BIOMASS DYNAMICS AND NET PRIMARY PRODUCTION IN A TROPICAL GRASSLAND OF WESTERN GHATS IN SOUTHERN INDIA

DINAMICA DE LA BIOMASA Y PRODUCCION PRIMARIA NETA EN PASTOS TROPICALES DE GHATS OCCIDENTAL EN EL SUR DE INDIA

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Additional keywords

Aboveground live. Litter. Monthly variation. System transfer. Tirunelveli. *Themeda triandra.*

Palabras clave adicionales

Fitomasa aérea viva. Capa orgánica superficial. Estacionalidad. Transferencia del sistema. Tirunelveli. *Themeda triandra.*

SUMMARY

The study deals with the plant biomass, net primary productivity and transfer dynamics of tropical grassland in the Western Ghats region of southern India. The maximum aboveground live shoot biomass was observed in August 1984 (291 g/m^2) and maximum belowground biomass in March 1984 (74 g/m^2). Total annual net primary production is estimated to be 1946 g/m^2. The system transfer function showed that about 40 p.100 of total production was channelled to aboveground and 60 p.100 of allocation was belowground production. The total output was 4.47 g/m^2/day, which was 84 p.100 of the total input. Thus, the grassland showed a net accumulation of surplus organic matter, indicating the seral nature of this grassland. The grassland showed that belowground components play a major role in faster recycling through decomposition.

RESUMEN

Se estudian la biomasa vegetal, productividad neta primaria y dinámica de transferencia de un pastizal tropical en la región occidental de Ghats, al sur de la India. La mayor cantidad de fitomasa aérea viva se observó en agosto de 1984 (291 g/m^2) y la máxima cantidad de biomasa subterránea en marzo de 1984 (74 g/m^2). La producción primaria neta total anual se estimó en 1946 g/m^2. La función de transferencia del sistema, mostró que alrededor del 40 p. 100 de la producción total fue encauzada a las partes aéreas y el 60 p. 100 a las partes subterráneas. El *output* total fue de 4,47 g/m^2/día, lo que supone el 84 p. 100 del *input* total. De este modo, el pasto mostró una acumulación neta de materia orgánica excedentaria lo que indica su naturaleza serial. Los componentes subterráneos juegan un papel importante en la aceleración del reciclaje a través de la descomposición.

INTRODUCTION

The progress of human life and animal husbandry mainly depend on grasslands. Livestock subsists about 75

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p.100 of grass in the natural grazing areas, of which 15 p.100 of grazing provide from forests. Grasslands in Western Ghats region of southern India owe their origin to indiscriminate tree felling and over-grazing and have many common features with several tropical grasslands. The existing grassland in Western Ghats are in a deteriorating condition, both in organic matter production and nutritive value because of over-grazing, tampering and clipping which inturn the economic resources. The grasslands of the Tirunelveli district of southern India are important in two respects (i) they cover a large area, and (ii) they provide fodder for the local and other domesticated animals. Therefore, structural characteristics of the primary producer of these grasslands was studied which included the plant biomass. Net primary production, net accumulation and disappearance and compartmental transfers were worked out as indices of the functional properties of the primary production of the grassland.

In India, most of the work on grassland has been studied extensively by Singh and Yadava (1974); Chaturvedi *et al.* (1988); Uma Shankar *et al.* (1991) in northern region and Ramakrishnan and Ram (1988) in north-eastern India, but little information is available on grassland ecosystems in Western Ghats region of southern India by Karunaichamy and Paliwal (1989) in Madurai and by Karunaichamy and Paliwal (1993, 1994) in Kanniyakumari district. Virtually no information is available on the Western Ghats natural grazing lands ecosystems of Tirunelveli district in southern part of this country. Hence the present study deals with the biomass, net primary production and system transfer functions of the humid grasslands in the Western Ghats region of southern India dominated by *Themeda triandra*, Frosskel.

MATERIAL AND METHODS

STUDY AREA AND CLIMATE

The study was conducted at Kottavasal (9° 05' N; 77° 15' E) at an elevation of 1200 m above mean sea level in Tirunelveli district, southern India. This area was open grazing land, grazed regularly by sheep and cattle. The total

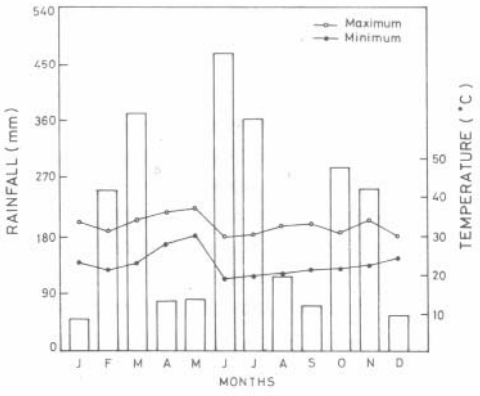

Figure 1. *Ombrothermic diagram for Kottavasal of Western Ghats region in southern India during January to December, 1984. Bars represent rainfall, (o—o) maximum temperature, (•—•) minimum temperature.* (Diagrama ombrotérmico para Kottaval (región de Western Ghats en el sur de India) desde enero a diciembre. Las barras representan la precipitación; (o—o) la temperatura máxima y (•—•) la mínima).

annual rainfall was 2449 mm, with the maximum rainfall in June (469 mm) and the minimum in January (52 mm). The mean maximum and minimum temperatures **(figure 1)** recorded during the study period (January - December 1984) were 32.8°C and 22.9°C, respectively.

The soils of the area are sandy clay loams. Water holding capacity of the soil was estimated to be 41.8 p.100. The soil is slightly alkaline (pH 7.9). Soil nutrient levels were organic carbon (1.63 p.100), nitrogen (0.26 p.100), phosphorus (0.03 p.100), potassium (0.11 p.100), calcium (0.01 p.100) and magnesium (0.90 p.100).

PHYTOSOCIOLOGY

Three replicates of 2 - 5 ha of grassland ecosystem were selected. Vegetational analysis was based on 1 m^2 quadrats laid randomly. Frequency, density and basal area were recorded for all species. Importance value index (IVI), which is an integrated measure of the relative frequency, relative density and relative dominance, was also estimated by the method of Curtis (1959).

BIOMASS AND PRODUCTIVITY

Biomass was estimated by the harvest method of Milner and Hughes (1968). Aboveground vegetation was harvested, by species, at monthly intervals, from ten randomly laid quadrats of 50 cm x 50 cm size each, and litter was picked up from the ground following the harvest. No quadrats were reharvested during entire period of study. The aboveground herbage was sorted into live shoots and dead shoots. The belowground biomass was sampled by a sub-sampling (25 x 25 x 30 cm) within the harvested plot. All plant samples collected were oven dried at 65 ±5°C to a constant weight, weighed, ground and stored in polythene bags for chemical analysls.

The aboveground net primary production (ANP) was calculated by the method of Singh and Yadava (1974). The belowground net primary production (BNP) was calculated by summation of positive increments of belowground biomass. Net accumulation and disappearance rates of dry matter were calculated by the methods of Singh and Yadava (1974) and Sims and Singh (1987b). Turnover rates for aboveground and belowground biomass were calculated by the method of Dahlman and Kucera (1965).

RESULTS

The most important species in the pasture (based on the importance value index, IVI) was *Themeda trianda (IVI =* 240.2) followed by *Crotalaria angulata* (30.7) and *Hedyotis auricularia (29.0).*

Monthly changes in live shoots, dead shoots, litter and belowground are depicted in **figure 2**. The live shoot biomass ranged between 91 and 291 g/ m^2 during the study period. The maximum live shoot biomass production was in August. There was a sharp decline in the biomass production in September. Live shoot biomass was related to density of vegetation in a linear fashion, according to the following equation:

$$Y = -10.99 + 0.19\ X$$

where Y is the live shoot biomass (g/ m^2) and X is the density of vegetation (tillers/m^2). This relationship explains

81 p.100 of the variation in live shoot biomass ($r = 0.90$, $p<0.001$).

A substantial amount (100 - 308 g/m^2) of dead shoot biomass was recorded throughout the study period **(figure 2)**. The pattern was similar to that of live shoots with peak in August, although a third peak occurred in October. The litter biomass ranged between 16 and 201 g/m^2. The maximum litter was obtained in December and the minimum was noticed in July. There was a sharp decline in May and then an increase in February. The belowground biomass ranged from 265 741 g/m^2, with peaks occurring in February and June. Continuous fluctuation in the amount of belowground was noticed throughout the study period.

The aboveground net primary production (ANP) was 774 g/m^2. The maximum sum of species biomass was 930 g/m^2. Thus, the estimate of net production obtained from the peak community biomass was lower than sum

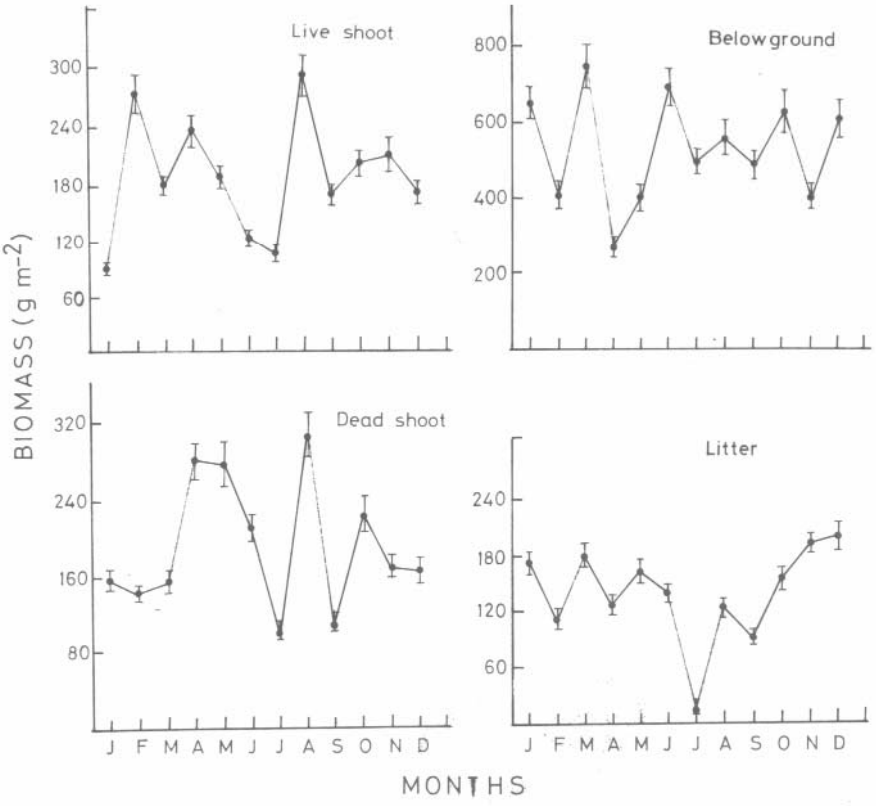

Figure 2. *Monthly variations in biomass of various compartments for Kottavasal grassland of Western Ghats region in southern India. Vertical bars represent ± SD.* (Variaciones mensuales de la biomasa en varios compartimentos del pasto de Kottavasal en la región de Western Ghats en el sur de India. Las líneas verticales representan ±DE).

of species biomass by 17 p.100 during the study period. The total net belowground primary production (BNP) was found to be 1172 g/m^2 and the total net primary production (TNP) was 1946 g/m^2. The turnover rate and time were observed to be 1.25 g/m^2 and 0.77 years for canopy and 1.58 g/m^2 and 0.63 years for belowground biomass, respectively.

DISCUSSION

Considerable differences occur in biomass of live shoots during the study period. The highest levels of standing herbage mass accumulated in August and the lowest levels were in January. The grasses showed fast growth after the commencement of monsoon and attained peak live shoot biomass during the rainy season, showed the active growth of *Themeda triandra* followed by few annual species. The accumulation of biomass in live shoots showed a bi-modal pattern of growth, the first peak occurred in February and the second peak in August. The peak growth of aboveground biomass of 6.2 g/m^2/day occurred in August. The value of peak growth reported for the present grassland is 50 p.100 less than the tropical grasslands in Kanniyakumari district of southern India reported by Karunaichamy and Paliwal (1993, 1994). The dead shoot production is always lower in humid than in arid and semi-arid regions which was reported by Sims and Coupland (1979). At low sheep densities, the more palatable species will be heavily grazed, while other herbage will be avoided, this leads to patchiness in the vegetation structure as reported by Sykora *et al.* (1990).

Singh *et al.* (1983) reported that the aboveground production ranged between 51 and 679 g/m^2 in the temperate grassland. These values are lower than the tropical grassland of Kanniyakumari district (1212 g/m^2) reported by Karunaichamy and Paliwal (1994) and 774 g/m^2 for the present study at Kottavasal. Belowground production was higher than the aboveground production at this study site, and was higher than values reported for tropical grassland at Kalikesam by Karunaichamy and Paliwal (1994) and lower than the value reported for a semiarid grazed area in Madurai by Karunaichamy and Paliwal (1989). In the humid tropical region, Ramakrishnan and Ram (1988) have recorded belowground production to be more than double the aboveground production because of the efficient uptake of nutrients in a situation of low soil fertility. The turnover rate appeared to be rapid. In general semi-arid grasses have lower turnover rates than those in humid regions. Similar observations were also made by Sims and Singh (1978a).

The total net primary production on whole year basis is 1945 g/m^2. Out of which 40 p.100 accounted for aboveground net production and 60 p.100 for belowground production. The maximum belowground accumulation could be because of the short grass nature and heavy grazing, which resulted in more biomass accumulation in below ground as suggested by Dickinson and Polwart (1982). Karunaichamy and Paliwal (1994) reported that the ratio of total net production to mean standing crop was higher (1.95) in tropical grassland whereas, Singh and Krishnamurthy (1981) reported that the values ranged between 0.48 and 1.16 for temperate grassland. The mean values

reported for the present grassland was 1.86, which is higher than the values reported by Singh and Krishnamurthy (1981), and Sah and Ram (1989) for the other temperate grasslands, indicating that the biomass in the present grassland is more biologically active and more efficient.

Dry matter dynamics of the present grassland community is presented through compartmental model in **figure 3**. The present grassland community accumulated total dry matter at the rate of 5.33 g/m²/day. Out of the total net production, the aboveground dry matter accumulated at a rate of 2.12 g/m²/day and the belowground dry matter at the rate of 3.21 g/m²/day. The transfer of live

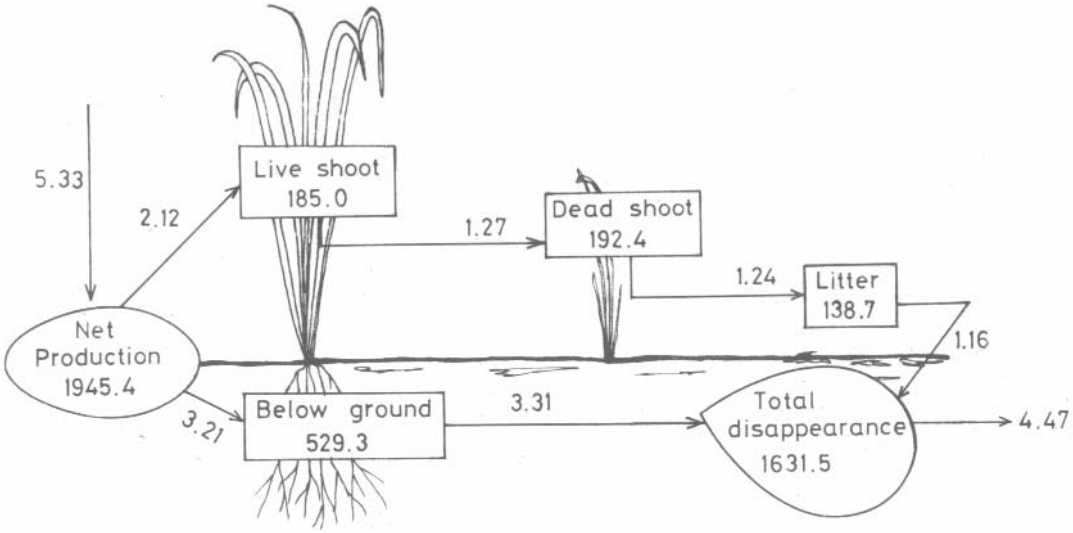

Figure 3. *Diagram depictıng net dry matter flow through the various compartments for Kottavasal grassland of Western Ghats region in southern India. Values in boxes are the mean annual standing crop in g/m²/year. Values on the arrows are net flux rates in g/m²/day.* (Diagrama mostrando el flujo neto de materia seca a través de varios compartimentos para el pasto de Kottavasal y región de Western Ghats en el sur de India. Los valores en los recuadros son la fitomasa media anual en g/m²/año. Los valores sobre las flechas son las tasas netas de flujo en g/m²/día).

shoots to dead shoots and dead shoots to litter occurred at the rates of 1.27 g/m^2/day and 1.24 g/m^2/day respectively (about 69 p.100). The rate of disappearance of litter was 1.16 g/m^2/day and that of below ground was 3.31 g/m^2/day. The sum of these values gives a total disappearance of 4.47 g/m^2/day which was 84 p.100 of the total input for the tropical grassland at Kottavasal. **Table I** shows the values of system transfer function of present grassland community. The maximum amount of total net production was channelled into belowground net production than into aboveground net production. About 60 p.100 of aboveground net production was transferred into dead shoots and 58 p.100 into litter. Approximately 94 p.100 of litter and 78 p.100 of total production was disappeared in the same year. The belowground disappearance was more than the accumulation.

There was a net surplus of organic material in the present grassland ecosystem over annual cycle. The present grassland showed a net accumulation of surplus organic material, which showed the seral nature of grassland. This was also reported by Gupta and Singh (1982); Karunaichamy and Paliwal (1993, 1994) for a tropical grassland and Sah and Ram (1989) for a temperate grassland. Ram *et al.* (1989) have reported that in central Himalayan high altitude grasslands, total output is similar to input indicating that the grassland is approximately in equilibrium, this could be due to differences in intrinsic, climatic, edaphic and species composition as reported by Gupta and Singh (1982) and Ram *et al.* (1989).

In conclusion, the phytomass cycling in this tropical grasslands of Kottavasal showed that belowground components play a major role in accumulation, decomposition and recycling of phytomass than aboveground components. These grasslands are developed and maintained under high biotic pressure and still it showed the resilience of the grassland ecosystem at Kottavasal.

Table I. *System transfer functions of a tropical grassland ecosystem of Western Ghats in southern India.* (Funciones de transferencia del sistema de un ecosistema de pasto tropical en la zona de Western Ghats en el sur de India).

Compartments From (input)	to (output)	System transfer functions
TNP	ANP	0.40
TNP	BNP	0.60
TNP	TD	0.78
TNP	L	0.23
ANP	SD	0.60
ANP	L	0.58
SD	L	0.98
L	LD	0.94

Abbreviations:
ANP = Aboveground net primary production (Producción primaria neta aérea); BNP = Belowground net primary production (Producción primaria neta subterránea); TNP = Total net primary production (Producción primaria neta total); L = Litter (Capa orgánica superficial); SD = Dead shoot (Tallos muertos); LD = Litter disappearance (Desaparición de la capa orgánica superficial); TD = Total disappearance (Desaparición total).

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