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STRUCTURE, COMPOSITION AND ABOVE GROUND STANDING PHYTOMASS OF SOME GRAZABLE GRASS-DOMINATED COMMUNITIES OF PAKISTAN COAST

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Abstract

Herbaceous communities that emerge on the Pakistan sea coast during monsoon have high percentage of therophytes followed by chamaephytes. Besides, dominant component of grasses, legumes were invariably present in all the sites. The number of species in a stand varied with the nature of the site and its salinity status. The above ground standing phytomass varied with the species dominating the community. The communities of non-saline sites appeared to be approaching to log-normal distribution of phytomass among the species, whereas, the distribution of phytomass in saline habitats was distinctly geometric. The standing phytomass of the sites was generally low and ranged from 89.68 to 411.61 $g.m^{-2}$. The communities on the basis of decreasing magnitude of phytomass can be arranged as: *Pennisetum divisum* > *Halopyrum mucronatum* > *Desmostachya bipinnata* > *Cenchrus pennisetiformis* > *Panicum turgidum* > *Dichanthium annulatum* > *Sporobolus arabicus*. *Indigofera oblongifolia* emerged as major legume with substantial phytomass in three communities of which two belonged to saline habitat (*Sporobolus* and *Desmostachya* dominated communities) and one associated with non-saline soil (*Dichanthium* community).

Introduction

Johnston & Hussain (1963) gave a general account of grass cover types of Pakistan. Ibrahim (1967) reviewed the pasture, range and fodder crop situation in near east countries. The herbaceous vegetation that emerges on the Pakistan sea coast during monsoon season is not only of ecological interest, but also has great potential as pasture. No data are available on the productivity of this vegetation. The present investigation describes the structure, composition and above-ground standing phytomass of some grazable grass-dominated herbaceous communities along Pakistan coast.

Description of the area: The coastline of Pakistan situated between Long. 62 and 68 east and Lat. 24 and 25 north, extends over 750 Km mostly lying in Makran and Lasbella divisions of Baluchistan with a small part in the province of Sindh. The area can be classified as *"sub-tropical coastline"* or *"Arid marine region of Pakistan"* (Ahmad, 1964) with bioclimate under the category of *"Tropical Desert Bush Formation"* (Holdridge, 1947). There is intense insolation with solar radiation around 180-200 Kcal. cm^{-1} $year^{-1}$ causing glare and visibility reduction (Budyko, 1980). With 4-5% error, the annual potential evapo-transpiration amounts to 1750 mm (Zubenok, 1977). In the area there is climatic transition between the Indian summer monsoon system to the east and the winter cyclonic system of south-west Asia to the west (Snead, 1968) where winter is mild and

summer very hot. Relative humidity is high in summer and lowest during December and January. The rain fall is scanty, irregular and uncertain, generally below 200 mm per annum with strong southwest and westwardly winds for most part of the year.

Materials and Methods

Field Methods. Twelve sites colonized by grazable grass communities in the coastal vicinity of Karachi (Hawk's Bay), Bhawani, Paradise Point, Karwat, Baram Bagh, Faliri and Jiwani were sampled by 30 randomly placed $1m^2$ quadrats in each site. The criteria of selection of a stand were, a) relatively visual homogeneity of vegetation, b) adequate size (of not less than 2 ha), and c) as far as possible free from biotic and physical disturbances. All the stands were exposed to certain degree of disturbance. Sampling around Karachi was performed in November, 1984 after 70-90 days of summer rainfall (c. 70mm). Due to lack of rainfall, observations on herbaceous vegetation of Makran were not possible, however a few *Desmostachya bipinnata* dominated sites in low lying plains and along ephemeral streams of Karwat, Baram Bagh, Chatti and Faliri were studied in March, 1985.

Most of the grasses were bunch forming by nature and in this case each bunch was regarded as an individual plant. In case of few sod-forming grasses any portion of plant possessing an independent shoot and root was considered as an individual following the practice of Singh & Yadava (1974). Number of individual of each species falling in each quadrat was recorded and contribution of different species to total biomass was evaluated by species separation. Standing phytomass was regarded in terms of fresh as well as the dry weight after drying in oven at 100°C for 24 h.

Soil analysis. Soil samples collected from three different sites in each stand up to a depth of 20 cm were pooled and the composite samples were analysed. EC_e was determined by electrical conductivity meter and pH by glass electrodes pH meter. Na^+ and K^+ were determined by flame photometric method, whereas Ca^{++} Mg^{++} were estimated on a Jarrell Ash (AA-782A) atomic absorption spectrophotometer. All the measurements were based on saturated soil extract.

Vegetation analysis. The species were assigned life-forms in according to Raunkiaer (1934) and also classified according to their longevity of life. Quantitative vegetation parameters viz., relative density and relative frequency were computed from the quadrat data. The importance value index (I.V.I.) for each species was obtained by direct summation of relative density and relative frequency following Curtis & McIntosh (1951).

Dominance for each stand was ascertained by Simpson's (1949) index (c) and also by Mc Noughton's (1968) index of community dominance (CDI) as follows:

$C = \sum_{i=1}^{S} Pi^2$ where pi is the proportion of the standing phytomass (DW) basis of the ith species to the total standing phytomass and:

$CDI = \frac{Y_1 + Y_2}{Y} \times 100$ where Y_1 is the standing phytomass of the leading dominant and Y_2, the standing phytomass of the subordinate (second) dominant and Y, the total average standing phytomass of the sample stand expressed on g/m^2 basis.

General diversity was determined by the information theory function ($H = -\sum_{i=1}^{S} pi.$ log. pi) where pi is the proportion of total phytomass belonging to the ith species (Margalef, 1957). Equitability was measured by $e = \overline{H}/\overline{H}$ max, where $\overline{H}$ max = log S (Pielou, 1969). Species richness was calculated as $d = S/\sqrt{N}$ (Menhinick, 1964) where S and N are the total number of species in sample stand and average total standing phytomass (g/m^2) of the stand, respectively. Inter-relationships among dominance and diversity measures were determined by computing product-moment-correlations and dominance-diversity curves (Whittaker, 1965) were plotted to portray the underlying relative-abundance-pattern on the standing phytomass basis.

Results

Sixteen grasses, 9 legumes and 32 other species were encountered during sampling. Most of the species were of minor importance. A proportion of 49.12% species occurred in single stand, *Indigofera oblongifolia* was the most wide-spread species which occurred in 7 stands. There were 26 therophytes, 17 chamaephytes, 6 geophytes, 6 hemicryptophytes and 2 phanerophytes. Only 17 species (29.82% of the total) are grazed by animals (Table 1). The species which are intensely grazed are even much lower in number and mostly are grasses. *Indigofera oblongifolia* is the only legume species which is most frequently grazed.

1) ***Leading dominants.*** *Sporobolus arabicus* occurred as leading dominant in 3 sites (Site No. 1, 2 and 3; Hawk's Bay, Karachi) and *Desmostachya bipinnata* in 4 sites (Site No. 8, 9, 10 and 11). Site No. 4, 5, 6 and 7 were, respectively, dominated by *Dichanthium annulatum, Cenchrus pennisetiformis, Panicum turgidum* and *Pennisetum divisum.* Site No. 12 of sandy beach, Jiwani was dominated by *Halopyrum mucronatum.* The sequence of dominance on the basis of I.V.I. was different in some instances from that based on phytomass (Table 2). Such a change may well be expected depending upon the relative abundance and life form of the constituent species.

2) ***Standing phytomass of communities.*** The values of average above ground standing phytomass are generally of low order. They varied with the species dominating the vegetation types (Table 2). Description of 7 community types identified is as follows:

Table 1. List of species encountered during sampling.

Species	Grazing Status	Life Span[1]	Life Form[2] Occurred	No. of Stands
Abutilon hirtum	–	LL	CH	1
Aerva persica	–	SLP	CH	3
Alhagi maurorum	+	SLP	CH	4
Atriplex griffithii	–	SLP	CH	2
Blepharis sindica	–	ANN	TH	1
Boerhavia diffusa	–	SLP	HE	1
Cenchrus biflorus	–	ANN	TH	2
Cenchrus pennisetiformis	+++	ANN	TH	3
Citrullus colocynthis	–	SLP	CH	1
Convolvulus cephalopodus	–	ANN	TH	1
Convolvulus rhyniospermus	–	ANN	TH	1
Corchorus depressus	–	SLP	CH	2
Corchorus trilocularis	–	ANN	TH	1
Cressa cretica	–	SLP	CH	3
Crotolaria burhia	–	LL	CH	1
Cynodon dactylon	+++	VLL	HE	1
Cymbopogon jwarancosa	–	LL	CH	1
Cyperus rotundus	–	ANN	CR	2
Dactyloctenium scindicum	+++	ANN	TH	3
Desmostachya bipinnata	++	VLL	HE	4
Dichanthium annulatum	+++	SLP	HE	2
Digera muricata	–	ANN	TH	1
Euphorbia thymifolia	–	ANN	TH	3
Fagonia indica	–	SLP	CH	2
Gynandropsis gynandra	–	ANN	TH	1
Halopyrum mucronatum	+	LL	HE	1
Halopeplis perfoliata	+	SLP	CH	1
Heliotropium rariflorum	–	LL	CH	1
Hibiscus micranthus	–	SLKP	CH	1
Indigofera cordifolia	–	ANN	TH	4
Indigofera hochstetrii	–	ANN	TH	2
Indigofera intricata	–	ANN	TH	1
Indigofera oblongifolia	+++	VLL	CH	7
Lasuirus scindicus	–	SL	GE	2
Launaea procumbens	–	SLP	CH	2
Letipes sengalensis	–	ANN	TH	1
Limonium stocksii	–	SLP	CH	1

(Table 1. Cont'd)

Species	Grazing Status	Life Span[1]	Life Form[2] Occurred	No. of Stands
Lotus sp.	–	SLP	CH	1
Nerium indicum	–	VLL	P	1
Octhocloa compressa	++	ANN	TH	2
Panicum turgidum	+++	LL	CH/GE	3
Pavonia procumbens	–	ANN	TH	1
Pennisetum divisum	+++	VLL	CH/GE	1
Peristrophe bicalyculata	–	ANN	TH	2
Puppalia lappacea	–	ANN	TH	1
Rhynchosia minima	–	ANN	TH	1
Sida ovata	–	ANN	TH	3
Sporobolus arabicus	+++	SLP	HE	3
Suaeda fruticosa	+	VLL	CH	3
Tamarix stricta	++	VLL	P	1
Tephrosia uniflora	–	ANN	TH	4
Tragus roxburghii	–	ANN	TH	3
Tribulus terrestris	–	ANN	TH	2
Trianthema petandra	–	ANN	Th	1
Urochondra setulosa	–	LL	GE	2
Vigna trilobata	++	ANN	TH	1
Zygophyllum simplex	–	ANN	TH	2

[1]ANN-Annual; SLP-Short lived perennial; LL-Long lived; VLL-Very long lived.

[2]TH-Therophyte; CH-Chamaephyte; HE-Hemicryptophyte; GE-Geophytes; P-Phanerophyte.

Grazing Status: – not grazed; + less frequently grazed; ++ moderately grazed; +++ intensely grazed.

i) *Sporobolus arabicus* – dominated community: The average above ground standing phytomass of *S. arabicus* dominated community ranged from 189.37 to 517.27 g/m^2 ($\bar{x}$ = 306.80 ± 105.47 on fresh weight basis and from 89.62 to 202 g/m^2 ($\bar{x}$ = 133.09 ± 35.08) on dry weight basis. The proportion of phytomass contributed by *Sporobolus* on dry weight basis ranged from 50.43 to 69.03%. This plant dominated in marginally non-saline (EC_e: 3-3.80 dS.m^{-1}) to slightly saline sodic sandy soil (EC_e: 7.5 dS.m^{-1}; SAR: 10.93) of Hawk's Bay (Table 3). In salinity-affected soil its phytomass, however, declined (approximately 42.5%) as compared to marginally non-saline situation. The second and third dominant of the community varied with respect to the salinity status of the habitat (Tables 2 and 3). *I. oblongifolia* was associated with each of the site. *Atriplex griffithii* and *Aerva javanica* were present in non-saline as well as in slightly saline sites (Site No. 2 and 3). Other associates included *Dichanthium annulatum* in non-saline site (Site No. 1) and *Zygophyllum simplex* in slightly saline stand only (Site No. 2).

Table 2. Above ground standing phytomass of 12 grass-dominated sites along Pakistan coast.

S. No.	Vegetation Types[1]	Standing Phytomass (g. m^{-2} FW)	Standing Phytomass (g. m^{-2} DW)
1	**1 *Sporobolus arabicus – Suaeda fruticosa – Urochondra setulosa*	517.269 (67.566)*	202.514 (69.032)*
2	**2 *Sporobolus arabicus – Dactyloctenium scindicum – Indigofera oblongifolia*	189.370 (65.295)	89.682 (62.044)
3	*Sporobolus arabicus – Indigofera oblongifolia – Zygophyllum simplex*	213.760 (45.920)	107.058 (50.428)
4	**3 *Dichanthium annulatum – Indigofera oblongifolia – Lasiurus scindicus*	387.600 (72.265)	142.022 (69.028)
5	**4 *Cenchrus pennisetiformis – Dactyloctenium scindicum – Indigofera cordifolia*	671.350 (61.752)	224.509 (55.397)
6	**5 *Panicum turgidum – Dactyloctenium scindicum – Ochthocloa compressa*	358.696 (27.35)	147.610 (26.605)
7	**6 *Pennisetum divisum – Panicum turgidum – Indigofera cordifolia*	1091.650 (50.346)	411.609 (42.727)
8	**7 *Desmostachya bipinnata – Indigofera oblongifolia – Nerium indicum*	454.870 (63.259)	241.805 (65.449)
9	*Desmostachya bipinnata – Indigofera oblongifolia – Alhagi maurorum*	305.300 (64.625)	153.224 (64.383)
10	*Desmostachya bipinnata – Indigofera oblongifolia – Alhagi maurorum*	394.200 (88.331)	280.328 (91.916)
11	*Desmostachya bipinnata – Alhagi maurorum – Cressa cretica*	628.380 (94.369)	290.441 (93.919)
12	*Halopyrum mucronatum – Urochondra setulosa – Halopeplis perfoliata*	1080.200 (63.414)	321.770 (68.123)

*Figures in parenthesis denotes the percentage proportion of phytomass contributed by the leading dominant.

[1]On the basis of relative standing phytomass.

The sequence of dominance in these communities on the basis of I.V.I. changes as follows:

**1 *Sporobolus arabicus – Limonium stocksii – Sueda fruiticosa* community

**2 *Sporobolus arbaicus – Dactyloctenium scindicum – Atriplex griffithii* community

**3 *Sporobolus arabicus – Cyperus rotundus – Indigofera oblongifolia* community

**4 *Indigofera cordifolia – Tragus roxburghii – Cenchrus pennisetiformis* community

**5 *Dactyloctenium scindicum – Ochthocloa compressa – Indigofera oblongifolia* community

**6 *Cenchrus biflorus – Indigofera cordifolia – Tragus roxburghii* community

**7 *Desmostachya bipinnata – Nerium indicum – Alhagi maurorum* community

ii) *Dichanthium annulatum* – dominated community: The standing phytomass of this community was 387.60 g/m² on fresh weight basis and 142.03 g/m² on dry weight basis. The contribution of *Dichanthium* to this phytomass on dry weight basis was 69.03%. *Lasuirus scindicus* and *I. oblongifolia* the third and second dominant of this site, occupied, respectively, 4.22 and 22.95% of the total phytomass. This community was associated with non-saline alluvial soil of Paradise Point (Table 3). Other associate of the community were *I. oblongifolia, I. cardifolia, I. hochstetrii, T. uniflora, R. minima* and *C. rotundus.*

iii) *Cenchrus pennisetiformis* – dominated community: The standing phytomass of this community amounted to 671.35 g/m² (FW) and 234.51 g/m² (DW). The contribution of *C. pennisetiformis* to the total phytomass on dry wt basis was 55.40%. *Dactyloctenium scindicum* and *I. oblongifolia* second and third dominant, respectively, contributed 13.75 and 11.94% of the total phytomass. This community was associated with non-saline sandy soil of Bhawani (EC_e: 0.50 $dS.m^{-1}$) (Table 3) comprising of plants like *I. cordifolia, I. hochstetrii, T. uniflora, T. roxburghii, C. dactylon, Tribulus terrestris, C. depressus, C. trilocularis, D. muricata, P. procumbens, T. pentandra, S. ovata, E. thymifolia, Convolvulus cephalopodus, C. rhyniospermus* and *Cyperus rotundus.*

iv) *Panicum turgidum* – dominated community: This vegetation type was associated with non-saline sandy soil of low calcium content and basic reaction (Table 3). The standing phytomass amounted to 358.97 g/m² (FW) and 147.61 g/m² (DW). *Panicum* though attained a position of leading dominant, its contribution to total phytomass was not more than 27% which amounted to 39.27 g/m² DW only. *D. scindicum* and *Ochthocloa compressa* second and third dominant, respectively, contributed phytomass of 36.69 and 13.32 g/m² DW which were 24.86% and 9.02% of the total phytomass, respectively. Large number of associates recorded from this community were *Abutilon indicum, C. biflorus, I. cordifolia, T. uniflora, C. depressus, T. roxburghii, S. ovata, G. gynandra, F.indica, V. trilobata, E. thymifolia, L. scindicus, P. lappacea, L. procumbens, P. bicalyculata, H. rariflorum* and *L. senegalensis.*

v) *Pennisetum divisum* - dominated community: This community type also correlated with non-saline non-sodic sandy soil of Bhawani (Table 3). The above ground standing phytomass of this site was maximum among the sites sampled and amounted to 1091.65 g/m² (FW) and 411.61 g/m² (DW). The contribution of the leading dominant to the total phytomass on dry weight basis was 42.73%. *P. turgidum* was second dominant in this community which contributed 33.51% of the total biomass on dry weight basis that amounted to 140.09 g/m². The associates of this community were essentially the same as those of community type (iv), however, species such as *C. colocynthis, C. burhia* and *I. intricata* were the additionals.

Table 3. Edaphic characteristics of 12 grass-dominated sites along Pakistan coast.

S. No.	Textual Class	pH	EC ($dS.m^{-1}$)	Na^+	K^+	$Ca^{++}+Mg^{++}$ (meq/l)	SAR	ESP	Location
1	Sandy	8.30	3.00	12.50	0.64	25.00	3.535	3.803	Hawk's Bay
2	Sandy Loam	7.50	7.50	65.76	1.28	72.40	10.929	12.938	Hawks Bay
3	Sandy	8.35	3.80	12.85	0.74	29.57	3.342	3.539	Hawks Bay
4	Alluvial Sandy Loam	8.30	0.70	3.80	0.64	16.00	1.345	0.718	Paradise Point
5	Sandy	8.35	0.50	1.76	0.67	3.20	1.391	0.786	Bhawani
6	Sandy	8.40	0.70	1.89	0.75	2.98	1.548	1.013	Bhawani
7	Alluvial Clay Loam	8.35	0.65	1.96	0.71	3.20	1.549	1.014	Bhawani
8	Alluvial Clay Loam	7.85	8.50	96.74	1.60	108.00	13.164	15.367	Karwat
9	Alluvial Clay Loam	7.80	11.00	157.61	3.20	113.00	20.968	22.879	Baram Bagh
10	Alluvial Clay Loam	7.90	8.00	107.00	2.22	118.00	13.930	16.168	Chatti
11	Alluvial Clay Loam	7.85	16.00	198.50	4.23	126.00	25.008	26.268	Faliri
12	Sandy (Beach)	8.00	50.00	298.40	3.50	96.00	43.070	38.374	Jiwani
CV (%)		3.689	149.529	120.611	265.607	84.977	110.151	103.809	

vi) *Desmostachya bipinnata* – dominated community: The standing phytomass of *Desmostachya* community ranged from 305.30 to 628.38 g/m^2 ($\bar{x}$ = 445.68 ± 68.20) on fresh weight basis and from 153.22 to 290.44 g/m^2 on dry weight basis ($\bar{x}$ = 241.45 ± 31.23). The contribution of the leading dominant was high (64.69–93.92%). The second dominant in this community was *Indigofera oblongifolia* (Site No. 8, 9 and 10) and *Alhagi maurorum* (Site No. 11). The contribution of *Indigofera* to the total phytomass on dry weight basis varied from 4.87 to 25.09% ($\bar{x}$ = 16.74 ± 6.10). *Alhagi* in Site No. 11 contributed only 5.99% of the phytomass. This community was associated with slightly to highly saline low lying plains of Gwadar and Pishukan areas viz., Karwat, Baram Bagh, Chatti and Faliri. *Cressa cretica* was the important associate of this community. At Karwat this community also harboured *N. indicum* and *T. stricta* with reduced growth.

vii) *Halopyrum mucronatum* – dominated community: This community was associated with highly saline beach and of Jiwani. Its phytomass was 1080.20 g/m^2 and 321.77 g/m^2 (DW). The contribution of *Halopyrum* to the total phytomass on dry weight basis was around 68%. *Urochondra setulosa*, the second dominant shared a proportion of 19.75% and *H. perfoliata*, the third dominant 11.62% of the total phytomass.

3) ***Ecological affinities among the important species.*** Most species showed restricted distribution with respect to the community types (Table 4). *Alhagi maurorum* was restricted in *Desmostachya bipinnata*-dominated community and *Desmostachya* in turn restricted in sites dominated by itself. Similarly *Halopyrum mucronatum* and *Sporobolus arabicus* were restricted in communities dominated by themselves. *Dactyloctenium scindicum* occurred in three commuity types and was represented with substantial phytomass in *Cenchrus* and *Panicum* dominated communities. *Tephrosia uniflora* and *Euphorbia thymifolia* occurred in community types 4 and 3, respectively, but with low phytomass. *Urochondra setulosa* occurred in saline habitats (*Sporobolus*- and *Halopyrum*-dominant sites). It had, however, higher phytomass in association of *Halopyrum*. Phytomass of *Indigofera cordifolia* was highest in *Cenchrus* dominated community followed by that in *Pennisetum*-dominated community and restricted in non-saline habitats. *Indigofera oblongifolia*, on the other hand, occurred with substantial phytomass in three communities of which two belonged to saline habitat (*Sporobolus* and *Desmostachya*-dominated communities) and one associated with non-saline (*Dichanthium* community).

4) ***Distribution of phytomass among grazable grasses, legumes and other species.*** Phytomass of grazable grasses was maximum in Site No. 7 dominated by *Pennisetum divisum*. It was lowest in *Sporobolus arabicus*-dominated sites. (Table 5). Legumes were present in all the sites studied but their number varied with the species dominating the site. Maximum number of legumes (5 in Number) was present in *Dichanthium*-dominated community associated with non-saline alluvial soil followed by *Cenchrus*-, *Panicum*- and *Pennisetum*-dominated sites, each with three legumes. The phytomass of legume component was, relatively high in *Pennisetum*-and *Desmostachya*-dominated communities and

Table 4. Average standing phytomass (g.m² DW) of few important species in various grass-dominated communities along Pakistan coast.

Species	COMMUNITIES						
	Sporobolus arabicus dominated	*Dichanthium annulatum* dominated	*Cenchrus pennisetiformis* dominated	*Panicum turgidum* dominated	*Pennisetum divisum* dominated	*Desmostachya bipinnata* dominated	*Halopyrum mucronatum* dominated
1 *Alhagi maurorum*	–	–	–	–	–	12.905 ± 2.003	–
2 *Cenchrus pennisetiformis*	–	–	124.371 ± 39.62	0.650	3.050 ± 1.446	–	–
3 *Cressa cretica*	0.231	–	–	–	–	0.641	–
4 *Dactyloctinium scindicum*	8.500	–	30.860	36.692	–	–	–
5 *Dichanthium annulatum*	1.731	98.035	–	–	–	–	–
6 *Desmostachya bipinnata*	–	–	–	–	–	196.839 ± 41.429	–
7 *Euphorbia thymifolia*	–	–	0.024	0.090	0.080	–	–
8 *Halopyrum mucronatum*	–	–	–	–	–	–	219.200
9 *Indigofera cordifolia*	–	1.200	26.817	11.655	15.295	–	–
10 *Indigofera oblongifolia*	15.250	32.600	–	–	–	33.705 ± 10.475	–
11 *Octhocloa compressa*	–	–	–	13.320	3.024	–	–
12 *Panicum turgidum*	–	–	1.080	39.272	140.080	–	–
13 *Pennisetum divisum*	–	–	–	–	175.872	–	–
14 *Sida ovata*	–	–	5.120	2.110	18.300	–	–
15 *Sporobolus arabicus*	83.144 ± 28.332	–	–	–	–	–	–
16 *Tephrosia uniflora*	–	0.065	1.808	0.480	0.810	–	–
17 *Tragus roxburghii*	–	–	14.362	2.210	1.974	–	–
18 *Urochondra setulosa*	26.030	–	–	–	–	–	63.550

Table 5. Apportionment of above ground standing phytomass into various groups.

S. No.	Standing phytomass ($g.m^2$) Grasses*	Legumes	Others	Dominant species**
1	[a]356.42 [b]141.53	14.23 4.65	156.64 56.33	*Sporobolus arabicus*
2	140.65 64.14	11.50 6.90	37.22 18.64	*Sporobolus arabicus*
3	98.16 53.99	76.00 34.20	39.60 18.87	*Sporobolus arabicus*
4	280.10 98.04	85.60 34.54	21.90 9.45	*Dichanthium annulatum*
5	496.47 156.66	91.44 32.20	83.44 35.65	*Cenchrus pennisetiformis*
6	224.74 89.73	27.41 12.77	106.82 45.11	*Panicum turgidum*
7	875.65 318.98	112.19 40.90	103.81 51.74	*Pennisetum divisum*
8	287.75 158.26	118.25 59.11	48.87 24.44	*Desmostachya bipinnata*
9	197.30 98.65	105.60 53.55	2.40 1.02	*Desmostachya bipinnata*
10	348.20 257.67	46.00 22.66	– –	*Desmostachya bipinnata*
11	593.00 272.78	34.80 17.40	0.58 0.26	*Desmostachya bipinnata*
12	658.00*** 219.20	3.20 1.62	392.00 100.95	*Halopyrum mucronatum*

[a]Fresh weight, [b]Dry weight, *Grazable grasses only, **On the basis of standing phytomass, ***Grazed rarely.

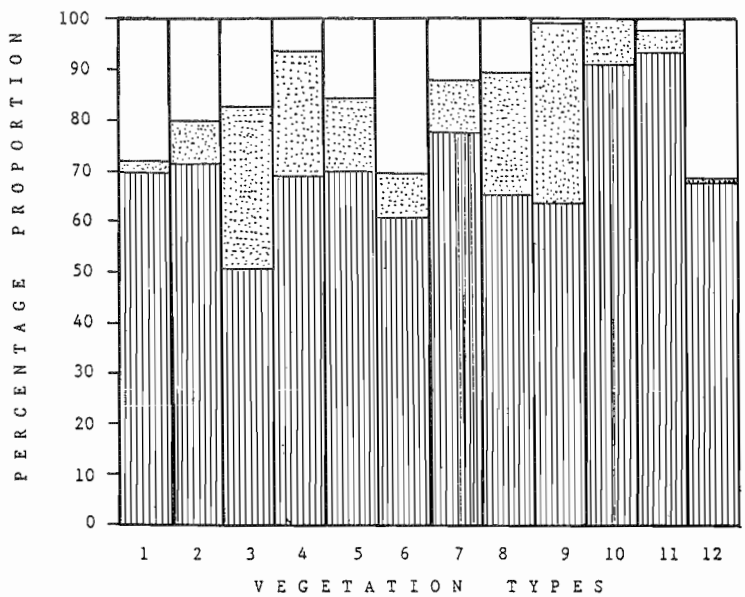

Fig. 1. Percentage proportion of above ground standing phytomass into various groups on dry weight basis.

▥ – Grazable grasses; ▭ – legumes; ▭ – Others

Vegetation types: 1, 2, 3 – *Sporobolus;* 4 – *Dichanthium;* 5 – *Cenchrus;* 6 – *Panicium;* 7 – *Pennisetum;* 8, 9, 10, 11 – *Desmostachya;* 12 – *Halopyrum* dominated.

low in *Halopyrum* community. On dry weight basis legumes represented appreciably high percentage proportion in association with *Sporobolus* (Site 3), *Dichanthium* (Site 4) *Panicum* (Site 5) and *Desmostachya* (Sites 8 and 9) (Fig. 1).

5) ***Pattern of species diversity and dominance.*** The vegetation of the study sites was simple in its organization and in general characterized by low species diversity (d, e and $\bar{H}$) and high dominance (c and CDI) with exception of communities dominated by *Cenchrus pennisetiformis, Panicum turgidum* and *Pennisetum divisum* which have moderate diversity and correspondingly lower dominance concentration. The species richness (S) was substantially lower in the communities associated with saline habitats (*Sporobolus-, Desmostachya-* and *Halopyrum*-dominated communities. (Table 6).

Dominance-diversity curves based on dry phytomass (Fig. 2) for sites No. 5, 6 and 7 were more or less sigmoid and showed some tendency to approach log-Normal distribution. Curves for other sites were more or less linear exhibiting geometric distribution. Dominance related inversely with the number of species (S) and general diversity and its components (Table 7). The relationship between species richness (d) and equitability (e) with dominance (c and CDI) was also negative. The general diversity (H) was positively related with its components (d and e). However, the degree of correlation between H and

Table 6. Some structural attributes of a few grass-dominated communities along Pakistan Cost.

S. No.	Communities	S	$d = s/\sqrt{N}$	$e = \bar{H}/\bar{H}_{max}$	$\bar{H} = -\sum pi \log pi$	$C = \sum pi^2$	$CDI = \frac{y_1 + y_2}{y} \times 100$	EC_e: $dS.m^{-1}$
1	*Sporobolus arabicus* dominated	6.66 ± 0.88	0.6066 ± 0.1191	0.6378 ± 0.0665	0.5149 ± 0.0408	0.4294 ± 0.0418	78.594 ± 3.538	4.766 ± 1.380
2	*Dichanthium annulatum* dominated	9.00	0.7552	0.2768	0.2641	0.5314	91.982	0.700
3	*Cenchrus pennisetiformis* dominated	20.00	1.3348	0.5150	0.6699	0.3470	69.142	0.500
4	*Panicum turgidum* dominated	23.00	1.8931	0.6841	0.9316	0.1635	51.463	0.700
5	*Pennisetum divisum* dominated	17.00	0.8314	0.5681	0.6990	0.2972	75.575	0.650
6	*Desmostachya bipinnata* dominated	3.75 ± 0.47	0.2499 ± 0.0418	0.4791 ± 0.0965	0.2729 ± 0.0827	0.6748 ± 0.1112	92.972 ± 3.261	10.875 ± 1.830
7	*Halopyrum mucronatum* dominated	4.00	0.2229	0.6194	0.3729	0.5166	87.873	50.000

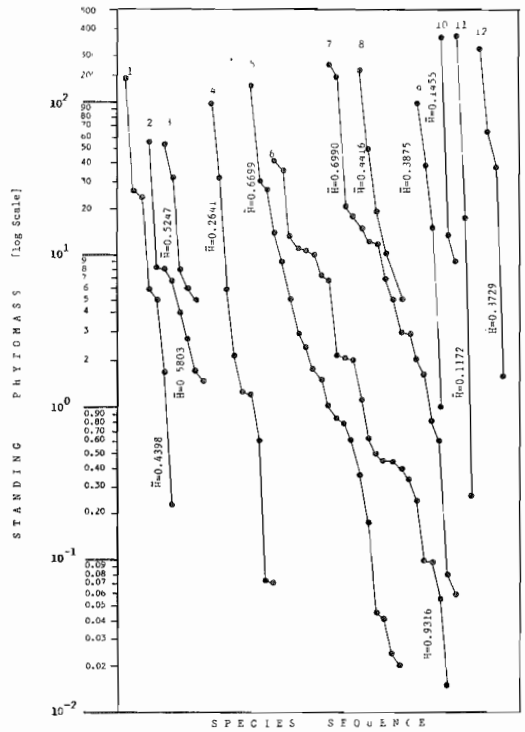

Fig. 2. Dominance-diversity curves of 12 herbaceous grass-dominated sites drawn on the basis of standing phytomass (gm/m² DW) of the constituent species.

Table 7. Linear correlation coeffecient matrix among diversity, equitability, richness and dominace measures of grass dominated communities. These were calculated on the basis of relative standing phytomass (Dry Wt.) of the constituent species.

	S	d	e	$\bar{H}$	c	
d	+ 0.9434***					
e	+ 0.1963 n.s.	+ 0.2548 n.s.				
$\bar{H}$	+ 0.8466***	+ 0.8481***	+ 0.6707*			
c	− 0.7446**	− 0.7553**	− 0.7261**	− 0.9409***		
CDI	− 0.8574***	− 0.9135***	− 0.5779*	− 0.9861***	+ 0.8729***	CDI

*P < 0.05, **P < 0.01, ***P < 0.001, n.s. – non-significant

d was of higher order compared to $\overline{H}$ and e indicating that general diversity of the study stands is being governed to greater extent by species richness (d). This shows that these communities are controlled to a greater extent by the biological interactions than by relatively harsh environmental conditions. The above ground standing phytomass was also attempted to relate with dominance and diversity and its components. However, no significant linear or curvilinear relationship was disclosed.

Discussion

The herbaceous grass-dominated communities in coastal vicinity of Pakistan have high pecentage of therophytes and chamaephytes that appears to be the result of aridity, grazing and browsing in the area. Grasslands, in general, are rich in hemicryptopytes (Braun-Blanquet, 1932). Bharucha & Dave (1944), however, found a grassland association in Bombay area dominated by *Themeda triandra* and *Pseudenthistria hetroclite* to be therophytic. Singh & Yadava (1974) also reported 62.5% therophytes in Varanasi grassland of India. They believed that high value of therophytes is an indicator of amount of influence of man and animals. According to Cain (1950) overgrazing tends to increase the percentage of therophytes through introduction and spread of weedy grasses.

The above ground standing phytomass for all the communities was low and varied, with the species dominating the vegetation. It may most probably be attributed to grazing, climatic aridity, rapid percolation of water in sandy soils and the life-form of the plants. On phytomass basis these communities in order of decreasing magnitude may be arranged as: *Pennisetum divisum*>*Halopyrum mucronatum* > *Desmostachya bipinnata* > *Cenchrus pennisetiformis* > *Panicum turgidum* > *Dichanthium annulatum* > *Sporobolus arabicus*. In this sequence the place of *P. turgidum* dominated community, is a bit anomalous. *P. turgidum* is a large tufted grass but it is its low density and abundance in this community which restricted the standing crop of the community at substantially low level. The dominance order of species in this community, on the basis of importance value index, was *Indigofera cordifolia* - *Tragus roxburghii* - *Cenchrus pennisetiformis*. The small herbs like *T. roxburghii* and *I. cordifolia*, which measure not more than 10 cm in height, had low contribution to phytomass but they showed high frequency and density. *Panicum* in this community appears to be a recent invader. However, it appears to be better associated with *P. divisum* community where it has contributed around 33.5% of the total biomass alone which is only 16.8% less than that of the dominant (*P. divisum*). This association may ecologically be important from range management point of view as both the species are good fodder plants in arid regions.

Whittaker & Likens (1975) have given the estimates of standing plant biomass of various ecosystem types. The plant biomass of desert and semi-desert scrub vegetation may vary between 100 and 4000 g/m^2 with a mean value of 700 g/m^2 and that of extreme desert conditions betweens 0 and 200 g/m^2 with a mean value of 20 g/m^2. Comparison of

these estimates with the results presented here suggests that phytomass values of the study sites fall somewhere in between that of semi-desert scrub vegetation and extreme desert vegetation types. The mean standing above ground biomass within exclosures of high subalpine snow zone herbaceous meadow of North Pole Basin, Colorado, has been reported to be 207.70 ± 5.34 g/m² (Anderson *et al.*, 1979). Comparing to this estimate, the mean biomass of the sites studied (217.71 ± 27.79 g/m²) is almost of the same order. Strictly speaking, however, the standing phytomass of *Sporobolus- Dichanthium-* and *Panicum* communities was comparatively lower and those of *Pennisetum-* and *Halopyrum-* dominated communities was considerably higher than the mean standing biomass for the subalpine snow zone communities.

It is evident by compartmentalization of standing phytomass into various biological units that major proportion of the phytomass is contributed by grazable grasses. Legumes also constitute a substantial proportion of these communities. Primary productivity though was not measured *sensu stricto*, yet the phytomass measured after the end of the monsoon period, may mimic the primary productivity. The values recorded for the phytomass are suggestive of the fact that productivity of the study sites is of low order as may obviously be expected in sandy arid regions. Among grasses, *P. divisum, D. annulatum, C. pennisetiformis, P. turgidum* and *S. arabicus* are important from the view point of grazing. *D. bipinnata* and *H. mucronatum* give high yield but they are less frequently grazed. Maclean in Stewart (1972) has reported that *D. bipinnata* is a good fodder grass in Afghanistan. *Sporobolus, Desmostachya* and *Halopyrum*, which yield reasonably good phytomass at saline soils are undoubtedly salt tolerant and may, therefore, be exploited for biosaline agriculture. *Sporobolus*, however, due to its high grazing potential, may be more preferable for pasture development and *Halopyrum* and *Desmostachya* could be used in fiber industry to produce paper, rayon, ropes, etc. (Zahran & Younes, 1982). Among legumes, *Indigofera oblongifolia* that occurred with relatively high phytomass in saline and non-saline sites is suggestive of its exploitation as an unconventional legume fodder crop under saline conditions.

Species diversity that is considered to be the important attribute of community structure and organization was calculated here from the biomass of individual species of the community because the best measure of the importance of a species in a community may be its productivity which both expresses its biological activity and indicates the share of the environmental resources that it utilizes (Vasander, 1984). The diversity irrespective of whether refers to the number of species (S) or the division of biomass between different species, was generally low. However, it was of relatively higher order in non-saline sites dominated by *C. pennisetiformis* and *Pennisetum divisum* and significantly low in habitats affected by various levels of salinity. It may be attributed to relatively lower number of species capable to withstand the saline environment. The communities which exhibited high species diversity tended to approach a log-normal distribution of phytomass among species. This is obviously because of the fact that these communities being situated on

non-saline sandy soils are relatively richer in species. The dominance-diversity curves of other sites exhibited well defined geometric distribution with respect to standing phytomass. This distribution implies that most successful species preempts a fraction 'k' of the available resources, the next a fraction 'k' of the remainder and so on (May, 1975). This phenomenon may be attributed to species poor and environmentally stressful conditions of salinity. Communities of severe environment and composed of small number of species, approach geometric series (Whittaker, 1975). In such communities the phenomenon of dominance is strongly developed. Anderson *et al.*, (1979) also observed geometric distribution of biomass among species of subalpine herbaceous meadow of North Pole Basin, Colorado, which they have largely attributed to soil moisture conditions. The communities of low diversity had straight dominance-diversity lines with a steep slope whereas the curves of communities of relatively high diversity were mostly more or less sigmoid resembling to those of *Cenchrus pennisetiformis- Panicum turgidum* and *Pennisetum divisum* dominated sites associated with non-saline habitats. According to Whittaker (1965), the sigmoid type of dominance-diversity curve, is characteristic of communities with more competitive species. None of the species usurpts an especially large portion of niche space and there is a large "middle class" of species utilizing similar portions of niche space.

Diversity is principally a mechanism which generates community stability while dominance is a mechanism which generates community productivity (Mc Naughton, 1967). Studies conducted by Singh & Misra (1969) on tropical grasslands, however, disclosed that these generalizations may not hold true for all grasslands rather converse is true for tropical grasslands of Varanasi. Interestingly, a curvilinear relationship between biomass (expressed on log-scale) of sea-weed communities of Karachi coast and their diversity or dominance was reported by Saifullah *et al.*, (1984).

In view of the above controversy, an attempt was made to relate dominance and diversity and its components with the above ground standing phytomass of herbaceous communities where no significant linear or curvilinear relationship was disclosed. This was presumably because of heterogenous community types included in the sample at hand. However, various measures of diversity and dominance were found to be closely related with each other as also reported by Singh & Misra (1969) and Shaukat *et al.*, (1978).

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