13 *Seasonal variation in nutritional status of adults and children in rural Senegal*

KIRSTEN B. SIMONDON, ERIC BÉNÉFICE, FRANÇOIS SIMONDON, VALÉRIE DELAUNAY AND ANOUCH CHAHNAZARIAN

Seasonal variation in nutritional status of adults and children in rural West Africa has been described previously, both for farmers (Gessain, 1978; Prentice *et al.*, 1981; Bénéfice & Chevassus-Agnès, 1985; Rosetta, 1986; Schultink *et al.*, 1990) and for pastoralists (Bénéfice *et al.*, 1984; Loutan & Lamotte, 1984).

The critical period during which nutritional status is impaired generally occurs around the end of the rainy season for farmers and around the end of the dry season for pastoralists. In both cases, the determinant invoked is the concomitance of increased physical activity in adults and seasonal food shortage.

This chapter describes seasonal variation in the nutritional status of adults and children in two agricultural societies in Senegal, West Africa. Socioeconomic characteristics of the two populations are very similar: both have low educational levels, both derive their subsistence from small scale farming while monetary income is generated from the sale of specific crops and through remittances of emigrees. Both areas are characterized by one marked rainy season per year. However, the major difference between the two study areas resides in the total independance from rainfall recently achieved in one of the areas (the Senegal River Valley) through massive irrigation works.

Data and methods

The Senegal River Valley study area

The Senegal River flows in the north of the country, forming the border with Mauritania (Fig. 13.1). Major developments have taken place since 1981 under the direction of *Office de Mise en Valeur du Fleuve Sénégal*

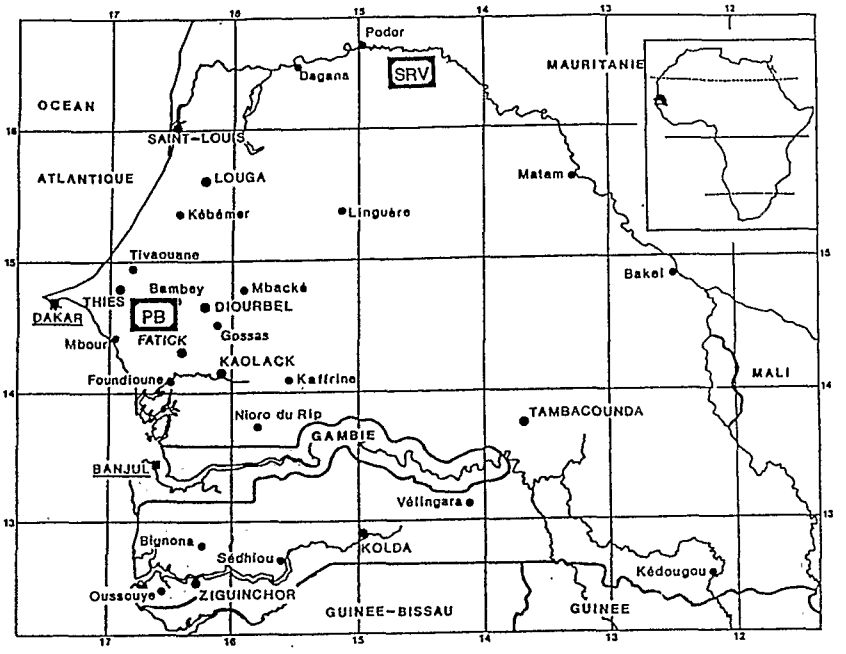

Fig. 13.1. Map of Senegal showing the two study areas, the Senegal River Valley (SRV) and the Peanut Basin (PB).

(OMVS). A reservoir-barrage has been built upstream at Manantali in Mali and an 'antisalt-barrage' constructed in the Senegal Estuary near St. Louis on the Atlantic Coast.

The aim is to replace the two main traditional farming methods, the *Diery* cultivation of millet during the rainy season and the *Walo* cultivation of sorghum in small basins flooded at the end of the rainy season (flood-recession culture), with irrigated agriculture across the year. Annual rainfall has varied between 97 and 320 mm during the last 10 years.

The nutritional study in the Senegal River Valley (SRV) was undertaken in January 1990 as a part of a multidisciplinary study of the impact of the agricultural development project on the health status of the population. The study area consists of three villages surrounding an irrigated area of 580 ha.

Irrigation started in June 1989 and the first rice harvest took place in December 1989. The population of 3300 belong to the Toucouleur ethnic group; they are sedentary farmers and fervent Muslims. Toucouleurs belong to the same ethnic group as Peuls, the *Hal puular* group. They have the same language, but while Peuls are nomadic pastoralists, Toucouleurs seem to have settled around the time of the twelfth century and are now

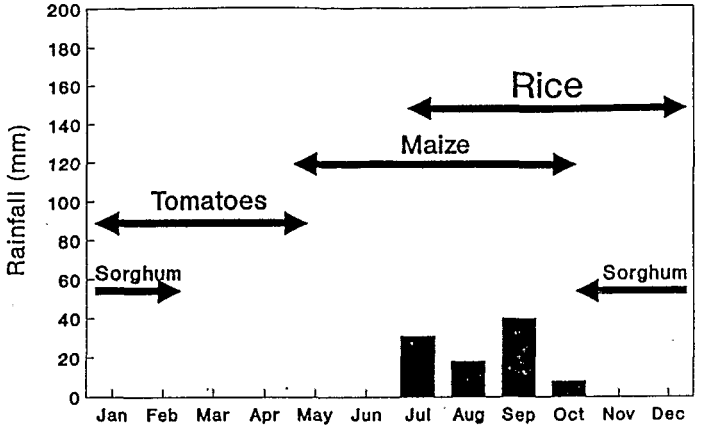

Fig. 13.2. Agricultural calendar in the Senegal River Valley in 1991.

essentially farmers. Peuls are widespread in West Africa with large communities in Mali, Niger, Burkina Faso and Cameroun.

Remittances from emigrated relatives (younger men) constitute a major contribution to income in the River Valley.

Fig. 13.2 presents the 1991 agricultural calendar. The major crop for most families was rice, which was sowed directly in the irrigated fields (without bedding out) in July, cleared during the following months and harvested in December. During the last month before harvest, children keep birds away from the rice fields. Maize was cultivated between May and October, mainly as a food crop, while tomatoes were grown, by the women only, between January and May as a cash crop (for canning). Sorghum was grown in traditional fields between October and February by a few families who had no access to the irrigated fields.

Subjects

A random sample consisting of 110 compounds was selected using a cluster design, whereby the probability for a given compound being selected was proportional to the number of members in the compound. The aim was to select one-third of the population in the nutritional study.

From that sample, all children aged less than 5 years ($n=330$) together with their mothers ($n=197$) and all men aged 20–60 years ($n=101$) were included.

Pregnant women were excluded from the analysis of anthropometric data, while lactating women were included independently of lactation stage.

Methods

Anthropometry

Anthropometric measurements were taken on all subjects present in February, June, October and December 1991 and in February 1992. Mean numbers of subjects were 66 infants, 300 preschool children, 164 women and 88 men. A smaller subsample of children (n = 145) and mothers ($n = 76$) were measured in April 1991, a few days after the end of Ramadan, the Muslim month of fasting.

Recumbent length was measured on children below the age of 24 months using a locally made wooden board (precision: ±0.1 cm). The same board was used for the measurements of height in older children. Children below approximately 10 kg were weighed naked on a SECA scale (precision: ±10 g) while heavier children and adults were weighed on an electronic Téfal scale (precision: ±200 g). They wore light clothing and no adjustment for the weight of clothes was made. Height of adults was measured using a Harpenden anthropometer (precision: ±0.1 cm), removing headclothes prior to measurement. Scales were calibrated every morning using standard weights.

Measurements were taken by a mobile team in each compound. In periods of intensive farming work, men were weighed in the fields. Birth dates of children were determined according to the Muslim calendar through interviews of their mothers. The Muslim birth dates were then converted into Gregorian birth dates. In children, the nutritional index weight for height (W/H) was computed using the package Anthro Version 1.01 (CDC/WHO, 1990).

Food intake

Family food consumption was measured on two occasions during 1991, in January and in June, on a subsample of 35 compounds. Intake was measured using the precise weighing method: all foods were weighed before preparation and after cooking; leftovers from the finished meal were also weighed. Weighing was carried out on mechanical Terraillon balances (10 000 g ± 5 g) during four consecutive days. The six locally recruited observers also noted whether the foods were locally produced or bought on the market.

Energy and nutrient contents were estimated using a compilation of several tables of food composition (Toury *et al.*, 1967; FAO, 1968, 1972) suited for West African diets (Chevassus-Agnès, 1982). As meals are taken from a common dish, individual intakes could not be estimated. Instead, the total intake of each nutrient was divided by the sum of individual recommended dietary allowances of the consumers, giving a mean

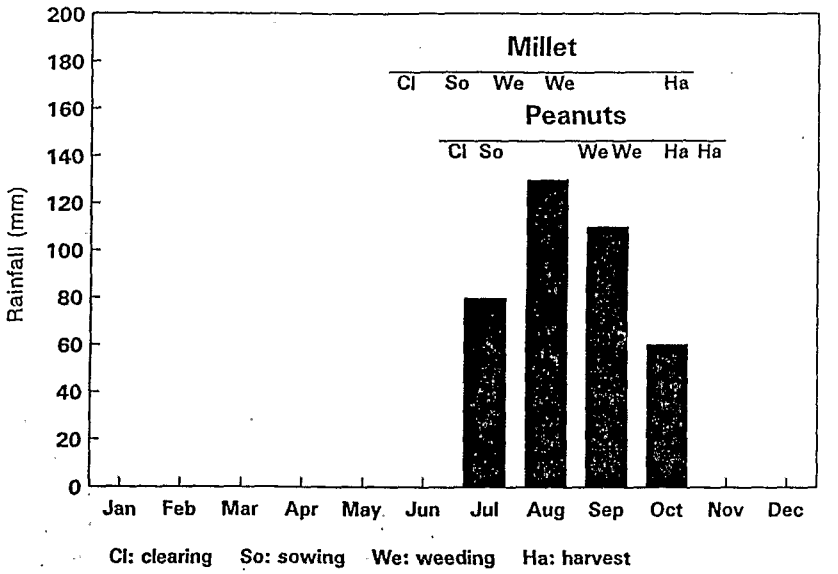

Fig. 13.3. Agricultural calendar in the Peanut Basin in 1991.

percentage of the recommended dietary allowance (% RDA) per nutrient and per food group (Chevassus-Agnès & Ndiaye, 1981). Energy needs were calculated using an estimate of the basal metabolic rate, BMR (which takes sex and age into account, FAO/WHO/UNU, 1985) together with estimates of energetic costs of physical activity.

Activity patterns and total energy expenditure

The physical activity of one woman and one man per compound was monitored during the four days of food consumption survey, using the diary method (Edholm, 1981). Every 15 min. between 8.00 a.m. and 8.00 p.m. an observer noted the dominant activity during the previous 15 minutes. When the subject was absent from the compound, the activities were obtained by interviews when he/she returned. Activities were divided into 17 groups based on the level of energy expenditure.

Total energy expenditure (TEE) was estimated from the recorded activities using measurements of activity-specific energy costs measured in previous studies in Burkina Faso (Bleiberg *et al.*, 1980; Brun *et al.*, 1981) and Guatemala (Torun *et al.*, 1982). Night energy costs were set to 1.0 × BMR for 8 hours and 1.2 × BMR for 4 hours.

The Niakhar study area

The Niakhar study area (the Peanut Basin, PB) is located about 150 km east of the capital city of Dakar. Its area of 230 km^2 has a population of 26 500

inhabitants. The study population belongs mostly (96%) to the Serere ethnic group. Main religions reported are Islam (72%) and Christianity (24%) but they have been introduced rather recently and animism is still very strong. Eighty-eight per cent of inhabitants above the age of eight years are farmers. Millet is grown for subsistence and peanuts are grown as a cash crop. Farming is totally dependent on rains, which occur between July and October. Mean annual rainfall, from measurements over a ten year period, is 414 mm (range: 227 to 560 mm, Niakhar Project, 1992).

The calendar of agricultural tasks is presented in Fig. 13.3. Clearing of the fields starts in May. Sowing of millet is done in June, just before the first rains, while peanuts need rain before sowing and are thus usually sown in the first half of July. The millet harvest takes place in late September–early October, while the peanut is harvested in October–November.

Subjects and methods

Mortality

Since 1987 a continuous demographic surveillance system has ensured highly reliable information on deaths, births, migrations and age at weaning. Briefly, demographic field workers visit all compounds weekly and register those of the above mentioned events that have occurred since their previous visit. The database is updated weekly at the headquarters in Dakar. Accuracy of event registration is checked through a yearly demographic census.

Anthropometry

Immunization sessions are conducted monthly in each of the three dispensaries in the area. All infants residing in the study area are invited to the vaccination sessions at ages 2, 4, 6 and 9 months, to receive the standard EPI vaccines. Eligible children may be enrolled in vaccine trials in which a standard vaccine may be substituted with a test vaccine. Absent infants are called up again the following month. Coverage rate is about 80% per session.

During the vaccination session anthropometric measurements are made on all infants present using methods identical to those used in the SRV.

Since December 1989 anthropometric measurements have also been made on mothers. Height is measured with a Metabo stadiometer (precision: ± 0.1 cm), headcloths being removed prior to measurement. They are also weighed, in the manner already described for the SRV. On average, 280 mothers (aged 15–50 years) and infants (aged 2–10 months) are measured each month.

Table 13.1. *Physical characteristics of adults in February 1991*

	Senegal River Valley		Peanut Basin
	Men ($n=91$)	Women ($n=162$)	Women ($n=265$)
Age (years)	38.4±10.8	29.7±7.4***	29.6±7.1
Height (cm)	174.4±7.6	163.8±5.2***	161.4±6.0***
Weight (kg)	65.4±9.0	57.8±10.4***	56.3±7.0***
MUAC (cm)	27.4±2.4	25.7±3.3***	26.7±2.6***
BMI (kg/m^2)	21.5±2.8	21.5±3.3	21.6±2.2

Values are mean±SD.
***$p<0.001$.
MUAC: mean left upper arm circumference, BMI: body mass index.

Morbidity

Since 1987 a morbidity surveillance system has covered all resident infants aged 2–12 months. During weekly interviews with the mothers, field workers record the dates of onset and end of 46 different symptoms. Only the two most prevalent symptoms, fever (34.2%) and diarrhoea (19.1%), are considered here.

Statistical analyses

Analysis of variance is used for general comparison of means. *T*-tests are used for comparison of means, two by two. In the case of multiple comparisons, the significance level is adjusted accordingly using Bonferroni's Inequality. The Kruskall–Wallis non parametric test is used in the analysis of food intake. All analyses are carried out using the BMDP statistical package (University of California, 1990).

Results

Anthropometry

Adults

In the Senegal River Valley men were significantly older than women (38.4 years versus 29.7 years, $p<0.001$; Table 13.1), but there were no sex differences in the mean body mass index (21.5 kg/m^2 in both sexes).

Body dimensions differed significantly between women in the two settings. The Toucouleur women were taller (163.8 cm versus 161.4 cm, $p<0.001$), while the Serere women had thicker arms (26.7 cm versus 25.7 cm, $p<0.001$). Mean body mass index did not differ between Toucouleur and Serere women (21.5 kg/m^2 versus 21.6 kg/m^2).

Prevalences of malnutrition among adults in February 1991 were low in both settings (Table 13.2). Using the cutoff points proposed by James *et al.*

Table 13.2. *Distribution of body mass index in adults (percentages)*

	Senegal River Valley		Peanut Basin
BMI (kg/m^2)	Men (n=91)	Women (n=162)	Women (n=265)
<16.0	1.1	3.1	0.0
16.0–16.9	1.1	1.2	0.0
17.0–18.4	4.4	10.5	5.3
≥18.5	93.4	85.2	94.7

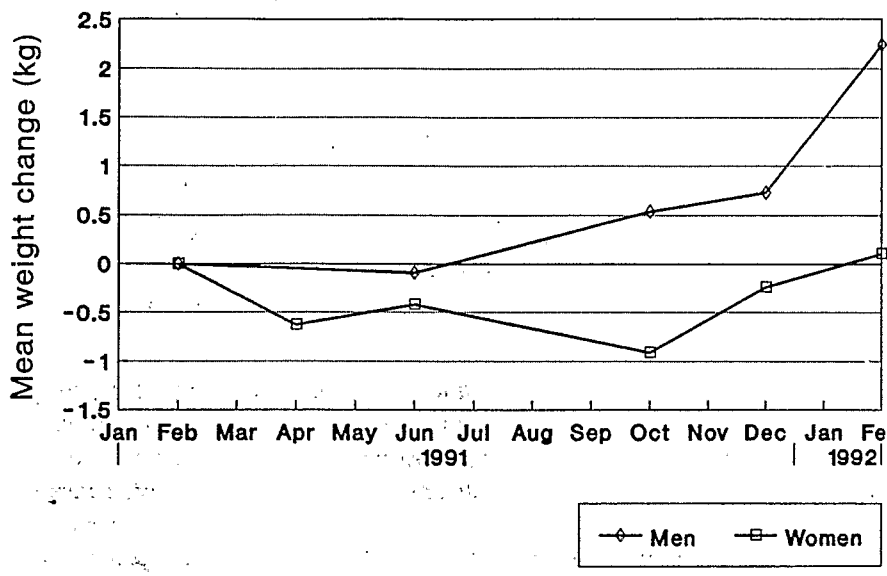

Fig. 13.4. Mean change in individual weight of adults in the Senegal River Valley.

(1988), at most 6.6% of the men and 14.8% of the women in the SRV are classified as malnourished, against 5.3% of the women in the PB.

The means of individual weight changes of adults in the SRV between successive measurements across the year are given in Fig. 13.4. Patterns differ between the sexes. For men, weight increased significantly between June and October (+0.63 kg, $p<0.05$) and between December and February (+1.5 kg, $p<0.001$), while women lost significant amounts of weight between June and October (−0.49 kg, $p<0.05$). Thereafter they regained the weight lost: between October and December (+0.67 kg, $p<0.01$) and between December and February (+0.35 kg, $p<0.05$).

Maximal weight change in 1991 is estimated to be 1.9 kg for women and 0.7 kg for men. A positive trend in the nutritional status of men is clear with the February 1992 weight being about 2 kg above the February 1991 weight.

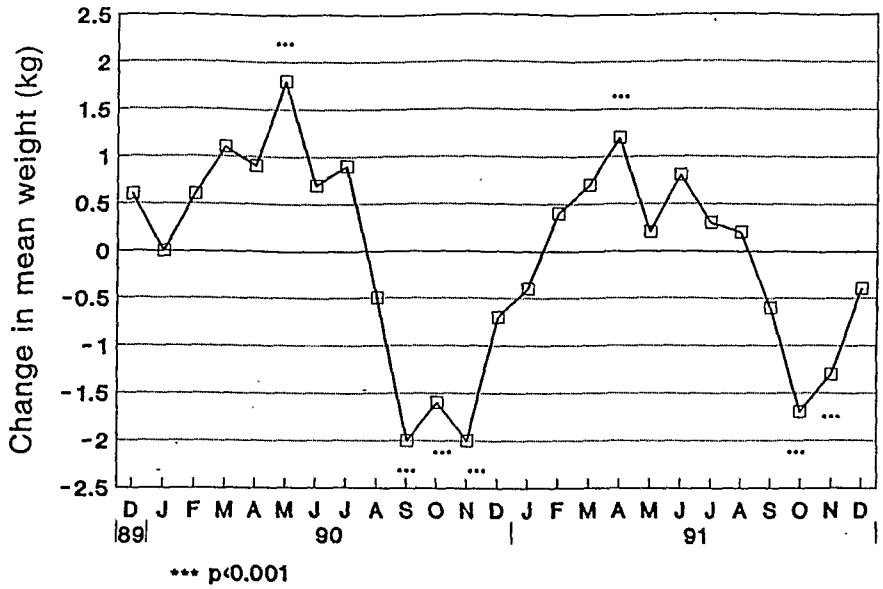

Fig. 13.5. Seasonal change in mean weight of women in the Peanut Basin.

In the PB, as each individual could have been measured up to four times, data were analyzed both cross-sectionally and longitudinally. The mothers' mean weights (Fig. 13.5) show large seasonal changes with the May 1990 and April 1991 values being significantly higher than the overall mean ($p<0.001$) and the September–November 1990 and October–November 1991 values being significantly lower ($p<0.001$). Maximal change in mean weight was 3.8 kg in 1990 and 2.9 kg in 1991.

Mean individual weight changes for women weighed both in April–May and September–November were 3.5 kg in 1990 (95% confidence, interval: 3.0–4.1, $n=87$) and 2.5 kg in 1991 (95% confidence, interval: 2.0–3.0, $n=145$).

Infants and children

Seasonal variation in nutritional status in infants showed similar patterns in the two study areas. In the SRV, mean weight for height varied significantly between seasons ($p<0.01$), with the June and October means being lower than the general mean ($p<0.05$, Fig. 13.6). Between October and December the mean increased sharply from -0.40 z-scores to $+0.28$ z-scores and then it declined again between December 1991 and February 1992. The seasonal pattern was similar for children aged 12–23 months while the weight for height of 24–59-month-old children showed no significant variation.

The PB younger infants (2–5 months) exhibited small and inconstant

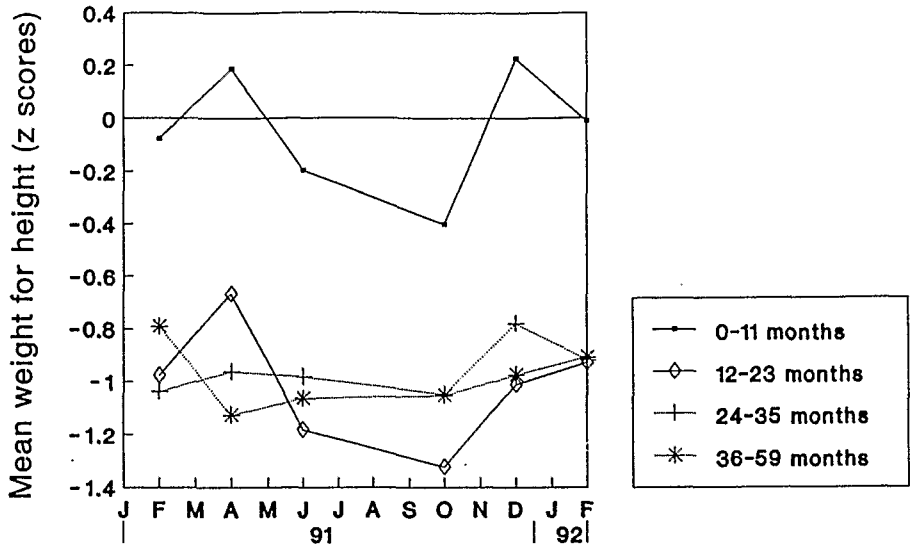

Fig. 13.6. Seasonal change in weight for height of preschool children in the Senegal River Valley.

declines in *W/H* at the end of the rainy season, while the maximal difference in *W/H* of older infants (9–10 months) was consistently large (range: 0.6–0.8 *z*-scores, Fig. 13.7). The decline was abrupt from July to September–October, and the increase was rapid from October–November to December.

Food intake in the Senegal River Valley

Energy intakes measured at the household level were globally sufficient to cover dietary allowances. Mean energy intake was significantly higher in January than in June (10.8 MJ/d (2591 kcal/d) versus 9.8 MJ/d (2353 kcal/d), $p < 0.05$).

In January, just after the rice harvest, rice consumption covered about 50% of the total energy intake. In June, significantly more foods were bought on the market than in January.

Total energy expenditure of adults in the Senegal River Valley

Total energy expenditure was higher in January than in June, both for men (11.1 MJ/d (2660 kcal/d) versus 10.1 MJ/d (2415 kcal/d), $p < 0.01$) and for women (11.5 MJ/d (2751 kcal/d) versus 10.0 MJ/d (2394 kcal/d), $p < 0.01$).

When expressed in multiples of BMR, women had higher energy expenditure than men in both seasons (2.0 × BMR in January and 1.8 × BMR in June versus 1.6 × BMR in January and 1.5 × BMR in June). Total energy expenditure divided by estimated individual energy intake

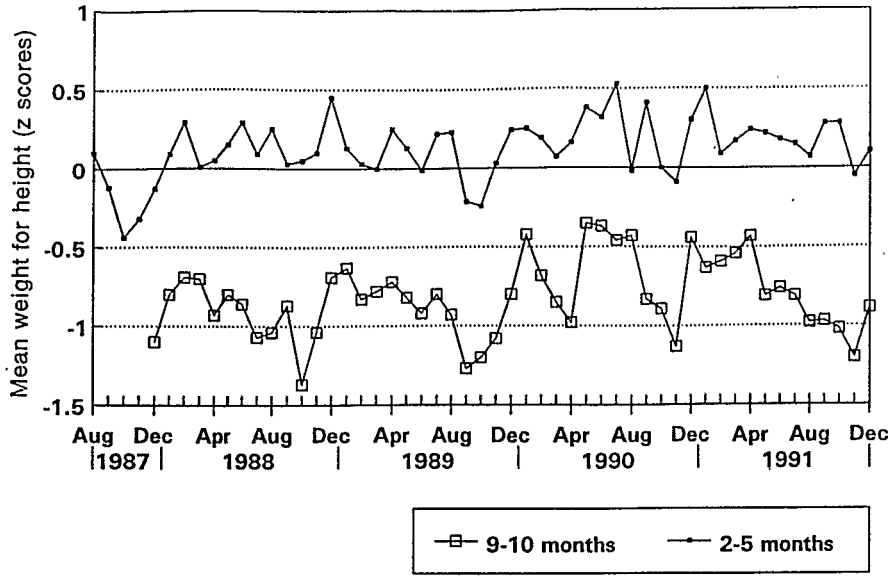

Fig. 13.7. Seasonal change in weight for height of infants in the Peanut Basin.

was constant for men (110% in January and 106% in June); and not significantly lower in January than in June for women (105% versus 112%).

Activity patterns in the Senegal River Valley

Women devoted an important part of their day to housework, mainly food preparation. Housework was either moderate or heavy in intensity. Moderate housework took up 29% of the day in January and 24% in June. Heavy activities such as pounding and drawing water took up 13% of the day in January and 12% in June (Table 13.3). Agricultural tasks involved 10% of the day in January and 6% in June, while the women were sitting, either active or inactive, for 25% of the day in January and 37% in June.

Men devoted 20% of the day to agriculture in January and 15% in June, while they were sitting, mostly inactive, during 32% of the day in both seasons. They took part in significantly more social activities such as games and religious ceremonies in June than in January (15% versus 7%, $p<0.05$). They also remained lying more (10% versus 5%, $p<0.01$) and moved around less in June than in January (9.2% versus 15.8%, $p<0.05$).

Morbidity during infancy in the Peanut Basin

No clear seasonal pattern was observed in the number of diarrhoea cases in children aged 2–12 months between 1988 and 1990 (Fig. 13.8).

Table 13.3. *Physical activity of adults (percentage of the day)*

	Women ($n=40$)		Men ($n=30$)	
	January	June	January	June
Moderate housework	28.7	24.0	3.9	3.5
Heavy housework	12.9	11.5	1.5	2.1
Agricultural tasks	10.0	5.6*	19.9	15.3
Other heavy tasks	5.3	4.4	14.6	12.6
Moving around	9.7	5.9	15.8	9.2*
Social activities	4.5	4.7	7.0	14.9*
Sitting	24.9	37.0***	32.3	32.3
Lying	4.0	6.8*	4.6	10.0**

Differences between seasons: *$p<0.05$, **$p<0.01$, ***$p<0.001$.

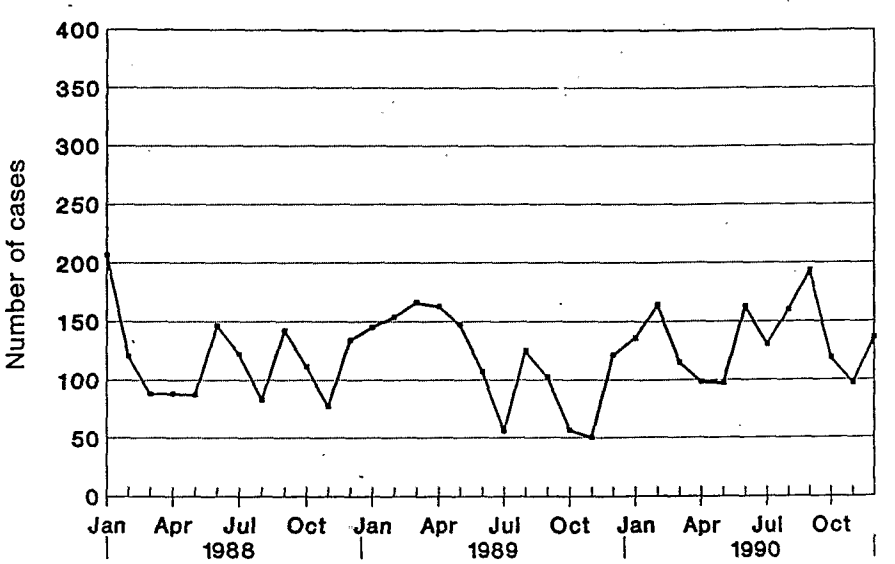

Fig. 13.8. Seasonal change in diarrhoea morbidity among infants in the Peanut Basin.

In contrast, the number of fever cases was two- to three-fold higher in September–October 1988 and 1989 than in July (Fig. 13.9). In 1990, the peak at the end of the rainy season was lower, although still marked.

Mortality during early childhood in the Peanut Basin

Mortality during early childhood was highly related to season. The number of fatality cases in September–November was five- to ten-fold higher than in February–April, both for infants (Fig. 13.10) and for one- to four-year-old children (Fig. 13.11). In both age groups the yearly minimal value was about four deaths per month while the yearly maximal value varied

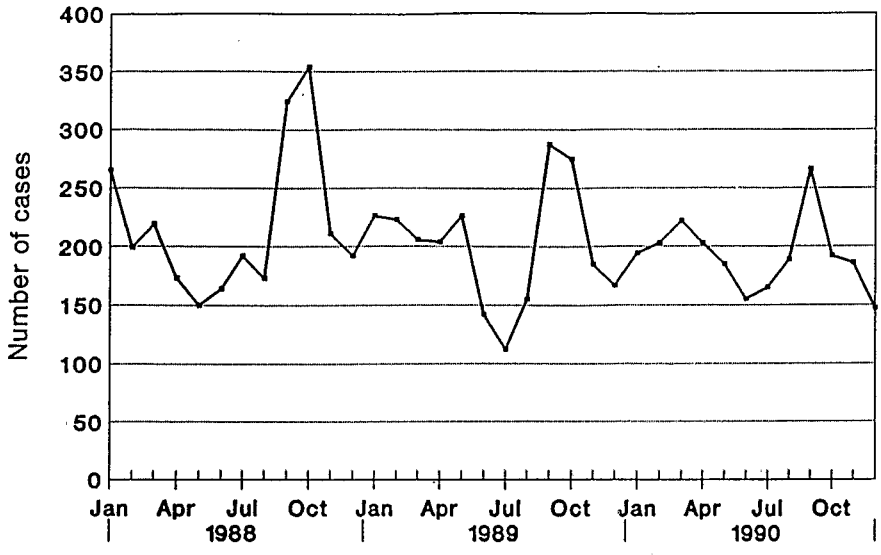

Fig. 13.9. Seasonal change in fever among infants in the Peanut Basin.

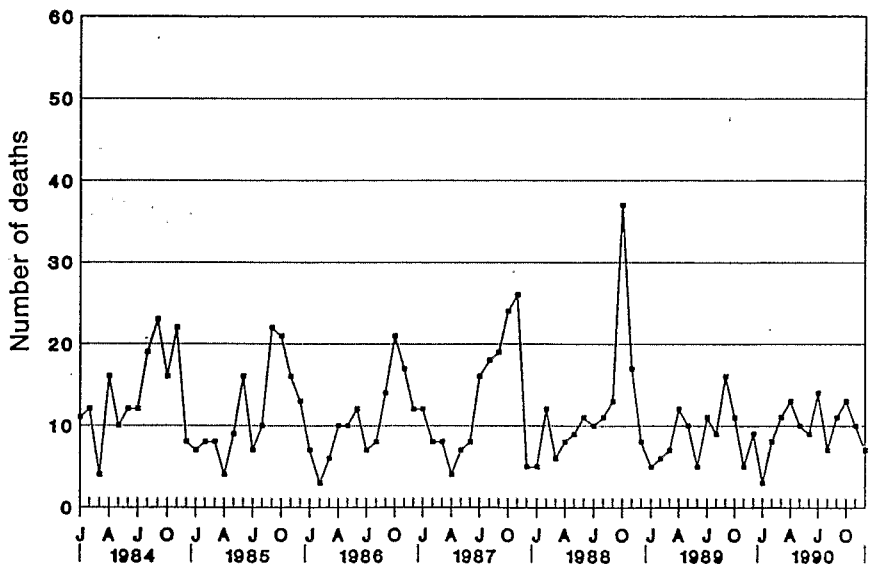

Fig. 13.10. Seasonal change in mortality of infants in the Peanut Basin.

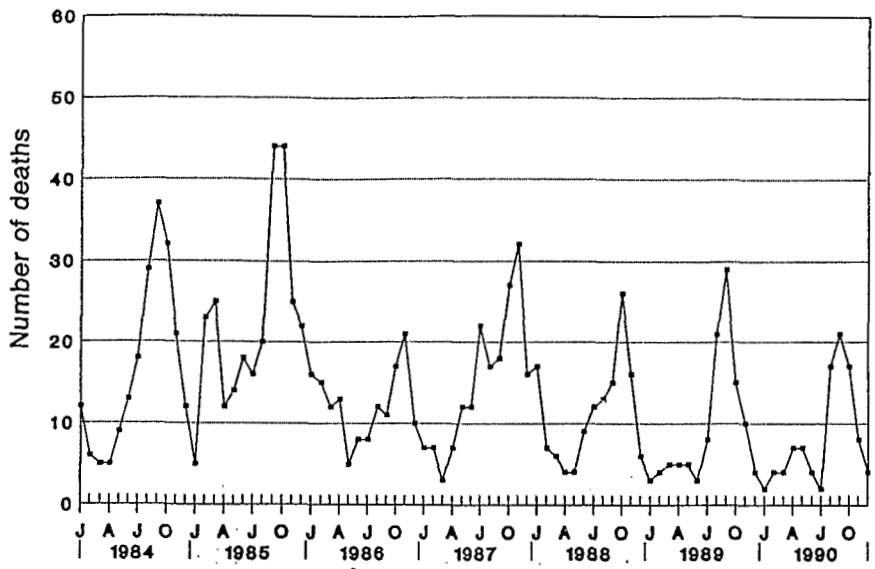

Fig. 13.11. Seasonal change in mortality of children aged 1–4 years in the Peanut Basin.

between 20 and 40 deaths per month. However, the peak during the end of the rainy season was not observed in the last two years (1989–90) for infants.

Discussion

The magnitude of mean seasonal weight loss experienced by women in the SRV (1.9 kg) fits in the range reported for developing countries (Ferro-Luzzi *et al.*, 1987). Mean weight loss was lower for men (0.7 kg) than for women, while most other studies report higher weight losses for men. The most striking phenomenon in the nutritional status of men is the positive annual trend. This result is consistent with the differences observed in total energy expenditure, which is higher for women than for men in both seasons (1.8–2.0 × BMR versus 1.5–1.6 × BMR). Unfortunately, in the absence of data on seasonality and nutritional status in this area before the onset of the agricultural project, the impact of the project on seasonality cannot be assessed.

The weight loss experienced by women in the PB (3.5 kg in 1990 and 2.5 kg in 1991) is one of the highest ever reported in the literature (Ferro-Luzzi *et al.*, 1987). In 1981–2, Rosetta (1986) studied seasonal anthropometric variation in Serere adults living in an area located only 25 km from the Niakhar study area. Men aged 18–54 years (mean age: 37.7 years) had a mean loss of 1.7 kg between March and August–September in

1981 ($n=53$) and of 1.8 kg in 1982 ($n=43$). Nursing non-pregnant women (mean age: 27.3 years) comparable to the Serere mothers of the infants in the present study lost 2.5 kg in 1981 ($n=19$) and only 0.1 kg in 1982 ($n=16$). It is, however, possible that weight loss in women occurred later in 1982 than in 1981 (in late September or October), but no weight measurements are available for those later periods.

Thus, in the PB severe seasonal weight variation coexists with an overall good nutritional status in women. Mean body mass index (BMI) in February 1991 was 21.6 kg/m^2, which is very high compared to a mean of 19.0 kg/m^2 in Ethiopia (Ferro-Luzzi *et al.*, 1990) and 18.5 kg/m^2 in Bangladesh (Huffman *et al.*, 1985). It is also higher than in most studies from West Africa, for example Benin (20.4 kg/m^2, Schultink *et al.*, 1990).

In fact, mean BMI of Toucouleur as well as Serere mothers is very similar to the reference data for well-off French women of similar ages (median at age 30 years: 21.1 kg/m^2, Rolland-Cachera *et al.*, 1991).

An important result of this study is therefore that the highest seasonal weight losses are not always to be expected in low BMI populations.

In addition, the seasonal weight losses reported here are probably slightly underestimated. In the SRV, subjects were only weighed every two to four months while, as the data from the PB show, weight variation occurs rather rapidly and the months of minima and maxima often change from one year to another, probably according to variations in the agricultural calendar. In the PB, mean weight was known for each month, but as rather few women had been weighed both in the month of maximal weight and in the month of minimal weight, the mean individual weight loss was calculated from a two month period in Spring (April–May) and a three month period in Autumn (September–November).

Seasonal variation in nutritional status of women was more important in the PB than in the SRV. A possible explanation for this difference is the rather homogeneous distribution of agricultural tasks throughout the year in the SRV, perhaps associated with better possibilities for purchasing foods in periods of food shortage. However, women lose weight during the rainy season in the SRV. Unfortunately, neither physical activity surveys nor food intake surveys were carried out in September–October, therefore the relative importance of these two factors could not be assessed.

No food consumption surveys are available from the PB area. Rosetta (1988) reports the results of family food consumption surveys in a similar area in two seasons in 1981: during the middle of the dry season (February–March) and at the end of the rainy season (August–September). The methodology was identical to that used here, and the study found no seasonal variation in energy intake at the household level (9.1 MJ/d (2182 kcal/d) during the dry season versus 8.8 MJ/d (2103 kcal/d) during the rainy season). When food consumption is measured at the household

level, intakes of subgroups, such as women, cannot be assessed. In particular, it is impossible to know whether the energy allocation among the members of the food group is performed in the same way in different seasons.

No data on physical activity were available from this study, but it is well documented from similar areas that September is the peak season for agricultural activities, involving both men and women (Prentice *et al.*, 1981; Bleiberg *et al.*, 1980; Brun *et al.*, 1981). In farmers from Burkina Faso, energy expenditure of women was 9.7 MJ/d (2320 kcal/d) in the dry season versus 12.1 MJ/d (2890 kcal/d) in the rainy season (Bleiberg *et al.*, 1980).

In both areas studied here, variation in the nutritional status of infants is similar to that in the nutritional status of their mothers. Is there a causal relationship, and if so, through what mechanisms does it operate? One hypothesis is that breast milk production may decline when women lose weight beyond a certain level. However, in the PB, younger infants, who are almost exclusively breastfed, suffered much less from seasonal weight losses than older infants.

Another hypothesis is that the intake of solids in infants and very young children may be reduced during periods of intensive field work because mothers have less time for child-care.

Morbidity (especially diarrhoea and fever) is an important determinant of *W/H* in young children (Black *et al.*, 1984; Rowland *et al.*, 1977). However, no increase in diarrhoea was seen during the rainy season in the PB. The absence of seasonal variation is unlikely to be explained by deficiencies in data quality, since the number of fever cases, collected a similar way, revealed significant seasonal variation. Black *et al.* (1982) also found little seasonal variation in the prevalence of diarrhoea.

The important increase in the number of fever cases at the end of the rainy season is probably a result of the seasonal increase in incidence of malaria.

The high mortality rates at the end of the rainy season in the PB are probably due in part to malaria, and in part to malnutrition. Even if diarrhoea prevalence does not increase at the end of the rainy season, diarrhoea fatality rates may be higher because of the high prevalence of acute malnutrition. The relative importance of these factors on the seasonal mortality peaks will be assessed in further studies through the analysis of cause-specific mortality rates.

Acknowledgements

The multidisciplinary health research programme *Eau et Santé dans les Contextes du Développement* conducted by ORSTOM in the Senegal River

Valley was supported by the French *Ministère de la Recherche et de la Technologie*.

The demographic census was carried out by Pascal Handschumacher. Marie Sy-Ndiaye (ORANA) and Daouda Ndiaye supervized the food consumption and activity surveys, while Pape Niokhor Diouf took the anthropometric measurements and Oumar Sall served as interpreter. Simon Chevassus-Agnès provided the software for the analysis of food consumption data.

Between 1987 and 1991 the Niakhar Study Area was supported in part by the Task Force for Child Survival, Atlanta, the World Health Organization, Geneva and Pasteur-Mérieux, Paris. Until August 1989, Michel Garenne coordinated research activities and managed the demographic surveillance system in the area. Anthropometric measurements of infants and mothers were taken under supervision of Bassirou Fall. The field staff in Niakhar collected the demographic and morbidity data, while the staff in Dakar handled data entry and verification.

Study subjects in the Senegal River Valley and in Niakhar collaborated with kindness and patience.

References

Bénéfice, E. & Chevassus-Agnès, S. (1985). Variations anthropométriques saisonnières des adultes appartenant à deux populations différentes de l'Afrique de l'Ouest. *Révue d'Epidémiologie et de Santé Publique*, **33**, 150–60.

Bénéfice, E., Chevassus-Agnès, S. & Barral, H. (1984). Nutritional situation and seasonal variations for pastoralist populations of the Sahel (Senegalese Ferlo). *Ecology of Food and Nutrition*, **14**, 229–47.

Black, R.E., Brown, K.H., Becker, S. & Yunus, M. (1982). Longitudinal studies of infectious diseases and physical growth of children in rural Bangladesh. I. Patterns of morbidity. *American Journal of Epidemiology*, **115**, 305–14.

Black, R.E., Brown, K.H. & Becker, S. (1984). Effects of diarrhea associated with specific enteropathogens on the growth of children in rural Bangladesh. *Pediatrics*, **73**, 799–805.

Bleiberg, F., Brun, T. & Goihman, S. (1980). Duration of activities and energy expenditure of female farmers in dry and rainy season in Upper Volta. *British Journal of Nutrition*, **43**, 71–82.

Brun, T., Bleiberg, F. & Goihman, S. (1981). Energy expenditure of male farmers in dry and rainy season in Upper Volta. *British Journal of Nutrition*, **45**, 67–75.

CDC/WHO (1990). *Anthro Version 1.01*. Atlanta: CDC.

Chevassus-Agnès, S. (1982). *Approche des besoins dans le logiciel de traitement de l'ORANA pour les enquêtes de consommation par groupes alimentaires*. Dakar: ORANA.

Chevassus-Agnès, S. & Ndiaye, A.M. (1981). Enquêtes de consommation alimentaires de l'ORANA de 1977 à 1979: méthodologie et résultats. In *Etat nutritionnel de la population rurale du Sahel: Rapport d'un groupe de travail*, pp. 57–66. Ottawa: CRDI.

Edholm, O. (1981). Habitual physical activity and energy expenditure. In *Practical*

Human Biology, ed. J. Weiner & J. Lourie, pp. 227–39. London: Academic Press.

FAO (1968). *Tables de composition alimentaire pour l'Afrique*. Rome: Food and Agriculture Organization.

FAO (1972). *Tables de composition alimentaire pour l'Asie du Sud-Est*. Rome: Food and Agriculture Organization.

FAO/WHO/UNU (1985). *Energy and Protein Requirements*. FAO/WHO/UNU Expert Consultation. Geneva: WHO.

Ferro-Luzzi, A., Pastore, G. & Sette, S. (1987). Seasonality in energy metabolism. In *Chronic Energy Deficiency: Consequences and Related Issues*, ed. B. Schürch & N.S. Scrimshaw, pp. 37–58. Lausanne: IDECG.

Ferro-Luzzi, A., Scaccini, C., Taffese, S., Aberra, B. & Demeke, T. (1990). Seasonal energy deficiency in Ethiopian rural women. *European Journal of Clinical Nutrition*, **44** (Suppl. 1), 7–18.

Gessain, M. (1978). Poids individuels saisonniers chez les Bassaris du Sénégal Oriental. *Bulletin et Mémoires de la Société d'Anthropologie de Paris*, **5**, 149–55.

Huffman, S.L., Wolff, M. & Lowell, S. (1985). Nutrition and fertility in Bangladesh: nutritional status of nonpregnant women. *American Journal of Clinical Nutrition*, **42**, 725–38.

James, W.P.T., Ferro-Luzzi, A. & Waterlow, J.C. (1988). Definition of chronic energy deficiency in adults. *European Journal of Clinical Nutrition*, **44**, 969–81.

Loutan, L. & Lamotte, J.-M. (1984). Seasonal variations in nutrition among a group of nomadic pastoralists in Niger. *Lancet*, **ii**, 947–9.

Niakhar Project (1992). *Population et santé à Niakhar. Niveaux et tendances des principaux indicateurs démographiques et épidémiologiques de la zone d'étude. 1984–1991*. Dakar: ORSTOM.

Prentice, A.M., Whitehead, R.G., Roberts, S.A. & Paul, A.A. (1981). Long-term energy balance in child-bearing Gambian women. *American Journal of Clinical Nutrition*, **34**, 2790–9.

Rolland-Cachera, M.-F., Cole, T.J., Sempé, M., Tichet, J., Rossignol, C. & Charraud, A. (1991). Body mass index variations: centiles from birth to 87 years. *European Journal of Clinical Nutrition*, **45**, 13–21.

Rosetta, L. (1986). Sex differences in seasonal variations of the nutritional status in Serere adults in Senegal. *Ecology of Food and Nutrition*, **18**, 231–44.

Rosetta, L. (1988). Seasonal variations in food consumption by Serere families in Senegal. *Ecology of Food and Nutrition*, **20**, 275–86.

Rowland, M.G.M., Cole, T.J. & Whitehead, R.G. (1977). A quantitive study into the role of infection in determining nutritional status in Gambian village children. *British Journal of Nutrition*, **37**, 441–50.

Schultink, W.J., Klaver, W., Van Wijk, H., Van Raaij, J.M.A. & Hautvast, J.G.A.J. (1990). Body weight changes and basal metabolic rates of rural Beninese women during seasons with different energy intakes. *European Journal of Clinical Nutrition*, **44** (Suppl. 1), 31–40.

Torun, B., McGuire, J. & Mendoza, R. (1982). Energy cost of activities and tasks of women from a rural region of Guatemala. *Nutrition Research*, **2**, 127–36.

Toury, R., Giorgi, R. & Favier, J.-C. (1967). Aliments de l'Ouest africain, tables de composition. *Annales de Nutrition et d'Alimentation*, **21**, 73–127.

University of California (1990). *BMDP statistical Software*. Berkeley: University of California.

SIMONDON

Society for the Study of Human Biology Symposium 35

Seasonality and Human Ecology

Edited by
S. J. ULIJASZEK &
S. S. STRICKLAND

Seasonal variation in nutritional status of adults and children in rural Senegal

KIRSTEN B. SIMONDON, ERIC BÉNÉFICE, FRANÇOIS SIMONDON, VALÉRIE DELAUNAY AND ANOUCH CHAHNAZARIAN