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NUTRITIONAL SITUATION AND SEASONAL VARIATIONS FOR PASTORALIST POPULATIONS OF THE SAHEL (SENEGALESE FERLO)

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The nutritional status and food consumption of a population of herders in the Ferlo (Senegal) was studied during a complete seasonal cycle.

The Ferlo region is in the Sahelian climatic belt where a long dry season (nine to ten months) alternates with a brief humid season (two to three months). In the existing traditional livestock production system, these climatic variations have an impact first on the living conditions of these people but also on the nutritional status of the herders.

Food intakes are insufficient during the rains and one finds a deep nutritional depression during this period; whereas during the dry season, to the contrary, food intake is very good and the nutritional status definitely improves. In an average situation, there is a balance between the losses that occurred during the wet season and the gains at the beginning of the dry season. This balance is nevertheless very precarious. To insure food and nutritional security for the herders, activities must concentrate on seeking solutions that will not threaten their social organization or their lifestyle.

KEY WORDS: Nutritional survey; food consumption survey; Senegal; Ferlo; Sahel; herding; agropastoralism; seasonal variations; PEM; nutritional anaemia.

INTRODUCTION

The nutritional situation in the Sahel region is generally thought of as very precarious due to the recurrence of serious food crises. The most recent of these was in 1972. Studies carried out at the time showed a dramatic increase in malnutrition (Brun, 1974a; Brun and Kovess, 1974b; Seaman *et al.*, 1973) and in the need for nutritional aid in order to overcome the crises (Greene, 1974; Ndiaye, Pele and Bideau, 1973; Aall and Helsig, 1976). The occurrence of such famines is neither new nor exceptional in the Sahel region (Chastanet, 1982; Marchal, 1980). From 1858 to 1945 in the upper valley of the river Senegal, there have been five serious crises of more than eight months duration, 22 crises of three to eight months duration, and in total only 34 years out of 87 did not pose a serious problem of food shortage (Chastanet, 1982). In Upper Volta from 1908 to 1945 at least ten serious food shortages can be identified (Marchal, 1980). There is a vast spectrum ranging from long and drawn-out famines to food shortages of a few weeks. So great is the probability that a seasonal food crisis will occur that it could even be said that the people of the Sahel have included the risk of a food shortage in their agricultural planning (Chastanet, 1982).

Analyses (Annegers, 1973a; 1973b; Perisse, 1966) show that seasonal deficit in livestock is marked in the savannah regions of the Sudanic belt or the Sahelian steppes where the climate is dominated by the alternation of a rainy season, which becomes increasingly short the further north one goes, and a long dry season. This

deficit is manifested by a change in the nutritional state and in particular by a loss of weight amongst adults (McGregor, 1967; Gessain, 1978; Bleiberg, Brun and Goihman, 1980) during the rainy season, also the time of agricultural labour.

Given these conditions one may ask if an acceptable standard of life is possible in these regions and if the "logics of survival" elaborated by the indigenous population are still efficient. On the answer given to these questions depends the type of solution proposed to improve the situation. If one decides that these lands can be no other than places of misery and hopelessness, the most radical actions involving the desertion of villages and a massive exodus toward the town will always appear desirable and necessary from a human point of view. If, on the other hand, one decides that in spite of a hostile environment, the local population has been able to organise and manage their land in such a way as to be able to survive and develop there without destroying it, then proposed improvements should aim to maintain people in their milieu and to respect their cultural values.

The work presented here analyses the nutritional situation of a community of Fulani herdsmen from the Senegalese Ferlo faced with the risk of seasonal food shortages. It seeks to describe the nutritional consequences and the reactions generated as well as the developments foreseeable in the future. The study is based on clinical observations, haematological and anthropometric measurements and food consumption surveys at different periods between January, 1980, and June, 1981.

ECOLOGICAL AND CULTURAL SETTING

The region which is being studied is that of the north Ferlo (see map, Figure 1) which lies between 15°30 and 16°30 latitude north and 14°30 longitude west in the interior of the bend of the Senegal river. This region has a typically Sahelian climate with 80 percent of its annual rainfall occurring between August and September. The average annual rainfall recorded before the decade 1970 to 1980 placed this area between isohyete 500 mm in the south and 228 mm in the north.

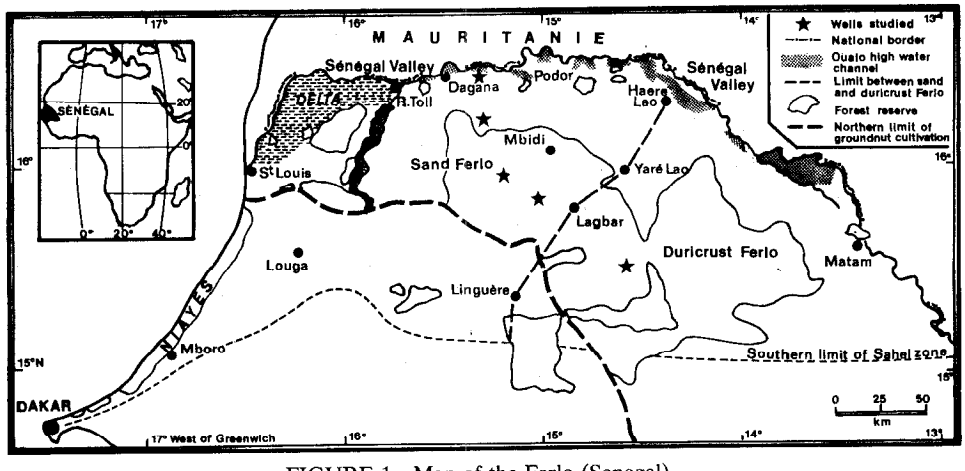

FIGURE 1 Map of the Ferlo (Senegal).

This region was without any permanent sources of water until deep wells were drilled in the 1940s after the discovery of the Maestrichtian water table more than 250 m below ground. It then consisted of a nomadic zone and cultivated fields in the wet season which had to be abandoned in the dry season for either the valley to the north of the river or for the Djolof region, which is situated between Louga and Linguère, to the south. This region was densely wooded, the vegetation forming a typical scrub savannah landscape and where a considerable number of wild animals were to be found.

The drilling of wells made it possible to stay permanently in the Ferlo region and for the huge pastures to be used continually. There has been a dramatic increase in livestock, a disappearance of the bigger wild animals, and then of the smaller ones, and the opening-up of the Savannah, making it more steppe-like. We are not, however, in the throes of a process of desertification but rather of "sahelianization" of the landscape, without that implying any quantitative or qualitative impoverishment of the grazing land (Barral, 1982). The animal best suited to herding is the Zebu, *Bos indicus*, from the *Gobra* species. Its introduction is believed to have coincided with the arrival of the first Fulani from the North-East to the Futa Toro (Valley of the Senegal river), possibly in the 5th or 6th century. This very hardy animal is able to adapt to the poor grazing land and long migrations, but its milk yield is mediocre.

With regard to human life, the arrival of wells has brought about the dispersal of the big encampments of former times for the defence against wild animals, and the increase in livestock makes necessary the use of new grazing lands.

Small groups spread out in the steppes and so the former authority diminishes whilst new forms of social grouping appear. But a more remarkable phenomenon is the reluctance of the population to settle in the locality of the wells. It is possible that the great seasonal migrations of former times have disappeared, reappearing only in exceptional circumstances like during the drought of 1972. Nevertheless a true nomadism, on a small scale, does exist—a "micronomadism," whose movements resemble those of the Fulani and the Kel Tamachek around the swamps of the Niger bend (Barral, 1977). This nomadism enables the continuation of a traditional pastoralism and thus of the Fulani culture in its most authentic form.

This region has a population of 30,000 and a density of less than three inhabitants per km^2. The dominant ethnic group is the Fulani: there are at least 35 different tribes but in practice only two can be distinguished, according to whether their former migrations were towards the Senegal valley, where they were complemented by the cultivation of flood plains, or whether they stopped on the edge of the Ferlo. All these groups are Islamic.

Pastoral production is carried out within the *Gallé*, which is the basic socio-economic unit. The Gallé is made up of the mono- or polygamous household of the head of the family and sometimes also by that of one of his brothers or of an elder son. This limited group comprises eight to ten people. Several Gallés, five at most, grouped together form an encampment. The Gallé collectively exploits and manages the same herd which is owned individually by its members or by outsiders (Santoir, 1982). The head of the Gallé is responsible for the herd.

Duties are allocated according to age and sex. It is the women's job to provide for the daily needs of the Gallé, for example, to cook, fetch the water, get the firewood, repair the huts. The small boys, sometimes only five years old, have the job of guarding the small ruminants. The older boys take the zebus out to the wells and the men and those approaching manhood have the job of looking after and guarding the big animals.

The activities of the herdsmen are determined by the rhythm of the climatic changes of the three main seasons in the year: a wet season (July to October); a cool, dry season (December to mid-march); and a hot, dry season (mid-March to June). During the wet season (see Figure 2) the herdsmen live in their encampment which consists at the time of large round semi-permanent huts built around ponds which fill up in the rainy season. This is the *Rumano.* The animals can graze in close proximity and the men can cultivate millet on site formerly used as a cattle enclosure, the land therefore has already been manured.

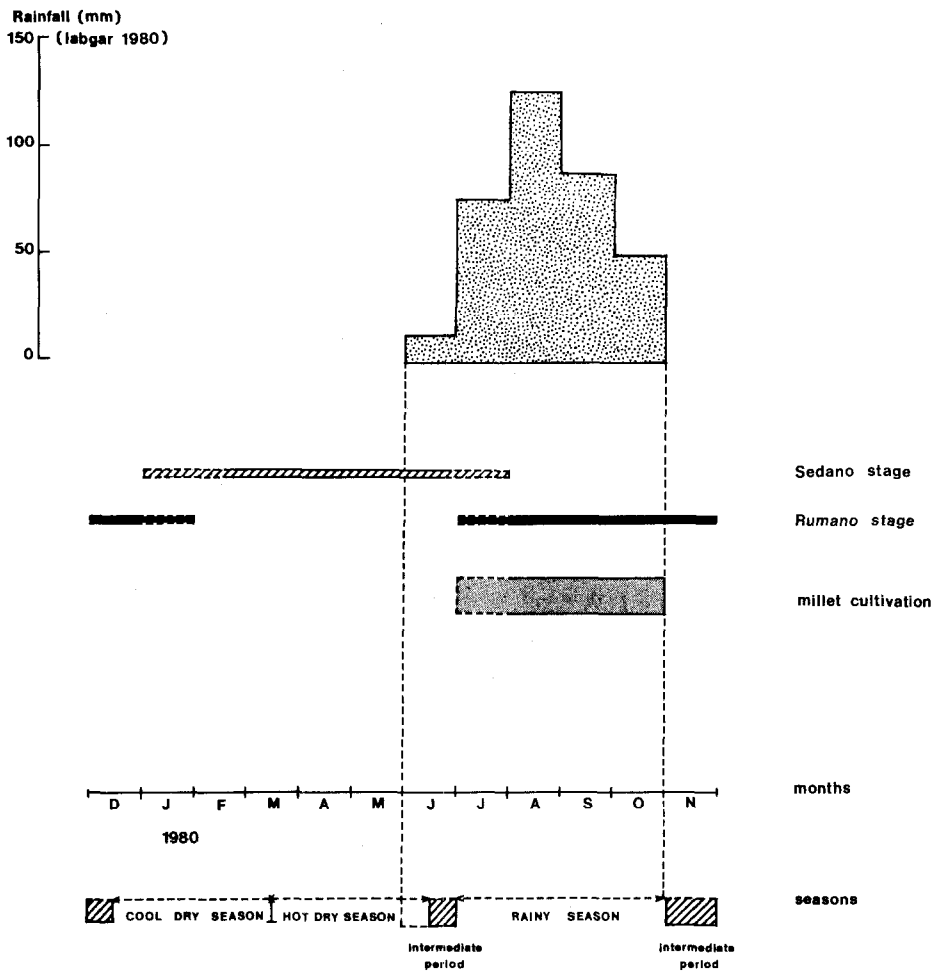

FIGURE 2 The seasonal cycle of agropastoralism in the Ferlo (Senegal).

This way of farming has tended to be abandoned since the 1972 drought. When the ponds dry up around October and November, the animals have to drink at the wells. Subsequently, the pastures between the Rumano and the well become exhausted and it is necessary to look for new ones. In order to insure that the new pastures are not too far from the encampment, the Rumano is abandoned toward the beginning of the cool, dry season, and the various Gallés of which it is comprised will continue their

nomadic activities either together or separately. This is the *Sedano* stage of nomadism. The Sedano is a temporary encampment made up of flimsy, almost spherical straw huts which can be dismantled when the time comes. It is usually erected on the edge of a wooded area whose branches and leaves can also be used as browsing for goats. The Sedano moves three or four times in the dry season depending on the availability of grazing land. In spite of this, the distances between the well, the Sedano and the grazing land become greater, and the animals only go to drink every other day once the hot season has begun. This trying situation continues right up until the rains begin. The return to the permanent encampment, the Rumano, takes place after the first rains when the ponds around which it is built are full of water again and the first of the grass is ready to be eaten.

Well sites are not a place of permanent residence for the herders. Apart from plentiful supplies of water it is possible to find there small shops which sell the basic essentials (millet, rice, oil, smoked fish, matches etc.). Certain wells are the site of weekly markets where transactions dealing in small ruminants take place and where women can find an outlet to sell milk products. Finally, it must be pointed out that there is practically no proper sanitation in this region.

CULTIVATION PATTERN

Millet and milk products are the staple foods of the herdsmen. Formerly the millet (*Pennisetum* spp. and *Sorghum vulgare*), came from several sources. Some of it was grown during the rainy season at the Rumano. The sorghum came from the cultivation of the flood plains in the river valley when the herds were moved in the dry season, and some of it could have been bartered from the non-nomadic population in exchange for milk products. A network of complex social relations presides over the use of the arable land and the practice of bartering. Because of this a very intricate and integrated economic structure exists between the zone of herdsmen and the zone of the cereal producers. Current development projects tend to channel the zones into specific production aims such as fattening of livestock or rice production or market gardening. This diversity of use of the millet, together with the rise of a monetary economy, causes these symbiotic relations to disappear, and so much so that the herdsmen are increasingly buying their millet with the proceeds of their livestock sales.

DIETARY PRACTICE AND COOKING METHODS

Millet has to be ground into flour, a tedious process which involved pounding, *vanning* (winnowing), hulling and washing. These chores are done by the women each morning. Some of the flour is used to make thick gruel, to which soured milk is added. It is eaten as the midday meal, when there is one. The remainder is put in a calabash and left in the shade. This flour is used in the evening by which time it should have begun to ferment, which in turn should have increased the riboflavin content (Toury *et al.*, 1967). The flour is then kneaded by hand and steamed at once. The wife then adds powdered Baobab leaves (*Adansonia digitata*), whose stickiness gives the millet a semolina-like consistency (Toury *et al.*, 1961).

After several cookings, the couscous is ready. Half of it is eaten in the evening with fresh milk, the other half is kept for the first meal of the following day.

Milk products are the second essential ingredient in the herdsman's diet. They are

the direct products of their activity. The cows are milked each morning and evening at the encampment. Some of the milk is left for the calves. Fresh milk is used to sprinkle over couscous. Most of it is put to sour in the shade to make soured milk. This, when watered down and sweetened, is the favourite drink of the Fulani. The cream is skimmed off and used to make butter, which is then sold.

Foods gathered from trees are equally needed but actual consumption is difficult to ascertain. The powdered leaves of the Baobab are used, as described above, to bind couscous, and the fruit pulp is used to make infusions. The new leaves of *Cassia tora*, which appear as soon as the rains begin, are eaten cooked with milk; the leaves of the legume *Vignia unguiculata* are used in various sauces.

At the onset of the dry season, the herders eat jujube berries (*Zizyphus mauritania*), and before the rains they eat the fruit of the *Sclerocarria birrea*. The fruit is extremely rich in ascorbic acid (Kerharo and Adam, 1974). At around this time when the period of food scarcity begins, herders collect the seeds of *Boscia senegalensis* which, when pounded, is left to soak for several days. When cooked the seeds can either be eaten in this form or made into biscuits. China green tea is drunk very sweet and it is an appreciated beverage. Meat is practically never eaten except on feast days, and only the young herders hunt small game. Dried fish (*Sardinella* spp.) is used in sauces eaten with rice.

Meals are eaten around communal dishes, with the men and older boys eating from one, the women and children from the other.

METHODS

Organisation of Fieldwork

The results were obtained from measurements taken at five different times on the same group of herdsmen (see Table I) nomadising in the area served by five wells. These wells were chosen in order to respect the different ecological and human characteristics of the Ferlo. It is for this reason that they are situated on a transect crossing the zone in a Northwest–Southeast diagonal (see map, Figure 1). The locations and the demography of the camps situated in the areas were not known precisely as the herdsmen's administrative link is with the villages situated along the main transport road. Our first task was to take a census of all the Gallés situated in

TABLE I

Characteristics of a survey of Senegalese nomads by season, type of fieldwork and selected age groups (numbers in samples)

Date	Type of fieldwork[a]	No. Gallés	0–5 years	6–14 years	Men	Women	Total
March 1980	C-A-H	41	114	119	106	157	496
July 1980[b]	D	—	—	—	—	—	—
Aug.-Sept. 1980	D-C-A-H	41	106	124	134	157	521
Jan.-Feb. 1981	D-C-A	37	88	114	101	142	445
June 1981	D-C-A	35	90	100	78	139	407
Total		154	398	457	419	595	1,869

[a] Type of fieldwork; C—Clinical evaluation; A—Anthropometric measurement; H—Haematological measurement; D—Dietary record.

[b] Fieldwork based on only 13 Gallés.

the five areas, which resulted in an estimated population of 11,000 people (one-third of the total population); and out of this number we chose a representative sample of Gallés, doing our utmost to respect the ethnic and social distribution, the different levels of wealth of livestock and to provide a geographical covering representative of the plains.

In order to carry out these different choices, we relied upon some former work on human geography (Santoir, 1977; 1980), on a livestock census carried out by the vaccination services and by development organisations, on administrative registers and lastly on our own observations.

Table I shows the many variations at different periods during the study. These variations are not the result of a negligence on our part of certain Gallés but were due to the wandering of small groups far beyond their usual circuit because of the destruction of their grazing land through drought or bush fires. We were able to relocate some of them elsewhere. The second factor, which is not obvious in the table, was a tendency amongst the younger adults to move toward the towns in the dry season. This migration is still relatively small. In the end everyone comes back to the Rumano. These variations constitute a bias in the representative sample and they involve a modification in the calculation of family needs which will be considered below.

Fieldwork Methodology

Two types of investigation were carried out: individual inquiries into the state of nutrition and investigations into food consumption by nutrition groups. Investigations into nutritional status were clinically evaluated according to a list of indices proposed by Jelliffe (Jelliffe, 1966) and by anthropometric and haematological measurements. These measurements were carried out with the same material and by the same observer each time.

Anthropometric measurements taken were of weight (W), height (H), mid-arm circumference (MAC) and triceps skinfold thickness (TSF).

Weight The subjects were weighed, lightly clothed, on scales accurate to 100 g. A systematic deduction was made of the weight of clothes and jewellery, estimated at 1 kg with adults and 500 g with children over five years. Children of up to two years were weighed in their mother's arms by a double weighing process.

Height Heights were taken accurate to 1 cm. Children up to the age of two years were measured lying down in an "infantometer" accurate to 1 mm.

Mid-arm circumference This parameter was measured half way up the left arm with a non-expanding fibreglass tape accurate to 1 mm.

Triceps skinfold Was measured using the Harpenden caliper at the same point as upper arm circumference, accurate to 1/10 mm.

We took samples of blood in March, 1980, and in August–September, 1980. We measured haemoglobin concentration with a portable spectrophotometer (Vitatron) using the cyanmethemoglobin method. Hematocrit was determined after centrifugation of capillary tubes in a portable centrifuge, and red cells count with a portable (Coulter) electronic meter. Vacutainers were used for the blood collection from adults, whereas in children blood was obtained from the pulp of the finger.

Investigations into food consumption were made quantitatively at the level of food groups. To do this we trained eight investigators who stayed five consecutive days in the Gallés. During this period they made a list of the consumers present; they also registered and weighed to an accuracy of 5 g all the food used to make the meals, the meal after it had been cooked and the leftovers. They made a record of all people present at each meal, and they ascertained what amount of food was consumed outside the family meal (fruit, milk, tea, etc.). They also determined by observation the activities of subjects aged over 13 years using a simplified code. Finally they determined the amounts of money spent on food during their stay in the Gallé.

The information was processed using a computer programme from the Organisation for Research for Food and Nutrition in Africa (Orana). This codex uses a food composition table with 270 entries derived from food analysis data applicable to Africa (Toury *et al.*, 1967; FAO, 1968) or Asia (FAO, 1972) complemented by data derived from studies by Orana. Energy requirements were individually calculated according to age, sex, weight, height, physiological condition and physical activity gauged according to the FAO classification system—light, moderate, very and exceptionally active. For the various requirements we followed the recommendations of the joint FAO/WHO committees (FAO/WHO, 1962; 1967; 1970; 1973a; 1973b; 1975) and of the National Academy of Sciences for folic acid (NAS, 1977). The results are expressed in a daily *per capita* allowance.

RESULTS

Thirty-two of the 41 Gallés in the initial sample owned herds; four former captives of the Fulani and two captives of the Moors did not own any cattle; three Gallés were of a carpenter caste attached to Fulani groups. All these families have the same dietary customs.

We asked mothers about their successive pregnancies and were able to establish that out of the 157 women in the survey at the end of their reproductive life they had given birth four or five times (4.7 ± 2.6) and lost one to two children (1.7 ± 1). Children are weaned at about 17 months; it is a very gradual process. A good supply of milk is obviously a very favourable factor in coping with this period.

Clinical Evaluation

Table II shows the occurrence of signs of malnutrition in infants, schoolchildren and adults. The numbers of positive signs were too few for statistical analysis of seasonal variation. It must be emphasised that not one sign can be considered on its own as indicative of a deficiency (Jelliffe, 1966). Most of the signs suggest Protein Energy Malnutrition (PEM) amongst young children, but we did not find at any time serious syndromes such as Kwashiorkor or Marasmus.

Anthropometric Measurements

Table III shows weight-for-height distribution, observed in March, 1980, during our first investigation and follows the methods and grades used by Jelliffe (Jelliffe, 1966), using as reference points those of the National Center for Health Statistics (Hamill *et al.*, 1979).

There is no serious malnutrition (weight-for-height less than 70 percent) amongst

TABLE II
Clinical signs observed in 1,869 Senegalese nomads in three age groups

Syndrome	Clinical sign	0–5 years	6–14 years	Adults
	hair: thin and lustreless	1	—	—
	dyspigmentation	4	—	—
Protein;	edema	—	—	—
energy;	lack of muscle	6	12	—
malnutrition	swollen abdomen	12	10	—
	hepatomegalia	6	—	—
	diffuse facial depigmentation	1	—	—
Vitamin A deficiency	xerodermia	—	1	—
Vitamin C deficiency	spongy gums	—	2	—
Riboflavin	magenta tongue	—	—	1
deficiency	cheilosis	—	—	10
	angular stomatitis	4	—	—
Nutritional anaemia = pale conjunctiva		5	15	21
Number of positive signs		39	48	32
Number of subjects		398	457	1,014
Total number of subjects				1,869

TABLE III
Distribution of percentage of weight-for-height in infants and children of Senegalese nomads

Weight for height (%)	69	70–79	80–89	90	Total
Grade of malnutrition	3 (severe)	2 (moderate)	1 (mild)	0	
0–5 years boys	0	3	13	44	60
0–5 years girls	0	1	13	40	54
6–9 years boys	1	2	12	8	23
6–9 years girls	1	5	12	17	35
10–14 years boys	0	3	10	8	21
10–14 years girls	2	8	23	7	40
					(233)
Percentage of all individuals	1.7	9.4	35.6	53.3	100

TABLE IV
Mean percentage weight-for-age and height-for-age of Senegalese nomad infants and children

	0–5 years	6–9 years	10–14 years
	%	%	%
Weight for age	90.4 ± 10.4	89.3 ± 6.0	79.0 ± 15.5
Height for age	97.7 ± 4.7	92.7 ± 6.6	96.4 ± 5.5

children from zero to five years and only four cases of moderate malnutrition (weight-for-height between 70 to 80 percent). The situation, however, is mediocre amongst older children. Out of the 238 children examined, 35 percent were suffering from mild malnutrition with weight-for-height less than 90 percent.

Table IV shows increasing deficits for weight-for-age. Height deficits for age are minimal. The adult population is slender. The men have a weight range of 58.8 ± 7.3 kg to 66 ± 9.7 kg and a mean height of 173.5 ± 6.5 cm. The weight and height of the women range from 54.1 ± 6.8 to 58.5 ± 9.7 kg and 161.5 ± 5.7 cm,

TABLE V

Changes in selected anthropological measurements of Senegalese nomads by season, age group and sex (means ± standard deviation)[a]

Group observations	(Hot dry season) March 1980	(Rainy season) August–September 1980	(Cold dry season) January–February 1981	(Hot dry season) June 1981	No. of observations	F value	Significance
1–5 years old							
% MAC	93.3 ± 6.9	89.7 ± 7.3	91.6 ± 6.8	91.3 ± 6.8	294	3.86	0.01
% TSF	82.0 ± 19.3	77.7 ± 19.2	93.7 ± 22.7	63.7 ± 18.7	279	21.5	0.001
% MC	94.9 ± 7.3	92.7 ± 8.0	93.5 ± 6.5	98.0 ± 6.9	277	6.6	0.001
% wt. for ht.	93.7 ± 9.5	91.5 ± 10.5	94.9 ± 9.4	94.4 ± 9.9	297	1.6	NS
6–9 years old							
% MAC	89.3 ± 6.0	87.0 ± 6.4	90.2 ± 7.9	89.8 ± 6.8	206	2.05	NS
% TSF	72.0 ± 15.0	66.5 ± 18.5	83.4 ± 25.2	51.9 ± 12.0	192	23.2	0.001
% MC	92.7 ± 6.6	91.0 ± 6.6	92.7 ± 6.6	97.1 ± 7.3	191	6.6	0.001
% wt. for ht.	88.0 ± 11.9	89.1 ± 11.4	93.9 ± 8.2	92.7 ± 7.6	243	4.9	0.001
10–14 years old							
% MAC	88.2 ± 7.9	83.4 ± 8.1	87.9 ± 12.1	90.9 ± 9.8	183	4.6	0.01
% TSF	67.5 ± 19.6	60.8 ± 17.8	82.6 ± 23.5	55.6 ± 12.2	180	14.0	0.001
% MC	92.1 ± 8.8	87.2 ± 8.7	89.9 ± 13.6	96.9 ± 11.3	179	5.9	0.001
% wt. for ht.	86.2 ± 10.9	83.7 ± 6.8	88.7 ± 8.1	89.1 ± 8.0	214	4.5	0.001
Adult males							
% MAC	87.2 ± 8.4	84.2 ± 8.5	86.4 ± 10.1	87.8 ± 9.90	338	2.6	0.05
% TSF	54.1 ± 21.2	49.3 ± 24.1	60.2 ± 33.8	47.0 ± 24.9	324	3.4	0.025
% MC	95.5 ± 8.6	89.3 ± 8.5	90.6 ± 11.5	94.2 ± 10.0	323	8.7	0.001
% wt. for ht.	87.0 ± 11.1	84.3 ± 10.1	88.4 ± 11.9	87.6 ± 11.2	419	3.3	0.025 to 0.01
Adult females							
% MAC	90.8 ± 10.8	85.5 ± 10.3	89.9 ± 11.4	90.8 ± 11.0	513	6.9	0.001
TSF	72.0 ± 26.0	63.9 ± 27.5	80.1 ± 31.2	63.6 ± 33.9	492	8.0	0.001
% MC	94.5 ± 10.3	90.0 ± 9.0	92.6 ± 10.9	96.8 ± 9.6	490	9.8	0.001
% wt. for ht.	93.4 ± 12.6	88.8 ± 12.7	92.3 ± 12.8	91.9 ± 12.1	595	3.8	0.01

[a]Values are expressed in an age percentage according to the standards of the NCHS for weight and height of children, and for those selected by Jelliffe (Jelliffe, 1966) for the other parameters (weight for height adult; MAC; TSF and MC). Mc = muscular circumference, calculated according to the Jelliffe formula (Jelliffe, 1966). MC = MAC − π × TSF.

respectively. These values conform with the known morphology of Sahelian peoples.

TABLE VI

Actual changes in anthropometric indices of Senegalese infants and children and seasonal differences in means[c]

Indicators	Change[a]	Residual variance	Season (i) wet 1980 versus hot 1980	(ii) wet 1980 versus cold 1981	(iii) cold 1981 versus hot 1981	(iv) hot 1980 versus hot 1981
0–5 years						
% MAC	2.29	48.5	−3.6[b]	−1.9 (NS)	+0.3 (NS)	+2 (NS)
% TSF	3.3	389.8	−4.3	−16	+30	+18.3
% MC	2.47	53.09	−2.2 (NS)	−0.8 (NS)	−4.5	−3.1
% wt. for ht.	(F ratio NS)		—	—	—	—
6–9 years						
% MAC	(F ratio NS)		—	—	—	—
% TSF	7.4	331.9	−5.5 (NS)	−16.9	+35.5	+20.1
% MC	2.7	45.8	−1.7 (NS)	−1.7 (NS)	−4.4	−4.4
% wt. for ht.	3.6	97.5	−1.1	−4.8	+1.2 (NS)	−4.7
10–14 years						
% MAC	3.9	88.1	−4.8	−4.5	−3 (NS)	−2.7 (NS)
% TSF	8.0	360.6	−6.7 (NS)	−21.8	+27	+11.9
% MC	4.4	108.3	−4.9	−2.7 (NS)	−7	−4.8
% wt. for ht.	3.3	74.4	−2.5 (NS)	−5	−0.4 (NS)	−2.9 (NS)
Adult males						
% MAC	2.8	82.7	−3	−2.2 (NS)	−1.4 (NS)	−0.6 (NS)
% TSF	8.06	658.1	−4.8 (NS)	−10.9	+13.2	+7.1
% MC	2.9	89.5	−6.2	−1.3 (NS)	−3.6	−1.3 (NS)
% wt. for ht.	3.06	123.3	−2.7 (NS)	−4.1	+0.6 (NS)	−0.6 (NS)
Adult females						
% MAC	2.7	118.2	−5.3	−4.4	−0.9 (NS)	0
% TSF	7.5	864.6	−8.1	−16.2	+16.5	+8.4
% MC	2.5	490	−4.5	−2.6	−4.2	−2.3
% wt. for ht.	2.9	157.7	−4.6	−3.5	+0.4 (NS)	+1.5 (NS)

[a] Minimal value that for difference of averages in order to be significant.

[b] The sign shows the direction of the difference. (Were the % MAC in the wet season is less than the value for the hot season.)

[c] To simplify the calculations, the comparisons have been made in relation to a value calculated in advance that the difference the change must reach in order to be significant to at least five percent. Bearing in mind the numbers involved it is necessary that $t = 2$, that is:

$$t = \frac{\Delta}{\sqrt{\frac{s^2}{n_1} + \frac{s^2}{n_2}}} = 2$$

s^2 = residual variance; n_1 = effective of first group; n_2 = effective second group to be compared (Schwartz, 1977).

We have not discovered any significant seasonal variations in the distribution of the weight-for-height measurements amongst children, but if we compare the exact averages by age group and sex, there are very significant variations (Table V). Little variation was found, however, in the weight-for-height of children aged between one to five years and the mid-arm circumference of six to nine year olds.

Table VI shows the results of individual comparisons of means. We notice that the measurements taken in the wet season are always less than those taken in the previous dry season (March, 1980) or in the following one (January to February, 1981, columns i and ii). This period can be considered as a depressed time as far as nutrition is concerned. Significant differences in the results are more frequent amongst adults, particularly in women.

The comparisons between different times of dry season give less clear results but, as a general rule, the cool, dry season is marked by an increase of triceps skinfold compared with other times and can be considered as a period of recuperation. The decrease in the triceps skinfold at the end of the dry season is not generally followed by a synchronised decrease in arm circumference, although the muscular mass, which is a calculated measurement, increases (column iii). The two hot dry seasons, 1980 and 1981, are not equivalent (column iv). It seems that the situation was better in 1980, triceps skinfold and weight-for height being higher. The hot, dry season heralds a decrease which will reach its maximum in the rainy season. The intensity of this reaction depends on the reserves of fat which have accumulated at the end of the wet season and in the cool season. These reserves are in turn dependent on the quality of the preceding wet season which depends on factors such as the earliness of the rains, quality of the pastures and possibility of millet growing. In such a schema the seasonal cycle carry on without identical replication from one year to the next. Annual variations exist within an overall pattern of a long term cycle.

TABLE VII

Daily per capita intakes of energy and nutrients by Senegalese nomads compared with WHO/FAO recommendations by season

	Intake noted	WHO/FAO requirement	Intake noted	WHO/FAO requirement	Intake noted	WHO/FAO requirement	Intake noted	WHO/FAO requirement
Period	July 1980		August–September 1980		January–February 1981		June 1981	
Energy Cal	2,153	2,156	2,005	2,264	2,619	1,986	2,432	2,134
MJ	9.0	9.0	8.4	9.4	10.9	8.3	10.2	8.9
Protein g	60.4	33.4	61.8	31.2	80.5	31.9	67.0	35.5
Calcium mg	576	544	1,073	543	1,468	558	853	564
Iron mg	26.2	12.0	18.1	9.3	63.9	9.5	24.3	11.6
Vit. A μg	199	625	818	623	543	630	371	623
Riboflavin mg	0.93	1.19	1.43	1.25	1.62	1.09	1.16	1.17
Niacin mg	24.6	14.2	24.5	14.9	31.2	13.1	26.7	14.0
Vit. C mg	4	28	55	28	30	28	17	29
Folates μg	128.6	352.8	100.8	345.8	156.2	349.1	127.2	351.2
Vit. B12 μg	3.3	1.9	7.0	1.9	4.3	1.8	3.5	1.8
Zinc mg	9.9	14.4	9.1	8.9	11.9	9.4	10.2	13.1
Magnesium mg	1,629	237	945	237	1,745	232	1,621	236
Copper μg	2,037	1,436	1,427	1,357	2,214	1,426	2,044	1,388
Thiamin mg	1,06	0.86	0.92	0.91	1.38	0.79	1.21	0.85

Energy and Nutrient Intake

Table VII shows the varying daily *per capita* intakes of energy and nutrients as well as estimates of requirements at different periods, according to the recommendations of the FAO/WHO. The results of the investigation of July, 1980, are based on a pilot investigation on only 13 Gallés, but they demonstrate clearly the transition between seasons.

Requirements vary with changes in physical activity as well as the evolution of the demographic structure of the groups. The return of the men to the Rumano in the wet season explains why their energy requirements are greater then than in the dry season.

Estimates of energy requirements are marginally met at the end of the dry season and food intake is inadequate to meet these requirements during the wet season. From the beginning of June the energy intake, together with that of other nutrients, decreases in relation to nutritional requirements. In the hot season (March to June) when the energy requirement is at its lowest level, there is conversely a noticeable net improvement in the supplies of vitamins A, C and Riboflavin. Energy requirements are most easily met in the cool season (January to March). Estimates of folate requirements are never met.

Table VIII shows that the variations in nutrient and energy intake are due to differences in food consumption in the various seasons. Cereals and milk between them supply 73 to 78 percent of the energy. The energy deficit during the wet season is linked to a cereal shortage, and the poor milk production at the end of the dry season explains why vitamin A and Riboflavin requirements are not met and that calcium requirements are scarcely covered. Other foods which have little energy values have qualitative importance. For example, consumption of vegetables and

TABLE VIII

Per capita dietary intake of Senegalese nomads by season

	July 1980		August–September 1980		January–February 1981		June 1981	
Food group	Weight (g)	Cal/MJ	Weight (g)	Cal/MJ	Weight (g)	Cal/MJ	Weight (g)	Cal/MJ
Cereal	473	1,356/5.6	346	1,131/4.7	479	1,466/6.0	479	1,555/6.5
Root	0	0	0	0	0	0	2.8	3/0.01
Legumes	12.0	59/0.2	0.7	3	38.2	173/0.7	8	37/0.1
Vegetables	6.6	10/0.04	43	29/0.1	8	16/0.06	8	14/0.06
Fruit	0	0	3	2	4	10/0.04	4	4/0.01
Oil	24	211/0.9	17	149/0.6	16.3	144/0.6	21	186/0.7
Butter	1	7/0.03	3.2	25/0.1	2.7	20/0.1	2.3	18/0.07
Sugar	40	15.2/0.06	37	140/0.6	41	156/0.6	42	160/0.67
Tea	9.3	0	11.3	0	13	0	11.6	0
Meat	53.1	12.4/0.05	44	98/0.4	45	99/0.4	33	79/0.3
Fish	4.3	1.4/0.006	10.3	3.6/0.01	4	11/0.04	6.2	18/0.07
Dairy products	278	220/0.9	500	389/1.6	682	543/2.2	443	358/1.5
% of energy supply by cereals + dairy products		73%		75.8%		76%		78%

leaves of *Cassia tora* in the wet season improves the supply of vitamin C, which is probably underestimated in this study. Dried fish and meat and some leguminous plants widely eaten in the cold season, *Arachis hypogea* and *Vigna unguiculata*, also improve the protein intake.

Protein quality was judged by the chemical score (Block and Mitchell, 1946). Out of all the Gallés studied, the chemical score was 1.0 in 41 percent of cases, and between 0.9 and 1.0 in 35 percent of cases. This indicates that the protein quality was "excellent to acceptable" in 76 percent of the Gallés. In the remaining 24 percent where the result was less than 0.9, the limiting amino acid is lysine which is the result of a cereal based-diet.

Hematological Data

Table IX shows the prevalence of hemoglobin values less than the threshold suggested by WHO at sea-level (WHO, 1972). The mean corpuscular volume (MCV)† was determined by hematocrit and blood count for a better characterization of the different forms of anemia amongst the 141 anemic subjects: On this basis 22 percent were anemia of the microcytic type (MCV $\leqslant 80\mu^3$), 50 percent were normocytic (MCV 80 to 100 μ^3) and 28 percent were macrocytic (MCV $> 100\ \mu^3$). Without being able to ascertain the etiology of these anemias, we note that if the alimentary iron needs are theorically covered, iron from plants and diets based on cereals may be poorly absorbed because of their high phytate and tannin content. Because folate requirements were not met, this nutrient may also be responsible for anemia.

TABLE IX

Hemoglobin levels in Senegalese nomads by age and sex

Group	1–5 years $N = 45$	6–14 years $N = 35$	Male $N = 15$	Non pregnant female $N = 46$	Total $N = 141$
Hb[a]	<11	<12	<13	<12	
	45	35	15	46	141
% sample	41	30	15	30	29

[a] WHO threshold (WHO, 1972).

Measurements were taken again in the wet season (Table X). Hemoglobin was significantly lower in men but not in other groups. Hematocrit levels were consistently lower except in children. This last result suggests that children were more protected from the seasonal depression than the other groups.

DISCUSSION

The observations recorded here show a contrasting nutritional situation which appears to be as good, if not better than that of non-nomadic people. No cases of serious malnutrition were found in the group of children studied during the 15 months' observation period. The prevalence of anemia is less than in Upper Volta

† $\text{MCV} = \dfrac{\text{Hematocrit mm}^3}{\text{Blood cell count millions/mm}^3}$

TABLE X
Mean hemoglobin (Hg) and hematocrit (Hcrt) levels in Senegalese nomads by age and season

	Parameter	Dry season	Wet season	t
0–5 years	Hcrt	34.7 ± 4.9	34.6 ± 4.2	NS
	Hb	10.9 ± 1.7	11.1 ± 1.4	NS
6–9 years	Hcrt	38.5 ± 4.0	36.9 ± 3.9	$p < 0.05$
	Hb	12.1 ± 1.4	12.4 ± 1.2	NS
10–14 years	Hcrt	40.6 ± 3.4	39.0 ± 3.2	$0.02 < p < 0.01$
	Hb	12.7 ± 1.7	12.5 ± 1.3	NS
Non pregnant female	Hcrt	38.0 ± 5.4	36.5 ± 4.8	$0.05 < p < 0.01$
	Hb	11.8 ± 1.9	11.5 ± 2.0	NS
Male	Hcrt	45.8 ± 4.3	43.0 ± 4.1	$p < 0.001$
	Hb	14.5 ± 1.5	13.9 ± 1.7	$p < 0.01$

(Benefice *et al.*, in press), in Mali (Benefice *et al.*, 1982) and other regions of Senegal (Chevassus-Agnes and Parent, 1979). Based on similar data collection procedures, the women seem to lose less children using the same interview technique than the women of Upper Volta, Mali or Casamance (Benefice *et al.*, 1983; Benefice and Chevassus-Agnes, 1982; Chevassus-Agnes and Parent, 1979). The data differ from that given by other investigations into the Sahel (Kloth *et al.*, 1976; Hogan, Staetling and Lane, 1977) and are comparable to other "nutritional successes" identified in arid zones elsewhere (Grivetti, 1978).

Nonetheless, serious nutritional problems do exist. The herdsmen face a food shortage and energy deficit of 1.1 MJ (260 Cal/day) below the estimated requirement during the wet season and 2.1 MJ (500 Cal) deficit daily compared with the cool season. While this deficit is accompanied neither by a significant increase in the frequency of malnutrition amongst children, nor by the appearance of clinical signs of deficiency, there is nevertheless a decrease in sub-cutaneous fat and a loss of weight. These modifications are very well defined amongst adults, whilst paradoxically children appear relatively protected. The following sequences can be distinguished in the seasonal variations. First, there is a nutritional decline in the wet season, a phase of recuperation in the cool, dry season, and a phase of progressive deterioration in the hot, dry season. The nutritional modifications do not generally change the muscle mass, (Figure 3) which is considered a good indicator of nutritional status and of protein reserves (Frisancho and Garn, 1971).

This population therefore appears to overcome the effects of a food deficit by mobilizing its reserves of subcutaneous fat.

Other factors can contribute to this success and, thus, the physical adaptation of these people to their milieu, particularly in a morphological way (Hiernaux and Froment, 1976). Similarly the transmission of certain parasitical diseases is thought to be less marked in the Sahel than in the Sudanic savannah; for it has been shown that infections and parasitical illnesses which have a seasonal character seriously affect the nutritional status (Poskitt, 1972; Thomson, 1977; McGregor, 1970). This is true also of attacks of diarrhoea in the wet season in tropical regions (Trowbridge and Newton, 1979). It is possible that these illnesses are less aggressive in the Ferlo which could explain the acceptable nutritional situation of young children. This fact remains to be proved, and if we have not been able to study with precision the

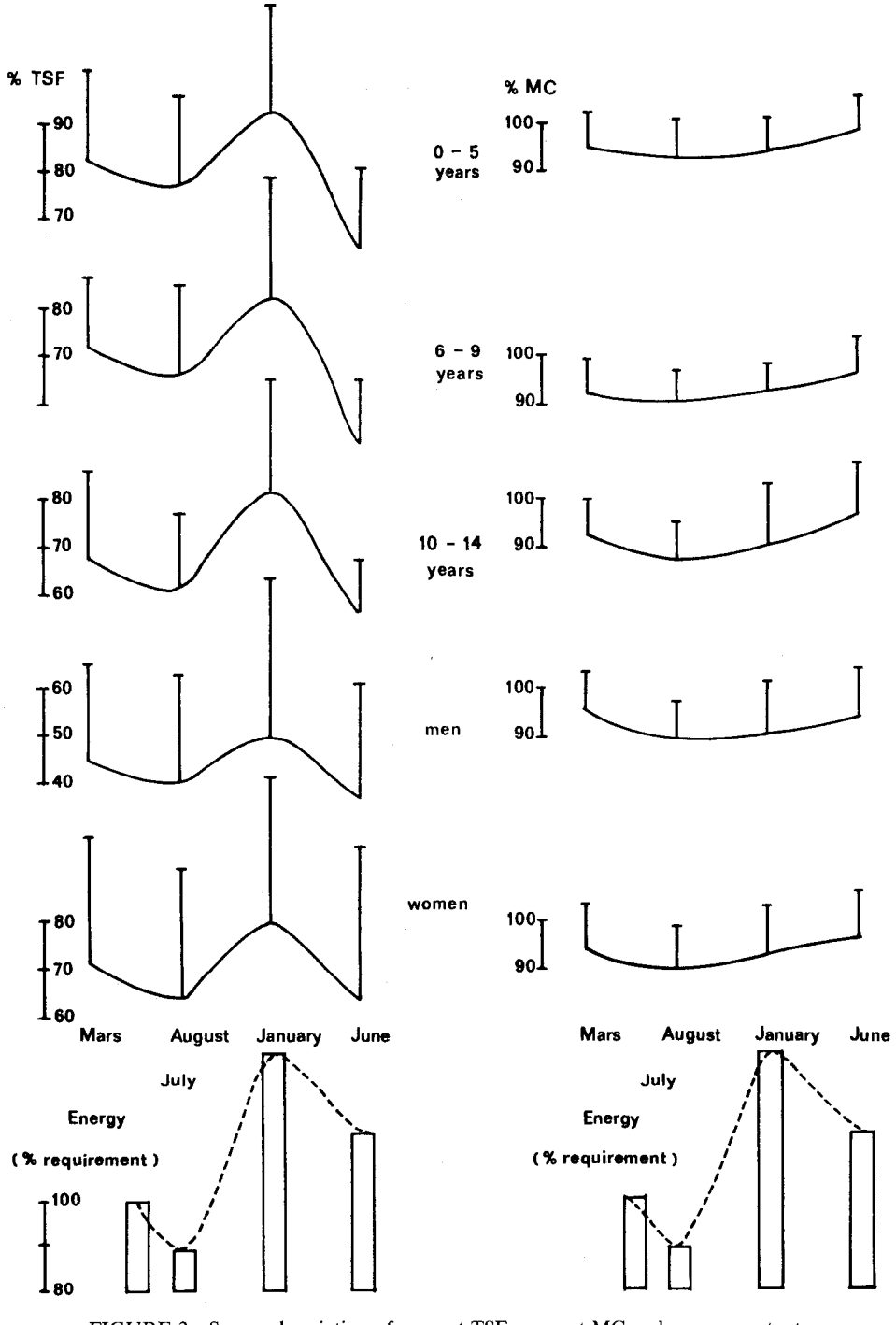

FIGURE 3 Seasonal variation of percent TSF, percent MC and energy content.

pathological burden, we have established that the most dangerous transmissible disease, malaria, is hyper-endemic in the rainy season (Parent, Benefice and Schneider, 1982). Our conviction is that food is the determining factor in both the depressed and recuperative nutritional phases.

To cope with the lack of food, people react in several ways. Physical activity, and therefore energy expenditure, is greatly reduced during the rainy season by the practice of the Rumano. Agricultural activities, if they take place, bear no comparison to the spectacular achievements of the peasants of the Sudanic savannah as have been seen in Upper Volta (Brun, Bleiberg and Goihman, 1981). It could be said that the herdsmen conserve their energy while they wait for better days. They attempt to offset the food shortage by resorting to food gathered from the wild. For example, the use of the leaves of *Cassia tora* was very widespread in September, 1981; but while this plant has little energy value, it is possible that its bulk helps to reduce the feeling of hunger. The fruit of *Boscia senegalensis* was eaten by several Gallés in July, 1980; it is considered as famine food by the farmers of the river valley. However, the increasing decline in flora which is now apparent is limiting this kind of recourse. There is a similar absence of game. The modern solution which is becoming more common is to replace millet shortages by purchases of rice. The quantities of rice consumed increase from 1.5 MJ (358.5 Cal) in the cool season to 2.0 MJ (478.0 Cal) in the wet season, when they equal millet consumption. The consumption of oil rises proportionally as milk products become more scarce (Table VIII).

In order to be able to buy these food supplies, the herdsmen must market their livestock more; sales which counted for 55 percent of their revenue in 1955 today count for 85 percent (Santoir, 1982). They increase regularly under the pressure of strong demand for meat in the towns and from policies of development organisations. There has been further stimulation from very high meat prices since 1972.

The nutritional evolution of the herdsmen appears to be as follows: deprived of their traditional exchanges through the commercial exploitation of the valley, they are forced to transform their traditional dairy herding into a commercial meat-producing venture. Their sources of supplies, formerly diversified by the practice of agro-pastoralism, of trading and of gathering wild fruit is now diminishing. They are becoming more economically vulnerable without benefiting from any greater food security. In the extreme this policy risks bringing about in the short term the disappearance of pastoral society as has been stressed by other observers (Teitelbaum, 1977; Santoir, 1982).

However, we hope that such a dramatic evolution will not take place, as current experiments prove that it is possible to reconcile the rational exploitation of a herd whilst placing at a distance the spectre of famine and assuring the maintenance of pastoral society.

CONCLUSIONS

The Fulani herdsmen whom we have studied enjoy a food and nutritional situation which does not correspond with the dramatic picture usually drawn. They encounter a period of food scarcity in the wet season accompanied by a loss of weight, but this is efficiently recovered in the following dry season. These facts bear witness to a remarkable understanding of the milieu and of its resources. Of particular importance is the fact that, far from passively submitting to the aggressiveness of the environment, the herdsmen have been able to construct a society of high cultural value and to develop a productive activity. Development actions to be undertaken

should take these facts into account in order to promote solutions which respect the norms of the pastoralist society.

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