species with the highest IVI in each site were used to name communities in these sites as follows; *Vetiveria-Poligonum-Rynchospora* in Site I, *Pycreus-Leersia-Cynodon* in Site II and *Polygonum-Digitaria-Poligonum* in Site III. In Sites IV and V the following species were found to be dominant: *Digitaria-Cymbopogon-Sacciolepis* and *Sacciolepis-Acroceras-Sporobulus*, respectively. In all a total of 45 herbaceous species were encountered and identified. The species were found in 5 families. The strength of the species is Poacaea 31 (68.8%), Cyperaceae 9 (20%), Poligonaceae 3 (6.7%), Ceasalpinnaceae 1 (2.2%) and Malvaceae 1 (2.2%).

Table 2: Constancy values of herbaceous species in Yankari Game Reserve

Class interval	Constancy values	Percentage
A 81-100	0	0.0
B 61-80	1	2.2
C 41-60	5	11.1
D 21-40	9	20.0
E 1-20	30	66.7
Total	45	100.0

Table 3: Association, similarity and correlation between sites for herbaceous species in Yankari Game reserve

Sites	Chi-square	Correlation	ad/bc	S_x	S_r
SiteI/II	0.00099699^{NS}	-0.00470690	-	44.9990030	1.004706938
SiteII/III	0.66465792^{NS}	-0.12153260	-	44.3353421	1.121532613
SiteI/IV	2.77779206^{NS}	-0.24845260	-	42.2222079	1.248452636
SiteI/V	5.22321429*	-0.34069260	-	39.7767857	1.340692572
SiteII/III	0.88898150^{NS}	-0.14055300	-	44.1110185	1.140552995
SiteII/IV	1.13556273^{NS}	-0.15885440	-	43.8644373	1.158854422
SiteII/V	3.31797235^{NS}	-0.27153770	-	41.6820276	1.271537693
SiteIII/IV	0.10008256^{NS}	-0.04715990	-	44.8999174	1.047159906
SiteIII/V	0.05184332^{NS}	0.03394221	+	45.0518433	0.966057788
SiteIV/V	0.86206897^{NS}	0.13840913	+	45.8620690	0.861590867

* = Significant at p>0.005; NS = Not Significant

Herbaceous species constancy values: The constancy values for the species are shown in Table 2. The values show the relative occurrences of individual species by site. Clearly only a species was in 61-80% Constancy Class (CC), 5 species were in 41-60% and 9 and 30 species were in 21-40 and 1-20% CC, respectively. None of the species falls within the 81-100% CC throughout the period of the study.

Association, correlation and similarity between sites: Table 3 shows the species association, similarity and correlation within sites under review. It is evident that there was a low association and negative correlation which was only significant between Sites I and V only. All other relationships were negative except those between Sites III and V and IV and V which were positive though not significant. The S_x and S_r values were similarly less than the total number of species in the data set (45) and >1 except for the two positive relationships depicting weak relationships and heterogeneity.

A total of 45 species belonging to five families were encountered throughout the survey period although this is not an exhaustive list of species that may be found in Yankari. Species presence and abundance especially that of annuals may change from year to year due to the influence of water regime and the density of the vegetation cover (Abdullahi *et al.*, 2009; Abdullahi and Sanusi, 2006). The most diverse genera were *Digitaria*, *Poligonum* and *Setaria* with three members each. Seven genera namely; *Andropogon*, *Cyperus*, *Echinochloa*, *Fimbristylis*, *Fuirena*, *Hyparrhenia* and *Oryza* have two members each. All other genera were represented with one species throughout the study period. The species dominating the herbaceous layer were basically as reported to occur either in tropical West Africa (Johnson, 1997) or the region East of Jos, Plateau (Keay, 1962). These are species mainly characteristic of the savanna moist areas (Von Maydell, 1989). However, the most important species encountered based on the IVIs were *Poligonum salicifolium*, *Digitaria gayana*, *Cymbopagon gigantum*, *Cyanadon dactylon*, *Leersia hexandra*, *Pycreus lanceolatus*, *Poligonum lanigerium*, *Sacciolepis africana*, *Vetiveria nigritana* and *Spobulus pyramidalis*. Cyperus difformis and *Fuirena umbellate*. Those at the bottom of the pyramid based on the same criterion were: *Andropogon gayanus*, *Digitaria horizontalis*, *Cassia mimosoides*, *Echinochloa stagnina*, *Pharagmites karka* and *Setaria barbata* among others. These are savanna moist area characteristic species (Blair, 1976; Von Maydell, 1989; Akobundu and Agyakwa, 1998; Abdullahi, 2010). So, in comparison they should be accorded less priority for conservation efforts. The IVI is imperative at comparing the ecological significance of species and it indicates the extent of dominance of a species in the structure of a vegetation stand (Curtish and McIntosh, 1951; Lamprencht, 1989; Dallmeier and Comiskey, 1998). The degree of regularity of the species is shown by the constancy values. These values give an approximate indication of homogeneity or heterogeneity of stand (Leigh *et al.*, 1982; Parthasarathy and Karthikeyan, 1997; Parthasarathy, 1999). The constancy value for all of the species does show that no species belonged to constancy class CC5 (81-100%). Only one species namely: *Digitaria gayana* belonged to constancy class CC4 (61-80%). This is therefore, the most widespread and successful on the sites it occurred. This is followed by the nine species that belonged to constancy class CC3 (41-60%). About 31 species belonged to class CC2 (21-40%). Majority of species encountered were infrequent. Studies have however shown that high values of higher constancy classes and low values in lower constancy classes indicate constant or similar species composition (Kumar, 1997). In the same vein, high values in lower constancy classes and low values in higher constancy classes does indicate a high floristic heterogeneity. In the present study, high values where obtained in lower constancy classes whereas low values were obtained in higher constancy classes. Therefore, according to the interpretation, it is possible to conclude that there exists a high degree of floristic heterogeneity in Yankari Game

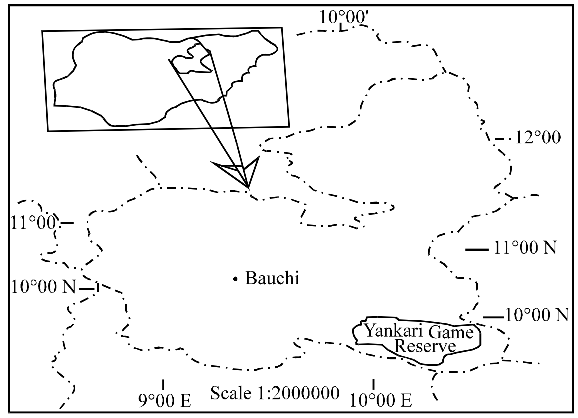

Fig. 1: Map of Nigeria showing Bauchi state and Yankari Game Reserve

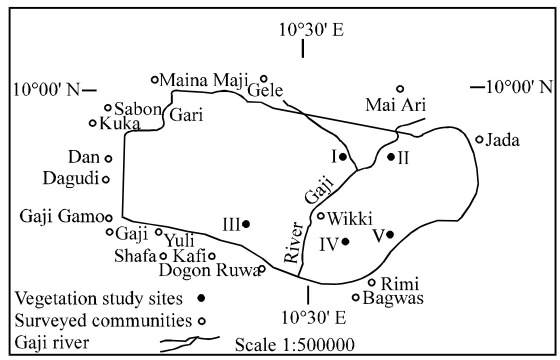

Fig. 2: Map of Yankari Game Reserve showing the study sites

Reserve (Fig. 1 and 2). The species appearing in the lower constancy classes have irregular occurrence whereas those appearing in higher classes have regular horizontal distribution (Rodgers and Panwar, 1988).

The most evident result of the current analysis is that among the studied sites, the vegetation types are more heterogeneous than otherwise. This is reflected of site selection from reconnaissance survey and this is in good accord with the well-known theory of plant species influence circles according to which all plant specimens are distributed randomly than otherwise (Zinke, 1962; Kochummen *et al.*, 1990; Virtanen *et al.*, 2000; Kumar *et al.*, 2006). However, the influence circles of trees may be superimposed on the environmental pattern and they can have privilege in the forming of the understorey vegetation structure (Abolin, 1974; Beatty, 1984; Boettcher and Kalisz, 1990). Obviously this is true only in the case of comparatively homogeneous microtopography (Beatty, 1984). If the latter is more heterogeneous rather remarkable differences can be discovered between the ecological conditions of different microsites and these factors may prove to be decisive for the formation of the horizontal pattern of the undergrowth (Parthasarathy, 1999). The result observed in this study indicates heterogeneous distributions of species between sites which is in good accord with other related investigations in similar microhabitats (Kochummen *et al*., 1990; Sanusi and Daura, 1997; Kumar *et al*., 2006; Abdullahi *et al*., 2009). However, both positive and negative associations were noticed for the herbaceous data based on the Chi-square and its related statistic. The higher the Chi-square value, the higher the magnitude of the association and the higher the correlation coefficient value the higher the correlation between sites. Despite similarity in certain ecological factors, data between sites showed positive associations and correlations at only two levels between Sites III and V and IV and V and none of the relations was found to be significant except between Site I and V, though this is negative association. Thus sites similarities do not necessarily imply similar structural composition (Banda *et al*., 2006) and thus not relevant in short time scale (Cox and Larson, 1993). Other environmental factors such as natural histories of plant distributions, continental drift and mutations which might have occurred in the distant past could be responsible for the present day distribution of plant species (Kellman, 1975; Solbrig, 1991). This could give rise to the presences and absences of species from one site to another giving advantage to species with wider ecological amplitudes that can respond to environmental rhythms within a given time frame.

CONCLUSION

Lack of uniform methodology has always been a concern for drawing meaningful insights into outlining structural complexities leading to conservation strategies. In the wake of the ever increasing biodiversity loss such studies highlighting distribution of plant resources at an entire ecosystem in a region will be vital. Besides, application of standard methodology will help in analyzing and interpreting data at larger spatial scale. We therefore recommend that more research should be carried out for better understanding of the successsional processes within the YGR.

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