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SEASONAL CHANGES IN THE PHYTOSOCIOLOGICAL AND PRODUCTIVE STRUCTURES OF TWO STANDS OF *ARISTIDA CYANANTHA* DOMINATED GRASSLANDS (VINDHYAN HILLS, INDIA)

Changements saisonniers dans la structure phytosociologique et la productivité primaire de deux formations végétales herbacées dominées par *Aristida cyanantha* (Monts Vindhyan, Inde)

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RESUME

Deux savanes, l'une protégée, l'autre pâturée, ont été étudiées du point de vue de leur structure phytosociologique et de leur productivité primaire de mai 1973 à mai 1974. La savane pâturée montre une diversité spécifique supérieure, une densité totale plus élevée mais une aire basale inférieure, sauf en été. En ce qui concerne la productivité primaire, la savane protégée possède des valeurs légèrement supérieures à la savane pâturée avec toutefois des différences saisonnières moins contrastées. En conclusion, le rôle du bétail apparaît comme positif, pour autant que le pâturage soit modéré et contrôlé.

ABSTRACT

Protected and open to grazing A r i s t i d a c y a n a n t h a dominated grassland were compared regarding phytosociological and primary productive structure from May 1973 to May 1974. Open to grazing grassland presents a higher species diversity, a higher total density but a lower basal area, except in Summer. Regarding primary productivity protected grassland has slightly higher values than open to grazing grassland but lesser season differences. In conclusion, under moderate controlled grazing, the role of cattle is advantageous.

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INTRODUCTION

About 80 km south east of Varanasi there are forest stands at Chakia, Naugarh and other ranges on the Vindhyan hills. There are extensive open lands dominated by grasses, a number of which have been fenced with barbed wire to offer protection against grazing. Plantation of bamboo seedlings have been done in these enclosures. A protected grassplot of about 250 hectares in Majgahi range (site I) and another open to grazing lying adjacent to it in Naugarh range (site II) are dominated by *Aristida cyanantha* Nees ex Steud. These have been studied for the phytosociological and primary productive structures from May 1973 to May 1974.

Site condition and climate.

The general elevation varies between 160 meters to 220 meters above sea level or between 90 to 150 meters above to surrounding plains below the hills. The gradient is almost flat for these grasslands. Site I in Majgahi range was fenced in early 1971 and site II in Naugarh range was open to grazing by cattle. The soil is coarse, reddish brown and slightly acidic (pH = 6 to 6.9), and shallow with parent rock underlying at varying depths upto a maximum of 1.5 m. The climate is characterised by three distinct seasons; the rainy season (July to October) which is hot and humid, the winter season (November to February) which is cold and mostly dry and the summer season (March to June) which is dry and very hot. Most of the rainfall is received by monsoon winds coming from the Bay of Bengal during the four rainy season months (85 %). The average annual precipitation is about 1100 mm. During January, the retreating monsoon from west, usually provides a few showers. Rest of the months are normally dry and sky is bright and clear. The rainfall and temperature averages for the study period are given in table I. During the study period the mean maximum temperature was highest in the summer month of June being 37.2° C and the lowest was 24.5° C in January and the mean minimum was also highest in June being 28.6° C and lowest was 6.7° C in January. The temperature starts falling from the advent of rainy season in July and touches the lowest value in January. It starts slowly increasing in the month of February and the highest temperature is reached in the end of May or beginning of June. Soil moisture content variations influence greatly the phytosociological and productive structures of these grassplots.

Month	Rainfall (mm)	Relative Humidity (%)	Mean max. Temperature (°C)	Mean min. Temperature (°C)
June	23	80.2	37.2	28.6
July	338	77.3	36.1	26.9
August	238	83.7	32.2	28.7
September	296	86.6	31.3	26.3
October	51	74.2	31.8	21.6
November	30	75.6	29.6	15.6
December	2	71.1	24.6	7.5
January	15	44.2	24.5	6.7
February	2	63.6	26.0	18.9
March	2	59.8	34.5	15.4
April	4	41.3	38.2	23.9
May	3	57.1	41.5	25.7

Tab. I : Climatic data of Varanasi for the period June 1973 - May 1974.

METHOD

Through 50 x 50 cm quadrats laid at random, frequency, density, basal cover, relative values of these, ecological importance values for the component species were analysed in the three different seasons. These were calculated on the basis of averages of a number of quadrats. The life forms of different species for the analysis of Raunkiaer's biological spectrum were also studied.

RESULTS

Biological spectrum.

Phanerophytes have been ignored due to their rare occurrence and sampling being confined to herbaceous systems. Chamaephytes are absent. Therophytes are predominent being 62.9 % followed by Hemicryptophytes (29.6 %) and Cryptophytes (7.4 %). These values are very close to the biological spectrum of Varanasi and Kurukshetra grasslands (Singh and Yadava 1974) (Tab. II).

Site	Percentages				
	Ph	Ch	Hc	Cr	Th
1. Vindhyan grasslands (Present study)	-	-	29.6	7.4	62.9
2. Kurukshetra grasslands	-	10.4	18.7	6.2	62.5
3. Varanasi grasslands	-	3.1	20.3	7.8	68.7
4. Raunkiaer's (World values)	46.0	9.0	26.0	4.0	13.0

Tab. II : Biological spectrum.

Frequency.

In the summer season 11 species occur in protected plot (site I) but in grazed site (site II) there were 13 species. This is due to the occurrence of four new species and absence of two from the site I. In grazed site, frequency class C is highest followed by B, D and E.

In the rainy season the total number of species increases to 19 in protected and 26 in grazed fields. Frequency class A accounts for more than 50 % in both the sites followed by classes B, C, D and E. There is very little difference from rainy season in the total number of species in winter and in protected the frequency class relation is A>B>C>D<E whereas in grazed it is A = B<C>D<E indicating wide variation from Raunkiaer's standard frequency diagram. Frequency diagram for protected and grazed sites in the three seasons are given in figure 1.

Density.

In plants with multiple rooting points or multiple short emergence points from the soil, it becomes difficult to distinguish individuals. On grounds of convenience as well as scientific accuracy each tiller emerging separately from the ground is regarded as an individual for the calculation of density and other phytosociological parameters as has been done by SINGH (1967) and STONE & FRYER (1935).

Summer season has the lowest number of species. Of the total density value of all the 11 species in protected site (106.8/m^2) *Aristida cyanantha* accounts for 33.2/m^2 followed by *Heteropogon contortus* (12.8/m^2) and *Chrysopogon montanus* (12.0/m^2). The total density is almost the same in grazed plot (109.2/m^2) with 13 species and in share of individual species *Aristida cyanantha* tops (37.6/m^2) with *Heteropogon*

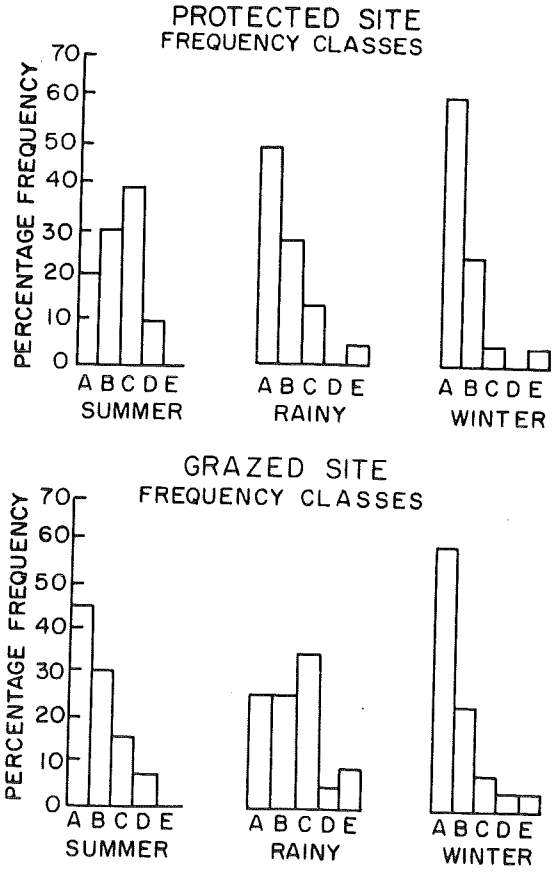

Fig. 1

($16.0/m^2$) coming next.

Rainy season shows a sharp rise in the variety of species reaching to 18 in protected and 26 in grazed sites. The total density increases to $164.0/m^2$ and $196.0/m^2$ respectively of which highest values are again for *Aristida cyanantha* ($55.0/m^2$ in I and $46.8/m^2$ in II) followed by *Bothriochloa pertusa* ($19.6/m^2$) in protected and *Aristida adscensiones* in grazed sites. The diversity in winter is still high being 20 in site I and 23 in site II but the total density increases further to $203.0/m^2$ and $234.0/m^2$ in protected and grazed conditions. *Aristida cyanantha* maintains the highest contribution in density values being $56.8/m^2$ and

Species	Summer season		Rainy season		Winter season		Life form
	Protected	Grazed	Protected	Grazed	Protected	Grazed	
Aristida cyanantha	80	85	95	100	85	90	Hc
Aristida adscensionis	-	-	20	30	45	85	Th
Ageratum sp.	-	25	-	15	-	35	Th
Apluda mutica	20	-	20	10	10	15	Hc
Bothriochloa pertusa	30	45	35	25	20	50	Cr
Cenchrus ciliaris	-	-	-	15	-	50	Th
Chrysopogon montanus	60	10	15	25	50	40	Hc
Chloris incompleta	35	-	10	15	20	15	Th
Chloris barbata	-	-	15	15	5	-	Th
Cassia tora	-	-	25	65	25	50	Th
Cyperus aristatus	50	20	20	15	25	70	Cr
Dactyloctenium aegyptium	-	-	-	20	-	-	Th
Desmostachya bipinnata	-	35	10	15	30	20	Hc
Desmodium triflorum	-	-	25	10	20	25	Th
Dichanthium annulatum	-	15	-	5	-	15	Hc
Eragrostiella bifaria	-	-	55	25	45	25	Th
Eragrostis gangetica	25	40	-	30	10	30	Th
Eragrostis tenella	-	-	40	50	15	60	Th
Evolvulus alsinoides	55	30	45	10	30	45	Hc
Euphorbia hirta	45	15	35	15	30	25	Th
Heteropogon contortus	40	50	20	20	25	60	Hc
Iseilema laxum	-	-	15	15	15	25	Th
Paspalidium flavidum	-	-	-	-	15	-	Th
Setaria glauca	-	-	-	50	-	45	Th
Sida acuta	-	10	15	15	10	20	Th
Sporobolus diander	-	-	-	30	-	45	Th
Vetiveria zizanioides	20	10	15	15	10	20	Hc

Tab. III : Percentage frequency of plant species in protected and grazed *Aristida* dominated grassland in different seasons.

Species	Summer season		Rainy season		Winter season	
	Protected	Grazed	Protected	Grazed	Protected	Grazed
Aristida cyanantha	33.2	37.6	55.6	46.8	56.8	53.6
Aristida adscensionis	-	-	4.4	20.4	37.2	52.0
Ageratum species	-	5.6	-	1.6	-	1.6
Apluda mutica	30.0	-	2.0	2.8	3.0	2.4
Bothriochloa pertusa	9.2	8.4	19.6	13.6	9.6	10.0
Cenchrus ciliaris	-	-	-	3.4	-	7.4
Chrysopogon montanus	12.0	2.0	-	11.4	12.8	7.0
Chloris incompleta	8.4	-	4.4	-	11.6	-
Chloris barbata	-	-	2.8	4.4	2.8	-
Cassia tora	-	-	2.8	4.8	2.0	3.0
Cyperus aristatus	10.0	9.8	4.8	4.4	3.2	3.0
Dactyloctenium sp.	-	-	-	4.8	-	7.4
Desmostachya bipinnata	-	7.4	4.4	6.8	4.4	6.0
Desmodium triflorum	-	-	5.2	2.2	4.4	3.4
Dichanthium annulatum	-	7.0	-	2.0	-	8.0
Eragrostiella bifaria	-	-	20.4	10.0	12.8	-
Eragrostis gangetica	4.8	7.6	-	10.2	5.6	9.0
Eragrostis tenella	-	-	13.6	11.4	4.0	12.0
Evolvulus alsinoides	7.2	3.8	5.6	2.2	5.2	2.8
Euphorbia hirta	2.8	1.8	2.8	2.0	3.2	2.8
Heteropogon contortus	12.8	16.0	9.6	5.0	16.8	17.8
Iseilema laxum	-	-	3.2	7.4	4.4	8.0
Paspalidium flavidum	-	-	-	3.4	-	-
Setaria glauca	-	-	-	7.8	-	6.0
Sida acuta	-	0.8	1.0	1.4	0.4	1.0
Sporobolus diander	-	-	-	7.4	-	7.8
Vetiveria zizanioides	3.2	5.0	2.4	3.4	2.8	2.6
Total d/m^2	106.8	109.2	164.6	196.4	205.0	234.6

Tab. IV : Seasonal variations in the density (individuals/tiller/m^2) of component species in protected and grazed site

53.6/m^2 in protected and grazed sites. The density of *Aristida adscensiones* shows a rapid rise to 37.2/m^2 and 52.0/m^2 in I and II sites respectively. *Heteropogon's* contribution comes next (16.8/m^2 in I and 17.8/m^2 in II). The density values are given in table IV.

Basal area.

The area of stems emerging from the soil at the ground level has been estimated for the different species in the two sites seasonally. *Aristida cyanantha* records more than 50 % of the total basal cover in all the seasons. In summer the basal cover in grazed site is higher but in other seasons the basal cover in protected site is more than that in grazed one. Other principal species significantly contributing to the basal cover are *Heteropogon contortus*, *Vetiveria zizanioides*, *Aristida adscensiones*, etc. Table V gives the basal cover values of the component species.

Importance value indices.

Aristida cyanantha tops both in all seasons and on annual basis in the ecological importance value indice (IVI). It was 83 and 88 in summer, 97 and 64 in rainy season and 86 and 61 in winter season in protected and grazed conditions respectively. *Aristida adscensiones* and *Heteropogon contortus* come next in the sequence of importance (Tab. VI).

Productive structure.

Through quadrats of 25 x 25 cm area in five replicates,plant material were sampled in monoliths upto 30 cm depth at monthly intervals in both the sites. The monoliths were soaked in water, washed carefully and the plant material for aboveground and belowground were separated for *Aristida cyanantha* and rest of the species. Litter for these components were also collected in five replicates from identical area. The plant samples were oven dried at 80° C until constant weight (24 - 36 hr). The positive differences in the biomass values were summed up for each of the four months i.e. summer, rainy and winter seasons. There are some months when there are positive gain in *Aristida cyanantha* and negative (loss) in other species or vice versa. In computing total productivity in such months the loss by one of components is deducted out of the positive value to get the total community productivity values (Tab. VII).

Species	Summer season		Rainy season		Winter season	
	Protected	Grazed	Protected	Grazed	Protected	Grazed
Aristida cyanantha	2531.7	2958.0	3491.7	2959.6	4320.6	4078.0
Aristida adscensionis	-	-	58.0	267.6	580.3	811.2
Ageratum sp.	-	896.0	-	156.8	-	288.0
Apluda mutica	480.0	-	420.0	420.0	320.0	318.8
Bothriochloa pertusa	467.4	497.5	713.0	544.0	487.7	508.0
Cenchrus ciliaris	-	-	-	764.4	-	960.0
Chrysopogon montanus	-	66.0	264.0	176.7	244.4	210.0
Chloris incompleta	295.7	-	104.0	71.4	464.0	136.0
Chloris barbata	-	-	61.6	92.8	101.0	-
Cassia tora	-	-	252.0	400.0	196.0	258.0
Cyperus aristatus	1410.0	137.2	590.4	540.2	468.5	414.0
Dactyloctenium sp.	-	-	-	355.2	-	529.2
Desmostachya bipinnata	-	-	63.0	149.6	256.6	180.0
Desmodium triflorum	-	-	30.2	12.3	60.2	32.0
Dichanthium annulatum	-	447.0	-	80.0	-	400.0
Eragrostiella bifaria	-	-	259.6	102.5	202.8	-
Eragrostis gangetica	63.0	554.0	44.4	640.6	-	682.2
Eragrostis tenella	-	-	803.8	109.4	300.8	187.2
Evolvulus alsinoides	50.8	36.5	42.9	16.3	64.7	33.1
Euphorbia hirta	95.2	60.4	66.0	80.0	128.0	61.6
Heteropogon contortus	805.8	1107.2	602.9	314.0	1273.4	1349.2
Iseilema laxum	-	-	40.3	94.4	86.5	150.4
Paspalidium flavidum	-	-	-	102.0	-	-
Setaria glauca	-	-	-	312.0	-	300.0
Sida acuta	-	78.4	68.0	227.2	55.2	88.0
Sporobolus diander	-	-	-	54.8	-	74.9
Vetiveria zizanioides	938.4	1380.0	542.4	768.4	828.0	677.6

Tab. V : Basal area.

Species	Summer season		Rainy season		Winter season	
	Protected	Grazed	Protected	Grazed	Protected	Grazed
Aristida cyanantha	83.3	88.0	97.8	64.8	86.7	61.8
Aristida adscensionis	-	-	7.0	16.1	15.1	29.6
Ageratum sp.	-	16.2	-	2.1	-	2.8
Apluda mutica	13.2	-	11.2	5.5	7.2	3.5
Bothriochloa pertusa	21.5	12.9	33.6	11.8	13.3	8.0
Cenchrus ciliaris	-	-	-	9.2	-	9.8
Chrysopogon montanus	-	3.5	19.8	6.0	27.9	4.3
Chloris incompleta	-	-	-	2.4	-	2.4
Chloris barbata	-	-	5.2	2.9	1.6	-
Cassia tora	-	-	9.6	6.5	7.9	3.1
Cyperus aristatus	39.6	10.5	14.2	7.5	10.5	4.4
Dactyloctenium sp.	-	-	-	5.8	-	6.3
Desmostachya bipinnata	-	7.9	5.7	4.4	12.6	3.8
Desmodium triflorum	-	-	8.3	1.1	6.9	1.6
Dichanthium annulatum	-	10.7	-	1.7	-	6.4
Eragrostiella bifaria	-	-	37.1	4.8	16.7	4.8
Eragrostis gangetica	-	13.4	-	11.2	5.1	8.9
Eragrostis tenella	-	-	26.2	6.3	7.4	6.2
Evolvulus alsinoides	19.6	3.8	12.4	1.1	8.6	1.3
Euphorbia hirta	13.3	2.3	9.1	1.7	8.1	1.5
Heteropogon contortus	31.5	28.2	17.5	5.5	25.5	18.3
Iseilema laxum	-	-	5.2	4.3	8.2	4.5
Paspalidium flavidum	-	-	-	1.7	-	-
Seteria glauca	-	-	-	3.6	-	2.5
Sida acuta	-	1.6	4.2	3.8	2.4	1.1
Sporobolus diander	-	-	-	3.9	-	3.8
Vetiveria zizanioides	13.3	5.1	9.1	9.3	8.1	6.5

Tab. VI : Importance value indices (see text).

Seasons	*Aristida cyanantha*			Other species			Total community			
	Above gr.	Below gr.	Litter	Above gr.	Below gr.	Litter	Above gr.	Below gr.	Litter	Total
Site - I - protected										
Summer	Nil	111.2	99.2	Nil	6.4	16.0	Nil	118	106.6	224
Rainy	1730.9	289.0	55.2	158.4	30.4	19.4	1870	288	72.9	2231
Winter	73.9	142.4	20.8	107.5	10.5	81.5	59	144	83.8	287
Annual	1804.9	542.6	175.2	265.9	47.3	116.9	2069	590	303	2742
Site - II - grazed										
Summer	9.7	Nil	61.2	101.6	40.6	11.3	32	41	60.8	134
Rainy	1068.2	355.0	74.9	217.4	4.7	14.7	1286	340	76.3	1703
Winter	983.0	102.0	41.0	79.5	23.0	39.0	910	107	66.4	1083
Annual	2060.9	457.5	177.1	398.5	68.3	65.0	2228	488	203	2920

Tab. VII : Net productivity in different seasons - g/m^2/time. Seasons of 4 months each.

In site I (protected) the lowest community productivity of 224 g/m^2/season is in summer and highest of 2231 g/m^2/season is in rainy season. The annual total productivity is as high as 2742 g/m^2/year. The belowground productivity values are higher in summer and winter than the aboveground productivity but a very high aboveground productivity in rainy season makes the overall aboveground/belowground ratio to about 4. The share of the dominant species *Aristida cyanantha* to the total community productivity is about 85 %.

In site II a more or less similar trend of productivity is obtained and the annual net productivity is slightly higher being 2920 g/m^2/year.

In summer the productivity is lowest being 134 g/m^2/season but in winter this value of 1083 g/m^2 is much higher than the corresponding value in protected site. Rainy season alone accounts for more than 50 % of the annual productivity. The percentage contribution of *Aristida cyanantha* to the total community productivity is about 90 %.

Under the moderate controlled grazing stress as obtained on these study sites, it is thus clear that despite some unaccounted quantity utilized by cattle, the net productivity value remains still higher than under blanket ban grazing. Therefore, it is concluded that in proper management of grasslands the role of cattle is advantageous in maintainence of higher diversity, better stability and greater productivity provided the stress is within limits.