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The Ecology of the Annual Migrations of Cattle in the Sahel

H. BREMAN, A. DIALLO, G. TRAORÉ, AND M. M. DJITEYE

Highlight

Quality of forage was an important restraint on animal production to a migrating Fulani herd of Zebu cattle studied in the Sahel, Africa, during 1977. Weight increases of ádult animals only occurred in the rainy season; but herdsmen were able to maintain their animals at constant weight during the dry season by choice of suitable grazing areas. Highly selective grazing by the cattle maintained a diet of adequate quality. Fire was an important tool for improving forage quality during the dry season. Overall balance of secondary production was positive with a 24 percent growth in total biomass and a 12 percent increase in the number of animals.

In the Sahel one finds 3 main systems of cattle-raising. The sedentary and the pure nomadic systems are of little importance in comparison with the semi-nomadic system which involves the process of "transhumance". Two of the authors, Diallo and Traoré, joined one of these semi-nomadic migrating herds from October 1976 till November 1977, to understand better this traditional system of utilizing the Sahelian pastures.

The herd was composed of Zebu cattle from the village of Diafarabé (Rep. of Mali). During 9 months of the dry season (November till July), the herd feeds on perennial grasses of the flood plain of the Niger. First, cattle are grazed on pasture reserves belonging to the village, and later they move to the common pastures in the middle of the Central Delta. During the rainy season, when the Delta is flooded, the herd moves on to the newly established pastures of annual grasses and herbs in the Southeast of Mauritania (Fig. 1). From there they return at the end of the rainy season, almost along the same route to the village, which then completes the yearly cycle. A number of the milking cows and their calves stay at the village during the dry season, where the women both use and sell the milk.

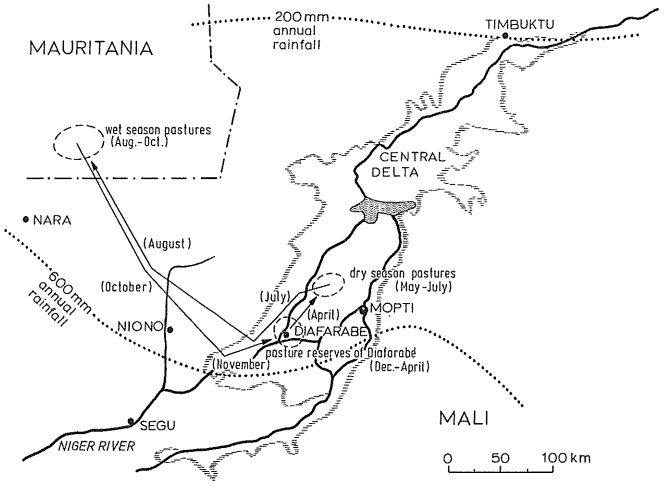

Fig. 1. Annual migration pattern of the herds of Diafarabé (Rep. of Mali).

The authors are Ecologists of the Malian-Dutch project "Primary Production Sahel," Rep. of Mali, Africa.

The study herd consisted of about 200 animals out of the 14,000 total animals belonging to the village. It is estimated that the same "bourtol" (route) to Mauritania is used by 100,000 head of cattle and 200,000 sheep and goats. The Delta as a whole is used by about 2 million cattle in the dry season. The data we obtained should have widespread interest and application. Information was collected on the quantity and quality of forage available and the species selected by the grazing cattle. Measurements were also made of animal growth and herd demography to other herds using a similar system.

Methods

Only animals within the migrating main herd and their food supply were studied. Cattle that stayed in the village and their associated pastures were beyond the scope of this study.

Herbage

Biomass

Estimates of standing crop were made by clipping plant species to ground level, followed by sun-drying and weighing. At about 40 different camping places biomass estimates of the main vegetation type were obtained from samples clipped from 10 to 20 individual square meter plots. At times when there was little movement of cattle, secondary vegetation types were also analyzed, following different periods of grazing. During migrations it was necessary to rely on visual estimates of the biomass. In clipped quadrats, the relative importance of the different plant species was estimated visually. When there was evidence of a high selectivity by the cattle for a certain plant part, its importance in the total standing crop was also visually estimated.

Quality

Samples of the herb layer from quadrats clipped for total biomass were sun-dried and analyzed to get an idea of seasonal variations in pasture quality. In addition samples of individual species and plant parts were also analyzed to estimate seasonal variations in diet quality.

Livestock

The herd composition was determined during 2 periods of vaccinations. Births, mortality and sales were recorded.

The activity pattern of the herd was measured once a month during a 24 hour observation period. The distance traveled daily to the grazing grounds was regularly estimated. The milk taken for human consumption was measured 1-4 times per month when the cows were milked once daily in the evening.

Growth

Thoracic perimeter was used as an indication of liveweight gains and losses. All calves born during the study period were measured 1-2 times a month. Measurements of older animals of both sexes and different age groups were done each month. These measurements started with 30 animals, but at the end only 19 remained, the others having left the herd or died.

Forage Selectivity

Once or twice a month the herd was followed during a complete grazing period of about 8 hours. The forage being selected by 30

representative animals was recorded every 15 minutes.

Results

The herd studied consisted of about 200 head of cattle, belonging to 3 different owners.

The percentage composition of the herd at November 1976 was: female calves 7 percent, male calves 5 percent, heifers 23 percent, young bulls 18 percent, cows 38 percent, bulls 1 percent and oxes 8 percent.

The migration studied is outlined in Fig. 1. The herd took 8 days to go from the village pastures to the dry season pastures in the middle of the Delta and 15 days to return to Diafarabe.

The route out of Mauritania took 25 days but on the way back only 15. During the rainy season on the pastures in Mauritania the herd was moved almost daily but in the dry season there were only a limited number of camps from which the herd went each day and night to grazing grounds in different directions around the campsite. During the year a total distance of more than 1000 km was covered.

Forage Availability and Quality

An enormous fluctuation in the quantity of available standing crop was found throughout the year (Fig. 2). The large decrease in biomass from November to April was mainly caused by fires. This can be seen by comparison with the hypothetical decline of the standing crop without burning, based on a calculated depletion by grazing of the herbage layer. The calculation is based on a feed-intake of 6.25 kg/day/cow. The protein content, however, is less than 5 percent without fire, so real intake could be lower than the calculated value.

The two sharp increases in biomass from April to July reflects the effect of the secondary migration and a single movement of the camp.

When the rains started in the second half of July the protein content increased rapidly to a maximum of almost 20 percent due to the growth of young grass. But the amount of available biomass was very low on the route to Mauritania where the rains began rather late in 1977.

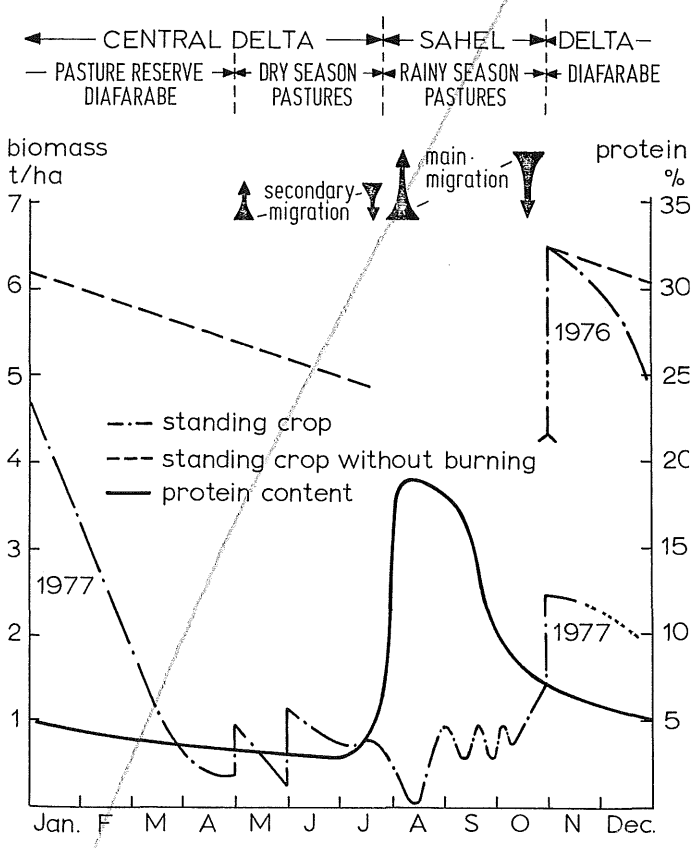

Fig. 2. Seasonal fluctuations of the standing crop and the mean protein content encountered by the migrating herds of Diafarabé.

During the rainy season the herdsmen were constantly looking for the best area on the pastures, and as soon as the available forage decreased they moved their herds. The mean protein content of the forage decreased with the development of the plants; when the plants had flowered or when the rains stopped the decline was accelerated.

On return to the Delta in November 1977 the biomass was only one third of the biomass there in the previous year. This was due to the limited inundation of the flood plain as a result of low rainfall.

Zebu Diet Selectivity

It is immediately apparent that the cattle need to exert a high level of forage selectivity to survive a 9 month period in which the mean protein content of the standing herbage is in general less than 5 percent (Fig. 2). This selectivity is illustrated in Fig. 3, where the protein content of the standing crop and the diet are given throughout the year. These curves are estimated on the basis of a first analysis of our results, given in Table 1.

Table 1. Comparison between the mean quantity and quality of available forage and the diet of Zebu cattle.

Period		t/ha	Protein content %	P %	Raw fibre %	Digestibility (in vitro) %
July	available forage	1,4	3	0,07	37	37
	diet	0,2	12	0,19	28	60
September	available forage	0,8	9	—	—	—
	diet	0,4	15	—	—	—

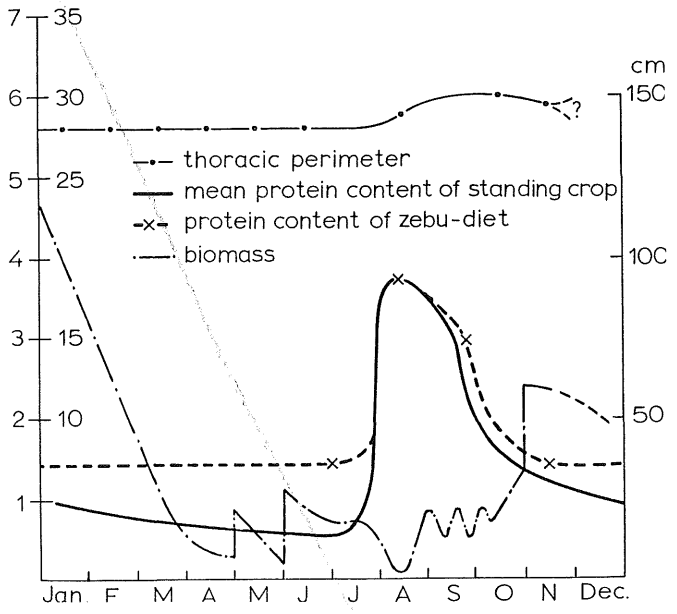

Fig. 3. Relationship between the growth of the animals, protein content of the diet and the total available forage.

During the most difficult periods of the year, at the end of the dry season, as well as in the rainy season only a portion of the available forage was chosen by the animals. This portion had very high quality and digestibility. However, the Zebu selected not only green parts or parts with a high protein content, but also their diets included the straw of bourgou *(Echinochloa stagnina)*. Its quality, in terms of N, P and raw fibre was of the same low quality as the whole standing crop, but the digestibility (in vitro) was 60 percent against only 37 percent for the total herbage estimates.

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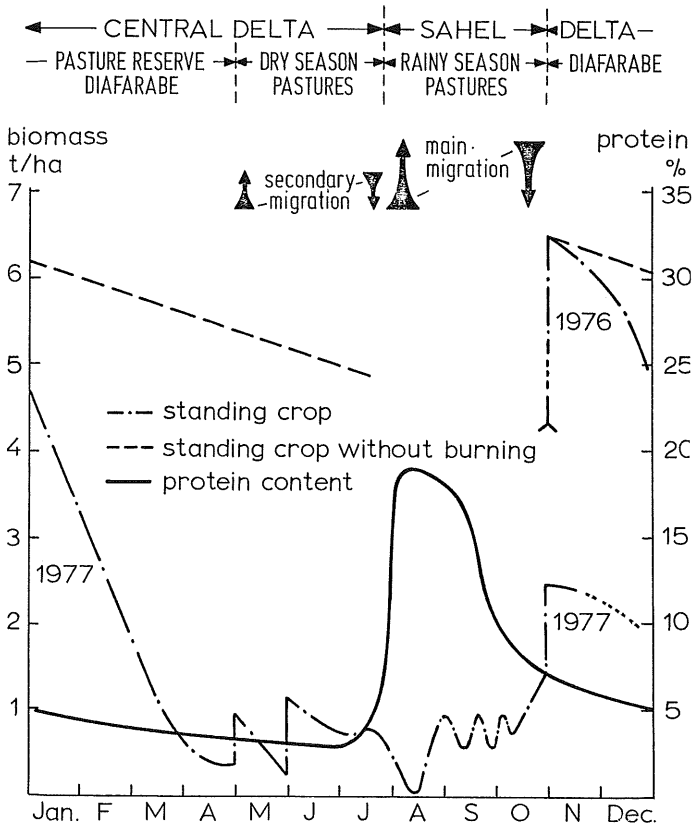

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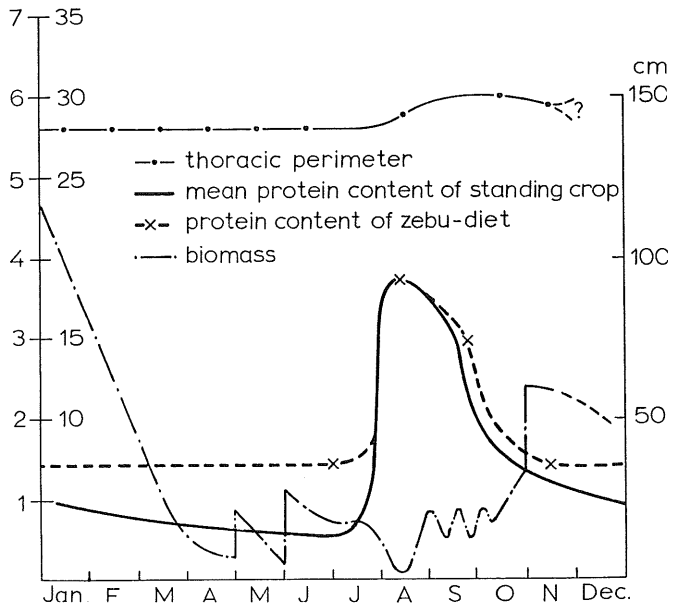

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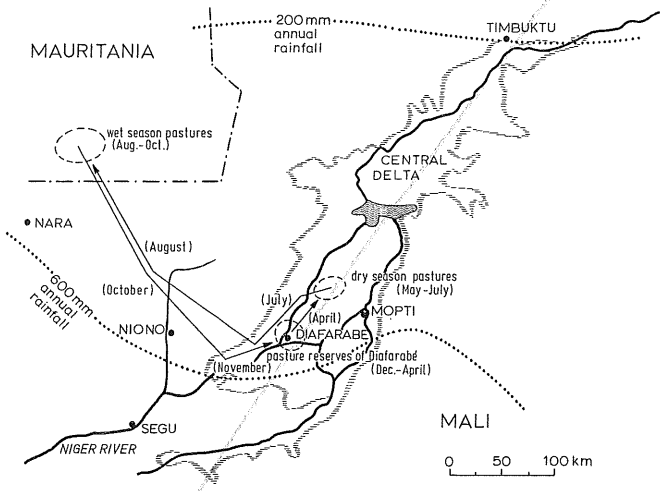
The herd was composed of Zebu cattle from the village of Diafarabé (Rep. of Mali). During 9 months of the dry season (November till July), the herd feeds on perennial grasses of the flood plain of the Niger. First, cattle are grazed on pasture reserves belonging to the village, and later they move to the common pastures in the middle of the Central Delta. During the rainy season, when the Delta is flooded, the herd moves on to the newly established pastures of annual grasses and herbs in the Southeast of Mauritania (Fig. 1). From there they return at the end of the rainy season, almost along the same route to the village, which then completes the yearly cycle. A number of the milking cows and their calves stay at the village during the dry season, where the women both use and sell the milk.



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Once or twice a month the herd was followed during a complete grazing period of about 8 hours. The forage being selected by 30

Bush-Fires

As shown in Fig. 2, the decrease in biomass during the dry season was mainly caused by fires. How harmful the fires may be for the total environment in the long run is unknown, but the direct nutritional benefit for the herd is obvious (Table 2). Without fire the cattle found little digestible food on the vast plains. It consisted mainly of *Vetiveria nigritana* when present as isolated standing green tussocks. These were the only tussocks which had enough green material to allow the cattle to select a diet without too much low quality straw. The regrowth after fire resulted in more available biomass of higher quality (Table 2). In addition to this regrowth the green tussocks remained available because they were left untouched by the fire due to their green foliage and isolation.

Table 2. Bush-fire and the availability and the quality of *Vetiveria nigritana*.

	Forage	t/ha	Protein content %	P %	Raw fibre %	Digestibility (vitro) %
Unburned	standing crop	1,6	3,2	0,07	38	25
	diet	0,1	6,6	0,09	33	35
Bush-fire	regrowth	0,3	7,2	0,14	35	42

Animal Growth

The period of body growth occurred during the rainy season while during the whole dry season the mean weight of the animals did not change (Fig. 3). The increase of the thoracic perimeter from 140 cm to 150 cm corresponds with a live weight gain from about 270 kg to 340 kg. It is not clear whether the observed slight decrease of the perimeter after the rainy season was the result of the poor food situation caused by low rainfall in the Northern Sahel and limited flooding of the Delta.

Besides the growth of the older animals, the birth of calves and their subsequent growth increased the total biomass of the herd. The growth rate over the first 2 months of life seemed to be the same for births at most times of the year. For calves born at the end of the cold season (February), the end of the dry season (June) and the end of the rainy season (September) the thoracic perimeter increased from 60 to 75 cm (about 21 to 42 kg). The calves born in February had a lower growth rate during the hot dry season, and at 5 months of age they weighed about 65 kg. The calves born in June however continued to grow fast after the first 2 months, during the rainy season. They had a mean weight of about 80 kg at 5 months of age. There were indications of a decrease in growth rate after the rainy season, a decrease which seemed to be more pronounced in the older calves.

Herd Demography and Productivity

Some important demographic data are given in Table 3. During the year of study the birth rate was twice as high as the mortality rate. Out of a total of 75 cows, 51 calves were born, which indicated a rather high calving rate of 64 percent. The mortality of young animals, however, was also very high. Only 3 of the 26 animals which died were adults. Most of the others were less than 1 year old.

Eighteen animals were sold, 2 sick cows and 16 oxes. Six were bought, consisting of 3 young bulls and 3 female calves.

Milk production seemed to be more influenced by the feed situation than by the number of recent births as may be seen from Fig. 3 and Table 3. Secondary production was largely positive during the year of study. Based on birth, mortality and growth (thoracic perimeter) data, it was estimated that there was a mean weight gain of about 50 kg/head over the year. Eighty percent of this gain was due to liveweight increase during the rainy season and the other twenty percent to the birth and growth of new born calves over the year. The total number of animals increased by 12 percent allowing for births and correcting for mortalities. Almost half of the year's production was sold. After adjusting for sales and purchases there was still an overall increase of 6 percent in the total number of animals.

Table 3. General information about the herd of 200 head of cattle of Diafarabé throughout the year.

Month	Birth rate (number)	Milk production[1] (liter/cow/day)	Mortality rate (number)	Grazing time (hrs/day)	Grazed distance (km)
Nov. '76	1	—	0	—	—
Dec.	11	—	0	—	—
Jan. '77	2	—	0	—	—
Feb.	8	0,5	3	9,4	10
Mar.	5	0,3	1	9,6	12
Apr.	5	0,6	0	—	15
May	8	—	6	8,9	—
Jun.	4	0,8	7	9,6	15
Jul.	1	0,6	3	8,6	16
Aug.	1	0,7	5	7,1	10
Sep.	4	0,7	1	8,2	11
Oct.	1	0,7	0	—	19
Nov.	0	0,4	0	8,4	11
Total	51		26		

[1]Cows were milked in the afternoon, after the daytime grazing without calves; during the nights and the rest of the day the calves were with their mothers.

Daily Grazing Pattern

The herd had two principal grazing times during the day, one in the afternoon and another after midnight. The daytime grazing was the most important. On the average it lasted 3 times longer than the night grazing. When the forage was abundant and of high quality (middle of August) the herd grazed for only 25 percent of the day whereas during the dry season in the Delta the grazing time increased to a maximum of 40 percent of the day (Table 3). During the night the herd stayed in the neighbourhood of the camp, but for daytime grazing the herdsman often moved to grazing areas up to 5-6 km from the camp. The total distance the herd moved per day was not directly correlated with the grazing time, but the fluctuations of both followed a similar pattern. Both increased with a decrease in the availability of forage of good quality. The presence of puddles with bourgou limited the necessity for movements in the Delta. Even in the middle of the rainy season the biomass of the annual pastures was never very high. This and the selectivity of the animals was the basis for important movements of the herds in the North. Besides the distance walked for grazing there were also the movements from one camp to the other, which in general took place in the mornings.

Discussion

High stocking rates with low levels of output is often described as one of the characteristics of cattle-raising in the Sahel. Even before the drought at the beginning of the 1970's there was a widespread problem of overgrazing. Numerous projects and studies began, following the starvation of millions of head of cattle during the drought. But, as far as we know, this is the first study which describes the biology of one complete annual cycle of "transhumance", the main traditional system of utilizing of the Sahelian pastures. The data we obtained indicate some of the factors limiting the productivity of a cattle herd in the major grazing area of Mali: the Central Delta of the Niger and the surroundings. The complete results will be published in thesis of the Centre Pédagogique Supérieur (Bamako, Mali).

Food Availability

There were only occasional days, especially during the migration to the North, that the herd, as far as the herbage was concerned, had little to feed upon. But during those days dry leaves of the legume tree *Pterocarpus lucens* were available.

The rainfall in 1977 was well below the average and the standing crop in the North was only about 50 percent of the standing crop of more normal rainfall years. But even in this bad year, only about half of the biomass was eaten by grazing at the time that the animals moved South again. In agreement with a suggestion of Breman (1975), general

overgrazing was not observed at the border of the Sahara, although localized overgrazing occurred. The main reason for this fortunate situation appears to be that the animals are forced to move South in October by a lack of drinking water and not by a lack of food.

On the dry season pastures of the Delta the food situation was less encouraging than for the rainy season pastures. At the end of the dry season the herd had increased their daily walking distance by 50 percent to get enough food. Surprisingly the animals did not appear to lose weight during the dry season as was suggested by Schiffers (1976), for example. However, it may be seen in Fig. 2 that the standing crop in November 1977 was only 30 percent of the standing crop in November 1976 and it remains to be seen whether the herd will maintain its weight during the dry season of 1978. Also the risk of overgrazing and of pasture degradation in 1978 will be much higher than in years after normal flooding of the area.

Food Quality

The main limiting factor for the herd we studied was the availability of forage of good quality. For herbage from which the cattle selected, there was only 400 kg/ha present during the rainy season, and at the end of the dry season this was only 200 kg/ha (Table 1). One may wonder if the food intake is not limited at such low densities. However, the intake was high enough to maintain the herd during the dry season and to permit weight gain during the rainy season. But the measured weight gains especially from the calves are lower than those found elsewhere, such as at the research station at Toukounous in Niger (Bartha, 1971).

Livestock Production

The data which were obtained about the demography and the production of the herd are similar to those found for the Delta by Coulomb (Sarniguet *et al.* 1975). A striking difference was in the mortality rate of the calves in their first year at a similar birth rate. We found 45 percent against Coulomb's 29 percent.

The weight gain of about 50 kg/head is higher than the production estimated by Coulomb for the area, but our observation is only based on the thoracic perimeter.

Improved Animal Production

It will not be easy to solve the problem of overgrazing and to assure at the same time the income of the population from their traditional way of cattle raising.

The problem apparent from ours and others results, is how to increase the availability of food of high quality. Only on rainy season pastures may this be realized by a more intensive use with higher stocking rates and a more homogeneous and longer period of exploitation by the creation of more drinking places. But this would increase the risk of degradation at the desert border, which up to now has been more common on the dry season pastures. However, this strategy with its increase in stock numbers would increase the pressure on the dry season pastures, which are already the limiting factor in the system (Breman, 1975). This is also likely to happen with other measures to increase productivity, which poses a difficult dilemma for future action.

The improvement of the dry season pastures may be one solution of the problem, but this does not seem to be very realistic at the moment in relation to their magnitude, costs of improvement, and their common use by the people. An exception is probably the pasture reserve of the village. Investment here will profit those who control the use of these pastures, while in the same time the food situation will be improved for those animals which have a key roll in the productivity of the whole herd. As has been mentioned previously, a significant number of the good milking cows and their calves stay in the village during the dry season, where the women use and sell the milk. The food supply for these cows seems to be worse than for the herd which migrates in the Delta. Furthermore, they are plagued by ticks. When they rejoin the herd at the beginning of the dry season, they are in a worse condition than the other cattle. Probably, this adversely affects both birth rate and calf mortality. Better management of these cows may increase the overall productivity of the herd. Also improved control of the tick seems necessary. Once these measures have been brought about it may be worth trying to increase the number of fertile cows on the improved pastures of the village, leaving the rest of the herd on the common pastures in the Delta.

Literature Cited

Bartha, R. 1971. Studien zu Fragen der Zebu-Rinderzucht in den Tropen, Afrika-Studien nr. 59, Weltforum Verlag, München.

Breman, H. 1977. Maximum carrying capacity of Malian grassland, Proceedings of the Seminar about Evaluation and Mapping of Tropical African Rangelands, Bamako-Mali, March 1975, International Livestock Centre for Africa, Addis Ababa.

Sarniguet, J., J. E. de Mieulle, P. Blanc, and J. Tyc. 1975. Approvisionnement en viandes de l'Afrique de l'Ouest, Tome 1, SEDES, Paris.

Schiffers, H. 1976. Nach der Dürre — die Zukunft des Sahel, Afrika-Studien nr. 94, Weltforum Verlag, München.

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The main limiting factor for the herd we studied was the availability of forage of good quality. For herbage from which the cattle selected, there was only 400 kg/ha present during the rainy season, and at the end of the dry season this was only 200 kg/ha (Table 1). One may wonder if the food intake is not limited at such low densities. However, the intake was high enough to maintain the herd during the dry season and to permit weight gain during the rainy season. But the measured weight gains especially from the calves are lower than those found elsewhere, such as at the research station at Toukounous in Niger (Bartha, 1971).

Livestock Production

The data which were obtained about the demography and the production of the herd are similar to those found for the Delta by Coulomb (Sarniguet *et al.* 1975). A striking difference was in the mortality rate of the calves in their first year at a similar birth rate. We found 45 percent against Coulomb's 29 percent.

The weight gain of about 50 kg/head is higher than the production estimated by Coulomb for the area, but our observation is only based on the thoracic perimeter.

Improved Animal Production

It will not be easy to solve the problem of overgrazing and to assure at the same time the income of the population from their traditional way of cattle raising.

The problem apparent from ours and others results, is how to increase the availability of food of high quality. Only on rainy season pastures may this be realized by a more intensive use with higher stocking rates and a more homogeneous and longer period of exploitation by the creation of more drinking places. But this would increase the risk of degradation at the desert border, which up to now has been more common on the dry season pastures. However, this strategy with its increase in stock numbers would increase the pressure on the dry season pastures, which are already the limiting factor in the system (Breman, 1975). This is also likely to happen with other measures to increase productivity, which poses a difficult dilemma for future action.

The improvement of the dry season pastures may be one solution of the problem, but this does not seem to be very realistic at the moment in relation to their magnitude, costs of improvement, and their common use by the people. An exception is probably the pasture reserve of the village. Investment here will profit those who control the use of these pastures, while in the same time the food situation will be improved for those animals which have a key roll in the productivity of the whole herd. As has been mentioned previously, a significant number of the good milking cows and their calves stay in the village during the dry season, where the women use and sell the milk. The food supply for these cows seems to be worse than for the herd which migrates in the Delta. Furthermore, they are plagued by ticks. When they rejoin the herd at the beginning of the dry season, they are in a worse condition than the other cattle. Probably, this adversely affects both birth rate and calf mortality. Better management of these cows may increase the overall productivity of the herd. Also improved control of the tick seems necessary. Once these measures have been brought about it may be worth trying to increase the number of fertile cows on the improved pastures of the village, leaving the rest of the herd on the common pastures in the Delta.

Literature Cited

Bartha, R. 1971. Studien zu Fragen der Zebu-Rinderzucht in den Tropen, Afrika-Studien nr. 59, Weltforum Verlag, München.

Breman, H. 1977. Maximum carrying capacity of Malian grassland, Proceedings of the Seminar about Evaluation and Mapping of Tropical African Rangelands, Bamako-Mali, March 1975, International Livestock Centre for Africa, Addis Ababa.

Sarniguet, J., J. E. de Mieulle, P. Blanc, and J. Tyc. 1975. Approvisionnement en viandes de l'Afrique de l'Ouest, Tome 1, SEDES, Paris.

Schiffers, H. 1976. Nach der Dürre — die Zukunft des Sahel, Afrika-Studien nr. 94, Weltforum Verlag, München.

Bush-Fires

As shown in Fig. 2, the decrease in biomass during the dry season was mainly caused by fires. How harmful the fires may be for the total environment in the long run is unknown, but the direct nutritional benefit for the herd is obvious (Table 2). Without fire the cattle found little digestible food on the vast plains. It consisted mainly of *Vetiveria nigritana* when present as isolated standing green tussocks. These were the only tussocks which had enough green material to allow the cattle to select a diet without too much low quality straw. The regrowth after fire resulted in more available biomass of higher quality (Table 2). In addition to this regrowth the green tussocks remained available because they were left untouched by the fire due to their green foliage and isolation.

Table 2. Bush-fire and the availability and the quality of *Vetiveria nigritana*.

	Forage	t/ha	Protein content %	P %	Raw fibre %	Digestibility (vitro) %
Unburned	standing crop	1,6	3,2	0,07	38	25
	diet	0,1	6,6	0,09	33	35
Bush-fire	regrowth	0,3	7,2	0,14	35	42

Animal Growth

The period of body growth occurred during the rainy season while during the whole dry season the mean weight of the animals did not change (Fig. 3). The increase of the thoracic perimeter from 140 cm to 150 cm corresponds with a live weight gain from about 270 kg to 340 kg. It is not clear whether the observed slight decrease of the perimeter after the rainy season was the result of the poor food situation caused by low rainfall in the Northern Sahel and limited flooding of the Delta.

Besides the growth of the older animals, the birth of calves and their subsequent growth increased the total biomass of the herd. The growth rate over the first 2 months of life seemed to be the same for births at most times of the year. For calves born at the end of the cold season (February), the end of the dry season (June) and the end of the rainy season (September) the thoracic perimeter increased from 60 to 75 cm (about 21 to 42 kg). The calves born in February had a lower growth rate during the hot dry season, and at 5 months of age they weighed about 65 kg. The calves born in June however continued to grow fast after the first 2 months, during the rainy season. They had a mean weight of about 80 kg at 5 months of age. There were indications of a decrease in growth rate after the rainy season, a decrease which seemed to be more pronounced in the older calves.

Herd Demography and Productivity

Some important demographic data are given in Table 3. During the year of study the birth rate was twice as high as the mortality rate. Out of a total of 75 cows, 51 calves were born, which indicated a rather high calving rate of 64 percent. The mortality of young animals, however, was also very high. Only 3 of the 26 animals which died were adults. Most of the others were less than 1 year old.

Eighteen animals were sold, 2 sick cows and 16 oxes. Six were bought, consisting of 3 young bulls and 3 female calves.

Milk production seemed to be more influenced by the feed situation than by the number of recent births as may be seen from Fig. 3 and Table 3. Secondary production was largely positive during the year of study. Based on birth, mortality and growth (thoracic perimeter) data, it was estimated that there was a mean weight gain of about 50 kg/head over the year. Eighty percent of this gain was due to liveweight increase during the rainy season and the other twenty percent to the birth and growth of new born calves over the year. The total number of animals increased by 12 percent allowing for births and correcting for mortalities. Almost half of the year's production was sold. After adjusting for sales and purchases there was still an overall increase of 6 percent in the total number of animals.

Table 3. General information about the herd of 200 head of cattle of Diafarabé throughout the year.

Month	Birth rate (number)	Milk production[1] (liter/cow/day)	Mortality rate (number)	Grazing time (hrs/day)	Grazed distance (km)
Nov. '76	1	—	0	—	—
Dec.	11	—	0	—	—
Jan. '77	2	—	0	—	—
Feb.	8	0,5	3	9,4	10
Mar.	5	0,3	1	9,6	12
Apr.	5	0,6	0	—	15
May	8	—	6	8,9	—
Jun.	4	0,8	7	9,6	15
Jul.	1	0,6	3	8,6	16
Aug.	1	0,7	5	7,1	10
Sep.	4	0,7	1	8,2	11
Oct.	1	0,7	0	—	19
Nov.	0	0,4	0	8,4	11
Total	51		26		

[1]Cows were milked in the afternoon, after the daytime grazing without calves; during the nights and the rest of the day the calves were with their mothers.

Daily Grazing Pattern

The herd had two principal grazing times during the day, one in the afternoon and another after midnight. The daytime grazing was the most important. On the average it lasted 3 times longer than the night grazing. When the forage was abundant and of high quality (middle of August) the herd grazed for only 25 percent of the day whereas during the dry season in the Delta the grazing time increased to a maximum of 40 percent of the day (Table 3). During the night the herd stayed in the neighbourhood of the camp, but for daytime grazing the herdsman often moved to grazing areas up to 5-6 km from the camp. The total distance the herd moved per day was not directly correlated with the grazing time, but the fluctuations of both followed a similar pattern. Both increased with a decrease in the availability of forage of good quality. The presence of puddles with bourgou limited the necessity for movements in the Delta. Even in the middle of the rainy season the biomass of the annual pastures was never very high. This and the selectivity of the animals was the basis for important movements of the herds in the North. Besides the distance walked for grazing there were also the movements from one camp to the other, which in general took place in the mornings.

Discussion

High stocking rates with low levels of output is often described as one of the characteristics of cattle-raising in the Sahel. Even before the drought at the beginning of the 1970's there was a widespread problem of overgrazing. Numerous projects and studies began, following the starvation of millions of head of cattle during the drought. But, as far as we know, this is the first study which describes the biology of one complete annual cycle of "transhumance", the main traditional system of utilizing of the Sahelian pastures. The data we obtained indicate some of the factors limiting the productivity of a cattle herd in the major grazing area of Mali: the Central Delta of the Niger and the surroundings. The complete results will be published in thesis of the Centre Pédagogique Supérieur (Bamako, Mali).

Food Availability

There were only occasional days, especially during the migration to the North, that the herd, as far as the herbage was concerned, had little to feed upon. But during those days dry leaves of the legume tree *Pterocarpus lucens* were available.

The rainfall in 1977 was well below the average and the standing crop in the North was only about 50 percent of the standing crop of more normal rainfall years. But even in this bad year, only about half of the biomass was eaten by grazing at the time that the animals moved South again. In agreement with a suggestion of Breman (1975), general