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MEASUREMENT OF THE AERIAL HERBACEOUS BIOMASS AND NET PRIMARY AERIAL PRODUCTION OF THREE GRASSLAND COMMUNITIES IN THE SAHELIAN ZONE OF SENEGAL

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Abstract : The herbaceous stratum in the sahelian ecosystems is generally constituted by annual species with a short growth-period. This paper describes the experimental and conceptual basis for the determination of the disappearance rate. This rate was determined and net primary aèrial production was calculated for three typical grassland communities in the sahelian zone during two years.

Resume : La strate herbacée des écosystèmes sahéliens est générelement constituée d'espèces annuelles possédent une courte période de croissance. L'article décrit une approche expérimentale et conceptuelle de la determination du taux de disparition de la litière. Ce taux a été détreminé et a servi à calculer la production nette aérienne de la strate herbacée de trois groupements végétaux de la zone sahélienne pendant deux ans.

Resumen : El estrato herbaceo en el ecosistema saheliano esta formado generalmente por especies anuales con un periodo corto de credimiento. Este artículo describe las bases conceptuales y experimentales para la determinación de la velocidad de desaparición. Se determino esta tasa de desaparición y se calculó la producción primaria neta aérea para las tres comunidades típicas de pastizal en la zona saheliana durante dos años.

Resumo : O estrato herbáceo nos ecosistemas do Sahel é constituido, geralmente por espécies anuais e um curto períodode crescimento. Este trabalho descreve as bases esperimentais e conceituais para a determinação da taxa de desaparecimento. Essa taxa foi determinada e a produção primária, líquida, aerea, foi calculada para três típicas comunidades de campinas na zona saheliana durante dois anos.

Key Words: Biomass, net production, grassland, *Tephrosia, Schoenfeldia, Zornia,* Sahel.

INTRODUCTION

For the ecologist, the understanding of the functional aspects of an ecosystem requires the knowledge of the processes of growth and productivity, which are the basic aspects of plant and community responses to the environmental factors.

"The net aerial primary production is the sum of biomass and litter increments and of dead material disappearance" (Menaut 1976). The determination of the net aerial primary production (NAPP) requires the time-series measurements of the biomass and of the standing crop of dead material (necromass) in addition to the disappearance rate of the dead material and actual mortality.

The Wiegert and Evans method (1964) revised by Lomnicki *et al.* (1968) is based on the use of paired plots and allows the calculation of NAPP, but without

accounting for the decomposition of dead material. Bille (1976a) shows that the calculation of the NAPP in the sahelian grassland communities requires the knowledge of the disappearance rate of dead material, because it is very high during the growing season. In the present work, a method based on paired plots is suggested for calculating disappearance rate, mortality and NAPP during a time interval.

METHODS

This study was conducted in the Livestock Research Center of Dahra, located in the sahelian zone of Senegal. The mean annual rainfall is 492 mm. The rainy season lasts only three months : July, August and September. The measurements were conducted on following three representative grassland communities : Community I_B characterized by *Tephrosia purpurea*; Community II_B by *Schoenfeldia gracilis*; Community I_C by *Zornia glochidiata*. The vegetation has been described in detail earlier (Cornet and Poupon 1977).

In each community, measurements were made on twenty replicates of paired plots. Each plot, a quadrat of 0.25 m^2 in area, was randomly selected in the vegetation. The measurements began when the seedlings appeared, and continued during the whole growing season, at time intervals of 7 or 14 days. The harvested material was dried at 80°C and weighed.

METHOD OF CALCULATION

In accordance with the Wiegert and Evans method, two similar, paired, plots were studied. At time t_o, an equal amount of biomass b_o, and an equal weight of dead material g_o, are present on each plot. On the plot No. 2 all the dead material was harvested.

At the time t_i the biomass b_i, is equal on the two plots. There is a weight g_i of dead material on plot No. 1, and on plot No. 2 an amount of dead material h_i accumulated during the time interval t_i-t_o. If y_i is the value of NAPP during the time interval t_i-t_o, and a_i is the value of the actual mortality, the NAPP of these plots can be calculated as :

$$y_i = b_i - b_o + a_i$$

The dead material on these plots is produced, and simultaneously, partly decomposed, in a similar manner as forest litter. The evaluation of the amount of dead material is in accordance with the methods followed by Olson (1963) and Bernhard-Reversat (1970).

If x=the weight of dead material at the instant (t), and a=the instantaneous mortality, and k=the disappearance rate of dead material, the variation of dead material can be expressed by the differential equation :

$$\frac{dx}{dt} = a - kx$$

$$\text{or} \quad \frac{dx}{\left(\frac{a}{k} - x\right)} = kdt$$

The general integral of this equation is :

$$L_N \left(\frac{a}{k} - x\right) = kt + C^{ste}$$

Coming back to the experimental conditions of the paired plots method, the two plots are assumed to be idential, and k has the same values on the two plots.

On the plot No. 2, the dead material is harvested at time t_o. In this case $x_o=o$, and the equation (3) gives :

$$L_N\left(\frac{a}{k}\right) = C^{ste}$$

and it can also be written as :

$$L_N\left(1 - \frac{k}{a}x\right) = -kt,$$

which can also be expressed in the exponential form :

$$1 - \frac{kx}{a} = e^{-kt}.$$

From this equation :

$$a = \frac{kx}{1-e^{-kt}}$$

If the interval between two measurements, is taken as time unit :

$$a_i = \frac{k_i x_i}{1-e^{-kt}}$$

As at time t_i, $x_i=h_i$ on the plot No. 2, it can be written

$$a_i = \frac{k_i h_i}{1-e^{-ki}}$$

On the plot No. 1, at time t_o, $x_o=g_o$, and at time t_i, $x_i=g_i$, but if no material had died between t_o and t_i, the weight of dead material at time t_i would be $x_i=gi-h_i$, because h_i is the amount of dead material accumulated during this interval. In this case the equation (2) becames :

$$\frac{dx}{dt} = -kx$$

$$\text{or } \frac{dx}{x} = -kdt,$$

the integral of this equation is $L_N\, x=kt+C^{ste}$. At time t_o, $x_o=g_o$ and $C^{ste}=L_Ng_o$, it can be written as :

$$L_N\left(\frac{x}{x_o}\right) = k_t.$$

If the interval between two measurements is taken as time unit,

$$k_i = -L_N\left(\frac{x_i}{x_o}\right)$$

and the disappearance rate k_i is given by :

$$k_i = -L_N\left(\frac{g_i-h_i}{g_o}\right)$$

This rate (k_i) can be calculated from the experimental data if $g_o=0$, and the net primary production can be calculated from the experimental data as follows :

$$y_i = b_i-b_o+\frac{k_i h_i}{1-e^{-k_i}}$$

RESULTS

The study was conducted in 1977 and 1978. In 1977 the rainfall was low, 296.7 mm, and the rainy season began late but was regular. In 1978, the rainy season began early, but was interrupted by many dry periods. The Fig. 1 shows biomass

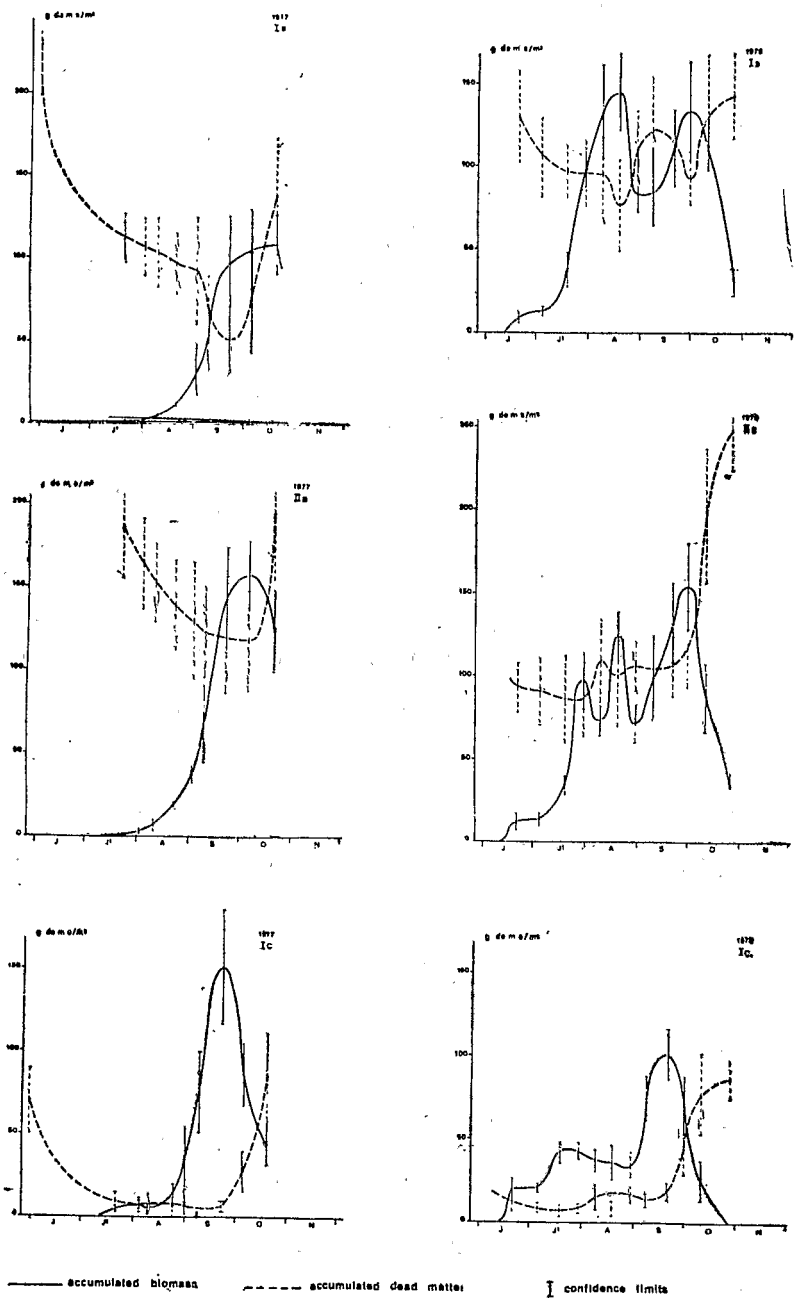

Fig. 1. Accumulation of biomass and amount of dead material in three grassland communities.

and dead material accumulation, for each community during the growing seasons of 1977 and 1978. During the dry season (from November to June) there is no living material on the plots. The dead material decreases is relation with the grazing.

Fig. 1 shows that the dry periods break up the growing curves in 1978, the effect of the dry periods is variable, depending on the community and soils.

The biomass was measured with mean confidence limit of 19.3% (probability 0.95). The confidence limit was 25.3% for the weight of dead materials.

The Table 1 gives the calculated results of NAPP and the actual mortality expressed in grams of dry weight/m^2, and the disappearance rate is expressed in $g/g/m_2$. The estimates of these values are shown in Fig. 2.

TABLE 1. *The calculated values of disappearance rate* (k_i), *mortality* (a_i) *and the net aerial primary production* (y_i).

		Community I_B			II_B			I_C		
Date	t_i-t_o	k_i	a_i	y_i	k_i	a_i	y_i	k_i	a_i	y_i
21/07/77 ..	9*			1.2**			1.6**			5.4**
02/08/77 ..	12	0.046	0	0.9	0.125	0	1.4	0.291	0.231	2.63
10/08/77 ..	8	0.040	0.61	2.91	0.078	0.52	4.52	0.054	1.03	0
21/08/77 ..	11	0.087	1.88	9.28	0.092	0.52	14.42	0.108	4.43	3.43
02/09/77 ..	12	0.056	1.44	20.44	0.082	1.77	18.87	0.227	1.34	23.94
09/09/77 ..	7	0.263	1.71	24.01	0.070	2.49	32.89	0.797	3.48	41.98
22/09/77 ..	13	0.575	12.89	55.39	0.158	15.78	91.28	0.336	3.30	79.0
05/10/77 ..	13	0.030	24.77	34.37	0.151	16.27	30.47	0.458	29.17	0
20/10/77 ..	15	0.029	65.5	67.55	0.047	84.03	49.63	0.004	58.1	15.4
Total 77 ..				216.05			245.0			176.8
26/06/78 ..	10*			9.4**			12.7*			20.8*
04/07/78 ..	14	0.213	2.22	5.52	0.065	3.2	4.7	0.505	2.29	2.39
19/07/78 ..	15	0.127	2.66	27.26	0.096	4.3	23.80	0.433	4.85	1.84
30/07/78 ..	11	0.037	2.55	63.25	0.057	4.11	67.81	0.543	5.14	5.14
09/08/78 ..	10	0.323	29.84	64.44	0.012	25.55	1.55	0.754	16.09	10.49
17/08/78 ..	10	0.381	14.55	25.55	0.181	81.86	59.16	0.420	10.55	9.55
30/08/78 ..	11	0.343	67.92	6.22	0.266	33.94	0	0.879	17.58	14.98
08/09/78 ..	9	0.574	76.87	77.67	0.472	46.67	73.77	0.811	8.90	50.10
21/09/78 ..	13	0.327	29.90	56.90	0.319	35.98	68.68	0.969	21.39	48.30
30/09/78 ..	9	0.593	38.98	61.98	0.425	58.92	81.72	0.690	48.63	17.53
11/10/78 ..	11	0.010	39.90	19.60	0.227	115.12	47.72	0.099	39.50	0
26/10/78 ..	15	0.287	50.61	0	0.030	58.69	5.59			
Total ..				417.8			447.2			203.2

*Since the germination.
**Is a sous-estimation

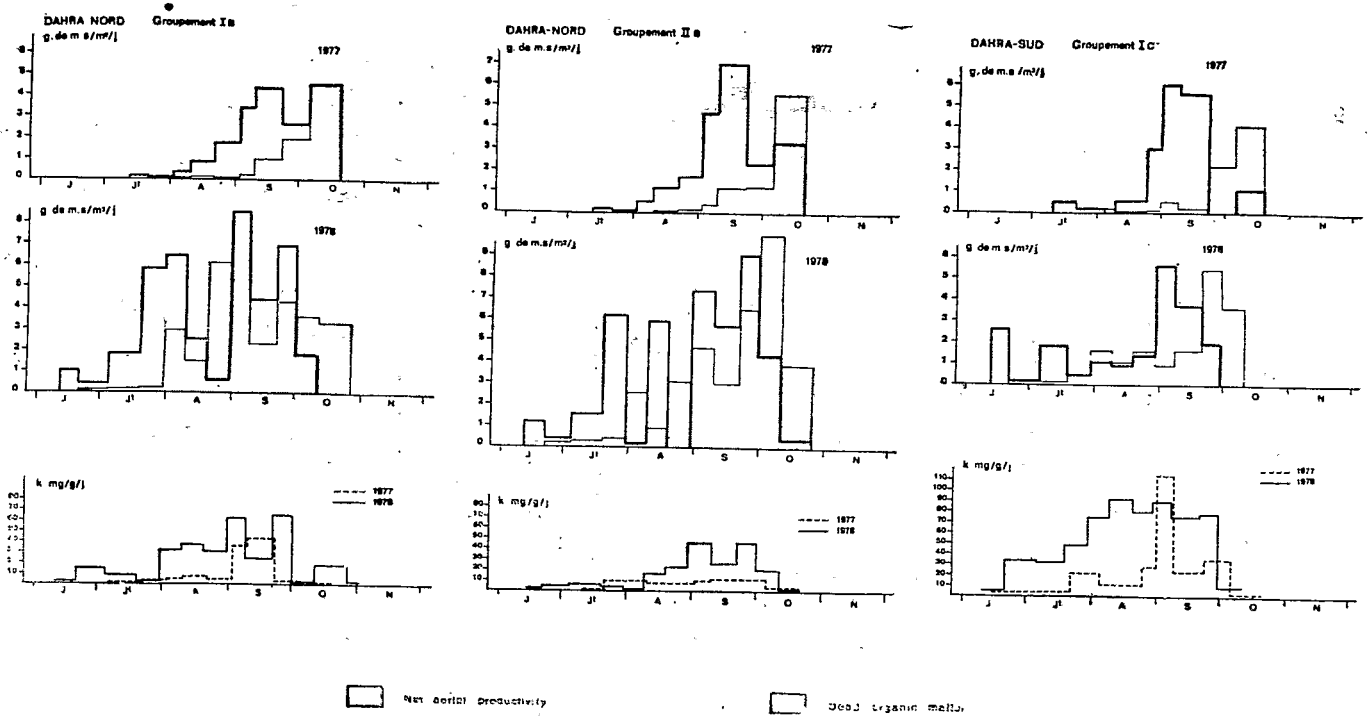

Fig. 2. Estimates of the net aerial productivity calculated, the actual mortality and the disappearance rate of dead material.

DISCUSSION AND CONCLUSION

From the results presented above, it is apparent that the net production is low in the beginning of the rainy season and then increases proportionally with the accumulation of biomass, because of the increasing photosynthetic surface. The net daily productivity peaks to a maximum in September, at this time the leaf area index is the highest and the water budget is good. The highest calculated values of productivity are : 9.1 g/m²/day for the II_B community in 1978; 8.5 g/m²/day for the I_B community in 1978, and 6.0 g/m²/day for the I_C community in 1977. The net productivity is related to the available water. During the growing season, the drought reduces or stops production.

The amount of dead material stored depends on the mortality and on the disappearance rate. It decreases during the active growing period, and can be reduced to zero (Bille 1976b) during the rainy years. The mortality is low at the biginning of the rainy season and then increases with the aging of plants, but occasional droughts lead to sharp increase in mortality.

The disappearance rate of dead material is the sum of the consumption by insects and other animals of the microfauna and of the microbial decomposition. The rate is low during the dry season because the insect populations are small and the microbial activity is reduced to zero by dessication. This rate increases during the growing season. During the rainy season of 1978, for the three communities, this rate is much higher than in the 1977 season. It is supposed that the plant material dead during the dry periods of the 1978 rainy season is easily decomposable, because it consists of young tissues.

Another experiment was conducted in another grassland-community of the sahelian zone (Bernhard-Reversat, personal communication). It consisted of weight losses measurements, from samples of dry grass, and the disappearance rates are comparable with those obtained in the present work.

In conclusion, in the grassland communities of the sahelian zone, the measurement based on the paired plots method can be used to calculate the net aerial primary production, if mortality and disappearance rate of dead material are calculated by the relations (5) (6) (7).

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