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Life-Form and Primary Productivity of An Indian Grassland Community

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ABSTRACT

The life-form and primary productivity of a grassland community located at Rangamatia of Mayurbhanj district, Odisha (21^0 56' N; 86^0 41' E). The floristic composition of the grassland community comprised of 36 species (15 were grasses and 21 were non - grasses). *Cynodon dactylon, Digitaria abludens, Eleusine indica, Vetiveria zizanioides* among the grasses and *Phyllanthus fraternus* and *Sida cordifolia* among the non-grasses were found dominant during the study period. The life-form of the community consisted of the class Chamaephytes 27.78%, Hemicryptophytes 25%, Cryptophytes (Geophytes) 16.67% and the Therophyte 30.55%. Phanerophytes were found to be absent. The annual grass production was found to be 3289.53 g m^{-2} yr^{-1}. The non-grass production showed maximum in the month of June (868.55 g m^{-2}) and minimum in the month of September (141.11 g m^{-2}). The annual non-grass production was found to be 2246.10 g m^{-2} yr^{-1}. The study of life-form and primary productivity helps to recovery of the natural ecosystems to the earlier balanced state and preservation the biodiversity of grassland community in world.

Key words : Biomass, Livegreen, standing dead, litter, below ground.

INTRODUCTION

The Indian grassland communities are fully depending upon the climatological factors and various biotic interferences. Some work has been done on the grassland communities especially in the eastern region of the country. So an attempt has made to assess the life-form and primary productivity of an Indian grassland community during December 2006 to December 2007 and also compared the other grassland community. Now a day the ecological research is greatly expanded by the establishment of ecological societies and publication of ecological journals. The European ecologists concerned themselves largely with the static approach of classifying vegetation on floristic basis, while their counterparts in America developed the dynamic system of vegetation analysis which emphasizes temporal changes in the community. Clements (1916) studied the phytogeography and the vegetation of North America and gave a comprehensive account of plant successions. Raunkiaer (1934) gave the concept of life-forms of plants. Tansley (1935), the first president of British Ecological Society introduced the term "ecosystem".

Champion (1936), proposed the classification of vegetation in his publication "A preliminary survey of the forest types of India and Burma". Lindman (1942) studied the tropic dynamic aspects of ecology. The grasslands of Southern British Columbia were analyzed by Tisdale (1947). Odum (1957), Ovington ***et al.*** (1963), Golley (1972), Daubenmire (1968), Precsenyi (1971), Golley and Misra (1972), Lieth and Whittaker (1975) and Murphy (1975) made

outstanding contributions to ecological energetic, productivity, dominance and ecological modeling. Literature referred reveals plenty of work on functional attributes like biomass and primary productivity in different climatic zones (Odum, 1960; Ovington ***et al.*** ,1963; Jain & Misra (1972), Dahlman & Kucera, 1965; Golley, 1965; Porter, 1967; Precsenyi, 1969, 1973; Bazaz & Bliss, 1971; Vershney, 1972; Ambasht et al. ,1972; Singh &Yadava , 1974; Redmann, 1975, Shrimal & Vyas, 1975; Billore & Mall, 1977; Pradhan & Mohanty, 1993. Here also an attempt was made to measure the monthly biomass and primary productivity of various components of the grassland community.

The present study aimed at a comparative assessment of plant species richness, evenness, diversity and primary productivity of a grassland community of India. This study draws a clear and better interpretation of the patterns of plant biodiversity and explores possible ways to restore the biodiversity of grassland communities in all over the world.

MATERIALS AND METHODS

Environmental conditions

The climate of the locality is monsoonal with three distinct seasons viz. rainy (July to October), winter (November to February) and summer (March to June). The total rainfall during this period was 1906.2 mm of which a maximum of 499.8 mm was recorded during July. The minimum and maximum atmospheric temperature during the study period was found to be normal. December showed the lowest temperature (9.93 ^{0}C) whereas May experienced the highest temperature (38.9^{0}C).

The wind velocity was maximum (4.31 km h^{-1}) during April and minimum (1.99 km h^{-1}) in the month of November **(Fig.1).** The soil of the experimental site was found to be moderately acidic (pH = 5.5). The available phosphorus content was high (1.2 ppm) in lower soil and minimum (0.5 ppm) in middle soil profile. The potassium showed gradual reduction from surface (100.3 ppm) to middle (87.6 ppm) and then to lower (81.1 ppm) soil depth. The overall organic carbon (0.61%), nitrogen based on organic carbon content (0.5 to 0.75%), and available potassium (59 to 140 ppm) were found medium where as the available phosphorus content was found to be very low (< 2 ppm) in the soil Table -1.

Sample collection and Identification

The plant specimens preferably along with reproductive parts were collected from the experimental site and brought to the laboratory for identification (Mueller Dombois and Ellenberg, 1974). Identification of all the species were made in consultation with various regional and national flora books i.e. The Botany of Bihar and Orissa (Haines, 1921-25); Supplement to the Botany of Bihar and Orissa (Mooney, 1950); Flora of Madras presidency (Gamble, 1915-36); Flora of Similipal (Saxena and Brahmam, 1989); Flora of Orissa (Saxena and Brahmam, 1994-96) and Flora of Madhya Pradesh (Verma ***et al.***, 1993; Mudgal ***et al.***, 1997 and Singh ***et al.***, 2001).

Biomass and primary productivity

Harvest method of Odum (1960) was employed for the estimation of plant biomass. 10 quadrats of 50cm x 50cm size were randomly harvested / clipped, 1cm above the ground during the last week of each month. Primary productivity of the grassland community was determined from the biomass values following "short term harvest" method as proposed by Odum (1960). The productivity for each category of plant materials i.e. live green, standing dead, litter and below ground parts was calculated by summing up of the positive increments of concerned biomass during the study period and was expressed as g m^{-2} yr^{-1}.

Litter disappearance (LD) was calculated by subtracting the total net productivity of litter during the year from the difference between final and initial litter biomass (Golley, 1965).Below ground disappearance (BGD) was calculated from the difference between peak below ground biomass and succeeding minimum below ground biomass (Sims & Singh, 1971).Total disappearance was obtained by adding litter disappearance and below ground disappearance.

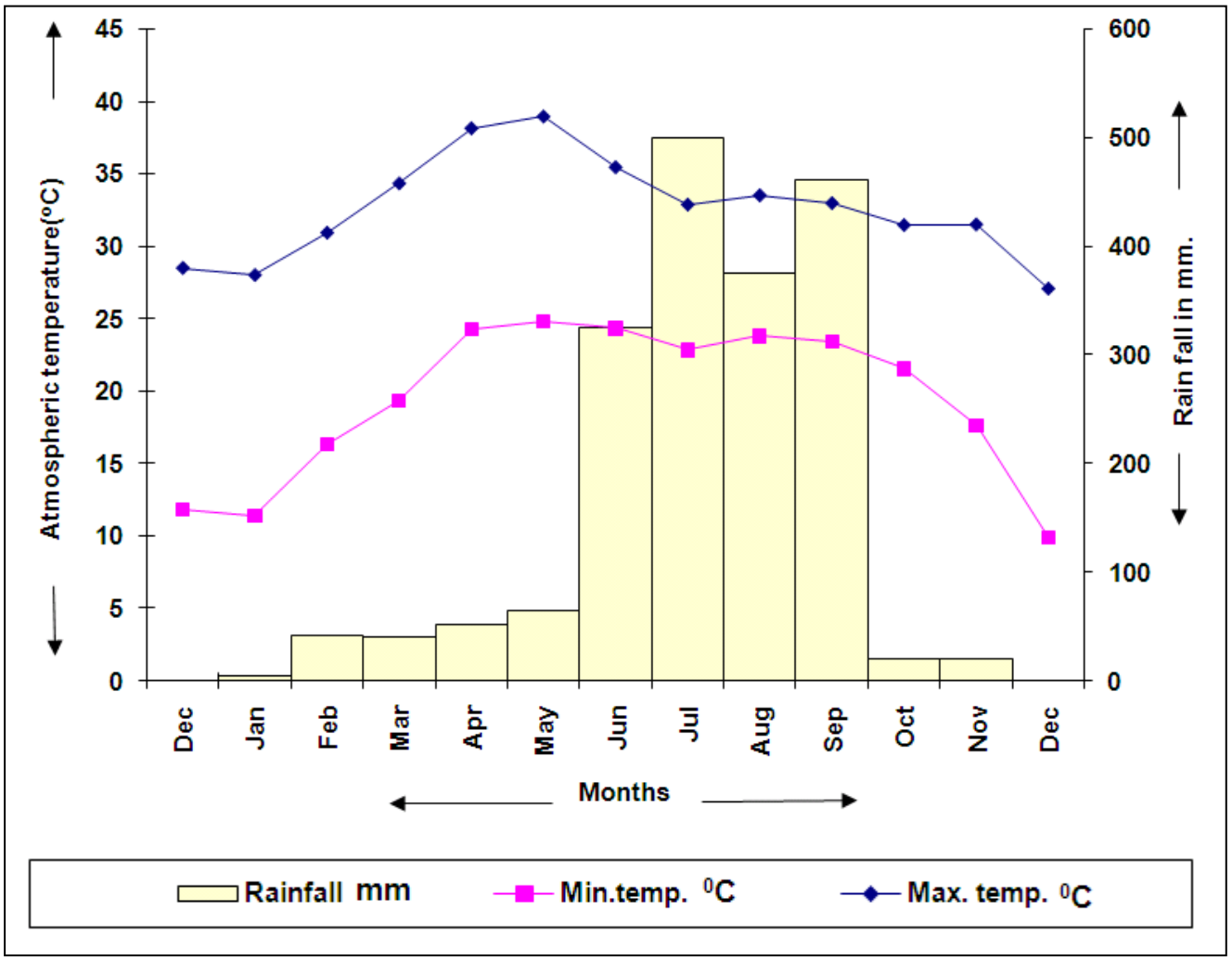

Fig-1: Monthly rainfall, mean minimum and mean maximum atmospheric Temperature of the experimental site during the study period.

RESULTS

The life form of all species revealed that the Therophyte percentage was found to be highest (30.55%) followed by Chamaephytes (27.78%), Hemicryptophytes (25%) and Geophytes (16.67%). The class Phanerophyte was found to be absent. Sequential harvest method was employed for the determination of biomass in the last week of every month. The live green biomass (grasses, non grasses and total live green) of the study site showed gradual declined in trend from December to January, February, March and lowest in the month of April. Thereafter it increased and attained a peak during September and onwards a gradual decreased in trend was observed till to the end of the sampling period. The standing dead biomass gradually decreased from December to June and onwards, the value started an increasing trend and showed the peak in the month of December (181.56 g m^{-2}).

Minimum standing dead biomass was recorded in the month of June (5.5 g m^{-2}).The litter biomass of the community exhibited an increasing trend from December to January, February, March, April and May. Thereafter the value showed a declined trend till August (65.08 g m^{-2}). The litter biomass again showed an increasing trend showing a maximum of 108.08 g m^{-2} during the last sampling period i.e. in the month of December. Total above ground biomass is the sum total of live green biomass

Surface depth in cm	pH	Conductivity	Organic carbon (C) (%)	Available phosphorus (P) (ppm)	Available potassium (K) (ppm)
0 to 10	5.46 ± 0.385	0.68 ± 0.179	0.56 ± 0.057	0.66 ± 0.321	100.3 ± 28.409
10 to 20	5.38 ± 0.311	0.50 ± 0.000	0.64 ± 0.092	0.50 ± 0.467	87.6 ± 26.658
20 to 30	5.64 ± 0.358	0.50 ± 0.000	0.62 ± 0.107	1.20 ± 0.689	81.1 ± 18.716

Table-1: The pH, conductivity , organic carbon (%), available phosphorus and potassium content of the soil content of the study site (values are in mean ± SD, n = 5 each)

and standing dead biomass. It was found to be minimum in the month of April (423.35 g m^{-2}) and maximum during September (6005.68 g m^{-2}). The sequence of monthly above ground biomass values showed similar trend to that observed in case of live green biomass values. The below ground biomass values decreased from December (274.76 gm^{-2}) to April (46.42 g m^{-2}) and onwards the values showed gradual increased in trend till September (737.8 g m^{-2}) and then decreased till December. The total biomass of the community ranges from 469.77 g m^{-2} to 6743.48 g m^{-2}. The maximum biomass was observed in September and minimum in the month of April.

A gradual decrease in total biomass value was found from December to April, then the value started increasing showing peak during September and onwards the value again followed decreasing trend till to the end of the sampling period (**Table-2).**

Grass production was found to be minimum during May (49.57 g m^{-2}) and maximum in the month of July (1274.09 g m^{-2}). The production of grass exhibited an increasing trend from May to June and then to July. Thereafter the value declined till September. The annual grass production was found to be 3289.53 g m^{-2} yr^{-1}.

Months	Live green			Standing	Litter	Above ground		Below	Total
	Grasses	Non grasses	Total	dead		Lg + Sd	Lg + Sd + L	ground	biomass
Dec.	1428.47	1101.70	2530.17	175.84	35.12	2706.01	2741.13	274.76	2980.77
Jan.	1052.17	571.84	1624.01	144.95	47.28	1768.96	1816.24	184.09	1953.05
Feb.	731.89	306.05	1037.94	118.13	51.00	1156.07	1207.07	118.86	1274.93
Mar.	387.97	114.05	502.02	68.21	60.56	570.23	630.79	58.91	629.14
Apr.	332.94	45.68	378.62	44.73	67.24	423.35	490.59	46.42	469.77
May.	382.51	245.11	627.62	37.03	77.84	664.65	742.49	70.13	734.78
Jun.	1555.85	1113.66	2669.51	5.50	73.24	2675.01	2748.25	306.68	2981.69
Jul.	2829.94	1614.13	4444.07	23.75	66.56	4467.82	4534.38	503.55	4971.37
Aug.	3509.57	2148.67	5658.24	53.92	65.08	5712.16	5777.24	628.68	6340.84
Sep.	3622.47	2291.78	5914.25	91.43	78.76	6005.68	6084.44	737.80	6743.48
Oct.	3066.50	2271.19	5337.69	132.24	83.40	5469.93	5553.33	674.43	6144.36
Nov.	2353.65	1852.63	4206.28	164.12	92.04	4370.40	4462.44	448.93	4819.33
Dec.	1482.05	1108.14	2590.19	181.56	108.08	2771.75	2879.83	280.49	3052.24
Total	**22735.98**	**14784.63**	**37520.61**	**1241.41**	**906.20**	**38762.02**	**39668.22**	**4333.73**	**43095.75**

Table- 2: Biomass (g m^{-2}) of different species during the study period.

Region	Pha%	Cha%	Hem%	Geo%	The%
Raunkiaer's normal spectrum (Raunkiaer, 1934)	16.0	9.0	26.0	6.0	43.0
Varanasi (Rao, 1968)	40.0	6.0	1.0	10.0	43.0
Varanasi (Singh & Ambasht, 1975)	-	4.2	19.2	6.3	70.2
Berhampur (Misra & Misra, 1979)	5.7	25.7	14.3	5.7	48.6
Berhampur (Malana & Misra, 1980)	10.00	26.66	23.33	3.33	36.33
Berhampur (Rath & Misra, 1980)	5.4	21.6	18.9	2.7	51.3
Western Orissa (Naik, 1985)	3.00	21.20	18.20	6.00	51.50
South Orissa (Patnaik, 1993)	3.58	17.86	25.00	10.71	42.86
Phulbani (Behera & Misra, 1993)	5.71	20.00	11.42	8.57	54.28
Bhubaneswar (Pradhan, 1994)	5.88	29.42	11.76	5.88	47.05
Berhampur (Barik & Misra, 1997)	-	25.81	12.90	9.68	51.61
Present study	-	27.78	25.00	16.67	30.55

Table- 3: Biological spectra of the study site as compared to other grassland types of India.

The non-grass production showed maximum in the month of June (868.55 g m^{-2}) and minimum in the month of September (141.11 g m^{-2}). The annual non-grass production was found to be 2246.10 g m^{-2} yr^{-1}.The total live green production showed their minimum and maximum value during May (249.00 g m^{-2}) and June (2041.89 g m^{-2}). Out of the annual net live green production (5535.63 g m^{-2} yr^{-1}) 59.42% was contributed by grasses and 40.58% by non-grasses. The standing dead production was found to be 176.06 g m^{-2} yr^{-1}.

The rate of production was nil during December to June. July and onwards continuous production of standing dead was observed showing a maximum of 40.81 g m^{-2} during October. Litter production was nil during June, July and August. The net annual litter production was 85.72 g m^{-2} yr^{-1}. Net above ground production was found to be 5711.69 g m^{-2} yr^{-1} of which June showed a maximum of 2041.89 g m^{-2}.The production was found to be nil in the month of January, February, March and April. The net above ground production exhibited a gradual declined in trend from June December showing a minimum of 17.44 g m^{-2} of production. A maximum of 236.55 g m^{-2} of below ground production was observed during June. Then the rate of production gradually decreased till September.

A minimum of 23.71 g m^{-2} of production was observed in the month of May. Total below ground production was found to be 691.38 g m^{-2} yr^{-1}.The total net production (6403.07 g m^{-2} yr^{-1}) was derived by adding the above ground net production (5711.69 g m^{-2} yr^{-1}) and below ground net production (691.38 g m^{-2} yr^{-1}). Gross primary production of the community was found to be 8323.99 g m^{-2} yr^{-1}. This was derived by adding respirator loss (1920.92 g m^{-2} yr^{-1}) to total net production of the community.

About 89.22% of the total net production remained in the above-ground parts and about 10.78% directed towards belowground parts. From the above ground net production 0.48 g m^{-2} day^{-1} was transferred to standing dead. The transfer rate from standing dead to litter was 0.23 g m^{-2} day^{-1}. The rate of disappearance of litter and below ground was 0.03 g m^{-2} day^{-1} and 1.25 gm^{-2} day^{-1} respectively. The total disappearance of organic matter was at the rate of 1.28 g m^{-2} day^{-1} or in other words about 7.34% of the total net production was lost annually.

DISCUSSIONS

Maximum percentage of Therophyte, Chameophytes and Hemicryptophytes and absent in Phenerophytic species attributed to be

Author (s)	Year	Location	Type of community (Dominance)	Annual rain fall mm	NPP (g m $^{-2}$yr^{-1})
Ambasht ***et al.***	1972	Varanasi	*Dichanthium*	725	1420
Varshney	1972	New Delhi	*Heteropogon*	800	1330
Singh & Yadava	1972	Kurukhetra	*Panicum*	770	2980
Misra	1973	Ujjain	*Dichantium*	1030	989
Billore & Mall	1977	Ratlam	Sehima	1257	846
Misra	1978	Berhampur	*Aristida*	1200	1447
Malana	1981	Berhampur	*Aristida*	1355	1180
Pradhan	1994	Bhubaneswar	*Aristida*	858	1474
Behera	1994	Phulbani	*Heteropogon*	1763	809
Barik	2006	Berhampur	*Aristida*	1341	929
Present study		Rangamatia	Mixed type	1906	6403

Table- 4: Total annual net primary production g m^{-2} yr^{-1} of different grassland community.

due to influence of periodicity, soil characteristics, climatic condition as well as the biotic interferences. Similar findings were also reported in grassland of Varanasi (Singh and Ambasht, 1975; Abdar, 2013) and Berhampur (Barik and Misra, 1997). Present findings when compared to normal biological spectrum of Raunkiaer (1934) showed 3.1 times higher than the percentage of Chamaephytes, 2.78 times in case of geophytes and 2.35 times in case of Therophytes whereas the percentage of Hemicryptophytes was nearly 0.96 times less than the normal spectrum. **Table- 3** showed in detail the biological spectra of the study site and other climatological region along with the Raunkiaer's normal spectrum.

The live green biomass of the community gradually declined from December to April and subsequently increased till September. Again there was a decreasing trend from September to December. It indicates that with the increase in atmospheric temperature the live green parts of the flora dry up and turn yellow and hence April showed less live green biomass. During May to September the rain fall, atmospheric temperature and soil condition were found to be suitable for the growth and development of all species so that September exhibited peak value. Onwards the amount of rain fall, atmospheric temperature along with the soil condition might not be favorable for the growth of vegetation as a result of which a gradual declined in green biomass was observed till to the end of the sampling period.

The total live green production of the experimental site indicates that the production attained peak during the month of June this might be due to favourable climatic condition. Live green grass production and live green non grass production were found to be maximum during July and June respectively. This variation was due to physiological and phenological differences of the species of the community. The total live green productions are changes due to adverse climatic conditions. The standing dead production was nil from December to June and thereafter the production was observed in July. It indicates that the climatic condition as well as the soil nutrient during December to June was not suitable for the standing dead production. From July, the dead production started increasing showing a peak in the month of October (40.81 g m^{-2}) might be due to gradual drying of live green parts of the grass and non grass species of the community. October onwards a declined trend of standing dead production was evident perhaps due to higher rate of litter decomposition.

The annual net above ground production of this grassland, with the production of other grasslands it was observed that the present value showed higher production than the values reported for other Indian grassland. The litter production of the community was evident from January to May and from September to December. No litter production was observed during June, July and August. This may perhaps be due to rapid decomposition of litter which

subsequently mixed with the soil. The atmospheric temperature, rainfall and soil condition might be favourable for such litter decomposition. Besides, wind factor may create a serious problem for litter production as it washes out the litter component from the community causing reduction in litter production.

The peak below ground production during June was perhaps due to suitable climatic condition. In the succeeding months the climatic condition of the site may be not in favour of below ground production as a result of which a gradual decline in below ground biomass was observed from June to September. The annual net belowground production of the present study when compared with the findings of other workers it shows that, the value was much less than that of Jain & Misra (1972) and Rath (1980)and much higher than most of the workers (Choudhury,1972; Misra,1973; Singh & Ambasht,1975; Billore &Mall, 1977;Misra, 1978;Malana, 1981; Pandya & Sidha,1987;Patnaik,1993; Pradhan, 1994 and Barik, 2006). This fluctuation in the belowground production was mainly due to the variation in soil characteristics, amount of precipitation and variable temperature of the locality.

Net primary production

Table-4 gives the annual, net primary production of some Indian grassland. It indicates that the net production in this study was no way similar to the findings of other workers as reported earlier. It showed marked higher value compared to the findings of Ambasht ***et al***. (1972), Varshney (1972), Singh & Yadava (1972), Misra (1973), Billore & Mall (1977), & Misra (1978), Malana (1981), Pradhan (1994), Behera (1994) and Barik (2006). It was observed that rain fall was not a single factor responsible for this variation. There were some other factors including rain fall that influenced the net production in the community. It might be due to phenology of the species, rate of evaporation, temperature variability, fertility of soil etc.

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